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THE STATE OF WORLD FISHERIES AND AQUACULTURE

MEETING THE SUSTAINABLE DEVELOPMENT GOALS

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ABIDJAN, CÔTE D'IVOIRE. Offloading tunas

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Food and Agriculture Organization of the United Nations
Rome, 2018

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FOREWORD

Human societies face the enormous challenge of having to provide food and livelihoods to a population well in excess of 9 billion people by the middle of the twenty-first century, while addressing the disproportionate impacts of climate change and environmental degradation on the resource base. The United Nations' 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) offer a unique, transformative and integrative approach to shift the world on to a sustainable and resilient path that leaves no one behind.

Food and agriculture are key to achieving the entire set of SDGs, and many SDGs are directly relevant to fisheries and aquaculture, in particular SDG 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development). Galvanized by public and political attention, in June 2017 the United Nations convened a high-level Ocean Conference in New York to support the implementation of SDG 14. This event was shortly followed by the appointment of Peter Thomson of Fiji as the UN Secretary-General's Special Envoy for the Ocean and the launch of the Communities of Ocean Action, an initiative to track and build on the over 1 400 voluntary commitments registered and announced at the Ocean Conference.

The global momentum on SDG implementation has framed much of the international discourse since the publication of the 2016 edition of *The State of World Fisheries and Aquaculture*. I would particularly highlight the specific SDG 14 target of ending illegal, unreported and unregulated (IUU) fishing by 2020. On 5 June 2016, the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) entered into force. The first operational version of the Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (Global Record), a phased and collaborative global initiative to make available certified vessel data from State authorities, was launched in 2017. The FAO Voluntary Guidelines on Catch Documentation Schemes for wild-captured fish caught for commercial purposes was approved in July 2017, while the FAO Guidelines for the Marking of Fishing Gear to assist in the prevention of abandoned, lost or otherwise discarded fishing gear and its harmful impacts will be tabled for approval at the 2018 session of the FAO Committee on Fisheries. The successful implementation of PSMA, the Global Record and these voluntary guidelines will mark a turning point in the fight against IUU fishing and in favour of the long-term conservation and sustainable use of living marine resources.

The Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), which came into force on 4 November 2016, has also become omnipresent in the international discourse on oceans. The agreement, which aims at keeping the global temperature rise this century well below 2 °C above pre-industrial levels, recognizes the fundamental priority of safeguarding food security and ending hunger. As co-leader of the UNFCCC Oceans Action Agenda, and in support of the Koronivia Joint Work on Agriculture launched at the twenty-third Conference of the Parties to UNFCCC (COP 23), FAO has elevated recognition of the essential role of fisheries and aquaculture for food security and nutrition in the context of climate change, especially in the developing world.

The State of World Fisheries and Aquaculture 2018 highlights the critical importance of fisheries and aquaculture for the food, nutrition and employment of millions of people, many of whom struggle to maintain reasonable livelihoods. Total fish production in 2016 reached an all-time high of 171 million tonnes, of which 88 percent was utilized for direct human consumption, thanks to relatively stable capture fisheries production, reduced wastage and continued aquaculture growth. This production resulted in a record-high per capita consumption of 20.3 kg in 2016. Since 1961 the annual global growth in fish consumption has been twice as high as population growth, demonstrating that the fisheries sector is crucial in meeting FAO's goal of a world without hunger and malnutrition. While annual growth of aquaculture has declined in recent years, significant double-digit growth is still recorded in some countries, particularly in Africa and Asia. The sector's contribution to economic growth and the fight against poverty is growing. Strengthened demand and higher prices increased the value of global fish exports in 2017 to USD 152 billion, 54 percent originating from developing countries.

The fisheries and aquaculture sector is not without challenges, however, including the need to reduce the percentage of fish stocks fished beyond biological sustainability, currently 33.1 percent; to ensure that biosecurity and animal disease challenges are tackled successfully; and to maintain complete and accurate national statistics in support of policy development and implementation. These and other challenges engendered FAO's Blue Growth Initiative, an innovative, integrated and multisectoral approach to the management of aquatic resources aimed at maximizing the ecosystem goods and services obtained from the use of oceans, inland waters and wetlands, while also providing social and economic benefits.

The State of World Fisheries and Aquaculture is the only publication of its kind, providing technical insight and factual information on a sector increasingly recognized as crucial for societal success. In addition to reporting major trends and patterns observed in global fisheries and aquaculture, this edition scans the horizon for new and upcoming areas that need to be considered if we are to manage aquatic resources sustainably into the future, including cooperation through regional fisheries bodies and advances such as blockchain technology, to ensure that in delivering the SDGs we tackle the root causes of poverty and hunger while building a fairer society that leaves no one behind.

Previous editions have been accessed on the Internet well over 1 500 times a day. I hope this edition will have the same quantitative and qualitative impact, making a valuable contribution to help meet the challenges of the twenty-first century.

José Graziano da Silva
FAO Director-General

METHODOLOGY

The State of World Fisheries and Aquaculture 2018 is the product of an 18-month process, initiated in January 2017. An editorial board comprising staff of the FAO Fisheries and Aquaculture Department and a representative of the Office of Corporate Communication, and chaired by the Director of the FAO Fisheries and Aquaculture Policy and Resources Division, met at regular intervals to plan the content and structure, refine terminology and review progress.

The structure was planned to follow that of previous editions for the most part, with some modifications: Part 2 (previously "Selected issues") would emphasize FAO's work and position in key thematic areas; Part 3 (previously "Highlights of special studies") would be renamed to focus on ongoing work in partnership; and Part 4 would address not only projections (outlook), but also emerging issues. The world review in Part 1 would follow the format and process of past years.

In April 2017, Fisheries and Aquaculture Department staff were invited to identify suitable topics and contributors for Parts 2, 3 and 4, and the editorial board compiled and refined the outline. Ultimately, the process from planning through review involved virtually all officers in the department, both headquarters and decentralized staff. Some 75 FAO authors contributed (many to multiple sections), as well as several authors external to FAO (see Acknowledgements).

In summer 2017, a summary of Parts 2 to 4 was prepared with the inputs of all lead authors and revised based on feedback from the editorial board. The summary document was submitted to Fisheries and Aquaculture Department management and the FAO Deputy-Director-General, Climate and Natural Resources, for approval in early September 2017. This document formed the blueprint guiding authors in the drafting of the publication.

Parts 2 to 4 were drafted between September and December 2017, edited for language and technical content, and sent in January 2018 for review by FAO Fisheries and Aquaculture Department management, by three external experts in the areas of capture fisheries, aquaculture and trade and market access, and by the editorial board.

The world review in Part 1 is based on FAO's official fishery and aquaculture statistics. To reflect the most up-to-date statistics available, this part was drafted in March 2018 upon annual closure of the various thematic databases in which the data are structured (see Overview in Part 1 for details). The statistics are the outcome of an established mechanism to ensure the best possible information, including assistance to enhance countries' capacity to collect and submit data according to international standards and a careful process of collation, revision and validation. In the absence of national reporting, FAO may make estimates based on the best data available from other sources or through standard methodologies.

The draft was sent for comments to other FAO departments and regional offices, and a final draft was submitted to the Office of the FAO Deputy Director General – Climate and Natural Resources and the Office of the FAO Director-General for approval.

ACKNOWLEDGEMENTS

The State of World Fisheries and Aquaculture 2018 was prepared under the overall direction of Manuel Barange and an Editorial Board under his leadership, comprising Jacqueline Alder, Uwe Barg, Simon Funge-Smith, Piero Mannini, Marc Taconet and Julian Plummer.

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Aquaculture production: Xiaowei Zhou (lead author), Junning Cai
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Part 3

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Part 4

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Projections: Stefania Vannuccini (lead author), Junning Cai

The publication also benefited from external review by three experts in aquaculture, capture fisheries and fisheries trade and market access: David Little (Stirling University, United Kingdom) and two others who wish to remain anonymous. They are acknowledged for their significant contributions. The report was reviewed internally by Vera Agostini, Manuel Barange and the SOFIA editorial board, as well as by colleagues in other technical divisions of FAO beyond the Fisheries and Aquaculture Department.

Andrea Perlis served as language editor and production coordinator, under the supervision of Marc Taconet. The Meeting Programming and Documentation Service of the FAO Conference, Council and Protocol Affairs Division provided translation and printing services.

The Publishing Group (OCCP) in FAO's Office for Corporate Communication provided editorial support, design and layout, as well as production coordination, for editions in all six official languages.

ACRONYMS AND ABBREVIATIONS

AFDB	African Development Bank
AIS	automatic identification system
ALDFG	abandoned, lost or otherwise discarded fishing gear
APFIC	Asia Pacific Fisheries Commission
AqGR	aquatic genetic resources
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CCRF	Code of Conduct for Responsible Fisheries
CDS	catch documentation scheme
CGRFA	Commission on Genetic Resources for Food and Agriculture
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COFI	Committee on Fisheries
COP	Conference of the Parties
COREP	Regional Fisheries Committee for the Gulf of Guinea
CPUE	catch per unit of effort
CSA	climate-smart agriculture
CSO	civil society organization
CWP	Coordinating Working Party on Fishery Statistics
DOALOS	United Nations Division for Ocean Affairs and the Law of the Sea
EAA	ecosystem approach to aquaculture
EAF	ecosystem approach to fisheries
EEZ	exclusive economic zone
EU	European Union
FCWC	Fishery Committee for the West Central Gulf of Guinea
FIRMS	Fisheries and Resources Monitoring System
GAP	Global Action Programme [on Food Security and Nutrition in Small Island Developing States]
GDP	gross domestic product
GEF	Global Environment Fund
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GRSF	Global Record of Stocks and Fisheries

ACRONYMS AND ABBREVIATIONS

GSSI	Global Sustainable Seafood Initiative
HCES	household consumption and expenditure survey
HLPF	High-Level Political Forum on Sustainable Development
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICT	information and communication technology
ILO	International Labour Organization
IMO	International Maritime Organization
IOC	Indian Ocean Commission
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
IUU	illegal, unreported and unregulated
LDC	least developed country
LIFDC	low-income food deficit country
LOA	length overall
MCS	monitoring, control and surveillance
MPA	marine protected area
MSP	marine spatial planning
MSY	maximum sustainable yield
NACA	Network of Aquaculture Centres in Asia-Pacific
NAP	National Adaptation Plan
NCD	non-communicable disease
NDC	Nationally Determined Contribution
nei	not elsewhere included
NGO	non-governmental organization
OECD	Organisation for Economic Co-operation and Development
OSPESCA	Central American Organization of the Fisheries and Aquaculture Sector
PSMA	Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing ("Port States Measures Agreement")
RECOFI	Regional Commission for Fisheries
RFB	regional fisheries body
RFMO	regional fisheries management organization
ROPME	Regional Organization for the Protection of the Marine Environment

RSN	Regional Fishery Body Secretariats' Network
SADC	Southern African Development Community
SDG	Sustainable Development Goal
SEAFDEC	Southeast Asian Fisheries Development Center
SIDS	small island developing States
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
SWIOFC	Southwest Indian Ocean Fishery Commission
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UNDG	United Nations Development Group
UNEP	United Nations Environment Programme
UNESCO-IOC	Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VGGT	Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security
VMS	vessel monitoring system
WAPI	World Aquaculture Performance Indicators
WECAFC	Western Central Atlantic Fishery Commission
WHO	World Health Organization
WTO	World Trade Organization

DJERBA ISLAND, TUNISIA
Fishers in the port of Ajim
©Nikos Economopoulos/
Magnum Photo

PART 1
WORLD REVIEW

PART 1

WORLD REVIEW

OVERVIEW

The 2030 Agenda for Sustainable Development (2030 Agenda for short) offers a vision of a fairer, more peaceful world in which no one is left behind. The 2030 Agenda also sets aims for the contribution and conduct of fisheries and aquaculture towards food security and nutrition, and the sector's use of natural resources, in a way that ensures sustainable development in economic, social and environmental terms, within the context of the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). A major challenge to implementation of the 2030 Agenda is the sustainability divide between developed and developing countries which has partially resulted from increased economic interdependencies, coupled with limited management and governance capacity in developing countries. To eliminate this disparity while making progress towards the target for restoration of overfished stocks set by the 2030 Agenda, the global community needs to support developing nations to achieve their full fisheries and aquaculture potential.

Global fish production[1] peaked at about 171 million tonnes in 2016, with aquaculture representing 47 percent of the total and 53 percent if non-food uses (including reduction to fishmeal and fish oil) are excluded. The total first sale value of fisheries and aquaculture production in 2016 was estimated at USD 362 billion, of which USD 232 billion was from aquaculture production. With capture fishery production relatively static since the late 1980s, aquaculture has been responsible for the continuing impressive growth in the supply of fish for human consumption (Figure 1). Between 1961 and 2016, the average annual increase in global food fish consumption[2] (3.2 percent) outpaced population growth (1.6 percent) (Figure 2) and exceeded that of meat from all terrestrial animals combined (2.8 percent). In per capita terms, food fish consumption grew from 9.0 kg in 1961 to 20.2 kg in 2015, at an average rate of about 1.5 percent per year. Preliminary estimates for 2016 and 2017 point to further growth to about 20.3 and 20.5 kg, respectively. The expansion in consumption has been driven not only by increased production, but also by other factors, including reduced wastage. In 2015, fish accounted for about 17 percent of animal protein consumed by the global population. Moreover, fish provided about 3.2 billion people with almost 20 percent of their average per capita intake of animal protein. Despite their relatively low levels of fish consumption, people in developing countries have a higher share of fish protein in their diets than those in developed countries. The highest per capita fish consumption, over 50 kg, is found in several small island developing States (SIDS), particularly in Oceania, while the lowest levels, just above 2 kg, are in Central Asia and some landlocked countries.

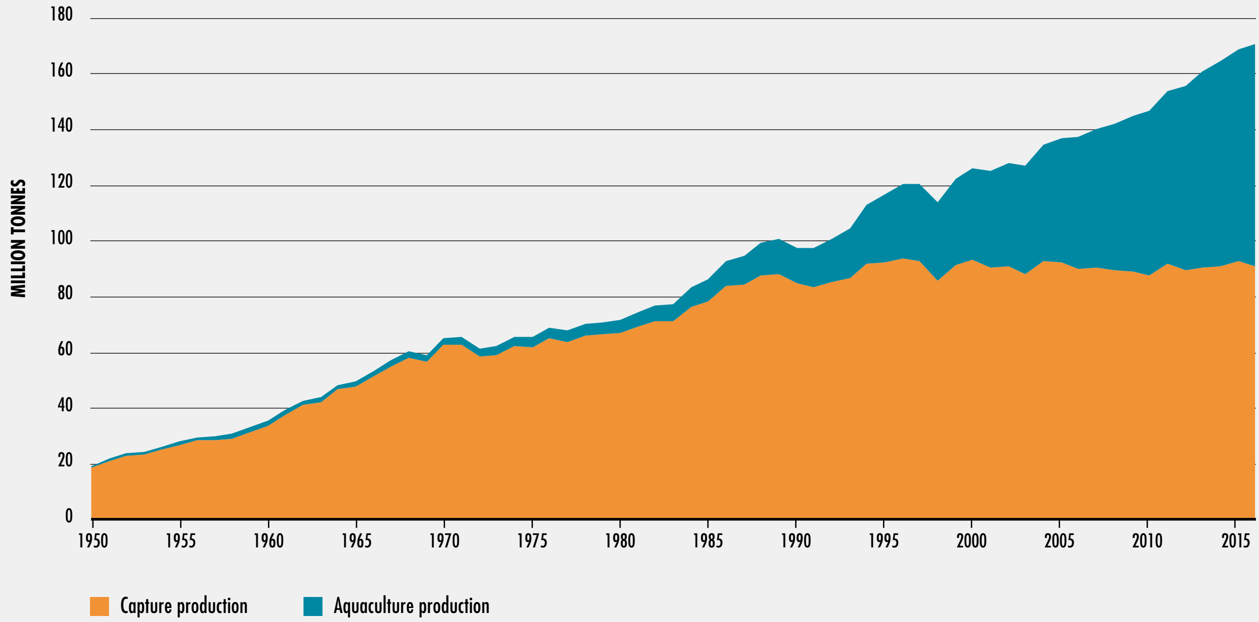
Global capture fisheries production was 90.9 million tonnes in 2016, a small decrease in comparison to the two previous years (Table 1).[3] Fisheries in marine and inland waters provided 87.2 and 12.8 percent of the global total, respectively. »

1 Unless otherwise specified, throughout this publication, the term "fish" indicates fish, crustaceans, molluscs and other aquatic animals, but excludes aquatic mammals, reptiles, seaweeds and other aquatic plants.

2 The term "food fish" refers to fish destined for human consumption, thus excluding fish for non-food uses. The term "consumption" refers to apparent consumption, which is the average food available for consumption, which, for a number of reasons (for example, waste at the household level), is not equal to food intake.

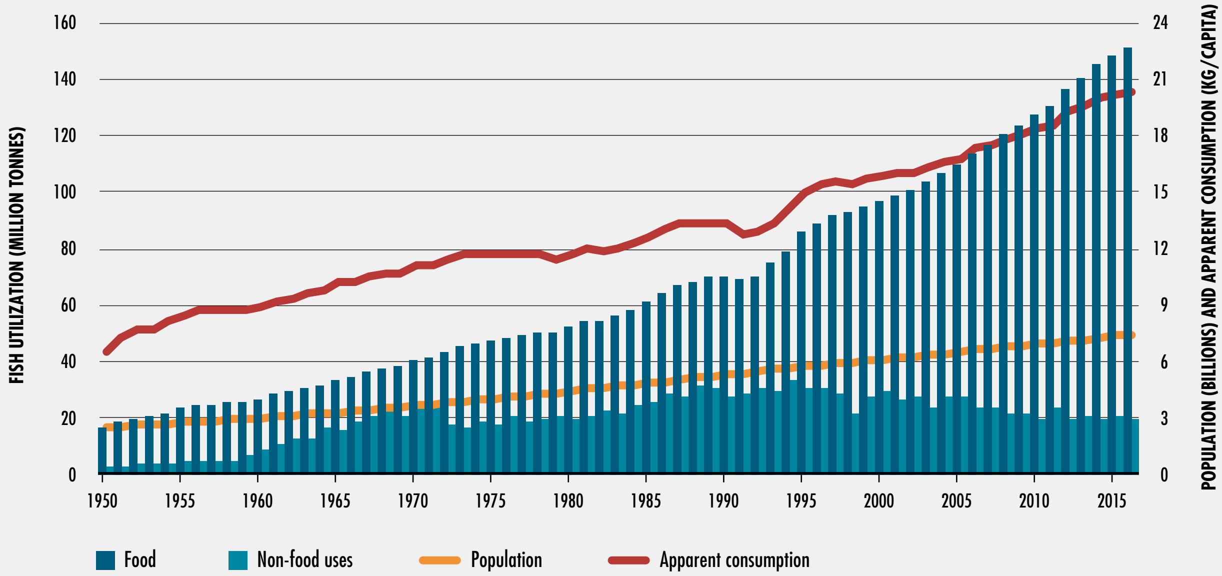
3 In the tables in this publication, figures may not sum to totals because of rounding.

FIGURE 1
WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants

FIGURE 2
WORLD FISH UTILIZATION AND APPARENT CONSUMPTION



NOTE: Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants

TABLE 1
WORLD FISHERIES AND AQUACULTURE PRODUCTION AND UTILIZATION (MILLION TONNES)[a]

Category	2011	2012	2013	2014	2015	2016
Production						
Capture						
Inland	10.7	11.2	11.2	11.3	11.4	11.6
Marine	81.5	78.4	79.4	79.9	81.2	79.3
Total capture	**92.2**	**89.5**	**90.6**	**91.2**	**92.7**	**90.9**
Aquaculture						
Inland	38.6	42.0	44.8	46.9	48.6	51.4
Marine	23.2	24.4	25.4	26.8	27.5	28.7
Total aquaculture	**61.8**	**66.4**	**70.2**	**73.7**	**76.1**	**80.0**
Total world fisheries and aquaculture	**154.0**	**156.0**	**160.7**	**164.9**	**168.7**	**170.9**
Utilization[b]						
Human consumption	130.0	136.4	140.1	144.8	148.4	151.2
Non-food uses	24.0	19.6	20.6	20.0	20.3	19.7
Population (*billions*)[c]	7.0	7.1	7.2	7.3	7.3	7.4
Per capita apparent consumption (*kg*)	18.5	19.2	19.5	19.9	20.2	20.3

[a] Excludes aquatic mammals, crocodiles, alligators and caimans, seaweeds and other aquatic plants.
[b] Utilization data for 2014–2016 are provisional estimates.
[c] Source of population figures: UN, 2015e.

» World total marine catch was 79.3 million tonnes in 2016, representing a decrease of almost 2 million tonnes from the 81.2 million tonnes in 2015. Catches of anchoveta by Peru and Chile, which are often substantial yet highly variable because of the influence of El Niño, accounted for 1.1 million tonnes of this decrease, with other major countries and species, particularly cephalopods, also showing reduced catches between 2015 and 2016. Total marine catches by China, by far the world's top producer, were stable in 2016, but the inclusion of a progressive catch reduction policy in the national Thirteenth Five-Year Plan for 2016–2020 is expected to result in significant decreases in the following years.

As in 2014, Alaska pollock again surpassed anchoveta as the top species in 2016, with the highest catches since 1998. However, preliminary data for 2017 showed a significant recovery of anchoveta catches. Skipjack tuna ranked third for the seventh consecutive year. Combined catches of tuna and tuna-like species levelled off at around 7.5 million tonnes after an all-time maximum in 2014. After five years of continuous growth that started in 2010, catches of cephalopods were stable in 2015 but dropped in 2016 when catches of the three major squid species showed a combined loss of 1.2 million tonnes. Capture production of other mollusc groups started declining much earlier – oysters in the early 1980s, clams in the late 1980s, mussels in the early 1990s and scallops since 2012. In contrast, the most valuable species groups with significant production – lobsters, gastropods, crabs and shrimps – marked a new catch record in 2016.

The Northwest Pacific continues to be by far the most productive fishing area, with catches in 2016 of 22.4 million tonnes, slightly higher than in 2015 and 7.7 percent above the average for the decade 2005–2014. All other temperate areas have shown decreasing trends for several years, with the sole exception of the Northeast Pacific, where catches in 2016 were higher than the average for 2005–2014 thanks to good catches of Alaska pollock, Pacific cod and north Pacific hake. Recent drops in catches in the Southwest Atlantic and the Southwest Pacific were the result of greatly reduced catches by distant-water fishing nations. In contrast to the temperate areas, and the upwelling areas which are characterized by high annual variability in catches, tropical areas have experienced a continuously rising trend in production as catches of large (mostly tuna) and small pelagic species continue to increase.

Capture fisheries in the world's inland waters produced 11.6 million tonnes in 2016, representing 12.8 percent of total marine and inland catches. The 2016 global catch from inland waters showed an increase of 2.0 percent over the previous year and of 10.5 percent in comparison to the 2005–2014 average, but this result may be misleading as some of the increase can be attributed to improved data collection and assessment at the country level. Sixteen countries produced almost 80 percent of the inland fishery catch, mostly in Asia, where inland catches provide a key food source for many local communities. Inland catches are also an important food source for several countries in Africa, which accounts for 25 percent of global inland catches.

Aquaculture continues to grow faster than other major food production sectors although it no longer enjoys the high annual growth rates of the 1980s and 1990s (11.3 and 10.0 percent, excluding aquatic plants). Average annual growth declined to 5.8 percent during the period 2000–2016, although double-digit growth still occurred in a small number of individual countries, particularly in Africa from 2006 to 2010.

Global aquaculture production in 2016 included 80.0 million tonnes of food fish and 30.1 million tonnes of aquatic plants, as well as 37 900 tonnes of non-food products. Farmed food fish production included 54.1 million tonnes of finfish, 17.1 million tonnes of molluscs, 7.9 million tonnes of crustaceans and 938 500 tonnes of other aquatic animals. China, by far the major producer of farmed food fish in 2016, has produced more than the rest of the world combined every year since 1991. The other major producers in 2016 were India, Indonesia, Viet Nam, Bangladesh, Egypt and Norway. Farmed aquatic plants included mostly seaweeds and a much smaller production volume of microalgae. China and Indonesia were by far the major producers of aquatic plants in 2016.

Farming of fed aquatic animal species has grown faster than that of unfed species, although the volume of the latter continues to expand. In 2016, the total unfed species production climbed to 24.4 million tonnes (30 percent of total farmed food fish), consisting of 8.8 million tonnes of filter-feeding finfish raised in inland aquaculture (mostly silver carp and bighead carp) and 15.6 million tonnes of aquatic invertebrates, mostly marine bivalve molluscs raised in seas, lagoons and coastal ponds. Marine bivalves and seaweeds are sometimes described as extractive species; they can benefit the environment by removing waste materials, including waste from fed species, and lowering the nutrient load in the water. Culture of extractive species with fed species in the same mariculture sites is encouraged in aquaculture development. Extractive species production accounted for 49.5 percent of total world aquaculture production in 2016.

Official statistics indicate that 59.6 million people were engaged (on a full-time, part-time or occasional basis) in the primary sector of capture fisheries and aquaculture in 2016 – 19.3 million in aquaculture and 40.3 million in capture fisheries. It is estimated that nearly 14 percent of these workers were women. Total employment in the primary sectors showed a general upward trend over the period 1995–2010, partly influenced by improved estimation procedures, and then levelled off. The proportion of those employed in capture fisheries decreased from 83 percent in 1990 to 68 percent in 2016, while the proportion of those employed in aquaculture correspondingly increased from 17 to 32 percent. In 2016, 85 percent of the global population engaged in the fisheries and aquaculture sectors was in Asia, followed by Africa (10 percent) and Latin America and the Caribbean (4 percent). Employment in aquaculture was concentrated primarily in Asia (96 percent of all aquaculture engagement), followed by Latin America and the Caribbean and Africa.

The total number of fishing vessels in the world in 2016, from small undecked and unmotorized boats to large sophisticated industrial vessels, was estimated to be about 4.6 million, similar to that in 2014. The fleet in Asia was the largest, consisting of 3.5 million vessels, accounting for 75 percent of the global fleet. In 2016, about

86 percent of the motorized fishing vessels in the world were in the length overall (LOA) class of less than 12 m, the vast majority of which were undecked, and those small vessels dominated in all regions. The number of engine-powered vessels was estimated to be 2.8 million globally in 2016, representing 61 percent of all fishing vessels, and similar to the number for 2014. Only about 2 percent of all motorized fishing vessels were 24 m and larger (roughly more than 100 gross tonnage [GT]), and the proportion of these large boats was highest in Oceania, Europe and North America. Worldwide, FAO estimated about 44 600 fishing vessels with LOA of at least 24 m for 2016.

The state of marine fishery resources, based on FAO's monitoring of assessed marine fish stocks, has continued to decline. The fraction of marine fish stocks fished within biologically sustainable levels has exhibited a decreasing trend, from 90.0 percent in 1974 to 66.9 percent in 2015. In contrast, the percentage of stocks fished at biologically unsustainable levels increased from 10 percent in 1974 to 33.1 percent in 2015, with the largest increases in the late 1970s and 1980s. In 2015, maximally sustainably fished stocks (formerly termed fully fished stocks) accounted for 59.9 percent and underfished stocks for 7.0 percent of the total assessed stocks. The underfished stocks decreased continuously from 1974 to 2015, whereas the maximally sustainably fished stocks decreased from 1974 to 1989, and then increased to 59.9 percent in 2015, partly as a result of increased implementation of management measures.

In 2015, among the 16 major statistical areas, the Mediterranean and Black Sea, Southeast Pacific and Southwest Atlantic had the highest percentages of assessed stocks fished at unsustainable levels, whereas the Eastern Central Pacific, Northeast Pacific, Northwest Pacific, Western Central Pacific and Southwest Pacific had the lowest. An estimated 43 percent of the stocks of the principal market tuna species were fished at biologically unsustainable levels in 2015, while 57 percent were fished within biologically sustainable levels.

The persistence of overfished stocks is an area of great concern. The United Nations Sustainable Development Goals (SDGs) include a target (14.4) for regulating harvesting, ending overfishing and restoring stocks to levels that can produce maximum sustainable yield (MSY) in the shortest time feasible. However, it seems unlikely that the world's fisheries can rebuild the 33.1 percent of stocks that are currently overfished in the very near future, because rebuilding requires time, usually two to three times the species' life span.

Despite the continuous increase in the percentage of stocks fished at biologically unsustainable levels, progress has been made in some regions. For example, the proportion of stocks fished within biologically sustainable levels increased from 53 percent in 2005 to 74 percent in 2016 in the United States of America, and from 27 percent in 2004 to 69 percent in 2015 in Australia. In the Northeast Atlantic and adjacent seas, the percentage of stocks where fishing mortality does not exceed the fishing mortality at MSY increased from 34 percent in 2003 to 60 percent in 2015. However, achieving SDG target 14.4 will require effective partnership between the developed and developing worlds, particularly in policy coordination, financial and human resource mobilization and deployment of advanced technologies. Experience has proved that rebuilding overfished stocks can produce higher yields as well as substantial social, economic and ecological benefits.

Of the 171 million tonnes of total fish production in 2016, about 88 percent (over 151 million tonnes) was utilized for direct human consumption, a share that has increased significantly in recent decades. The greatest part of the 12 percent used for non-food purposes (about 20 million tonnes) was reduced to fishmeal and fish oil. Live, fresh or chilled is often the most preferred and highly priced form of fish and represents the largest share of fish for direct human consumption (45 percent in 2016), followed by frozen (31 percent). Despite improvements in fish processing and distribution practices, loss or wastage between landing and consumption still accounts for an estimated 27 percent of landed fish.

Fishmeal production peaked in 1994 at 30 million tonnes (live weight equivalent) and has followed a fluctuating but overall declining trend since then. A growing share of fishmeal is being produced from fish by-products, which previously were often wasted. It is estimated that by-products account for about 25 to 35 percent of the total volume of fishmeal and fish oil produced. Fishmeal and fish oil are still considered the most nutritious and most digestible ingredients for farmed fish feeds, but their inclusion rates in compound feeds for aquaculture have shown a clear downward trend as they are used more selectively.

Fish and fish products are some of the most traded food items in the world today. In 2016, about 35 percent of global fish production entered international trade in various forms for human consumption or non-edible purposes. The 60 million tonnes (live weight equivalent) of total fish and fish products exported in 2016 represent a 245 percent increase over 1976. During the same period, world trade in fish and fish products also grew significantly in value terms, with exports rising from USD 8 billion in 1976 to USD 143 billion in 2016. In the past 40 years the rate of growth of exports from developing countries has been significantly faster than that of exports from developed countries. Regional trade agreements have contributed to this growth through the increased regionalization of fish trade since the 1990s, with regional trade flows increasing faster than external trade flows. In 2016, trade increased by 7 percent over the year before, and in 2017 economic growth strengthened demand and lifted prices, again increasing the value of global fish exports by about 7 percent to peak at an estimated USD 152 billion.

China is the main fish producer and since 2002 has also been the largest exporter of fish and fish products, although the rapid growth of the 1990s and 2000s has subsequently slowed. After China, the major exporters in 2016 were Norway, Viet Nam and Thailand. The European Union (EU) represented the largest single market for fish and fish products, followed by the United States of America and Japan; in 2016 these three markets together accounted for approximately 64 percent of the total value of world imports of fish and fish products. Over the course of 2016 and 2017, fish imports grew in all three markets as a result of strengthened economic fundamentals.

Preparation of *The State of World Fisheries and Aquaculture* relies heavily on FAO's fishery and aquaculture statistics. FAO is the only source of global fisheries and aquaculture statistics. These statistics are structured within different data collections (capture and aquaculture production, stocks status, fish commodities production and trade, fishers and fish farmers, fishing vessels, and apparent fish consumption) and are made available to external users through different formats and tools.[4] FAO has established a series of mechanisms to ensure that the best available information is submitted by countries according to international standards. The data are then carefully and consistently collated, revised and validated, either directly (e.g. through food balance sheets) or indirectly (e.g. using consumption surveys). In the absence of national reporting – a concern noted in several sections of Part 1 of this publication – FAO may make estimates based on the best data available from other sources or through standard methodologies, or may simply repeat previous values, which diminishes the accuracy of the statistics. Complete, accurate and timely national statistics are critical for monitoring the fisheries and aquaculture sectors, for supporting policy development and implementation at the national, regional and international levels, and for measuring progress towards meeting the Sustainable Development Goals. The importance of country reporting of fisheries and aquaculture data to FAO, in accordance with the obligations of FAO membership, is highlighted, and FAO continues to enhance countries' capacity to collect these data. ■

CAPTURE FISHERIES PRODUCTION

Global total capture fisheries production, as derived from the FAO capture database, was 90.9 million tonnes in 2016, a decrease in comparison to the two previous years (see Table 1 in "Overview", above). Catch trends in marine and

4 Information on the different formats, tools and products through which users can access FAO fisheries and aquaculture statistics is available at: www.fao.org/fishery/statistics inland waters, which represent respectively 87.2 and 12.8 percent of the global total, are discussed separately in the following sections.

National reports are the main, although not the only, source of data used to maintain and update FAO's capture fishery databases. Hence, the quality of these statistics depends in large measure on the accuracy and reliability of the data collected nationally and provided to FAO. Improvements in the overall quality of FAO's global databases can only be obtained by enhancing the national data collection systems, to produce better information that can support policy and management decisions at national and regional levels (FAO, 2002; and see "FAO's approach to improving the quality and utility of capture fishery data" in Part 2). Unfortunately, the annual proportion of non-reporting countries grew from 20 to 29 percent in the past two years. As a consequence, FAO has had to estimate more of the data. It is crucial that countries give due importance to collecting catch statistics and transmitting them to FAO, to ensure that the quality of the time series is maintained.

FAO continues to support projects to improve national data collection systems, including sampling schemes based on sound statistical analysis, coverage of fisheries subsectors not sampled before, and standardization of sampling at landing sites. FAO is well aware that in many cases an upgraded system may result in an increase of registered and reported catches, creating an apparent disruption of the national trend (Garibaldi, 2012; FAO, 2016c, p. 16). This issue is difficult to address, but FAO tries to minimize its impact through backward revision of the catch statistics in the database, carried out in collaboration with national offices whenever possible. Although improved data collection systems have influenced some national trends, given the large number of countries and territories in the FAO capture database (more than 230), even significant revisions (as in the case of Myanmar; see details in the following sections) have not altered the global trend.

Marine capture production

World total marine catch was 81.2 million tonnes in 2015 and 79.3 million tonnes in 2016, representing a decrease of almost 2 million tonnes. Catches of anchoveta (*Engraulis ringens*) by Peru and Chile, which are often substantial yet highly variable because of the influence of El Niño, accounted for 1.1 million tonnes of this decrease, with other major countries and species, particularly cephalopods, also showing reduced catches between 2015 and 2016 (Tables 2 and 3). Decreasing catches affected 64 percent of the 25 top producer countries, but only 37 percent of the remaining 170 countries.

Total marine catches by China, by far the world's top producer, were stable in 2016, but the inclusion of a progressive catch reduction policy in the national Thirteenth Five-Year Plan for 2016–2020 is expected to result in significant decreases in coming years, with a predicted reduction of more than 5 million tonnes by 2020 (see Box 31 under "Outlook" in Part 4).

In 2016 China reported about 2 million tonnes from its "distant water fishery", but provided details on species and fishing area only for those catches marketed in China (about 24 percent of distant-water catches). In the absence of information, the remaining 1.5 million tonnes have been entered in the FAO database under "marine fishes nei [not elsewhere included]" in fishing area 61, Northwest Pacific, possibly overstating the catches of that area. Thus a great quantity of distant-water catches by China is in the FAO database, although partly not under the correct fishing area and not ascribed down to species level.

Starting with 2015 data and going back to 2006, FAO revised Myanmar's marine and inland catches substantially downward, on the basis of structural data that are more reliable than the official catch statistics which are based on target levels. Before the revision Myanmar ranked ninth as marine capture producer, whereas it now ranks seventeenth. FAO had questioned the data for this country since 2009, when the average annual growth of marine catches was reported to be above 8 percent even after the 2008 cyclone Nargis caused the worst natural disaster in the country's recorded history. FAO is currently running a project to improve fishery data collection in Myanmar's Yangon region. If successful, the methodology could later be expanded to the whole country. »

TABLE 2
MARINE CAPTURE PRODUCTION: MAJOR PRODUCER COUNTRIES

Country		Production *(tonnes)*			% Variation		Variation, 2015 to 2016 *(tonnes)*
		Average 2005–2014	2015	2016	2005–2014 (average) to 2016	2015 to 2016	
China		13 189 273	15 314 000	15 246 234	15.6	–0.4	–67 766
Indonesia		5 074 932	6 216 777	6 109 783	20.4	–1.7	–106 994
United States of America		4 757 179	5 019 399	4 897 322	2.9	–2.4	–122 077
Russian Federation		3 601 031	4 172 073	4 466 503	24.0	7.1	294 430
Peru	Total	6 438 839	4 786 551	3 774 887	–41.4	–21.1	–1 011 664
	Excluding anchoveta	989 918	1 016 631	919 847	–7.1	–9.5	–96 784
India		3 218 050	3 497 284	3 599 693	11.9	2.9	102 409
Japan[a]		3 992 458	3 423 099	3 167 610	–20.7	–7.5	–255 489
Viet Nam		2 081 551	2 607 214	2 678 406	28.7	2.7	71 192
Norway		2 348 154	2 293 462	2 033 560	–13.4	–11.3	–259 902
Philippines		2 155 951	1 948 101	1 865 213	–13.5	–4.3	–82 888
Malaysia		1 387 577	1 486 050	1 574 443	13.5	5.9	88 393
Chile	Total	3 157 946	1 786 249	1 499 531	–52.5	–16.1	–286 718
	Excluding anchoveta	2 109 785	1 246 154	1 162 095	–44.9	–6.7	–84 059
Morocco		1 074 063	1 349 937	1 431 518	33.3	6.0	81 581
Republic of Korea		1 746 579	1 640 669	1 377 343	–21.1	–16.0	–263 326
Thailand		1 830 315	1 317 217	1 343 283	–26.6	2.0	26 066
Mexico		1 401 294	1 315 851	1 311 089	–6.4	–0.4	–4 762
Myanmar[a]		1 159 708	1 107 020	1 185 610	2.2	7.1	78 590
Iceland		1 281 597	1 318 916	1 067 015	–16.7	–19.1	–251 901
Spain		939 384	967 240	905 638	–3.6	–6.4	–61 602
Canada		914 371	823 155	831 614	–9.1	1.0	8 459
Taiwan, Province of China		960 193	989 311	750 021	–21.9	–24.2	–239 290
Argentina		879 839	795 415	736 337	–16.3	–7.4	–59 078
Ecuador		493 858	643 176	715 357	44.9	11.2	72 181
United Kingdom		631 398	65 451 506	701 749	11.1	–0.4	–2 753
Denmark		735 966	868 892	670 207	–8.9	–22.9	–198 685
Total 25 major countries		**65 451 506**	**66 391 560**	**63 939 966**	**–2.3**	**–3.7**	**–2 451 594**
Total other 170 countries		**14 326 675**	**14 856 282**	**15 336 882**	**7.1**	**3.2**	**480 600**
World total		**79 778 181**	**81 247 842**	**79 276 848**	**–0.6**	**–2.4**	**–1 970 994**
Share of 25 major countries		***82.0%***	***81.7%***	***80.7%***			

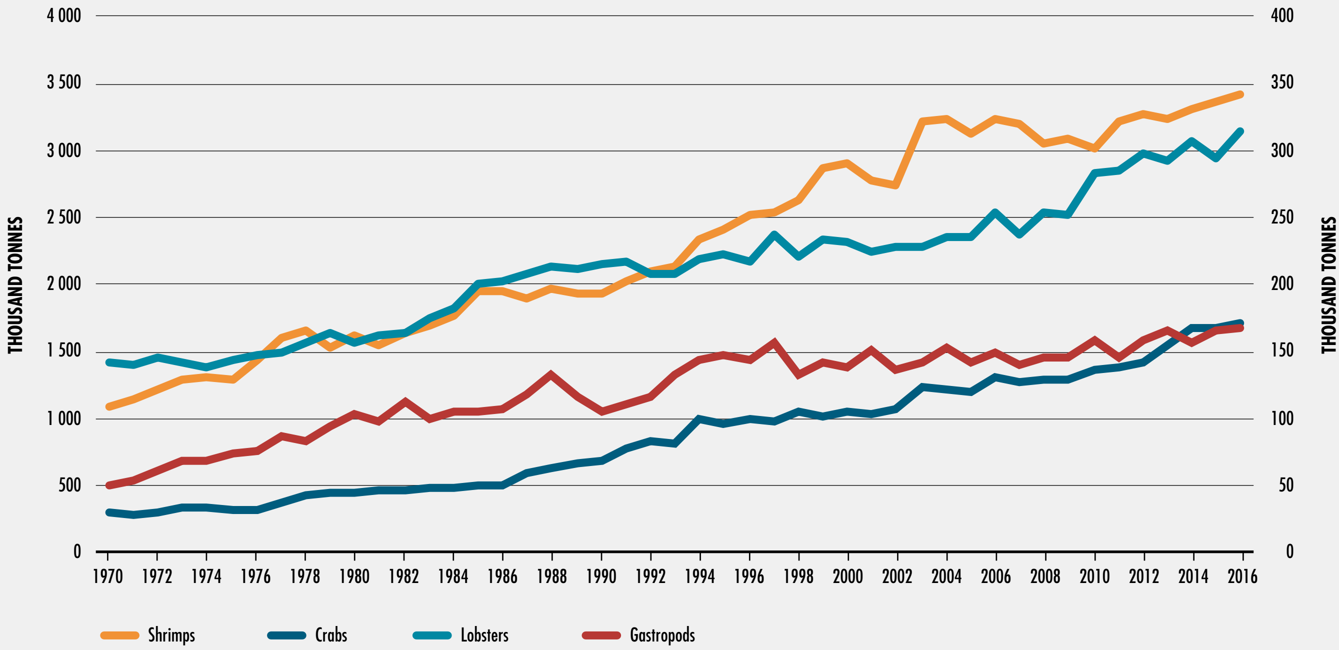
[a] Production figures for 2015 and 2016 are FAO estimates.

TABLE 3
MARINE CAPTURE PRODUCTION: MAJOR SPECIES AND GENERA

Scientific name	FAO English name	Production *(tonnes)*			% Variation		Variation, 2015 to 2016 *(tonnes)*
		Average 2005–2014	2015	2016	2005–2014 (average) to 2016	2015 to 2016	
Theragra chalcogramma	Alaska pollock (=walleye pollock)	2 952 134	3 372 752	3 476 149	17.8	3.1%	103 397
Engraulis ringens	Anchoveta (=Peruvian anchovy)	6 522 544	4 310 015	3 192 476	–51.1	–25.9%	–1 117 539
Katsuwonus pelamis	Skipjack tuna	2 638 124	2 809 954	2 829 929	7.3	0.7%	19 975
Sardinella spp.[a]	Sardinellas nei	2 281 285	2 238 903	2 289 830	0.4	2.3%	50 927
Trachurus spp.[a]	Jack and horse mackerels nei	2 463 428	1 738 352	1 743 917	–29.2	0.3%	5 565
Clupea harengus	Atlantic herring	2 111 101	1 512 174	1 639 760	–22.3	8.4%	127 586
Scomber japonicus	Pacific chub mackerel	1 454 794	1 484 780	1 598 950	9.9	7.7%	114 170
Thunnus albacares	Yellowfin tuna	1 219 326	1 356 883	1 462 540	19.9	7.8%	105 657
Gadus morhua	Atlantic cod	995 853	1 303 726	1 329 450	33.5	2.0%	25 724
Engraulis japonicus	Japanese anchovy	1 323 022	1 336 218	1 304 484	–1.4	–2.4%	–31 734
Decapterus spp.[a]	Scads nei	1 394 772	1 186 555	1 298 914	–6.9	9.5%	112 359
Sardina pilchardus	European pilchard (=sardine)	1 098 400	1 174 611	1 281 391	16.7	9.1%	106 780
Trichiurus lepturus	Largehead hairtail	1 315 337	1 269 525	1 280 214	–2.7	0.8%	10 689
Micromesistius poutassou	Blue whiting (=poutassou)	1 054 918	1 414 131	1 190 282	12.8	–15.8%	–223 849
Scomber scombrus	Atlantic mackerel	822 081	1 247 666	1 138 053	38.4	–8.8%	–109 613
Scomberomorus spp.[a]	Seerfishes nei	889 840	903 632	918 967	3.3	1.7%	15 335
Dosidicus gigas	Jumbo flying squid	855 602	1 003 774	747 010	–12.7	–25.6%	–256 764
Nemipterus spp.[a]	Threadfin breams nei	541 470	629 062	683 213	26.2	8.6%	54 151
Brevoortia patronus	Gulf menhaden	464 165	536 129	618 719	33.3	15.4%	82 590
Sprattus sprattus	European sprat	567 697	677 048	584 577	3.0	–13.7%	–92 471
Portunus trituberculatus	Gazami crab	414 034	560 831	557 728	34.7	–0.6%	–3 103
Acetes japonicus	Akiami paste shrimp	582 763	543 992	531 847	–8.7	–2.2%	–12 145
Sardinops melanostictus	Japanese pilchard	257 346	489 294	531 466	106.5	8.6%	42 172
Scomber colias	Atlantic chub mackerel	314 380	467 796	511 618	62.7	9.4%	43 822
Rastrelliger kanagurta	Indian mackerel	324 049	498 149	499 474	54.1	0.3%	1 325
Total 25 major species and genera		**34 858 465**	**34 065 952**	**33 240 958**	***–4.6%***	**–2.4**	**–824 994**
Total other 1 566 species items		**44 919 716**	**47 181 890**	**46 035 890**	***2.5%***	**–2.4**	**–1 146 000**
World total		**79 778 181**	**81 247 842**	**79 276 848**	***–0.6%***	**–2.4**	**–1 970 994**
Share of 25 major species and genera		***43.7%***	***41.9%***	***41.9%***			

[a] Catches for single species have been added to those reported at the genus level when the latter account for at least 30 percent of the total for the whole genus.
Note: nei = not elsewhere included.

FIGURE 3
CATCH TRENDS OF VALUABLE SPECIES GROUPS



NOTE: Values for shrimps and crabs on the left axis, values for lobsters and gastropods on the right axis.

» As in 2014, Alaska pollock (*Theragra chalcogramma*) again surpassed anchoveta as the top species in 2016 (Table 3), with the highest catches since 1998. However, preliminary data for 2017 showed a significant recovery of anchoveta catches. Skipjack tuna (*Katsuwonus pelamis*) ranked third for the seventh consecutive year.

After five years of continuous growth that started in 2010, catches of cephalopods were stable in 2015 but dropped in 2016. The three major squid species –jumbo flying squid (*Dosidicus gigas*), Argentine shortfin squid (*Illex argentinus*) and Japanese flying squid (*Todarodes pacificus*) – decreased by 26, 86 and 34 percent, respectively, for a combined loss of 1.2 million tonnes between 2015 and 2016.

Capture production of other mollusc groups started declining much earlier – oysters in the early 1980s, clams in the late 1980s, mussels in the early 1990s – while catches of scallops reached the maximum ever in 2011 but have since declined by one-third. Negative trends of bivalve species groups could be a result of pollution and degradation of marine environments, as well as trends favouring aquaculture production for some of these species.

All the most valuable species groups with significant production – lobsters, gastropods, crabs and shrimps, with an estimated average value by group of USD 8 800 to USD 3 800 per tonne – marked a new catch record in 2016. Although their historical catch trends show several annual ups and downs, their rising trajectories have been basically steady throughout the years (Figure 3). However, it is difficult to state whether the reason for these positive trends is ecological or economic (e.g. an increasing focus on valuable species in the fishing industry) or both, and whether such growth is sustainable in the long term.

Within the shrimp group, the performance of Argentine red shrimp (*Pleoticus muelleri*) remained outstanding in 2016. In *The State of World Fisheries and Aquaculture 2012* (FAO, 2012d, pp. 21–22), large fluctuations in abundance of this species were noted because, after a major drop in 2005, its catches recovered and exceeded the previous peak, in part as a result of management measures implemented by national authorities. After a minor decrease in 2012, catches of *Pleoticus muelleri* have been growing at a 22 percent average annual rate and in 2016 doubled those of 2011.

Catches of much lower-priced small pelagics – which in many developing countries are important for food security but in others are largely processed into fishmeal and fish oil – have been rather stable, with the total annual catches of the 13 small pelagic fishes listed in Table 3 averaging about 15 million tonnes. Following a taxonomic split that has become widely adopted in the scientific literature, catches in Atlantic areas previously classified as Pacific chub mackerel (*Scomber japonicus*) are now classified as Atlantic chub mackerel (*Scomber colias*).

Catches of tuna and tuna-like species levelled off at around 7.5 million tonnes after a maximum ever in 2014. A few species – skipjack, yellowfin (*Thunnus albacares*) and bigeye (*Thunnus obesus*) tunas and seerfishes (*Scomberomorus* spp.) nei – make up about 75 percent of the catches of this group.

Throughout the past 20 years, FAO has made efforts to improve the taxonomic breakdown of the "Sharks, rays, chimaeras" group. Currently, the FAO database includes 180 species items in this group, but catches of too many Elasmobranchii are still not reported at the species level, mostly because some major Asian fishing countries only report non-identified catches of sharks and rays or do not report any statistics at all for this group. Total catches of Elasmobranchii have been relatively steady since 2005, ranging between 0.7 and 0.8 million tonnes.

Catch statistics by FAO major fishing area for the last two available years, as well as the 2005–2014 average, are presented in Table 4. Clear tendencies can be noted if fishing areas are roughly classified in three main categories (Figure 4):

- temperate areas (areas 21, 27, 37, 41, 61, 67 and 81);
- tropical areas (areas 31, 51, 57 and 71);
- upwelling areas (areas 34, 47, 77 and 87).

After two peaks in 1988 and 1997 at about 45 million tonnes, catches in temperate areas decreased to 37 million tonnes in 2009 but then recovered to 40.5 million tonnes and 38.9 million tonnes in 2015 and 2016, respectively. However, this rebound can be attributed to China's catches of marine fishes nei in area 61, the Northwest Pacific, of which a good portion, as explained above, are distant-water catches that include fish caught in other areas.

All other temperate areas have shown decreasing trends for several years, with the sole exception of area 67, the Northeast Pacific, where catches in 2016 were higher than the average for 2005–2014 thanks to good catches of gadiform species (Alaska pollock, Pacific cod [*Gadus macrocephalus*] and north Pacific hake [*Merluccius productus*]).

Recent drops in catches in areas 41 and 81, the Southwest Atlantic and the Southwest Pacific, were the result of greatly reduced catches by distant-water fishing nations targeting cephalopods in the Southwest Atlantic and various species in the Southwest Pacific. In area 27, the Northeast Atlantic, catches by European Union countries increased in 2015 by 4.4 percent but decreased in 2016 by 6.7 percent, even though the European Union has been implementing the landing obligation to eliminate discards since January 2015, which was expected to increase recorded catches. However, according to a recent statement by the European Commission (Vella, 2017), the economic performance of the European Union fleet has improved considerably and its profits are increasing.

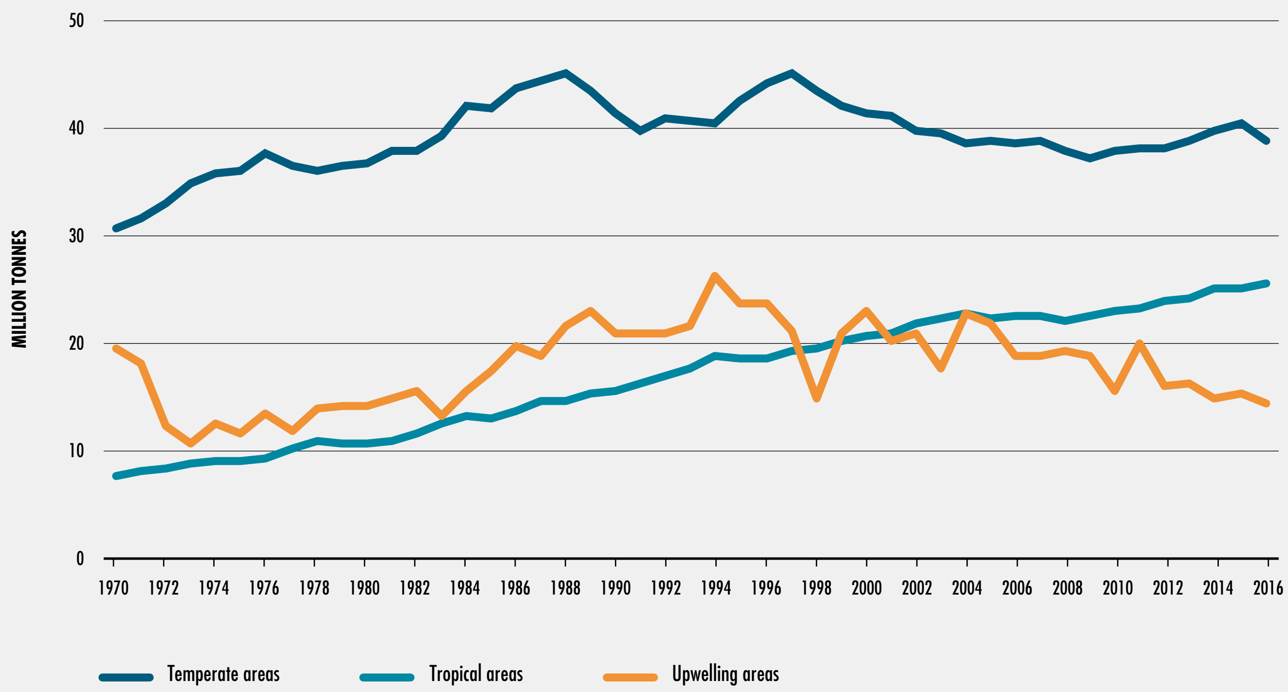
Most notable in Figure 4 is the continuously rising trend in catches in tropical areas. In contrast with the situation in temperate waters, mainly fished by developed countries, in fishing areas that mostly lie in tropical regions catches of large »

TABLE 4
CAPTURE PRODUCTION: FAO MAJOR FISHING AREAS

Fishing area code	Fishing area name	Production *(tonnes)* Average 2005–2014	2015	2016	% Variation 2005–2014 (average) to 2016	2015 to 2016	Variation, 2015 to 2016 *(tonnes)*
Inland							
01	Africa – inland waters	2 609 727	2 804 629	2 863 916	9.7	2.1	59 287
02	America, North – inland waters	178 896	207 153	260 785	45.8	25.9	53 632
03	America, South – inland waters	384 286	362 670	340 804	−11.3	−6.0	−21 866
04	Asia – inland waters	6 959 783	7 584 414	7 708 776	10.8	1.6	124 362
05	Europe – inland waters[a]	373 523	431 179	440 790	18.0	2.2	9 611
06	Oceania – inland waters	17 978	18 030	17 949	−0.2	−0.4	−81
Marine							
21	Atlantic, Northwest	2 041 599	1 842 787	1 811 436	−11.3	−1.7	−31 351
27	Atlantic, Northeast	8 654 911	9 139 199	8 313 901	−3.9	−9.0	−825 298
31	Atlantic, Western Central	1 344 651	1 414 318	1 563 262	16.3	10.5	148 944
34	Atlantic, Eastern Central	4 086 427	4 362 180	4 795 171	17.3	9.9	432 991
37	Mediterranean and Black Sea	1 421 025	1 314 386	1 236 999	−13.0	−5.9	−77 387
41	Atlantic, Southwest	2 082 248	2 427 872	1 563 957	−24.9	−35.6	−863 915
47	Atlantic, Southeast	1 425 775	1 677 969	1 688 050	18.4	0.6	10 081
51	Indian Ocean, Western	4 379 053	4 688 848	4 931 124	13.9	5.2	242 276
57	Indian Ocean, Eastern	5 958 972	6 359 691	6 387 659	7.2	0.4	27 968
61	Pacific, Northwest	20 698 014	22 057 759	22 411 224	7.7	1.6	353 465
67	Pacific, Northeast	2 871 126	3 164 604	3 092 529	7.7	−2.3	−72 075
71	Pacific, Western Central	11 491 444	12 625 068	12 742 955	10.9	0.9	117 887
77	Pacific, Eastern Central	1 881 996	1 675 065	1 656 434	−12.0	−1.1	−18 631
81	Pacific, Southwest	613 701	551 534	474 066	−22.8	−14.0	−77 468
87	Pacific, Southeast	10 638 882	7 702 885	6 329 328	−40.5	−17.8	−1 373 557
18, 48, 58, 88	Arctic and Antarctic areas	188 360	243 677	278 753	48.0	14.4	35 076
World total		**90 302 377**	**92 655 917**	**90 909 868**	**0.7**	**−1.9**	**−1 746 049**

[a] Includes the Russian Federation.

FIGURE 4
TRENDS IN THREE MAIN CATEGORIES OF FISHING AREAS



» (mostly tuna) and small pelagic species continue to increase. Catches in area 31, the Western Central Atlantic, exceeded 1.5 million tonnes in 2016, a level that had not been reached since 2004. However, over one-third of total capture production in area 31 consists of catches by the United States of America of Gulf menhaden (*Brevoortia patronus*), a clupeoid species that is processed into fishmeal and fish oil.

Capture production in both the Western and Eastern Indian Ocean (areas 51 and 57) reached a maximum in 2016. Catches in these areas have been increasing almost steadily since the 1980s, with restrained growth only during the early and mid-2000s. In the past decade, small pelagics, coastal fishes and shrimps have been the major contributors to the increased production in the Indian Ocean, while catches of the tuna group have been steady at about 1.6 million to 1.8 million tonnes since 2012.

On the contrary, the sustained growth in area 71, the Western Central Pacific, is mostly due to tuna and tuna-like species, with catches of skipjack alone regularly over 1.6 million tonnes since 2012. In this area small pelagics have shown a decreasing trend in recent years. Unfortunately, unspecified catches lumped together under "marine fishes nei" still represent over one-fourth of the catches in both this area and area 57, the Eastern Indian Ocean.

Catches in upwelling areas are characterized by high annual variability. Their combined trend trajectory (Figure 4) is highly influenced by catches in area 87, the Southeast Pacific, where El Niño oceanographic conditions strongly influence the abundance of anchoveta.

Distant-water fishing nations have historically fished in the two upwelling areas along the west coast of Africa (areas 34 and 47, the

Eastern Central Atlantic and Southeast Atlantic), but their share in total catches has been dropping (from 57.5 percent in 1977 to 16.9 percent in 2016 in area 34, and from 65.3 percent in 1978 to 6.4 percent in 2016 in area 47), increasing the availability of fish for coastal states and local populations. The overall trends in the two areas are opposite: In area 34 catches have grown to a peak of 4.8 million tonnes, and in area 47 they have progressively decreased from the overall maximum reached in 1978, although they have been recovering in the past three years.

Despite annual variability, since 2000 total catches in area 77, the Eastern Central Pacific, have stabilized between 1.6 and 2 million tonnes. In contrast, total catch in area 87, even if analysed excluding anchoveta, has been decreasing dramatically since its peak in 1991. The decrease was mostly caused by the drop in catches of Chilean jack mackerel (*Trachurus murphyi*), which were 0.4 million tonnes in 2016, only 8 percent of those landed in 1995. This drop was partially compensated by the high-value catches of jumbo flying squid, which have been growing significantly since the 2000s.

Antarctic krill (*Euphausia superba*), by far the most caught species in the Antarctic areas, has seen an increasing catch trend since the mid-1990s. Since 2005, catches of Patagonian toothfish (*Dissostichus eleginoides*) have stabilized between 10 500 and 12 400 tonnes. This valuable species was previously largely targeted by illegal, unreported and unregulated (IUU) fleets, whose estimated catches were curbed from over 30 000 tonnes in 1997 to less than 1 500 tonnes in 2014. These positive outcomes reflect management measures implemented by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), often taken as a model by other regional fisheries management organizations (RFMOs).

Catch statistics for area 18, the Arctic Sea, have only been officially reported to FAO in some years by the Russian Federation (and formerly by the Soviet Union) and Canada (marine mammals) as other countries bordering the parts of the Arctic Sea accessible to fisheries have probably registered their minor catches from area 18 as caught in neighbouring areas. No catches from the Central Arctic Ocean should be expected in the coming years, as at the end of 2017 five bordering countries (Canada, Denmark [Greenland], Norway, the Russia Federation and the United States of America) and other possible fishing countries (China, Iceland, Japan, the Republic of Korea and the European Union) agreed on a fishing ban for the next 16 years to give scientists time to understand the region's marine ecology – and the potential impacts of climate change – before fishing becomes widespread (Hoag, 2017).

Inland waters capture production

Total global catch in inland waters was 11.6 million tonnes in 2016, representing 12.8 percent of total global capture fishery production. The 2016 global catch shows an increase of 2.0 percent over the previous year and of 10.5 percent in comparison to the 2005–2014 average. The continuously increasing trend of inland fisheries production may be misleading, however, as some of the increase can be attributed to improved reporting and assessment at the country level and may not be entirely due to increased production. The improvement in reporting may also mask trends in individual countries where fisheries are declining.

Sixteen countries produce almost 80 percent of the inland fishery catch (Table 5), mostly in Asia, where inland catches provide a key food source for many local communities. Asia as a whole has a consistent share of two-thirds of global inland production (Table 4). Inland catches are also important for food security in several countries in Africa, which accounts for 25 percent of the global catches. Europe, the Americas and Oceania account for 9 percent.

The total inland water catches for 2014 have been adjusted to 11.3 million tonnes from the 11.9 million tonnes reported in *The State of World Fisheries and Aquaculture 2016* (2016c) because of the replacement of Myanmar's official statistics with FAO estimates. Myanmar, which had ranked second among global producers of inland fish – thanks to an unreliable average growth of 15 percent per year – now more realistically ranks fourth (Table 5).

TABLE 5
INLAND WATERS CAPTURE PRODUCTION: MAJOR PRODUCER COUNTRIES

Country	Production *(tonnes)*			% Variation		Variation, 2015 to 2016 *(tonnes)*
	Average 2005–2014	2015	2016	2005–2014 (average) to 2016	2015 to 2016	
China	2 252 368	2 277 299	2 318 046	2.9	1.8	40 747
India[a]	1 088 082	1 346 104	1 462 063	34.4	8.6	115 959
Bangladesh	1 018 987	1 023 991	1 048 242	2.9	2.4	24 251
Myanmar[a]	745 483	863 450	886 780	19.0	2.7	23 330
Cambodia	422 801	487 905	509 350	20.5	4.4	21 445
Indonesia	346 722	472 911	432 475	24.7	−8.6	−40 436
Uganda	417 016	396 205	389 244	−6.7	−1.8	−6 961
Nigeria	287 937	337 874	377 632	31.2	11.8	39 758
United Republic of Tanzania	305 635	309 924	312 039	2.1	0.7	2 115
Russian Federation	243 337	285 065	292 828	20.3	2.7	7 763
Egypt	248 141	241 179	231 959	−6.5	−3.8	−9 220
Democratic Republic of the Congo	224 263	227 700	229 300	2.2	0.7	1 600
Brazil[a]	243 213	225 000	225 000	−7.5	0.0	0
Mexico	113 854	151 416	199 665	75.4	31.9	48 249
Thailand	211 927	184 101	187 300	−11.6	1.7	3 199
Philippines	182 205	203 366	159 615	−12.4	−21.5	−43 751
Total 16 major countries	**8 351 970**	**9 033 490**	**9 261 538**	**10.9**	**2.5**	**228 048**
Total other 136 countries	**2 172 222**	**2 374 585**	**2 371 482**	**9.2**	**−0.1**	**−3 103**
World total	**10 524 192**	**11 408 075**	**11 633 020**	**10.5**	**2.0**	**224 945**
Share of 16 major countries	***79.4%***	***79.2%***	***79.6%***			

[a] Production figures for 2015 and 2016 are FAO estimates.

Most major producing countries show increased catches in recent years, with the exception of Egypt, the Philippines, Thailand and Uganda. Brazil, by far the major producer in South America, has not reported official catch data to FAO since 2014, so its statistics have been estimated.

Concerning the major species groups in inland waters, the group “tilapias and other cichlids” has shown a continuous increase, reaching 1.6 million tonnes in 2016 and doubling the 2005 catches. The group “carps, barbels and other cyprinids”, which exceeded the former group in 2005, has kept steady at between 0.7 and 0.8 million tonnes per year. Freshwater crustaceans and freshwater molluscs had peaks in the early 2000s and mid-1990s, respectively, but after periods of decreasing catches, they have been relatively stable since 2010 at 0.45 and 0.36 million tonnes.

FAO is currently evaluating options for establishing an approach to inland fishery assessment that would enable member countries to track key fisheries, which would assist in global monitoring of inland fishery resources as well as in the development of appropriate national policy and management measures. ■

AQUACULTURE PRODUCTION

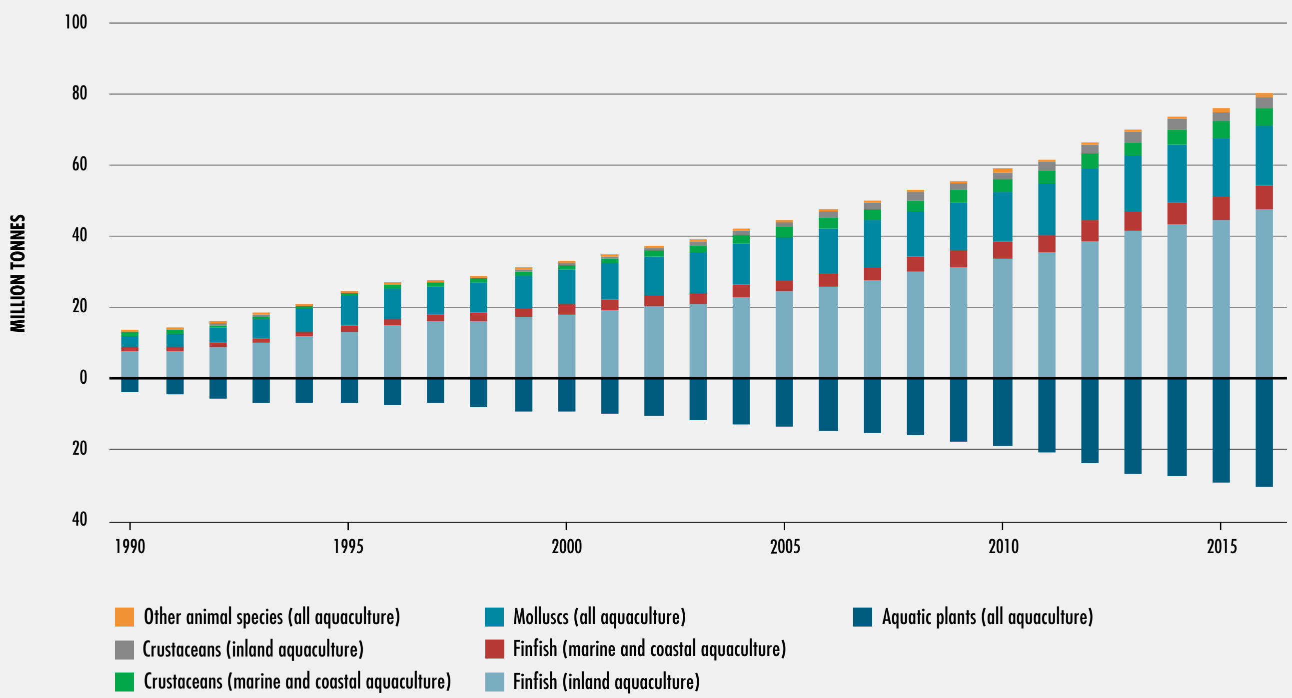
Production and growth

Global aquaculture production (including aquatic plants) in 2016 was 110.2 million tonnes, with the first-sale value estimated at USD 243.5 billion. The first-sale value, re-estimated with newly available information for some major producing countries, is considerably higher than previous estimates. In general, FAO's data for aquaculture production volume are more accurate and reliable than those for value.

The total production included 80.0 million tonnes of food fish (USD 231.6 billion) and 30.1 million tonnes of aquatic plants (USD 11.7 billion) (Figure 5) as well as 37 900 tonnes of non-food products (USD 214.6 million). Farmed food fish production included 54.1 million tonnes of finfish (USD 138.5 billion), 17.1 million tonnes of molluscs (USD 29.2 billion), 7.9 million tonnes of crustaceans (USD 57.1 billion) and 938 500 tonnes of other aquatic animals (USD 6.8 billion) such as turtles, sea cucumbers, sea urchins, frogs and edible jellyfish. Farmed aquatic plants included mostly seaweeds and a much smaller production volume of microalgae. The non-food products included only ornamental shells and pearls.

Since 2000, world aquaculture no longer enjoys the high annual growth rates of the 1980s and 1990s (10.8 and 9.5 percent, respectively) (Figure 6). Nevertheless, aquaculture continues to grow faster than other major food production sectors. Annual growth declined to a moderate 5.8 percent during the period 2001–2016, although double-digit growth still occurred in a small number of individual countries, particularly in Africa from 2006 to 2010.

FIGURE 5
WORLD AQUACULTURE PRODUCTION OF FOOD FISH AND AQUATIC PLANTS, 1990–2016



The contribution of aquaculture to the global production of capture fisheries and aquaculture combined has risen continuously, reaching 46.8 percent in 2016, up from 25.7 percent in 2000. If China is excluded, aquaculture's share reached 29.6 percent in 2016, up from 12.7 percent in 2000. At the regional level, aquaculture accounted for 17 to 18 percent of total fish production in Africa, the Americas and Europe, followed by 12.8 percent in Oceania. The share of aquaculture in Asian fish production (excluding China) increased to 40.6 percent in 2016, up from 19.3 percent in 2000 (Figure 7).

In 2016, 37 countries were producing more farmed than wild-caught fish. These countries are in all regions except Oceania, and collectively they account for close to half of the world's human population. Aquaculture accounted for less than half but over 30 percent of national total fish production in another 22 countries in 2016.

Lack of reporting by about 35 to 40 percent of the producing countries, coupled by insufficient quality and completeness in some of the reported data, hinders FAO from presenting a clearer and more detailed picture of world aquaculture development status and trends. FAO received just below 120 national data reports for the 2016 reference year, representing 84.3 percent (67.5 million tonnes, excluding aquatic plants) of total food fish production by volume; however, if China is excluded the percentage is much lower. FAO estimates for the non-reporting countries account for 15.1 percent (12.1 million tonnes) of the total production. The remaining data are official statistics collected on an ad hoc basis from a few countries that did not respond officially to FAO's request for national data.

Inland aquaculture

World production of farmed food fish relies increasingly on inland aquaculture, which is »

FIGURE 6
AVERAGE ANNUAL GROWTH RATE OF AQUACULTURE PRODUCTION BY VOLUME (excluding aquatic plants)

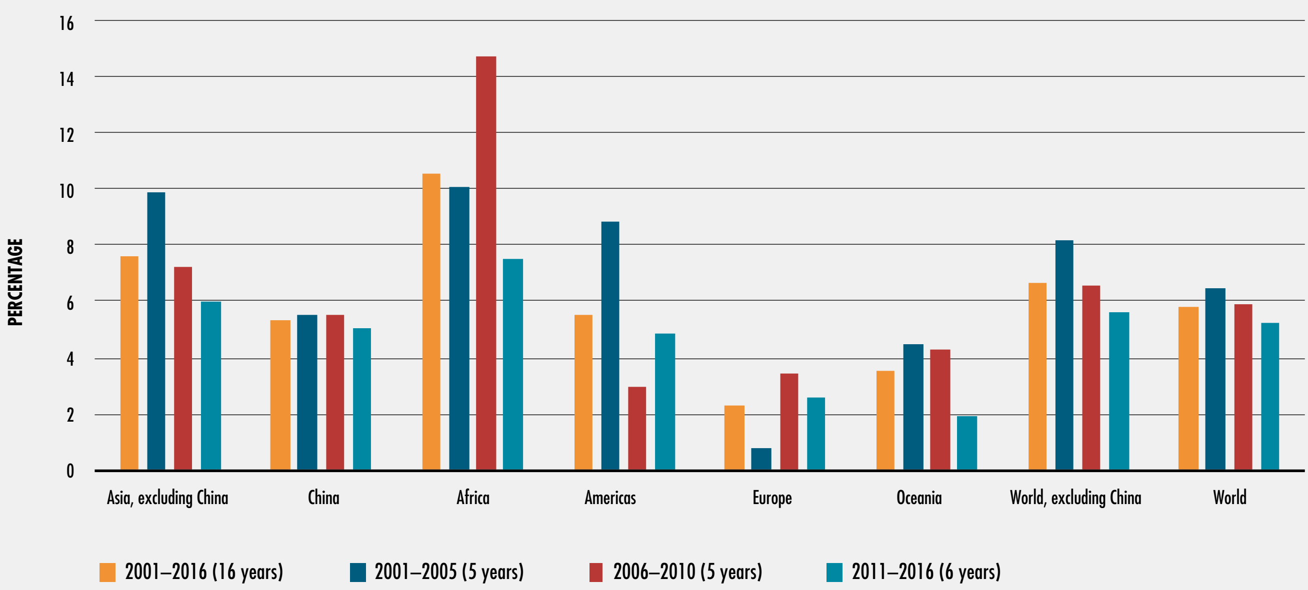


FIGURE 7
AQUACULTURE CONTRIBUTION TO TOTAL FISH PRODUCTION (excluding aquatic plants)

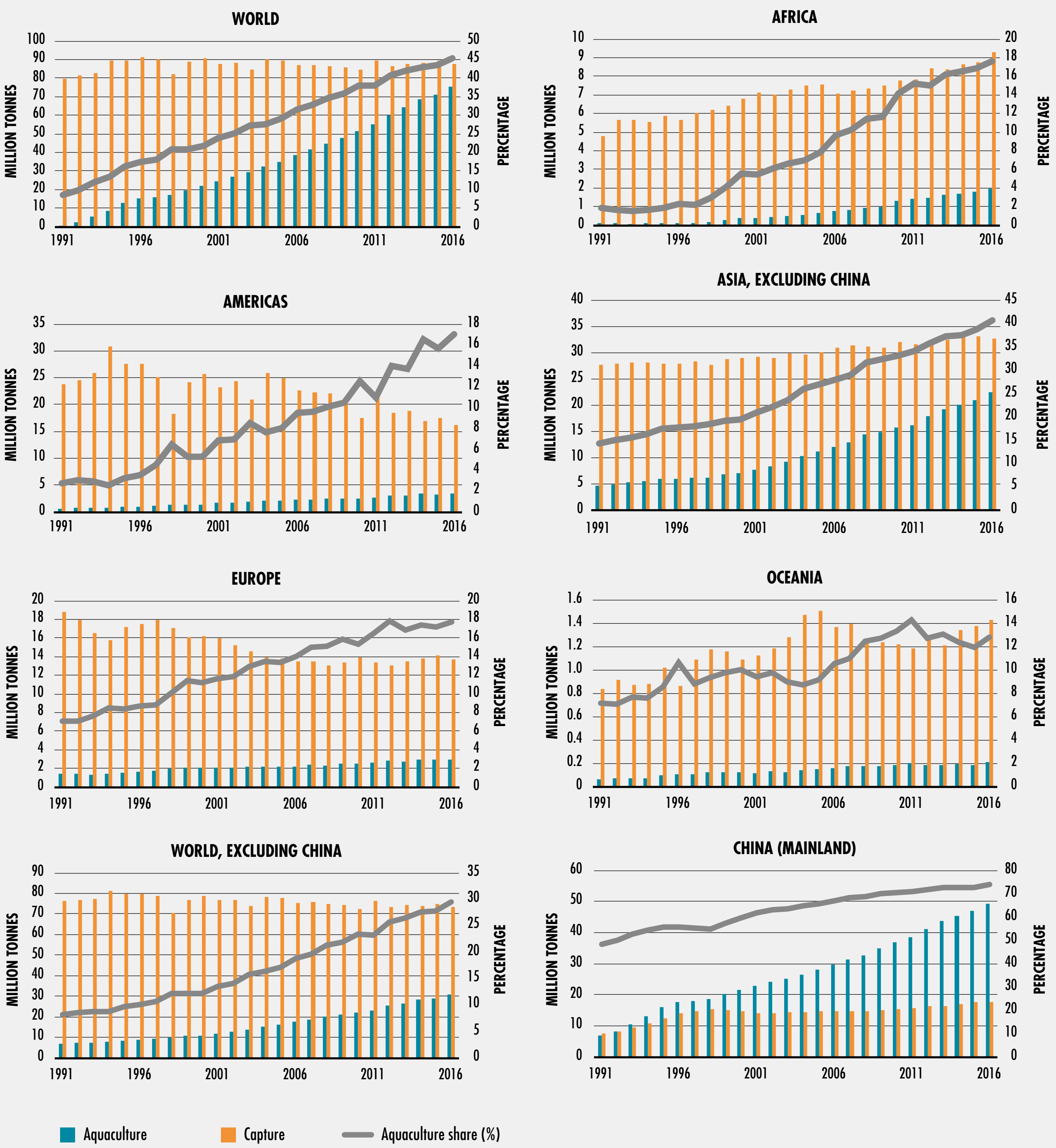


TABLE 6
AQUACULTURE PRODUCTION OF MAIN GROUPS OF FOOD FISH SPECIES BY CONTINENT, 2016 (thousand tonnes, live weight)

Category	Africa	Americas	Asia	Europe	Oceania	World
Inland aquaculture						
Finfish	1 954	1 072	43 983	502	5	47 516
Crustacea	0	68	2 965	0	0	3 033
Molluscs			286			286
Other aquatic animals		1	531			531
Subtotal	1 954	1 140	47 765	502	5	51 367
Marine and coastal aquaculture						
Finfish	17	906	3 739	1 830	82	6 575
Crustacea	5	727	4 091	0	6	4 829
Molluscs	6	574	15 550	613	112	16 853
Other aquatic animals	0		402	0	5	407
Subtotal	28	2 207	23 781	2 443	205	28 664
All aquaculture						
Finfish	1 972	1 978	47 722	2 332	87	54 091
Crustacea	5	795	7 055	0	7	7 862
Molluscs	6	574	15 835	613	112	17 139
Other aquatic animals	0	1	933	0	5	939
Total	**1 982**	**3 348**	**71 546**	**2 945**	**210**	**80 031**

» typically practised in a freshwater environment in most countries. In a small number of countries (e.g. China and Egypt), aquaculture with saline-alkaline water is carried out with suitable species in areas where soil conditions and the chemical properties of available water are inhospitable for conventional food grain crops or pasture. Earthen ponds remain the most commonly used type of facility for inland aquaculture production, although raceway tanks, above-ground tanks, pens and cages are also widely used where local conditions allow. Rice–fish culture remains important in areas where it is traditional, but it is also expanding rapidly, especially in Asia.

In 2016, inland aquaculture was the source of 51.4 million tonnes of food fish, or 64.2 percent of the world's farmed food fish production, as compared with 57.9 percent in 2000. Finfish farming still dominates inland aquaculture, accounting for 92.5 percent (47.5 million tonnes) of total production from inland aquaculture. However, this proportion was down from 97.2 percent in 2000, reflecting relatively strong growth in the farming of other species groups, particularly crustaceans in inland aquaculture in Asia, including shrimps, crayfish and crabs (Table 6). Inland aquaculture production includes some marine shrimp species, such as white-leg shrimp, that can grow in freshwater or inland saline-alkaline water after acclimatization.

Marine and coastal aquaculture

Marine aquaculture, also known as mariculture, is practised in the sea, in a marine water environment, while coastal aquaculture is practised in completely or partially human-made structures in areas adjacent to the sea, such as coastal ponds and gated lagoons. In coastal aquaculture with saline water, the salinity is less stable than in mariculture because of rainfall or evaporation, depending on the season and location. On the world level, it is hard to distinguish between mariculture and coastal aquaculture production, mainly because of the aggregation of production data from several major producing countries in East and Southeast Asia, especially for finfish species that are farmed in marine cages as well as in coastal ponds. Most of the finfish production reported under marine and coastal aquaculture in Africa, the Americas, Europe and Oceania (Table 6) is produced through mariculture.

FAO recorded 28.7 million tonnes (USD 67.4 billion) of food fish production from mariculture and coastal aquaculture combined in 2016. In sharp contrast to the dominance of finfish in inland aquaculture, shelled molluscs (16.9 million tonnes) constitute 58.8 percent of the combined production of marine and coastal aquaculture. Finfish (6.6 million tonnes) and crustaceans (4.8 million tonnes) together were responsible for 39.9 percent.

Aquaculture production with and without feeding

The growth of farming of fed aquatic animal species has outpaced the farming of unfed species in world aquaculture. The share of unfed species in total aquatic animal production decreased gradually from 2000 to 2016, shrinking by 10 percentage points to 30.5 percent (Figure 8). In absolute terms, the volume of unfed species farming output still continues to expand, but the expansion is slower than for fed species. In 2016, the total unfed species production climbed to 24.4 million tonnes, consisting of 8.8 million tonnes of filter-feeding finfish raised in inland aquaculture (mostly silver carp [*Hypophthalmichthys molitrix*] and bighead carp [*Hypophthalmichthys nobilis*]) and 15.6 million tonnes of aquatic invertebrates, mostly marine bivalve molluscs raised in seas, lagoons and coastal ponds.

In Asia, Central and Eastern Europe and Latin America, filter-feeding carps are typically raised in multispecies polyculture farming systems, which enhance fish production by using natural food and improving the water quality in the production system. In recent years another filter-feeding finfish species, Mississippi paddlefish (*Polyodon spathula*), has emerged in polyculture in a few countries, particularly in China, where the production volume is estimated to be several thousand tonnes.

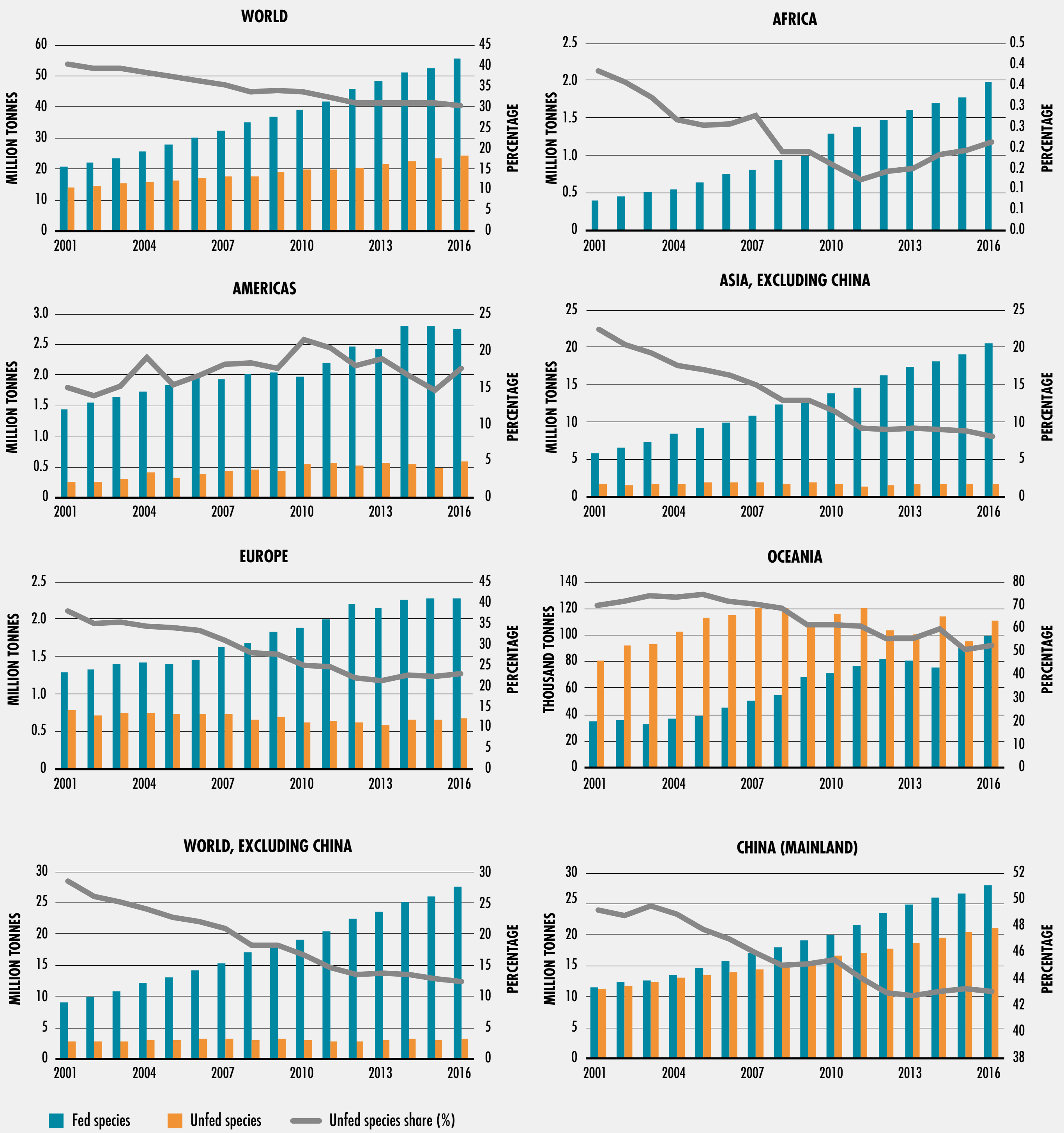
Marine bivalves, which extract organic matter for growth, and seaweeds, which grow by photosynthesis by absorbing dissolved nutrients, are sometimes described as extractive species. When farmed in the same area with fed species, they benefit the environment by removing waste materials, including waste from fed species, and lowering the nutrient load. Culture of extractive species with fed species in the same mariculture sites is encouraged in aquaculture development planning and zoning exercises. Extractive species production accounted for 49.5 percent of total world aquaculture production in 2016.

Species produced

As of 2016, global production has been recorded for a total of 598 "species items" ever farmed in the world. A species item refers to a single species, a group of species (where identification to the species level is not possible) or an interspecific hybrid. Species items recorded so far include 369 finfishes (including 5 hybrids), 109 molluscs, 64 crustaceans, 7 amphibians and reptiles (excluding alligators, caimans or crocodiles), 9 aquatic invertebrates and 40 aquatic algae. These numbers do not include those species, known or unknown to FAO, produced from aquaculture research experiments, cultivated as live feed in aquaculture hatchery operation, or ornamental aquatics produced in captivity. In the past ten years, the total number of commercially farmed species items recorded by FAO increased by 26.7 percent, from 472 in 2006 to 598 in 2016, a combined result of FAO's investigative efforts and improvement in data reporting by producing countries. However, the diversification of the FAO data does not keep pace with the actual speed of species diversification in aquaculture. Numerous single species registered in the official statistics of many countries consist in reality of multiple species and sometimes hybrids. While FAO has recorded only five finfish hybrids in commercial production, the number of hybrids farmed is much greater.

Despite the great diversity in the species raised, aquaculture production by volume is dominated by a small number of "staple" species or species groups at national, regional and global levels. Finfish farming, »

FIGURE 8
FED AND NON-FED FOOD FISH AQUACULTURE PRODUCTION, 2001–2016



» the most diverse subsector, relied on 27 species and species groups over 90 percent of the total production in 2016, while the 20 most produced species items accounted for 84.2 percent of the total production (Table 7). Compared with finfish, fewer species of crustaceans, molluscs and other animals are farmed.

TABLE 7
MAJOR SPECIES PRODUCED IN WORLD AQUACULTURE

Species item	2010	2012	2014	2016	% of total, 2016
Finfish					
Grass carp, *Ctenopharyngodon idellus*	4 362	5 018	5 539	6 068	11
Silver carp, *Hypophthalmichthys molitrix*	4 100	4 193	4 968	5 301	10
Common carp, *Cyprinus carpio*	3 421	3 753	4 161	4 557	8
Nile tilapia, *Oreochromis niloticus*	2 537	3 260	3 677	4 200	8
Bighead carp, *Hypophthalmichthys nobilis*	2 587	2 901	3 255	3 527	7
Carassius spp.	2 216	2 451	2 769	3 006	6
Catla, *Catla catla*	2 977	2 761	2 770	2 961	6
Freshwater fishes nei, *Osteichthyes*	1 378	1 942	2 063	2 362	4
Atlantic salmon, *Salmo salar*	1 437	2 074	2 348	2 248	4
Roho labeo, *Labeo rohita*	1 133	1 566	1 670	1 843	3
Pangas catfishes nei, *Pangasius* spp.	1 307	1 575	1 616	1 741	3
Milkfish, *Chanos chanos*	809	943	1 041	1 188	2
Tilapias nei, *Oreochromis* (=*Tilapia*) spp.	628	876	1 163	1 177	2
Torpedo-shaped catfishes nei, *Clarias* spp.	353	554	809	979	2
Marine fishes nei, Osteichthyes	477	585	684	844	2
Wuchang bream, *Megalobrama amblycephala*	652	706	783	826	2
Rainbow trout, *Oncorhynchus mykiss*	752	883	796	814	2
Cyprinids nei, *Cyprinidae*	719	620	724	670	1
Black carp, *Mylopharyngodon piceus*	424	495	557	632	1
Snakehead, *Channa argus*	377	481	511	518	1
Other finfishes	5 849	6 815	7 774	8 629	16
Finfish total	38 494	44 453	49 679	54 091	100
Crustaceans					
Whiteleg shrimp, *Penaeus vannamei*	2 688	3 238	3 697	4 156	53
Red swamp crawfish, *Procambarus clarkii*	616	598	721	920	12
Chinese mitten crab, *Eriocheir sinensis*	593	714	797	812	10
Giant tiger prawn, *Penaeus monodon*	565	672	705	701	9
Oriental river prawn, *Macrobrachium nipponense*	226	237	258	273	4
Giant river prawn, *Macrobrachium rosenbergii*	198	211	216	234	3
Other crustaceans	700	606	654	767	10
Crustaceans total	5 586	6 277	7 047	7 862	100

TABLE 7
(CONTINUED)

Species item	2010	2012	2014	2016	% of total, 2016
Molluscs					
Cupped oysters nei, *Crassostrea* spp.	3 678	3 972	4 374	4 864	28
Japanese carpet shell, *Ruditapes philippinarum*	3 605	3 775	4 014	4 229	25
Scallops nei, *Pectinidae*	1 408	1 420	1 650	1 861	11
Marine molluscs nei, Mollusca	630	1 091	1 135	1 154	7
Sea mussels nei, Mytilidae	892	969	1 029	1 100	6
Constricted tagelus, *Sinonovacula constricta*	714	720	787	823	5
Pacific cupped oyster, *Crassostrea gigas*	641	609	624	574	3
Blood cockle, *Anadara granosa*	466	390	450	439	3
Chilean mussel, *Mytilus chilensis*	222	244	238	301	2
Other molluscs	1 808	1 683	1 748	1 795	11
Molluscs total	14 064	14 874	16 047	17 139	100
Other animals					
Chinese softshell turtle, *Trionyx sinensis*	270	336	345	348	37
Japanese sea cucumber, *Apostichopus japonicus*	130	171	202	205	22
Aquatic invertebrates nei, Invertebrata	223	128	111	97	10
Frogs, *Rana* spp.	82	86	97	96	10
Other miscellaneous animals	112	118	139	193	21
Other animals total	818	839	894	939	100

Aquatic plants

In 2016, aquaculture was the source of 96.5 percent by volume of the total 31.2 million tonnes of wild-collected and cultivated aquatic plants combined.

Global production of farmed aquatic plants, overwhelmingly dominated by seaweeds, grew in output volume from 13.5 million tonnes in 1995 to just over 30 million tonnes in 2016 (Table 8). The rapid growth in the farming of tropical seaweed species (*Kappaphycus alvarezii* and *Eucheuma* spp.) in Indonesia as raw material for carrageenan extraction has been the major contributor to growth in farmed aquatic plant production in the recent past. Indonesia increased its seaweed farming output from less than 4 million tonnes in 2010 to over 11 million tonnes in 2015 and 2016.

Of the 30 million tonnes of farmed seaweeds produced in 2016 (Table 9), some species (e.g. *Undaria pinnatifida, Porphyra* spp. and *Caulerpa* spp., produced in East and Southeast Asia) are produced almost exclusively for direct human consumption, although low-grade products and scraps from processing factories are used for other purposes, including feed for abalone culture.

Although FAO recorded 89 000 tonnes of farmed microalgae from 11 countries in 2016, 88 600 tonnes were reported from China. Farming of microalgae such as *Spirulina* spp., *Chlorella* spp., *Haematococcus pluvialis* and *Nannochloropsis* spp., ranging in scale from backyard to large-scale commercial production, is well established in many countries for production of human nutrition supplements and other uses. The FAO data understate the real »

TABLE 8
WORLD AQUACULTURE PRODUCTION OF AQUATIC PLANTS (thousand tonnes, live weight)

Species item	2005	2010	2011	2012	2013	2014	2015	2016
Eucheuma seaweeds nei, *Eucheuma* spp.	987	3 481	4 616	5 853	8 430	9 034	10 190	10 519
Japanese kelp, *Laminaria japonica*	4 371	5 147	5 257	5 682	5 942	7 699	8 027	8 219
Gracilaria seaweeds, *Gracilaria* spp.	933	1 691	2 171	2 763	3 460	3 751	3 881	4 150
Wakame, *Undaria pinnatifida*	2 440	1 537	1 755	2 139	2 079	2 359	2 297	2 070
Elkhorn sea moss, *Kappaphycus alvarezii*	1 285	1 888	1 957	1 963	1 726	1 711	1 754	1 527
Nori nei, *Porphyra* spp.	703	1 072	1 027	1 123	1 139	1 142	1 159	1 353
Seaweeds nei, Algae	1 844	3 126	2 889	2 815	2 864	449	775	1 049
Laver (nori), *Porphyra tenera*	584	564	609	691	722	674	686	710
Spiny eucheuma, *Eucheuma denticulatum*	172	259	266	288	233	241	274	214
Fusiform sargassum, *Sargassum fusiforme*	86	78	111	112	152	175	189	190
Spirulina nei, *Spirulina* spp.	48	97	73	80	82	86	89	89
Brown seaweeds, Phaeophyceae	30	23	28	17	16	19	30	34
Others	20	28	27	28	18	15	14	17
Total	**13 503**	**18 992**	**20 785**	**23 555**	**26 863**	**27 356**	**29 365**	**30 139**

TABLE 9
MAJOR FARMED SEAWEED PRODUCERS (thousand tonnes, live weight)

Country	2005	2010	2011	2012	2013	2014	2015	2016	% of total, 2016
China	9 446	10 995	11 477	12 752	13 479	13 241	13 835	14 387	47.9
Indonesia	911	3 915	5 170	6 515	9 299	10 077	11 269	11 631	38.7
Philippines	1 339	1 801	1 841	1 751	1 558	1 550	1 566	1 405	4.7
Republic of Korea	621	902	992	1 022	1 131	1 087	1 197	1 351	4.5
Democratic People's Republic of Korea	444	444	444	444	444	489	489	489	1.6
Japan	508	433	350	441	418	374	400	391	1.3
Malaysia	40	208	240	332	269	245	261	206	0.7
Tanzania	77	132	137	157	117	140	179	119	0.4
Madagascar	1	4	2	1	4	7	15	17	0.1
Chile	16	12	15	4	13	13	12	15	0
Solomon Islands	3	7	7	7	12	12	12	11	0
Viet Nam	15	18	14	19	14	14	12	10	0
Papua New Guinea	0	0	0	1	3	3	4	4	0
Kiribati	5	5	4	8	2	4	4	4	0
India	1	4	5	5	5	3	3	3	0
Others	25	14	15	16	13	12	16	8	0
Total	**13 450**	**18 895**	**20 712**	**23 475**	**26 780**	**27 270**	**29 275**	**30 050**	

» scale of world microalgae farming because of unavailable data from important producers such as Australia, France, India, Israel, Japan, Malaysia and Myanmar.

Aquaculture production distribution and major producers

Of the 202 currently existing countries and territories with aquaculture production recorded by FAO, 194 have been active producers in the past few years. The prevailing uneven production distribution pattern among regions and among countries within the same region has remained pronounced and largely unchanged in the past decade despite major changes in absolute production (Table 10). Asia has accounted for about 89 percent of world aquaculture production for over two decades. Over the same period, Africa and the Americas have lifted their respective shares in world total production, while those of Europe and Oceania have dropped slightly. Among major producing countries, Egypt, Nigeria, Chile, India, Indonesia, Viet Nam, Bangladesh and Norway have strengthened their share in regional or world production to varying degree over the past two decades. China has gradually weakened its share in global production from 65 percent in 1995 to less than 62 percent in 2016.

As illustrated in Figure 9, while the level of overall aquaculture development varies greatly among and within geographical regions, a few major producers dominate the production of main groups of farmed species produced in inland aquaculture and in marine and coastal aquaculture. Inland finfish farming is dominated by developing countries, while a number of developed countries are major contributors to world marine finfish farming, especially cold-water species. Marine shrimps dominate the production of crustaceans typically farmed in coastal aquaculture, and are an important source of foreign exchange earnings for a number of developing countries in Asia and Latin America. Although the quantity of marine molluscs produced by China dwarfs that of all other producers, a number of countries in all regions rely rather heavily on mussels, oysters and, to a lesser extent, abalone for their aquaculture production.

The China factor

China has produced more farmed food fish than the rest of the world combined every year since 1991. Although its contribution has gradually decreased since the late 1990s, the great importance of Chinese aquaculture and its implications for world total fish supply are not likely to fade soon. Since production of farmed food fish exceeded that of wild-caught fish for the first time in 1993, aquaculture's share has steadily increased to 73.7 percent in 2016, and it is expected to expand further. The country's ability to feed its large population with domestically produced fish from aquaculture contributes to world food security and nutrition as a whole.

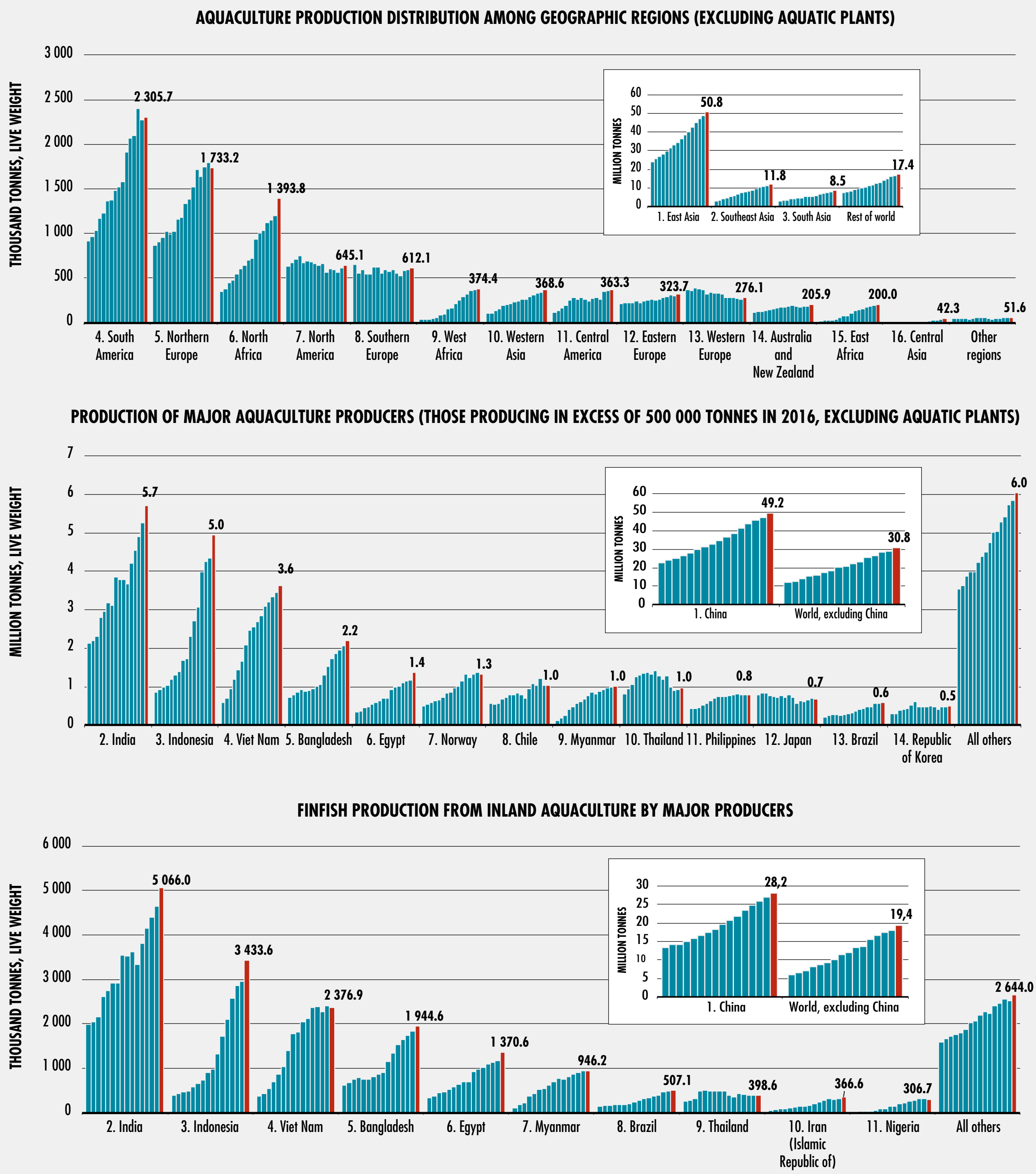
In the past few years, the Chinese fishery and aquaculture sector has experienced gradual but accelerated transformation in several aspects as a result of adjustment in public policies as well as consumer and market influences at home and abroad that affect the entire production value chain. Transformation within the sector includes greater attention to environmental responsibility and sustainability; quality improvement and product diversity; improved economic efficiency and benefits to fish farmers; and strengthened business integration along the value chain and economies of scale. The national Thirteenth Five-Year Plan for Fisheries Development, together with other newly introduced public policies and regulations, is rapidly pushing greater changes (see Box 31 in the projections section of Part 4, page 183). Unlike most of the previous five-year development plans, the new plan sets no production targets for aquaculture. However, several large-scale undertakings in Chinese aquaculture are having noticeable effects.

Across the country, aquaculture operations, together with animal husbandry, are approved or prohibited based on environmental assessment under a new zoning exercise. Results have included the large-scale removal of fish pens and cages from lakes, rivers and reservoirs to eliminate fed-species aquaculture in many provinces. In Hubei, for example, the largest inland aquaculture producer in the country for over two decades, between December 2016 and March 2017 all fish pens and cages were removed from several major lakes where fish farming was »

TABLE 10
AQUACULTURE FOOD FISH PRODUCTION BY REGION AND SELECTED MAJOR PRODUCERS (thousand tonnes; percentage of world total)

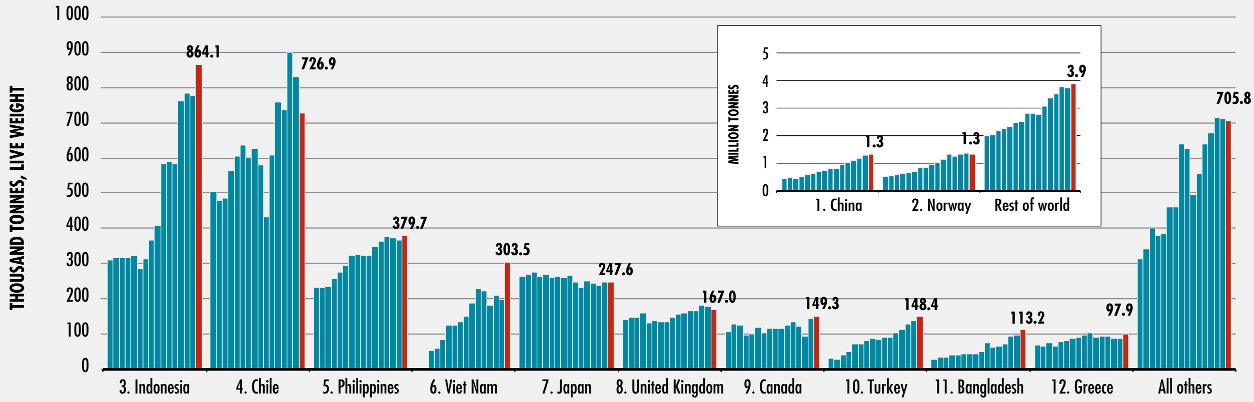
Region/selected countries	1995	2000	2005	2010	2015	2016
Africa	110	400	646	1 286	1 772	1 982
	0.5%	*1.2%*	*1.5%*	*2.2%*	*2.3%*	*2.5%*
Egypt	72	340	540	920	1 175	1 371
	0.3%	*1.1%*	*1.2%*	*1.6%*	*1.5%*	*1.7%*
Northern Africa, excluding Egypt	4	5	7	10	21	23
	0%	*0%*	*0%*	*0%*	*0%*	*0%*
Nigeria	17	26	56	201	317	307
	0.1%	*0.1%*	*0.1%*	*0.3%*	*0.4%*	*0.4%*
Sub-Saharan Africa, excluding Nigeria	17	29	43	156	259	281
	0.1%	*0.1%*	*0.1%*	*0.3%*	*0.3%*	*0.4%*
Americas	920	1 423	2 177	2 514	3 274	3 348
	3.8%	*4.4%*	*4.9%*	*4.3%*	*4.3%*	*4.2%*
Chile	157	392	724	701	1 046	1 035
	0.6%	*1.2%*	*1.6%*	*1.2%*	*1.4%*	*1.3%*
Rest of Latin America and the Caribbean	284	447	785	1 154	1 615	1 667
	1.2%	*1.4%*	*1.8%*	*2.0%*	*2.1%*	*2.1%*
North America	479	585	669	659	613	645
	2.0%	*1.8%*	*1.5%*	*1.1%*	*0.8%*	*0.8%*
Asia	21 678	28 423	39 188	52 452	67 881	71 546
	88.9%	*87.7%*	*88.5%*	*89.0%*	*89.3%*	*89.4%*
China (mainland)	15 856	21 522	28 121	36 734	47 053	49 244
	65.0%	*66.4%*	*63.5%*	*62.3%*	*61.9%*	*61.5%*
India	1 659	1 943	2 967	3 786	5 260	5 700
	6.8%	*6.0%*	*6.7%*	*6.4%*	*6.9%*	*7.1%*
Indonesia	641	789	1 197	2 305	4 343	4 950
	2.6%	*2.4%*	*2.7%*	*3.9%*	*5.7%*	*6.2%*
Viet Nam	381	499	1 437	2 683	3 438	3 625
	1.6%	*1.5%*	*3.2%*	*4.6%*	*4.5%*	*4.5%*
Bangladesh	317	657	882	1 309	2 060	2 204
	1.3%	*2.0%*	*2.0%*	*2.2%*	*2.7%*	*2.8%*
Rest of Asia	2 824	3 014	4 584	5 636	5 726	5 824
	11.6%	*9.3%*	*10.4%*	*9.6%*	*7.5%*	*7.3%*
Europe	1 581	2 051	2 135	2 523	2 941	2 945
	6.5%	*6.3%*	*4.8%*	*4.3%*	*3.9%*	*3.7%*
Norway	278	491	662	1 020	1 381	1 326
	1.1%	*1.5%*	*1.5%*	*1.7%*	*1.8%*	*1.7%*
EU-28	1 183	1 403	1 272	1 263	1 264	1 292
	4.9%	*4.3%*	*2.9%*	*2.1%*	*1.7%*	*1.6%*
Rest of Europe	121	157	201	240	297	327
	0.5%	*0.5%*	*0.5%*	*0.4%*	*0.4%*	*0.4%*
Oceania	94	122	152	187	186	210
	0.4%	*0.4%*	*0.3%*	*0.3%*	*0.2%*	*0.3%*
World	**24 383**	**32 418**	**44 298**	**58 962**	**76 054**	**80 031**

FIGURE 9
AQUACULTURE PRODUCTION OF MAJOR PRODUCING REGIONS AND MAJOR PRODUCERS OF MAIN SPECIES GROUPS, 2001–2016

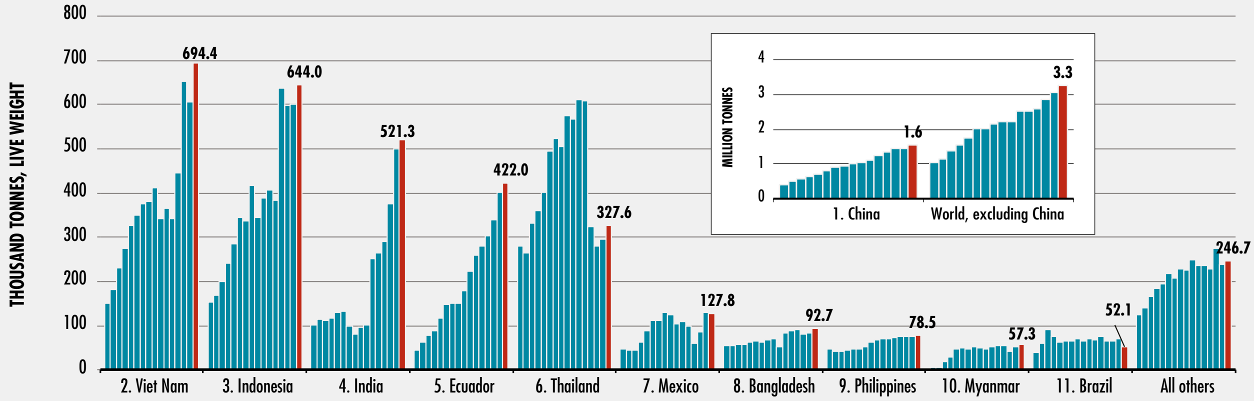


NOTE: Bars for each entry represent production for the years from 2001 to 2016.

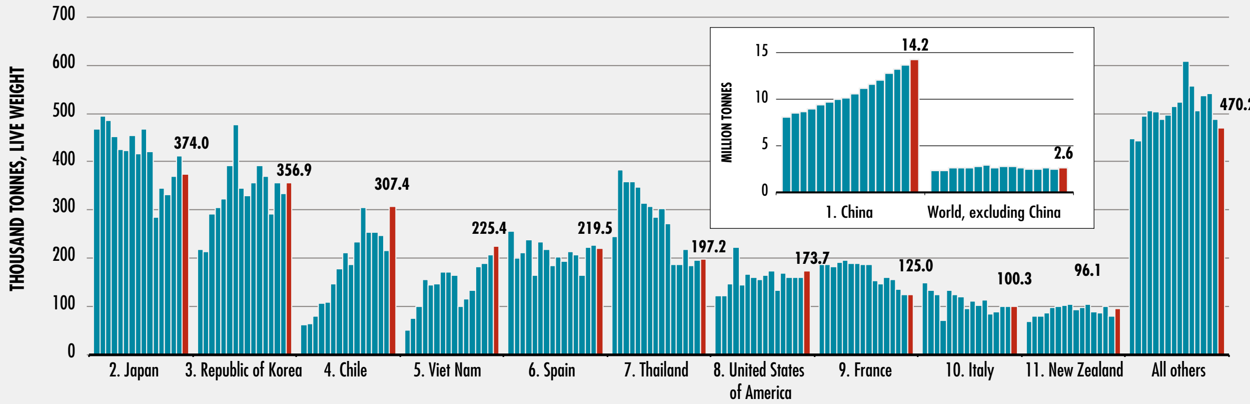
FINFISH PRODUCTION FROM MARINE AND COASTAL AQUACULTURE BY MAJOR PRODUCERS



AQUACULTURE PRODUCTION OF MARINE CRUSTACEANS BY MAJOR PRODUCERS (EXCLUDING MARINE SHRIMP SPECIES PRODUCED FROM INLAND AQUACULTURE)



AQUACULTURE PRODUCTION OF MARINE MOLLUSCS BY MAJOR PRODUCERS



» previously allowed. As a consequence, Hubei fisheries officials envisaged a plunge in fish production of close to 7 percent in 2017. On the other hand, fisheries authorities have intensively promoted a series of new aquaculture technologies and high-yielding farming systems since 2016, coupled with large-scale expansion of crop–fish integration, including rice–fish culture. The immediate effect of these actions on fish production is not yet known at the time of preparing this report, but it is not expected to be as significant for total fish supply as the effects of planned cuts to the country's fishing capacity. ■

FISHERS AND FISH FARMERS

Many millions of people around the world find a source of income and livelihood in the fisheries and aquaculture sectors. The most recent official statistics (Table 11) indicate that 59.6 million people were engaged in the primary sector of capture fisheries and aquaculture in 2016, with 19.3 million people engaged in aquaculture and 40.3 million people engaged in fisheries.

Total employment in the sectors showed a general upward trend over the period 1995–2010, followed by a levelling off. The increase was influenced to some extent by improvements in the statistical estimation routines applied. The proportion of those employed in capture fisheries decreased from 83 percent in 1990 to 68 percent in 2016, while the proportion of those employed in aquaculture correspondingly increased from 17 to 32 percent.

In 2016, 85 percent of the global population engaged in the fisheries and aquaculture sectors was in Asia, followed by Africa (10 percent) and Latin America and the Caribbean (4 percent). More than 19 million (32 percent of all people employed in the sectors) were engaged in aquaculture, concentrated primarily in Asia (96 percent of all aquaculture engagement), followed by Latin America and the Caribbean (2 percent of the total or 3.8 million people) and Africa (1.6 percent or 3.0 million people). Europe, North America and Oceania each had less than 1 percent of the global population engaged in the sectors.

The trends in the number of people engaged in the fisheries and aquaculture primary sectors vary by region. Europe and North America have experienced the largest proportional decreases in the number of people engaged in both sectors, with particular decreases in capture fishing (Table 11). In contrast, Africa and Asia, with higher population growth and increasing economically active populations in the agriculture sector, have shown a generally positive trend for the number of people engaged in capture fishing and even higher rates of increase in those engaged in aquaculture. The Latin America and Caribbean region stands somewhere in between these two trends, with decreasing population growth, a decreasing economically active population in the agriculture sector in the last decade, moderately growing employment in the fisheries and aquaculture sectors, and rather high sustained growth in aquaculture production. However, the region's vigorously growing aquaculture production may not result in equally high growth in the number of employed fish farmers, as several of the important organisms cultivated in the region are intended for highly competitive foreign markets. Increasing their production thus requires a focus on efficiency, quality and lower costs and relies more on technological developments than on human labour.

In Oceania, a large increase in the number of fishers was reported for 2015 and 2016, attributed to the availability of improved estimates on subsistence fishers.

Table 12 presents the engagement statistics for selected countries. Engagement in fisheries and aquaculture in China remained between 14.2 million and 14.6 million in the period 2012–2016 (about 25 percent of the world total). In 2016, 9.4 million people were engaged as fishers and 5.0 million in aquaculture.

Employment data are a keystone for socio-economic assessment of the fisheries and aquaculture sectors, as the activities generate food, income and livelihoods. The main focus of FAO's socio-economic data collection programme is on estimation of the number of people directly involved in the activities, in addition to demographic patterns, the contribution of remuneration to livelihoods and general profitability of the activity (e.g. following the

TABLE 11
WORLD EMPLOYMENT FOR FISHERS AND FISH FARMERS BY REGION (thousands)

Region	1995	2000	2005	2010	2011	2012	2013	2014	2015	2016
Fisheries and aquaculture										
Africa	2 392	4 175	4 430	5 027	5 250	5 885	6 009	5 674	5 992	5 671
Asia	31 296	39 646	43 926	49 345	48 926	49 040	47 662	47 730	50 606	50 468
Europe	530	779	705	662	656	647	240	394	455	445
Latin America and the Caribbean	1 503	1 774	1 907	2 185	2 231	2 251	2 433	2 444	2 482	2 466
North America	382	346	329	324	324	323	325	325	220	218
Oceania	121	126	122	124	128	127	47	46	343	342
Total	**36 223**	**46 845**	**51 418**	**57 667**	**57 514**	**58 272**	**56 716**	**56 612**	**60 098**	**59 609**
Fisheries										
Africa	2 327	4 084	4 290	4 796	4 993	5 587	5 742	5 413	5 687	5 367
Asia	23 534	27 435	29 296	31 430	29 923	30 865	29 574	30 190	32 078	31 990
Europe	474	676	614	560	553	544	163	328	367	354
Latin America and the Caribbean	1 348	1 560	1 668	1 937	1 966	1 982	2 085	2 092	2 104	2 085
North America	376	340	319	315	315	314	316	316	211	209
Oceania	117	121	117	119	122	121	42	40	334	334
Total fishers	**28 176**	**34 216**	**36 304**	**39 157**	**37 872**	**39 411**	**37 922**	**38 379**	**40 781**	**40 339**
Aquaculture										
Africa	65	91	140	231	257	298	267	261	305	304
Asia	7 762	12 211	14 630	17 915	18 373	18 175	18 088	17 540	18 528	18 478
Europe	56	103	91	102	103	103	77	66	88	91
Latin America and the Caribbean	155	214	239	248	265	269	348	352	378	381
North America	6	6	10	9	9	9	9	9	9	9
Oceania	4	5	5	5	6	6	5	6	9	8
Total fish farmers	**8 049**	**12 632**	**15 115**	**18 512**	**19 015**	**18 861**	**18 794**	**18 235**	**19 316**	**19 271**

methodology in Pinello, Gee and Dimech, 2017). Remuneration is one of the most important of the socio-economic indicators to estimate; in combination with employment, it provides a key for beginning to understand the sectors' contribution to livelihoods.

It is estimated that in 2016, overall, women accounted for nearly 14 percent of all people directly engaged in the fisheries and aquaculture primary sector (Box 1), as compared with an average of 15.2 percent across the reporting period 2009–2016. The decrease could be partially ascribed to decreased sex-disaggregated reporting. Monfort (2015) found that when both the primary and secondary sectors of aquaculture and fisheries were considered, the work force was evenly divided between men and women. However, FAO does not collect statistics for the secondary sector from Member Countries. Enhanced statistics on both industrial and small-scale operators, together with data on the secondary post-harvest and service sectors, would greatly improve the understanding of the importance of women's contribution to fisheries and aquaculture, food security and livelihoods. ■

TABLE 12
NUMBER OF FISHERS AND FISH FARMERS IN SELECTED COUNTRIES AND TERRITORIES AND WORLDWIDE (thousands)

Fishery	1995	2000	2005	2010	2012	2013	2014	2015	2016
World									
Fisheries + aquaculture	36 223	46 845	51 418	57 667	58 272	56 780	56 632	60 098	59 609
Index	*70*	*91*	*100*	*112*	*113*	*110*	*110*	*117*	*116*
Fisheries	28 174	34 213	36 304	39 155	39 412	37 962	37 879	40 781	40 338
Index	*78*	*94*	*100*	*108*	*109*	*105*	*104*	*112*	*111*
Aquaculture	8 049	12 632	15 115	18 512	18 861	18 818	18 753	19 316	19 271
Index	*53*	*84*	*100*	*122*	*125*	*125*	*124*	*128*	*127*
China									
Fisheries + aquaculture	11 429	12 936	12 903	13 992	14 441	14 282	14 161	14 588	14 506
Index	*89*	*100*	*100*	*108*	*112*	*111*	*110*	*113*	*112*
Fisheries	8 759	9 213	8 389	9 013	9 226	9 090	9 036	9 484	9 484
Index	*104*	*110*	*100*	*107*	*110*	*108*	*108*	*113*	*113*
Aquaculture	2 669	3 722	4 514	4 979	5 214	5 192	5 124	5 103	5 022
Index	*59*	*82*	*100*	*110*	*116*	*115*	*114*	*113*	*111*
Taiwan, Province of China									
Fisheries + aquaculture	302	314	352	330	329	374	331	326	322
Index	*86*	*89*	*100*	*94*	*93*	*106*	*94*	*93*	*91*
Fisheries	204	217	247	247	238	285	244	236	229
Index	*83*	*88*	*100*	*100*	*97*	*115*	*99*	*95*	*93*
Aquaculture	98	98	105	84	90	89	87	90	93
Index	*93*	*93*	*100*	*79*	*86*	*85*	*83*	*86*	*88*
Iceland									
Fisheries	7	6	5	5	5	4	5	5	5
Index	*137*	*120*	*100*	*104*	*96*	*78*	*90*	*88*	*88*
Indonesia									
Fisheries + aquaculture	4 568	5 248	5 097	5 972	6 093	5 984	6 011	6 047	5 946
Index	*90*	*103*	*100*	*117*	*120*	*117*	*118*	*119*	*117*
Fisheries	2 463	3 105	2 590	2 620	2 749	2 640	2 667	2 703	2 602
Index	*95*	*120*	*100*	*101*	*106*	*102*	*103*	*104*	*100*
Aquaculture	2 105	2 143	2 507	3 351	3 344	3 344	3 344	3 344	3 344
Index	*84*	*85*	*100*	*134*	*133*	*133*	*133*	*133*	*133*
Japan									
Fisheries	301	260	222	203	174	181	173	167	160
Index	*136*	*117*	*100*	*91*	*78*	*82*	*78*	*75*	*72*
Mexico									
Fisheries + aquaculture		262	279	272	266	273	271	295	294
Index		*94*	*100*	*97*	*95*	*98*	*97*	*106*	*105*
Fisheries	250	244	256	241	210	216	215	239	238
Index	*98*	*96*	*100*	*94*	*82*	*84*	*84*	*93*	*93*
Aquaculture		18	24	31	56	56	56	56	56
Index		*78*	*100*	*131*	*239*	*234*	*234*	*234*	*234*
Morocco									
Fisheries	100	106	106	107	114	103	110	105	108
Index	*94*	*100*	*100*	*102*	*108*	*98*	*103*	*99*	*102*
Norway									
Fisheries + aquaculture	28	24	19	19	18	18	18	18	19
Index	*151*	*130*	*100*	*99*	*96*	*93*	*93*	*95*	*99*
Fisheries	24	20	15	13	12	12	11	11	11
Index	*163*	*138*	*100*	*89*	*83*	*77*	*75*	*74*	*75*
Aquaculture	5	4	4	6	6	6	6	7	8
Index	*109*	*102*	*100*	*131*	*139*	*142*	*151*	*164*	*179*

NOTE: Index relative to 100 in 2005.

BOX 1
SEX-DISAGGREGATED EMPLOYMENT STATISTICS

The first sex-disaggregated employment data were reported by Japan in 1970, and since then the reporting of sex-disaggregated employment data by FAO Member Countries has been slowly improving in regularity and quality. These data are receiving increasing policy attention and are critical in support to decision-making on gender issues in fisheries and aquaculture (Biswas, 2017).

Sex-disaggregated reporting for employment in the fishery and aquaculture sectors varies greatly among countries and regions (Table 13). Some countries in every region reported only "men" or "unspecified", and it cannot always be determined whether these figures truly indicate that no women are employed in the sectors or whether, as is more likely, sex-disaggregated data have not been collected. In some cases, particularly when countries previously provided fully sex-disaggregated statistics but have reverted to reporting only "unspecified", FAO has applied estimations.

Table 14 presents sex-disaggregated employment statistics in the primary sector for selected countries, showing time series data for the period 2010–2016.

TABLE 13
REPORTING OF SEX-DISAGGREGATED EMPLOYMENT (WOMEN, MEN AND UNSPECIFIED) IN FISHERIES AND AQUACULTURE, BY REGION, 2016

Region	Women		Men		Unspecified	
	No. ('000)	%	No. ('000)	%	No. ('000)	%
Fisheries						
Africa	585.1	11	4 249.3	79	532.6	10
Latin America and the Caribbean	394.4	19	1 383.6	66	306.7	15
North America	<0.1	0	37.9	18	171.1	82
Asia	4 843.9	15	25 020.5	78	2 125.2	7
Europe	6.4	2	115.3	33	232.0	66
Oceania	49.1	15	150.0	45	134.7	40
Aquaculture						
Africa	33.1	11	211.8	70	58.6	19
Latin America and the Caribbean	29.3	8	229.8	60	122.3	32
North America		0		0	9.3	100
Asia	2 764.3	15	14 068.5	76	1 645.5	9
Europe	16.7	18	56.7	62	17.5	19
Oceania	1.5	19	5.2	68	1.0	13

BOX 1
(CONTINUED)

TABLE 14
SEX-DISAGGREGATED ENGAGEMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE IN SELECTED COUNTRIES (thousands)

Country/sex	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Australia												
Female	2.9	1.7	2	1.7	1.2	2.2	1	1.3	1.3	15.3	2.6	2.4
Male	9.4	8.1	11.7	7.5	10.2	9.4	9.6	7.3	7.4	80.8	11.6	10.5
Chile												
Female	4.8	5.9	8.2	10.8	12.9	15.7	21.3	22.5	23.7	29.4	25.8	31.7
Male	52.2	54.6	57.4	59.9	62.9	66.5	92.4	95.8	88.9	87.3	86.7	91.3
Unspecified	20.6	20.7	20.3	20.8	50.5							
Ireland												
Female		0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.1	0.1	0.3	0.3
Male		1.8	1.7	3.6	3.6	3.1	3.1	3.1	1.7	1.7	3.2	3.3
Unspecified	7.6	11.3	4.5	6.8	10.9	6.3	8	7.8	8	7.9	6.1	6.1
Japan												
Female	36.1	34.5	33.2	34.1	32.5	30	25.2	24.4	23.9	22.6	21.9	20.5
Male	186	178	171.1	187.8	179.4	172.9	152.7	149.3	157.1	150.5	144.7	139.5
Mauritius												
Female	0.6	0.8	0.8	0.8	0.8	1.1	1	1	1.1	1.1	1.1	1.1
Male	26	25.9	26.8	25.8	26.1	28.1	28.1	28.1	28.2	28.3	28.2	28.0
Saint Lucia												
Female	0	0	0	0	0	0	0.1	0.1	0.2	0.2	0.1	0.2
Male	2.3	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.7	2.8	2.9	3.0
Sri Lanka												
Female	1.5	1.6	3.1	12.2	10	17.6	20.9	16.5	10.7	14.2	19.4	21.9
Male	160.6	167	185.3	196.4	189.2	218.9	248	243.4	257.3	276.5	276.5	291.2

THE FISHING FLEET

Estimate of the global fleet and its regional distribution

The total number of fishing vessels in the world in 2016 was estimated to be about 4.6 million, unchanged from 2014. The fleet in Asia was the largest, consisting of 3.5 million vessels, accounting for 75 percent of the global fleet (Figure 10). In Africa and North America the estimated number of vessels declined from 2014 by just over 30 000 and by nearly 5 000, respectively. For Asia, Latin America and the Caribbean and Oceania the numbers all increased, largely as a result of improvements in estimation procedures.

Globally, the number of engine-powered vessels was estimated to be 2.8 million in 2016, remaining steady from 2014. Motorized vessels represented 61 percent of all fishing vessels in 2016, down from 64 percent in 2014, as the number of non-motorized vessels increased, probably because of improved estimations. Generally, motorized vessels make up a much higher proportion in marine-operating vessels than in the inland water fleet. However, data reporting was not of sufficient quality to disaggregate marine and inland water fleets.

Figure 11 shows the proportion of motorized and non-motorized vessels by region. The motorized fleet is distributed unevenly around the world (Figure 12), with Asia having nearly 80 percent of the reported motorized fleet in 2016 (2.2 million vessels), followed by Africa with about 153 000 powered vessels. In Europe, the fleet capacity has continued to decline steadily since 2000 as a result of management measures to reduce the fleet capacity. This region has the highest percentage of motorized vessels in the overall fleet. »

FIGURE 10
DISTRIBUTION OF MOTORIZED AND NON-MOTORIZED FISHING VESSELS BY REGION, 2016 (thousands)

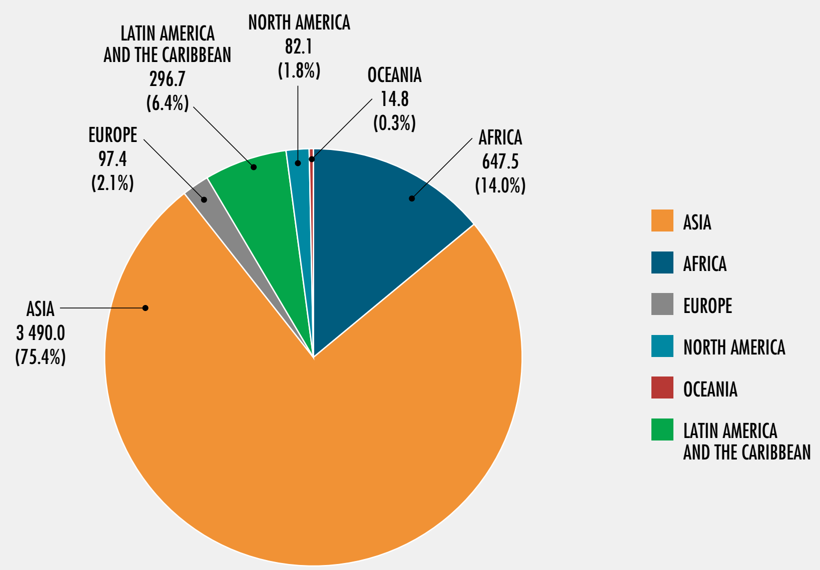


FIGURE 11
PROPORTION OF FISHING VESSELS WITH AND WITHOUT ENGINE, BY REGION, 2016

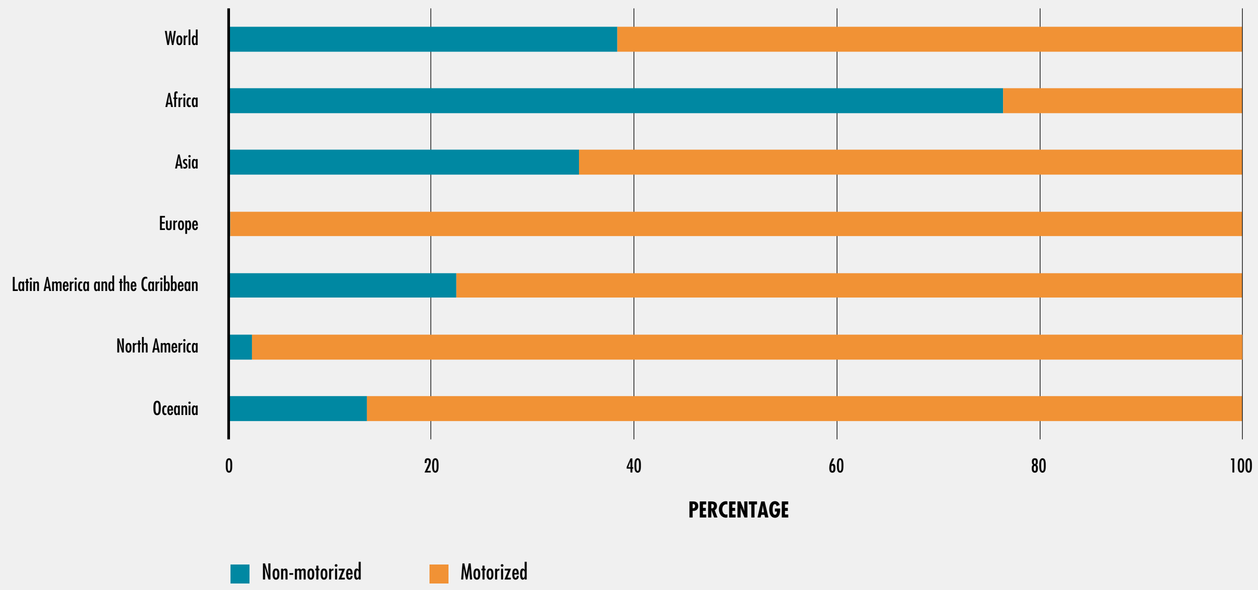


FIGURE 12
DISTRIBUTION OF MOTORIZED FISHING VESSELS BY REGION, 2016 (thousands)

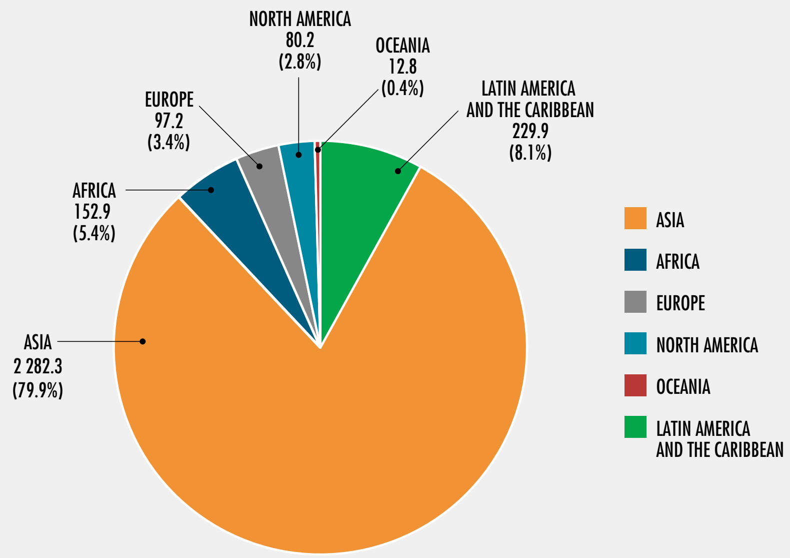
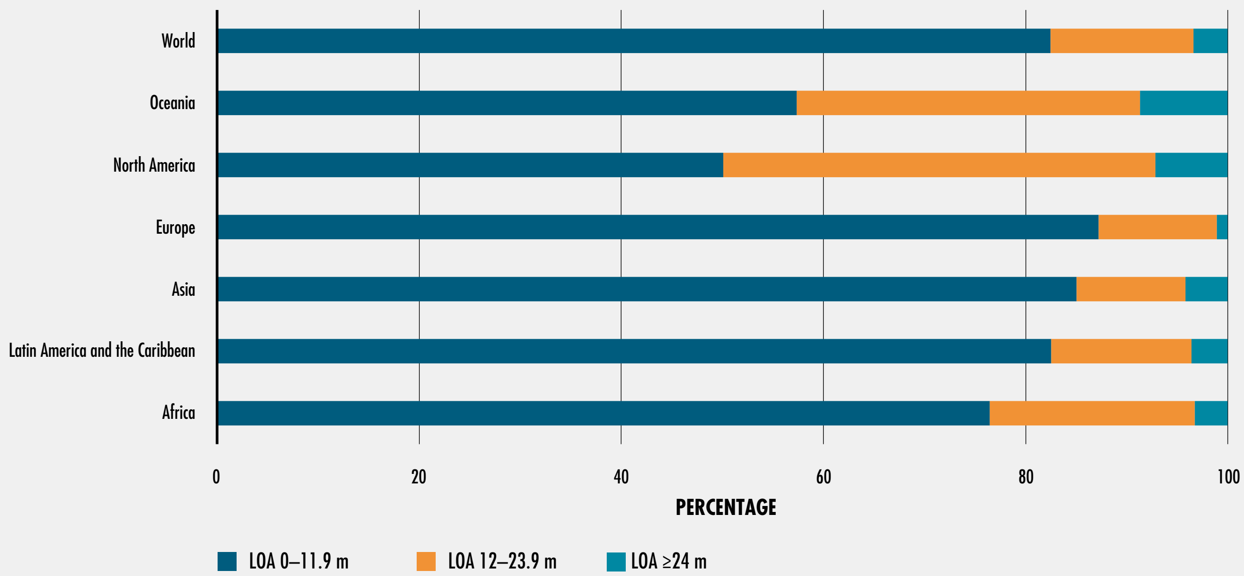


FIGURE 13
SIZE DISTRIBUTION OF MOTORIZED FISHING VESSELS BY REGION, 2016



» The largest absolute number of unpowered vessels was in Asia, with over 1.2 million in 2016, followed by Africa (just under 500 000 non-motorized boats), Latin America and the Caribbean, Oceania, North America and Europe in descending order. These undecked vessels were mostly in the length overall (LOA) class of less than 12 m and included the smallest boats used for fishing.

Size distribution of vessels and the importance of small boats

In 2016, about 86 percent of the motorized fishing vessels in the world were in the LOA class of less than 12 m, the vast majority of which were undecked, and those small vessels dominated in all regions (Figure 13). Asia had the largest absolute number of motorized vessels under 12 m, followed by Latin America and the Caribbean. Only about 2 percent of all motorized fishing vessels were 24 m and larger (roughly more than 100 gross tonnage [GT]), and the proportion of these large boats was highest in Oceania, Europe and North America. Worldwide, FAO estimated about 44 600 fishing vessels with LOA of at least 24 m for 2016.

Despite the global prevalence of small vessels, estimations of their numbers are likely to be less accurate, as they are often not subject to registration requirements as larger vessels are, and even when registered they may not be reported in national statistics. The lack of information and reporting is particularly acute for inland water fleets, which are often entirely omitted from national or local registries.

Table 15 shows the number of vessels reported by selected countries and territories from each region, categorized by LOA class and motorization status. While these figures are not necessarily representative of each region, it is notable that only eight of the 28 countries and territories shown had 200 or more vessels over 24 m LOA. Usually the non-motorized vessels are a minor component of the total national fleet; exceptions include Benin, where »

TABLE 15
REPORTED NUMBER OF MOTORIZED AND NON-MOTORIZED VESSELS BY LOA CLASS IN FISHING FLEETS FROM SELECTED COUNTRIES AND TERRITORIES, 2016

Country	Non-motorized <12 m	Non-motorized 12–24 m	Non-motorized >24 m	Motorized <12 m	Motorized 12–24 m	Motorized >24 m
Africa						
Angola	5 337			3 785	114	156
Benin	51 771			1 363	134	14
Mauritius	130			1 556	36	9
Senegal	3 987	414	2	9 646	4 958	161
Sudan				1 375	21	2
Tunisia	8 360			3 862	656	266
Latin America and the Caribbean						
Bahamas				751	160	23
Chile	859	39		12 179	2 342	204
Guatemala				50	35	2
Guyana	10			439	339	
Mexico				74 029	1 696	271
Saint Lucia				815	7	
Suriname				368	439	68
Asia						
Bangladesh	34 811			32 858	45	203
Cambodia	39 726			172 622		
Kazakhstan	875	55		997	58	6
Republic of Korea	888	15		57 361	7 313	1393
Lebanon	81			1 834	47	
Myanmar	12 583			14 099	1 992	770
Oman	2 184			20 676	680	113
Sri Lanka	19 761	3		28 429	2 474	
Taiwan, Province of China	504	2	2	14 819	6 306	934
Europe						
Norway				4 827	813	308
Ukraine	141			2 986	130	55
Poland	71	2		599	120	51
Oceania						
New Caledonia				184	13	4
New Zealand	5			741	443	65
Vanuatu				95	7	59

» they constituted the large majority, and Bangladesh, Myanmar and Sri Lanka, where they represented up to 50 percent of the total. In the selected countries in Europe, Latin America and the Caribbean and Oceania, the great majority of the vessels were motorized.

Information on vessels is essential for effective performance-based fisheries governance. It is therefore a serious concern that data on vessels are often most lacking for small-scale fisheries, which are typically a key source of livelihoods and nutrition for coastal communities. ■

THE STATUS OF FISHERY RESOURCES

Marine fisheries

Sustainability of fishing levels

Based on FAO's monitoring of assessed stocks (see FAO, 2011a for methodology), the fraction of fish stocks that are within biologically sustainable levels (see Box 2) has exhibited a decreasing trend from 90.0 percent in 1974 to 66.9 percent in 2015 (Figure 14). In contrast, the

BOX 2
ABOUT STOCK STATUS CLASSIFICATION

Definitions

In *The State of World Fisheries and Aquaculture*, fish stocks are classified into two categories:

- **Fished within biologically sustainable levels:** stocks with abundance at or above the level associated with maximum sustainable yield (MSY)
- **Fished at biologically unsustainable levels:** stocks less abundant than the level needed to produce MSY

The percentage of stocks fished within biologically sustainable levels is the indicator used to measure progress towards the Sustainable Development Goals (SDGs) target for marine fisheries (target 14.4), and can therefore be used for SDG monitoring and reporting (see "Fisheries and the Sustainable Development Goals: meeting the 2030 Agenda" in Part 2).

Stocks are also characterized in three more traditional categories, to give more information about the production potential of a fish stock in relation to its current status:

- **Overfished:** having abundance lower than the level that can produce MSY
- **Maximally sustainably fished:** having abundance at or close to the level of MSY
- **Underfished:** abundance above the level corresponding to MSY

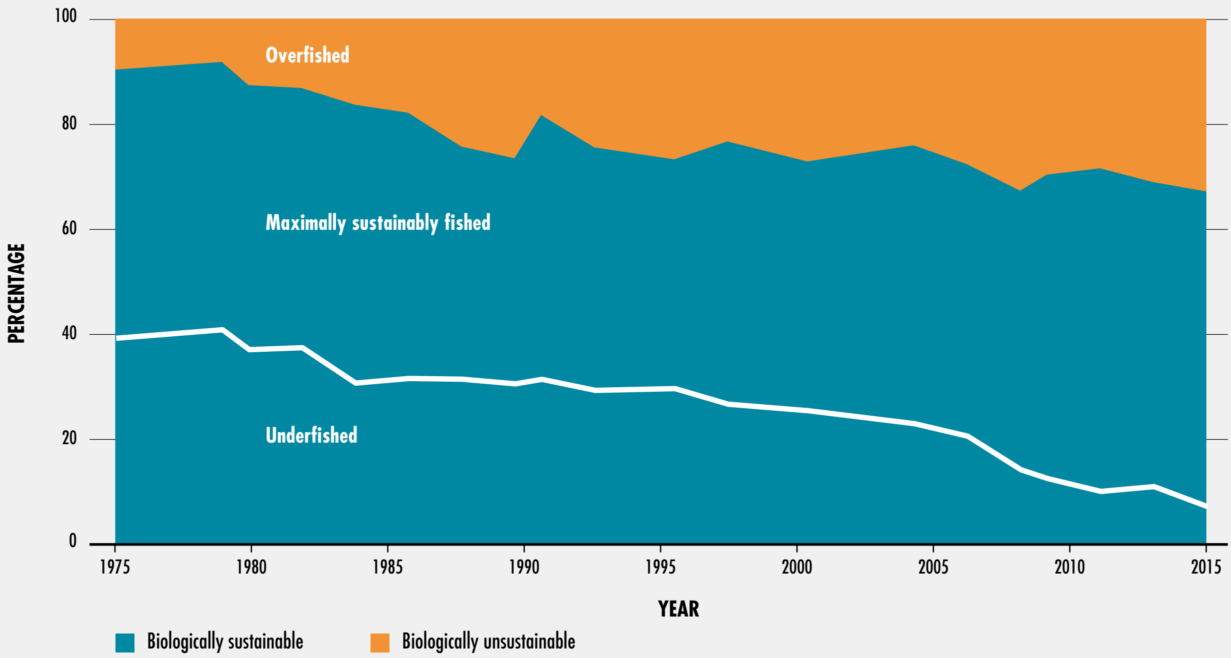
In previous editions the category "maximally sustainably fished" was labelled "fully fished". That term was often misinterpreted and has been modified for greater conceptual clarity.

How to use the classification results

It is recommended that fishery managers:

- **DO** manage fisheries at maximally sustainably fished levels when food production is a priority and the maximum sustainable yield can be harvested without compromising the reproductive capacity of the stock.
- **DO** keep particular fish stocks underfished if a precautionary approach is warranted to protect the status of the ecosystem in question, consistent with ecosystem-based approaches.
- **DO** reduce fishing intensity to rebuild fish stocks when they are assessed as overfished.
- **DO NOT** overfish a stock, as it will not only reduce long-term yield but also have negative impact on biodiversity and ecosystem functioning and services.
- **DO NOT** group the categories "maximally sustainably fished" and "overfished". The former is generally the target of fishery management, while the latter is a situation to be avoided or overcome through fishery regulations.

FIGURE 14
GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISH STOCKS, 1974–2015



percentage of stocks fished at biologically unsustainable levels increased from 10 percent in 1974 to 33.1 percent in 2015, with the largest increases in the late 1970s and 1980s.

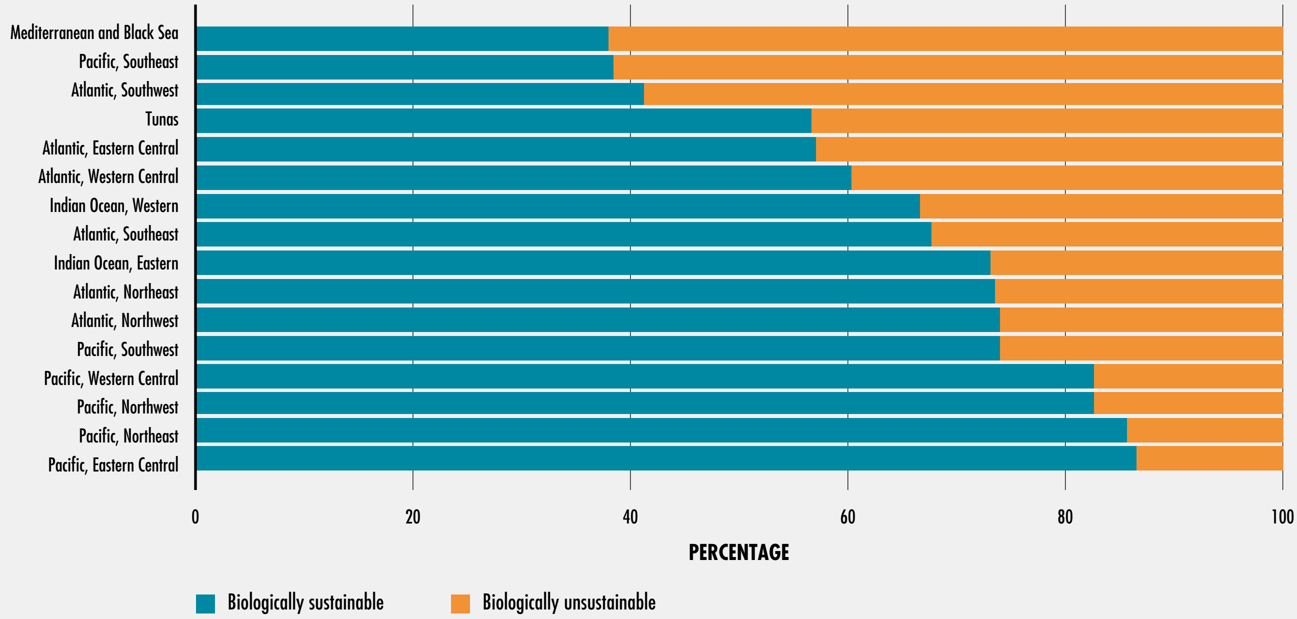
In 2015, maximally sustainably fished stocks accounted for 59.9 percent and underfished stocks for 7.0 percent of the total assessed stocks (separated by the white line in Figure 14). The underfished stocks decreased continuously from 1974 to 2015, whereas the maximally sustainably fished stocks decreased from 1974 to 1989, and then increased to 59.9 percent in 2015.

In 2015, among the 16 major statistical areas, the Mediterranean and Black Sea (Area 37) had the highest percentage (62.2 percent) of unsustainable stocks, closely followed by the Southeast Pacific 61.5 percent (Area 87) and Southwest Atlantic 58.8 percent (Area 41) (Figure 15). In contrast, the Eastern Central Pacific (Area 77), Northeast Pacific (Area 67), Northwest Pacific (Area 61), Western Central Pacific (Area 71) and Southwest Pacific (Area 81) had the lowest proportion (13 to 17 percent) of fish stocks at biologically unsustainable levels. Other areas varied between 21 and 43 percent in 2015.

The temporal pattern of landings differs from area to area depending on the productivity of fishery ecosystems, fishing intensity, management and fish stock status. In general, after excluding Arctic and Antarctic areas, which have minor landings, three groups of patterns can be observed (Figure 16):

- areas with a continuously increasing trend in catches since 1950;
- areas with catches fluctuating around a globally stable value since 1990, associated with the dominance of pelagic, short-lived species;
- areas with an overall declining trend following historical peaks.

FIGURE 15
PERCENTAGES OF STOCKS FISHED AT BIOLOGICALLY SUSTAINABLE AND UNSUSTAINABLE LEVELS BY FAO STATISTICAL AREA, 2015



NOTE: Tuna stocks are singled out as they are largely migratory and straddling across statistical areas.

The first group had the highest proportion of biologically sustainable stocks (72.6 percent), in comparison with the second group (67.0 percent) and the third group (62.8 percent).

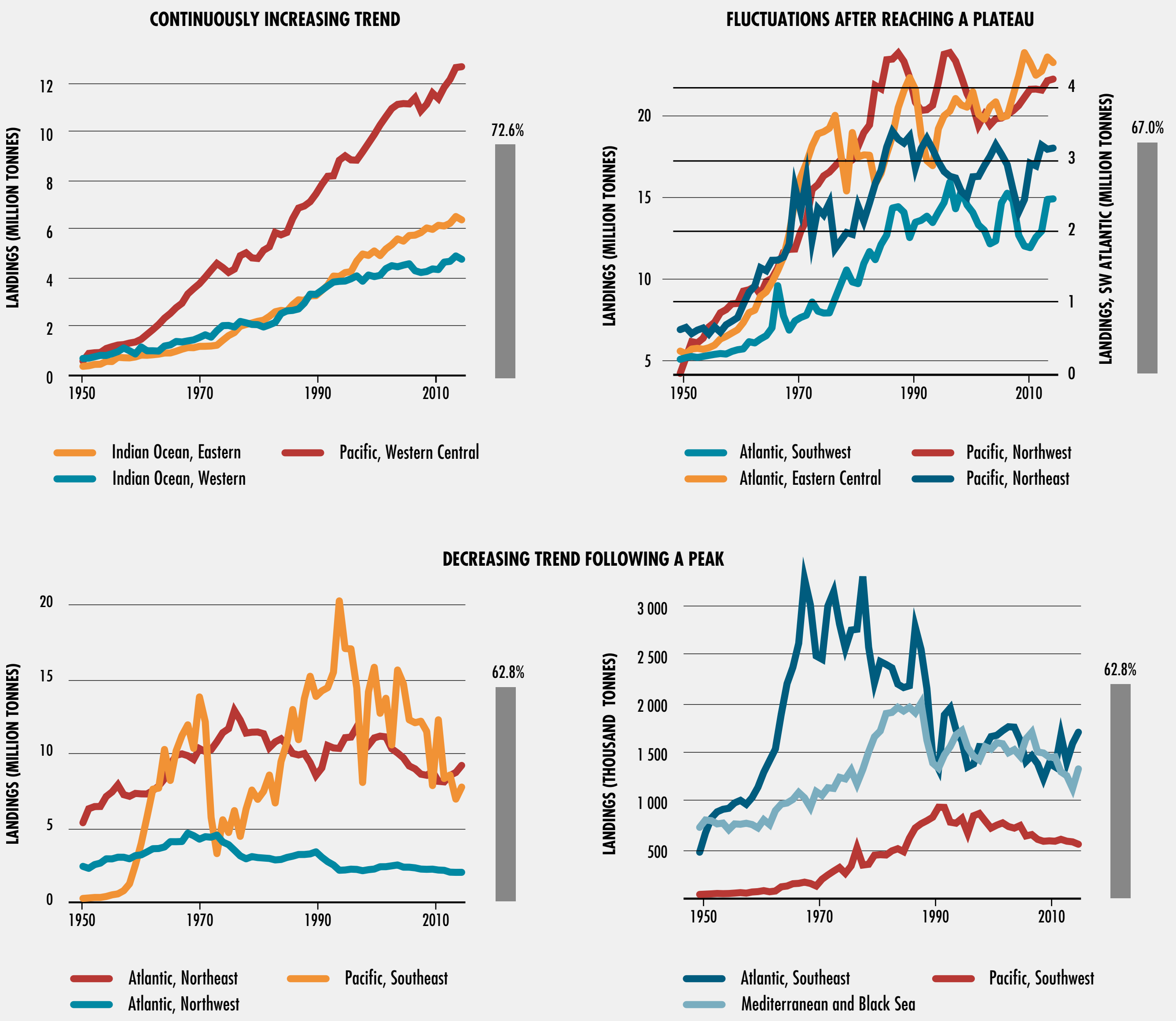
Linking the catch pattern with stock status is not straightforward. In general, an increasing trend in catch usually suggests an improving stock status or an expansion in fishing intensity, whereas a decreasing trend is more likely to be associated with declines in abundance or with management measures that are either precautionary or aimed at rebuilding stocks. However, many other factors may also contribute to a decreasing catch, such as environmental changes and market conditions.

Status and trends by major species

Productivity and stock status also vary greatly among species. For the ten species that had the largest landings between 1950 and 2015, including anchoveta (*Engraulis ringens*), Alaska pollock (*Theragra chalcogramma*), Atlantic herring (*Clupea harengus*), Atlantic cod (*Gadus morhua*), Pacific chub mackerel (*Scomber japonicus*), Chilean jack mackerel (*Trachurus murphyi*), Japanese pilchard (*Sardinops melanostictus*), skipjack tuna (*Katsuwonus pelamis*), South American pilchard (*Sardinops sagax*) and capelin (*Mallotus villosus*), 77.4 percent of stocks were fished within biologically sustainable levels in 2015 – better than the average for all stocks, which may reflect the fact that large fisheries attract greater attention in policy-making and management implementation. Of these ten species, Chilean jack mackerel, Atlantic cod and capelin had higher than average proportions of overfished stocks.

Tunas are of great importance because of their high economic value and extensive international trade, and their sustainable management is subject to great challenges owing to their highly migratory and often straddling distributions. Total landings of the principal market tuna species – albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), bluefin (*Thunnus thynnus*,

FIGURE 16
THE THREE TEMPORAL PATTERNS IN FISH LANDINGS, 1950–2015



NOTE: In each graph, the grey bar shows the percentage of stocks fished at biologically sustainable levels.

Thunnus maccoyii, Thunnus orientalis), skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*) – were 4.8 million tonnes in 2015 and have demonstrated a continuously increasing trend since 1950. In 2015, among the seven principal tuna species, 43 percent of the stocks were estimated to be fished at biologically unsustainable levels, while 57 percent were fished within biologically sustainable levels (maximally sustainably fished or underfished).

Tuna stocks are generally well assessed, and the status is unknown or very poorly known for very few stocks of the principal tuna species. Market demand for tuna is still high, and tuna fishing fleets continue to have significant overcapacity. Effective management, including the implementation of harvest control rules, is needed to restore the overfished stocks.

Status and trends by fishing area

The Northwest Pacific has the highest production among FAO fishing areas. Its total catch fluctuated between 17 million and 24 million tonnes in the 1980s and 1990s, and was about 22.0 million tonnes in 2015. Pelagic and demersal species are the most abundant resources in this area. Historically, the Japanese pilchard and Alaska pollock were the most productive species, with peaks of 5.4 million in 1988 and 5.1 million tonnes in 1986, respectively, but their catches have declined significantly over the last 25 years. The landings of squids, cuttlefishes, octopuses and shrimps have increased greatly since 1990. In 2015, Japanese anchovy (*Engraulis japonicus*) was overfished, and two stocks of Alaska pollock were fully sustainably fished and another one was overfished. Overall, about 74 percent of the assessed stocks were fished within biologically sustainable levels in the Northwest Pacific.

Catches in the Eastern Central Pacific fluctuated between 1.5 and 2.0 million tonnes from 2002 to 2015. Landings in this area include important stocks of California pilchard (*Sardinops caeruleus*), anchovy (*Engraulis mordax*), Pacific jack mackerel (*Trachurus symmetricus*), squids and prawns. Overfishing currently affects selected coastal resources of high value, such as groupers and shrimps. In this area 87 percent of the assessed fish stocks were fished at biologically sustainable levels in 2015, a slight improvement in comparison with 2013.

The Eastern Central Atlantic has seen an overall increasing trend in catches, but with fluctuations since the mid-1970s, reaching 4.3 million tonnes in 2015. Sardine (*Sardina pilchardus*) is the single most important species, with reported catches of close to 1 million tonnes per year from 2004 to 2015. A recent assessment indicates that the sardine stocks have been underfished. Another important small pelagic species in this area is the round sardinella (*Sardinella aurita*), which forms the basis for many fisheries across the region, both small-scale and industrial. Catches for this species in 2015 were about 200 000 tonnes, and average catches in the last five years have seen a decline as compared to the previous five years. Some of the stocks of this species have been considered overfished. The demersal resources are to a large extent fully sustainably fished in most of the area. Overall, 57 percent of the stocks assessed were considered to be within biologically sustainable levels in the Eastern Central Atlantic.

In the Southwest Atlantic, total catches have fluctuated between 1.8 million and 2.6 million tonnes (after a period of increase that ended in the mid-1980s), reaching 2.4 million tonnes in 2015. The most important species in terms of landings is the Argentine shortfin squid (*Illex argentinus*); about 1.0 million tonnes were produced in 2015, a historical maximum, and the species is considered maximally sustainably fished. Argentine hake (*Merluccius hubbsi*) is also an important species, producing about 336 000 tonnes in 2015, and is considered overfished with signs of recovery. Argentine red shrimp (*Pleoticus muelleri*) has also shown record catches, reaching 144 000 tonnes in 2015, and is considered fished within biologically sustainable levels. In this area, 42 percent of the assessed stocks were fished within biologically sustainable levels.

Northeast Pacific landings in 2015 remained at the same level as in 2013, about 3.2 million tonnes, with no significant changes seen in species composition of the catches. Alaska pollock remained the most abundant species, representing about 40 percent of the total landings. Pacific cod (*Gadus microcephalus*), hakes and soles are also large contributors to the catches. Overall, 86 percent of the assessed stocks were fished within biologically sustainable levels.

In the Northeast Atlantic, total catches reached a peak of 13 million tonnes in 1976. Then, after a drop, they recovered between 1990 and 2000, declined to 8 million tonnes in 2012, and again recovered slightly to 9.1 million tonnes in 2015. Fishing mortality has been reduced for cod, hake and haddock stocks, with recovery plans in place for the major stocks of these species; their total catch recovered from 2.0 million tonnes in 2011 to

3.5 million tonnes in 2015. Atlantic horse mackerel (*Trachurus trachurus*) and capelin remained overfished. Data for redfishes and deep-water species are limited, but their likely vulnerability to overfishing is of concern. Northern prawn (*Pandalus borealis*) and Norway lobster (*Nephrops norvegicus*) stocks are generally in good condition. This area had 73 percent of the assessed stocks within biologically sustainable levels in 2015.

The Northwest Atlantic produced 1.8 million tonnes of fish in 2015, about the same as in 2013, but still low compared with the 4.2 million tonnes of the early 1970s. The group of Atlantic cod, silver hake (*Merluccius bilinearis*), white hake (*Urophycis tenuis*) and haddock (*Melanogrammus aeglefinus*) has not shown good recovery, with landings remaining at about 0.1 million tonnes since the late 1990s (only 5 percent of this group's historical peak of 2.2 million tonnes). The lack of recovery may largely be due to other factors than fishing pressure (e.g. environmental), but further management actions are still needed. In contrast, American lobster (*Homarus americanus*) landings showed a rapid increase to 160 000 tonnes in 2015. This area had 72 percent of the assessed stocks fished at biologically sustainable levels in 2015.

Total catches in the Western Central Atlantic reached a maximum of 2.5 million tonnes in 1984, then declined gradually to 1.2 million tonnes in 2014 and bounced back slightly to 1.4 million tonnes in 2015. Important stocks such as Gulf menhaden (*Brevoortia patronus*), round sardinella, skipjack tuna and yellowfin tuna were estimated to be maximally sustainably fished. The use of fish aggregating devices (FADs) by small-scale fisheries has allowed some island nations in the Caribbean Sea to increase their landings of tropical tunas and other pelagic fishes in the last decade. Stocks of valuable invertebrate species such as the Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*) appear to be maximally sustainably fished in most of their range, as do those of shrimp resources in the Gulf of Mexico. However, some stocks of penaeid shrimps in the Caribbean and Guianas shelf have not shown signs of recovery in recent years, despite reductions in fishing effort. In addition, stocks of American cupped oyster (*Crassostrea virginica*) in the Gulf of Mexico are now experiencing overexploitation. Overall, 60 percent of the assessed stocks were fished within biologically sustainable levels in 2015.

The Southeast Atlantic has shown a decreasing trend in landings, from a total production of 3.3 million tonnes in the early 1970s to 1.6 million tonnes in 2015 (a slight recovery from the 2013 value of 1.3 million tonnes). The most important species in the region are horse mackerels and hakes, contributing 25 and 19 percent of the total landings, respectively. Stocks of both deep-water and shallow-water hake off South Africa and Namibia have recovered to biologically sustainable levels as a consequence of good recruitment and strict management measures introduced since 2006. However, the condition of the Southern African pilchard (*Sardinops ocellatus*) stocks has degraded appreciably, warranting special conservation measures from both Namibian and South African fisheries regulators. The sardinella (*Sardinella aurita* and *Sardinella maderensis*) stocks, very important off Angola and partially in Namibia, are still within biologically sustainable levels. Whitehead's round herring (*Etrumeus whiteheadi*) is underfished, while Cunene horse mackerel (*Trachurus trecae*) remained overfished in 2015. The condition of the perlemoen abalone (*Haliotis midae*) stock, targeted heavily by illegal fishing, continues to deteriorate and remains overfished. Overall, 68 percent of the assessed stocks were fished within biologically sustainable levels in 2015.

The total landings in the Mediterranean and Black Sea reached a maximum of about 2 million tonnes in the mid-1980s, then declined to a low of 1.1 million tonnes in 2014 and showed a slight recovery to 1.3 million tonnes in 2015. Demersal resources such as hake (*Merluccius merluccius*), red mullets (*Mullus* spp.), turbot (*Psetta maxima*), common sole (*Solea vulgaris*), sea breams (*Pagellus* spp.) and small pelagic resources such as anchovy (*Engraulis encrasicolus*) and sardine are overfished. Most stocks of sardinellas (*Sardinella* spp.), deep-water shrimps (*Parapenaeus longirostris*, *Aristeus antennatus* and *Aristaeomorpha foliacea*) and cephalopods are probably maximally sustainably fished to overfished. The General Fisheries Commission for the Mediterranean (GFCM) has recently launched a mid-term strategy to reverse the overfishing and address other important threats in the region, such as illegal, unreported and unregulated (IUU) fishing and the effects of climate change. In 2015, the area had 38 percent of the assessed stocks at biologically sustainable levels,[5] the lowest among all the statistical areas.

Total production in the Western Central Pacific grew continuously to a new high of 12.6 million tonnes in 2015. Major species are tuna and tuna-like species, which contribute about 25 percent of total landings. Sardinellas and anchovies are also major species in the region. This area contributes about 15 percent of global marine production. Few stocks are underfished, particularly in the western part of the South China Sea. The high reported catches have probably been maintained through expansion of fishing to new areas. The tropical and subtropical characteristics of this region and the limited data availability complicate stock assessment, which involves great uncertainties. Overall, 83 percent of the assessed fish stocks in this area were fished at biologically sustainable levels in 2015.

The Eastern Indian Ocean continues to show an increasing trend in catches, reaching 6.4 million tonnes in 2015. The monitoring of the status and trends of stocks in the Bay of Bengal and Andaman Sea regions is relatively uncertain owing to data limitations. However, the analysis of catch trends indicates that most stocks of shads and coastal fishes (e.g. croaker, mullets, catfish, hairtails) are probably fished at or below the MSY level. Small pelagic resources, including Indian oil sardine (*Sardinella longiceps*), anchovies and squids, are probably maximally sustainably fished to underfished. Stocks of prawns off Western Australia are considered maximally sustainably fished. In 2015, 73.5 percent of the assessed stocks were within biologically sustainable levels.

In the Western Indian Ocean, total landings continued to increase, reaching 4.7 million tonnes in 2015. The main penaeid shrimp stocks in the Southwest Indian Ocean, a main source of export revenues, have shown clear signs of overexploitation, prompting the fisheries authorities in the concerned countries to introduce more stringent management measures. Both data availability and stock assessment capacity are limited in the region. The Southwest Indian Ocean Fisheries Commission (SWIOFC) continues to produce updates to the assessment of the status of main commercial stocks. Overall, 67 percent of the assessed fish stocks were estimated to be exploited at biologically sustainable levels in 2015.

Prospects for rebuilding the world's marine fish stocks

The world's marine fisheries had 33.1 percent of stocks classified as overfished in 2015. This presents a worrisome situation. Overfishing – stock abundance reduced by fishing to below the level that can produce maximum sustainable yield – not only has negative ecological consequences, but also reduces fish production in the long term, which subsequently has negative social and economic consequences. Ye *et al*. (2013) have estimated that rebuilding overfished stocks could increase fishery production by 16.5 million tonnes and annual rent by USD 32 billion, which would certainly increase the contribution of marine fisheries to the food security, economies and well-being of coastal communities. The situation seems particularly acute 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, which entered into force in 2001, should be used more effectively as the legal basis for management measures of high-seas fisheries.

The United Nations Sustainable Development Goals (SDGs) set a target (14.4) for marine fisheries: "By 2020, effectively regulate harvesting and end overfishing, illegal, unreported, and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their

5 According to the GFCM publication *The State of Mediterranean and Black Sea Fisheries 2016* (FAO, 2016l), about 80 percent of the stocks scientifically assessed in the Mediterranean and Black Sea are not sustainably exploited. There are two main reasons for the discrepancy with the assessment presented here: first, differences in the reference list of species included in the GFCM assessments as compared with the FAO historical database; second, differences in the geographical boundaries of stock units.

biological characteristics". The indicator to measure progress against this target is the "proportion of fish stocks within biologically sustainable levels" (see also "Fisheries and the Sustainable Development Goals: meeting the 2030 Agenda" in Part 2). Based on FAO's assessment, this proportion was 66.9 percent in 2015. It seems very unlikely that the world's fisheries can rebuild the 33.1 percent of stocks that are overfished in the very near future, because rebuilding requires time, usually two to three times the species' life span.

However, the continuous increase in the percentage of stocks fished at biologically unsustainable levels does not mean that the world's marine fisheries have not made any progress towards achieving SDG target 14.4. Yet the world has diverged, with worsening overcapacity and stock status in developing countries and improved fisheries management and stock status in developed countries (Ye and Gutierrez, 2017). For example, the proportion of stocks fished within biologically sustainable levels increased from 53 percent in 2005 to 74 percent in 2016 in the United States of America (2018), and from 27 percent in 2004 to 69 percent in 2015 in Australia (FRDC, 2016). This divergence is fueled by economic interdependencies through international trade and fisheries access agreements, coupled with limited management and governance capacities in developing countries (see Box 4 in Part 2, page 91). Achieving SDG target 14.4 will require effective partnership between the developed and developing worlds, particularly in policy coordination, financial and human resource mobilization and deployment of advanced technologies (e.g. for monitoring fisheries). Practical experience, as reflected in the above examples, has proved that overfished stocks can be rebuilt, and rebuilding will produce not only higher yields, but also substantive social, economic and ecological benefits. For some fisheries, increased stock abundance will eventually bring higher catch rates which can benefit fishers through increased profitability.

Inland fisheries

FAO does not have a system for tracking the status of inland fisheries comparable to that used in marine capture fisheries. Almost 95 percent of the world's inland fisheries catch is in developing countries (Bartley *et al.*, 2015), and 90 percent of inland capture production is consumed in the developing world (World Bank, 2012). Approximately 43 percent of global inland catch occurs in low-income food deficit countries (LIFDCs) (see Box 11 in Part 2, page 117). This is important, as it illustrates how allocation of resources for monitoring and catch data collection of inland fisheries is often not a priority in countries with more pressing issues to address. One effect of the limited monitoring of inland fisheries is that national catch statistics may be under-reported, as noted in previous editions of *The State of World Fisheries and Aquaculture* and other in-depth analyses. Partly as a consequence of this inaccuracy, the potential for inland fisheries to contribute to nutrition and livelihood resilience in vulnerable countries may not be fully recognized, particularly in relation to competing demands for the use of water (see "Global inland fisheries revisited: their contribution to achievement of the SDGs" in Part 2).

The catch figure reported at the national level represents an aggregate of all national production and hence does not provide information on individual fisheries. Increasing or decreasing national catch does not necessarily reflect the state and sustainability of individual fisheries and their stocks, or provide insight into whether declines in one fishery (or subnational area) are offset by gains in another.

In the absence of a management framework and systematic monitoring, production statistics do not typically provide information on the status of inland fisheries, but rather an estimate of their contribution to food supply. Long-term trend analyses of production are also weak indicators of how well fisheries are managed and the sustainability of the fishing pressure. There are considerable challenges to deriving even an indication of the sustainable production level from many of the world's inland fisheries, let alone detailed assessments as to the condition of the fishery resources.

Monitoring of individual fisheries may provide a clearer picture of how well the world's inland fisheries are managed, as well as the status of the fishery resources. Data on fisheries are easier to collect on larger water bodies and highly concentrated fisheries, and the trends in these fisheries are clearer. However, they are only a subset of the national inland fisheries and may not be indicative of an overall national trend.

It might be possible to derive an overall picture of the state of the world's inland fisheries resources by monitoring the state of major inland fisheries at river basin level. Inland fisheries vary notably from year to year because they are influenced not only by fishing pressure but also by often dramatic fluctuations in climatic conditions (rainfall, temperature and seasonal effects), water dynamics (flooding, water flow and connectivity), nutrient availability, water quality and pollution. Tracking such changes in river basins over a five- to ten-year period would help describe and explain trends in inland fisheries.

At the country level, it could be beneficial to monitor the catch and identify key drivers in nationally important inland fisheries – those with high overall production (and thus contribution to national catch) or high participation (e.g. dispersed floodplain fisheries). It could then be possible to determine a national trend and the fisheries (floodplain, riverine, wetland, human-made and natural water bodies) driving it. The tracking of a number of fishery-relevant indicators (e.g. environmental drivers and fisheries production) would also make it possible to identify underlying causes of declines (overexploitation, environmental change). FAO is currently evaluating options of how to establish an approach for inland fishery assessment which would enable member countries to track key fisheries both for global tracking of inland fishery resources and for national policy and management responses. ■

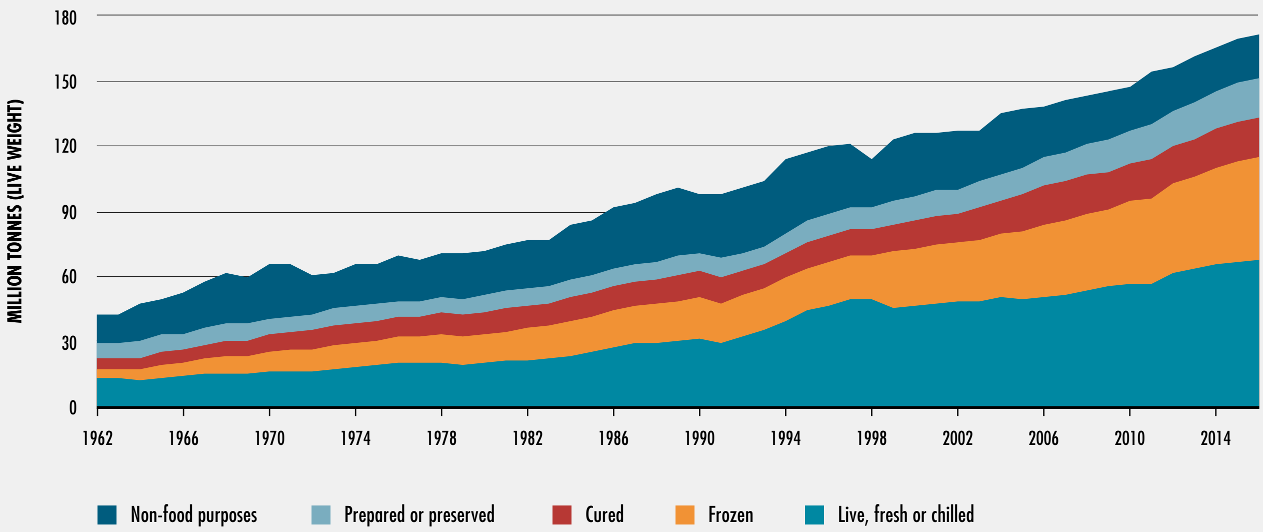
FISH UTILIZATION AND PROCESSING

Fish is a versatile food commodity; the wide variety of species can be prepared in many different ways. As fish can spoil more rapidly than many other foods, post-harvest handling, processing, preservation, packaging, storage and transportation require particular care to maintain its quality and nutritional attributes and avoid waste and losses. Preservation and processing can reduce the rate of spoilage and thus allow fish to be distributed and marketed worldwide in a wide range of product forms destined for food or non-food uses, from live organisms to more complex preparations. Food processing and packaging technology is being developed in many countries, with increases in the efficiency, effectiveness and profitability of the use of raw materials and innovation in product diversification. Moreover, expansion in the consumption and commercialization of fish products in recent decades (see section on consumption later in Part 1) has been accompanied by growing interest in food quality and safety, nutritional aspects and waste reduction. In the interests of food safety and consumer protection, increasingly stringent hygiene measures have been adopted at the national and international trade levels. For example, the Codex Code of Practice for Fish and Fishery Products (Codex Alimentarius Commission, 2016) provides guidance to countries on practical aspects of implementing good hygienic practices and the Hazard Analysis Critical Control Point (HACCP) food safety management system (see also "International trade, sustainable value chains and consumer protection" in Part 3).

In 2016, of the 171 million tonnes of total fish production, about 88 percent or over 151 million tonnes were utilized for direct human consumption (Figure 17). This share has increased significantly in recent decades, as it was 67 percent in the 1960s. In 2016, the greatest part of the 12 percent used for non-food purposes (about 20 million tonnes) was reduced to fishmeal and fish oil (74 percent or 15 million tonnes), while the rest (5 million tonnes) was largely utilized as material for direct feeding in aquaculture and raising of livestock and fur animals, in culture (e.g. fry, fingerlings or small adults for ongrowing), as bait, in pharmaceutical uses and for ornamental purposes.

Live, fresh or chilled is often the most preferred and highly priced form of fish and represents the largest share of fish for direct human consumption, 45 percent in 2016, followed by frozen (31 percent), prepared and preserved (12 percent) and cured (dried, salted, in brine, fermented smoked) (12 percent). Freezing represents the main method of processing fish for human consumption; it accounted for 56 percent of total processed fish for human consumption and 27 percent of total fish production in 2016.

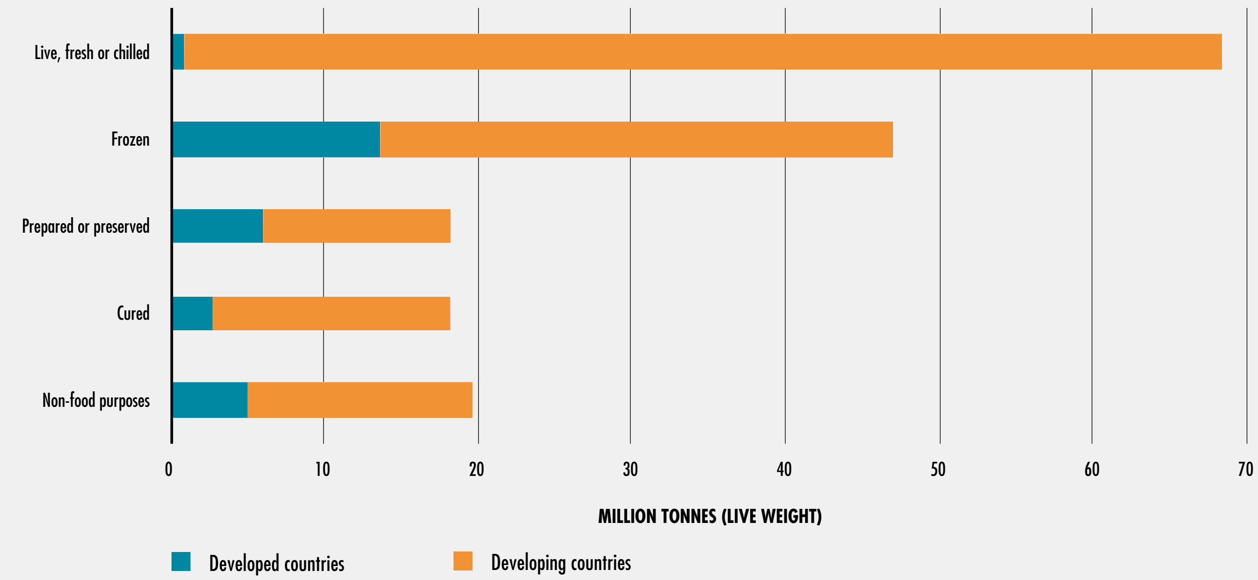
FIGURE 17
UTILIZATION OF WORLD FISHERIES PRODUCTION, 1962–2016



The global averages mask significant differences in the utilization of fish and, more significantly, processing methods among regions and countries and even within countries. Latin American countries produce the highest percentage of fishmeal. In Europe and North America, fish in frozen and prepared and preserved forms represents more than two-thirds of the production of fish used for human consumption. In Africa, the proportion of cured fish is higher than the world average. In Africa and Asia, a large amount of production is commercialized in live or fresh form. Live fish is principally appreciated in eastern and southeastern Asia (especially by the Chinese population) and in niche markets in other countries, mainly among immigrant Asian communities.
Commercialization of live fish has grown in recent years as a result of technological developments, improved logistics and increased demand. Systems for transporting live fish range from simple artisanal systems of plastic bags with an atmosphere supersaturated with oxygen, to specially designed or modified tanks and containers, and on to sophisticated systems installed in 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, quality standards and animal welfare requirements (in the European Union, for example). In China and some Southeast Asian countries, live fish have been traded and handled for more than 3 000 years; practices are based on tradition and are not formally regulated.

Major improvements in processing as well as in refrigeration, ice-making and transportation have allowed increasing commercialization and distribution of fish in a greater variety of product forms in the past few decades. For example, in developing countries growth has been seen in the share of production destined for human consumption that is utilized in frozen form (from 3 percent in the 1960s to 8 percent in the 1980s and 26 percent in 2016) and in prepared or preserved form (from 4 percent in the 1960s to 9 percent in 2016) (Figure 18). However, developing countries still mainly use fish in live or fresh

FIGURE 18
UTILIZATION OF WORLD FISHERIES PRODUCTION: DEVELOPED VERSUS DEVELOPING COUNTRIES, 2016



form (53 percent of the fish destined for human consumption in 2016), soon after landing or harvesting from aquaculture. Fish preserved using traditional methods such as salting, fermenting, drying and smoking – particularly customary in Africa and Asia – represented 12 percent of all fish destined for human consumption in developing countries in 2016.

In developed countries, most fish production destined for human consumption is retailed in frozen, prepared or preserved form. In these countries, the share of frozen fish has risen from 27 percent in the 1960s, to 43 percent in the 1980s, to a record high of 58 percent in 2016. Prepared and preserved forms accounted for 26 percent, while cured forms accounted for 12 percent.

In recent decades, the fish food sector has become more heterogeneous and dynamic. In more advanced economies, fish processing has diversified particularly into high-value fresh and processed products and ready and/or portion-controlled, uniform-quality meals. In many developing countries, fish processing has been evolving from traditional methods to more advanced value-adding processes 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, shifts in available species, outsourcing of processing, and producers' increasing linkages with, and coordination by, processors and large firms and retailers, sometimes outside the country. Supermarket chains and large retailers are increasingly the key players in setting product requirements and influencing the expansion of international distribution channels. Processors and producers are working together more closely to enhance the product mix, obtain better yields and respond to evolving quality and safety requirements in importing countries as well as consumers' sustainability concerns (which have led to the emergence of multiple certification systems, discussed under "International trade, sustainable value chains and consumer protection" in Part 3). In addition, the outsourcing of processing activities to other countries and regions is common, although its extent depends on the species, product form, cost of labour and transportation. Further outsourcing of production to developing countries might be constrained by sanitary and hygiene requirements that are difficult to meet, by growing labour costs in some countries (particularly in Asia) and by higher transport costs. All of these factors could lead to changes in distribution and processing practices and to increases in fish prices.

Despite the technical advances and innovations, many countries, especially less developed economies, still lack adequate infrastructure and services for ensuring fish quality, such as hygienic landing centres, electric power supply, potable water, roads, ice, ice plants, cold rooms, refrigerated transport and appropriate processing and storage facilities. This shortcoming, especially when associated with tropical temperatures, can result in high post-harvest losses, as fish can spoil in the boat, at landing, during storage or processing, on the way to market and while awaiting sale. In Africa, some estimates put post-harvest losses at 20 to 25 percent, and even up to 50 percent, and deterioration of quality can account for more than 70 percent of the loss (Akande and Diei-Ouadi, 2010). Throughout the world, post-harvest fish losses are a major concern and occur in most fish distribution chains; an estimated 27 percent of landed fish is lost or wasted between landing and consumption. As noted in the discussion of post-harvest loss and waste in Part 3 (see "International trade, sustainable value chains and consumer protection"), when discards prior to landing are included, 35 percent of global catches are lost or wasted and therefore not utilized (Gustavsson *et al.*, 2011).

A significant, but declining, proportion of world fisheries production is processed into fishmeal and fish oil. This portion contributes indirectly to human food production and consumption when these ingredients are used as feed in aquaculture and livestock raising. Fishmeal is a proteinaceous flour-type material obtained after milling and drying of fish or fish parts, while fish oil is obtained through the pressing of the cooked fish and subsequent centrifugation and separation. These products can be produced from whole fish, fish trimmings or other fish by-products resulting from processing. Many different species are used for fishmeal and fish oil production, small pelagic species predominating. Many of the species used, such as anchoveta (*Engraulis ringens*), have comparatively high oil yields but are rarely used for direct human consumption.

Fishmeal and fish-oil production fluctuate according to changes in the catches of these species. Anchoveta catches, for example, are dominated by the El Niño phenomenon, which affects stock abundance (see section on capture fisheries production). Over time, adoption of good management practices and the implementation of certification schemes have decreased the volumes of catches of species targeted for reduction to fishmeal. Fishmeal production peaked in 1994 at 30 million tonnes (live weight equivalent) and has followed a fluctuating but overall declining trend since then. In 2016, landings from fisheries directed for fishmeal production were down to less than 15 million tonnes (live weight equivalent) because of reduced catches of anchoveta. Owing to the growing demand for fishmeal and fish oil, in particular from the aquaculture industry, and coupled with high prices, a growing share of fishmeal is being produced from fish by-products, which previously were often wasted. It is estimated that by-products account for about 25 to 35 percent of the total volume of fishmeal and fish oil produced, but there are also regional differences. For example, by-product use in Europe is comparatively high at 54 percent (Jackson and Newton, 2016). With no additional raw material expected to come from whole fish caught by reduction-dedicated fisheries (in particular, small pelagics), any increase in fishmeal production will need to come from use of by-products, which can, however, have a negative impact on its nutritional value as feed (see the section on projections in Part 4).

Fish oil represents the richest available source of long-chain polyunsaturated fatty acids (PUFAs), important in human diets for a wide range of critical functions. However, the Marine Ingredients Organisation (IFFO) estimates that approximately 75 percent of annual fish oil production still goes into aquaculture feeds (Auchterlonie, 2018). Because of the variable supply of fishmeal and fish oil production and associated price variation, many researchers are seeking alternative sources of PUFAs, including large marine zooplankton stocks such as Antarctic krill (*Euphausia superba*) and the copepod *Calanus finmarchicus*, although concerns remain over the impacts for marine food webs. However, the cost of zooplankton products is too high for their inclusion as a general oil or protein ingredient in fish feed. Krill oil in particular is destined for products for direct human consumption. Krill meal is finding a niche in production of certain aquafeeds.

Fishmeal and fish oil are still considered the most nutritious and most digestible ingredients for farmed fish feeds, but their inclusion rates in compound feeds for aquaculture have shown a clear downward trend, largely as a result of supply and price variation. They are increasingly used selectively, for example for specific stages of production, particularly for hatchery, broodstock and finishing diets. Their incorporation in grower diets has decreased over time. For example, their share in grower diets for farmed Atlantic salmon is now often less than 10 percent.

Fish silage (Kim and Mendis, 2006), a rich source of protein hydrolysate, is a less expensive alternative to fishmeal and fish oil and is increasingly important as a feed additive, for example in aquaculture and in the pet food industry. Obtained by preserving whole fish or fish by-products with an acid and letting enzymes from the fish hydrolyse the proteins, silage has potential to increase growth and reduce mortality of animals that receive it in their feed.

The expansion of fish processing is creating increasing quantities of offal and other by-products, which may constitute up to 70 percent of fish used in industrial processing (Olsen, Toppe and Karunasagar, 2014). In the past, fish by-products were often thrown away as waste; used directly as feed for aquaculture, livestock, pets or animals reared for fur production; or used in silage and fertilizers. However, other uses of fish by-products have been gaining attention over the past two decades, as they can represent a significant source of nutrition and can now be used more efficiently as a result of improved processing technologies. In some countries, the use of fish by-products has developed into an important industry, with a growing focus on their handling in a controlled, safe and hygienic way. Fish by-products are usually only placed on the market after further processing because of consumer preferences and sanitary regulations, which may also govern their collection, transport, storage, handling, processing, use and disposal.

Fish by-products can serve a wide range of purposes. Heads, frames and fillet cut-offs and skin can be used directly as food or processed into fish sausages, cakes, snacks (crispy snacks, nuggets, biscuits, pies), gelatin, sauces and other products for human consumption. Small fish bones, with a minimum amount of meat, are consumed as snacks in some Asian countries. By-products are also used in the production of feed (not only in the form of fishmeal and fish oil), biodiesel and biogas, dietetic products (chitosan), pharmaceuticals (including oils), natural pigments, cosmetics and constituents in other industrial processes. Some by-products, in particular viscera, are highly perishable and should therefore be processed while still fresh. Fish viscera and frames are a source of potential value-added products such as bioactive peptides for use in food supplements and in biomedical and nutraceutical industries (Senevirathne and Kim, 2012). Shark by-products (cartilage, but also ovaries, brain, skin and stomach) are used in many pharmaceutical preparations and reduced to powder, creams and capsules. Fish collagens are used in cosmetics and in extraction of gelatin.

The internal organs of fish are an excellent source of specialized enzymes. A range of proteolytic fish enzymes are extracted, e.g. pepsin, trypsin, chymotrypsin, collagenases and lipases. Protease, for example, is a digestive enzyme used in the manufacture of cleaning products, in food processing and in biological research. Fish bones, in addition to being a source of collagen and gelatin, are also an excellent source of calcium and other minerals such as phosphorus, which can be used in food, feed or food supplements. Calcium phosphates present in fish bone, such as hydroxyapatite, can help hasten bone repair after major trauma or surgery. Fish skin, in particular from larger fish, provides gelatin as well as leather for use in clothing, shoes, handbags, wallets, belts and other items. Species commonly used for leather include shark, salmon, ling, cod, hagfish, tilapia, Nile perch, carp and seabass. Shark teeth are used in handicrafts.

As the production and processing of crustaceans and bivalves have increased, efficient use of their shells has become important, not only to maximize financial return, but also to address waste disposal problems because of their slow natural degradation rate. Chitosan, produced from shrimp and crab shells, has shown a wide range of applications, for example in water treatments, cosmetics and toiletries, food and beverages, agrochemicals and pharmaceuticals. Crustacean wastes also yield pigments (carotenoids and astaxanthin) for use in the pharmaceutical industry. Mussel shells provide calcium carbonate for industrial use. In some countries, oyster shells are used as a raw material in building construction and in the production of quicklime (calcium oxide). Shells can also be processed into pearl powder, used in medicines and cosmetics, and shell powder, a rich source of calcium in diet supplements for livestock and poultry. Scallop and mussel shells are used in handicrafts and jewellery, and for making buttons.

Research has revealed a number of anticancer agents in marine sponges, bryozoans and cnidarians. However, for conservation reasons, these agents are not extracted directly from the marine organisms but are chemically synthesized. The culture of some sponge species for this purpose is also being investigated. Some marine toxins may have pharmacological applications. Ziconotide, for example, found in cone snails, is a powerful painkiller, and a synthetic version of this molecule has been commercialized (Marine Biotech, 2015).

Seaweeds and other algae are also used as food (traditionally in China, Japan and the Republic of Korea), in animal feed, fertilizers, pharmaceuticals and cosmetics and for other purposes. In medicine, for example, they are used to treat iodine deficiency and as a vermifuge. In 2016, about 31 million tonnes of seaweeds and other algae were harvested globally for direct consumption or further processing. The composition of seaweeds is highly variable, depending on species, collection time and habitat. Seaweeds are industrially processed to extract thickening agents such as alginate, agar and carrageenan or used, generally in dried powder form, as an animal feed additive. Increasing attention is also focusing on the nutritional value of several seaweed species, because of their high content of vitamins, minerals and plant-based protein. Many seaweed-flavoured foods (including ice creams) and drinks are being launched. Their main market is in Asia and the Pacific, but interest is growing in Europe and North America. Several cosmetics have been commercialized from the seaweed *Saccharina latissima*, and other products have been developed from marine macroalgae (Marine Biotech, 2015). Research is also exploring the use of seaweed as a salt substitute and in the industrial preparation of biofuel. ■

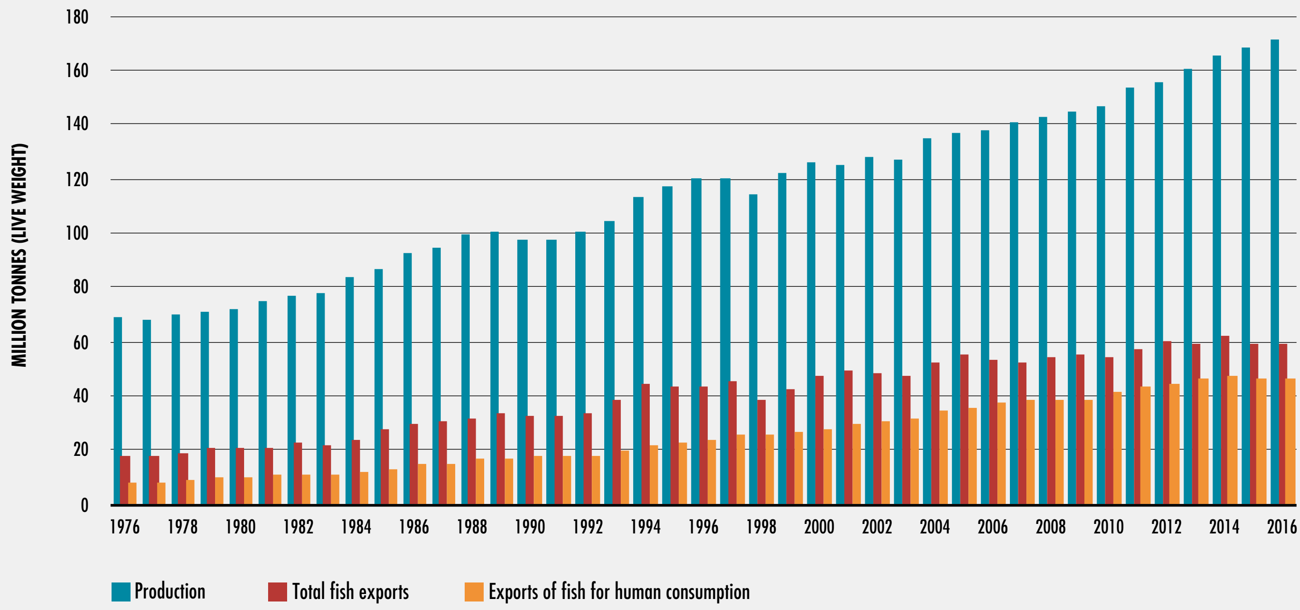
FISH TRADE AND COMMODITIES

Trade of fish and fish products plays an essential role in boosting fish consumption and achieving global food security by connecting producers with distant markets for which local supply may otherwise be insufficient. It also provides employment and generates income for millions of people working in a range of industries and activities around the world, particularly in developing countries. Exports of fish and fish products are essential to the economies of many countries and numerous coastal, riverine, insular and lacustrine regions. For example, they exceed 40 percent of the total value of merchandise trade in Cabo Verde, Faroe Islands, Greenland, Iceland, Maldives, Seychelles and Vanuatu. Globally, trade in fish and fish products currently represents above 9 percent of total agricultural exports (excluding forest products) and 1 percent of world merchandise trade in value terms.[6]

Fish and fish products are some of the most traded food items in the world today, and most of

6 Trade data quoted in this section refer to the available information up to mid-March 2018. These figures could differ slightly from those in the FAO fisheries commodities production and trade dataset 1976–2016 and in the Commodities section of the *FAO Yearbook of Fishery and Aquaculture Statistics 2016*, to be released in early summer 2018. The updated data can be accessed through the tools indicated at: www.fao.org/fishery/statistics/global-commodities-production

FIGURE 19
WORLD FISHERIES AND AQUACULTURE PRODUCTION AND QUANTITIES DESTINED FOR EXPORT



the world's countries report some fish trade. In 2016, about 35 percent of global fish production entered international trade (Figure 19) in various forms for human consumption or non-edible purposes. This share has been even higher in the past (about 40 percent in 2005) and fluctuates according to the amount of fishmeal being exported. The share of fish and fish products for human consumption alone has shown an upward trend, from 11 percent in 1976 to 27 percent in 2016. The 60 million tonnes (live weight equivalent) of total fish and fish products exported in 2016 represent a 245 percent increase over 1976, and the increase is more than 514 percent if only trade in fish for human consumption is considered. During the same period, world trade in fish and fish products also grew significantly in value terms, with exports rising from USD 8 billion in 1976 to USD 143 billion in 2016, at an annual growth rate of 8 percent in nominal terms and 4 percent in real terms. This amount excludes the potentially significant value of trade in fisheries and aquaculture services (e.g. business and resource management, capital equipment operation and servicing, infrastructure construction and research). The overall value generated by these services is not yet available, as it is usually recorded together with the value of services related to other activities.

The rapid rate of expansion of international trade in fish and fish products over recent decades has taken place in the context of a broader process of globalization, a large-scale transformation of the world economy driven by trade liberalization and technological advancements. Globalization is characterized by the widespread reduction and removal of trade barriers that inhibit the movement of goods, services, capital and labour; increasing specialization, resulting in the geographic segmentation of economic activities; longer and more complex supply chains, enabled by new logistical technologies; a proliferation of multinational corporations pursuing horizontal consolidation and vertical integration; and a broadening of consumer tastes, concerns and expectations. This transformation has made trade an increasingly important driver of global economic output, with the share of merchandise trade in world gross domestic product (GDP) exceeding 42 percent in 2016, almost 2.5 times the equivalent figure in 1960. Another significant aspect of globalization has been an increase in international social and cultural integration, accelerated by the rise of information technology, greatly increasing the speed and ease with which consumer tastes, trends and concerns are spread from one country to another.

It is estimated that some 78 percent of fish and fish products are exposed to international trade competition (Tveterås *et al*., 2012), and supply and demand dynamics for many species are increasingly global in nature. Producers are consolidating and increasingly supply and operate in multiple countries. Processing activity is concentrated in countries with lower labour costs; some countries even export fish for processing and later import it back for final sale and consumption. International marketing campaigns, a range of new product types and lower prices, supported by economies of scale and lower wages in processor countries, all contribute to generating strong competition for domestically produced fish, particularly among urban consumers seeking new tastes and greater convenience. Large retail and food service chains, many operating in multiple countries, are imposing new requirements on their suppliers for consistency in quality, food safety, traceability and sustainability.

As demand for fish and fish products is sensitive to income levels of consumers, trends in international fish trade depend to a large degree on the global economic environment, although other important factors influence domestic consumption, such as exchange rate trends, climatic events and large-scale disease outbreaks. While differences among countries and regions remain substantial, global GDP growth since the 2008–2009 financial crisis has generally been sluggish relative to the long-term trend. Trade expansion has also slowed; the 1.3 percent increase in global merchandise trade volume in 2016 was the lowest since 2008 (WTO, 2017), while a strong United States dollar and low commodity prices translated into a 3.3 percent drop in value the same year. Historically, world trade has grown at a significantly faster rate than GDP, but since the financial crisis these two growth rates have been relatively similar because of a poor investment climate, weak global markets for heavily traded commodities and a slowdown in many major economies. However, global trade and GDP strengthened in 2017, benefiting from a cyclical upturn in global capital spending (World Bank, 2018). Trade in fish and fish products has largely followed the prevailing trend, with a decline in 2009 after the 2008 economic crisis, a rebound in 2010–2011 and moderate growth in 2012–2014. In 2015, trade in fish and fish products decreased by 10 percent compared to 2014. Reasons for this contraction include the weakening of many key emerging markets, lower prices for a number of important species and especially the significant strengthening of the United States dollar versus an array of major currencies in 2015, making the value of trade conducted in those currencies seem relatively low. In 2016, trade increased by 7 percent compared to the year before, and in 2017, the uptick in economic growth strengthened demand and lifted prices, increasing the value of global trade in fish exports by about 7 percent to peak at an estimated USD 152 billion.

Table 16 shows the top exporters and importers.[7] The key trends are illustrated below, with highlights of 2017 data when available. China is the main fish producer and since 2002 has also been the largest exporter of fish and fish products, although they represent only 1 percent of its total merchandise trade. After exceptionally rapid gains through the 1990s and 2000s, the average annual increase in the value of Chinese exports of fish and fish products dropped from 14 percent in 2000–2008 to 9.1 percent in 2009–2017. In 2017, Chinese exports of fish and fish products reached USD 20.5 billion, with an increase of 2 percent relative to 2016 and of 4 percent relative to 2015. Since 2011 China has also been the world's third largest importer of fish and fish products, partly because large quantities of fish are imported for processing and then re-exported, but also because rising incomes and

7 Usually, exports are recorded at their free-on-board (FOB) value and imports at their cost, insurance and freight (CIF) value. Therefore, at the world level, the value of imports should be higher than that of exports. However, since 2011 this has not been the case. Work is under way to understand the reasons for this anomalous trend.

TABLE 16
TOP TEN EXPORTERS AND IMPORTERS OF FISH AND FISH PRODUCTS

Country	2006		2016		APR[a] (%)
	Value (million USD)	Share (%)	Value (million USD)	Share (%)	
Exporters					
China	8 968	10.4	20 131	14.1	8.4
Norway	5 503	6.4	10 770	7.6	6.9
Viet Nam	3 372	3.9	7 320	5.1	8.1
Thailand	5 267	6.1	5 893	4.1	1.1
United States of America	4 143	4.8	5 812	4.1	3.4
India	1 763	2.0	5 546	3.9	12.1
Chile	3 557	4.1	5 143	3.6	3.8
Canada	3 660	4.2	5 004	3.5	3.2
Denmark	3 987	4.6	4 696	3.3	1.7
Sweden	1 551	1.8	4 418	3.1	11.0
Top ten subtotal	**41 771**	**48.4**	**74 734**	**52.4**	**6.0**
Rest of world total	**44 523**	**51.6**	**67 796**	**47.6**	**4.3**
World total	**86 293**	**100.0**	**142 530**	**100.0**	**5.1**
Importers					
United States of America	14 058	15.5	20 547	15.1	3.9
Japan	13 971	15.4	13 878	10.2	-0.1
China	4 126	4.5	8 783	6.5	7.9
Spain	6 359	7.0	7 108	5.2	1.1
France	5 069	5.6	6 177	4.6	2.0
Germany	4 717	5.2	6 153	4.5	2.7
Italy	3 739	4.1	5 601	4.1	4.1
Sweden	2 028	2.2	5 187	3.8	9.8
Republic of Korea	2 753	3.0	4 604	3.4	5.3
United Kingdom	3 714	4.1	4 210	3.1	1.3
Top ten subtotal	**60 533**	**66.6**	**82 250**	**60.7**	**3.1**
Rest of world total	**30 338**	**33.4**	**52 787**	**39.3**	**5.7**
World total	**90 871**	**100.0**	**135 037**	**100.0**	**4.0**

[a] APR: average annual percentage growth rate for 2006–2016.

changes in consumption habits create markets for species not produced locally. After years of sustained growth up to 2011, Chinese imports of fish and fish products then experienced a slowdown in expansion, and in 2015 they declined slightly. However, after an increase of 4 percent in 2016, Chinese imports rebounded strongly in 2017, with an increase of 21 percent over 2016, in line with an upturn in the economy.

Behind China, Norway is the next largest exporter of fish and fish products. Norway has developed an extensive salmonid aquaculture sector and maintains a large fishing fleet, targeting cod, herring, mackerel and other whitefish and small pelagic species. Compared with 2015, Norwegian exports rose by 17.2 percent in 2016, reaching USD 11.7 billion, and by a further 5.1 percent in 2017, because of high prices for some of its major species, particularly cod and Atlantic salmon.

Viet Nam, with exports of USD 7.3 billion in 2016, is the world's third largest exporter, with most of its revenue coming from exports of farmed Pangas catfishes *(Pangasius* spp.*)* and shrimp, in addition to a significant trade in processed and re-exported products. Viet Nam has maintained a high GDP growth rate of around 6 percent per year for the past decade, and rising income levels have strengthened consumer demand for relatively expensive imported fish and fish products such as salmon.

Thailand has been one of the top exporters of fish and fish products for decades, but its exports have declined as its important farmed shrimp industry has encountered repeated problems with disease during the past few years, which are only gradually being overcome. Thailand is also a major processing and canning centre for tuna catches landed by a range of foreign long-distance fleets, but over the course of 2015 to 2017 weak global demand for canned tuna has suppressed revenue growth.

Since its establishment, the European Union has represented the largest single market for fish and fish products, followed by the United States of America and Japan. Combined, in 2016 these markets accounted for approximately 64 percent of the total value of world imports of fish and fish products, or approximately 56 percent if trade within the European Union is excluded. Over the course of 2016 and 2017, imports of fish and fish products grew in all three markets as a result of strengthened economic fundamentals, with the added effect of currency appreciation in the case of the United States of America. In developed countries, which have large urban populations of high-income consumers, demand for fish and fish products far outweighs domestic production, and consumption levels can only be maintained through heavy dependence on imports (see the following section, on consumption).

The trade embargo that has been enforced by the Russian Federation since mid-2014 has also had an impact on trade of fish and fish products, with Russian imports in 2017 lower by 43 percent in value terms than in 2013 despite an ongoing economic recovery. The embargo has also brought about a general shift in trade flows, as volumes previously sourced from large producers in Europe such as Norway are currently being imported from alternative producers such as Chile and the Faroe Islands, while those suppliers subject to the embargo have been forced to seek new markets.

In addition to the above-mentioned countries, many emerging markets and exporters, such as Brazil, India and Indonesia, have gained importance, in part thanks to improved distribution systems and increasing production.

Interregional flows (Figure 20) continue to be significant, although this trade is often not adequately reflected in official statistics, in particular for Africa and selected countries in Asia. Oceania, the developing countries of Asia and the Latin America and the Caribbean region remain solid net fish exporters. Latin American exports, comprising primarily shrimp, tuna, salmon and fishmeal from Ecuador, Chile and Peru, were boosted in 2016 and again in 2017 by higher production and an upturn in tuna prices. Europe and North America are characterized by a fish trade deficit (Figure 21). Africa is a net importer in volume terms but a net exporter in terms of value, reflecting the higher unit value of exports, which are destined primarily for developed country markets, particularly Europe. The total value of African imports of fish and fish products rose by an average of 17 percent per year in the period 2000–2011, but in recent years this rate has dropped substantially because of reduced economic growth in many African countries. African imports have relatively low value, consisting largely of cheaper small pelagic species such as mackerel, which represent an important source of dietary diversification.

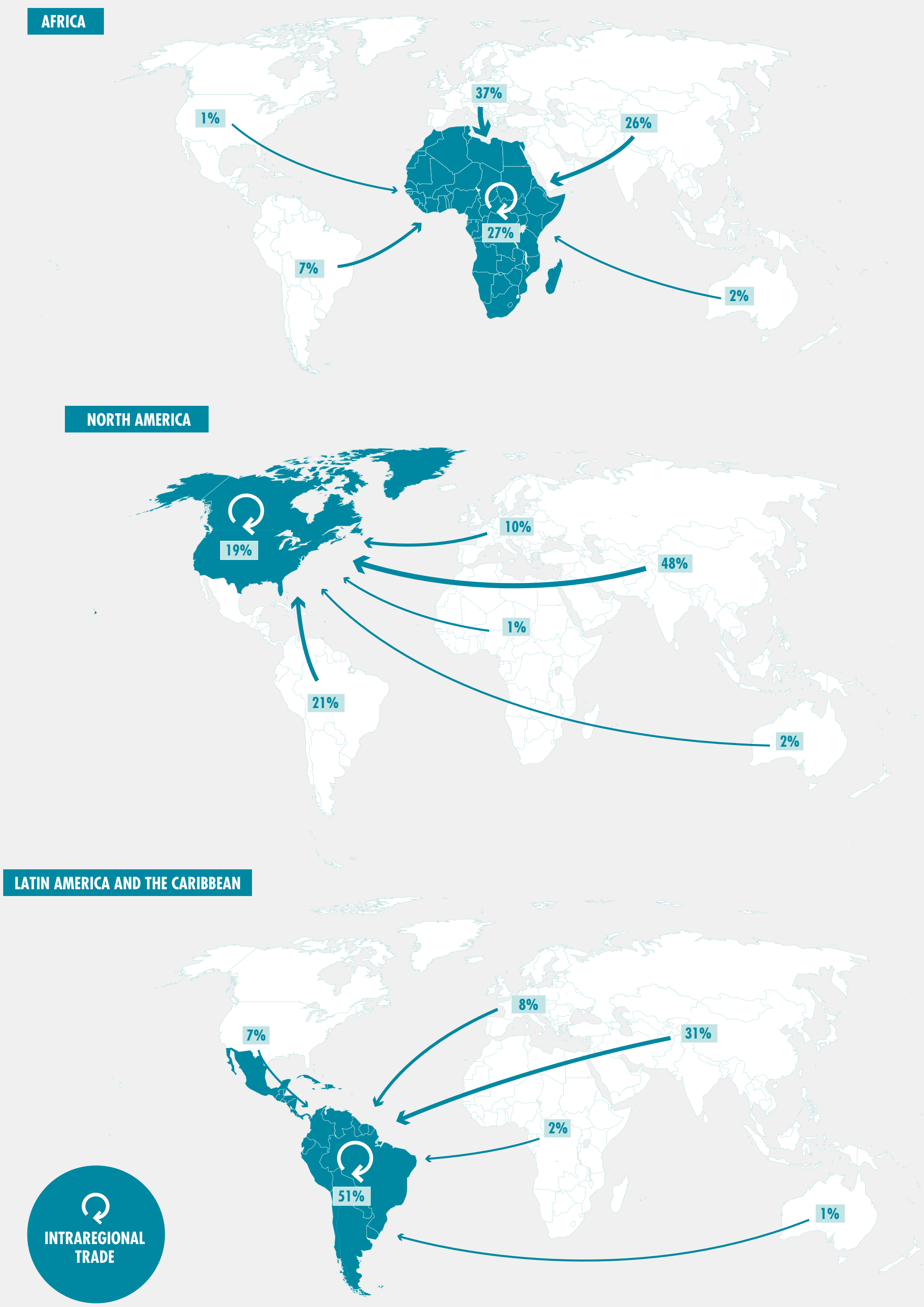
A characterizing trend of global trade in fish and fish products over the past 40 years has been the significantly faster rate of growth in exports from developing countries compared with those from developed countries (Figure 22). From 1976 to 2000, exports from developing countries increased by an average of 9.9 percent per year, in value terms, compared with 7.4 percent for developed countries. The rate has slowed for both groups in more recent years, particularly since the 2008–2009 financial crisis. In 2016 and, according to preliminary figures, also in 2017, developing country exports made up approximately 54 percent of the total value and about 59 percent of the total quantity (in live weight equivalent) of exports of fish and fish products. Both as a source of export revenue and as a provider of employment, trade in fish and fish products represents an important contributor to economic growth in these countries. However, some studies indicate that benefits are unevenly distributed along the value chain, with small-scale producers receiving proportionally smaller economic benefit than processors and retailers (Bjorndal, Child and Lem, 2014). In 2016, fish exports of developing countries were valued at USD 76 billion, and their net fish export revenues (exports minus imports) reached USD 37 billion, higher than those of other agricultural commodities (such as meat, tobacco, rice and sugar) combined.

In 2016, the average unit value of imports of fish and fish products by developing countries was USD 2.4 per kilogram, while the corresponding figure for developed countries was USD 5.1. Thus while the import volumes of the two groups were comparable, developed countries accounted for about 71 percent of global import value in 2016 and, according to preliminary data, also in 2017. This discrepancy is in large part explained by the role of income levels in determining the types of products that consumers demand, in addition to different habits in food consumption. Another factor driving down the unit value of developing-country imports is the extent of processing and re-export activities in these regions. However, as the middle-class urban demographic expands in emerging markets, demand for more expensive fish items such as salmon and shrimp is also growing, and as a result the unit value gap between developed and developing country fish imports is narrowing.

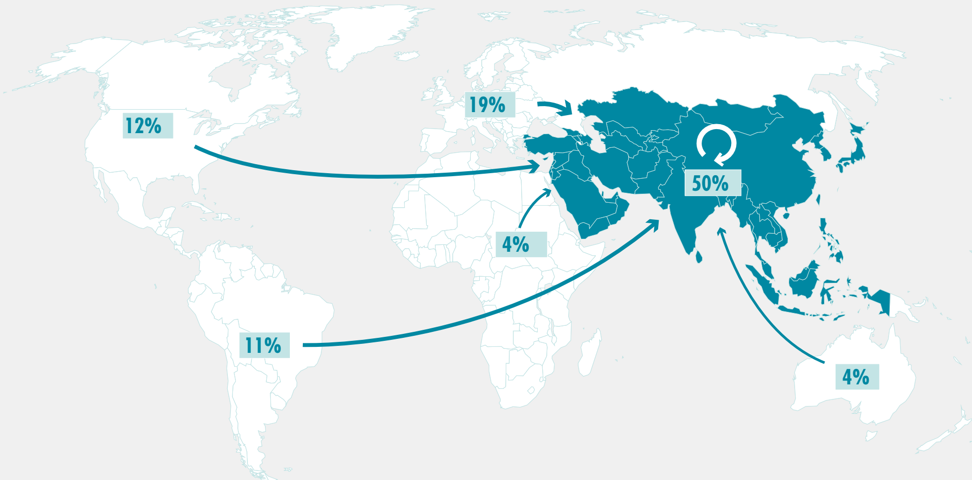
Tariffs are among the most widely utilized trade policy tools and are important determinants of global trade flows. Tariffs are used to generate income and to protect domestic industries and are typically higher for processed products than for raw materials. The World Trade Organization (WTO) principle of most-favoured nations generally prevents members from discriminating against trading partners, but tariffs can be reduced or removed as part of free-trade agreements or to facilitate market access for developing countries through the application of preferential tariff regimes such as the Generalized System of Preferences. In developed countries, which depend on imports to satisfy domestic consumption, tariffs on fish are rather low, albeit with a few exceptions (i.e. for some value-added products or selected species). Developed countries are thus able to export to other developed countries (which accounted for about 78 percent of the exports of fish and fish products of developed countries in 2016), and developing countries are able to expand their exports by supplying markets in developed countries without facing prohibitive customs duties (although they may face market access issues related to non-tariff measures). For some specific products, such as canned tuna, tariff rate quotas are applied, whereby a certain quantity per year may be imported at a reduced tariff. The widespread reduction of import tariffs has been a major driver of the expansion in international trade over the past 25 years. On the other hand, many developing countries still apply high tariffs for fish and fish products, reflecting fiscal or protective policies, which can limit interregional trade. Thanks to regional and bilateral trade agreements, tariffs are bound to fall further over time, even in developing countries, with some exceptions in least developed countries.

Regional trade agreements are reciprocal trade agreements establishing preferential terms of trade among two or more trading partners in the same geographic region. They have been important drivers of global trade expansion in the past several decades and apply to a large proportion of global trade, also for fish and fish products. Regional trade agreements have contributed to the increased regionalization of fish trade since the 1990s, with regional trade flows increasing faster than external trade flows. In developing regions, rising incomes and the associated increase in fish consumption are also important factors behind the regionalization trend. As demand strengthens in neighbouring countries, exports previously destined for developed markets are redirected to regional partners. »

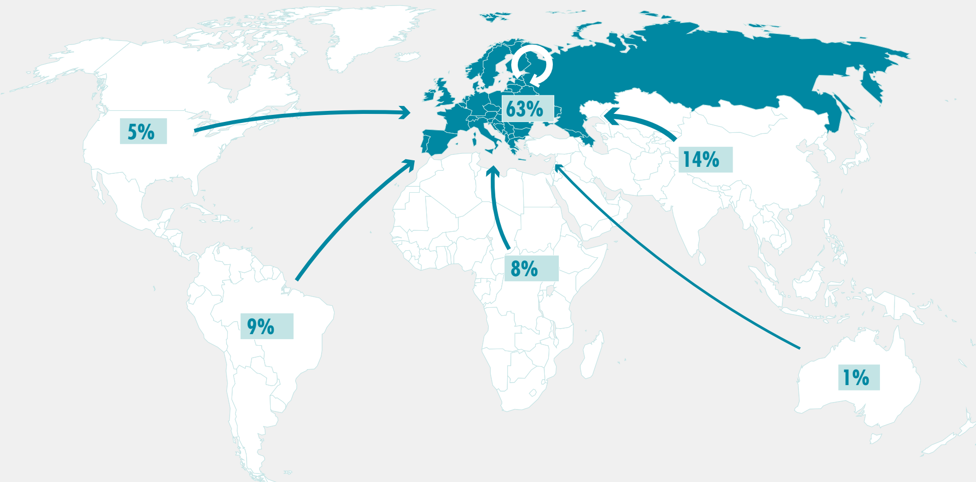
FIGURE 20
TRADE FLOWS OF FISH AND FISH PRODUCTS BY CONTINENT (SHARE OF TOTAL IMPORTS, IN VALUE), 2016



ASIA



EUROPE



OCEANIA

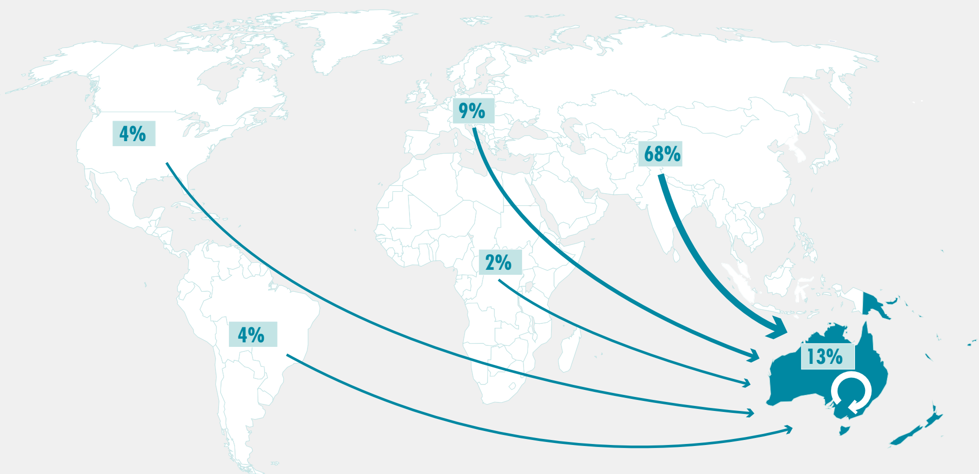


FIGURE 21
IMPORT AND EXPORT VALUES OF FISH PRODUCTS FOR DIFFERENT REGIONS, INDICATING NET DEFICIT OR SURPLUS

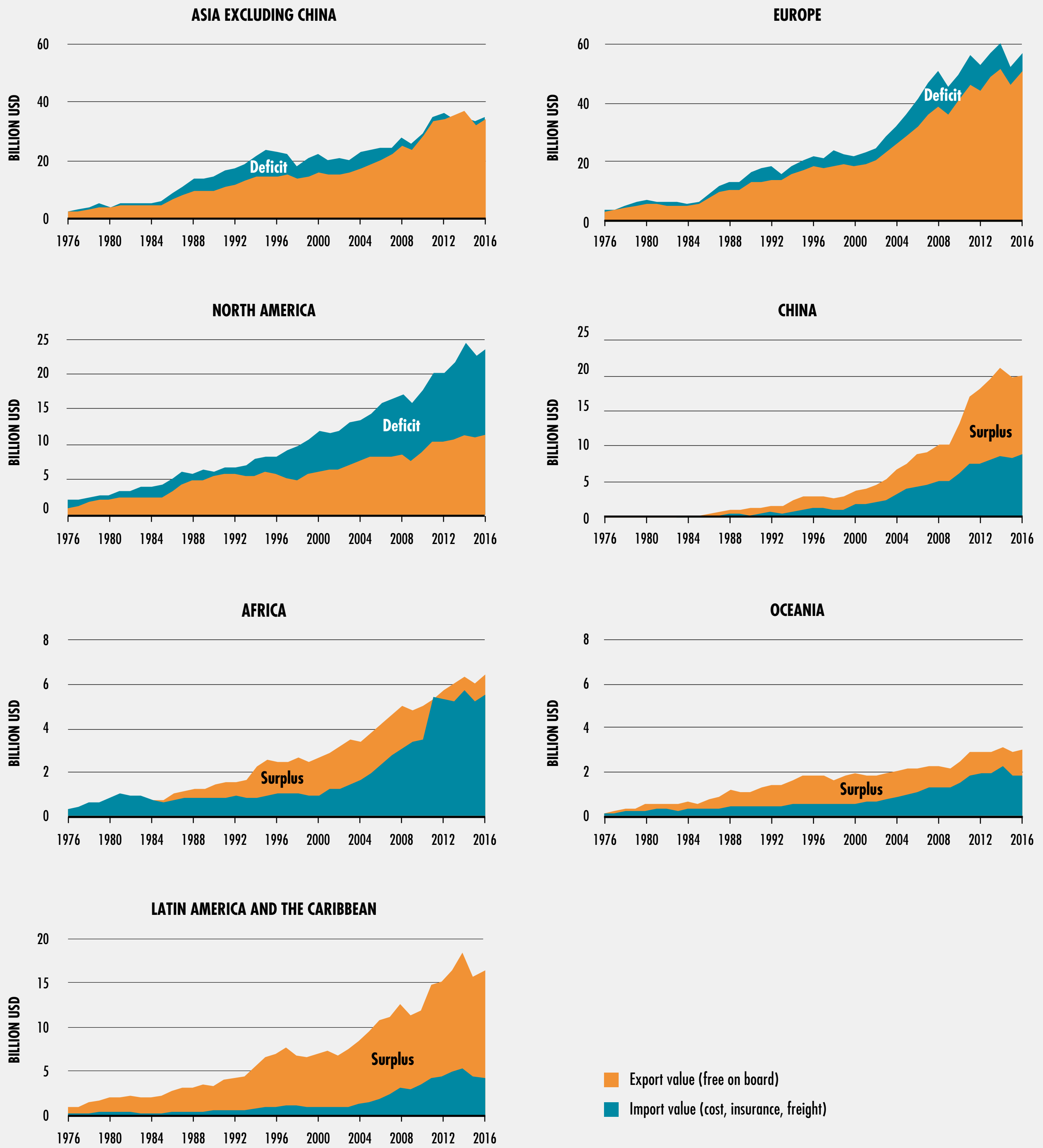
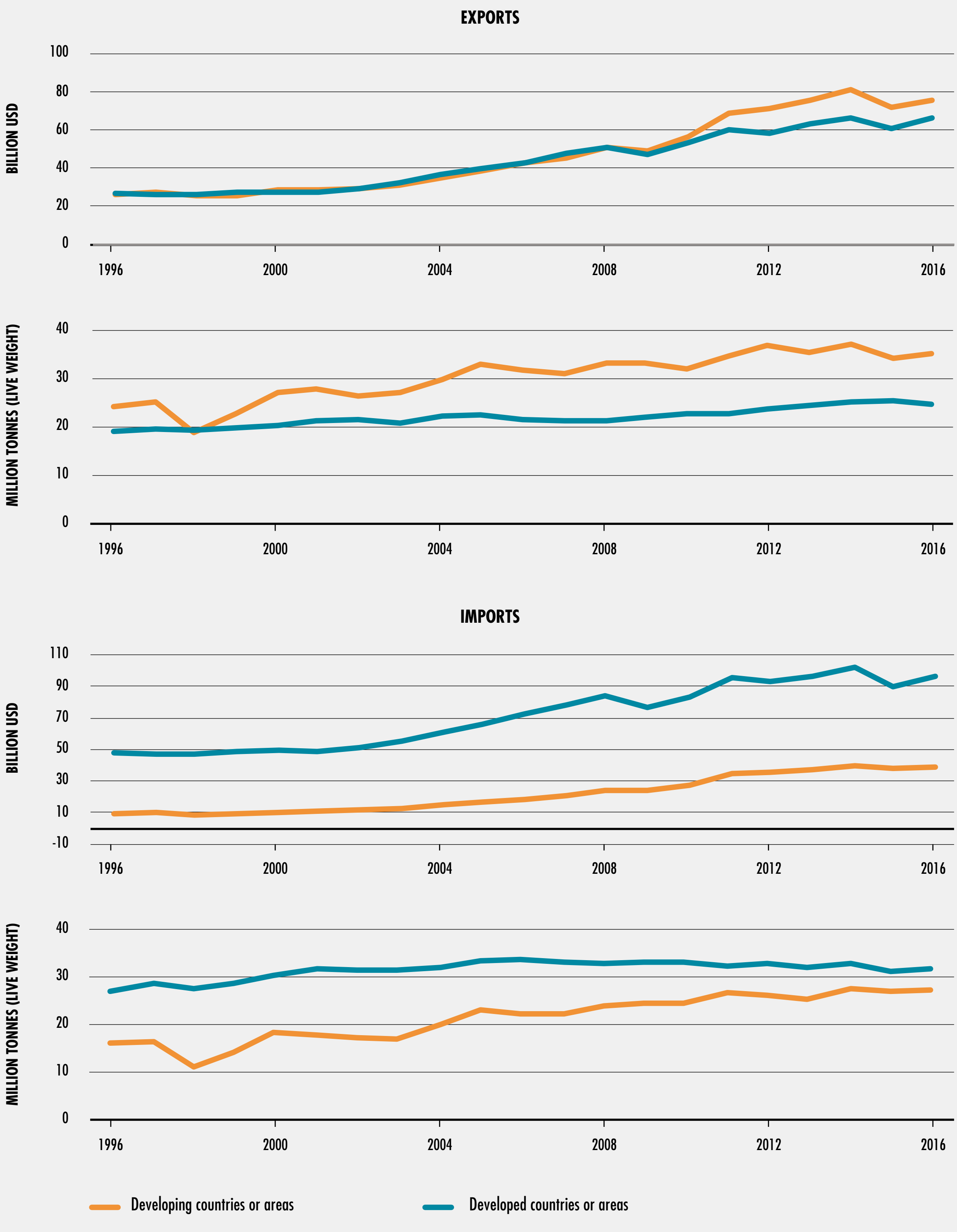


FIGURE 22
TRADE OF FISH AND FISH PRODUCTS



» Several factors affect access to international markets by exporting countries. Structural problems in some countries can affect the quality of fish products, contributing to product loss or difficulty in marketing them. Other hurdles include non-tariff trade measures such as required product standards, sanitary and phytosanitary measures, procedures for import licensing, rules of origin and conformity assessment; and handling of customs classifications, valuation and clearance procedures, including lengthy or duplicative certification procedures and customs fees. In the near future, the full implementation of the WTO Trade Facilitation Agreement, which entered into force in 2017, is expected to expedite the movement, release and clearance of goods across borders, reducing these negative influences on trade.

The WTO Agreement on Technical Barriers to Trade (TBT Agreement) aims to ensure that compulsory technical regulations and voluntary standards such as quality, packaging and labelling requirements are non-discriminatory and do not constitute unnecessary obstacles to trade, while at the same time recognizing their function in protecting human health and the environment. Developing countries are particularly susceptible to the trade-inhibiting consequences of regulations and standards, as compliance is constrained by high costs and relatively low capacity in terms of infrastructure, technology and expertise. For fish and fish products, the regulations and standards associated with the environmental dimensions of the production process are most relevant in this regard, as they are many and diverse. This is an area of significant potential for trade conflicts if an appropriate balance between fair market access and environmental concerns is not achieved. In general, the proliferation of multiple standards in different markets increases the likelihood of such conflicts. The TBT Agreement therefore encourages the cooperative development of international standards and conformity assessment systems.

Main commodities

Trade of fish and fish products is characterized by an enormous diversity of 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 exported to low-income consumers in developing countries. However, in recent years, emerging economies in developing regions have increasingly been importing species of higher value for domestic consumption.

Accurate and detailed trade statistics are essential for monitoring and understanding the global market in terms of its structure, dynamics and impact on the environment. They can play a key role in monitoring the trade of endangered species and of products sourced from IUU activities and can be used to support appropriate fisheries management – but only if statistics are accurate and species and product forms are specified, to the extent possible. In collating trade data on fish and fish products, FAO uses the maximum level of detail made available by the countries. The basis for the recording of trade statistics by all countries is the Harmonized Commodity Description and Coding System (HS), developed and maintained by the World Customs Organization (WCO). Countries may develop more detailed national classifications based on HS to take into account additional species or product forms relevant to the country. Through FAO's initiative, the coverage of HS codes on fish and crustaceans, molluscs and other aquatic invertebrates was revised in 2012 and 2017 to address the issue of inadequate breakdown by species and product forms. However, despite these improvements, many countries still provide little breakdown of information.

Furthermore, international trade statistics do not distinguish between wild and farmed origin of products, and national statistics rarely do so, despite the rapid growth of the aquaculture sector and the growing proportion of farmed species and products. Hence, the breakdown between products of capture fisheries and aquaculture in international trade is open to interpretation. The most recent estimates attribute about one-quarter of traded quantities and one-third of traded value to aquaculture products. This share is even higher if trade in non-food fish commodities (including fishmeal, fish oil and fish for ornamental purposes) is excluded. The higher proportion in the case of traded value points to the fact that heavily traded aquaculture species, particularly salmon, shrimp and some bivalves, have a relatively high unit value. In addition to the production process itself, aquaculture differs from capture fisheries in many fundamental ways, including business and industry structure, inputs, risk factors, environmental impact and infrastructure requirements. Each of these differences has implications for the dynamics and development of global trade in fish and fish products.

As aquaculture producers can exercise a greater degree of control over the production process, aquaculture supply volumes are more predictable in the short term. Vertical and horizontal integration have created economies of scale and logistical efficiencies that allow large consolidated producers to supply consistent volumes of consistent size and quality to an array of international markets, even in fresh or chilled form. The aquaculture sector is still susceptible to substantial shocks due to disease or other environmental events, however, and the impacts of these events on prices are transmitted across international markets increasingly efficiently. Between markets for wild and farmed fish, producers in one sector will generally be exposed to price trends in the other within the same market segment, although the degree of integration varies significantly across species. There is no overall consensus as to whether farmed fish prices will always respond to those of wild fish or vice versa, and whether one commands a natural premium. These dynamics depend on the species, the product form and the particular market. However, some heavily traded species such as salmon and shrimp do appear to display a significant degree of integration in terms of prices, suggesting that increased supply from aquaculture in these markets has been and will remain a major influencing factor in price trends.

Overall, international prices of fish were relatively high in 2017. With a base year of 2002–2004 = 100, the FAO Fish Price Index (developed in cooperation with the University of Stavanger, Norway, and with data support from the Norwegian Seafood Council) seeks to capture price trends in the most frequently traded species groups and for farmed and wild fish and fish products. The average index value over the third quarter of 2017 was 157, compared with 147 in the third quarter of 2016 and 138 for the same period in 2015 (Figure 23). This upward trend is observed in most species groups, both farmed and wild, reflecting a combination of improved economic conditions and supply shortages for a number of key species.

Over 90 percent of the quantity (in live weight equivalent) of trade in fish and fish products consisted of processed products (i.e. excluding live and fresh whole fish) in 2016, with frozen products representing the highest share. The high perishability of fish notwithstanding, consumer demand and innovative chilling, packaging and distribution technology have led to increased trade in live, fresh and chilled fish, which represented about 10 percent of world fish trade in 2016. About 78 percent of the quantity exported consisted of products destined for human consumption. Much fishmeal and fish oil is traded because, generally, the major producers (in South America, Scandinavia and Asia) are not the same countries as the main consumption centres (in Europe and Asia).

The value given above for exports of fish and fish products in 2016, USD 143 billion, does not include an additional USD 1.7 billion from trade in seaweeds and other aquatic plants (57 percent), inedible fish by-products (32 percent) and sponges and corals (11 percent). Trade in aquatic plants increased from USD 60 million in 1976 to more than USD 1 billion in 2016, with Indonesia, Chile and the Republic of Korea the major exporters, and China, Japan and the United States of America the leading importers. Owing to the increasing production of fishmeal and other products derived from fish processing residues (see the previous section, "Fish utilization and processing"), trade in inedible fish by-products has also surged, up from USD 9 million in 1976 to USD 0.5 billion in 2016.

Salmon and trout

Trade in salmon has increased at an average of 10 percent per year in value terms since 1976, and since 2013 it is the largest single fish commodity by value (Table 17). This growth has been partially driven by rising incomes and urbanization in emerging markets, particularly in East and Southeast Asia, but salmon has also retained a »

FIGURE 23
FAO FISH PRICE INDEX

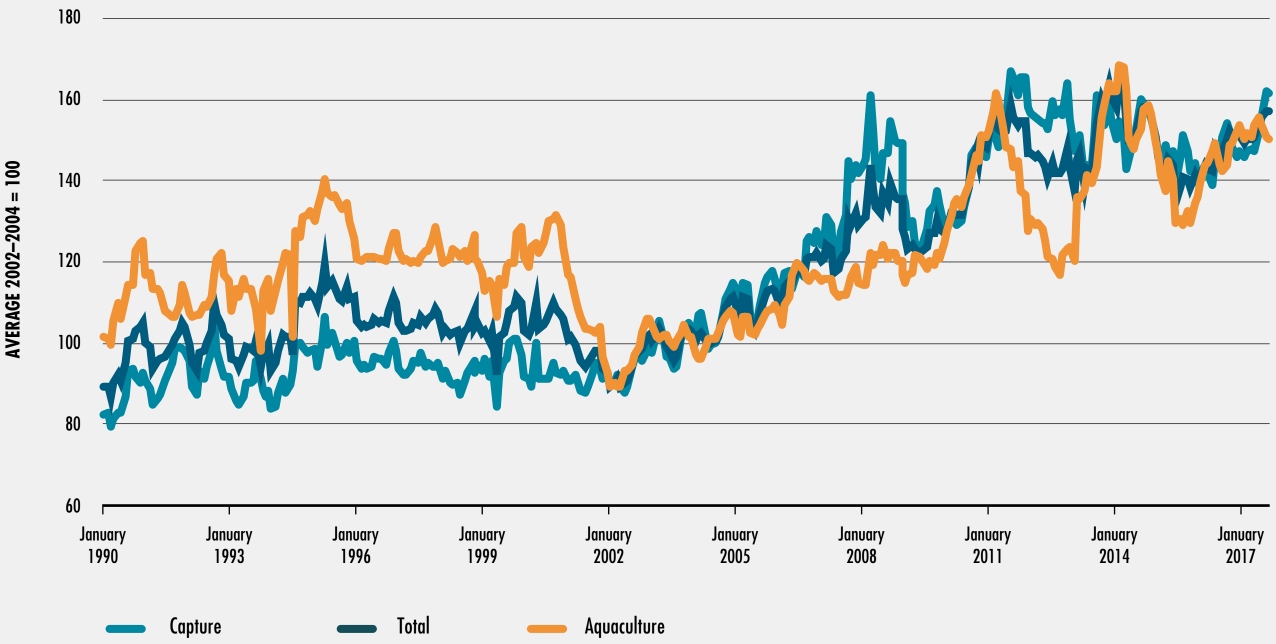


TABLE 17
SHARE OF MAIN GROUPS OF SPECIES IN WORLD TRADE OF FISH AND FISH PRODUCTS, 2016 (%, live weight)

Species group	Share in value	Share in quantity
Fish	65.4	79.8
Salmons, trouts, smelts	18.1	7.4
Tunas, bonitos, billfishes	8.6	8.6
Cods, hakes, haddocks	9.6	14.0
Other pelagic fish	6.1	11.7
Freshwater fish	3.2	4.5
Flounders, halibuts, soles	2.1	1.6
Other fish	17.8	32.0
Crustaceans	23.0	8.3
Shrimps, prawns	16.1	6.2
Other crustaceans	6.9	2.1
Molluscs	11.0	11.1
Squids, cuttlefishes, octopuses	6.4	3.8
Bivalves	3.2	6.0
Other molluscs	1.4	1.3
Other aquatic invertebrates/animals	0.6	0.8
Total	**100.0**	**100.0**

» large and growing consumer base in large developed markets, including the European Union, the United States of America and Japan. Most salmon consumed today comes from aquaculture, supplied by Norway, Chile and a number of smaller producers mainly in Europe and North America. Various wild Pacific salmon species are also traded internationally in significant quantities. International marketing campaigns, product innovation and advances in logistical and production technology have helped to establish salmon as a popular item in markets all around the world, and demand has grown rapidly even if physical (e.g. aquaculture site availability) and regulatory constraints have led the supply to increase less quickly. As a result, prices have risen sharply across international markets, particularly in 2016 and the first half of 2017, with major producers such as Norway benefiting from a steep upward trend in export revenues. For farmed trout, produced in many of the same countries, the diversification of export markets by Norwegian industry following the Russian embargo established in 2014 has created additional demand and depleted supply, with sustained high prices resulting.

Shrimp

Shrimp and prawns are heavily traded commodities and represent the second main group of exported species in value terms. Countries in Latin America and East and Southeast Asia account for by far the major share of production, but a large proportion of consumption takes place in developed markets. Although wild shrimp catches contribute large volumes to total supply, most shrimp today is farmed. In recent supply developments, disease and poor weather conditions have been an ongoing challenge for some large Asian aquaculture producers, particularly Thailand and China, but strong production growth in other countries such as India and Ecuador translated into an overall increase in supply volumes in 2017. Demand in developing countries continues to grow as consumer preferences have evolved with rising incomes and a growing share of production is absorbed by domestic and regional markets. Traded prices for shrimp and prawns have increased over the past two years in line with the general trend (Figure 24).

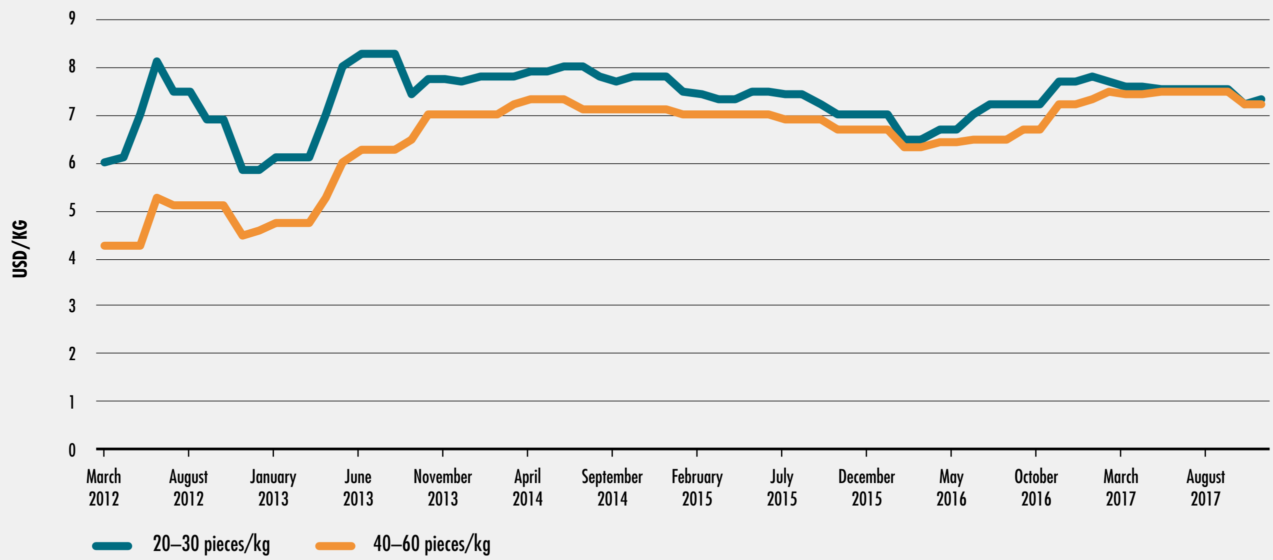
Groundfish and other whitefish

The whitefish market segment, historically dominated by wild species such as cod and Alaska pollock, is now increasingly shared with lower-priced farmed species such as *Pangasius* spp. and tilapia. China is the largest producer of tilapia, while the vast majority of *Pangasius* spp. originates in Viet Nam. Among developed markets, tilapia and *Pangasius* spp. have gained market share particularly in the United States of America and to a lesser extent in the European Union. China also exports significant and growing quantities of tilapia to several African countries. The traditional groundfish species are primarily sourced from fisheries in the Northern Hemisphere, with the Russian Federation, the United States of America and Norway the top three producers. With some fluctuations, cod had high traded prices in 2016 and 2017 (Figure 25), the result of strong demand in a number of important markets and limited supply because of quota reductions. Seabass and seabream are farmed almost entirely in the Mediterranean and exported largely to markets in the European Union, although the rise of Turkey as a producer has also seen more diversification of markets.

Tuna

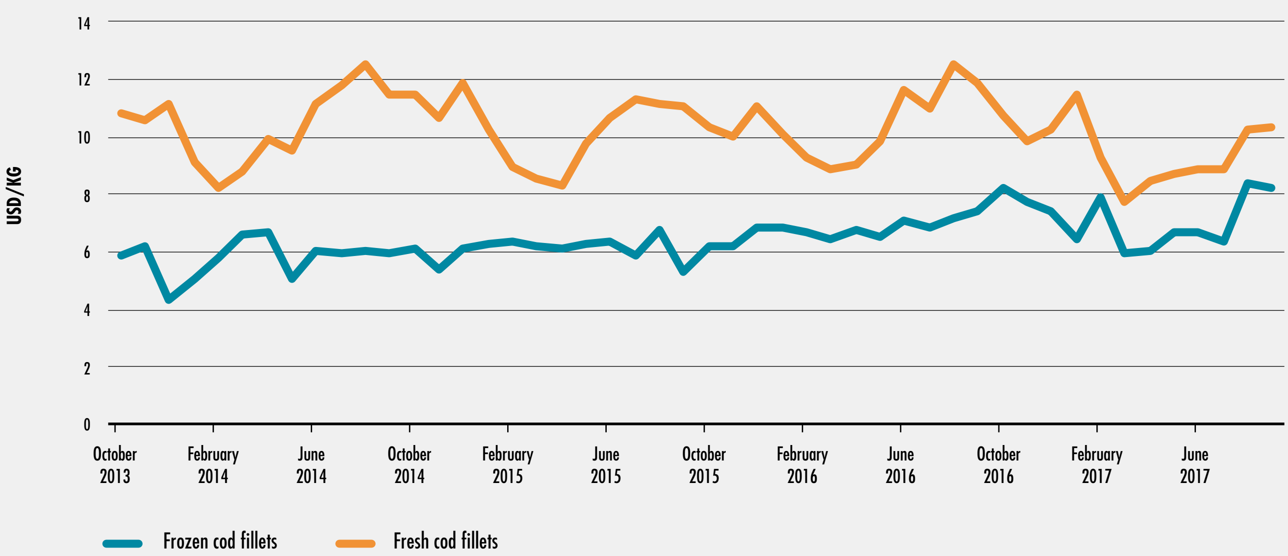
The European Union and the United States of America, the two largest markets for canned tuna, are supplied by a number of developing country exporters in Latin America, Southeast Asia and Africa. Thailand is by far the largest processor of canned tuna, although Ecuador, Spain, China and the Philippines also have significant canning and export industries. Differing tariff regimes and import quotas are an important determinant of tuna trade flows for the canned market, and proposed adjustment to these regimes is a central issue in trade negotiations for fish and fish products. Japan is the world's largest sushi and sashimi market, and its imports mainly comprise fresh and frozen tuna, whole or as loins. Bluefin and bigeye tuna are typically used for sashimi and sushi, while skipjack, albacore and yellowfin are used in canned and other prepared and preserved products. Canned tuna is marketed and sold increasingly through consolidated supermarket chains as a cheap and affordable food fish item, while sashimi and sushi are targeted at modern health-conscious consumers amid a general increase in the »

FIGURE 24
SHRIMP PRICES IN JAPAN



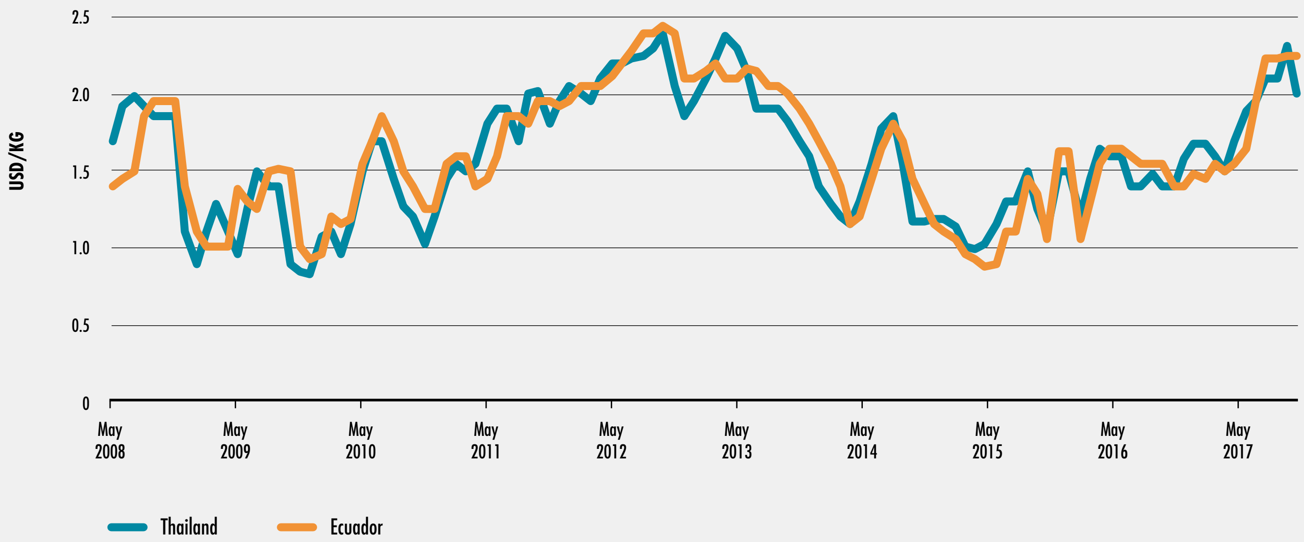
NOTES: Data refer to FOB export prices for head-on, shell-on Argentine red shrimp. Origin: Argentina.

FIGURE 25
GROUNDFISH PRICES IN NORWAY



NOTE: Average Norwegian cod export prices, FOB Norway.
SOURCE: Norwegian Seafood Council data

FIGURE 26
SKIPJACK TUNA PRICES IN ECUADOR AND THAILAND



NOTES: Data refer prices for 4.5–7.0 pounds (2.0–3.2 kg) of fish. For Thailand, C&F (cost and freight); for Ecuador, ex-vessel.

» popularity of Japanese cuisine in international markets. Tuna prices rose over the course of 2017 (Figure 26), although demand growth in both developing and developed markets is less robust than that of some other heavily traded commodities such as salmon and shrimps.

Cephalopods

The class of cephalopods includes octopus, squid and cuttlefish. In the past two years, China and Morocco were the largest exporters of octopus, while China, Peru and India were the top three exporters of squid and cuttlefish. Japan, the United States and larger southern European countries such as Spain and Italy are the most important consumer markets. China and Thailand are also large importers, although much of this volume is raw material for processing and re-export. The growing worldwide popularity of Japanese cuisine, as well as Hawaiian poke (fish salad) and Spanish tapas, has helped to boost demand for cephalopods, particularly squid and octopus. However, poor catches meant tightened supplies in 2016 and 2017, and traded prices rose strongly.

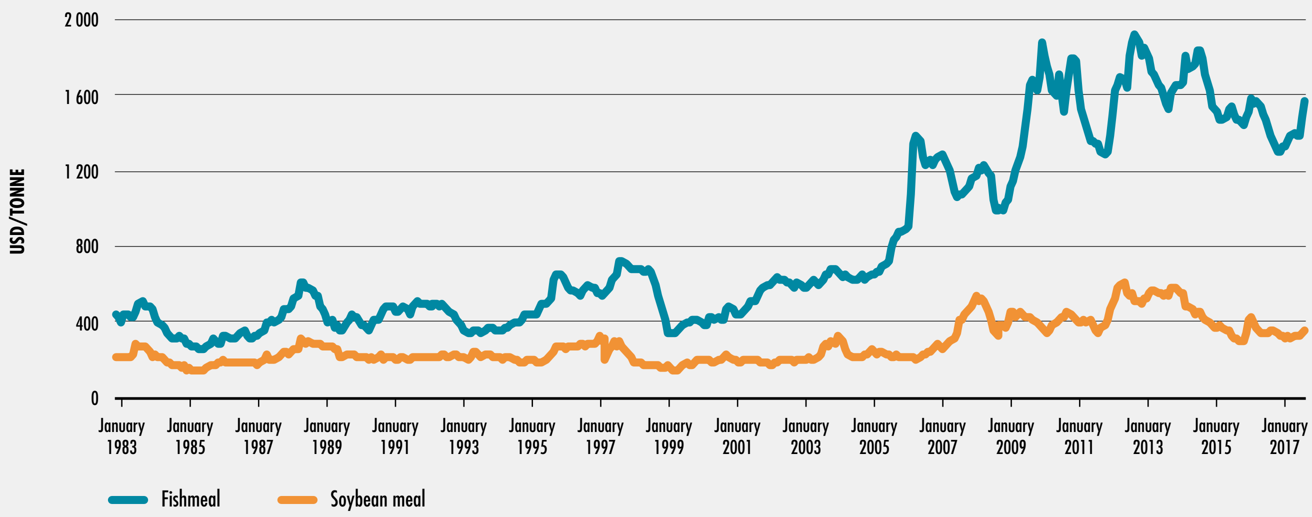
Bivalves

The most heavily traded bivalve mollusc species are mussels, clams, scallops and oysters, and the vast majority are farmed. China is by far the largest exporter of bivalves, exporting almost three times as much as Chile, the second largest exporter, in 2016. China also has significant domestic consumption, although the European Union is the largest single market for bivalves. Bivalves are widely promoted as healthy and sustainable food items, and demand has been rising in recent years.

Small pelagics and fishmeal and fish oil

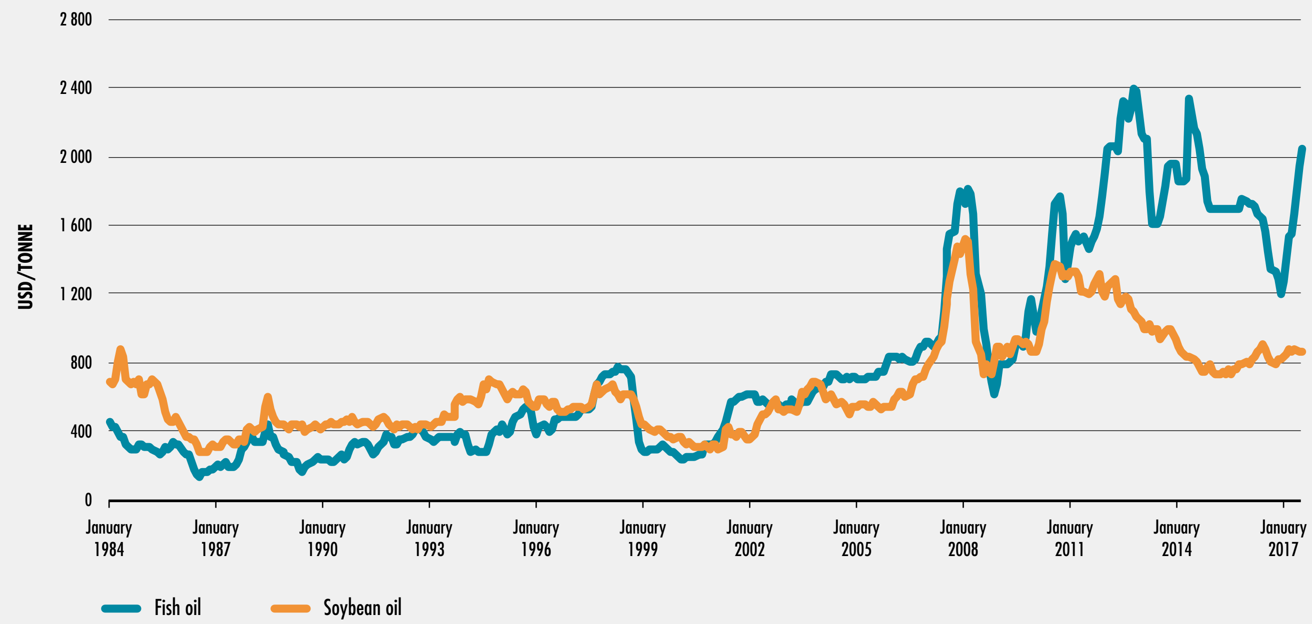
Small pelagic fish include, among others, a number of different species of mackerel, herring, sardine and anchovy. The fisheries for these species, and the major exporters, are widely geographically dispersed, and the network of international trade flows is large and complex. Small pelagic species are used for both human consumption – especially in African markets – and the production of fishmeal and fish oil, used primarily as feed ingredients in the aquaculture and livestock industries. Over late 2016 and early »

FIGURE 27
FISHMEAL AND SOYBEAN MEAL PRICES IN GERMANY AND THE NETHERLANDS



NOTES: Data refer to CIF (cost, insurance and freight) prices. Fishmeal: all origins, 64–65 percent, Hamburg, Germany. Soybean meal: 44 percent, Rotterdam, the Netherlands.
SOURCE: Data from Oil World and FAO's GLOBEFISH project

FIGURE 28
FISH OIL AND SOYBEAN OIL PRICES IN THE NETHERLANDS



NOTE: Data refer to c.i.f. prices, Rotterdam, the Netherlands. Origin: South America.
SOURCE: Data from Oil World and FAO's GLOBEFISH project

» 2017, fishmeal and fish oil prices followed a downward trend (Figures 27 and 28) owing to the normalization of climatic conditions in South America following El Niño as well as good catches in European small pelagic fisheries supplying raw material, but they later rebounded. Because of the steady and growing demand, long-term fishmeal and fish oil prices are expected to increase again. In the past two years Peru continued to be the leading world producer and exporter of fishmeal and fish oil. China has consistently been the main consumption market for fishmeal and Norway for fish oil, primarily for their impressive aquaculture industries. ■

FISH CONSUMPTION

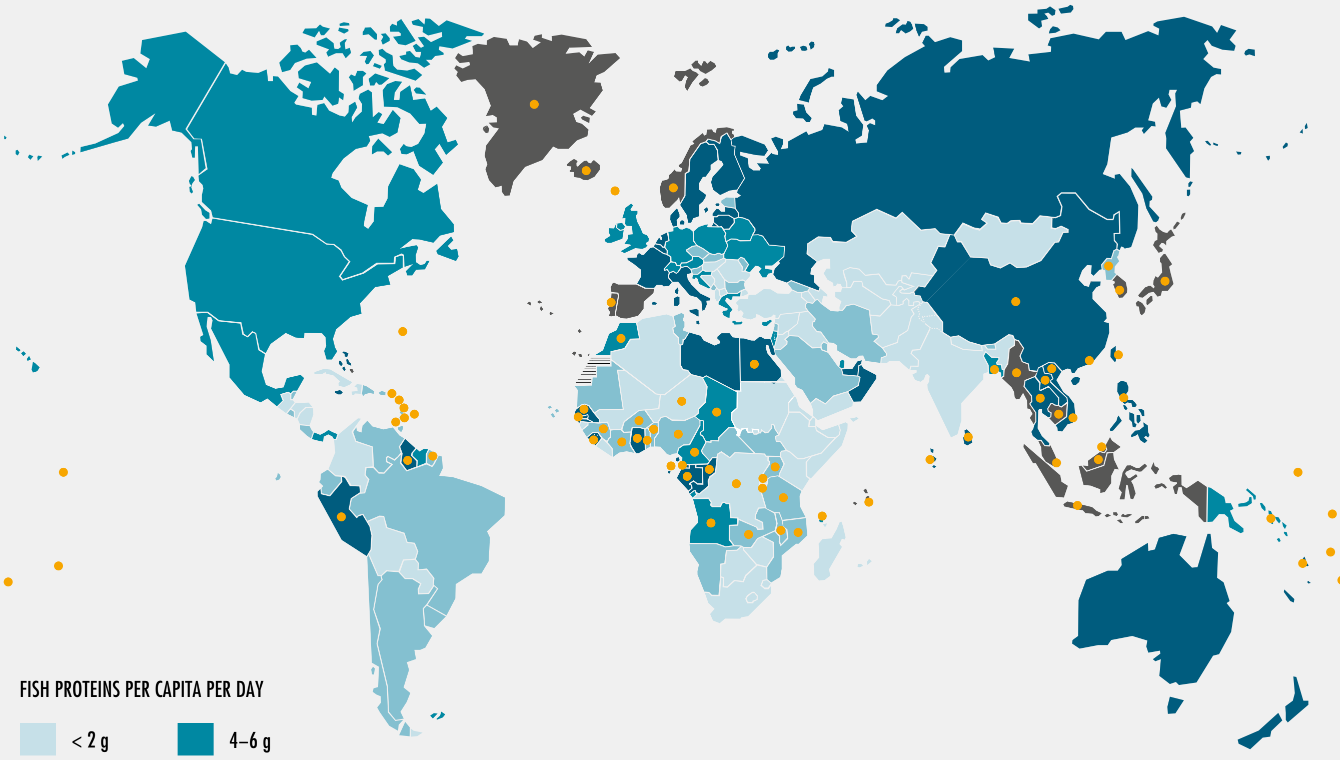
The significant growth in fisheries and aquaculture production since the middle of the twentieth century, and especially in the past two decades, has enhanced the world's capacity to consume diverse and nutritious food. Since 1961, the average annual increase in global apparent food fish consumption[8] (3.2 percent) has outpaced population growth (1.6 percent) and exceeded consumption of meat from all terrestrial animals, combined (2.8 percent) and individually (bovine, ovine, pig, other), except poultry (4.9 percent). In per capita terms, food fish consumption has grown from 9.0 kg in 1961 to 20.2 kg in 2015, at an average rate of about 1.5 percent per year. Preliminary estimates for 2016 and 2017 point to further growth to about 20.3 and 20.5 kg, respectively. The expansion in consumption has been driven not only by increased production, but also by a combination of many other factors, including reduced wastage, better utilization, improved distribution channels and growing demand, linked with population growth, rising incomes and urbanization.

8 All consumption statistics reported in this section refer to apparent consumption derived from FAO Food Balance Sheets as per March 2018 (FAO, 2018d). Consumption data for 2015 should be considered preliminary. The Food Balance Sheets refer to "average food available for consumption" (or apparent consumption), which, for a number of reasons (e.g. waste and losses), is likely to be higher than average food intake or average actual food consumption. Apparent consumption is calculated as production (capture fisheries and aquaculture) minus non-food uses (including amount used for reduction into fishmeal and fish oil), minus fish exports, plus fish imports, plus or minus stocks. All calculations are expressed in live weight equivalent. Records of production from subsistence and recreational fisheries, as well as cross-border trade between some developing countries, may be incomplete, which may lead to underestimation of consumption.

Fish and fish products have a crucial role in nutrition and global food security, as they represent a valuable source of nutrients and micronutrients of fundamental importance for diversified and healthy diets (see "Fish for food security and human nutrition" in Part 2). Public awareness of these health benefits has been growing in recent years, amid a broader trend of increasing health consciousness among consumers, particularly in middle-income and developed markets. In lower-income countries, the importance of fish as a food group is enhanced by the fact that fish contains many of the vitamins and minerals required to address some of the most severe and widespread nutritional deficiencies. For pregnant women and very young children in particular, fish can be an essential component of a nutritious diet, as it contributes to neurodevelopment during the most crucial stages of an unborn or young child's growth. In addition, there is evidence of beneficial effects of fish consumption in mental health and prevention of cardiovascular diseases, stroke and age-related macular degeneration. In low-income populations that depend heavily on a narrow range of calorie-dense staple foods, fish can represent a much-needed means of nutritional diversification that is relatively cheap and locally available. While average per capita fish consumption may be low, even small quantities of fish can provide essential amino acids, fats and micronutrients, such as iron, iodine, vitamin D and calcium, which are often lacking in vegetable-based diets. Experts agree that the positive effects of high fish consumption largely outweigh the potential negative effects associated with contamination or other safety risks (FAO and WHO, 2011).

Globally, fish and fish products provide an average of only about 34 calories per capita per day. However, their daily contribution can exceed 130 calories per capita in countries where alternative protein foods are lacking and where a preference for fish has developed and endured (e.g. Iceland, Japan, Norway, the Republic of Korea and several small island States). More than as an energy source, the dietary contribution of fish is significant in terms of high-quality, easily digested animal proteins. A portion of 150 g of fish provides about 50 to 60 percent of an adult's daily protein requirement. Fish proteins are

FIGURE 29
CONTRIBUTION OF FISH TO ANIMAL PROTEIN SUPPLY, AVERAGE 2013–2015



NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.

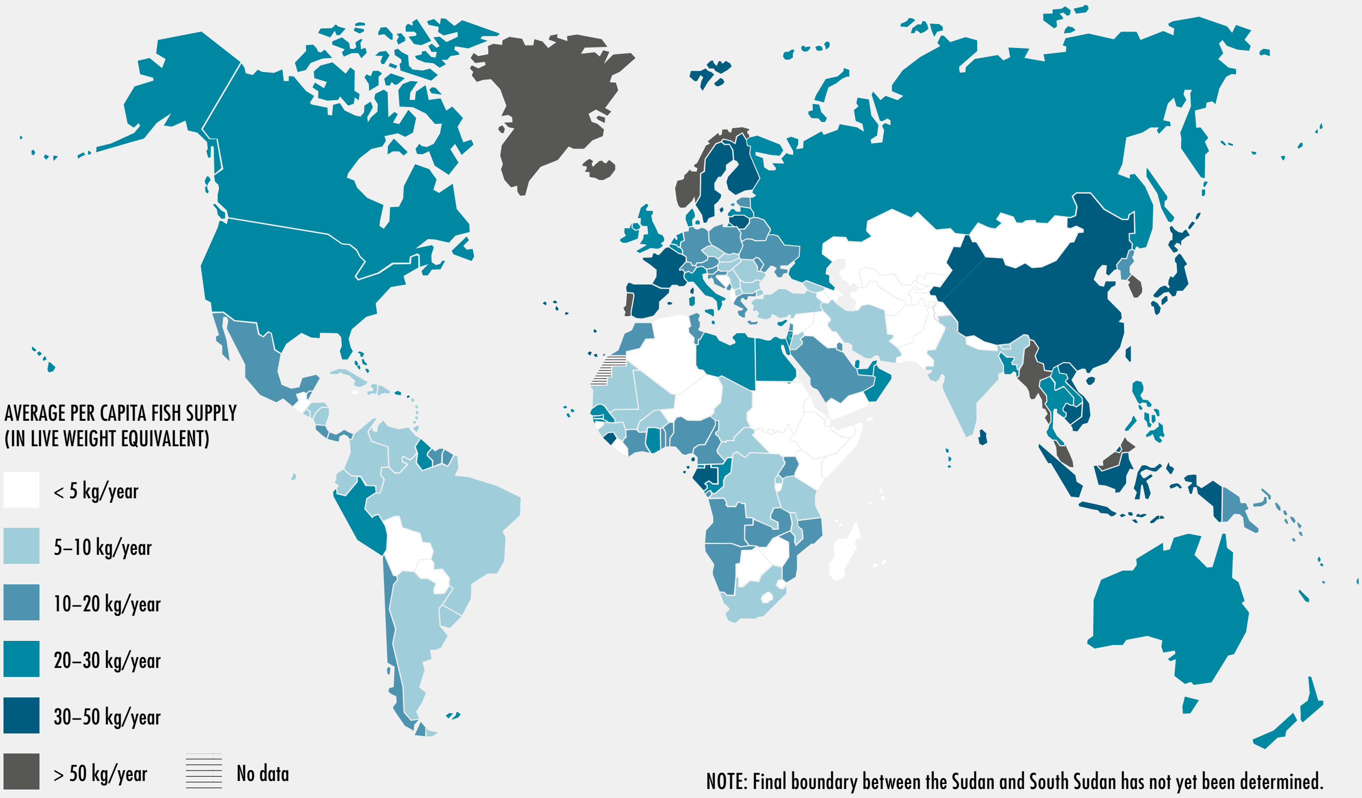
essential in the diet of some densely populated countries where the total protein intake is low, and are particularly important in the diets of small island developing States (SIDS) (see Box 10, "Fish in the food systems of Pacific island countries" in Part 2, page 115). For these populations, fish often 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. In 2015, fish accounted for about 17 percent of animal protein, and 7 percent of all proteins, consumed by the global population. Moreover, fish provided about 3.2 billion people with almost 20 percent of their average per capita intake of animal protein (Figure 29). In Bangladesh, Cambodia, the Gambia, Ghana, Indonesia, Sierra Leone, Sri Lanka and some SIDS, fish contributed 50 percent or more of total animal protein intake.

Average per capita fish consumption varies significantly across and within countries and regions because of the influence of cultural, economic and geographic factors. Across countries, annual per capita fish consumption varies from less than 1 kg to more than 100 kg (Figure 30). Within countries, consumption is usually higher in coastal marine and inland water areas. Annual per capita fish consumption has grown steadily in developing regions (from 6.0 kg in 1961 to 19.3 kg in 2015) and in low-income food-deficit countries (LIFDCs) (from 3.4 to 7.7 kg during the same period) but is still considerably higher in developed countries[9] (24.9 kg in 2015), although the gap is narrowing.

Despite their relatively low levels of fish consumption, people in developing countries have a higher share of fish protein in their diets

9 Compared with previous editions of *The State of World Fisheries and Aquaculture*, the amount quoted for developing and developed countries differs slightly following changes in their composition (UN, 2018a).

FIGURE 30
APPARENT FISH CONSUMPTION PER CAPITA, AVERAGE 2013–2015



NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.

than those in developed countries. In 2015, fish accounted for about 26 percent of animal protein intake in least developed countries (LDCs), 19 percent in other developing countries and about 16 percent in LIFDCs. This share had been increasing but has stagnated in recent years because of the growing consumption of other animal proteins. In developed countries, the share of fish in animal protein intake, after consistent growth from 12.1 percent in 1961 to a peak of 13.9 percent in 1989, decreased to 11.4 percent in 2015, while consumption of other animal proteins continued to increase.

Europe, Japan and the United States of America together accounted for 47 percent of the world's total food fish consumption in 1961 but only about 20 percent in 2015. Of the global total of 149 million tonnes in 2015 (Table 18), Asia consumed more than two-thirds (106 million tonnes at 24.0 kg per capita). Oceania and Africa consumed the lowest share. The shift is the result of structural changes in the sector and in particular the growing role of Asian countries in fish production, as well as a significant gap between the economic growth rates of the world's more mature fish markets and those of many increasingly important emerging markets around the world, particularly in Asia. Although consumers in many advanced economies have a wide choice of value-added fish products and are not deterred by price increases, their per capita consumption levels have been approaching their saturation point in terms of quantity. Growth of per capita fish consumption has slowed in the past few years in the European Union and the United States of America and over the past two decades in Japan (albeit from a high level), while per capita consumption of poultry and pig meat has increased.

The growth in fish consumption in Asian countries, particularly in eastern (minus Japan) and southeastern Asia has been driven by a

TABLE 18
TOTAL AND PER CAPITA APPARENT FISH CONSUMPTION BY REGION AND ECONOMIC GROUPING, 2015

Region/economic grouping	Total food fish consumption *(million tonnes live weight equivalent)*	Per capita food fish consumption *(kg/year)*
World	148.8	20.2
World (excluding China)	92.9	15.5
Africa	11.7	9.9
North America	7.7	21.6
Latin America and the Caribbean	6.2	9.8
Asia	105.6	24.0
Europe	16.6	22.5
Oceania	1.0	25.0
Developed countries	31.4	24.9
Least-developed countries	12.0	12.6
Other developing countries	105.4	20.5
Low-income food-deficit countries	20.8	7.7

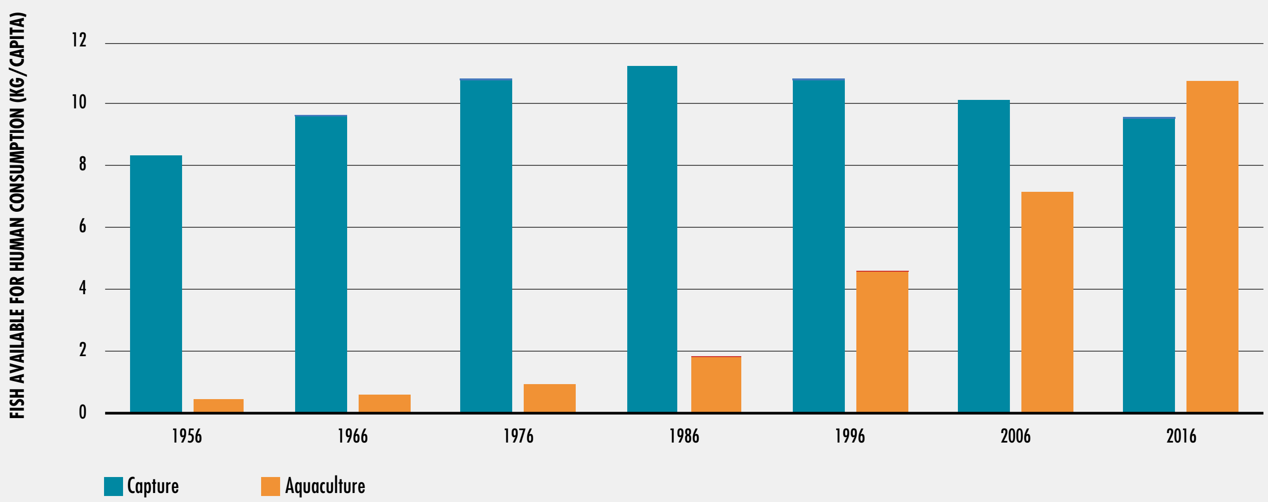
NOTE: Data are preliminary. Discrepancies with Table 1 in the Overview, page 4, are due to the impact of trade and stock data in the overall calculation of the FAO Food Balance Sheets (FAO, 2018d).

combination of a large, growing and increasingly urban population, dramatic expansion of fish production, in particular from aquaculture, rising incomes and increased international fish trade. China, by far the world's largest fish consuming country, consumed 38 percent of the global total in 2015, with per capita consumption reaching about 41 kg, fuelled by growing domestic income and wealth. More diverse types of fish have become available to consumers in China owing to a diversion of some fishery exports towards the domestic market as well as an increase in fishery imports. If China is excluded, annual per capita food fish consumption in the rest of the world was about 15.5 kg in 2015, having risen from 10.3 kg in 1961 and grown in a more sustained way since the early 2000s, with food fish consumption outpacing population growth (at annual rates of 2.5 and 1.7 percent, respectively).

In Africa, absolute levels of fish consumption remain low (9.9 kg per capita in 2015), ranging from a maximum of about 14 kg per capita in western Africa to a mere 5 kg per capita in eastern Africa. Major growth was observed in North Africa (from 2.8 to 13.9 kg between 1961 and 2015), while per capita fish consumption has remained static or decreased in some countries in sub-Saharan Africa. The low fish consumption is the result of a number of interconnected factors, including population increasing at a higher rate than food fish supply; limitations in expansion of fish production because of pressure on capture fisheries resources and a poorly developed aquaculture sector; low income levels; inadequate storage and processing infrastructure; and a lack of the marketing and distribution channels necessary to commercialize fish products beyond the localities where they are captured or farmed. However, it is also important to mention that in Africa, actual values may be higher than indicated by official statistics in view of the under-recorded contribution of subsistence fisheries, some small-scale fisheries and some cross-border trade.

The highest per capita fish consumption, over 50 kg, is found in several SIDS, particularly in Oceania, which underlines the diminishing but still important role of geography in the disparities in fish consumption among regions. The lowest levels, just above 2 kg, are in Central Asia and some landlocked countries such as Afghanistan, Ethiopia and Lesotho. International trade has helped to reduce the impact of geographical location and limited domestic production, broadening the markets for many species and offering wider choices to

FIGURE 31
RELATIVE CONTRIBUTION OF AQUACULTURE AND CAPTURE FISHERIES TO FISH FOR HUMAN CONSUMPTION



consumers. Imports make up a substantial and increasing portion of fish consumed in Europe and North America (about 70 percent) and Africa (about 40 percent) because of solid demand, including that for non-locally produced species, in the face of static or declining domestic fishery production. In many developing countries fish consumption is mainly based on domestic production, and consumption is stimulated more by supply than by demand. However, with rising domestic income, emerging economies are increasing their imports to diversify the types of fish consumed. Despite trade expansion and technological advances in processing, preservation and transportation over recent decades, fish is a highly perishable food, and supplying markets distant from where fish is caught or farmed involves significant logistical challenges and cost considerations. Beyond these supply-related issues, consumer demand may be lacking where people have not historically consumed fish in large quantities and do not have cultural and dietary familiarity with fish as a food group. In these markets, increasing fish consumption requires marketing and awareness raising campaigns in addition to the establishment of supply infrastructure.

Although fish producers and marketers can maintain a degree of responsiveness to the evolution of consumer preferences, natural resource constraints and biological considerations are key in determining which species and products are made available to consumers. This characteristic of the fishery and aquaculture sector is clearly reflected in the rapid growth of the aquaculture industry since the mid-1980s, coinciding with the relative stability of capture fisheries production since the late 1980s. In parallel with the growth in aquaculture production, the share of farmed fish in human diets has increased quickly, with a milestone reached in 2013 when the aquaculture sector's contribution to the amount of fish available for human consumption overtook that of wild-caught fish for the first time. The share of aquaculture products in total food fish consumption was 51 percent in 2015 and, according to preliminary estimates, 53 percent in 2016, as compared with 6 percent in 1966, 14 percent in 1986 and 41 percent in 2006 (Figure 31). Aquaculture producers are able to exercise much greater control over fish production processes than capture fisheries, and the aquaculture sector is more conducive to vertical and horizontal integration in production and supply chains. Thus the aquaculture sector has potential for more efficient supply chains in conveying fish from the producer to the consumer and is generally able to address consumer concerns related to sustainability and product origin more easily than capture fishery producers. The significant aquaculture production of some low-value freshwater species (also through integrated farming) destined mainly for domestic consumption is important for food security.

The expansion of aquaculture production, especially for species such as shrimps, salmon, bivalves, tilapia, carp and catfish (including *Pangasius* spp.), is evident in the relative growth rates of per capita consumption of different species groups in recent years. Since 2000, average annual growth rates have been most significant for freshwater fish (3.1 percent), molluscs, excluding cephalopods (2.9 percent) and crustaceans (2.8 percent). In 2015, global per capita consumption of freshwater fish was 7.8 kg, or 38 percent of the total, as compared with 17 percent in 1961.

Aquaculture is also the main source of edible aquatic plants, accounting for 96 percent of production in 2016. At present, seaweeds and other algae are not included in the FAO Food Balance Sheets for fish and fish products. However, they are important in several cultures, particularly in East Asia, where they are popular for use in soups, and the red seaweed *nori* (*Pyropia* and *Porphyra* species) is used to wrap sushi. The most widely cultivated species include Japanese kelp (*Laminaria japonica*), *Eucheuma* seaweeds, elkhorn sea moss (*Kappaphycus alvarezii*) and *wakame* (*Undaria pinnatifida*). The nutritional contribution of seaweeds consists mainly of micronutrient minerals (e.g. iron, calcium, iodine, potassium, selenium) and vitamins, particularly A, C and B-12. Seaweed is also one of the only non-fish sources of natural omega-3 long-chain fatty acids.

The broad economic trends that have driven growth in global fish consumption in recent decades have been paralleled by many fundamental changes in the ways consumers choose, purchase, prepare and consume fish products. The globalization of fish and fish products, propelled by increasing emphasis on trade liberalization in many parts of the world and facilitated by advances in food transportation technologies, has lengthened supply chains to the point where a single product may be produced in one country, processed in another and consumed in yet another. This development has allowed consumers access to species of fish that are caught or farmed in regions far from their point of purchase and has introduced new products and tastes to what were previously only local or regional markets. Although the choices available to an individual consumer have multiplied, at the global level the choices are increasingly similar among countries and regions. Seasonal variation in the availability of individual species is also mitigated to some extent by the international diversification of supply sources and advances in preservation technologies, but major supply shocks affecting key species are now likely to affect consumption for a greater number of people in more geographically dispersed markets. Consumers' awareness of the non-local origin of much of the fish they can buy is driving demand for traceability systems and certification schemes intended to guarantee the sustainability and quality of a growing array of fish and fish products.

Urbanization has also shaped the nature and extent of fish consumption in many countries. While the global rural population is currently near its peak, since 2007 the urban population has accounted for more than half of the world's people, and it continues to grow. It is projected that in 2050, the urban population will have increased by more than two-thirds and will make up 66 percent of the global population (UN, 2015d). Nearly 90 percent of this increase will take place in Africa and Asia. Urban inhabitants typically have more disposable income to spend on animal proteins such as fish and eat away from home more often. In addition, the physical infrastructure and increased population density that are characteristic of urban areas allow for more efficient storage, distribution and marketing of fish and fish products. Hypermarkets and supermarkets are becoming more numerous, particularly throughout Latin America and Asia, and fish products are increasingly sold through these channels in lieu of traditional fishmongers and fish markets. At the same time, the ease and speed of food preparation represents an increasingly important consideration for urban dwellers with fast-paced lifestyles and increased demands on their time; as a result, fish products prepared and marketed for convenience, through both retail and fast-food services, have been growing in popularity. The tastes of modern consumers are also characterized by an emphasis on healthy living and a relatively high interest in the origin of the foods they eat, trends that will continue to influence fish consumption patterns in both mature and developing markets.

Beyond sector-specific considerations, overall levels of fish consumption also depend on market developments for other animal meats, led in terms of quantity by poultry, pig and bovine meat. Rising incomes, trade liberalization and widespread urbanization have affected demand for these terrestrial meats, as they have for fish. Between 1961 and 2013 (the last year for which consumption figures for terrestrial meat are available in FAO [2018e]), total terrestrial meat consumption increased by 2.8 percent per year, while per capita consumption grew at an average annual rate of 1.2 percent, from 23.1 to 43.2 kg. While pig meat had the highest share in world terrestrial animal meat consumption in 2013, this share rose only modestly from 35 percent in 1961 to 37 percent in 2013. Consumption of poultry has risen faster than that of any other animal meat, including fish. The share of poultry in terrestrial meat consumption was 35 percent in 2013, a substantial gain relative to the 1961 figure of 12 percent. Conversely, the share of bovine meat fell remarkably (from 41 to 22 percent between 1961 and 2013). The degree to which fish is a market substitute for other sources of animal protein is the subject of continuing research; it is affected by many factors including taste, nutritional habits and prices. In this respect, the development of the poultry sector is likely to be the most relevant for fish consumption over the next decade, as poultry, like fish, is an inexpensive lean protein of significant and increasing importance in the diets of developing country populations (OECD and FAO, 2017).

Despite improvements in per capita availability of food and positive long-term trends in nutritional standards, undernutrition (including inadequate consumption of protein-rich food of animal origin) remains a huge and persistent problem, predominantly in the rural areas of developing countries. According to *The State of Food Security and Nutrition in the World 2017* (FAO *et al.*, 2017), many people still lack the food they need for an active and healthy life. In 2016, the overall number of chronically undernourished people reached 815 million, up from 777 million in 2015 although still down from about 900 million in 2000, with the largest numbers and proportions in Asia and Africa. After a prolonged decline, this recent increase could signal a reversal of trends. The food security situation has worsened particularly in parts of sub-Saharan Africa and southeastern and western Asia, most notably in situations of conflict, in some cases combined with droughts or floods. In some countries, multiple forms of malnutrition – child undernutrition, anaemia among women, adult obesity – coexist. Overweight and obesity are increasing in children in most regions and in adults in all regions, primarily because of excessive consumption of high-fat and processed products. Fish, with its low fat content and valuable nutritional properties, could play a major role in correcting unbalanced diets, especially if specific policies are put in place to increase its consumption. ■

GOVERNANCE AND POLICY

The contributions of fisheries to achieving the Sustainable Development Goals

The United Nations (UN) system has affirmed its commitment to putting equality and non-discrimination at the heart of the implementation of the 2030 Agenda (CEB, 2016). In fisheries and aquaculture, the commitment to leave no one behind is a call to focus action and cooperation on achieving the core ambitions of the 2030 Agenda for the benefit of all fish workers, their families and their communities (see "Fisheries and the Sustainable Development Goals: meeting the 2030 Agenda" in Part 2).

Achieving the SDGs is the collective responsibility of all countries and all actors. It will depend on collaboration across sectors and disciplines, international cooperation and mutual accountability, and requires comprehensive, evidence-based and participatory problem-solving, financing and policy-making.

Increased economic interdependencies, coupled with limited management and governance capacity in developing countries, have increased the sustainability divide between developed and developing countries (see Box 4 in Part 2, page 91). To eliminate this disparity while making progress towards the zero-overfishing target set by the 2030 Agenda, the global community needs to support developing nations in fully realizing the potential contributions of fisheries and aquaculture.

SDG 14, Life below water, has clear connections to the fisheries and aquaculture sectors. Fisheries are an integral part of healthy ecosystems, and the ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) are being mainstreamed in management of capture fisheries and aquaculture (see "Implementing the ecosystem approach to fisheries and aquaculture: achievements and challenges" in Part 2). However, the sector is also highly relevant to nine other SDGs:

- **Goal 1: Eradication of poverty.** Responsible fisheries and fisheries value chains support the livelihoods of the poor and the vulnerable with inclusive access to fisheries and related economic resources.
- **Goal 2: Zero hunger.** In terms of food utilization, the benefits of fish in the human diet are well established.
- **Goal 3: Good health and well-being.** Fisheries contribute to health and well-being not only through improved nutrition and livelihoods, but also in the biocontrol of disease vectors.
- **Goal 5: Gender equality.** Fisheries empower women and contribute to gender equity; however, their role has largely been unrecognized (HLPE, 2014).
- **Goal 6: Clean water and sanitation.** Healthy inland aquatic ecosystems are indicators of good water quality, with benefits both in terms of productive fishery resources and in terms of municipal drinking-water that requires minimal treatment.
- **Goal 8: Decent work and economic growth.** The capture fisheries and aquaculture primary sector provided work for almost 60 million people globally in 2016, with particular importance in developing countries.
- **Goal 12: Responsible consumption and production.** Many fisheries are increasingly addressing issues of waste through more complete utilization and reductions in post-harvest losses.
- **Goal 13: Climate action.** Fisheries and aquaculture have a lower environmental impact than ruminant meat production (Clark and Tilman, 2017). Inland fisheries have a particularly low carbon footprint in comparison with other food sources (Ainsworth and Cowx, 2018).
- **Goal 15: Life on land.** Freshwater ecosystems, of which inland fisheries are very much a part, are a rich source of biodiversity (see "Global inland fisheries revisited: their contribution to achievement of the SDGs" in Part 2).

The international community is seeking to ensure the involvement of stakeholders from the fisheries and aquaculture sector in the SDG discussions and is raising awareness to promote policies and practices that will ensure the sector's contributions towards meeting all ten relevant SDGs. Events and initiatives designed to reinforce and support the sector's role in achieving the SDGs include the series of Our Ocean conferences (hosted by the United States of America [2014], Chile[2015], Malta [2017], Indonesia [2018], Norway [2019] and Palau [2020]), the 2017 and 2020 United Nations Ocean Conferences, the new annual International Day for the Fight against Illegal, Unreported and Unregulated Fishing on 5 June, and the International Year of Artisanal Fisheries and Aquaculture in 2022 (see Box 18 in Part 3, page 139). The biennial meetings of the FAO Committee on Fisheries (COFI) – which serves as the only global intergovernmental forum examining major international fisheries and aquaculture issues – support the 2030 Agenda through recommendations and guidance addressed to governments, regional fishery bodies, non-governmental organizations (NGOs), fish workers, FAO and the international community (Figure 32).

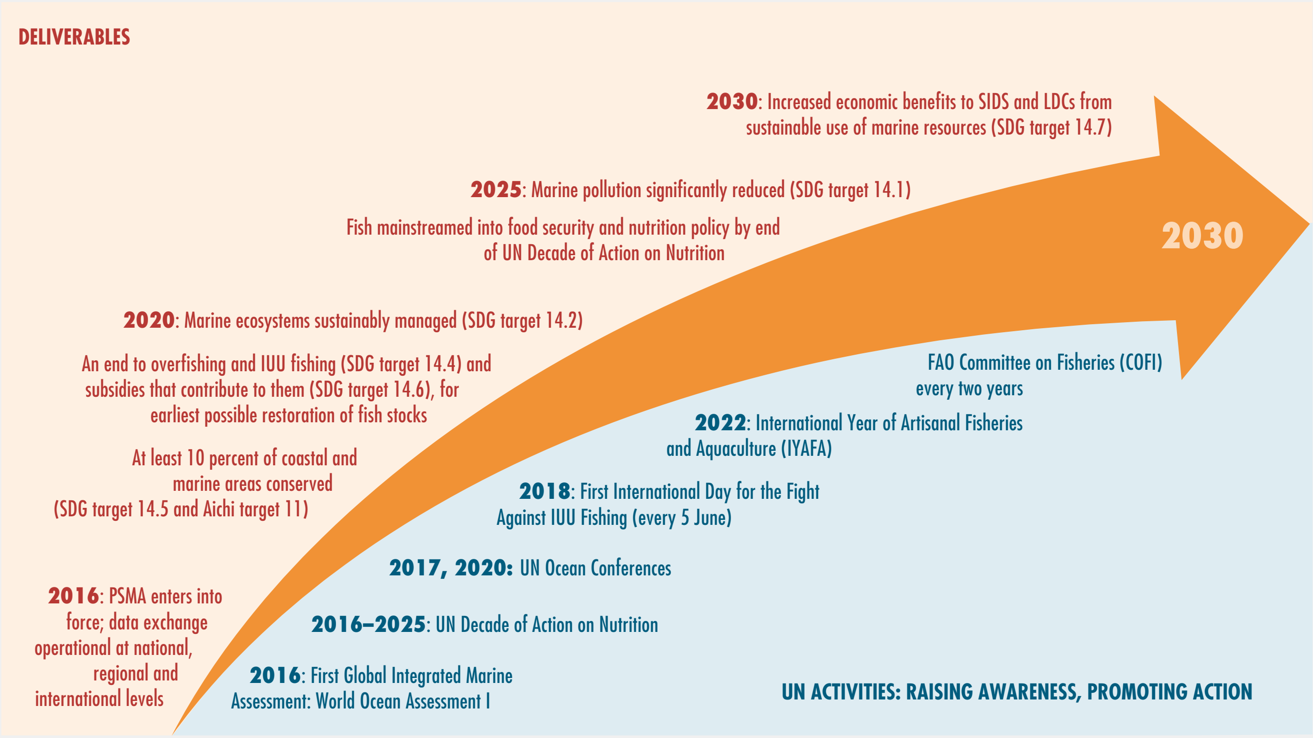
Fisheries and global governance

Fisheries in the oceans science–policy interface

The United Nations General Assembly continues to address multiple ocean-related matters, including those concerning fisheries and aquaculture, with annual resolutions on Oceans and the Law of the Sea and on Sustainable Fisheries.

The 2002 Johannesburg World Summit on Sustainable Development called for a regular

FIGURE 32
KEEPING MOMENTUM TO ACHIEVE THE 2030 AGENDA



process for the global reporting and assessment of the state of the marine environment, including socio-economic aspects. In 2016, the First Global Integrated Marine Assessment, also known as the World Ocean Assessment I, was published as the outcome of the first cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects. Extensive in its coverage, the report is at the nexus of the science–policy interface and provides a basis for future assessments and work on the SDGs.

The United Nations Ocean Conference in 2017 (formally, the high-level United Nations Conference to Support the Implementation of SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development) was the first UN global event dedicated to oceans. The conference brought together States, UN entities, academia, NGOs, civil society organizations and the private sector to discuss the implementation of SDG 14. The outcomes included adoption of a Call for Action which focuses on concrete and action-oriented recommendations and more than 1 300 voluntary commitments for future work related to the implementation of SDG 14.

Discussion on the science–policy interface continued with the thirteenth round of informal consultations of States Parties to the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNFSA), held at UN Headquarters in New York, United States of America, in May 2018.

The science–policy nexus now includes climate and ocean policies. In 2017, the United Nations General Assembly discussed the topic of the effects of climate change on oceans during the eighteenth UN Informal Consultative Process on Oceans and the Law of the Sea. Oceans Action Day has been part of the official programme of the Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) since COP 22 in 2016. At COP 23, the presiding Government of Fiji not only supported this event, but also launched the Oceans Pathway Partnership to support the inclusion of oceans in the official negotiations on climate. In addition, the "Because the Ocean" declaration launched at COP 21 has been signed by an increasing number of countries. With this increased emphasis on oceans, action is moving from awareness raising and advocacy to the implementation of concrete actions and initiatives around the world to enhance the key roles of oceans and aquatic systems in adaptation and mitigation.

Fisheries and biodiversity

Since the 1992 adoption of the Convention on Biological Diversity (CBD), biodiversity considerations in relation to management of fisheries and aquaculture have been focused on policies and actions for the conservation of threatened species and vulnerable habitats (see "Biodiversity, fisheries and aquaculture" in Part 2).

Many regional fisheries management organizations (RFMOs) and national fishery authorities have updated their management instruments or replaced them with new ones incorporating more proactive management rules for species and habitats of particular conservation concern, increasingly in close collaboration with environment-sector interests. The Sustainable Ocean Initiative, for example, aims to ensure the convergence of actions by regional seas organizations and RFMOs by facilitating partnerships to link various initiatives (CBD, 2018). Aichi target 6 (a series of deliverables for fisheries) and Aichi target 11 (effective area-based management of biodiversity in inland water, coastal and marine areas) coupled with SDG target 14.5 (By 2020, conserve at least 10 percent of coastal and marine areas) not only outline fisheries' accountability for the full footprint of its activities; they also facilitate the measurement of countries' action in mainstreaming biodiversity in their policies and management measures. On the high seas, the biodiversity beyond national jurisdiction (BBNJ) process is a strong force for multisectoral governance (see "The emerging role of regional cooperation for sustainable development" in Part 4).

Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), well aware of the benefits of diverse, sustainable fisheries and productive oceans, are increasingly responding to recognized depletions of aquatic species. Since 2013, CITES has listed 20 commercially exploited fish species, while the Convention on the Conservation of Migratory Species of Wild Animals (CMS) has listed 28. Some of these listings come with binding provisions that regulate trade; their implementation thus requires not only a shift in practices across industrial and artisanal fisheries, but also actions on the part of countries, regional fisheries bodies (RFBs) and others.

Sustainable aquaculture and fisheries rely on sound management and conservation of aquatic genetic resources (AqGR), for example to protect genetically independent populations from the harmful effects of stocking and resettlement measures and non-native strain escapees from aquaculture. Assessment of AqGR is important in this connection. The Federal Ministry of Food and Agriculture of Germany, for instance, is currently engaged in a project for the molecular genetic documentation of genetic management units of crayfish, brown trout, lake trout, sea trout, barbel, burbot, grayling and tench. The knowledge gained during this project is to be incorporated in practical recommendations for the stock management of these species, respecting the genetic diversity of the entire population.

For aquaculture, the value of AqGR is the potential for increased production, resilience, efficiency and profitability. In particular, high-quality seed and genetic improvement programmes in aquaculture, and specifically selective breeding, have served as an effective means for increasing production efficiency and improving aquatic animal health. The Genetic Improvement of Farmed Tilapia (GIFT) project, for example, has played an important role in the expansion of Nile tilapia culture (now reported in 87 countries) by helping to avoid the negative impacts of inbreeding or poor genetic management (Gjedrem, 2012). Through maintenance of high levels of genetic variation and genetic selection for important traits, the project has resulted in superior performance in many aquaculture stocks.

Fisheries and internationally shared resources

Achieving the SDGs requires cooperation at the regional level, as exploitation of fishery resources often involves several countries. SDG 14 provides a strong impetus for regional and institutional cooperation to coordinate efforts to meet ocean-related targets across areas and ecosystems. In this regard, RFMOs are uniquely and strategically positioned to take a leading part in regional and global efforts in the fight against illegal, unreported and unregulated (IUU) fishing and addressing overfishing.

RFBs, and particularly RFMOs, have long been essential for support to and implementation of management of shared fishery resources. Increasingly, they are also providing key services in capacity building and strengthening of regional and global scientific knowledge in support to development and management of fisheries and aquaculture. The Regional Fishery Body Secretariats Network (RSN) is increasingly playing a key role in this regard through coordination and the sharing of information and experiences among the 53 RFBs.

Similarly, as more demands are made on the use of the coastal and aquatic environment by an ever-growing array of sectors, and as demand for fisheries and aquaculture products increases worldwide, the need for cooperation between RFBs and organizations that deal with the management of human activities in other sectors rises rapidly. In response, cooperation frameworks are being developed between regional seas programmes and various RFBs. Examples include a draft Memorandum of Understanding between the Southwest Indian Ocean Fishery Commission (SWIOFC) and the Nairobi Convention in the Southwestern Indian Ocean, and an initiative to advance cooperation between the Regional Commission for Fisheries (RECOFI) and the Regional Organization for the Protection of the Marine Environment (ROPME) in the Arabian Sea (see "The emerging role of regional cooperation for sustainable development" in Part 4).

Responding to recommendations from a variety of fora – the United Nations General Assembly (2005), the twenty-sixth and twenty-seventh sessions of COFI (2005, 2007) and the first Kobe meeting of tuna RFMOs (2007) – RFMOs are increasingly using four criteria to review their performance:

- assessment of the conservation and management of fish stocks;
- the level of compliance with and enforcement of international obligations;
- the status of current legal frameworks, financial affairs and organization;
- the level of cooperation with other international organizations and non-member States.

These reviews are being institutionalized and undertaken with increasing regularity and frequency. As at 23 October 2017, 15 RFMOs had undergone performance reviews,[10] and six of them (CCSBT, ICCAT, IOTC, NASCO, NEAFC, SEAFO) had also conducted a second performance review, with more planned by others.

Integrating fisheries into area-based management decisions

Fisheries and fishers have been increasingly considered in area-based management discussions, for example during the fourth International Marine Protected Areas Congress (IMPAC4) and the United Nations Ocean

10 Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); Commission for the Conservation of Southern Bluefin Tuna (CCSBT); General Fisheries Commission for the Mediterranean (GFCM); Inter-American Tropical Tuna Commission (IATTC); International Commission for the Conservation of Atlantic Tunas (ICCAT); Indian Ocean Tuna Commission (IOTC); International Pacific Halibut Commission (IPHC); Northwest Atlantic Fisheries Organization (NAFO); North Atlantic Salmon Conservation Organization (NASCO); North-East Atlantic Fisheries Commission (NEAFC); North Pacific Anadromous Fish Commission (NPAFC); Pacific Salmon Commission (PSC); Regional Commission for Fisheries (RECOFI); South East Atlantic Fisheries Organisation (SEAFO); Western and Central Pacific Fisheries Commission (WCPFC).

Conference in 2017. EAF and EAA provide fundamental frameworks for considering and undertaking area-based management.

Global guidance is available to ensure that area-based management, including the consideration of marine protected areas, is integrated within broader fisheries management frameworks and follows good practices with regard to participatory approaches, especially for small-scale fisheries. Both the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) (FAO, 2015a) and the Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (VGGT) (FAO, 2012a) describe such practices and outline, among other things, the need to respect customary and informal tenure rights (discussed in the section on biodiversity in Part 2).

The issue is not limited to marine coastal areas. The contribution of fisheries to SDG 15, Life on land, is significant because inland fisheries are one of the important provision services of freshwater ecosystems and indicators of good water quality and so can provide the justification for habitat protection or rehabilitation. The efficiency and value of inland fishery production are just starting to be recognized as a consideration in resolving competing demands among sectors, especially for water.

Nor are the considerations limited to capture fisheries. Aquaculture has the potential to address the gap between aquatic food demand and supply and to help countries achieve their economic, social and environmental goals. However, the ability of aquaculture to meet future demand for food will to a significant extent depend on the availability of space in suitable sites. Aquaculture spatial planning, integrated with area-based planning, is fundamental for integrated management of land, water and other resources and to enable the sustainable development of aquaculture in a way that accommodates the needs of competing economic sectors, minimizes conflict and integrates social, economic and environmental objectives. The ecosystem approach to aquaculture (see discussion in Part 2) and blue growth (see discussion in Part 4) are useful frameworks in this context (FAO and World Bank, 2015).

Fisheries and the global nutrition agenda

Given its nutritional value and prevalence in many diets, fish has an important place in agriculture- and food-based approaches to food security and nutrition (Kawarazuka and Béné, 2010). The United Nations General Assembly proclamation of the UN Decade of Action on Nutrition for 2016–2025 provides an opportunity to raise awareness about the role of fish and to ensure that it is mainstreamed in food security and nutrition policy. The World Health Organization (WHO) and FAO are leading efforts in this regard, in collaboration with the World Food Programme (WFP), the International Fund for Agricultural Development (IFAD) and the United Nations Children's Fund (UNICEF). This work is essential, as fish provides more than 20 percent of the average per capita animal protein intake for 3 billion people (more than 50 percent in some less developed countries) and is especially critical for rural populations, which often have less diverse diets and higher rates of food insecurity (see "Fish for food security and human nutrition" in Part 2).

Fisheries and the global trade agenda

Together with new market demands for fish and fish products, trade policies such as tariffs, subsidies and food safety and sustainability standards can have a significant influence on fisheries trade, and particularly on access to international markets. Some trade measures, despite having legitimate objectives, can create technical or financial obstacles and restrict market access, especially for developing countries and small-scale fishers. In trade negotiations, such as current efforts to revitalize fisheries subsidies at the World Trade Organization (WTO), knowledge of fisheries issues and awareness of the interconnectivity of the various policy frameworks applicable to the fisheries sector are necessary to assess challenges, opportunities and concerns and to avoid the creation of unnecessary barriers to trade. Technical assistance to trade negotiators has become essential for bridging possible knowledge gaps.

The United Nations Conference on Trade and Development (UNCTAD), FAO and the United Nations Environment Programme (UNEP) have been working together to provide countries with a comprehensive understanding of the main driving forces and various concurrent processes (e.g. WTO and Agenda 2030) associated with trade of fish and fish products. In July 2016, these agencies issued a joint statement, "Regulating fisheries subsidies must be an integral part of the implementation of the 2030 sustainable development agenda", during the fourteenth session of UNCTAD, which emphasized the need to address harmful fisheries subsidies as specified in SDG target 14.6 (By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation).

Subsequently, the side event "Fish Trade, Fisheries Subsidies and SDG 14" at the eleventh WTO Ministerial Conference (December 2017) brought together UNCTAD, FAO, the Commonwealth Secretariat, the European Union, Argentina, Norway, Papua New Guinea and representatives of the private sector and civil society to build political consensus and deepen understanding of trade-related aspects of SDG 14. Such joint activities help to avoid duplication of effort and redundancy and to improve allocation of the resources of international organizations for the benefit of their members.

Furthering implementation of the Code of Conduct for Responsible Fisheries

With people consuming more fish than ever, the Code of Conduct for Responsible Fisheries (CCRF) (FAO, 1995) is increasingly relevant as the guiding framework for implementing the principles of sustainable development in fisheries and aquaculture. New initiatives being taken to advance the implementation of CCRF include efforts to move towards SDG-compliant investments, integrated networks for reducing IUU fishing and management of the risks of food production from aquaculture.

Investing in fisheries for sustainability

The focus of fisheries governance and development has broadened to include not only conservation of resources and the environment, i.e. a biological conception of sustainability, but also recognition of the social agency, well-being and livelihoods of people working in the sector. Greater weight is placed on the role of fisheries as sources of livelihoods (e.g. income, food and employment), sites of expression of cultural values and a buffer against shocks for poor communities.

The three pillars of sustainability – environmental, economic and social – are now more firmly embedded in fisheries management. Key fisheries instruments provide the context and the framework for investment in fisheries to achieve the SDGs. Both the SSF Guidelines (FAO, 2015a) and VGGT (FAO, 2012a) serve as policy frameworks for making small-scale fisheries more sustainable.

A number of development partners (such as the Oak Foundation, KfW Development Bank, the German Agency for International Cooperation [GIZ], the United States Agency for International Development [USAID] and other organizations) and investment funds (such as the consortium of funds supporting the Principles for Investment in Sustainable Wild-Caught Fisheries, launched at the World Ocean Summit 2018 [Environmental Defense Fund, Rare/Meloy Fund and Encourage Capital, 2018]) are now including CCRF, the SSF Guidelines and VGGT in investment and action-oriented strategies relevant to fisheries.

To support these commitments to sustainable small-scale fisheries development, it is crucial to develop the understanding and knowledge base about small-scale fisheries. Several initiatives are under way to improve and expand existing empirical information and to quantify the importance of the marine and inland small-scale fisheries sector, including an update of the World Bank (2012) study *Hidden harvest: the global contribution of capture fisheries* (see

"Small-scale fisheries and aquaculture" in Part 3 and Box 19, page 140). Other important opportunities to expand the evidence base include the global conference Tenure and User Rights in Fisheries 2018: Achieving Sustainable Development Goals by 2030 (September 2018) and the third Global Congress on Small-Scale Fisheries, organized through the Too Big To Ignore research partnership (October 2018).

Tightening the net around illegal, unreported and unregulated fishing

Addressing IUU fishing and its impacts on biodiversity and the social and economic sustainability of fisheries continues to be an essential part of fisheries governance, as IUU fishing threatens resource conservation, the sustainability of fisheries and the livelihoods of fishers and other stakeholders in the sector and exacerbates malnutrition, poverty and food insecurity (see "Combating illegal, unreported and unregulated fishing: global developments" in Part 2).

Confronting the issue is especially critical in developing countries which lack the capacity and resources for effective monitoring, control and surveillance. Strong political will and concerted action by flag States, port States, coastal States and market States are required to tackle the many facets of the problem, which include:

- fishing and fishing-related activities conducted in contravention of national, regional and international laws (illegal);
- non-reporting or misreporting of information on fishing operations and their catches (unreported);
- fishing by Stateless (unregistered) vessels (unregulated);
- fishing in convention areas of RFMOs by non-party vessels (unregulated);
- fishing activities that are not fully regulated by States and cannot be easily monitored and accounted for (unregulated);
- fishing connected with areas or fishery resources for which there are no conservation or management measures (unregulated).

A major achievement in the global effort to combat IUU fishing, the binding FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing ("Port State Measures Agreement", PSMA), entered into force on 5 June 2016. As of 5 April 2018, the agreement had 54 Parties, including the European Union. The Parties to PSMA are now working together towards its effective implementation, including by encouraging non-Parties to adhere to the agreement.

The First Meeting of the Parties, in May 2017, defined roles and responsibilities and established a roadmap supported by a workplan, not only for the Parties, but also for international organizations and bodies, including FAO and RFMOs (FAO, 2017j). The workplan includes the development of mechanisms and a staged approach for data exchange. Monitoring of implementation of the agreement, including challenges faced, will initially take place every two years. The Parties also agreed to begin reporting on national contact points, designated ports and other relevant information for the implementation of the agreement, and to publish the information in a dedicated section within the FAO website. Meetings of the Parties will be held every two years.

Collaboration among RFMOs and States in the exchange of information on fishing vessels and on their activities to implement PSMA supports not only port States in combating IUU fishing, but also flag States in the control of their vessels, coastal States in protecting their fishery resources and market States in ensuring that products derived from IUU fishing do not enter their markets. Properly implemented, such cooperation to ensure effective enforcement will lead to much more sustainable fisheries around the world.

Catch documentation schemes (CDSs) are market-related measures that have been developed specifically to combat IUU fishing and complement the PSMA. Trying to avoid a proliferation of unilaterally developed CDSs, FAO members in 2017 endorsed the Voluntary Guidelines on Catch Documentation Schemes (discussed in the section on IUU fishing in Part 2). Next steps to keep the process moving forward will be to address the practical aspects and to generate global guidance on implementation of these voluntary guidelines.

Reducing risks in aquaculture

Farmers, policy-makers and other stakeholders are increasingly aware of the risks of food production and are working together to manage them efficiently. Adoption of national aquatic animal health strategies (FAO/NACA, 2000, 2001; FAO, 2007) is helping to address biosecurity and ensure the health and welfare of aquatic animals (see "Realizing aquaculture's potential" in Part 3). The following resources provide guidance on specific aspects of effective aquaculture biosecurity governance.

- diagnostics: Bondad-Reantaso *et al.* (2001), Bondad-Reantaso, McGladdery and Berthe (2007)
- quarantine: Arthur, Bondad-Reantaso and Subasinghe (2008)
- risk analysis: Arthur and Bondad-Reantaso (2012)
- surveillance and zoning: Subasinghe, McGladdery and Hill (2004)
- emergency preparedness and contingency plans: Arthur *et al.* (2005)
- emergency disease investigations: FAO (2017q)
- early warning/forecasting: the quarterly *Food Chain Crisis Early Warning Bulletin*

Climate-smart agriculture (CSA) – which includes aquaculture and aquaponics – is starting to be used to help develop the technical, policy and investment conditions needed to achieve sustainable agricultural development for food security under climate change (FAO, 2017r, 2017s). CSA entails simultaneous attention to increasing productivity, mitigating climate change and adapting to it. It is thus starting to serve as an alternative and innovative approach for increasing aquaculture production while avoiding adverse impact on sustainability. The challenge is to implement climate-smart aquaculture in accordance with CCRF and EAA in order to address the three interlinked economic, environmental and social dimensions of sustainability. ■

PRAIA, CABO VERDE
Fishers pulling in their nets
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PART 2
FAO FISHERIES AND AQUACULTURE IN ACTION

PART 2

FAO FISHERIES AND AQUACULTURE IN ACTION

FISHERIES AND THE SUSTAINABLE DEVELOPMENT GOALS: MEETING THE 2030 AGENDA

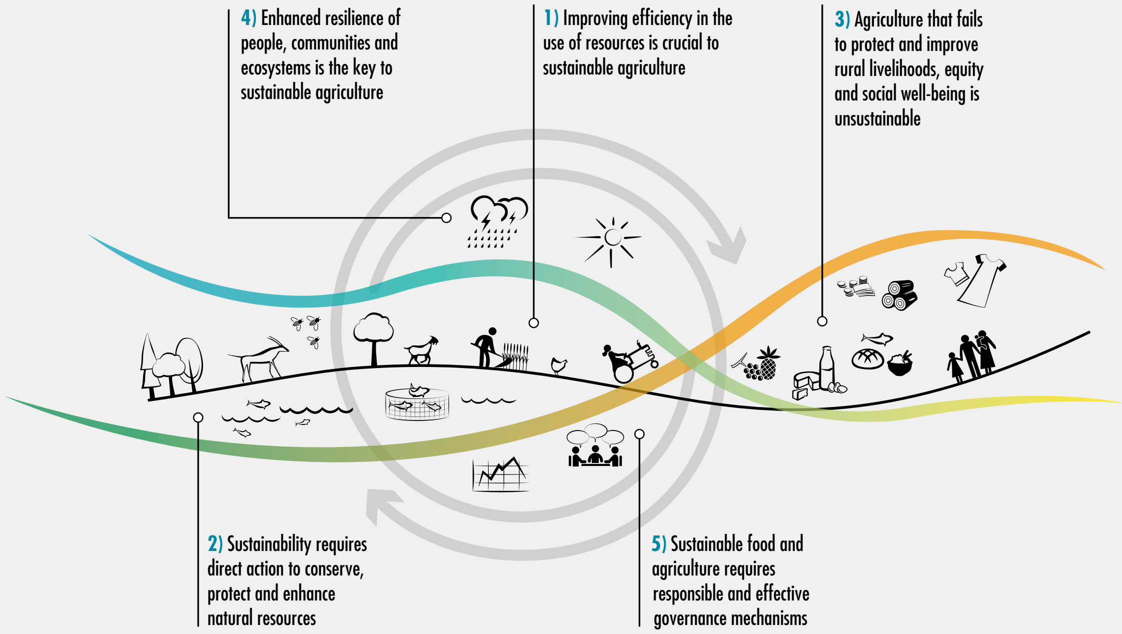
The 2030 Agenda for Sustainable Development (2030 Agenda for short) (UN, 2015a) offers a vision of a just and sustainable world, free of fear and violence, with full realization of human potential contributing to shared prosperity, achieved through rights-based, equitable and inclusive development in which no one is left behind. The 2030 Agenda not only calls for an end to poverty, hunger and malnutrition and for universal access to health care – all with major emphasis on gender issues – but also demands the elimination of all forms of exclusion and inequality everywhere. The United Nations (UN) system affirmed its commitment to putting equality and non-discrimination at the heart of the implementation of the 2030 Agenda (CEB, 2016).

The 2030 Agenda, the Sustainable Development Goals (SDGs) and related ongoing international and national processes are highly relevant to the fisheries and aquaculture sector, including fish processing and trade, and in particular to the sector's governance, policy, investment and capacity development needs, to stakeholder participation and collaboration and to international partnerships. The commitment to leave no one behind in fisheries and aquaculture is a call to focus action and cooperation on efforts that will help to achieve the core ambitions of the 2030 Agenda for the benefit of all fish workers, their families and their communities. The vast majority of inland fisheries, for example, are small-scale operations of poorer groups and are essential for their food and economic security (Lynch *et al.*, 2017) (see also "Global inland fisheries revisited: their contribution to achievement of the SDGs" in this volume).

The 2030 Agenda and the SDGs present sustainable development as a universal challenge – and a collective responsibility – for all countries and for all actors. Achieving them will depend on collaboration across sectors and disciplines, international cooperation and mutual accountability and will demand comprehensive, evidence-based and participatory problem-solving and policy-making. The SDGs are truly transformative and interlinked, and they call for integrative and innovative approaches to combine policies, programmes, partnerships and investments to achieve common goals (FAO, 2016a). Numerous authors have explored the links between SDG 14 – Conserve and sustainably use the oceans, seas and marine resources for sustainable development – and the other SDGs (Blanchard *et al*. 2017; ICSU, 2017; Ntona and Morgera, 2017; Singh *et al.*, 2017; Le Blanc, Freire and Vierros, 2017; Nilsson, Griggs and Visbeck, 2016). The United Nations Development Group (UNDG, 2017a, 2017b) and FAO (2017a) provide general guidance for mainstreaming of the 2030 Agenda and related integrated programming at the country level.

FAO has elaborated a common vision for sustainable food and agriculture (FAO, 2014a) as a framework for addressing sustainable development in agriculture, forestry, fisheries and aquaculture in a more effective and integrated way. It sets out five basic principles for the policy dialogue and governance arrangements needed to identify sustainable development pathways across the SDGs, across sectors and along related value chains (Figure 33). This unified perspective – valid across all agricultural sectors

FIGURE 33
THE FIVE PRINCIPLES OF SUSTAINABLE FOOD AND AGRICULTURE – FAO'S COMMON VISION ACROSS AGRICULTURE, FORESTRY, FISHERIES AND AQUACULTURE



SOURCE: FAO, 2017t

and taking into account social, economic and environmental considerations – will ensure the effectiveness of action on the ground and is underpinned by knowledge based on the best available science, adapted at the community and country levels to ensure local relevance and applicability. The common vision has been endorsed by the FAO Committees on Agriculture and Forestry and the FAO Committee on Fisheries (COFI) Sub-Committee on Aquaculture. Guidelines are being developed for policy-makers on how to engage agriculture, forestry and fisheries in the 2030 Agenda (FAO, forthcoming).

In 2017, the COFI Sub-Committee on Fish Trade reviewed 2030 Agenda issues such as food loss and waste, climate change, threatened species, marine protected areas and social sustainability in fish value chains (FAO, 2017b), while the COFI Sub-Committee on Aquaculture discussed the 2030 Agenda (FAO, 2017c; Hambrey, 2017), recommending that FAO develop guidelines for sustainable aquaculture based on lessons learned from successful aquaculture developments worldwide.

Update on progress towards meeting SDG 14

The United Nations Conference to Support the Implementation of SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development ("the Ocean Conference"), held 5 to 9 June 2017 in New York, brought together leaders from government, science, industry and civil society to explore the challenges and ways to address them. Small island developing States (SIDS), having a high dependence on oceans, were instrumental in driving this high-level conference, with leadership from Fiji and Sweden. The conference had the support of 95 country co-sponsors.

The outcome of the Ocean Conference included the identification of partnerships for delivery on SDG 14 and new voluntary commitments for these partnerships, plus a political declaration in the form of a Call to Action (UN, 2017a), all focusing on concrete actions for implementing SDG 14. "Communities of Ocean Action" will follow up in supporting and monitoring the implementation of these actions, catalysing and generating new voluntary commitments and facilitating collaboration and networking among different actors in support of SDG 14. Regional fisheries bodies (RFBs), regional fisheries management organization (RFMO) contracting parties, cooperating non-contracting parties and partner organizations have picked up the momentum to deliver on the wide range of SDG 14 target components by 2020, and have started formalizing their aspirational goals and commitments in the process of updating or replacing their constitutive instruments (FAO, 2017d).

The 2017 High-Level Political Forum on Sustainable Development (HLPF) conducted an in-depth review of SDGs 1 (No poverty), 2 (Zero hunger), 3 (Good health and well-being), 5 (Gender equality), 14 (Life below water) and 17 (Partnership for the goals) under the overarching theme "Eradicating poverty and promoting prosperity in a changing world" (HLPF, 2017a), resulting in a ministerial declaration (ECOSOC, 2017a) and 43 voluntary national reviews (HLPF, 2017b). To support the discussion of progress on SDG 14, FAO and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO-IOC) led a thematic review of the implementation of its components and provided recommendations for future investment on a wide range of ocean issues (ECESA Plus, 2017), highlighting ongoing work, opportunities and needs for further action on key issues: minimizing impacts of ocean acidification and pollution; reducing harmful fishing effort (through actions on illegal, unreported and unregulated [IUU] fishing and removing, where possible, harmful fishery subsidies); enhancing effective area management for the conservation of biodiversity; and strengthening implementation of global agreements on climate. The HLPF review noted that much progress was being made and highlighted current opportunities for nations to benefit from technological and scientific advances to support implementation in areas such as data collection, sharing of information, infrastructure improvement and capacity development.

The fourth Our Ocean conference, hosted by the European Union (Malta, October 2017), also addressed implementation of actions required for delivery of SDG 14 and resulted in new commitments (EC, 2017). Reiterating and building on the commitments made at the UN Oceans Conference in June, FAO pledged continued support to the implementation of components of SDG 14, especially:

- strengthening of fisheries governance and States' capacities to prevent, deter and eliminate IUU fishing through technical support to developing States Parties;
- upscaling of work to support small-scale fisheries by raising awareness, strengthening institutional capacities, empowering small-scale fisheries organizations, generating and sharing knowledge, supporting policy reform and providing technical assistance to support the implementation of FAO's Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) (FAO, 2015a);
- supporting fish trade so that it can contribute towards the achievement of the SDGs by reinforcing the multilateral trading system and ensuring that trade policies and strategies are coherent with other enabling national policies.

In their pledges, many countries and organizations directly highlighted the work of FAO and/or their collaboration with FAO towards achievement of SDG 14 targets.[11] Most pledges focused on actions to prevent, deter and eliminate IUU fishing through both the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) (FAO, 2017e) and the Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (FAO, 2017f) (see section on combating IUU fishing in this volume), followed by support for the blue economy and small-scale fisheries, with decent work in fisheries and aquaculture also an important focus.

11 The European Union, Japan, Norway, Philippines, Spain, the African Confederation of Artisanal Fisheries Professional Organizations (CAOPA) and the Global Environment Fund (GEF) all directly highlighted FAO in their pledges.

Update on development and application of SDG 14 indicators under FAO's custodianship

As a custodian agency for the four fisheries-related SDG 14 indicators (presented in Table 19), FAO (2017g) has continued its efforts of:

- reporting on the proportion of marine fish stocks within biologically sustainable limits (target 14.4);
- developing and applying available methodologies for indicators for targets 14.6 and 14.b;
- promoting technical consensus-building on possible methodologies for reporting on the target 14.7 indicator;
- collaborating with the UN Oceans (UN, 2017a) network on methodology development for the target 14.c indicator;
- providing capacity development, through targeted training workshops and online learning materials, to countries on SDG 14 fisheries-specific reporting at the national level.

TABLE 19
SDG 14 INDICATORS FOR WHICH FAO IS CUSTODIAN OR CONTRIBUTING AGENCY

SDG 14 target	Indicator
FAO as custodian agency	
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	**14.4.1** Proportion of fish stocks within biologically sustainable levels
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	**14.6.1** Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	**14.7.1** Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries
14.b Provide access for small-scale artisanal fishers to marine resources and markets	**14.b.1** Progress by countries in adopting and implementing a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries
FAO as contributing agency, UN Division for Ocean Affairs and the Law of the Sea (DOALOS) as custodian agency	
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS [United Nations Convention on the Law of the Sea], which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in Paragraph 158 of "The future we want"	**14.c.1** Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in UNCLOS, for the conservation and sustainable use of the oceans and their resources

SOURCE: FAO, 2017g

BOX 3
REPORTING ON SDG TARGETS 14.4., 14.6 AND 14.b

Target 14.4. Based on FAO's assessment, the fraction of world marine fish stocks that are within biologically sustainable levels declined from 90 percent in 1974 to 66.9 percent in 2015 (see "The status of fishery resources" in Part 1). Thus, 33.1 percent of fish stocks were estimated as fished at a biologically unsustainable level and therefore overfished in 2015. While the decreasing trend has slowed since 2008, perhaps because of improved management, little progress has been made towards achieving SDG target 14.4 at the global level.

Target 14.6. Almost all respondents to the 2015 CCRF survey reported having taken measures to combat IUU fishing, most importantly through the improvement of coastal State controls and monitoring, control and surveillance (MCS) and legal frameworks. The percentage of respondents identifying IUU fishing as a problem dropped from 90 percent in 2013 to 79 percent in 2015. Of these countries, 69 percent have drafted a National Plan of Action on IUU fishing (NPOA-IUU), and 84 percent of countries with an NPOA-IUU have started implementing it.

Target 14.b. Some 70 percent of the respondents to the 2015 CCRF survey, representing 92 countries and the European Union, have introduced or developed regulations, policies, laws, plans or strategies specifically targeting small-scale fisheries. Some 85 percent confirmed the existence of mechanisms through which small-scale fishers and fish workers can contribute to decision-making processes.

FAO contributed to the *Sustainable Development Goals Report 2017* (UN, 2017b) and the 2017 UN Secretary-General's report on progress towards the SDGs (ECOSOC, 2017b). For SDG target 14.4, the latter report highlights the biologically unsustainable levels of over 30 percent of assessed marine fish stocks (Box 3).

The existing SDG indicator 14.4.1 (proportion of fish stocks within biologically sustainable levels) is based on assessments by FAO of major fishing areas and needs to be adapted for country-level assessment, as the ownership and responsibility of estimating and reporting SDG indicators lie with Members. Assessing the status of fish stocks within exclusive economic zones (EEZs) may present numerous governance and reporting challenges to many developing countries (see Box 4), because formal stock assessment is data demanding, skill intensive and financially costly (see the section on "FAO's approach to improving the quality and utility of capture fishery data"). At the global level, a consistent monitoring framework is needed to meet the requirements of transparency and comparability in estimating the indicator across time and countries, especially the coverage of the reference list of stocks to be monitored and the methods used in each country. FAO provides the SDG reporting framework with necessary technical support and capacity building through technical workshops, guidelines on methodologies, standards and operational procedures of estimating and reporting on indicator 14.4.1.

Indicators for targets 14.6[12] and 14.b rely on data generated through country responses to the biennial Code of Conduct for Responsible Fisheries (CCRF) questionnaire. The methodology used to compile and to facilitate ease of reporting of such data is being continuously improved. An FAO workshop on target 14.b, held in late 2017 for representatives from governments, regional organizations and civil society organizations (CSOs), discussed capacity development needs related to monitoring and implementation of efforts towards achieving target 14.b. FAO provides support on related data collection, analysis and reporting through e-learning courses, for example on SDG indicator 14.b.1, securing sustainable small-scale fisheries (FAO, 2017h). »

12 The current target 14.6 indicator does not encompass all elements of SDG target 14.6, as it focuses on instruments to combat IUU fishing but does not cover fisheries subsidies.

BOX 4
THE GAP BETWEEN DEVELOPED AND DEVELOPING COUNTRIES' SUSTAINABILITY TRENDS IN RELATION TO MARINE CAPTURE FISHERIES

Despite efforts to meet the SDG target of ending overexploitation of marine resources by 2020, capture fishery landings have stabilized around 90 million tonnes in recent decades, but the percentage of overfished fish stocks continues to increase, exceeding 33 percent globally in 2015. The global picture masks disparate patterns between developed and developing countries: Developed countries are significantly improving the way they manage their fisheries, while the situation in least developed countries is worsening in terms of fleet overcapacity, production per unit of effort and stock status (Ye and Gutierrez, 2017).

For instance, FAO data show that marine capture fishery production in the developed world decreased by about 50 percent from its peak in 1988 (43 million tonnes) to 21 million tonnes in 2015. In contrast, developing countries saw a continuous increase in fish production from 1950 to 2013. Furthermore, fishing effort (in kW days) in 2012 was eight times higher in developing countries than in developed countries and increasing, while it has been decreasing in developed countries since the early 1990s, mostly as a result of stringent regulations and management interventions. Since the late 1990s, developed countries have managed to halt the decline in overall production rate (catch per unit of effort [CPUE]) by reducing fishing pressure to allow recovery of overfished stocks in many jurisdictions.

Fishing restrictions in developed nations have resulted in reduced domestic fishery production and reduced self-sufficiency. To compensate for their decline in production so as to meet high demand from domestic consumers, developed countries have increased their imports of fish and fish products from developing countries or in some cases made fishing access agreements with them to allow developed country fleets to fish in their national waters. The resulting economic interdependencies, coupled with limited management and governance capacity in developing countries, have increased the sustainability divide between developed and developing countries.

A global effort to achieve sustainability is justified by the relative indivisibility and interconnectedness of marine ecosystems, the roaming of long-distance fleets, the common nature and dynamics of fishery resources, and the intertwining of countries through international trade and bilateral fishing agreements. To eliminate the current disparity between developed and developing countries, and to make progress towards the zero-overfishing target set by the 2030 Agenda, the global community needs to renew its efforts to support developing nations in the pursuit of sustainability.

The solutions include:

- enhancing regional and global partnerships to share management knowledge and enhance the institutional and governance capacity of developing countries;
- adjusting fishing capacity to sustainable levels through policy and regulations, including judicious use of targeted incentives, while eradicating subsidies that contribute to overcapacity and overfishing or support IUU fishing;
- establishing a trading system for fish and fish products that promotes resource sustainability;
- encouraging a global mechanism and financial support to accelerate parties' fulfilment of legally binding and voluntary instruments.

Replication and adaptation of successful policies (for example, in management interventions) and implementation of transformational changes (that is, lasting policies that influence entire sectors of the economy) are needed if exploitation of global fishery resources is to be truly sustainable.

» In light of the focus on SIDS of target 14.7, FAO will consult with regional SIDS stakeholders on the indicator methodology being developed – in particular to help describe the value of sustainable fisheries – at three regional workshops (for SIDS in the Pacific; in the Atlantic, Indian Ocean, Mediterranean and South China Sea [AIMS]; and in the Caribbean) to be convened in collaboration with regional agencies. As a first step towards the development of the indicator for this target, FAO is developing a methodology for calculating the contribution of fisheries and aquaculture to gross domestic product (GDP), using data obtained through the System of National Accounts (the GDP indicator). However, because of the limitations associated with the GDP indicator, a more comprehensive indicator will be developed to complement it; this indicator will incorporate IUU fishing, resource rent and trade in fisheries services and will also take into account small-scale, subsistence and recreational fisheries.

Ongoing studies on the factors that may have an impact on the effectiveness of monitoring for SDG 14 targets (Recuero Virto, 2017) are reviewing the existing framework for the SDG 14 indicators and examining potential synergies with multilateral environmental agreement indicators as well as links among the SDG 14 targets and with other SDG targets. In analytical efforts complementary to the official SDG monitoring, the SDG Index and Dashboards report (Sachs *et al.*, 2017), using indicators different from those adopted by the UN Statistical Commission (ECOSOC, 2017c), confirms that worldwide no country has yet achieved SDG 14. ■

FAO'S APPROACH TO IMPROVING THE QUALITY AND UTILITY OF CAPTURE FISHERY DATA

Fisheries and aquaculture statistics have a critical role in informing national, regional and global policy and decision-making, and in particular in supporting the 2030 Agenda for Sustainable Development. The collection and dissemination of statistical information on the fisheries and aquaculture sector constitute an essential part of FAO's mission concerning food and nutrition. This function is embedded in Article 11 of the Constitution of FAO and has been performed since the Organization's establishment in 1945. FAO is the only source of global fisheries and aquaculture statistics, which represent a unique global asset for sector analysis and monitoring. Data collections on capture and aquaculture production, fisheries commodities production and trade, fishers and fish farmers, fishing vessels and apparent fish consumption were primarily established to determine the contribution of fisheries to food supply and to the national economy (Box 5). The advent of the SDGs engendered adaptation of FAO's fisheries and aquaculture statistics to ensure their relevance, accuracy, appropriate level of detail, timeliness and accessibility in support of the three pillars of sustainable development (economic, social and environmental). While this section deals with capture fishery data, many of the issues and solutions discussed (e.g. meeting policy needs, data quality, data processing, capacity building) also apply in relation to aquaculture data.

Quality assurance, cooperation and transparency

As a custodian agency for four indicators of SDG 14, FAO is tasked with ensuring correct implementation, monitoring and consistent reporting through high-quality data that are sufficiently disaggregated, consistently comparable across national, regional and international bodies and comprehensive in their coverage of all dimensions of fisheries (commercial, subsistence and recreational). FAO is thus responsible for supporting countries' national statistical systems to meet this demand, in keeping with its mission to assemble and disseminate global fishery statistics at the highest possible quality level.

The definition and coordination of statistical work programmes worldwide to meet the demand for SDG monitoring has become a high priority (HLG-PCCB, 2018). Accordingly, FAO is working to improve the quality and credibility of its fishery statistics by building a cohesive and more transparent statistical framework, through both internal and external collaboration. »

BOX 5
ESTIMATING TOTAL FISH CATCHES AND THEIR MEANING

FAO maintains the only global capture production database available. The database is a collection of nominal catches, which are defined as the net weight of the quantities landed, as recorded at the time of landing, converted to their live-weight equivalents. The database is primarily based on the official statistics submitted by member countries, but these may be complemented or replaced with data from other sources (e.g. "best scientific data" from RFBs). The concepts and standards for the collection and processing of FAO fishery statistics are set by the FAO Coordinating Working Party on Fishery Statistics (CWP) (Garibaldi, 2012).

FAO capture statistics were established primarily to determine the contribution of fisheries to food supply. It is recognized that the FAO capture database does not include all fish caught in the wild, as it omits the portion of the catch that is discarded at sea and catches from illegal, unreported or unregulated (IUU) fisheries, which are both inherently difficult to estimate. In this regard, FAO has commissioned several evaluations of global discards in which the total volumes differed significantly, a reflection of the methodological difficulties associated with their estimation (Kelleher, 2005). FAO also convened a workshop in 2015 aimed at updating global IUU estimates, which concluded that the lack of robust and consistent methodology and the intrinsic lack of transparency in IUU fishing result in highly uncertain estimates (FAO, 2015c).

In recent years a number of studies have attempted to estimate the volume of total removals (e.g. Pauly and Zeller, 2016; Watson and Tidd, 2018), which fundamentally requires estimation of discards at sea and IUU fishing with geographical and temporal precision. These exercises conclude that the amount of fish entering food networks may be much larger than the reported statistics indicate, but diverge on the temporal trends in total removals, largely as a result of differing methodological assumptions for IUU estimation (discussed in detail in Ye *et al.*, 2017).

FAO recognizes the potential value of catch reconstructions, especially for drawing attention to problematic statistics. Such exercises may provide additional information on fisheries' contributions to food security and nutrition as well as discarded catches, help identify fishery subsectors that are not well covered in national data collection systems and so help countries refine their data collection methodologies and, if necessary, revise their statistics. However, the large uncertainty involved must be recognized, especially in interpreting contrasting trends derived from differing and highly debated methodological approaches (see Ye *et al.*, 2017). FAO recommends that statistics from primary sources (i.e. countries' and RFBs' submissions) be clearly separated from data derived from secondary studies to avoid confusion in their interpretation by the user community.

Interpreting trends in global capture fisheries production requires caution, primarily because they are the sum of thousands of combinations of species, fishing areas, fleets and countries and influenced by management measures that may or may not be in operation over time. It is well known that catches do not necessarily reflect abundance and thus stock status. It would be misleading to associate catch trends with stock sustainability without considering changes in fishing effort, including those caused by management regulations (and their implementation over time), as overfishing and efficient management systems designed to rebuild stocks can both result in a decline in catch. It is for this reason that the FAO (2016c) interpretation that global marine capture fisheries have been stable over the past 30 years (especially if the highly variable and abundant anchoveta, *Engraulis ringens,* is excluded) does not imply that the state of the resources is also stable (Ye *et al.*, 2017). It is recognized that well-assessed fisheries have been moving towards sustainability in recent decades (Costello *et al.*, 2012; Worm *et al.*, 2009). However, over 30 percent of global stocks are overfished, a share that has been increasing over time. A change in direction is crucial to reach the targets of SDG 14.

Internally, FAO has engaged in a major effort to develop an Organization-wide statistical quality assurance framework, in which quality is defined as the degree to which its statistical outputs fulfil requirements in the following dimensions of quality: relevance, accuracy and reliability, timeliness and punctuality, coherence, accessibility and clarity. As a baseline, FAO collects data reported by Members through standard questionnaires, collates them and processes them, ensuring application of agreed standards and estimating missing data where necessary. FAO has established a series of mechanisms to ensure that the best available information is submitted, revised and validated, either directly or indirectly (e.g. using consumption surveys or satellite images). Improving fisheries dataset quality has historically meant applying a number of best practices, including:

- ensuring the highest possible rate of response by countries through collaboration with national offices whenever possible;
- improving the level of species breakdown (the number of taxa reported doubled between 1996 and 2016);
- prioritizing the best source of statistical information, including external sources where necessary;
- ensuring consistency through backward revision of catch trends when improvements in national data collection systems result in abrupt changes in reported time series (Garibaldi, 2012);
- checking overall consistency across multiple datasets through supply utilization accounts;
- fostering use and feedback by increasing the diversity and accessibility of dissemination channels (for example, online query panels, the *FAO Yearbook of Fishery and Aquaculture Statistics* and FishStatJ software, which provides access to a variety of fishery statistical datasets) (FAO, 2018a).

FAO's corporate quality assurance framework is now furthering this effort through improved questionnaires, more systematic and standard data processing methodologies, full traceability of decisions made and relevant supporting metadata to ensure transparency. Eventually, quality scores will be published for each FAO statistical dataset.

Externally, FAO is pursuing improvements in several dimensions of quality with RFBs under the umbrella of the Coordinating Working Party on Fishery Statistics (CWP) (FAO, 2017i), an international governance body for fishery statistical standards for which FAO provides the secretariat. Since 1960, CWP members have worked together in developing standard statistical concepts and international classifications, with the aim to ensure coherence and eventually enable consistent regional and global fisheries statistics.

An example of improvement regards streamlining of arrangements for improving consistency, reducing discrepancies among published global and regional datasets and reducing the reporting burden for countries. Such arrangements include the STATLANT standardized questionnaires (since the 1970s) and formal agreements between FAO and other CWP member organizations such as Eurostat (since the 1980s), tuna RFMOs (since the late 1990s) and the Southeast Asian Fisheries Development Center (SEAFDEC) (since 2007). Further work is now being conducted to expand such agreements to other institutions such as the Organisation for Economic Co-operation and Development (OECD) and additional RFBs (e.g. Regional Fisheries Committee for the Gulf of Guinea [COREP], Fishery Committee for the West Central Gulf of Guinea [FCWC], Regional Commission for Fisheries [RECOFI], Western Central Atlantic Fishery Commission [WECAFC]). In addition, best practices on streamlining statistical data workflow are being developed. Formal data sharing agreements among agencies should eventually address the six main lines of activity in FAO's vision of a streamlined reporting mechanism for fishery statistics:

- alignment of calendars;
- consistency in concepts, standards and definitions;
- mainstreamed data provision serving several reporting requirements for Member Countries;
- improved accessibility through harmonized published formats;
- active collaboration for analysis of gaps and discrepancies;
- transparency through systematic processing and documentation of sources.

While these data sharing agreements may represent additional challenges for the institutions, they will add immense value in terms of improved data quality.

Improvements are also pursued through CWP's regular review of policy and research requirements, undertaken cooperatively among its member organizations, to ensure the relevance of fisheries statistics in terms of scope, coverage and level of detail. In the mid-2000s, at the request of the UN General Assembly in relation to implementation of the United Nations Fish Stocks Agreement, CWP recommended action to enable separate reporting of catches within and outside EEZs at the global level. Several RFBs revised statistical geographic divisions accordingly, but unfortunately progress has been only partial because of a perceived lack of country commitment to transparency in this regard (UN, 2016). More recently, FAO (2016b) has drawn CWP's attention to small-scale fisheries and their distinction from large-scale fisheries, an issue of increasing international interest (Pauly and Zeller, 2016), strongly relevant to the 2030 Agenda and its focus on people, coastal communities and livelihoods. FAO recently proposed a statistical definition of small-scale food producers (Khalil *et al.*, 2017), which could serve as a model for categorizing small-scale fisheries in global fishery statistics.

Supporting data collection, availability and use

Enhancing the data supply chain is a prerequisite for improvement in the overall quality of FAO's unique and valuable fishery statistics database and for provision of better information that can support management and policy decisions at the national, regional and global levels (FAO, 2002; Ababouch *et al.*, 2016). To build sustainable long-term data collection capacity, action must be taken at each of these levels, in collaboration with national institutions, RFBs, international organizations, funding institutions and research partners.

At the national level, and particularly in countries where capacity is weak, challenges related to data availability should be tackled both by improving data collection systems and by bringing to light knowledge and data that have heretofore been unavailable. Since the 1970s FAO has supported the efforts of national institutions to improve data collection systems through field projects, training activities and translation of accumulated scientific and field experience into guidelines and software (e.g. Bazigos, 1974; Caddy and Bazigos, 1985; FAO, 1999a; Stamatopoulos, 2002). Projects have introduced sampling schemes based on statistical analysis, coverage of fisheries subsectors not sampled before and standardization of sampling at landing sites. A new training course on fisheries statistics has been delivered in over a dozen countries,[13] in collaboration with RFBs[14] and with financial support from the World Bank (de Graaf *et al.*, 2014).

To reconcile limited budgets and the pressure to collect an increasing range of data (FAO, 2018b), it has become crucial to promote non-government data collection and management systems. It has also become important to rationalize scattered data collection efforts, as existing data are often poorly integrated in national systems, remaining buried in computer spreadsheets or paper files and thus unavailable for analysis or reporting (Gutierrez, 2017; FAO, 2018b). On both issues, innovative information technology can significantly enhance progress: At the local level smartphones and tablets already contribute to improved data collection from beaches (de Graaf, Stamatopoulos and Jarrett, 2017) and on board vessels, and they also offer opportunities for co-managed data collection with non-State actors such as fishers or recreational fishery organizations (Caribbean ICT Research Programme, 2014; ABALOBI, 2017). To integrate and curate scattered data files, FAO is developing a global software framework built on cloud technology, geared to supporting national initiatives for integrated fishery statistics and management information systems.[15] Web-based inventories of stocks and fisheries, as used by the Fisheries and Resources

13 Benin, Burundi, Cameroon, Comoros, the Congo, Democratic Republic of the Congo, Côte d'Ivoire, Ghana, Madagascar, Myanmar, Nigeria, Sao Tome and Principe, Togo and United Republic of Tanzania.

14 COREP, FCWC, Southwest Indian Ocean Fishery Commission (SWIOFC).

15 In the Bahamas, Trinidad and Tobago, Oman and the Islamic Republic of Iran.

Monitoring System (FIRMS) (FAO, 2018c) to monitor global trends, constitute a nice solution for capturing, structuring and disseminating qualitative or empirical knowledge on fishery resources and fisheries.

Through the above activities, during the decade 2008–2018 FAO has supported no fewer than 50 countries in building their capacity in fisheries data collection, curation and processing.

RFBs have a key role in capacity building and strengthening of regional and global scientific knowledge. The assessment of migratory species and stocks straddling EEZs and the high seas and related management decisions rely on data collated among all concerned fisheries. It is important to ensure, through regional cooperation, that all data are collected in a harmonized manner and that they can be interpreted coherently. The data must also address the range of fisheries from artisanal to industrial scale, which requires different approaches to data collection. FAO is engaged in strengthening such data frameworks in a number of RFBs,[16] for example through activation of data and statistics working groups, the development of a regional data collection framework covering aspects such as minimum data requirements and statistical standards, and the implementation of regional databases to support stock assessment and fisheries management needs in a range of data-limited situations.

At the global level, FAO supports these regional and national processes through the global data framework for blue growth (FAO, 2016c, pp. 108–113). In particular, FIRMS, iMarine (2018) and Global Fishing Watch (2018) are three key partnership initiatives that FAO is developing into a global cloud-based collaboration platform to support fishery resource monitoring. Online tools provided by FAO include a regional database for intercountry data sharing and collaborative analysis; hands-on interactive training on basic assessment methods (Coro *et al.*, 2016); publishing of globally unique identifiers for stocks and fisheries to facilitate global monitoring for stocks and traceability schemes for fisheries (see Box 22, page 150 in Part 3); and automatic identification system (AIS) data services (discussed under "Disruptive technologies" in Part 4), which FAO is testing in the endeavour to improve estimates of geographically distributed fishing activities, to be published in an atlas of fishing footprint and effort – a compilation of AIS-based maps.

It is necessary to stimulate all aspects of the data and statistics supply chain (policy-making, international standards and procedures, technical and operational support) across national data collection, regional data sharing and global collation and dissemination, in order to facilitate and improve global assessments and monitoring. At all levels, collaboration and partnerships with Member Countries and other organizations, including intergovernmental and non-governmental organizations, academia and civil society, are crucial to improve fishery and aquaculture databases, information and knowledge and to assist in their interpretation and use.

Assessing and monitoring stock status

Assessment and monitoring of stock status is a key example demonstrating the need for and use of fishery data. Stock status is one of the critical parameters used in the implementation of management plans to assess the sustainability of fisheries and fishery resources in relation to reference points. Monitoring stock status over time can provide valuable information on resource productivity and fishery sustainability and enables a systematic review of the efficiency and effectiveness of fishery policy and regulatory measures. The percentage of world fish stocks fished within biologically sustainable levels is thus one of the indicators (14.4.1) for measuring progress towards SDG 14, specifically target 14.4 (on regulation of harvesting and ending overfishing, IUU fishing and destructive fishing practices).

FAO develops stock assessment methods and provides capacity building and technical support to Members in their initiatives to assess and monitor stock status. FAO has been assessing and monitoring world marine fishery resources since 1973 (FAO, 2011a). FAO's global assessment

16 e.g. COREP, FCWC, General Fisheries Commission for the Mediterranean (GFCM), ICCAT, Indian Ocean Tuna Commission (IOTC), RECOFI, WECAFC, SWIOFC.

builds on assessments from various sources, including those of national institutions and RFBs. However, many species and large ocean areas are not covered by any form of assessment; these are assessed with simple, non-model-based approaches mostly using catch trends from the FAO global capture database. The results are published every two years in *The State of World Fisheries and Aquaculture* (see Part 1). The global assessment was used, for example, as a data source for one of the indicators of the United Nations Millennium Development Goals (UN, 2015b) and provides main inputs to the United Nations World Ocean Assessment (UN, 2018b).

Challenges

Stock assessment is not properly carried out in many developing countries, and assessed stocks represent only about 25 percent of world catches (Branch *et al*., 2011). Indeed, assessing the status of fish stocks is not easy, as it is not only data demanding, but also technically intensive and financially costly. To increase the coverage of stock assessment and monitoring, the following multifaceted challenges need to be addressed.

Overcoming technical limitations. Stock status assessment and monitoring largely rely on classical assessment methods. Describing population dynamics and estimating stock status require refined numerical skills for the use of mathematical and statistical models, together with comprehensive fishery-dependent data, such as catch and fishing effort derived from regular fishery monitoring, as well as fishery-independent data on biomass trends, natural mortality, growth, gear selectivity and recruitment. Increasing attention is being given to improving fishery-dependent data, for example through the use of the latest technology, including satellites and smartphones, in data collection and transmission. Traditional assessment methods nevertheless continue to be demanding of expertise and of data which are expensive to collect. Recent advances have focused on methods that can be applied to data-limited fisheries (Rosenberg *et al*., 2014), including the development of empirical indicators to inform management. A technical breakthrough is needed, however, to make data-limited methods as reliable as classical methods in determining stock status. Taking an ecosystem approach to the assessment, which means including multi-species considerations as well as social, economic and environmental factors, is also a challenge.

Collecting minimal data. Stock status cannot be accurately assessed without sufficient data. High-quality fisheries data are often not available, particularly in developing countries. In some situations, minimal data such as total catch and number of vessels involved in a fishery are not even recorded. Stock assessment reliability can improve if basic catch data are augmented by other data such as catch per unit of effort (CPUE) for at least one involved fleet, length or age frequency distribution of species caught, and fishery-independent survey data, although the last are usually expensive to collect.

Institutional and human capacity building. The numerical modelling skills required for stock assessment are often in short supply and cannot be instilled through brief training. Many developing countries lack modelling professionals, and this shortage can only be addressed through long-term planning at the institutional level. A root cause of poor institutional capacity is the lack of understanding of modelling work and/or appreciation of the utility of its results by policy-makers and even other fishery scientists, and the consequent failure to use it for management purposes or to regard it as a priority. Strengthened institutional capacity along the entire intellectual chain from assessment to policy implementation is needed to facilitate effective fisheries management.

Complexity of shared stocks and migratory species. Many fish species migrate and straddle national EEZs and areas beyond national jurisdiction (high seas). For these species, the challenges of assessment, monitoring and management are different from those for species occurring only within EEZs. Migratory species occur in different areas at different life stages. However, because they are considered a single biological unit, fishing in any area will affect the whole stock, and integrated management among all areas is thus required. To achieve this goal, political agreements for joint management among the concerned countries must be strengthened or established. Mechanisms are then required for cooperation in data collection and exchange of information on fishing activity. These complex issues cannot be properly addressed in the absence of mandated regional fishery bodies or arrangements, and they may be exacerbated by climate change (see "Climate change impacts and responses" in Part 3). ■

COMBATING ILLEGAL, UNREPORTED AND UNREGULATED FISHING: GLOBAL DEVELOPMENTS

The promotion, regulation and monitoring of responsible fishing practices, through robust fisheries management and governance frameworks, are essential for the sustainability of fisheries resources in both coastal areas and high seas. The principles of responsible fisheries management have been prescribed in a number of international ocean and fisheries instruments and have been supported and strengthened by RFMOs around the globe. However, States do not always satisfactorily fulfil their duties in line with such instruments and regional mechanisms, and IUU fishing often occurs, undermining national, regional and global efforts to manage fisheries sustainably.

The international community, recognizing IUU fishing as a major threat to the sustainability of fisheries resources, to the livelihoods of the people that depend on them and to marine ecosystems in general, has addressed it extensively over the past decade. It is not enough for States to detect IUU fishing; they must strengthen fisheries laws and regulations, be able to take effective action against perpetrators to deter non-compliance, establish mechanisms that encourage compliance and ensure that subsidies or any other benefits that they grant to their fishing sectors do not nurture IUU fishing. While innovations in technology have enabled States to monitor their fishing fleets better and to safeguard their fisheries resources, there is a need to improve flag State performance and to implement port State measures, supported by the use of monitoring, control and surveillance mechanisms and tools. In addition, strengthening other areas of fisheries management, such as ensuring the consistent marking of fishing gear, can also be useful in the fight against IUU fishing.

Important achievements in the fight against IUU fishing include the development and adoption of international guidelines to improve flag States' compliance with their duties and to promote the use of catch documentation schemes (CDSs) for better traceability of fish and fish products in the value chain; the global and regional development of fishing vessel records; and – since fishing vessels also depend on the use of ports in States other than their own – the adoption of the FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA).

The SDGs address the importance of tackling IUU fishing under SDG 14. Target 14.4 explicitly identifies the need to end IUU fishing as a means for restoring fish stocks, while target 14.6 includes the elimination of subsidies that contribute to IUU fishing. Additionally, the fight against IUU fishing, although not specifically mentioned, has a major role in achieving targets 14.7 (increasing economic benefits to SIDSs and least developed countries) and 14.b (safeguarding access to marine resources for small-scale fishers). Furthermore, target 14.c, on implementing international law as reflected in UNCLOS, particularly in relation to duties of States for the conservation and sustainable use of oceans and marine ecosystems, is also relevant for the fight against IUU fishing.

Implementation of the Port State Measures Agreement

The PSMA (FAO, 2017j) sets conditions for the entry and use of ports by foreign fishing vessels. It defines minimum international standards to be applied by port States in reviewing information prior to the vessels' entry into port; conducting inspections in their designated ports; taking measures against vessels found to have engaged in IUU fishing; and exchanging information with concerned States, RFMOs and other international entities. The global implementation of the PSMA would effectively establish "compliance check-points" at ports around the world for a large number of fishing vessels, especially those that

BOX 6
CAPACITY DEVELOPMENT INITIATIVES TO SUPPORT IMPLEMENTATION OF THE PORT STATE MEASURES AGREEMENT AND COMPLEMENTARY INSTRUMENTS

In 2017, to support developing States (irrespective of whether they are Parties to the PSMA) in their efforts to combat IUU fishing, FAO launched a global capacity development umbrella programme: "Support for the Implementation of the 2009 Port State Measures Agreement and Complementary Instruments to Combat Illegal, Unreported and Unregulated Fishing". This programme assists States in strengthening their policy and legal frameworks, institutional setup and enforcement capacity, as well as their monitoring, control and surveillance systems and operations, placing them in a better position to combat IUU fishing effectively. It is being implemented in collaboration with partners including FAO Members, regional fishery bodies and other international organizations such as the United Nations Office on Drugs and Crime (UNODC), the International Maritime Organization (IMO) and the International Labour Organization (ILO).

operate in waters outside the jurisdiction of the flag State and seek entry into ports of other States. The agreement provides an opportunity for States to collaborate and exchange information on fishing vessels and their activities, which can also be done through and with RFMOs. It thereby creates a network that supports port States in combating IUU fishing, flag States in the control of their vessels, coastal States in protecting their fishery resources and market States in ensuring that products derived from IUU fishing do not enter their markets. Inspection and compliance records of fishing vessels compiled through the information exchange mechanism under the PSMA could serve as a reliable resource for inclusion in national risk assessments and could help States take appropriate action in cases of non-compliance with national, regional or international laws and regulations, including the prohibition or freezing of subsidies by the flag States concerned.

The PSMA entered into force in June 2016 with 30 Parties, including the European Union as one Party. The momentum has continued to build even after the PSMA entered into force; as of 5 April 2018, the agreement had 54 Parties (including the European Union), and numerous other States had initiated steps to take part, ensuring that the number of ports for use by IUU fishing vessels will continue to decrease.

The entering into force of the PSMA, while an important achievement, was only the beginning in terms of putting it into action. As requested by the Parties, a first meeting was held in 2017 to discuss issues concerning PSMA implementation, including the roles and responsibilities of States, RFMOs and other international organizations in implementing the agreement. Stakeholders outlined a workplan to ensure that the needed mechanisms would be in place. Recognizing the importance of access to basic information to fulfil the requirements of the PSMA, the Parties proposed the establishment of a global mechanism to facilitate the exchange and publication of information as a priority. FAO was tasked to develop this mechanism in consultation with the Parties. The Parties also outlined a process for monitoring and reviewing the implementation of the PSMA, an essential procedure at this preliminary stage.

Developing States Parties, constituting the majority of Parties and the majority of coastal States globally, are key to ensuring widespread implementation of the PSMA. Recognition of the requirements of developing States is paramount, and Parties emphasized the development of a framework to support developing States in their implementation of the agreement. A dedicated working group is tasked with addressing the requirements of developing States Parties, including the administration of required funding to support capacity development efforts (see Box 6).

Within a year after the PSMA entered into force, some notable achievements have already been made. At the national level, a number of States made efforts, such as updating relevant legislation and increasing port inspection capacity, to be able to implement the PSMA even before it entered into force, setting examples for the other Parties. At the regional level, the number of RFMOs that have adopted conservation and management measures regarding IUU fishing, and more specifically regarding port State measures, has continued to increase. Also at the regional level, initiatives to combat IUU fishing have increased in number and scope, including the adoption of Regional Plans of Action to combat IUU fishing, workshops and conferences. Achievements in combating IUU are expected to grow with the increased uptake and implementation of the PSMA and as the global commitment to combat IUU fishing continues to build.

Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels

The Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels (Global Record) was launched in April 2017, less than a year after the entry into force of the PSMA. This information system, which has been widely supported by FAO Members and Observers, is expected to close the information gap on vessels carrying out fishing and fishing-related activities. In addition to recording identification information such as registration, vessel characteristics and ownership, it also includes information relevant to the fight against IUU fishing such as previous vessel names, owners and operators as well as authorizations to fish, transship or supply and history of compliance.

This first version of the Global Record, initially available to FAO Members for data upload, was developed with the contributions of experts from FAO Member Countries and observers through the Global Record Working Group and Specialized Core Groups. These groups facilitated not only the design of the tool itself, but also the standardization of data exchange mechanisms and data formats, which is necessary for such a global system. States with some of the world's major fleets have already submitted data, and it is expected that other States will contribute before long. FAO's target is to release the Global Record to the public in 2018, making the data available to all stakeholders and demonstrating the international commitment to increase transparency and deter IUU fishing.

It is widely accepted that the Global Record will play an important role in support of the PSMA and other international instruments such as the United Nations Fish Stocks Agreement, particularly by providing reliable, up-to-date information about the identity and characteristics of vessels and their activities which is useful for counterchecking the information provided by the masters of vessels when requesting entry into port or upon arrival in port. The information is also useful in risk analysis on which to base inspection decisions. This global tool will not only be useful to port and coastal States, but also to flag States, which can check on the history of a vessel (names, flags, owners and operators) when taking decisions on registering vessels under their flag. It will also provide valuable information to market States on the legal (or not) origin of the fishery products that enter national and international markets, particularly through linkages with catch documentation schemes through the Unique Vessel Identifier.

Catch documentation schemes

Voluntary Guidelines on Catch Documentation Schemes were officially approved by the Conference of FAO in July 2017, following a lengthy development process.

The first documentation scheme was the Trade Documentation Scheme, introduced by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 1992. Catch documentation was first formally mentioned in the International Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (FAO, 2001) under "Internationally agreed market–related measures". In the Fisheries Resolution adopted by the UN General Assembly in December 2013, UN Member States expressed serious concerns over the continued threat to fish stocks and aquatic ecosystems presented by IUU fishing, and recognized FAO's work on CDSs and traceability. The resolution called on Member States to work with FAO to elaborate guidelines and other relevant criteria relating to CDSs (including possible formats), in accordance with international law, including relevant agreements established under the World Trade Organization (WTO).

The guidelines are designed to provide assistance to States, RFMOs, regional economic integration organizations and other intergovernmental organizations in developing and implementing new CDSs or harmonizing or reviewing existing CDSs. The guidelines outline basic principles and provide guidance for their application. They address cooperation, notification, recommended functions and standards and the special requirements of developing States and small-scale fisheries. They call upon States, relevant international organizations (both governmental and non-governmental) and financial institutions to provide financial and technical assistance, technology transfer and training to help developing States implement the guidelines, particularly in regard to the issuance of electronic catch certificates. An annex summarizes core information elements for catch certificates, including information along the supply chain.

Port States have a significant role in the implementation of the CDS guidelines, with their capacity to deny access to the supply chain for catches derived from IUU fishing. The PSMA establishes the minimum legal framework that would enhance a port State's capacity to fill this role and enable the port State to cover critical points along the supply chain. Once the products of IUU fishing are denied market access through the effective implementation and enforcement of CDSs and PSMA, the financial incentives underlying IUU fishing operations will be reduced. As such, the PSMA, the CDS Guidelines and the Global Record represent a synergistic framework for combating IUU fishing.

Efforts of regional fisheries management organizations in the fight against IUU fishing

As highlighted in a recent email-based survey conducted through the Regional Fishery Body Secretariats Network (RSN), RFMOs are playing a leading part in regional and global efforts in the fight against IUU fishing, through integrated conservation and management measures, monitoring, control and surveillance (MCS) requirements and information exchange. Approximately 90 percent of RFMOs surveyed have adopted, or are in the process of adopting, relevant measures for combating IUU fishing (see Box 7),

BOX 7
EXAMPLES OF INITIATIVES AND MEASURES ADOPTED BY RFMOs TO COMBAT IUU FISHING

- Port State measures
- IUU vessel lists (with some RFMOs having both Contracting Party and non-Contracting Party lists)
- Vessel monitoring systems in conjunction with catch documentation schemes, vessel catch reporting and transshipment notification
- Satellite aperture radar
- Vessel authorization, licensing and marking requirements
- Consolidated List of Authorized Vessels (CLAV) (in the case of tuna RFMOs)
- Market-related measures
- Information sharing on particular areas or species
- Enforcement committees
- Actions to promote compliance by non-Contracting Party vessels
- Procedures for application of sanctions
- Participative discussions with non-governmental organizations
- Capacity building activities to support the implementation of relevant measures
- Regular evaluation and monitoring of compliance by Contracting Parties
- Performance reviews to provide comprehensive analysis of compliance and enforcement and to improve the functioning of RFMOs

and most of them already have such conservation and management measures in place.[17]

IUU fishing has been reduced in areas regulated by some RFMOs over the years. RFMOs that continue to face challenges in this respect are applying recommendations from performance reviews and developing new MCS tools, using CDSs and implementing or considering regional vessel monitoring systems (VMSs). Some RFMO Contracting Parties carry out patrolling and radar satellite surveillance. Collaboration among RFMOs, other organizations and agencies facilitates and supports efforts to combat IUU fishing. RFMOs are strategically positioned to coordinate efforts with key stakeholders in their respective regions to enforce necessary measures. ■

BIODIVERSITY, FISHERIES AND AQUACULTURE

The world's aquatic ecosystems are structurally and functionally highly biodiverse, a vital web of thousands of interconnected species which support fisheries and aquaculture, contributing to the nutritional, economic, social, cultural and recreational betterment of human populations (Box 8). All phyla but one are found in the oceans (34 phyla), compared to 15 phyla that are found on land. Aquatic biodiversity is sustained in the wild across marine (oceans, seas, estuaries), brackish and freshwater (lakes, reservoirs, rivers, rice paddies and other wetlands) environments, as well as in culture within managed production systems. Freshwater ecosystems, although they contain less than 1 percent of all water, hold about 40 percent of the world's fish species (Balian *et al*., 2008).

Maintaining biodiversity is critical to meeting the objectives of the three pillars of sustainability – environmental, social and economic. An erosion of biodiversity would not only affect the structure and function of ecosystems (see also "Blue growth in action" in Part 4), but would also impair the potential for such systems to adapt to new challenges such as population growth and climate change (see "Climate change impacts and responses" in Part 3). In the past few decades, the role of biodiversity in supporting a number of critical ecosystem services has gained more and more attention (Beaumont *et al*., 2007). Most recently, a number of governments have made international commitments to conservation of marine biodiversity within the framework of the 2030 Agenda and the Convention on Biological Diversity (CBD).

Area-based management measures in coastal areas and inland waters

A number of both static and dynamic area-based management tools are used to support the conservation of biodiversity, enhancing countries' ability to implement the ecosystem approach to fisheries (discussed in the last section of Part 2). Spatial and temporal fishing restrictions, including long-term "no-take" closures, have a long history of use in fisheries alongside a range of other measures, and predate the current concept of aquatic protected areas for biodiversity conservation. More recently, with an increase in ocean technology and the ability to acquire information in real time, other concepts such as dynamic ocean management have gained increasing traction (Dunn *et al*., 2016), offering great promise for the sustainable management of ocean resources.

Protected areas

Aquatic protected areas, including marine protected areas (MPAs), were initially introduced in the context of biodiversity conservation to protect aquatic ecosystems and reverse the degradation of their habitats, and are increasingly promoted by the environment sector as a complement to fisheries management measures to address overfishing and unsustainable resource utilization (FAO, 2011b). A number of international policy instruments have recently been established in support of marine protected areas. Aichi target 11 and SDG target 14.5, in particular, aim for the designation of 10 percent

17 RFMOs surveyed: Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); General Fisheries Commission for the Mediterranean (GFCM); Inter-American Tropical Tuna Commission (IATTC); Indian Ocean Tuna Commission (IOTC); Northwest Atlantic Fisheries Organization (NAFO); North Atlantic Salmon Conservation Organization (NASCO); North-East Atlantic Fisheries Commission (NEAFC); North Pacific Anadromous Fish Commission (NPAFC); North Pacific Fisheries Commission (NPFC); Regional Commission for Fisheries (RECOFI); South East Atlantic Fisheries Organisation (SEAFO); South Indian Ocean Fisheries Agreement (SIOFA).

BOX 8

MAINSTREAMING BIODIVERSITY CONCERNS IN FISHERIES

Biodiversity mainstreaming, the consideration of biodiversity across fisheries and aquaculture, has gained substantially in profile since the 1992 adoption of the Convention on Biological Diversity. The broader impact of fisheries on natural renewable resources and the environment more generally was enshrined in the 1982 Law of the Sea Convention, which shows due regard to target species in fisheries, but also to associated and dependent species. The United Nations Conference on Environment and Development (UNCED) and its Agenda 21 spurred research on the effects of differing gear, bycatch, habitat impacts and perturbations of trophic relationships on the ecosystem. FAO, as the UN agency with competence for fisheries, developed the Code of Conduct for Responsible Fisheries (FAO, 1995) and guidelines on sustainable indicators, the precautionary approach and the ecosystem approach, which contributed directly to mainstreaming of biodiversity in fisheries policy and management (Sinclair and Valdimarsson, 2003). The adoption of the Aichi Targets by the Parties to CBD in 2010 reflects the global societal expectation of biodiversity conservation in sectoral management, with Aichi target 6 outlining a comprehensive series of deliverables for fisheries and Aichi target 11 focusing on effective area-based management of biodiversity in the oceans. This international process, and the related SDG 14, outlines fisheries' accountability for the full footprint of its activities and facilitates the measurement of countries' action in mainstreaming biodiversity into their policies and management measures.

At the UN Biodiversity Conference in Mexico in 2016 (the thirteenth meeting of the Conference of the Parties to CBD) – which had the theme "Mainstreaming of Biodiversity for Well-Being" – FAO and its partners showed how consideration of biodiversity had been strengthened in relation to management and conservation of fisheries, with a particular focus on policies and actions in relation to conservation of threatened species and vulnerable habitats, and announced the creation of a multistakeholder dialogue on biodiversity (FAO, 2018f). FAO also highlighted efforts by RFMOs and national fishery authorities to update their management instruments or replace them with new ones incorporating more active management rules for species and habitats of particular conservation concern, often in close collaboration with environment sector interests. The Sustainable Ocean Initiative, for example, aims to strengthen the convergence of actions by RFMOs and regional seas organizations (CBD, 2018).

of coastal and marine waters as protected areas by 2020. Governments, foundations, non-governmental organizations (NGOs) and local communities around the world are channelling substantial interest, capacity and funding to the establishment of MPAs. It is important to recognize that while MPAs have positive effects on biodiversity inside no-take zones, efforts to secure the sustainability of aquatic resources must build on a wider range of natural resource management interventions. Implemented in isolation, MPAs can result in shifting of fishing pressure to areas that lack adequate management measures, or may have significant impacts on the livelihoods and food security of fisheries-dependent communities. As with any management tool, it is critical to evaluate protected areas in terms of their potential management and conservation outcomes, yield and economic performance, taking into consideration the cost of effective implementation and long-term management (FAO, 2011b).

Dynamic ocean management

Dynamic ocean management is defined as management that changes in space and time in response to the shifting nature of the ocean and its users, based on the integration of new biological, oceanographic, social and/or economic data in near real-time (Maxwell *et al.*, 2015). Proponents of this approach maintain that by better aligning human and ecological scales of use, it can increase the efficacy and efficiency of fisheries management compared to static approaches (Dunn *et al.*, 2016). Three types of dynamic ocean management measures have been considered:

- grid-based hot-spot closures, which are usually implemented on a weekly or monthly basis when bycatch has exceeded a threshold level in a specific area;
- real-time closures based on move-on rules, which operate according to a similar threshold principle, but entail fishers moving a set distance away from the affected area, rather than referring to predefined grid cells on a map;
- oceanographic closures, based on the oceanographic characteristics of a specific area (e.g. sea surface temperature).

Marine zoning

The increasing competition for marine space has generated pressure on both marine users (such as fishers and tourism operators) and the ecosystem. Given the scale and complexity of the issues, a systematic approach is required to mitigate conflict, conserve biodiversity, accommodate multiple uses and ultimately support sustainable development. Marine spatial planning (MSP) is such an approach. MSP is defined as a "public process of analysing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process" (Ehler and Douvere, 2009). Its main output is a spatial management plan for a specific area, which defines priorities in time and space. Implementation of MSP usually takes place via a marine zoning map and/or permit system. It does not replace single-sector planning, but it provides guidance to help single sectors make decisions in a more holistic, comprehensive way. A marine zoning map can outline a number of types of areas related to fisheries, including marine protected areas, areas of seasonal fishing closures and biodiversity hot-spot protection. MSP can also be used to designate zones within a marine protected area (MPA), from multiple-use to no-take areas.

Interaction of area-based management tools with livelihoods and food security

Area-based management measures are intended to regulate human behaviour. Successful protected-area planning and implementation requires participatory approaches to recognize and incorporate people's different views and values. The process by which a spatial closure is designated is key to whether it will be accepted, respected and hence able to meet its objectives and provide the benefits for which it has been established (FAO, 2011b; Charles *et al.*, 2016). The objectives need to be clear, and planning should explicitly integrate broad objectives of both ecological and human well-being, including food security and local livelihoods (FAO, 2016d; Garcia *et al.*, 2016; Singleton *et al.*, 2017). It is also important to ensure that area-based management measures do not conflict with the cultural and livelihood practices of indigenous groups, to avoid impacts on their food security (Westlund *et al.*, 2017).

The SSF Guidelines (FAO, 2015a) and the Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security (FAO, 2012a) outline the need to respect customary tenure rights. In addition, they highlight the need to ensure active, free, effective, meaningful and informed participation of all stakeholders, including indigenous peoples and both men and women, in all decisions related to fishery resources and areas where small-scale fisheries operate, as well as adjacent land areas. If these principles are respected, area-based management tools can provide a mechanism for increasing stewardship of marine resources and for recognizing and protecting traditional fishing grounds and places of cultural importance for local and indigenous peoples. The setting aside of aquatic areas to provide a higher degree of protection for particular biological and/or habitat diversity can also lead to the reduction of conflicts among fishers, offer protection for small-scale fishing areas (for example, through demarcation of exclusive coastal areas for small-scale fishers) and help to enhance local livelihoods where fishery resources recover and catches improve over time – both within the protected area and in adjacent waters (FAO, 2011b).

In supporting knowledge generation and awareness-raising on area-based management approaches and fisheries, livelihoods and food security, FAO aims to ensure that protected areas are integrated within broader fisheries management frameworks and follow good practices with regard to participatory approaches, especially for small-scale fisheries (FAO, 2017k).

Management and conservation of threatened species

Although species extinctions in the oceans are markedly lower than on land (McCauley *et al*., 2015), FAO works with its Members, regional fishery bodies and partners to respond to recognized biodiversity threats across marine and freshwater realms. Species become threatened for a range of reasons which include overfishing of target stocks and impact of fishing activity on non–commercially exploited stocks. FAO helps countries respond to such situations, largely through strengthening of national and regional fisheries management and conservation measures to rebuild stocks or avoid interactions with fishing. These activities cross areas of governance, management of fishing effort, stock assessments, market measures and work on related socio-cultural values.

In its efforts to secure sustainability of threatened stocks, FAO collaborates with the 182 Parties of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), a multilateral treaty that aims to ensure that international trade does not threaten the survival of species in the wild. CITES puts in place specific binding regulations for the export and import of the species listed in its appendices, including aquatic (marine and freshwater) species, to help control their international trade. Species can be listed under one of three appendices, each with concomitant provisions (ranging from permit requirements, for species that are not now threatened with extinction, to prohibition of trade for the most endangered species) that countries need to service to comply with CITES (CITES, 2017).

Up until 1994, relatively few aquatic species were listed in the CITES appendices (for example, less than 150 fish species as compared with over 3 000 species of mammals, birds and reptiles and more than 30 000 species of flora). More recently, CITES Parties have shown greater willingness to put trade controls on marine species; since 2013, new listings added to Appendix II (species whose trade may be authorized through permits if the relevant authorities are satisfied that it will not be detrimental to the survival of the species in the wild) include 20 commercially exploited shark and ray species, 1 ornamental fish species and 1 invertebrate species.

Supporting countries in CITES implementation and species listing amendment processes

Both FAO and CITES recognize sustainable use of aquatic resources as part of their respective strategic visions. Under a Memorandum of Understanding signed in 2006, they work together to advise on listing of aquatic species and to strengthen implementation of management of species already listed in CITES appendices. As the UN Agency with responsibilities for fisheries, FAO is mandated in the CITES convention text (Art. XV 2b) to provide expert advice on whether commercially exploited aquatic species meet the CITES listing criteria.

COFI has endorsed the setting up of an FAO/International Union for Conservation of Nature (IUCN) joint technical working group to encourage cooperation among all the main stakeholders to promote better understanding of, and complementarity among, the various criteria used to define species as threatened (i.e. CITES criteria, IUCN Red List and Red List Index criteria). FAO, through its Expert Advisory Panel for the Assessment of Proposals to Amend CITES Appendices I and II, brings together experts on fisheries management, aquatic species and trade to determine if a species proposed for a listing amendment meets specific criteria to warrant a change in its status. This panel also advises on the merits of each species proposal in terms of the likely effectiveness of a CITES listing for its conservation.

FAO is currently working with countries to raise awareness on species that have been suggested for listing amendments at the next Conference of the Parties to CITES, which will be held in Colombo, Sri Lanka in May 2019 (for species examples, see FAO, 2017l). FAO has also asked the CITES Secretariat to intervene where it can to ensure that the process for consideration of aquatic species listing amendments offers fair and considered advice for its voting Parties. This effort is important, as many CITES Party representatives do not have a fisheries background, experience of aquatic science or knowledge of the governance frameworks that are established and in place for management and conservation of marine and freshwater resources.

The need for capacity development, processes and tools to help Members implement the fish-related requirements of CITES is growing, especially for developing countries that wish to ensure continuation of fish trade where CITES provisions can be met. FAO works collaboratively with partners, including the CITES Secretariat, to promote and support capacity building for implementation of fisheries management that supports CITES provisions (for legality and sustainability of trade), for example through:

- decision support and shared programme planning or management of species in CITES appendices, including the development of National Plans of Action to guide national fisheries management (e.g. for sharks and rays, humphead wrasse);
- assessment and communication of fisheries responses to threatened species listings, for example through a Web-based portal documenting the broad range of national and regional management responses in relation to fisheries for chondrichthyes (a database of measures put in place to document management and conservation of sharks and rays) (FAO, 2017m).

Looking ahead

FAO will continue to support its Members and CITES Parties through the species listing process by delivering science-based information, alongside other bodies with responsibility or expertise for the species that are proposed for CITES consideration. FAO also continues to work collaboratively with the CITES Secretariat and CITES Parties to improve understanding of the practical application of CITES listings (FAO, 2016e). Understanding the successes and challenges in the application and impacts of implementing CITES provisions helps FAO inform countries of best practices and steer investment in management and conservation where it is most needed, with the overall intent of improving the implementation of the convention.

FAO also continues to strengthen country capacity for species-level reporting from fishery and trade activity, and to determine the abundance and range of traded commodities, for species listed under CITES Appendix II – for example, to fill the recognized gap in the global knowledge of the level or importance of trade in non-fin shark and ray commodities, which includes meat for consumption, skin, oil and cartilage. The outlook for collaborative work between FAO and CITES continues to improve, with new funding from the European Union, Japan and the United States of America supporting collaborative opportunities for the fisheries and environment sectors to work together to ensure sustainable and productive oceans, now and into the future.

Aquatic genetic resources

The diversity of aquatic genetic resources (AqGR) – genetic diversity among different species, populations and even individuals (natural and as a result of breeding programmes) – represents a valuable and in many cases unexplored reserve of the "building blocks" that underpin sustainable production and trade of fish, invertebrates and plants in both capture fisheries and aquaculture.

With modern assessment tools, it has become easier to describe AqGR, in order to manage and conserve them and to enhance their contribution to food security, nutrition and livelihoods. For capture fisheries and aquaculture, the value of AqGR for increased production, resilience, efficiency and profitability has been demonstrated. The untapped potential of the world's AqGR for future food supply is becoming increasingly evident with further understanding of the genetic variability of wild stocks and the ability to breed for desirable character traits in aquaculture species. To assist the development, management, conservation and responsible use of AqGR in fisheries and aquaculture, FAO promotes the development of science-based policies by providing expert technical and scientific advice to inform decision-makers and the public on AqGR-related issues (e.g. recording and sharing of existing information on AqGR, accessibility of AqGR, initiatives to protect known genetic strains). The challenge is to maintain a broad genetic base for the future, rather than focusing only on improving a limited number of commercially viable fish strains.

The increasing scope for use and trade of genetic resources requires policy-makers, government resource managers, the aquaculture private sector and rural communities to implement new approaches to management and responsible use of these resources and genetic technologies (e.g. selective breeding, hybridization and genetic characterization). To this end, information on the use of technologies and resources must be traceable, and consolidated information must be available on the effectiveness of management through monitoring against standard indicators. Despite the crucial role of wild aquatic species and their farmed relatives in contributing to global food security and sustainable livelihoods, this information is still somewhat disaggregated and generally incomplete, with recognized gaps in reporting of data at the country level and hence to FAO at the international level. Furthermore, characterization of aquatic genetic diversity at below-species level is currently limited to relatively few species and countries. In response to this challenge, FAO is currently working with its Members to develop appropriate and commonly agreed AqGR diversity indicators.

Reporting on the state of the world's aquatic genetic resources

Improved information on the status, trends and drivers affecting AqGR is increasingly important to underpin sound management of sustainable aquaculture and fisheries and to improve opportunities for supporting food security and nutrition. At the same time, many countries have limited policy frameworks and legislation for managing and conserving AqGR and currently lack the capacity and/or the resources to collect and report information on aquatic genetic diversity. To improve the collection and sharing of information on AqGR, FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA) tasked FAO with producing a *State of the World's Aquatic Genetic Resources for Food and Agriculture* report. The new report, following review by the Intergovernmental Technical Working Group on Aquatic Genetic Resources for Food and Agriculture, will be submitted for endorsement by the 33rd Session of COFI in July 2018.

The report is based primarily on country reports submitted to FAO by its Members, which have been incorporated into a database for periodic updating and analysis (proposed for every ten years). As of November 2017, nearly 100 country reports had been received, from which the following observations can be made:

- several countries reported on more species and species types than in the past;
- the wild relatives of farmed aquatic species are extremely important in aquaculture and capture fisheries;
- the populations of many wild relatives that are fished have declined in recent years;
- the main reason for the decline in wild relatives is habitat loss and degradation;
- national policies regarding the use of AqGR often constrain access to them;
- numerous strains of aquatic species are used in aquaculture, but there is currently no agreed global norm or mechanism for documenting or monitoring their use;
- although selective breeding is the most common form of genetic improvement, most aquaculture facilities farm the wild type, i.e. strains that are not domesticated or genetically improved;
- the use of non-native species is extremely important in aquaculture.

Five thematic background studies complement the state of the world report (available at www.fao.org/aquatic-genetic-resources/background/sow/background-studies), providing information that has not previously been reported to FAO:

- Incorporating genetic diversity and indicators into statistics and monitoring of farmed aquatic species and their wild relatives
- Genome-based biotechnologies in aquaculture
- Genetic resources for farmed seaweeds
- Genetic resources for farmed freshwater macrophytes
- Genetic resources for microorganisms of current and potential use in aquaculture

In the context of reporting on the state of the world's AqGR, it is worth noting that the ninth session of the COFI Sub-Committee on Aquaculture (COFI SCA), held in October 2017, recognized a number of issues for future attention, including the lack of capacity in genetic characterization of farmed species and strains used in aquaculture, the long-term investment required for genetic improvement and the need for comprehensive guidelines on approaches on a range of genetic improvement options. COFI SCA stressed the importance of high-quality seed and genetic improvement programmes in aquaculture and specifically cited selective breeding, particularly as an effective means for increasing production efficiency and improving aquatic animal health. ■

GLOBAL INLAND FISHERIES REVISITED: THEIR CONTRIBUTION TO ACHIEVEMENT OF THE SDGs

With the 11.6 million tonnes harvested from inland capture fisheries and 51.4 million tonnes from inland aquaculture, freshwater ecosystems are important sources of food fish and have accounted for about 40 percent of all fish destined for human consumption in recent years. As inland capture fisheries production is often under-reported, its importance as a source of food, income and livelihood in many developing countries and food-insecure areas may be even larger than these figures imply. The majority of global inland fishery production is in developing countries in Asia and Africa (Figure 34). Low-income food deficit countries (LIFDCs) provide 43 percent of global inland capture fish production (see Box 11 in "Fish for food security and human nutrition", page 117). Indeed 15 of the 21 countries with the highest per capita inland fish production are LIFDCs. The impact of inland capture fisheries may be focused in specific areas of a country. In Brazil, for example, the national average consumption of freshwater fish (from inland capture fisheries and freshwater aquaculture) is rather low at 3.95 kg per capita per year in 2013 (FAO, 2017n), but in the flood plains of the Amazon, per capita inland captured fish consumption by riverine communities is close to 150 kg per capita per year (Oliveira *et al.*, 2010).

The contribution of inland fisheries has often been overlooked in policy discussions and the global sustainable development agenda (FAO, 2016f), mainly because of lack of awareness of the real contribution of inland fisheries and the ecosystems that support them. In addition, inland fisheries are dispersed and not generally associated with intensive yields or taxable revenue. In many developing countries and particularly LIFDCs, inland fisheries, the people that depend on them and the ecosystems that support them are extremely vulnerable to impacts of ill-advised development, poor labour practices, pollution, habitat loss and climate change. Furthermore, at present, most inland fisheries are poorly managed or not managed at all. Competition for freshwater from more powerful sectors, such as agriculture and energy, typically reduces water quantity and quality for inland fisheries. Post-harvest losses are substantial in some regions.

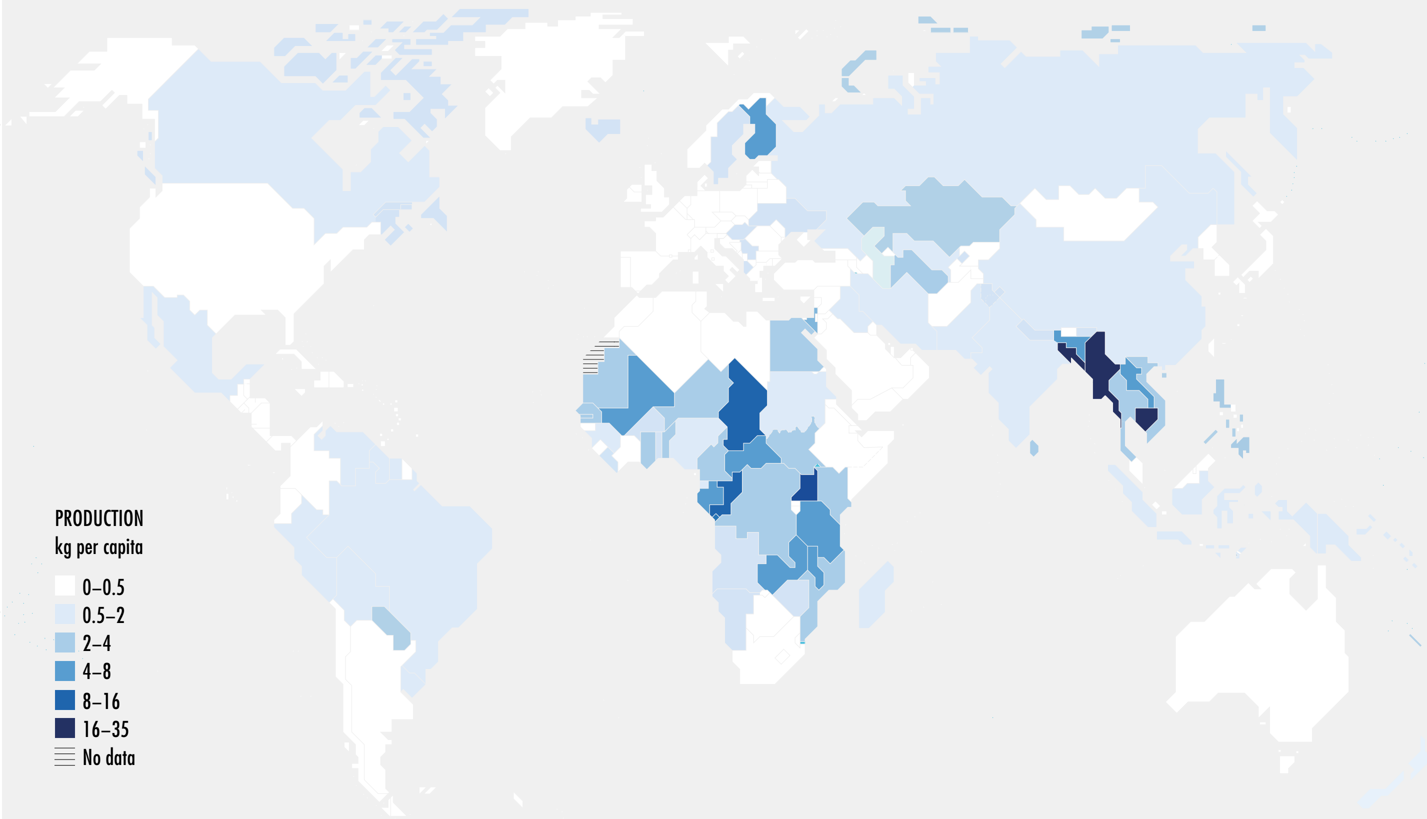
As asserted in the "Rome Declaration: ten steps to responsible inland fisheries" (FAO, 2016f), inland fisheries are an essential element of the SDG package adopted by the UN in 2015 to end poverty, protect the planet and ensure prosperity. Using a combination of an ecosystem approach (Beard *et al.*, 2011) and a human rights–based approach to develop and manage inland fisheries, through application of the SSF Guidelines (FAO, 2015a) (see "Small-scale fisheries and aquaculture" in Part 3), would help achieve SDGs related to biodiversity, human health, poverty alleviation, improved nutrition and climate change.

Inland fisheries and the SDGs

Goal 1: Eradication of poverty

The World Bank (2012) estimated that in 2009, inland capture fisheries and their value chains (i.e. primary and secondary sectors) provided income and employment to over 60 million people worldwide. Inland fishers who depend on fishing for their livelihoods are among the poorest and most vulnerable rural populations. These fisheries contribute to poverty reduction and resilience building by providing food, income and employment. Fishery-related livelihoods are particularly important in rural and remote areas where alternative employment is lacking. Fisheries strengthen resilience by acting as a safety net during lean times and when disaster strikes, when other food-producing sectors (e.g. agriculture) do

FIGURE 34
INLAND FISH PRODUCTION PER CAPITA OF POPULATION PER YEAR, 2015



NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.
SOURCE: FAO, 2017n

not function. Inland fishing households in Cambodia get more than 50 percent of their income from fishing; in the mainstream Mekong River 20 percent of household income comes from fishing; in parts of the Zambezi Basin, fish provides more household income than cattle; in the Brazilian Amazon, households obtain 30 percent of household income from fishing (FAO, 2010a). Small-scale fisheries in the drylands of sub-Saharan Africa can be highly productive and resilient. They may be highly seasonal or even periodic, but with appropriate investment they could generate increased income for both fishers and processors (Kolding *et al.*, 2016).

Determining the global value of inland fisheries remains a challenge, as FAO does not collect value data on capture fisheries from its Members. Global inland fisheries production is generally considered to be underestimated (FAO, 1999b, 2003a; Welcomme, 2011). Thorpe, Zepeda and Funge-Smith (2018) present a preliminary, conservative estimate of the total use value of reported global inland finfish as USD 26 billion for 2015. This figure increases to over USD 43 billion if hidden, unreported production and freshwater molluscs and crustaceans are included. The global non-market use value of inland recreational fisheries was estimated to be USD 65 billion to USD 79 billion (Box 9).

Goal 2: Zero hunger

Inland fisheries provide benefits towards all four of the pillars of food security. Fish, crustaceans,

BOX 9
CONTRIBUTION OF RECREATIONAL FISHING IN INLAND WATERS

FAO (2012b) defines recreational fishers as those who do not rely on fishing to supply a necessary part of their diet or income. In those countries where recreational fishing is a common pastime (primarily in developed countries, but increasingly in developing countries as well), it is estimated that participation is on average 6.7 percent of the national population. In some countries, occasional fishing by household members may have a dual role of providing recreation as well as food fish for the household. Reporting of recreational catches (requested by FAO since 1995) remains rare, even when they contribute to household food availability and livelihoods. Although securing food is not a primary purpose of recreational fishing (unlike subsistence fishing), the retained catch from recreational inland fisheries may be more than 4 percent of the total global reported inland fishery catch. In addition to contributing to economies and general well-being, recreational fisheries may be a driver for improved habitat and ecosystem conservation (Cowx, Arlinghaus and Cooke, 2010).

molluscs and plants from wetlands, rivers, lakes, reservoirs and rice fields provide a sustainable source of food, containing a wealth of nutrition, to the populations that exploit them. The global catch of 11.6 million tonnes is equivalent to the total dietary animal protein requirement of 158 million people, or 2 percent of the global population. In an area of the Democratic Republic of the Congo, fish was consumed on average over five times per week, and 31 percent of households consumed fish every day (HLPE, 2014).

Inland fishery resources are accessible to people, often landless poor people, in remote, open-access, rural and developing areas. The fishing gear is inexpensive and often requires little or no mechanization. Around 94 percent of the small-scale inland production is consumed within the country of origin (Mills *et al.*, 2011). The products are inexpensive, often consumed by producer households, often processed with traditional methods such as fermentation, and use the entire fish, including bones and organs, with little or no waste (World Bank, 2012).

In terms of food utilization, the benefits of inland fish in the human diet are well established (Roos, 2016) (see section on "Fish for food security and human nutrition"). In a study of women in rural Cambodia, inland fish and other aquatic animals contributed on average 37, 51, 39 and 33 percent of their total protein, calcium, zinc and iron intake, respectively (HLPE, 2014).

Goal 3: Good health and well-being

Inland fisheries contribute to health and well-being not only through improved nutrition and livelihoods (see above), but also in the biological control of disease vectors. Mosquitofish, carp and tilapia have been used in many areas to control vectors of diseases such as malaria, Zika and bilharzia through predation on the hosts of the parasites. In East Africa, Lake Victoria supplies drinking-water to millions of people in the lake basin, and the wetlands surrounding the lake act as natural bio-filters treating wastes and improving water quality for humans and fish. Replacing this ecosystem service would cost the equivalent of 35 percent of the value of crop production from those wetlands (Simonit and Perrings, 2011).

Goal 5: Gender equality

Inland fisheries can and do empower women and contribute to gender equity. The World Bank (2012) indicated that about 35 million of the estimated 60 million people engaged in global inland fisheries and their value chains – about half – are women. However, their role has largely been unrecognized (HLPE, 2014). Women are strongly associated with the post-harvest sector, e.g. processing, sales, distribution and marketing; however, women also fish. They obtain income, independence and power through these activities. Income earned by women often has a stronger, more beneficial impact on household incomes (Porter, 2012). In 61 countries that report disaggregated data to FAO and where women are recognized as fishers, the ratio is one fisherwoman to every 7.3 fishermen (Simmance, Funge-Smith and Gee, 2018). Women are most often involved in fishing when the water body is close to the household. Although comprehensive information is lacking, it appears that much of women's catch is of small highly nutritious fish and other aquatic animals and is consumed by their households.

Goal 6: Clean water and sanitation

Healthy inland aquatic ecosystems are indicators of good water quality, with benefits in terms of productive fishery resources and municipal drinking-water that requires minimal treatment. The need to manage inland fisheries has been an important driver in the creation of national and cross-border lake and river basin authorities, which supervise many freshwater systems around the world. Examples of international authorities include the Lake Victoria Fisheries Organization in East Africa and the Great Lakes Fishery Commission in North America. Unfortunately, only a small proportion of transboundary inland water bodies have such authorities, and where they do exist, their mandates vary considerably between water management and environment and only occasionally include the management of fisheries resources.

Goal 8: Decent work and economic growth

Inland capture fisheries are important as a source of direct employment and income to an estimated 16.8 million to 20.7 million people globally, particularly in developing countries. It has been conjectured that more than twice as many people may be involved along the supply chain, including women (see above) (HLPE, 2014; Funge-Smith, 2018). Most inland fisheries are small in scale. Small-scale fisheries create employment several times greater than large-scale fishing, as the lesser mechanization of the fishing operations typically requires greater human input (World Bank, 2012). In at least 11 countries in Latin America and the Caribbean, 20 percent or more of the people working in capture fisheries work in inland fisheries, although inland fisheries constitute only 3 percent of catches in the region (FAO, 2016g). Recreational fishing on inland waters also contributes to global economies (Box 9).

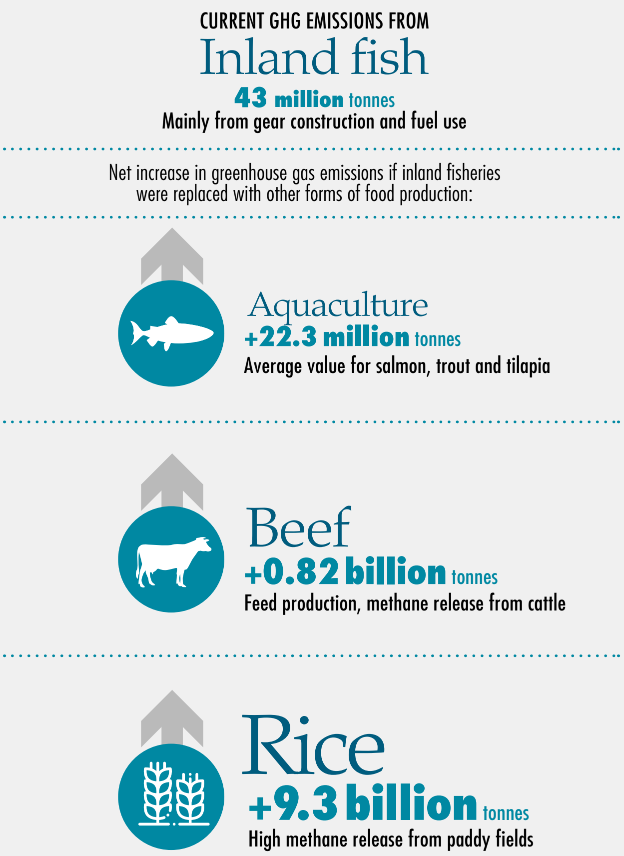
Goal 12: Responsible consumption and production

Inland fisheries are typically in remote areas, although they can be found in peri-urban and even urban areas in some countries. They are difficult to manage, and related management policies are hard to enforce, as they involve few or no recognized landing sites or processing plants and fishers are largely not organized.

As mentioned above, many small indigenous inland fish species are consumed or processed whole and consumed locally with little waste. As natural production systems, inland fisheries have a far lower environmental footprint than agricultural production systems. To replace the basic energy (kilocalorie) content of the 11.5 million tonnes of wild inland-water fish, it has been estimated that lower-intensity developing-country crop production would have to increase by 14.3 million tonnes (Ainsworth and Cowx, 2018). Similarly, chicken production would have to increase by 11.7 million tonnes and aquaculture by 6.8 million tonnes. Complete replacement of current global inland fish production with aquaculture-produced fish (e.g. common carp and tilapia) would require conversion of 2.4 million square kilometres, as production efficiencies are currently low in many regions. Conversion for beef would be similar (2.1 million square kilometres), with the added challenge that beef would require an additional 196.95 km^3 of water. It is important to note that inland fishery production figures are almost certainly underestimated, and these replacement equivalents are likely to be higher.

An aspect of inland fisheries production that may not be immediately obvious is its relative nutritional efficiency in comparison with other fish production systems such as marine fisheries and aquaculture. As 81 percent of nutritional dependence on freshwater fish occurs in nations with per capita gross domestic product (GDP)

FIGURE 35
ESTIMATED INCREASE IN GREENHOUSE GAS EMISSIONS IF INLAND FISHERIES WERE REPLACED BY OTHER FORMS OF FOOD PRODUCTION



SOURCE: Ainsworth and Cowx, 2018

below the global median (less than USD 4 800 purchasing power per capita per year), the impact of this fish supply is even more important (Macintyre, Reidy Liermann and Revenga, 2016). In contrast with many marine capture fisheries, inland fisheries involve very little unused bycatch or discards. However, in a few important inland fisheries and value chains, post-harvest quality loss is substantial (e.g. approximately 30 percent loss in the small pelagic fisheries of the African Great Lakes). Efforts to reduce waste in these value chains and to improve the nutritional value provided by inland fisheries can yield considerable benefits.

Preservation greatly increases the geographic scope of many inland fisheries. In particular, the dried fish trade in Africa results in the movement of considerable tonnages of freshwater fish within countries and often between them.

Goal 13: Climate action

Inland fisheries are a low carbon footprint food source compared to terrestrial agriculture, marine fisheries and fed aquaculture. Inland fisheries require neither feed nor fertilizer (the main contributors to greenhouse gas emissions in agriculture) and often use non-mechanized gear that does not require fuel (consumed by boats using active fishing gear in major marine fisheries) (Clark and Tilman, 2017). Global greenhouse gas emissions would be significantly higher if inland fisheries had to be replaced with other forms of animal protein production (Lymer *et al.*, 2016b; Ainsworth and Cowx, 2018) (Figure 35).

Goal 14: Life below water

This goal is primarily directed at marine ecosystems. Nevertheless, coastal environments and even marine species can depend greatly on the integrity of freshwater systems, which not only provide nutrients that allow coastal production to take place, but also support anadromous fish species which make up substantial coastal and marine fisheries (e.g. salmon, Hilsa shad [*Tenualosa ilisha*] and other shad) and high-value fisheries for diadromous eel around the world. While Goal 14 does not explicitly include sustainability indicators for inland fisheries, countries may report on the status of these fisheries in relation to Goal 14 if they wish to do so.

Goal 15: Life on land

Freshwater ecosystems are a rich source of biodiversity. They cover about 1 percent of the Earth's surface but provide habitat for almost half (about 14 000) of the world's fish species. Rice fields are a particular source of freshwater biodiversity; in some cases this diversity has greater economic value than the rice (Muthmainnah and Prisantoso, 2016). Rice fields were shown to contain about 200 different species useful for local communities (Halwart and Gupta, 2004). When managed for this biodiversity, for example through integrated pest management, farmers use lower amounts of pesticides and herbicides in addition to receiving additional food and income. This biodiversity is threatened primarily due to habitat loss and degradation (Dudgeon *et al.*, 2006) and changing agricultural practices.

Inland fish are one of the important provisioning services of freshwater ecosystems, but to sustain their benefits it is crucial to conserve the aquatic ecosystem. Inland fisheries are vulnerable to activities in the water sector and changes in land use that result in substantial changes to water flow and quality. Inland fisheries can provide a justification for protecting and/or rehabilitating habitats. Indeed one of the criteria for designating a wetland as a Ramsar Site of International Importance is the presence of important fisheries or aquatic species (Ramsar Convention, 2005). However, the inland fishery sector has limited negotiating power and usually obtains concessions from other sectors only as part of regulatory requirements or environmental trade-offs.

Moving forward: securing the contribution of inland fisheries

Inland capture fisheries are important stakeholders that both contribute directly to the achievement of the SDGs and are indirectly affected by the efforts of others. They will particularly benefit from those efforts aimed at improving protection of freshwater habitats and environments and at more effective integrated resource management in watershed areas, which in turn will enhance the resource base. The productivity of some inland waters can potentially be enhanced through culture-based fisheries, habitat enhancement and more effective management of water. A key to ensuring the contribution of inland fisheries is to focus on greater appreciation of their role in nutrition and livelihood resilience and securing this role in vulnerable countries. It is also important to recognize the efficiency and value of current inland fishery production as an asset that should not be traded off lightly against competing demands from other sectors, especially for water, as recommended in the SSF Guidelines (FAO, 2015a, p. 6). However, effective strategies for achieving this outcome are few so far. Funge-Smith (2018) summarizes these contributions and progress being made across a range of SDGs. ■

FISH FOR FOOD SECURITY AND HUMAN NUTRITION

The fisheries and aquaculture sector is crucial to improving food security and human nutrition and has an increasingly important role in the fight against hunger, as articulated in the 2030 Agenda. People have never consumed as much fish as they do today, with per capita global fish consumption having doubled since the 1960s. Trade in fish products is also rising, particularly from and among developing countries (Thompson and Amoroso, 2014), and the demand is likely to continue to grow. The United Nations Decade of Action on Nutrition for 2016–2025, led by FAO and the World Health Organization (WHO), provides a critical opportunity to raise awareness about the role of fish and to ensure its mainstream incorporation into food security and nutrition policy.

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Progress towards food security differs markedly within countries as well as across regions. It is estimated that in the period 2014–2016 more than one in nine people in the world suffered from hunger, while 13 percent of developing region populations were undernourished (FAO, IFAD and WFP, 2015). In addition to providing nutrients, fish also contributes to the food and nutritional security of poor households in developing countries through livelihood diversification and income generation (Thompson and Amoroso, 2014; Béné *et al.*, 2015).

Fish: a treasure store of nutrients

Fish is an important, consistently affordable dietary component worldwide, albeit with large geographic variance. It provides more than 20 percent of the average per capita animal protein intake for 3 billion people, and more than 50 percent in some less developed countries (see Boxes 10 and 11). It is especially critical for rural populations, which often have less diverse diets and lower food security rates (Thompson and Amoroso, 2014). Fish and fish products are excellent sources of high-quality protein; bioavailability of protein from fish is approximately 5 to 15 percent higher than that from plant sources. Fish contains several amino acids essential for human health, such as lysine and methionine. Many fish (especially fatty fish) are a source of long-chain omega-3 fatty acids, which contribute to visual and cognitive human development, especially during the first 1 000 days of a child's life (Roos, 2016). Fish also provides essential minerals such as calcium, phosphorus, zinc, iron, selenium and iodine as well as vitamins A, D and B, thus helping to reduce the risks of both malnutrition and non-communicable diseases which may co-occur when high energy intake is combined with a lack of balanced nutrition (Allison, Delaporte and Hellebrandt de Silva, 2013). Nutritional content is especially high in small fish species consumed whole and in fish parts that are not usually consumed (such as heads, bones and skin) (HLPE, 2014), which paradoxically have lower economic value. It is desirable to increase the production and consumption of small fish and to find ways of transforming the non-consumed parts into nutritious products.

While large-scale fisheries land more fish, only 80 percent is destined for direct human consumption, as compared with almost every fish caught in small-scale fisheries. Today, small-scale and larger-scale fisheries contribute approximately the same amount for human consumption. Since the 1980s, virtually all of the increase in the amount of fish consumed has come from aquaculture, which has outpaced population growth and become the world's fastest growing food production industry (FAO, 2016c, 2017o). Since 2014, aquaculture has provided more fish for human consumption than capture fisheries, and by 2030 it is expected to provide 60 percent of the fish available for human consumption (see "Projections of fisheries, aquaculture and markets" in Part 4). With a higher proportion of freshwater fish being consumed, people are deriving smaller amounts of omega-3 fatty acids from aquatic foods, because these fats are more prevalent in marine than in freshwater fish (Beveridge *et al.*, 2013). Increasingly intensive aquaculture production methods, with greater use of crop-based feedstuffs and lower fishmeal and fish oil inclusion rates, are likely to influence the nutrient content of farmed aquatic products, particularly fat content and fatty acid profiles. A focus on the nutrient content of farmed aquatic foods is especially important where they have a key role in food-based approaches to food security and nutrition.

Despite the increasing role of aquaculture in global fish supplies, the capture sector is expected to remain dominant in the supply of many species and to be vital for domestic and international food security (OECD and FAO, 2016). Per capita fish consumption is expected to continue to expand more strongly in developing countries than in developed countries, with the fastest growth rates projected for Asia and the Pacific.

Maximizing the potential

A 2013 review found that "fish is strikingly missing from strategies for reduction of micronutrient deficiency, precisely where it could potentially have the largest impact" (Allison, Delaporte and Hellebrandt de Silva, 2013). Although the sector's untapped potential is now being recognized and is attracting global interest, it is still a challenge to incorporate the sector into the food security and nutrition agenda (and vice versa) (FAO and EU, 2017). Given the prevalence of fish in diets and its nutritional value, it is important to include fish in the design of nutrition-sensitive agriculture and food-based approaches to food security and nutrition (Kawarazuka and Béné, 2010).

There remains considerable scope to increase the amount of fish – or nutrients derived from fish – for human consumption by reducing post-harvest losses, especially from capture fisheries; by more efficient use of fishmeal and fish oil and in animal (especially aquaculture) feeds; and by improved feed formulations for farmed fish and crustaceans (see "Realizing aquaculture's potential" in Part 3). The fish industry often only extracts fillets for human consumption, »

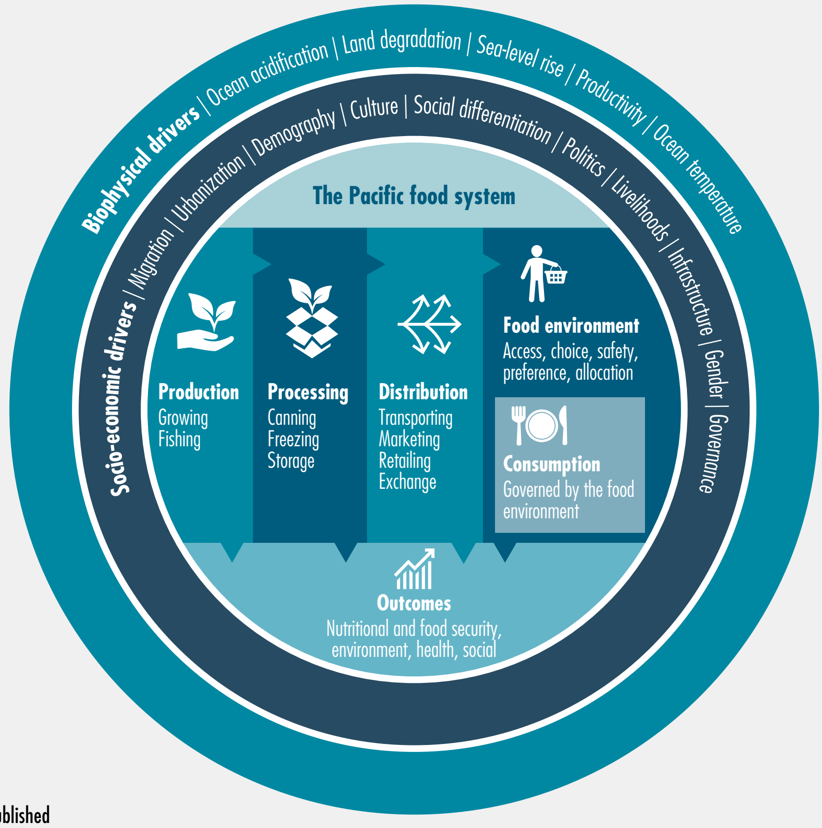
BOX 10
FISH IN THE FOOD SYSTEMS OF PACIFIC ISLAND COUNTRIES

A food system is the set of interacting activities and outcomes relating to the production, processing, trade and consumption of food. In addition to these four aspects, considered the pillars of the food system, environmental change and social drivers of consumption (the food environment) must also be considered in policy interventions. Food systems are usually complex, operate at many scales and have very different outcomes in terms of wealth creation and public health.

External drivers of change, both physical and social, affect the production and consumption of food in Pacific Island countries (Figure 36). Among the physical drivers, climate change has been recognized as a key concern and is expected to exacerbate predicted shortfalls in coastal fisheries production. Nutritional security is further challenged by population growth and urbanization, shortages of arable land, and cheap, low-quality food imports from burgeoning global trade, with culture, choice and politics also having an influence.

By many accounts, the Pacific Island countries require substantial change in their food systems in order to meet the food and nutrition security needs of their people. Per capita agricultural production is declining, and imports of less nutritionally rewarding food are increasing. Many Pacific Island countries are affected by the triple burden of malnutrition: undernutrition, nutrient deficiency and overweight or obesity. The resulting rise of non-communicable diseases (NCDs) such as childhood stunting and anemia has major implications for economic growth, aid policy and development. An estimated 75 percent

FIGURE 36
DRIVERS OF CHANGE IN PACIFIC ISLAND FOOD SYSTEMS



SOURCE: N.L. Andrew *et al.*, unpublished

BOX 10
(CONTINUED)

of adult deaths in the subregion are due to NCDs, with the majority of the deaths occurring among adults in the economically active age bracket (Pacific Islands Forum Secretariat, 2011).

Fish has a unique and substantial role in livelihoods, nutrition, food security and wealth generation in Pacific Island countries. The people living in this subregion consume, on average, two to three times the global average of fish per capita per year (Gillett, 2016). Fish also accounts for 50 to 90 percent of animal protein in the diets of coastal populations, and most of it comes from coastal fisheries (e.g. reef fish and small pelagic species) (Bell *et al.*, 2011). In 2015, the total catch of tuna, including yellowfin, albacore, bigeye and skipjack, in national waters in the subregion stood at more than 587 000 tonnes, but the vast majority of this catch is exported from the subregion (WCPFC, 2016). Canned tuna is an important and growing source of fish in the diet, particularly in Melanesia. Aquaculture production is modest and has contributed little to food security in most of these countries.

A central challenge in securing and increasing the role of fish in the Pacific Island countries is to consider production and consumption under a range of ecological and social drivers of change. Production and consumption vary across the subregion and between coastal and inland areas of its larger nations; however, a systemic reframing of the challenge is needed to improve the economic, environmental and public health outcomes that are tied naturally to the food system. Some recent policy narratives, such as the Framework for Pacific Regionalism (Pacific Islands Forum Secretariat, 2014) and the 2015 Noumea Strategy (SPC, 2015), seek more integrated approaches for fish in nutrition and food security considerations.

Adaptations to increase the supply of coastal fish and increase the availability and accessibility of tuna will require interventions at a range of scales, from community-level initiatives to national and regional governance changes, and at all stages of the food system.

» consigning nutritious co-products to be used for animal feeds instead of exploring their use in tackling micronutrient deficiencies. Fish processing co-products, such as fish carcasses, which are increasingly used to produce fishmeal and fish oil, represent an underutilized source of nutrients and micronutrients for human consumption. The fishmeal and fish oil content of aquaculture feeds can be reduced without compromising the nutrient content of farmed aquatic products. Improvements in feed formulations and in feed manufacture, combined with better on-farm feed management, can hugely reduce the quantities of feed (and thus fishmeal and fish oil) used per kilogram of farmed aquatic food produced.

Greater product assurance in fresh fish value chains is needed to safeguard food safety and ensure that the nutritional benefits of fish products are accessible to all consumers. Effective food safety control and inspection systems must be systematically implemented. The health risks associated with specific chemical contaminants (such as methylmercury and dioxins) that may be present in fish and other seafood, both wild and farmed, are well documented. In 2010, an FAO and WHO Expert Consultation made a series of key recommendations to minimize risks and maximize benefits associated with eating fish (HLPE, 2014; FAO and WHO, 2011). Experts emphasized that fish consumption reduces mortality due to coronary heart disease in the adult population and improves the neurodevelopment of fetuses and infants and is therefore important for women of childbearing age, pregnant women and nursing mothers. The benefits thus outweigh the health risks associated with mercury and dioxins when consumption guidelines are followed. »

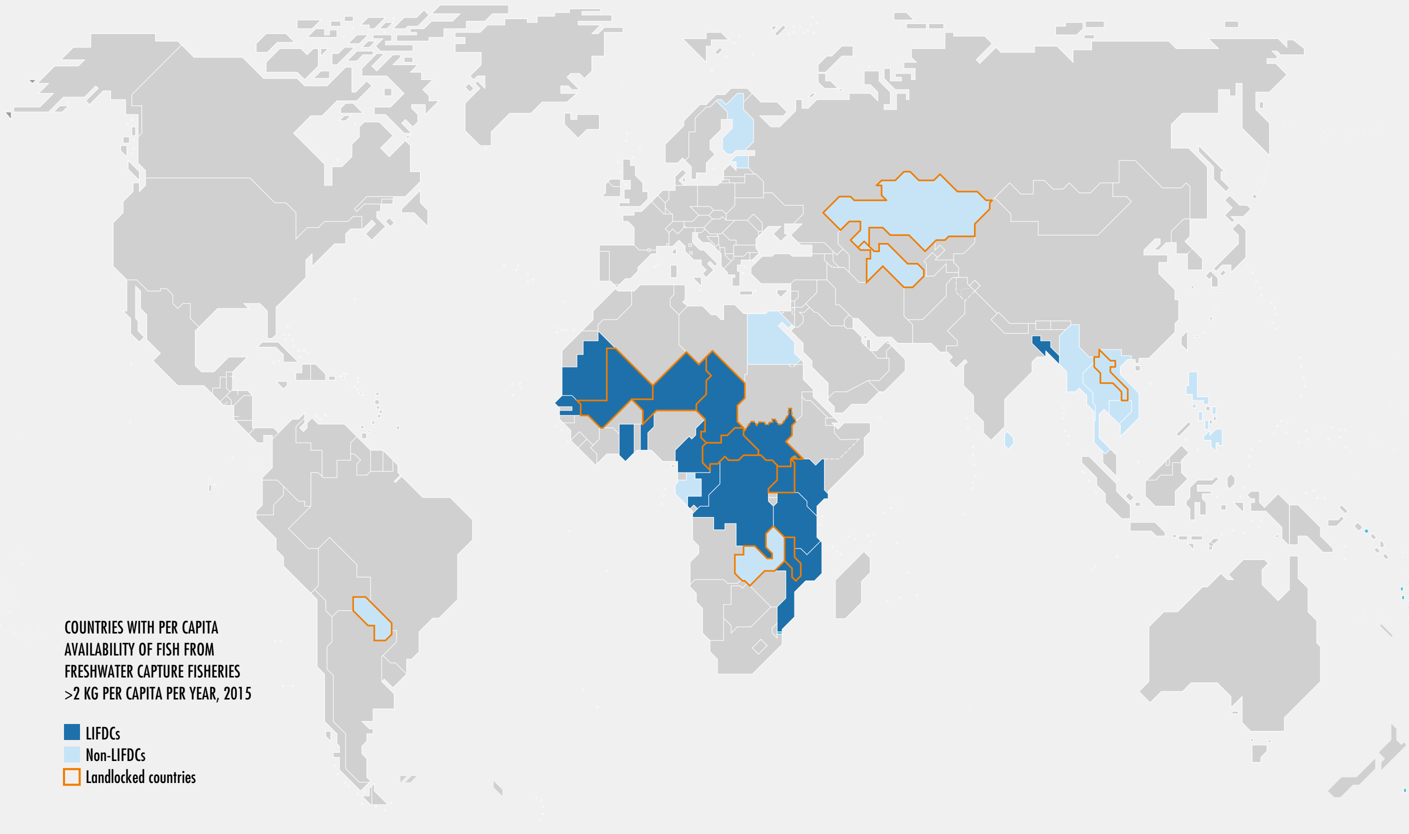
BOX 11
IMPORTANCE OF INLAND FISH FOR LOW-INCOME FOOD-DEFICIT COUNTRIES AND LANDLOCKED COUNTRIES

The distribution of inland capture fishery production is worldwide, and over 90 percent is directed for human consumption. Freshwater fish are a rich source of protein for human health, particularly for the poorest and most vulnerable (Belton and Thilsted, 2014; Lymer *et al.*, 2016a). LIFDCs are characterized by constraints on food security and nutrition and by inadequate or uncertain food production capacity to meet the needs of their populations. Landlocked countries do not have marine capture fisheries and depend on freshwater fish production (from inland fisheries or aquaculture) unless they are able – and choose – to compete for fish on global markets.

Of a total of 161 countries that report inland capture fisheries, 50 are classified as LIFDCs (representing 28 percent of the global population). They produce 4.9 million tonnes of freshwater fish each year, or 43 percent of global inland production. The 44 landlocked countries account for 11 percent of global inland fishery production. Of these, 20 countries are both landlocked and LIFDCs; these countries produce 9 percent of total global inland fish. Thirteen of these landlocked LIFDC countries are in Africa. Of the 13 countries with the highest per capita inland fish consumption, 8 are LIFDCs and 7 are landlocked (Figure 37).

Freshwater fish consumption in these countries ranges from 5.2 to 35 kg per capita per year. The access of rural populations in LIFDCs to imported (marine and freshwater) fish products for food is highly constrained because of economic and distribution limitations. The current state of aquaculture development in many of these countries is also extremely low – with notable exceptions being (in descending order of production) India, Bangladesh, the Democratic People's Republic of Korea, Nigeria and Uganda. Thus, obtaining fish locally within the rural environment is the primary, and typically the only, way to obtain fish in the diet.

FIGURE 37
COUNTRIES WITH HIGH PER CAPITA AVAILABILITY OF FISH FROM FRESHWATER CAPTURE FISHERIES, HIGHLIGHTING LOW-INCOME FOOD DEFICIT COUNTRIES AND LANDLOCKED COUNTRIES



NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.
SOURCE: FAO, 2017n

» The challenge of meeting consumer needs with a sustainable supply of aquatic foods persists, and fisheries management and environmental protection are important in this regard. In the future, aquaculture and aquaponics may play a greater role in coping with the increased demand of a growing world population. Traditional forms of aquaculture (such as rice–fish production) can have positive outcomes including income diversification, improved food security and nutrition and environmental benefits (reduced pesticide use). Emphasizing those species most beneficial to target populations can strengthen the opportunities for policies and programmes to improve food security and nutrition outcomes.

The SSF Guidelines (FAO, 2015a), endorsed by COFI in 2014, have the principal objective of enhancing the contribution of small-scale fisheries to global food security and nutrition and to the progressive realization of the right to adequate food. The 2017 Conference of FAO in Rome (FAO, 2017p) recommended the development of policy and field programmes to promote investment by countries in nutrition-focused fish and aquaculture value-chain development.

Data-driven support for food security and nutrition policy

Quantitative information on the role of fisheries (notably small-scale fisheries) and aquaculture in food security and nutrient supplies is generally lacking. When available, such information tends to be scattered, which leads to its underutilization and sometimes misuse. Fish has thus been largely absent in the development of food-based approaches for greater food security and nutrition. FAO therefore has an important role in coordinating existing databases on the nutritional composition of fish and fish products and in addressing information gaps and research needs related to their contribution to improved nutrition.

An increasing number of data sources support indicator development in the sector, covering parameters ranging from fish supply to nutrient composition and food access.

The FAO Food Balance Sheets (available at www.fao.org/faostat/en/#data/FBS) present countries' annual food supply patterns. As they present national averages, they are generally used in policy analysis and decision-making, assessing self-sufficiency, evaluating whether nutritional requirements are met and projecting food demand. For fish and fish products, they are also useful for monitoring developments in overall domestic fish availability and supply utilization and changes in the species consumed. They give an indication of the role of fish in total food supply and its share in animal and overall proteins. They are also a powerful instrument for verifying and cross-checking the quality of the data collected, linking production to use. FAO continuously adapts and improves the calculation methodology and conversion factors. Recent efforts have been made to ensure that fishery data from the Food Balance Sheets are available to users on a wider range of platforms. In using the data, it is important to consider that they only show the food available for human consumption, but not the amount effectively eaten or any waste along the supply chain (which can only be monitored through other means such as household or individual consumption surveys).

The FAO/INFOODS Global Food Composition Database for Fish and Shellfish (uFiSH) (FAO, 2016h) includes a complete nutrient profile (minerals, vitamins, amino acids and fatty acids) for 78 species in raw, cooked and processed forms. The data were extracted from 2 630 food records from 250 data sources and compiled following international FAO/INFOODS (International Network of Food Data Systems) standards. The uFiSh database is relevant for examining the importance of aquatic foods in food security and nutrition at a range of geographic scales. It can be used to compare nutrient composition, to estimate nutrient share of fish in agricultural production and diets, and to identify appropriate species and products for production and healthy diets. In short, uFiSh is an excellent tool for well-targeted programme and policy design and implementation. For example, it has been used in the forthcoming updates of the Kenyan and West African food composition tables to help decision-makers promote programmes and policies for improving nutrition in their countries by producing more nutritious fish and fish products. The uFiSh database can be downloaded free of charge in Excel format with documentation (www.fao.org/infoods/

infoods/tables-and-databases/faoinfoods-databases). Additional data and support would be welcome so as to include more fish species, especially species from developing countries and inland fish, and processed fish products.

FAO and WHO are building a Global Individual Food Consumption Data Tool (FAO/WHO GIFT) to better inform agricultural and food policies and programmes at the global, national and subnational levels and to make them more nutrition sensitive (available at www.fao.org/nutrition/assessment/food-consumption-database). Indicators such as food consumption, food safety and nutrition status are derived from quantitative age- and gender-disaggregated data on food consumption. Harmonized microdata from dietary surveys are also made available on the platform. FAO/WHO GIFT makes it possible to describe dietary patterns and to assess diet adequacy. It can, for example, be used to identify and quantify fish and fish products that are sources of key nutrients in the diet of a population of interest. The data can also be used to assess dietary exposure to food hazards and to identify the main food sources of these hazards.

The World Aquaculture Performance Indicators (WAPI) is a user-friendly tool developed by FAO to collate data from many sources and generate easy access to quantitative information on aquaculture sector performance at the national, regional and global levels. Two WAPI modules, one on aquaculture production and the other on fish consumption, have recently been made available for public use (Cai, 2017). The WAPI modules provide a large amount of quantitative information that can be used to generate indicators on the contribution of fish to food security and nutrition. A technical paper prepared as a background document for the two modules estimates potential future fish demand and supply gaps for nearly 200 countries or territories (Cai and Leung, 2017). The short-term, five-year projections can facilitate policy and planning as well as sector management at a range of geographic levels. WAPI modules on other subjects (e.g. fish trade, human resources and employment, and GDP) are under preparation.

To promote the integration of fisheries in countries' food and nutrition security policies, FAO has facilitated dialogue between the two sectors to demonstrate the importance of fish and fish products in food security and nutrition through scientific evidence and policy analysis. The scientific evidence is assembled in the form of a dashboard of indicators (based primarily on data from FAO and the World Bank) covering availability, accessibility and affordability, including the contribution of fish to animal protein supply, fisheries as a source of employment and income, and fish prices versus those of other animal protein foods (Kurien and López Ríos, 2013). The FAO estimates of per capita fish supply depend heavily on the quality of capture and aquaculture production statistics; thus the importance of these basic pillars of reliable data collection cannot be undervalued if the data are to have a proper influence on food security and nutrition policy at the national level.

Policy analysis showed that good knowledge of the fisheries and aquaculture sector, including reliable statistics and management systems, is a requisite for its integration in food and nutrition policy. Where reliable statistics are not available, targeted studies, such as household consumption surveys or value-chain analyses of fish products, can highlight the importance of fish in diets, which in turn can influence policy-makers to invest in the fishery sector. Although experience to date is limited to a handful of African and Caribbean countries, policy frameworks have been successfully modified and data collection systems improved as a result of better appreciation of the role of fisheries in meeting national food security and nutrition objectives.

National household consumption and expenditure surveys (HCESs) are potential alternative sources of fish consumption data for countries that lack an effective fishery monitoring system (Hortle, 2007; Mills *et al.*, 2011; Funge-Smith, 2016). HCESs may also be more statistically representative of geographically dispersed fishery activities and landings than periodic monitoring of a limited number of landing sites or gears (de Graaf *et al.*, 2015; Funge-Smith, 2016). Such surveys have indicated, for example, that inland capture fishery production is much higher than officially reported by many countries (see "Small-scale fisheries and aquaculture" in Part 3 and "Global inland fisheries revisited" in Part 2).

Increased collaboration recently fostered under FAO's food security and nutrition strategies has led to complementary approaches in data collection and analysis, making it possible to enrich the dashboard with estimates of the actual fish consumption per capita, further refined to reflect age, gender, subnational situations and nutritional intake. In order to transform these prospects into operational evidence-based support, investments will need to focus on improved coverage (e.g. nutritional value of farmed species), measurement of food access, harmonization of indicators and efficient and timely integration of the available analytical tools. ■

IMPLEMENTING THE ECOSYSTEM APPROACH TO FISHERIES AND AQUACULTURE – ACHIEVEMENTS AND CHALLENGES

Ecosystem considerations in marine science and management have been in place for more than a century, but have been addressed more explicitly since the terms "ecosystem-based management" and "ecosystem approach to management" gained acceptance after UNCED. Both concepts imply the management of a resource sector in a way that is holistic and integrated and that accounts for all key factors affecting the entire ecosystem.

The ecosystem approach to fisheries (EAF) and the ecosystem approach to aquaculture (EAA) are strategies developed and promoted by FAO in recognition of the need for wider frameworks for the planning, development and management of sustainable fisheries and aquaculture, taking into consideration the effects of other sectors on fisheries and aquaculture and the effects of fisheries and aquaculture on the ecosystem. EAF and EEA both support the practical implementation of the principles of sustainable development, first explicitly introduced to fisheries by the Code of Conduct for Responsible Fisheries (FAO, 1995) (Box 12). They provide a framework for considering not only the ecological, but also the social and economic aspects of sustainability and the governance context in which the fisheries and aquaculture sectors operate.

The political commitment to EAF formally materialized in connection with the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem in 2001. In its wake, 45 participating countries signed a declaration and a pledge to incorporate ecosystem considerations in fisheries management. Shortly thereafter, FAO (2003b) published guidelines for EAF implementation. This commitment was restated in connection with the World Summit on Sustainable Development (WSSD) in 2002, and 2010 was agreed as the target for its application in the WSSD Plan of Implementation, Paragraph 30d (UN, 2002). The twenty-seventh session of COFI in 2007 broadly agreed that "EAF was the appropriate and necessary framework for fisheries management" and highlighted the "need for aquatic production to follow an ecosystem approach to aquaculture".

The rapid growth of the aquaculture sector worldwide, and the interaction of aquaculture activities with other economic sectors and natural resources users, has required a responsible and integrated approach to aquaculture development, as expressed in Article 9 of the Code of Conduct for Responsible Fisheries. In response to the explicit request of its Member Countries in 2006 to improve the management and enhance the socio-economic impacts of aquaculture, FAO initiated the development of an ecosystem approach to aquaculture. Guidelines for EAA became available in 2010 (FAO, 2010b) to improve the management and enhance the socio-economic impact of aquaculture. Since then, the development and application of EAF and EAA by FAO and increasingly by national and international partners have followed parallel paths.

FAO has developed or supported the development of numerous products for EAF/EAA, including guidance at regional and national levels (Box 13).

BOX 12
2016–2017 MARGARITA LIZÁRRAGA MEDAL

The FAO Margarita Lizárraga Medal is awarded every two years to a person or organization that has served with distinction in the promotion and application of the Code of Conduct for Responsible Fisheries. In 2016–2017, the award was given to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) in recognition of its outstanding, practical, tangible, sustainable and catalytic contribution to the conservation and management of marine living resources in the convention area (the Southern Ocean). In particular, CCAMLR was recognized for its precautionary and ecosystem-based approach to balancing environmental conservation with the rational utilization of resources. This achievement is considered as a model for similar initiatives and could have a catalytic effect on other RFBs. The CCAMLR Secretariat is based in Tasmania, Australia.

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FAO Director-General José Graziano da Silva presents the Margarita Lizárraga Medal to Monde Mayekiso, Chair of CCAMLR

In addition, the guidelines in support of implementation of the Code of Conduct for Responsible Fisheries are all relevant to the application of EAF/EAA.

Key features of the ecosystem approach to fisheries and aquaculture

The key features of the EAF/EAA framework, as proposed in the FAO guidelines for both fisheries and aquaculture, are characteristic of a participatory risk-based management process adapted to the fisheries and aquaculture sectors and include:

- wide stakeholder participation at all levels of planning and implementation;
- comprehensive and explicit consideration of all key components of a fishery or aquaculture system (ecological, social, economic and governance) as well as external drivers (e.g. climate change);
- reconciliation of environmental/conservation and social/economic management objectives, including explicit consideration of trade-offs between them;
- decision-making based on "best available knowledge", including both scientific and traditional knowledge, with promotion of risk assessment and risk management, and recognition that in the absence of detailed scientific knowledge decisions must still be taken;
- focus on sustainability issues that need attention, identified and prioritized through a formal participatory process (e.g. risk assessment);
- reliance on a formal management plan developed for a specific area or system with operationally defined boundaries;
- an adaptive management process that includes mechanisms for feedback loops at different time scales to adjust the management plan based on past and present observations and experiences;
- building on existing management institutions and practices.

Full implementation of EAF/EAA entails establishing a management cycle that includes initial planning, implementation and feedback

BOX 13
KEY FAO INFORMATION RESOURCES SUPPORTING IMPLEMENTATION OF THE ECOSYSTEM APPROACH TO FISHERIES AND AQUACULTURE

EAF guidelines: FAO. 2003. *Fisheries management 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome.

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

Simplified version of EAF guidelines: FAO. 2005. *Putting into practice the ecosystem approach to fisheries.* Rome.

EAF Toolbox: FAO. 2012. *EAF Toolbox: the ecosystem approach to fisheries.* Rome.

Interactive online version of EAF Toolbox: FAO. 2011–2017. EAF-Net. EAF Toolbox. [online]. Rome. Updated 27 May 2011. www.fao.org/fishery/eaf-net/toolbox

Use of GIS tools to support implementation of EAF: Carocci, F., Bianchi, G., Eastwood, P. & Meaden, G. 2009. *Geographic information systems to support the ecosystem approach to fisheries: status, opportunities and challenges.* FAO Fisheries and Aquaculture Technical Paper No. 532. Rome, FAO.

Community-based EAF: South Pacific Community (SPC), FAO and The Nature Conservancy (TNC). 2010. *A community-based ecosystem approach to fisheries management: guidelines for Pacific Islands countries.* Secretariat of the Pacific Community. Noumea, New Caledonia

EAA guidelines: FAO. 2010. *Aquaculture development. 4. Ecosystem approach to aquaculture.* FAO Technical Guidelines for Responsible Fisheries. No. 5, Suppl. 4. Rome.

Spatial tools for EAA: Aguilar-Manjarrez, J., Kapetsky, J.M. & Soto, D. 2010. *The potential of spatial planning tools to support the ecosystem approach to aquaculture.* Expert Workshop, Rome, 19–21 November 2008. FAO Fisheries and Aquaculture Proceedings No. 17. Rome, FAO.

Legislating for EAF: Cacaud, P., Cosentino-Roush, S., Kuemlangan, B., Kim, Y.J. & Koranteng, K. 2016. *A how to guide on legislating for an ecosystem approach to fisheries.* FAO EAF-Nansen Project Report No. 27. Rome, FAO.

Example of regional guidance: Bay of Bengal Large Marine Ecosystem Project (BOBLME). 2014–2017. The Essential EAFM training course. [online]. Rome, FAO. www.boblme.org/eafm

Trawl guidelines developed by the Asia Pacific Fisheries Commission (APFIC) to support EAF-compatible decision-making: FAO. 2014. *APFIC/FAO Regional Expert Workshop on "Regional guidelines for the management of tropical trawl fisheries in Asia".* Phuket, Thailand, 30 September – 4 October 2013. RAP Publication 2014/01. Bangkok, FAO Regional Office for Asia and the Pacific.

loops that are essential under an adaptive framework.

None of the individual elements in EAF/EAA are new or exclusive to the approach; its novelty is in bringing these elements together in a common formal framework and demanding explicit accounting of many processes or assumptions that were often not considered in the fisheries management process.

In the context of climate change adaptation, the EAF/EAA process assists in the monitoring of climate change impacts and in coping with them, as improving the general resilience of fisheries and aquaculture systems will reduce their vulnerability to climate change (De Silva and Soto, 2009). Biodiversity-rich, well-managed systems may be less sensitive to change than overfished and biodiversity-poor systems. As an example, healthy coral reef and mangrove systems can provide many benefits, including natural barriers to physical impacts. Fisheries- and aquaculture-dependent communities with strong social systems and diversified livelihood options have higher adaptive capacity and lower sensitivity to change.

Practical implementation

Together with a number of partners, FAO continues to dedicate substantial effort to promoting EAF/EAA among its Members through publications, regional and expert meetings and projects in more than 20 countries to date. The main objective of these activities has been to address sustainability at the local level by enabling multistakeholder participation and promoting the EAF/EAA process.

A particular line of work that has merited a great deal of attention and effort has been the development of EAF/EAA management plans and capacity development initiatives for national and regional administrations on their development and implementation. FAO and its partners have supported the development and implementation of EAF in over 50 fisheries management plans across Africa, Asia and the Pacific and Latin America and the Caribbean, with the support of national authorities, other organizations and projects such as the EAF-Nansen project (Box 14), the GEF International Waters Programme and the World Bank. In particular, the Bay of Bengal Large Marine Ecosystem (BOBLME), the Benguela Current Commission (BCC), the Canary Current Large Marine Ecosystem (CCLME), the Caribbean Large Marine Ecosystem (CLME), the Guinea Current Large Marine Ecosystem (GCLME) and the Agulhas and Somali Current Large Marine Ecosystem (ASCLME) explicitly include implementation of EAF in their scope of work. FAO has funded EAA implementation projects in a number of countries including Chile, Kenya, Malawi, Nicaragua, the Philippines, Turkey and Zambia.

Spatial planning of aquaculture, considering the social, economic and environmental dimensions of sustainability, is particularly important in the EAA framework, especially when aquaculture takes place in common property such as the sea or natural water bodies (FAO and World Bank, 2015). In recent years, FAO has provided guidance on spatial planning to many countries, including aquaculture zoning and site selection with an ecosystem perspective (Aguilar-Manjarrez, Soto and Brummett, 2017).

In Europe, three regional projects financed by the European Commission and involving FAO have adopted the principles of EAA: "Developing Site Selection and Carrying Capacity Guidelines for Mediterranean Aquaculture within Aquaculture Appropriate Areas" and "Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean", both implemented through the General Fisheries Commission for the Mediterranean; and the Europe-wide project EU H2020 "AquaSpace – Making Space for Aquaculture".

A three-year participatory process in the early 2010s led to the development of an EAA/EAF management plan for Estero Real, a tropical estuary in Nicaragua (FAO, 2014c). Elements in the plan include improving environmental performance in shrimp farming, implementing a monitoring system to assess impacts of climate change, developing a programme to shift fishers into the shrimp aquaculture value chain, improving local governance and implementing an extension programme. Implementation of the plan is moving forward slowly but with strong ownership, gender inclusion, political will and improved public–private cooperation.

In Central America, awareness raising about EAF/EAA for key stakeholders from eight countries, supported by the Central American Organization of the Fisheries and Aquaculture Sector (OSPESCA), led to the development of a regional EAF/EAA management plan for shrimp fisheries and aquaculture (Gumy, Soto and Morales, 2014). The participating countries are making efforts to create conditions for the implementation of the plan.

In Chile, the Fisheries and Aquaculture Law is being reviewed to include EAF/EAA, and a 20-year policy for aquaculture development is being prepared using EAA for guidance.

BOX 14

THE EAF-NANSEN PROGRAMME

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The new research vessel *Dr Fridtjof Nansen*

On 24 March 2017, the new EAF-Nansen Programme, "Supporting the application of the ecosystem approach to fisheries management, considering climate and pollution impacts", was signed by the Norwegian Agency for Development Cooperation (Norad), the Institute of Marine Research (IMR) of Bergen, Norway and FAO as the executing agency. The new EAF-Nansen Programme is FAO's largest initiative focusing on improving the knowledge base for and supporting the implementation of EAF. The programme has its roots in the Nansen Programme, which supported improved knowledge of fisheries resources in developing countries using the research vessel *Dr Fridtjof Nansen*, beginning in the early 1970s; and the EAF-Nansen project, which began in the late 2000s, with a focus on Africa.

In the first phase of the EAF-Nansen project, the partners worked with national and regional fisheries research institutions and management agencies in 32 African countries to improve scientific knowledge and to refocus fisheries management through the adoption and implementation of an ecosystem approach to fisheries. A key goal was to enable nations and RFBs to design and implement their own fisheries management plans according to the principles of EAF, and to empower RFBs to serve their members as they began implementing EAF. With the project's support, more than ten EAF fisheries management plans were developed and approved (Koranteng, Vasconcellos and Satia, 2014). Importantly, national or regional task groups, led by the responsible national or regional fisheries management agencies, took full ownership and responsibility for the development and approval of the plans, with the technical support of the project under a clear roadmap. The project's support was organized in clusters, to facilitate regional cooperation and sharing of experiences: artisanal fisheries (Sierra Leone and Liberia), beach seine fisheries (Western Gulf of Guinea), small and medium pelagic fish (Kenya and United Republic of Tanzania), industrial shrimp fisheries (Central Gulf of Guinea), demersal fisheries (Comoros and Madagascar), line fish fisheries (Mozambique) and small pelagic fisheries (Northwest Africa). For most countries, these were the first management plans drafted according to EAF principles. The national or regional ownership and leadership of the process through the task groups, the regional exchange and a capacity development strategy strongly anchored in the development of the management plans were key factors for the success of these activities. The project also supported and made recommendations to many countries for improvements in legislation, offering practical guidance on how to develop or amend national legislation in support of EAF (Cacaud *et al.*, 2016).

The new EAF-Nansen Programme aims at consolidating the results of the previous phase and at addressing the multiple impacts of human activities on fish stocks in particular, and the marine environment in general, in order to preserve the productivity of the oceans for the benefit of future generations. In this new phase the programme includes the significant added responsibility to assess the impacts of climate change and marine pollution, operating in some of the least observed waters in the world. The programme is served by a new research vessel, also called *Dr Fridtjof Nansen*, which continues to operate as a unique platform for knowledge generation, capacity development and research exchange. The vessel is 74.5 m long, features specialized laboratories (including a climate change lab) and state-of-the-art scientific equipment, and can support up to 30 scientists.

TABLE 20
PERCENTAGE OF COUNTRIES ADOPTING EAF OR SIMILAR ECOSYSTEM APPROACHES, BY REGION

Region	%
Africa	77
Asia	86
Europe	75
Latin America and the Caribbean	84
Near East	50
North America	100
Southwest Pacific	75

SOURCE: FAO questionnaire on implementation of the Code of Conduct for Responsible Fisheries, 2015 data

Main successes and achievements

Substantial progress has been made in implementing elements of EAF/EAA, from raising awareness among policy-makers and fisheries and aquaculture stakeholders to creating profitable and job-producing fisheries and aquaculture operations that are only possible with a sustainable, integrated approach to the use of aquatic living resources and their environment. The proliferation of EAF/EAA projects and their promotion by many governmental and non-governmental organizations dealing with natural resource management, sustainable development, environmental protection and other sustainability-related themes are a good measure of this progress.

National fisheries administrations and regional fisheries bodies are increasingly adopting EAF and EAA as overall fisheries management frameworks, to realign policy in preparation for practical implementation. According to data from the questionnaire on implementation of the Code of Conduct for Responsible Fisheries sent every two years to all FAO Member Countries, the percentage of countries adopting EAF or a similar approach increased from 69 percent in 2011 to 79 percent in 2015. However, the level of adoption varies among regions (Table 20). The Near East has the lowest adoption of EAF (perhaps not surprisingly, considering the overall level of social unrest in the region during the past decade), while North America has the highest adoption rate.

The approach is also being taken up in the work of RFBs. Currently, over 40 percent of RFBs include in their convention text a specific reference to the ecosystem approach as a management principle. In addition, many of the older RFBs have also adopted policy texts, or implemented projects, aimed at the use of EAF in their science and management procedures. Although not all RFBs have the same level of formal or de facto adoption of EAF/EAA, practically all of them are increasingly using multiple elements of the approach in their regular work. Some of the key successes of EAA projects so far include the development of capacity and the direct involvement of national and local authorities and stakeholders, enabling wider ownership of the aquaculture planning and management processes.

A recent development, consistent with the ecosystem approach, is the explicit consideration of the interactions between fisheries and aquaculture and management of these within a single framework (Soto *et al.*, 2012). This joint EAF/EAA approach is particularly relevant in those situations where it is difficult to separate fisheries and aquaculture, as in capture-based aquaculture and aquaculture-based fisheries (e.g. restocking programmes and sea-ranching), and where the spatial, operational and resource interactions between the two are increasing. The fact that about 36 percent of the world's RFBs now include aquaculture as part of their mandate gives an indication of the need to address interactions between fisheries and aquaculture development. FAO has begun to develop projects that effectively consider fisheries and aquaculture as part of a single planning and management framework, the most complete example being the management plan of Estero Real in Nicaragua. Where EAF and EAA have been applied side by side, conflicts between capture fisheries and aquaculture have generally been reduced.

Many stakeholders, from Norway to Mozambique and Nicaragua, Turkey and Lebanon, report the legitimacy of the fisheries management process as much improved thanks to the inclusion of ecosystem considerations. The formal consultation processes of EAF, for example, and the requirement for inclusion of local knowledge, have given a voice to many stakeholders, including fishers, who previously felt excluded from the decision-making process. The requirement to minimize impacts on the natural ecosystem, together with the consultation process, has helped to reduce conflict between the fisheries and aquaculture sector and conservation interests and to improve their cooperation, and ultimately will lead to more sustainable fisheries. In the Southwest Indian Ocean, for instance, active cooperation is now in place between nature conservation organizations and the national fisheries management institutions, as well as the corresponding RFB (SWIOFC); such examples are increasing.

Enforcement of fisheries regulations, a major difficulty in most if not all fisheries, has also benefited from the open participation of multiple stakeholders in defining the management measures for the sector. In the Kapenta fishery (two freshwater sardines) in Mozambique, for which an EAF management plan was developed, as well as in other fisheries in the Mediterranean and in Africa, fishers and other stakeholders are taking up the task of promoting and ensuring compliance with the regulations. In this way the EAF process is reducing the burden of enforcement for the State, increasing stewardship by resource users and supporting the legitimacy of the management process.

Finally, by opening the concept of "stakeholder" to others than simply fishers, the EAF/EAA process has led to a growing alignment between fisheries management and other societal management processes, including environment and human health as well as social protection.

Applying lessons learned

As the number of projects on EAF/EAA increases, so does the opportunity to draw lessons from their development and implementation. Three lessons are common across the regions where these projects have been carried out.

- **Participation.** Participation is essential and key to effective management, allowing diverse interests to agree on a common approach, but it must be perceived by all stakeholders as fair and effective. Participation must be ensured both at the planning stage and as part of the regular management cycle, including data collection and research activities.
- **Adaptation.** EAF/EAA implementation requires institutional processes that ensure regular monitoring and decision-making in relation to the agreed objectives established in the management plans. Mechanisms for mid-term review of management plans should also be built into institutional processes. These processes do not always exist, and where they have been established they seldom include stakeholder participation.
- **Misconceptions.** Despite awareness-raising efforts, EAF/EAA is widely misconceived as an approach mainly concerned with conservation, when in reality it is an enhanced sectoral or multisectoral management approach (depending on the context) for achieving sustainability by considering the dynamic ecosystem that underpins any fishery and the social and economic goals of those involved in the sector.

Importantly, EAF provides a formal framework for weighing and defining trade-offs among conflicting societal goals. However, obtaining widespread agreement on which ones to prioritize will remain a challenge for years to come. Global pressures, such as population growth and globalization, will also continue to affect the dynamics of the sector. Overall, most of the progress with EAF/EAA so far has been with the development of implementation processes and the evolution of attitudes in recognizing its benefits. Like most efforts aimed at improving how the Earth's natural resources are extracted and used, EAF/EAA requires important changes in attitude and mentality for its full implementation. Progress has been slow but nevertheless consistent. EAF/EAA, if widely adopted in a coherent process based on sound management principles, will continue to benefit society while respecting the nature of the resource base. ■

BAN BOR RAE, THAILAND
Fish farming
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PART 3
HIGHLIGHTS OF ONGOING STUDIES

PART 3

HIGHLIGHTS OF ONGOING STUDIES

CLIMATE CHANGE IMPACTS AND RESPONSES

The Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC) (UN, 2015c), which came into force on 5 October 2016, strengthens the global response to climate change, with its signatories committing to keep global temperature rise this century well below 2 °C above pre-industrial levels. The agreement also emphasizes the relationship among climate change actions, sustainable development and the eradication of poverty, and recognizes the particular vulnerabilities of food production systems to the adverse impacts of climate change. The Paris Agreement is an integral part of the 2030 Agenda, wherein SDG 13 calls for urgent actions to combat climate change and its impacts.

Implementation of the Paris Agreement is based on nationally determined contributions (NDCs), through which Parties report progress on their actions. Over 80 countries have so far included fisheries and/or aquaculture in their priority adaptation areas and actions (Strohmaier *et al.*, 2016) (Box 15). In general, the priority adaptation areas outlined by countries have limited specificity and ambition, mainly because of limited empirical understanding of the impacts of climate change at spatial and temporal scales relevant for decision-making; insufficient guidance on the potential adaptation tools available to the sector; and insufficient technical capacity to make the case for including fisheries and aquaculture in the development of NDCs. Addressing these three elements would ensure that effective measures are taken to maximize the opportunities and minimize the negative impacts of climate change.

BOX 15
CLIMATE CHANGE AND POVERTY ERADICATION IN FISHERIES

To further the understanding of the climate change and poverty nexus, FAO is conducting an analysis of Nationally Determined Contributions (NDCs) to find complementarities and gaps between the international climate change regime narrative and national implementation plans in the fisheries and aquaculture sector (Kalikoski *et al.*, 2018). The narrative presented by IPCC and the Paris Agreement prioritizes actions that account for vulnerable people, places and ecosystems. However, only a few of the NDC documents analysed (9 of 155) include strategies that will concretely improve fishers' livelihoods and environments such as social protection schemes, decent rural employment, access to services or even a gender focus. This means most NDCs will not reach the poor and most vulnerable to climate change (sectors of the population that the Paris Agreement prioritizes) in fisheries and aquaculture. This lack of social development strategies could result in weak NDC plans and inefficient use of time and resources.

Assessing climate change impacts for fisheries and aquaculture

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) includes the most comprehensive summary of the effects of climate change on aquatic ecosystems and their resources (IPCC, 2014). The main risks for fisheries and aquaculture are reasonably well understood: A number of marine species, depending on their mobility and habitat connection, are responding to climate impacts by shifting their distributions poleward and to deeper waters (see Box 16 and Figure 38). The increased uptake of carbon dioxide by oceans, resulting in higher water acidity, is also of particular concern for calcifying organisms in natural environments (including mariculture facilities), although the full ecosystem effects are still inconclusive. Competition for water, changes in the water cycle, increased frequency of storms and sea level rise are all expected to affect both inland fisheries and aquaculture industries (Seggel, De Young and Soto, 2016).

A number of researchers have published evidence to strengthen these arguments. Primary production of the global ocean, on which the marine food web and ultimately fish rely, is expected to decline by 6 percent by 2100 and by 11 percent in tropical zones (Kwiatkowski *et al*., 2017). Diverse models predict that by 2050, the total global fish catch potential may vary by less than 10 percent (Barange *et al*., 2014; Cheung *et al*., 2010) depending on the trajectory of greenhouse gas emissions, but with very significant geographical variability. While impacts will be predominately negative in many fisheries-dependent tropical regions, opportunities will also arise in temperate regions (Barange *et al*., 2014) (Figure 39).

In 2016, IPCC commissioned the *Special report on the ocean and cryosphere in a changing climate*, to be finalized in 2019, which will have a particular focus on marine ecosystems and dependent communities. At the same time, FAO commissioned a report to update an earlier study on the impacts of climate change for fisheries and aquaculture (Cochrane *et al*., 2009). These efforts recognize that the risks and vulnerabilities in the fisheries and aquaculture sector, and in the communities that rely on it, depend not only on predicted physical, chemical and biological changes (and the likelihood of their occurrence), but also on the vulnerability of their contexts.

Recent projections from the Inter-Sectoral Impact Model Intercomparison Project (www.isimip.org) have suggested that changes in marine fisheries production may be just as large as those in crop agriculture, which is often claimed to be the sector most affected by climate change. Furthermore, the projections reveal decreases in both marine and terrestrial production in almost 85 percent of coastal countries analysed, varying widely in their national capacity to adapt (Blanchard *et al*., 2017). These findings underline the importance of responding to climate change in a coordinated manner across all food systems, to ensure opportunities are maximized and negative impacts reduced, and to secure food and livelihood provision. Necessary actions in fisheries and aquaculture, as in agriculture, must include effective governance, improved management and conservation, efforts to maximize societal and environmental benefits from trade, increased equitability of distribution and innovation in food production, and the continued development of low-input and low-impact aquaculture.

BOX 16
PREDICTING CHANGES IN SPECIES DISTRIBUTIONS

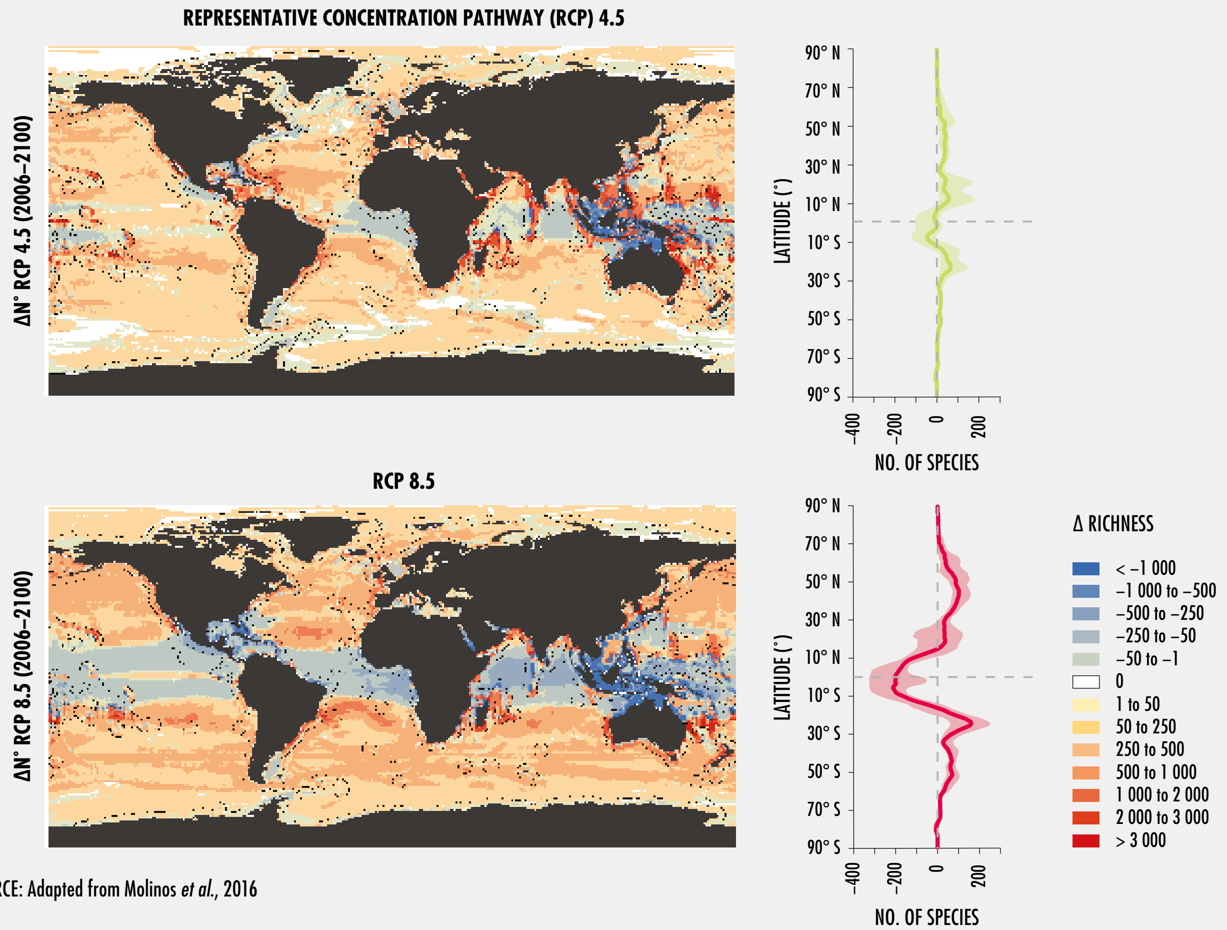
It is now known with high confidence that climate change is producing shifts in the distribution of aquatic species and that this trend is to continue. Marine species have been expanding the leading edges of their distributions, generally poleward, by 72 km per decade on average, while the arrival of spring conditions in marine habitats has been advancing by 4.4 days per decade (Poloczanska *et al.*, 2013; Pinsky *et al.*, 2013). These trends are consistent with species keeping to their thermal or related ecological preferences. The concern is that these shifts will affect biological interactions, and by consequence the functioning of marine ecosystems. As a result, climate change could substantially alter the provision of the goods and services obtained from marine ecosystems.

Recent evidence indicates that poleward expansion will result in a net local increase in species richness in most places, except in tropical regions, where strong decreases in richness are expected (Molinos *et al.*, 2016) (Figure 38), although the patterns in species richness are ultimately determined by multiple local drivers in addition to temperature change (Batt *et al.*, 2017).

While advancements in modelling suggest that range shifts will continue (Cheung *et al.*, 2016), not all shifts will be predictable. The rate and direction of change in temperature, known as climate velocity, shifts over space and time (Pinsky *et al.*, 2013; Burrows *et al.*, 2014). The nature, direction and speed of change will be determined by how species and communities interact with climate shifts, how tolerant they are to thermal changes, their dependency on specific habitats, the length of their life cycle and their interactions with other species. The vulnerability of species to the indirect effects of climate change – such as changes in dissolved oxygen levels, ocean acidification (Branch *et al.*, 2013), precipitation and river discharges – further complicates these predictions (Poloczanska *et al.*, 2013), as does fishing pressure, which can amplify or dampen climate impacts.

Distributional shifts can have managerial, jurisdictional and/or operational implications. Research will be needed on strategies for allowing both fisheries and the species they exploit to adapt smoothly to global climate change, particularly in light of possible feedback between them.

FIGURE 38
DIFFERENCE BETWEEN PROJECTED (2100) AND CURRENT (2006) SPECIES RICHNESS FOR LOW (TOP) AND HIGH (BOTTOM) GREENHOUSE GAS EMISSION PATHWAYS



SOURCE: Adapted from Molinos *et al.*, 2016

FIGURE 39
EXAMPLES OF PROJECTED IMPACTS AND VULNERABILITIES ASSOCIATED WITH CLIMATE CHANGE IN OCEAN SUBREGIONS (TOP), WITH EXAMPLES OF RISKS TO FISHERIES FROM OBSERVED AND PROJECTED IMPACTS (BOTTOM)

○ PROJECTED IMPACTS AND VULNERABILITIES ASSOCIATED WITH CLIMATE CHANGE

1) Expansion of low productivity areas as a consequence of thermal stratification (Low)

6) Decline in dissolved oxygen through changes in solubility and ocean circulation (Medium)

3) Upwelling, hence productivity, changes as a result of climate variability (Low)

9) Mass coral bleaching and mortality in response to warming (Very high)

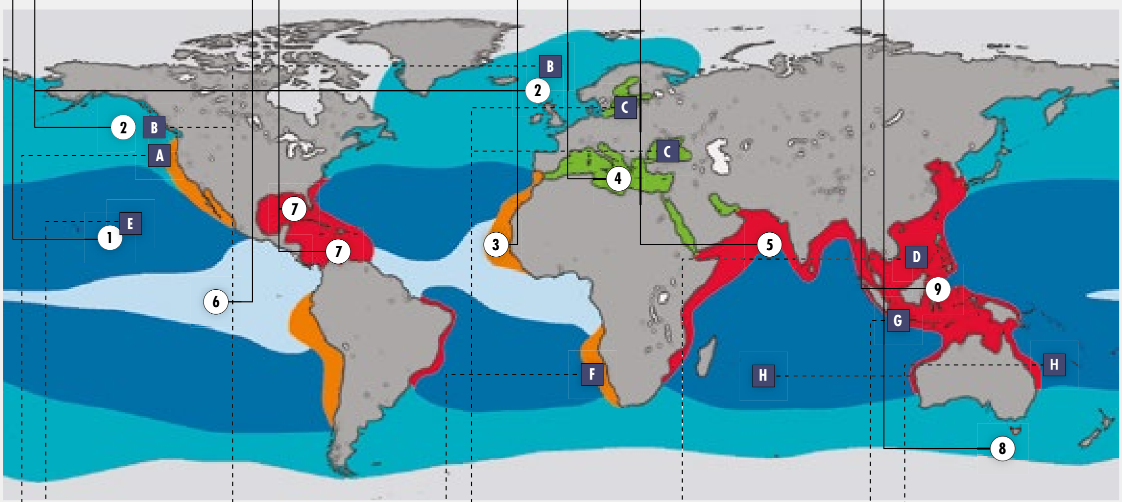
4) Spread of tropical species originating from Indian and Atlantic Oceans (High)

2) Northward expansion of fish communities; increase in fish biomass at high latitude fringes (High)

7) Expansion of seasonally hypoxic waters due to thermal stratification and eutrophication; mass coral bleaching events (High)

5) Expansion of Oxygen Minimum Zones (High)

8) Shoaling of aragonite saturation horizon reduces biological calcification (High)



E) Decline in primary production and reductions in fish catch (Low)

B) Increased fish catches at high-latitude fringes with economic disruptions and jurisdictional tensions as some fish stocks shift distributions (Medium)

C) Thermal stratification and eutrophication reduces dissolved oxygen (Medium)

D) Sea level rise modifies coastlines and increases flooding (Medium)

H) Temperature-driven shifts in stocks of large pelagic fish create winners and losers (High)

A) Acidification affects shellfish aquaculture (Medium)

F) Increase in variability of upwelling in some Eastern Boundary Upwelling Systems (Medium)

G) Degradation of coral reefs and associated fish stocks as the extent and intensity of mass coral bleaching and mortality increases (High)

☐ RISKS TO FISHERIES FROM OBSERVED AND PROJECTED IMPACTS

IPCC OCEAN SUBREGIONS

- High-Latitude Spring Bloom Systems
- Semi-Enclosed Seas
- Coastal Boundary Systems
- Eastern Boundary Upwelling Systems
- Equatorial Upwelling Systems
- Subtropical Gyres

NOTE: Level of confidence is indicated in brackets
SOURCE: Modified from Figure 30-12 in Hoegh-Guldberg *et al.*, 2014

Adaptation concepts and tools

The Paris Agreement (UN, 2015) is the first climate agreement that puts adaptation on the same footing as mitigation within the overall context of food production (Article 2). The Paris Agreement also establishes, for the first time, a global goal on adaptation: "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change" (Article 7). Resilience is defined as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance", and vulnerability as "the propensity or predisposition to be adversely affected" (IPCC, 2014).

IPCC (2014) defines adaptation as "the process of adjustment to actual or expected climate and its effects". The development field prefers the term "climate resilience", to emphasize the strong link between adaptation and development. In fisheries and aquaculture, actions for adaptation (or climate resilience) are taken in the private (fishers, fish farmers, their communities) and public (local and/or national authorities, regional fishery bodies) sectors, in domestic and/or regional settings for different types of impact and fishing typology (small-, medium- and large-scale fishing and fish farming).

Adaptation interventions may be designed to target three areas (Table 21), or a combination of these:

- **Institutions and management:** Interventions, mainly on the part of public bodies, address governance mechanisms, legal, regulatory, policy and management frameworks and public investments and incentives; they will include the planning, development and management of fisheries and aquaculture in a manner that addresses the dynamic nature of natural systems and societal needs in the face of climate change, following EAF/EAA principles.
- **Livelihood adaptation:** Interventions, mostly in the private sector, include a mix of public and private activities, within or among sectors, most commonly through diversification strategies within or outside the sector to reduce vulnerability.
- **Resilience and risk reduction:** Interventions include a mix of public and private activities to promote early warning and information systems, improve risk reduction (prevention and preparedness) strategies and enhance response to shocks.

In adaptation planning it is necessary to consider when and how to adapt, trade-offs between the present and the future and the risks and returns of adaptive investments. Increased and uncertain impacts will also require increased monitoring and reporting. The Fifth Assessment Report of IPCC (2014) recognizes iterative risk management as a useful framework for decision-making (Figure 40); this involves assessment of the widest possible range of impacts to understand the benefits and trade-offs of alternative actions, combined with an evaluation and learning process to improve future adaptation.

While fishers, fish farmers and fish workers are accustomed to climate variability, they require adequate adaptive capacity to deal with long-term as well as sudden or unpredictable change (Box 17). Low-income countries and low-income population groups, in particular, often lack the institutional, financial and technological capacity to adapt effectively. The Paris Agreement thus urges a significant increase in financial assistance for adaptation in developing countries.

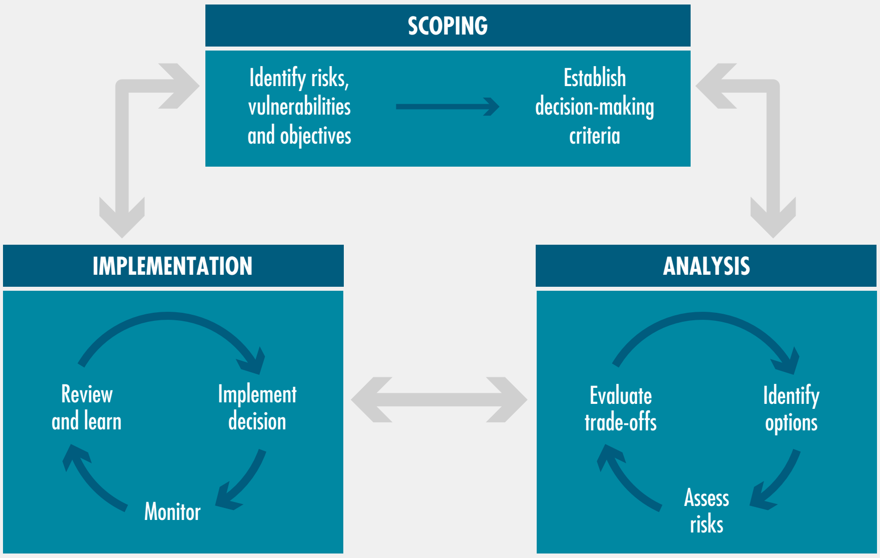
Guiding countries on the integration of fisheries and aquaculture in National Adaptation Plans

National Adaptation Plans (NAPs) are mechanisms to enhance medium- to long-term climate change adaptation planning formally established at the sixteenth Conference of the Parties to UNFCCC (COP 16) in 2010. In support of the NAP process, the Least Developed Countries Expert Group of UNFCCC (LEG, 2012) issued technical guidelines to provide advice for national planning processes, identifying and addressing capacity gaps, preparing national adaptation plans and establishing a monitoring and evaluation system. These guidelines are not specific to any sector, and agencies and partners were invited to submit sector-specific supplements to them. FAO has developed a set of supplementary guidelines for all agricultural sectors (crops, livestock, »

TABLE 21
EXAMPLES OF ADAPTATION OPTIONS FOR FISHERIES AND AQUACULTURE

Type of intervention	Examples
Institutions and management	
Public policies	Considering fisheries and aquaculture in regional, national and local adaptation policies and plans Building political support for management change Cross-sectoral coordination and regulation
Legal matters	Mechanisms for protecting tenure and access rights
Institutional design/set-up	Building capacity of institutions to integrate research, management and policy Encouraging partnership between science and policy institutions so that research is developed at relevant scales for decision-making Enhanced institutional cooperation agreement(s) among countries to enhance the capacity of fleets to move across national boundaries in response to change in species distribution
Planning and management	Implementation of the ecosystem approach to fisheries and to aquaculture Integrated coastal zone (ICZ) management Flexible seasonal rights Redistribution of rights among neighbouring municipalities to share responsibilities Risk-based zoning and siting through risk analysis Temporal and spatial planning to permit stock recovery during periods when climate is favourable Transboundary stock management to take into account changes in distribution Aquaculture area management plans to minimize climate-related risks
Livelihoods	
Within sector	Diversification of patterns of fishing or fish farming activities with respect to the species exploited, location of fishing grounds or farms and gear used Improvement or change in post-harvest techniques/practices and storage Improvement in product quality: ecolabelling, reduction of post-harvest losses Investment in aquaculture (e.g. mud crab, seaweed, fish cages) Diversification of markets and fish products, access to higher-value markets
Outside sector	Livelihood diversification (e.g. switching among rice farming, tree crop farming and fishing in response to seasonal and interannual variations in fish availability)
Resilience/risk	
Early warning	Early warning communication and response system Monitoring trends Information to anticipate price/market variability Extreme weather forecasting
Pooling/risk sharing (or transfer)	Risk insurance, savings, credit, social protection
Prevention	Aquaculture zoning and area management Safety at sea and vessel stability Effective management of natural barriers to provide a natural first line of protection from storm surges and flooding Coastal zone management permitting movement of fish along with sea level rise Social safety nets for the most vulnerable
Preparedness and response	Documenting and disseminating best practices in the sector Guidebooks and training package on disaster needs assessment and response in the sector Sharing of property and risks among community members Insurance provision Activities aimed at strengthening social cohesion

FIGURE 40
RISK ASSESSMENT FRAMEWORK INCORPORATING ITERATIVE RISK MANAGEMENT



SOURCE: IPCC, 2014

» forestry and fisheries) (Karttunen *et al.*, 2017) and specific guidelines for fisheries and aquaculture (Brugère and De Young, 2018).

The guidance for fisheries and aquaculture builds on the principles of EAF/EAA. It proposes clear steps to ensure that the specificities of the sector are reflected in the NAP process and support adaptation planning within the sector. Plans should be developed in consultation with key stakeholders and should consider potential interactions with other sectors. The guidance is intended to be as practical as possible, with step-by-step advice and examples under the following four elements.

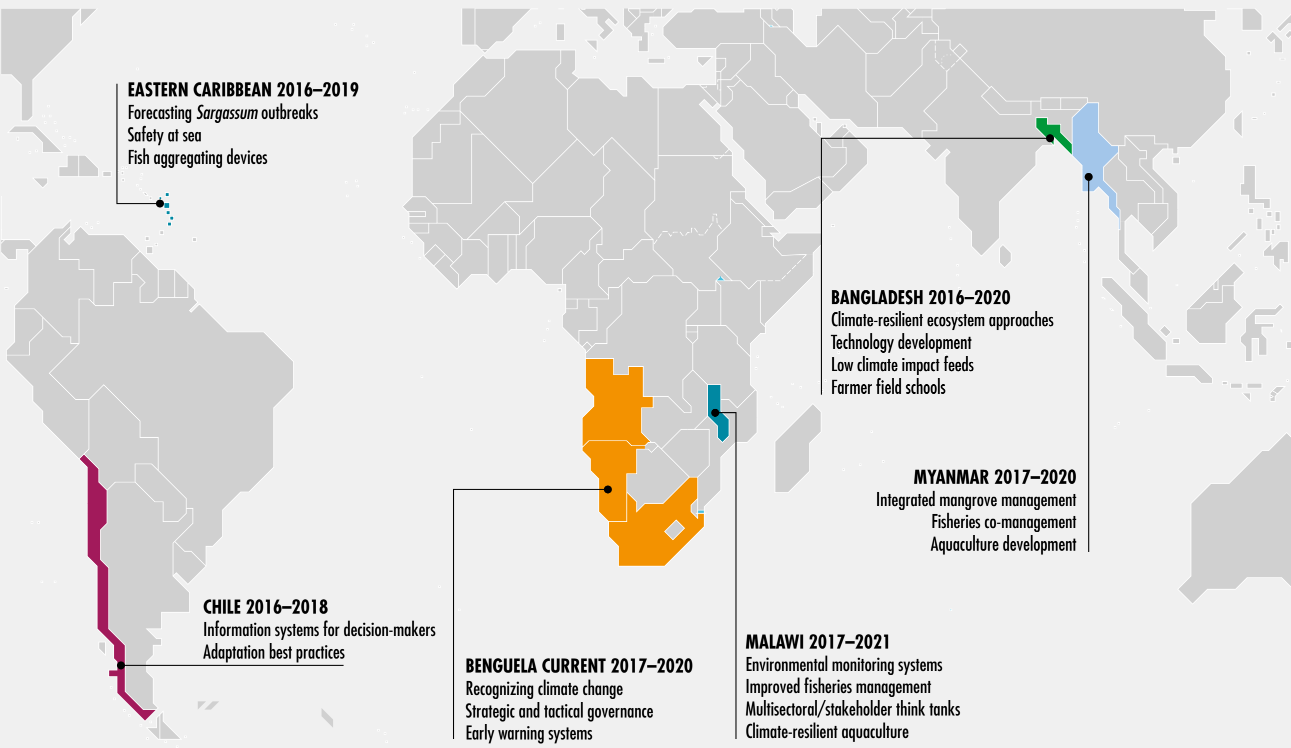
- **Institutional stocktaking and assessment** sets the scene for engaging key stakeholders in cross-sectoral NAP development and implementation. It involves taking stock of the sectors' previous experience in climate adaptation planning so as to build upon it, and evaluating the availability of the institutional and individual skills and mechanisms needed to support the mainstreaming of fisheries and aquaculture in NAPs.
- **Technical assessment** involves documenting the impact of climate change on aquatic systems and the fisheries and aquaculture activities and value chains that they support, identifying the social groups that will be affected, and analysing the reasons for the vulnerability of people and systems to the impact of climate change.
- **Planning integration** involves consolidating adaptation options in policies and strategies and including them in broader processes. The guidance addresses the information needed for adaptation planning and how to ensure the visibility and mainstreaming of fisheries and aquaculture in NAPs and national development policies.
- **Implementation** involves defining the adaptation mechanisms to include in the NAP and the practical actions and mechanisms that need to be in place to support their implementation. Monitoring and evaluation are required to determine whether and how fisheries and aquaculture are adapting to climate change and to assess the effectiveness of actions taken. ■

BOX 17
INCREASING THE ADAPTIVE CAPACITY OF THE FISHERIES AND AQUACULTURE SECTOR: FAO SUPPORT TO COUNTRIES

In response to direct requests, FAO has supported a number of countries and regions in mobilizing resources for project development and capacity building on the impacts of climate change in fisheries and aquaculture. Six national and regional climate change adaptation projects – in Bangladesh, the Benguela Current region (Angola, Namibia, South Africa), Chile, the Eastern Caribbean (Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago), Malawi and Myanmar – began implementation in 2016 and 2017 (Figure 41), with support from the GEF Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF).

These projects have the overall goal of increasing the adaptive capacity of the fisheries and aquaculture sector and enhancing its resilience. However, as fuller understanding of climate change implications is still needed at the national and local levels, strengthening knowledge and awareness – on climate change in riparian and coastal communities and on the need to adapt the management and exploitation practices of fisheries and aquaculture – is an important part of the projects. This awareness is expected to assist in the development of strong adaptation actions, their integration in national policies and their smooth implementation. The projects also seek to overcome barriers such as weaknesses in the institutional framework (national and local) and limited application of good management practices in the sector. They include a strong fisheries and aquaculture management component, mainly based on EAF/EAA principles and tools.

FIGURE 41
FAO CLIMATE CHANGE ADAPTATION PROJECTS



BOX 17
(CONTINUED)

Vulnerability assessments are a key to sound understanding of climate impacts and provide a pathway to the development of robust adaptation actions. Given the multitude of available approaches and methodologies for assessing vulnerability (Brugère and De Young, 2015), the initial phase of each project includes participatory and detailed vulnerability assessments at the regional, national, local and/or community levels to identify the areas and communities that are most at risk, with due consideration for gender and age groups. The next step is to identify suitable adaptation measures and provide a sound technical basis for informing policy changes. Project activities foreseen, specifically targeted to different stakeholder groups, include capacity strengthening to enable all stakeholders to assess the risks posed by climate change to their livelihoods and security and to ensure adaptation to address those risks.

SMALL-SCALE FISHERIES AND AQUACULTURE

Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries – towards delivering results on the ground

Four years after COFI endorsed the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (FAO, 2015a), governments, partners and stakeholders are showing keen interest in small-scale fisheries (Box 18).

Several countries and regional organizations have incorporated reference to the SSF Guidelines in relevant policies and strategies, and new initiatives by NGOs and development partners are increasingly addressing small-scale fisheries issues in new ways and more explicitly. CSOs also continue to create awareness among their member fishers and fish workers of this unique international instrument which is entirely dedicated to small-scale fisheries. But is real change happening on the ground, in the lives and livelihoods of coastal, riverside and lakeshore communities?

The SSF Guidelines follow a human rights–based approach and see small-scale fisheries through a broader lens, looking beyond the fisheries and aquaculture sector. They promote a holistic approach to small-scale fisheries governance and management that takes fishery-based livelihoods into consideration. The thematic areas covered by the SSF Guidelines hence include social development, the post-harvest sector, gender, disaster risks and climate change in addition to responsible fishing and management.

This complexity can appear challenging and could potentially hinder real progress on implementation. FAO is therefore providing guidance to support the uptake of the SSF Guidelines in the hope of motivating change on the ground. For example, two expert workshops organized by FAO in 2016 were dedicated to exploring the human rights–based approach in implementing and monitoring the SSF Guidelines (Yeshanew, Franz and Westlund, 2017) and in gender-equitable small-scale fisheries (Correa, 2017), respectively. The latter was the culmination of a participatory process to develop a handbook on gender-equitable small-scale fisheries in support of the implementation of the SSF Guidelines (Biswas, 2017). A legal guide in support of implementation of the guidelines is currently under development. Through the Too Big To Ignore research network, in which FAO is a partner, over 90 researchers, practitioners and civil society representatives contributed to the book *The Small-Scale Fisheries Guidelines: global implementation* (Jentoft *et al.*, 2017), which contains case studies identifying entry points on how the SSF Guidelines can contribute to securing sustainable small-scale fisheries.

While advice is being developed, concrete actions are already taking place on the ground, although not yet on a large scale. Costa Rica, for example, has developed a draft law on small-scale fisheries

BOX 18
2022 ANNOUNCED AS THE INTERNATIONAL YEAR OF ARTISANAL FISHERIES AND AQUACULTURE

On 22 November 2017, the seventy-second session of the General Assembly of the United Nations proclaimed 2022 as the International Year of Artisanal Fisheries and Aquaculture (IYAFA) and invited FAO to serve as lead agency for celebration of the year, in collaboration with other relevant organizations and bodies of the United Nations system (UN, 2017c). The year was first proposed by the FAO Regional Conference for Latin America and the Caribbean in 2016, to affirm the role of artisanal fisheries and aquaculture in the eradication of hunger, food insecurity, malnutrition, poverty and the sustainable use of fisheries resources and hence their contribution to achieving SDGs 1, 2 and 14. The proposal was then endorsed by COFI; the Council of FAO endorsed a draft resolution to declare the year, and the fortieth Conference of FAO endorsed the resolution.

The IYAFA is intended to sensitize public opinion and governments about the importance of adopting specific public policies and programmes to promote sustainable artisanal fisheries and aquaculture, paying particular attention to the most vulnerable rural areas, constrained by poor governance and low capacity for sustainable resource use. The IYAFA will also provide a unique opportunity to promote the objectives of the SSF Guidelines. The five years leading to 2022 provide ample opportunity to chart a road map for action.

to provide a regulatory framework that recognizes the contribution of the sector to food security and poverty eradication. This law is complemented by specific activities to empower communities, for example the granting of harvesting permits to a cooperative, comprising mainly women, whose activities were previously informal. The United Republic of Tanzania is also embarking on the process of developing a National Plan of Action to implement the SSF Guidelines.

At the regional level, the incorporation of the SSF Guidelines in relevant policies, strategies and initiatives provides an enabling policy environment for change. Regions are using different entry points to put those policies and strategies into action, as shown in the following examples.

- SEAFDEC organized a workshop on the human rights–based approach and gender equity in regional implementation of the SSF Guidelines in September 2017 in Bangkok.
- The Central Asian and Caucasus Regional Fisheries and Aquaculture Commission (CACFish) second regional expert group meeting on small-scale fisheries in Turkey in 2017 drew conclusions from a small-scale fisheries survey and developed recommendations in support of effective implementation of the SSF Guidelines in the subregion.
- The first meeting of the new permanent Working Group on Small-Scale and Recreational Fisheries of GFCM agreed in September 2017 to carry out a socio-economic survey and to establish a regional platform of small-scale fisheries organizations to strengthen the capacity of these actors to participate directly in decision-making and management processes.
- The Indian Ocean Commission (IOC), in collaboration with the Southern African Development Community (SADC) and FAO, organized a regional consultation on the implementation of the SSF Guidelines for the Indian Ocean and Southern African region in Mauritius in December 2016. Participants discussed modalities and identified priorities for the region, taking into account existing regional frameworks of the African Union, SADC and IOC.
- In June 2016, OSPESCA and the Confederation of Artisanal Fisherfolk of Central America convened a workshop on the new guidelines for small-scale fisheries in Nicaragua, as well as the first meeting of the OSPESCA small-scale fisheries working group.
- The adoption of a model law on small-scale fisheries through the Latin American Parliament (Parlatino) provides concrete guidance on improving regulatory frameworks in support of small-scale fisheries.

BOX 19
HIDDEN HARVEST 2: EXPANDING MEASURES OF THE SOCIO-ECONOMIC CONTRIBUTIONS OF SMALL-SCALE FISHERIES

The SSF Guidelines provide a policy framework for how to move small-scale fisheries into sustainability through a holistic and integrated approach. However, this transformation needs substantial support, including better data and information on the contributions of small-scale fisheries to the three dimensions of sustainable development: social, economic and environmental. For this reason, FAO has proposed a new study to build on the World Bank (2012) *Hidden harvest* report, to deepen empirically verifiable information on small-scale fisheries and their socio-economic contributions, as well as to identify the key threats to these contributions and/or opportunities to enhance them. To elaborate plans for the study, FAO organized the Workshop on Improving our Knowledge on Small-Scale Fisheries: Data Needs and Methodologies from 27 to 29 June 2017 in Rome (Basurto *et al.*, 2017), supported by World Fish and Duke University, which are partnering with FAO in this effort.

The study will be conducted throughout 2018 and 2019 and is expected to be the most extensive compilation to date of information available on the diverse contributions of small-scale fisheries to communities and countries around the world. The backbone of the effort will be national-level case studies from coastal and island States, where most of the world's small-scale fishers live and work. Since the publication of the 2012 study, additional regional and global data sets have become available, including household surveys and census information, nutritional information on fish species, consumption among coastal indigenous peoples and location-based catch estimates, among others. Worldwide estimates will be generated to the extent possible using a mixed-methods approach, with data drawn from both the available global datasets and the national case studies. The study may also provide a framework for continual monitoring of the socio-economic contributions from small-scale fisheries, so that this information will remain available to policy-makers and support the tracking of progress in the implementation of the SSF Guidelines.

In these initiatives, better understanding of the specific characteristics of small-scale fisheries and capacity development for key State and non-State actors are commonly perceived needs.

Stakeholder empowerment remains a key pillar of SSF Guidelines implementation. Fisher organizations continue to take an active role in raising awareness and supporting organizational strengthening. In particular, member organizations of the International Planning Committee for Food Sovereignty (IPC) Fisheries Working Group organized five national and two regional consultations in support of SSF Guidelines implementation in 2016–2017. They, as well as other partners, are also responsible for translating the SSF Guidelines into non-FAO languages, including Bengali, Kannada, Portuguese and Tamil. FAO partnered with the Fund for the Development of the Indigenous Peoples of Latin America and the Caribbean to develop capacities of indigenous peoples' representatives, and with governments and OSPESCA in Central America to use the SSF Guidelines as a constructive tool for empowerment.

The interest in the SSF Guidelines by a wide variety of partners confirms their value as a tool for triggering change. An important task for FAO will be to support partners further in their efforts to apply and mainstream the SSF Guidelines, and to facilitate a learning and experience sharing process that can inform future implementation. A key requirement for application of the SSF Guidelines is to improve information on small-scale fisheries (see Box 19). New information and communication technology (ICT) provides opportunities for small-scale fisheries in areas such as safety, governance, efficiency, capacity building, networking and sharing of local knowledge (Box 20).

Assessing small-scale aquaculture

Small-scale aquaculture contributes to global aquaculture production and to rural livelihood development through provision of food, livelihoods and income-generating opportunities, improving social equity and enhancing the quality of life of poor rural communities. In the »

BOX 20
INFORMATION AND COMMUNICATION TECHNOLOGY IN SUPPORT OF SMALL-SCALE FISHERIES AND AQUACULTURE

The rapid spread of ICT has already revolutionized the fisheries and aquaculture sector, whether for identifying fishing resources, planning and monitoring or providing market information (electronic catch documentation and traceability systems, price information) (see also "Disruptive technologies" in Part 4). ICT has also become more personal through affordable mobile devices that facilitate safety at sea, spatial planning, co-management and social networking. It can also benefit resource-poor stakeholders.

Safety first and early warning
Fishers' safety during operations or rescue relies on ICT. Electronic beacons, optionally combined with automatic identification systems (AIS) or vessel monitoring systems (VMS), can serve as safety devices and at the same time provide vessel activity information.

Mobile phone advisory services provide early warning information on weather and extreme events and allow fishers to call for assistance. Social networks can also be an early warning source for emergencies such as disease outbreak. Epizootic Ulcerative Syndrome in the Democratic Republic of the Congo, for example, was first mentioned on SARNISSA (Sustainable Aquaculture Research Networks in Sub-Saharan Africa), an African aquaculture stakeholders' mailing list (FAO, 2017q).

Governance
Social media and other Internet-based applications, which can be accessed using mobile phones and tablets, can improve access to and sharing of reliable data such as catch and effort and fisheries management rules and regulations, thus helping to empower stakeholders, especially during negotiation of co-management partnerships. An example is ABALOBI, an information-management system and mobile application suite co-developed by academics, the government and fisher communities in South Africa to empower small-scale fishers by providing them with access to and control over information and resource networks in areas from fishery monitoring and maritime safety to local development and market opportunities (Figure 42).

ICTs also support efforts to combat IUU fishing. The use of global positioning systems (GPS), for example, is increasing in monitoring, control and surveillance of fishing through VMS on larger vessels and smaller tracking devices such as SPOT trackers.

Efficiency
Aquaculture management software allows farmers to optimize production. New developments include air-based and aquatic sensors and drones for inspecting equipment and moorings, monitoring the environment and fish, and assisting in the optimization of farm operations.

In fisheries, navigation aids such as GPS make it possible to mark fishing areas, log trips and plan fuel-efficient trips. Some vessels use ICT to combine information from sonar, used to locate fish, sea beds and underwater debris, with trip reports, providing new datasets for improved efficiency.

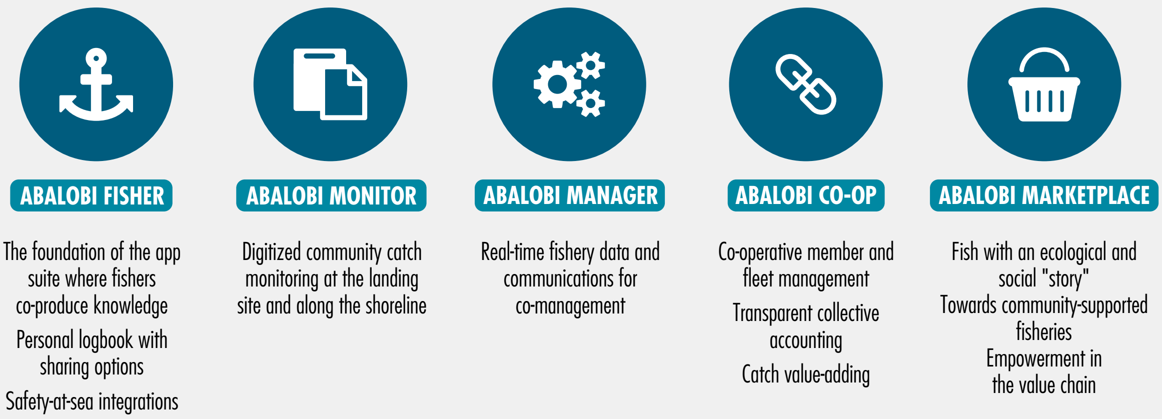
Capacity building and social networking
ICTs have broadened the tools available for capacity building, especially for isolated or remote communities. The electronic delivery of extension services, for example, may complement traditional fisheries and aquaculture extension systems, allowing those involved in the sector to obtain information more easily on modern and sustainable practices along the supply chain. An example is the Philippines e-Extension Portal for agriculture, fisheries and natural resource sectors (http://e-extension.gov.ph). Social networking can offer workers in small-scale fisheries and aquaculture opportunities for sharing knowledge and staying connected to families and social groups, which is of particular importance when they are out at sea or need to migrate for fishing/farming activities.

Local knowledge for monitoring change
Easily accessible ICTs offer potential for harnessing local knowledge of fishing and fish-farming communities through, for example, citizen science platforms that enable stakeholders to use smartphones and websites to share information on changes in their aquatic environments, such as new species sightings or habitat loss (see, for example, www.redmap.org.au).

BOX 20
(CONTINUED)

Lessons learned
As experience in the use of ICT for small-scale fisheries and aquaculture grows, so does knowledge on the benefits and risks associated with different ICTs and on good practices in their development and implementation. For example, recent experiences of the Regional Fisheries Livelihood Programme for South and Southeast Asia (RFLP) are shared through lessons learned notes on the potential uses and users' benefits, tips, issues to consider and potential pitfalls, as well as critical questions to ask before committing to the use of any information or communication technology (FAO, 2012c).

FIGURE 42
ABALOBI – A RANGE OF INTEGRATED MOBILE PHONE APPLICATIONS FOR SOUTH AFRICAN SMALL-SCALE FISHERS



SOURCE: ABALOBI, 2017

» past, the status, potential, limitations and constraints of small-scale aquaculture at the country level could only be evaluated through case studies or the use of methods such as rapid rural appraisal, participatory rural appraisal or impact assessment to evaluate its role in poverty alleviation and food security. These approaches were useful for sectoral planning and development; however, they did not permit systematic assessment of the contribution of small-scale aquaculture to aquaculture overall or to rural livelihood development. In 2008, at an expert workshop in Nha Trang, Viet Nam, FAO and partners launched the development of assessment indicators to measure the performance of the sector and to support local, regional and national policy-makers in accounting its contributions (Bondad-Reantaso and Prein, 2009). The Nha Trang indicator system is intended to enhance understanding of the risks and threats to small-scale aquaculture as a basis for designing appropriate interventions, setting

BOX 21
NHA TRANG INDICATORS TO MEASURE THE CONTRIBUTION OF SMALL-SCALE AQUACULTURE TO SUSTAINABLE RURAL DEVELOPMENT

Natural capital
1 Types and number of nutrient flows
2 Number of farm production uses of water

Physical capital
3 Number of small-scale aquaculture (SSA) farms and farm areas increased over three years in the study area
4 Types and number of rural infrastructure investments induced by SSA
5 Types and number of rural infrastructure investments induced not purposely for SSA but benefiting SSA

Human capital
6 Per capita annual consumption of fish in SSA household (only fish for their own SSA harvest)
7 Season of the year when the household relies more on its own harvest than on fish from other sources

Financial capital
8 Percentage of cash income from SSA to total household cash income
9 Economic return from SSA to households
10 Percentage of economic value from SSA production to production from all aquaculture in the province

Social capital
11 Percentage of farm households that are active members of SSA programmes/associations/organizations
12 Percentage of number of SSA farm activities in which women take the major decision-making role
13.1 Number of SSA households that share fish products and other farm resources
13.2 Number of activities in which farmers work together to improve the shared resources in the community (e.g. water system, road, reservoir)
14 Ratio of family labour who previously worked solely or mainly in non-SSA (including off-farm jobs) but now work in SSA to total family labour

SOURCE: Bondad-Reantaso and Prein, 2009

priorities and allocating resources. Pilot tests of the indicators have been carried out in a number of Asian countries.

The indicator system (Box 21) is based on a definition in which small-scale aquaculture is characterized as a continuum of:

- systems involving limited investment in assets and small investment in operational costs, including largely family labour and in which aquaculture is just one of several enterprises (known in earlier classifications as Type 1 or rural aquaculture);
- systems in which aquaculture is the principal source of livelihood, in which the operator has invested substantial livelihood assets in terms of time, labour, infrastructure and capital (also known as Type 2 aquaculture).

The system was developed through the following steps (FAO, 2010c): understanding the subject of measurement; identifying an analytical framework and setting criteria; developing a list of small-scale aquaculture contributions; categorizing the contributions based on the analytical framework and agreed criteria; devising and organizing indicators of the contributions; and measuring the indicators. The sustainable livelihood approach was used as the conceptual framework and accuracy, measurability and efficiency as the agreed criteria. The sustainable livelihood approach reflects the primary objective of a small-scale aquaculture system, i.e. to balance the use and/or development of the five types of livelihood capital or assets (natural, physical, human, financial and social).

Examining the impacts of small-scale aquaculture on households, communities and the environment: testing the Nha Trang indicators

A set of case studies (FAO, forthcoming) used the Nha Trang indicators to examine the contribution of small-scale aquaculture to the five livelihood assets for different small-scale systems in China (pond freshwater polyculture, integrated fish farming system), the Philippines (seaweed, tilapia in cages), Thailand (freshwater pond finfish polyculture, catfish in plastic-lined ponds) and Viet Nam (tiger shrimp ponds, lobster in cages, shrimp–finfish ponds). Results revealed the complex, multi-faceted impact of small-scale aquaculture on households, communities and the environment.

The impacts on natural capital were mixed. Some aquaculture systems (in China, Thailand and Viet Nam) adopted sustainability-enhancing practices such as reuse of water and material flows, while others (in Viet Nam and the Philippines) contributed to nutrient loading, threatening environmental harm.

The impacts on on-farm physical capital formation were likewise mixed, with growth seen in some study sites and contraction in others. Most of the systems studied, except those in Viet Nam, showed negligible changes in farms and farm areas. Small-scale aquaculture did not usually develop infrastructure, but the sector benefited from existing infrastructure.

In terms of human capital, some but not all small-scale aquaculture systems contributed to seasonal food security.

The financial capital indicators formed a clear pattern. Intensive (Type 2) aquaculture systems generated the highest cash income and net returns, but these were highly variable (and the systems therefore more risky). These systems showed profitability (although small) and improvement in household cash flow.

The studies also showed that small-scale aquaculture encourages formation of community farmer organizations, women's empowerment and voice in economic enterprise, networks and collective action. Small-scale aquaculture fosters social harmony through the sharing of harvest and technical knowledge and expertise. Concerning indicator 12, related to the role of women, some small-scale aquaculture systems provided an opportunity for women to assume major decision-making roles, for example in obtaining loans, managing household expenses, farm record keeping and sale and allocation of fish harvest.

As a whole, the results showed the tremendous diversity of small-scale aquaculture activities across commodities, production systems and locations, which makes measuring the contributions to sustainable rural development often challenging. The Nha Trang indicators are a useful step in this direction, but further refinements are needed to make the system more adaptable to the intricacies of diverse small-scale aquaculture systems. ■

REALIZING AQUACULTURE'S POTENTIAL

With most fishery stocks expected to remain maximally sustainably fished or overfished for at least the next decade, aquaculture must bridge the growing gap between supplies of aquatic food and demand from a growing and wealthier global population. Aquaculture has the potential to address the gap between aquatic food demand and supply and to help countries achieve their economic, social and environmental goals, thus contributing to the 2030 Agenda (Hambrey, 2017; FAO, 2017c).However, the growth of aquaculture raises a number of questions in relation to the resources that it consumes (e.g. space, feedstuffs), its products (see "Fish for food security and human nutrition" in Part 2) and the threats that the sector faces from external factors such as climate change and disease.

Aquaculture spatial planning and area management

The ability of aquaculture to meet future demand for food will to some extent depend on the availability of space. Common space-related problems that limit aquaculture development include: introduction and spread of aquatic animal diseases, environmental concerns, limited production, social conflicts, restricted access to post-harvesting services, risks for financing, and a lack of resilience to climatic variability, climate change and other threats and disasters (FAO and World Bank, 2015). Aquaculture spatial planning is fundamental for integrated management of land, water and other resources and to enable the sustainable development of aquaculture in a way that accommodates the needs of competing economic sectors and minimizes conflict. Spatial planning should integrate social, economic, environmental and governance objectives of sustainable development in accordance with the FAO Code of Conduct for Responsible Fisheries (FAO, 1995). The ecosystem approach to aquaculture (see section on this topic in Part 2) and blue growth (see Part 4) are useful frameworks in this context (FAO and World Bank, 2015). Blue growth adds value to the ecosystem approach by linking it to other advances such as improved energy efficiencies, climate change adaptation and innovations that can improve social, economic and ecosystem outcomes.

A growing number of countries are engaging in aquaculture spatial planning. For example, in the Mediterranean, the General Fisheries Commission for the Mediterranean (GFCM) is promoting the concept of allocated zones for aquaculture (AZAs) (Sanchez-Jerez *et al.*, 2016). Some initiatives in wider marine spatial planning processes integrate the spatial concerns of fisheries and aquaculture with those of other users of the marine space (Meaden *et al.*, 2016), which aim to optimize the sustainable use of marine space for all stakeholders.

Aquaculture spatial planning offers many specific opportunities, including:

- mapping the presence, absence and distribution of aquatic animal disease to support disease surveillance, zoning and risk assessment of disease spread (disease risk prevention and management);
- ensuring that aquaculture operations stay within the ecosystem's carrying capacity;
- reducing conflicts;
- improving public perceptions of aquaculture;
- promoting the creation of management areas to facilitate certification (Kassam, Subasinghe and Phillips, 2011);
- enabling access to finance;
- improving management practices;
- creating a resilient sector that is better adapted to climate change and other threats;
- improving market linkages (e.g. proximity to transport and markets).

Continuing advances in remote sensing (e.g. satellites and drones) and mapping technologies, ICT, ecological modelling, improved Internet connectivity and computer processing enhance support to spatial planning and management processes. FAO provides technical assistance on spatial planning to its Members through studies, technical guidance, capacity development and innovative tools (Aguilar-Manjarrez, Soto and Brummett, 2017).

For the future promotion of sustainable aquaculture, it is imperative that integrated spatial planning be effectively applied at both the national and regional levels. In addition, a sound legal and regulatory planning and development framework should be in place. Participatory spatial planning, resource allocation and management are essential if aquaculture is to maximize its potential to secure food security for a growing population. Spatial planning processes and tools need to be adaptable to a range of local factors, including changing markets, competition, input costs and supply, capital, labour and the urgency of problems or opportunities, as well as the potential impacts of climate change.

Feed resources

During the period 1995 to 2015, production of farmed aquatic species reliant on feeds increased more than fourfold, from 12 to 51 million tonnes, largely through intensification of production methods for shrimp, tilapias, carps and salmonids (Hasan, 2017a). Today, 48 percent of total global aquaculture production including aquatic plants (66 percent excluding aquatic plants) is produced using exogenous feed. Given the projected increase in aquaculture production, are the trends in feed use sustainable?

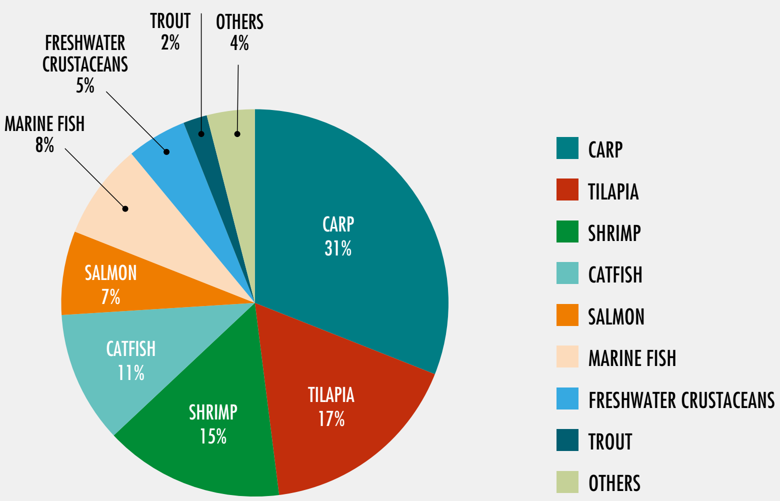
While some feeds are farm made and/or comprise fresh ingredients, commercially manufactured feeds are increasingly widely used. Feed may be used to supplement natural production (often termed "semi-intensive aquaculture") or to supply all the farmed aquatic animal's nutrition needs ("intensive aquaculture"). The trend towards increasing use of feed is driven by greater availability and by profitability (i.e. with profits increased by judicious use of feed). Thus, between 1995 and 2015, production of industrial aquaculture feeds increased sixfold, from 8 to 48 million tonnes (Figure 43) (Tacon, Hasan and Metian, 2011; Hasan, 2017b).

Aquaculture feeds are manufactured from a variety of crops and crop co-products, wild fish and fish and livestock processing co-products. Some of them, such as fishmeal and fish oil, are produced from reductions of highly nutritious wild fish. However, the proportion of fish from capture fisheries being reduced to fishmeal and fish oil has been declining in recent decades, and it is projected that a growing share of fishmeal and fish oil production will be obtained from fish processing co-products (see "Projections of fisheries, aquaculture and markets" in Part 4).

The dietary inclusion rates of fishmeal and fish oil in aquaculture feeds have also been falling, increasingly replaced by crops, especially oilseeds (Tacon, Hasan and Metian, 2011; FAO, 2012d; Hasan and New, 2013; Little, Newton and Beveridge, 2016). Fishmeal and fish oil inclusion rates in Atlantic salmon diets, for example, fell from 65 to 24 percent and from 19 to 11 percent, respectively, between 1990 and 2013 (Ytrestøyl, Aas and Åsgård, 2015). Food conversion ratios (the ratio of biomass of food fed to fish produced) over the past 25 years have fallen from around 3:1 to around 1.3:1 (GSI, 2017), largely because of better feed formulations, feed manufacturing methods and on-farm feed management.

Although the use of fishmeal and fish oil in aquafeeds is more prevalent among higher trophic level finfish and crustaceans, low trophic level finfish species or groups (e.g. carp, tilapia, catfish, milkfish) are also fed with fishmeal and fish oil at rates of 2 to 4 percent of their diets. In total usage terms, the largest consumers of fishmeal in 2015 were marine shrimp, followed by marine fish, salmon, freshwater crustaceans, fed carp, tilapia, eel, trout, catfish and miscellaneous freshwater fish and milkfish (Tacon, Hasan and Metian, 2011; Hasan, 2017b).

FIGURE 43
SHARE OF CONSUMPTION OF TOTAL AQUACULTURE FEED BY SPECIES GROUP, 1995–2015 (%)



SOURCE: Updated from Tacon, Hasan and Metian, 2011

Greenhouse gas emissions from aquaculture remain relatively small, estimated to be 5 percent those from agriculture (Waite *et al*., 2014), but have been growing because of increased use of feeds. Reducing fishmeal and fish oil use and feed conversion ratios (FCRs) can be important in minimizing emissions (Hasan and Soto, 2017).

While discussions on aquaculture diets have focused on fishmeal and fish oil resources, the sustainability of aquaculture sector growth also remains closely linked to supplies of terrestrial animal and plant proteins, oils and carbohydrates (FAO, 2012d; Troell *et al*., 2014). Much research is being directed into novel aquaculture feedstuffs, including microbial seaweed and insect sources, but it is likely to be some years before these become widely available and affordable.

Aquaculture biosecurity and aquatic animal health management

The aquaculture sector is vulnerable to exotic, endemic and emerging disease epizootics. Acute hepatopancreatic necrosis disease, *Enterocytozoon hepatopenaei* and tilapia lake virus have emerged during the past few years; the geographical distribution of epizootic ulcerative syndrome and infectious myonecrosis virus has recently expanded; and white spot syndrome virus, infectious salmon anaemia and other bacterial, parasitic and fungal infectious diseases continue to affect farmed aquatic species. Constraints in dealing with aquaculture diseases include, among others, limitations in diagnostic techniques; the existence of cryptic pathogens and benign organisms that may become pathogenic when introduced to new hosts and new environments; limitations in control options for aquatic animal diseases; the occurrence of multifactorial disease syndromes and frequent subclinical infections; the undomesticated status of most farmed aquatic species; and the paucity of information on the health status of aquatic animals.

The responsible use of veterinary medicines, including antimicrobials, has benefits in terms of improved on-farm biosecurity and husbandry (e.g. through the use of vaccines and disinfectants). Such medicines are useful in treating chronic diseases that cause reduced growth, low food conversion rate and poor survival, and in battling epizootic diseases that can cause mass mortalities. However, the imprudent use of antibiotics in aquaculture has led to issues concerning antimicrobial residues and antimicrobial resistance.

Too often, a long time elapses from the first observation of mortality in the field to the identification and reporting of the causative agent and the application of appropriate control and risk management measures. A paradigm shift is needed in dealing with aquaculture biosecurity risks.

Addressing biosecurity requires significant resources, strong political will and concerted international action and cooperation. National strategic planning for aquatic animal health and biosecurity is vital; without it, a country can only react in a piecemeal fashion to new developments in international trade and serious transboundary aquatic animal diseases, and its aquaculture and fisheries sectors will remain vulnerable to new and emerging diseases. FAO encourages Member Countries to develop and formalize national aquatic animal health strategies and health management procedures (FAO, 2007) and to use the Progressive Management Pathway (PMP), a step-wise risk management framework based on similar frameworks used to develop and monitor national strategies for important livestock diseases such as foot-and-mouth disease, African animal trypanosomiasis, Peste des Petits Ruminants and rabies (FAO, 2011c). The actions must be risk-based, proactive and collaborative and should adhere to international standards and regional agreements (both obligatory and voluntary), particularly for those countries sharing transboundary waterways. Responsibilities must be shared among key national, regional and international stakeholders from government, the production sector and academia as well as other players in the value chain, building on each other's strengths towards a common goal.

The basic principle of aquatic animal health management remains a thorough consideration of host, pathogen and environment interactions. However, the application of findings from emerging fields such as metagenomics (the study of genetic materials recovered directly from environmental samples) and the pathobiome approach (looking at how the interaction of pathogens with other microorganisms may influence or drive disease causation) offer novel ways forward (Stentiford *et al*., 2017). Genetics and nutrition also play important roles in producing healthy, nutritious and resilient hosts.

Cooperative learning and innovative research programmes (e.g. for more efficacious vaccines, more sensitive and rapid diagnostic tools, and biosecurity strategies using specific pathogen free [SPF], specific pathogen tolerant [SPT] and specific pathogen resistant [SPR] stocks) are needed for long-term biosecurity management and sustainable development of aquaculture. While the number of commercially available fish vaccines has grown in recent years, there are still numerous diseases for which vaccines are unavailable or do not perform well. Shrimp, for example, cannot be vaccinated as they lack an adaptive immune system.

An integrated surveillance programme within the One Health Platform, which includes study of antimicrobial usage and antimicrobial genes in different sectors (human, agriculture, veterinary, aquaculture), can improve understanding of the drivers leading to selection and spread of antimicrobial resistance in the aquatic environment. Safer trade and safer practices should be promoted. The four pillars of the FAO Action Plan on Antimicrobial Resistance (2016–2020) – awareness, evidence, governance and best practice – are good starting points (FAO, 2016i).

Other essential actions include enhancement of emergency preparedness and provision of emergency contingency funds; private–public sector partnership (e.g. for co-financing of projects, product development, early warning and disease reporting); and socio-economic assessments of disease impacts and cost–benefit analysis of existing biosecurity programmes and other alternatives.

A national aquatic animal health strategy includes all of the above, the building blocks for biosecurity capacity that is relevant to national needs at every stage. Special attention to the needs and empowerment of small-scale producers should be accorded priority, as they often lack the means to undertake the measures needed in any biosecurity system.

Climate-smart aquaculture

FAO designed the concept of climate-smart agriculture (CSA) – which includes aquaculture – to help develop the technical, policy and investment conditions needed to achieve sustainable agricultural development for food security under climate change (FAO, 2017r, 2017s). CSA addresses the triple challenges of increasing productivity and adapting to climate change while reducing or removing greenhouse gas emissions (mitigation), where possible. CSA differs from other approaches such as sustainable intensification of aquaculture in its explicit focus on addressing climate change and in its aim to maximize synergies and trade-offs among productivity, adaptation and mitigation while ensuring accessible and nutritious food for all. While linking competing priorities such as productivity and social and environmental sustainability remains a challenge, some researchers and fish farmers are already looking at CSA as an alternative and innovative adaptation practice for increasing aquaculture production while avoiding adverse impact on sustainability. For example, integrated multi-trophic aquaculture (IMTA) works at the ecosystem level, uses a combination of fish and other aquatic animals and plants to remove particulate and dissolved wastes from fish farming, and thereby provides a self-sustaining source of food (Troell *et al*., 2009).

Managing aquaculture operations to achieve the goals of CSA will require a new, more holistic view of aquaculture, combining reduction of food losses and optimization of land, labour, energy and other resources with reduction in the vulnerability of the sector to climate change and mitigation of greenhouse gases. Targeted assistance will be needed to ensure that the most vulnerable countries, production systems, communities and stakeholders have the potential to develop and apply CSA approaches in aquaculture. Achieving universal food security in the face of climate change will also require a transformation of production and consumption patterns, as called for in the Paris Agreement. The new target of limiting global warming to under 2 °C, and aiming for the 1.5 °C mark, will place greater attention on the carbon footprint of food systems, which may encourage the use of plant-based feeds in aquaculture (Hasan and Soto, 2017). In addition, climate-smart aquaculture needs to be anchored in the internationally agreed FAO Code of Conduct for Responsible Fisheries and in approaches to support its implementation, such as the ecosystem approach to aquaculture and blue growth, in order to address the three interlinked dimensions of sustainability (economic, environmental and social). Guidance for adequate planning and management must take into account climate change impacts and fish farmers' needs. ■

INTERNATIONAL TRADE, SUSTAINABLE VALUE CHAINS AND CONSUMER PROTECTION

Of all animal protein commodities, fish and fish products are among the most traded in terms of value and the most subject to competition from imported products. Around 78 percent of fish production is subject to international trade competition (Tveterås *et al.*, 2012). This trade flow is particularly important for developing countries, which accounted for 59 percent of world exports and 46 percent of world imports of fish and fish products in 2016, by quantity (in live weight equivalent). The considerable international trade flow of fish and fish products generates opportunities, but also raises the issue of potential trade barriers.

In terms of market opportunities for fish and fish products, the strong demand in the major importing countries and regions and the variety of existing tradable fish species create a natural incentive to trade. To take advantage of these trade opportunities, many countries, particularly developing ones, must overcome difficulties not only in obtaining the necessary information for assessing market opportunities in foreign markets and identifying specific niches for their products, but also in acquiring the necessary knowledge and expertise to implement technical and food safety measures to comply with international standards.

FAO provides information, analysis and news on world fish trade through its long running Globefish programme. It has been enriching the information on the Globefish website (www.fao.org/in-action/globefish) and has made concerted efforts to increase the usability and availability of the raw and processed data. New areas include regulations for market access and border rejection data for major importing countries and regions, market analyses and price data for 30 major species of finfish, crustaceans, cephalopods and other molluscs, and country-specific economic, production and export data, including non-tariff measures, to facilitate assessment of possible market opportunities.

Trade policies implemented by countries – including tariffs, subsidies and non-tariff measures, such as food safety and sustainability standards – significantly shape fisheries production and trade, particularly with regard to access to international markets. While many trade measures have legitimate objectives, in practice some of them, including private standards, traceability requirements (see Box 22), higher tariffs for products with added value and certification requirements, can create technical or financial obstacles and restrict market access. A recent study by the United Nations Conference on Trade and Development (UNCTAD) indicated that on average the number of technical measures applicable to fish products is about 2.5 times that applicable to manufactured products (Fugazza, 2017). Developing countries, as major suppliers of fish and fish products in international trade, face challenges in their capacity to implement these measures (in both the private and public sectors) and in their ability to analyse and question possibly protectionist measures in international fora. In addition, because fish is perishable, lengthy bureaucratic procedures can easily lead to the loss of valuable cargo.

To reduce the potential negative impact of trade measures, FAO promotes debate on market access issues at the sessions of the Subcommittee on Fish Trade and works jointly with other international bodies such as the United Nations Environment Programme (UNEP), UNCTAD, WHO and WTO. In 2016, FAO, UNCTAD and UNEP developed and widely promoted the Joint Statement on Fisheries Subsidies, which has since »

BOX 22
UNIQUE IDENTIFIERS FOR STOCKS AND FISHERIES

The Global Record of Stocks and Fisheries (GRSF) is an initiative funded by the European Union Horizon 2020 BlueBRIDGE project that seeks harmonization among the standards used by international, regional and national data providers to allow a standardized global view of the status of fisheries. GRSF assigns unique identifiers to stocks and fisheries: a machine-readable universally unique identifier (UUID) and a human-readable semantic identifier with codes and labels (Figure 44) (Tzitzikas *et al.*, 2017).

GRSF enables management of a comprehensive and transparent inventory of stocks and fisheries records across multiple data providers to facilitate and promote monitoring of stocks and fisheries status and trends. It thus aims to stimulate responsible consumer practices. The information in GRSF is intended to serve the needs of regional fisheries bodies and their member countries, the fish food industry (from suppliers to retailers), national government agencies dealing with stocks and fisheries reporting, researchers analysing the state of global fishery resources, NGOs promoting sustainable fisheries, consumers and the general public.

So far, the unique identifiers for stocks and fisheries have been used to support development of global, regional or national state of stocks indicators and public and private ecolabelling and traceability initiatives for sustainable fisheries. Unique identification of stocks and fisheries under a shared harmonized standard could be the basis for the application of additional technologies for fish traceability, such as blockchain technology (see "Disruptive technologies" in Part 4).

FIGURE 44
EXAMPLE OF A SEMANTIC IDENTIFIER (ID) AND A UNIVERSALLY UNIQUE IDENTIFIER (UUID) FOR STOCKS AND FISHERIES

STANDARD CODING SYSTEM FOR:

- Stocks <Species> + <Assessment Area(s)>
- Fisheries <Species> + <Fishing area(s)/Management area(s)> + <Management Authority(ies)> + <Geartype> + <Flag State>

EXAMPLE OF SEMANTIC IDENTIFIER, AND OF ITS FULL LABEL

asfis:COD + fao:21.3.M + authority:INT:NAFO + isscfg:03.12 + iso3:LTU
Gadus morhua - Atlantic, Northwest/21.3.M - Northwest Atlantic Fisheries Organization (NAFO) - NAFO area of competence - Single boat bottom otter trawls - Lithuania

Species: **Gadus morhua**
Species code: **COD**
Fishing Area: **FAO 21.3.M**
Management Authority: **Northwest Atlantic Fisheries Organization (NAFO)**
Jurisdiction: **NAFO area of competence**
Fishing Gear: **Single boat bottom otter trawls**
Fishing Gear code: **03.12**
Flag State: **Lithuania**
Flag State Code: **LTU**
ID: **asfis:COD + fao:21.3.M + authority:INT:NAFO + isscfg:03.12 + iso3:LTU**
UUID: http://.../b99fd03e-709e-3139-9f5d-133df0b103fd

» been endorsed by over 90 countries and forms a strong foundation for WTO discussions towards regulating fisheries subsidies. FAO has continuously supported international efforts to achieve SDG target 14.6 (By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of WTO fisheries subsidies negotiation), for example by promoting related high-level sessions during the Ocean Conference in 2017 and by coordinating events with UNCTAD, such as the Oceans Forum, to advance the implementation of trade in fish related to targets under SDG 14.

Sustainability certification in global markets

The initial goal of sustainability certification was to provide market-based incentives for producers to engage in responsible fishing or aquaculture practices so as to obtain preferred market access and, in some cases, a premium price. Since the establishment of the first scheme in 1999, the number of voluntary ecolabelling certification schemes has significantly increased, reflecting the sustainability and environmental concerns of consumers, major producers and retailers of fish and fish products.

Although from the beginning the schemes purported to represent internationally agreed fisheries and aquaculture management norms, they developed different standards and different assessment methodologies. Member Countries consequently requested that FAO develop relevant guidelines for certification schemes. The FAO Guidelines for Ecolabelling of Fish and Fishery Products from Marine/Inland Capture Fisheries and the FAO Technical Guidelines on Aquaculture Certification were developed between 2005 and 2011, closely aligned to the Code of Conduct for Responsible Fisheries (FAO, 1995).

According to Potts *et al.* (2016), around 14 percent of global production (both captured and farmed fish) was certified in 2015; 80 percent of the certified fish was from capture fisheries and 20 percent from aquaculture.

Certification schemes can be owned by public- or private-sector bodies. The majority are owned by NGOs. In recent years, for various reasons including concerns over cost, more regional, national or subnational schemes have emerged. Examples include the Alaska Responsible Fisheries Management (RFM) Certification Program in the United States of America, the Iceland Responsible Fisheries Management (IRFM) Certification Programme and the Marine Eco-Label Japan.

While the existence of multiple schemes offers more choice, it may also add to the problem of a multiplicity of compliance procedures faced by many fish product exporters, particularly those exporting from developing countries and sourcing from small-scale fisheries. Instead of creating a clear path and incentive for the sector to improve environmental and other sustainability credentials, the proliferation of schemes has led to confusion among producers, retailers and consumers. Since the extent to which the various schemes are in compliance with international reference documents varies enormously, many importers and retailers are not in a position to assess the criteria, benefits and equivalence of schemes. Producers may be obliged to adhere to specific schemes designated by importers or retailers or may have to seek certification by multiple schemes in order to service their customers, which may unnecessarily push up costs and distort trade.

To level the playing field, FAO supported the development of a common benchmark for fishery certification schemes. The Global Benchmark Tool, developed by the Global Sustainable Seafood Initiative (GSSI) with FAO technical support, includes requirements that certification schemes (for both capture fisheries and aquaculture) need to meet in order to demonstrate that they are based on the principles and requirements of the main FAO instruments dealing with sustainability in fisheries and aquaculture. The Global Benchmark Tool also includes indicators that allow stakeholders to understand the differences among schemes. By August 2017, GSSI had successfully benchmarked three ecolabel certification schemes – RFM, IRFM and the Marine Stewardship Council (MSC) – and one aquaculture certification scheme – Best Aquaculture Practices Certification. Other schemes from both sectors are in the pipeline for recognition.

Ecolabelling and certification in fish and fish product markets nonetheless face several important challenges, related to, among others, inclusiveness (particularly in connection with developing countries and small-scale fishers and producers), the willingness of consumers to pay more for certified products, the balance of costs and benefits for those seeking certification and (most recently) the expansion of certification criteria to include social standards, for which there are limited internationally agreed performance norms. FAO continues to work closely with its Members, the private sector, NGOs and other stakeholders to develop solutions.

Post-harvest loss and waste

Post-harvest loss and waste can easily offset the food security and nutrition benefits of fish and fish products, and typically occur in those countries that can least afford to waste a valuable source of food and nutrition. Gustavsson *et al.* (2011) estimated that the food loss and waste for the whole fisheries sector amounted to 35 percent of global catches, with between 9 and 15 percent of these losses due to fish discards at sea, mostly in trawl fisheries. However, loss and waste are found along the whole value chain, from production to the consumer. FAO workshops in India and Mexico associated losses with the employment of gillnets and trammel nets, which are predominantly used in artisanal, small-scale and household-based fisheries in tropical and subtropical regions (Suuronen *et al*., 2017). An FAO workshop for the Near East region in 2013 linked significant waste at the household and consumption levels to food traditions and habits (Curtis *et al*., 2016).

Post-harvest quality losses can account for more than 70 percent of the total loss in a given value chain (FAO, 2014b) and result in loss of high-quality protein, important fatty acids and micronutrients. Removal of fish from the food chain also results in a physical loss and further contributes to reduced availability. Both types of loss have negative impact on food and nutrition security, as consumers have access to less fish or fish of lower quality, while the value chain actors have poorer economic returns.

The United Nations Conference on Sustainable Development (Rio+20) in 2012 acknowledged the global importance of food loss and waste, and SDG 12 (Responsible consumption and production) addresses the problem specifically, with the target: "By 2030, to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses".

FAO studies (Diei-Ouadi *et al*., 2015; Wibowo *et al*., 2017) have found that 65 percent of post-harvest fish loss and waste is due to technical, technological and/or infrastructure deficiencies, coupled with inadequate knowledge and skill in post-harvest handling. The remaining 35 percent of loss and waste is linked to the social and cultural dimensions of vulnerability, governance, regulations and their enforcement.

FAO has been working with developing countries to combat fish losses since the 1990s. Its programme in this area has developed methods to assess post-harvest loss in small-scale fisheries, facilitating prioritization of mitigation measures, and identified simple technologies to reduce loss and waste along the value chain, with significant results. For example, in inland fisheries, the use of raised racks for fish drying resulted in a 50 percent reduction in post-harvest losses in two years in Lake Tanganyika riparian countries (Griliopoulos, 2014). In coastal fisheries, the upgrade of mud crab (*Scylla serrata*) handling facilities reduced losses from 25 to 9.4 percent in the Indian Ocean region (Kasprzyk and Rajaonson, 2013).

In July 2016, COFI requested the development of international guidelines on post-harvest losses. In support of this effort, the Government of Norway funded a seed project to examine the feasibility of a single repository of loss scenarios and loss reduction options to inform the development of solutions to food loss scenarios at targeted points of the supply chain in fisheries and aquaculture.

Consumer protection

Fisheries' contribution to food security and public health can be compromised when food safety is not well understood and controlled throughout the fisheries and aquaculture supply chains. Given the growing complexity of these chains (due to factors such as increased value addition demands, climate change impacts and trade globalization), internationally recognized frameworks for ensuring food safety in the international context are extremely important. In the fisheries sector, these include Article 11 of the FAO Code of Conduct for Responsible Fisheries, guiding post-harvest practices and trade; the Codex Alimentarius standards and codes of practice (www.fao.org/fao-who-codexalimentarius/standards); and the WTO Agreements on the Application of Sanitary and Phytosanitary Measures and Technical Barriers to Trade, which set out the basic rules for food safety standards. In support of food safety, FAO provides scientific advice jointly with WHO through established expert committees, expert meetings and ad hoc consultations.

Owing to concerns about the impact of climate change, Codex committees have given special importance to the evaluation of toxins in recent years. In response to a request from Codex for scientific advice on this topic, FAO and WHO (2016) jointly produced the technical paper *Toxicity equivalence factors for marine biotoxins associated with bivalve molluscs*.

Ciguatoxin causes between 10 000 and 50 000 food-borne illnesses annually (Lehane, 2000). As requested by the Codex Committee on Contaminants in Foods, FAO and WHO are currently planning a risk assessment of ciguatoxins, with a view to establishing a maximum permissible level for the toxin and agreeing on standard analytical methods for ciguatoxin detection and quantification, to provide the basis for routine analysis and surveillance.

The bivalve mollusc production industry has grown, from nearly 1 million tonnes in 1950 to 16.1 million tonnes in 2015. In view of this rapid growth, together with changes in water conditions, FAO and WHO (2018) have produced technical guidance for the development of bivalve mollusc sanitation programmes, as requested by the 2017 International Conference on Molluscan Shellfish Safety. This guidance is mainly intended for primary production of bivalves for consumption live or raw, and primarily considers general requirements and microbiological hazards.

In food safety management, FAO has worked closely in the past two years with key partners such as UNEP, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)[18] and academics in a global response to the possible food safety threat of microplastics and nanoplastics in fish and fish products (see "Selected ocean pollution concerns", below), providing a set of recommendations and listing research needs (Lusher, Hollman and Mendoza-Hill, 2017).

Over 50 percent of fishery production for food comes from aquaculture, and some food safety and public health issues are specific to this sector. Misuse of antimicrobials in many parts of the world is recognized as the key driver of the emergence and spread of antimicrobial resistance (AMR). AMR currently causes around 700 000 global deaths annually, and the number could reach 10 million by 2050 (O'Neill, 2014). FAO is working closely with the World Organization for Animal Health (OIE) and WHO in a tripartite response to the global threat of AMR (FAO, OIE and WHO, 2010). The Codex Alimentarius Commission (2017) has recently updated maximum residue limits and risk management recommendations for residues of veterinary drugs in foods.

At the national level, FAO's multidisciplinary teams provide technical support to governments in developing effective national food safety frameworks. Due consideration is given to

18 GESAMP sponsors are IMO, FAO, UNESCO-IOC, the United Nations Industrial Development Organization (UNIDO), the World Meteorological Organization (WMO), the International Atomic Energy Agency (IAEA), the United Nations, UNEP and the United Nations Development Programme (UNDP).

harmonizing legal frameworks with WTO requirements and basing them on Codex standards, guidelines and related texts, which constitute the benchmark for food safety at the international level.

Fish fraud

Food fraud, while not a new phenomenon, has come under the spotlight in recent years. A multicountry horsemeat scandal in the European Union in 2013 exposed the vulnerability of the international food chain to organized crime. National, regional and international food fraud networks and platforms, such as the European Union Agency for Law Enforcement Cooperation (EUROPOL), have been established for sharing information and fostering cooperation to combat food fraud. Food fraud is committed when food is illegally placed on the market with the intention of deceiving the customer, usually for financial gain, and involves criminal activity that can include mislabelling, substitution, counterfeiting, misbranding, dilution and adulteration. Fish fraud is no different.

Fish and fish products are particularly at risk of fraud; the European Parliament (2013) identified them as the second highest risk category of foods, and INTERPOL/EUROPOL (2016) identified them as the third highest in a study covering 57 countries. Fish fraud can take place at multiple points along the fish supply chain. Examples include intentional mislabelling, species substitution and overglazing (excess ice) and undeclared use or overuse of water-binding agents to increase the weight of products.

The main problem is species substitution, most often involving low-value species sold as more expensive species. Fraud also occurs when species substitution is used to hide the geographical origin or to hide an illegally harvested or protected species or a species from a protected area. Such activities can bring fishery product fraud into the domains of IUU fishing and CITES.

Several major studies in recent years have shown significant amounts of mislabelling (Oceana, 2016; Pardo, Jiménez and Pérez-Villarreal, 2016), affecting between 20 and 30 percent of fish sampled, from various parts of the marketing chain. More specific studies (among many) found mislabelling of 75 percent of red snapper in the United States of America (Marko *et al.*, 2004); 41 percent of fish at retail level in Canada (Hanner *et al.*, 2011); and 43 percent of fillets in southern Italy (Tantillo *et al.*, 2015).

Although many fish fraud incidents do not pose an immediate risk to public health, some cases have resulted in actual or potential harm to consumers' health. When toxic species, such as pufferfishes, histamine-contaminated scombroid fish, escolar, oilfish or ciguatoxic fish, are substituted for non-toxic species, the consumer is unaware of the potential dangers. Unexpected exposure to veterinary drug residues can also pose a public health risk when farmed fish with excessive residue levels are sold as wild species.

When fish is processed, for example into fillets, ready-to-eat products and pre-prepared fish meals, visual identification to species level is difficult, if not impossible. However, molecular identification methods, such as DNA barcoding, can now definitively identify species, allowing much greater scrutiny and transparency in fish marketing. While DNA barcoding is a rapid and reliable method for identifying fish species and is an ideal tool for control purposes, developing countries may need technical assistance to integrate it into their food control structures. The method also needs to be standardized and accredited before it can be routinely used.

An FAO review (Reilly, 2018) suggests the following mitigating measures that can help reduce fish fraud: establishing agreed lists of fish names; setting mandatory labelling requirements; strengthening official food control systems; strengthening industry food safety management systems; and developing specific Codex Alimentarius guidelines. ■

SELECTED OCEAN POLLUTION CONCERNS

Ocean pollution caused by marine litter and microplastics continues to receive a great deal of international attention. An exponential rise of public awareness about the issue has stimulated enhanced scientific research geared to understanding its extent and reducing its impact. Countries have expressed a growing sense of urgency to tackle this issue, adopting resolutions on marine litter, marine plastic debris and/or microplastics in every session of the United Nations Environment Assembly to date (UNEP, 2014, 2016, 2017). These resolutions build on the outcome document of the UN 2012 Conference on Sustainable Development, "The future we want" (UN, 2012), in which States committed to take action to reduce marine debris significantly by 2025. The same urgency is reiterated in SDG 14, particularly its target 14.1 (by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution). Other significant commitments include the declaration "Our ocean, our future: call for action" adopted by UN Member States at the Ocean Conference in 2017 (UN, 2017d) and the G-20 Action Plan on Marine Litter (G20, 2017).

From the fisheries and aquaculture perspective, two types of ocean pollution are of particular concern. The first is abandoned, lost or otherwise discarded fishing gear (ALDFG) from capture fisheries, which has negative impacts on fisheries and the marine ecosystem. The second is microplastics, which are increasingly present in aquatic environments and are of concern for their impact on fish as food for human consumption and on the health of marine ecosystems.

Abandoned, lost or otherwise discarded fishing gear

ALDFG has negative impacts on marine ecosystems, wildlife, fisheries resources and coastal communities. Some ALDFG continues to catch both target and non-target species and entangles or kills marine animals, including endangered species ("ghostfishing"). Some near-bottom ALDFG can cause physical damage to the seabed and coral reefs. Surface ALDFG often presents a navigation and safety hazard for ocean users. Once washed ashore, ALDFG pollutes beaches with plastic litter that does not readily degrade. ALDFG is also a source of microplastics when it disintegrates over time. Retrieval and clean-up of ALDFG has huge cost implications for authorities and for the fishing industry. The international community now broadly agrees that preventive measures should be the priority for reducing ALDFG, alongside measures to remove existing ALDFG from the marine environment and to reduce its harmful impacts.

Building on earlier global reviews on ALDFG (Macfadyen, Huntington, and Cappel, 2009; Gilman *et al.*, 2016), FAO and various partners such as the Global Ghost Gear Initiative (GGGI), the Global Partnership on Marine Litter (GPML), the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA) and IMO are actively working to address ALDFG and ghostfishing issues. FAO is working to develop "best practice" guidelines for various fishing gear and fisheries and, together with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), has just begun an elaborate global assessment to quantify the scale and distribution of gear loss and to establish a benchmark for monitoring and evaluating future mitigation measures.

Marking fishing gear, to identify its ownership and location and to ascertain its legality, is an integral requirement of the Code of Conduct for Responsible Fisheries (FAO, 1995) but is still not universally applied. Properly marked fishing gear with gear tracking technology and an associated reporting system can reduce ALDFG and its impacts, including ghostfishing. Gear marking helps to identify sources of ALDFG, to aid recovery of lost gear and to facilitate management measures such as penalties for gear abandonment and inappropriate disposal, as well as incentives for the proper management of fishing gear, including its disposal. Consistent application of an approved gear marking system may also assist the application of measures to identify and prevent IUU fishing, which in turn should reduce gear abandonment and disposal.

FAO has been leading the development of guidelines for the marking of fishing gear. Following an expert consultation in 2016, FAO has conducted two pilot projects to support the future implementation of the guidelines: one on gillnet fisheries in Indonesia focusing on the practical application of gear marking and lost gear retrieval in small-scale coastal fisheries, and the other a feasibility study focusing on drifting fish aggregation devices (FADs) used by the purse seine industry. At an FAO technical consultation in February 2018, member countries agreed on a set of draft voluntary guidelines on the marking of fishing gear, which will be tabled for approval at the 2018 FAO Committee of Fisheries.

Recycling, repurposing and appropriate disposal of end-of-life fishing gear can also reduce ALDFG in the sea and its impact on marine life and the ocean environment. Despite investment in infrastructure, inappropriate disposal of fishing gear, whether at sea or on land, adds to the ALDFG problem. Ports should provide adequate reception facilities for the disposal of fishing gear in accordance with Annex V of the International Convention for the Prevention of Pollution from Ships (MARPOL). However, accessible low-cost disposal facilities for plastics are still not available or are not properly maintained in many fishing ports; and where they do exist, fishers may have limited incentives to use them. FAO engages with IMO on these issues and provides technical assistance to FAO Members on cleaner fishing harbours by disseminating experiences, promoting good practices, producing manuals and guidelines, facilitating capacity development for harbour masters and the fishing industry, and promoting stakeholder participation in the management of fishing harbours and landing centres.

Microplastics

Plastic is a general term for a range of polymer materials that are mixed with different additives (such as plasticizers, antioxidants, flame retardants, ultraviolet stabilizers, lubricants, colourants) depending on the requirement of the end product. These materials can leach to the surrounding environment. Although definitions may vary, it is generally agreed that microplastics include particles and fibres of plastic of different shapes and colours measuring less than 5 mm, including nanoplastics measuring less than 0.1 µm. Microplastics tend to attract persistent and bioaccumulative contaminants that are present in the water, as well as living organisms (marine invertebrates, bacteria, fungi, viruses) that use them as a substrate. Microplastics entering the ocean come from a wide variety of land- and sea-based sources (GESAMP, 2016) and can be categorized in two groups: primary microplastics that are intentionally manufactured (pellets, powders, scrubbers) and secondary microplastics resulting from the breakdown of larger material such as plastic bags, or from the abrasion of car tyres during use. In the fisheries and aquaculture sector, the construction, use, maintenance and disposal of fishing gear, cages, buoys, boats and product packages are sources of secondary microplastics. Lebreton *et al.* (2017) estimated that 67 percent of plastic pollution in marine environments comes from 20 rivers, mostly in Asia.

Currently, little is known on the occurrence of microplastics in freshwaters, especially in developing countries. In marine environments, microplastics have been found in surface waters, throughout the water column, on the seafloor, along the shoreline and in biota, but quantitative information is still scarce. Efforts to estimate the global distribution of plastic fragments have generated varying results because of the different types of assessment models used and definitions adopted (Galgani, Hanke and Maes, 2015; Law, 2017). However, the Pacific, the Bay of Bengal and the Mediterranean Sea are likely to have the highest concentrations (GESAMP, 2015, 2016).

Microplastic uptake by aquatic fauna has been reported in a wide range of habitats as well as in aquaculture cages. Ingestion is the main means of uptake, as plastic fragments can be confused with small-sized natural prey or consumed through filter feeding or ventilation. Over 220 species of marine animals (not counting birds, turtles and mammals) have been found to ingest microplastics in their natural environment, half of them of commercial importance (Lusher, Holman and Mendoza-Hill, 2017).

In wild organisms, microplastics have so far been observed only in the gastrointestinal tract (i.e. gut). The largest microplastics cannot penetrate the cell membranes of the gastrointestinal tract and enter the bloodstream of animals, including humans. Fragments of less than 150 µm (the smallest microplastics and nanoplastics) seem to be able to cross cell membranes and lead to internal exposure. However, there are currently no methods available for detection and quantification of the smallest particles. This knowledge gap needs to be filled. In addition, little is known about the capacity of microplastics to alter ecological processes and to accumulate through trophic transfer in natural conditions.

As far as food safety hazards are concerned, even though microplastics have been found in various foods such as beer, honey and table salt (Liebezeit and Liebezeit, 2013, 2014; Karami *et al.*, 2017), most studies have been carried out on fish and fish products (Lusher, Hollman and Mendoza-Hill, 2017). As microplastics are mainly found in the animal's gut, fish fillets and other products not including the intestine are not a likely source of microplastics. Small fish, crustaceans and molluscs that are eaten with their guts are main concerns in terms of dietary exposure to microplastics through consumption of fishery and aquaculture products.

FAO advocates the use of risk analysis, including risk assessment, management and communication (FAO and WHO, 2006), when dealing with potential safety hazards that may be associated with microplastics in fishery products. Data are currently lacking to carry out a detailed risk assessment. However, risk assessment based on the worst-case exposure scenario of human consumption of bivalves showed that the quantities of microplastics ingested are low and that the associated additives and bioaccumulative contaminants would have a negligible effect in terms of exposure, contributing less than 0.1 percent to total dietary intake of such additives and contaminants (Lusher, Holman and Mendoza-Hill, 2017). While the food safety risk from additives and contaminants due to consumption of fishery and aquaculture products is believed to be negligible, the toxicity of the most common plastic monomers and polymers present in these products has not been evaluated (Lusher, Hollman and Mendoza-Hill, 2017).

Finally, although it has been documented that plastic debris can act as a substrate for diverse microbial communities, data are currently insufficient to include pathogens in any risk profiling on microplastic exposure through consumption of fishery and aquaculture products.

Moving forward

Collaboration will be key to the reduction of ALDFG and microplastic by 2025, and FAO continues to engage actively with stakeholders and relevant organizations and partners towards achieving this. Priority must be given to preventive measures that reduce marine litter and microplastics in the ocean, including consideration of circular economy approaches to prevent waste generation and phasing out of single-use plastic. For example, under the Common Oceans ABNJ (Areas Beyond National Jurisdictions) Tuna Project, and in partnership with the International Seafood Sustainability Foundation, FAO has supported the testing of biodegradable materials in drifting FADs to be used in tuna purse seine fisheries. Cutting the sources of plastic pollution is a collective effort that must involve all relevant industries and all citizens. For the fisheries and aquaculture sector, finding alternatives to plastic use and minimizing ALDFG would contribute to decreasing the sources of marine litter and microplastics. In developing countries where infrastructure may be lacking to deal with plastic waste, or where authorities or the fishing industry lack the capacity to apply adequate preventive or curative measures, increased resources and support through international development assistance and investments may be important (Jambeck *et al.*, 2015). ■

SOCIAL ISSUES

Calls and actions to address the wide range of social sustainability issues in fisheries and aquaculture continue to attract the increasing attention of policy-makers, industry, civil society consumers and the media. The many ongoing initiatives in the sector address such areas as human rights–based approaches, poverty eradication through collective action, gender equality and women's empowerment, decent work and social protection.

Human rights–based approaches

Fisheries governance and development have evolved from focusing on conservation of resources and the environment, i.e. a biological conception of sustainability, to recognizing the social agency, well-being and livelihoods of people working in the sector. Accordingly, fisheries are not just seen as resources; they are also viewed as sources of livelihoods (e.g. income, food, employment), sites of expression of cultural values and a buffer against shocks for poor communities. The SSF Guidelines (FAO, 2015a) reflect this evolution; their objectives include realization of the right to adequate food and the equitable socio-economic development of fishers and fishing communities. Furthermore, they promote a human rights–based approach (HRBA) to achieve these objectives. HRBA in this context refers to ensuring the non-discriminatory and effective participation of fishers and fish workers in transparent and accountable decision-making processes, and addressing the root causes of poverty such as discrimination, marginalization, exploitation and abuse.

HRBA has been increasingly recognized as a programming principle in the United Nations system, but experience with its application in small-scale fisheries is limited. FAO has engaged with partners in a number of venues to address this gap. The Workshop on Exploring the Human Rights–Based Approach in the Context of the Implementation and Monitoring of the SSF Guidelines, held in 2016 (Yeshanew, Franz and Westlund, 2017), attended by experts from governments, fisher organizations, civil society, academia and intergovernmental institutions, drew attention to:

- the need to recognize the diverse existing socio-legal and cultural norms and knowledge systems in the governance of tenure;
- the importance of fair, transparent and participatory methodologies and processes for recognizing diverse legitimate tenure rights;
- the need for strengthened political will and organizational capacity to ensure intersectoral coordination and to empower small-scale fishers and their organizations to voice their needs, concerns and interests;
- the mainstreaming of HRBA in implementation of the SSF Guidelines;
- continuous exploration of HRBA application in the small-scale fisheries sector, with development of case studies and supporting guidance materials.

HRBA in fisheries has also been promoted at other international and intergovernmental events (see Box 23). In addition, the Southeast Asian Fisheries Development Center focused on HRBA in a workshop on a regional approach for the implementation of the SSF Guidelines in 2017. HRBA is also being emphasized at the national level. Indonesia has adopted a legislative framework on the protection of human rights in the fisheries sector, with the technical assistance of FAO. Costa Rica developed a draft law on small-scale fisheries with specific reference to human rights.

Poverty eradication trough collective action

The SSF Guidelines also pursue poverty eradication, a central goal of the 2030 Agenda. The guidelines aim to deal with the millions of small-scale fishers around the world who live close to, or in, poverty. They underline that "Policies, strategies, plans and actions for improving small-scale fisheries governance and development … should be informed by existing conditions, implementable and adaptable to changing circumstances, and should support community resilience" (FAO, 2015a). The key problem is that these fisheries-dependent households are ignored and marginalized, politically and otherwise, because they do not usually appear under a given poverty line. This invisibility in many cases excludes them from inclusive pro-poor development interventions.

Since poverty eradication is high on FAO's agenda, the Organization is evaluating possible solutions, as well as their potential for replication and upscaling. An FAO workshop on strengthening collective action in fisheries generated evidence on how poverty eradication can benefit from collective action such as the formation of small-scale fisheries stakeholder and community organizations. The studies presented show that strategies and solutions must share common principles and be context specific. They also demonstrate that small-scale fishers and fishing communities often struggle under the dominance of powerful actors within and outside the fisheries sector that dictate the politics of fisheries governance (Siar and Kalikoski, 2016).

BOX 23
PROMOTION OF THE HUMAN RIGHTS–BASED APPROACH IN SMALL-SCALE FISHERIES AT MAJOR INTERNATIONAL CONFERENCES, 2016–2017

- Side event "Human Rights, Food Security and Nutrition and Small-Scale Fisheries" at the 2016 session of the Committee on World Food Security (CFS), discussing entry points for applying HRBA, how to identify good practices and the roles and responsibilities of various actors, in particular States as duty-bearers
- Side event "SDGs and Small-Scale Fisheries: Meeting Commitments and Realizing the Right to Adequate Food" at the 2017 session of CFS
- Side event "Joining Forces for Sustainable Small-Scale Fisheries through a Human Rights–Based Approach to Ocean Conservation" at the UN Ocean Conference in 2016, stressing interlinkages among SDGs, particularly between target 14.b and SDGs 1 and 2
- Sessions on "Human Rights in Small-Scale Fisheries Governance and Development" and "The Small-Scale Fisheries Guidelines: Global Implementation" at the MARE Conference in 2017, the latter based on an analysis produced through the Too Big To Ignore research partnership (Jentoft *et al.*, 2017) which includes three chapters specifically addressing HRBA

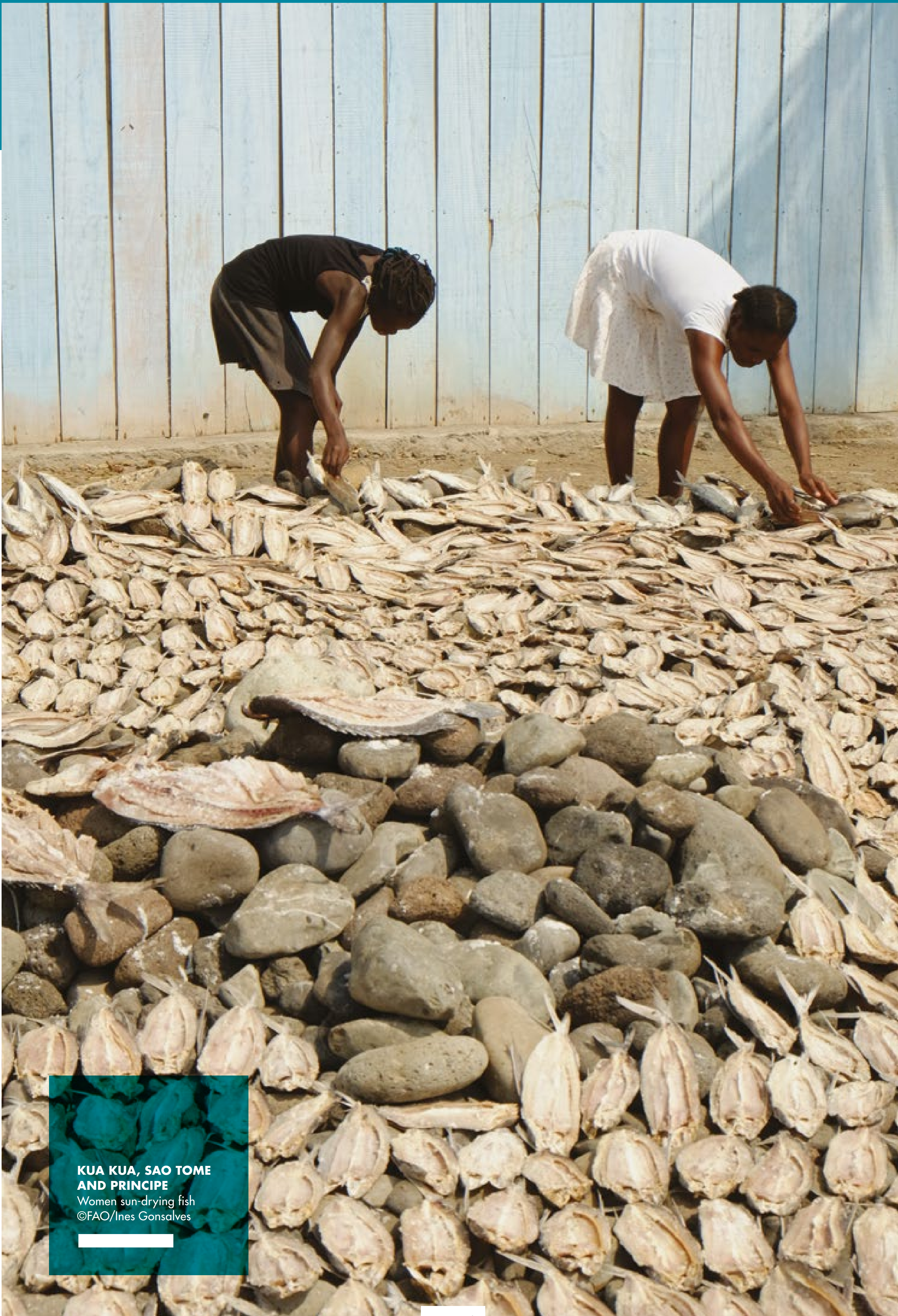
Poverty eradication efforts through governance of small-scale fisheries need to empower fishing communities and make them gain more control over the basic conditions that determine their well-being. Collective action can take the form of organizations that help empower small-scale fishers. Once such organizations are in place, collective action – which may otherwise be spontaneous and ad hoc – becomes coordinated, directed, routinized and more powerful and so can actively contribute to governance processes. Governance of small-scale fisheries should follow the "subsidiarity principle", which allows fishing communities to be more in control through collective action within a supportive and enabling environment where the government and CSOs also have a role to play.

Achieving gender equality and women's empowerment

The 2030 Agenda calls for gender equality and the empowerment of all women and girls (SDG 5), which is particularly relevant to the fisheries sector. Lentisco and Lee (2015) have demonstrated the extent of women's participation in fisheries and the importance of their contributions to fish supply. A handbook recently produced by FAO and the International Collective in Support of Fishworkers (ICSF) (Biswas, 2017), developed in a participatory way, highlights experiences, concepts and guidance for moving towards gender-equitable small-scale fisheries governance and development in support of the implementation of the SSF Guidelines (FAO, 2015a).

Participation in fisher organizations offers women an important pathway for engaging in management. FAO supports gender mainstreaming to improve gender equality through the participation of women in fisher organizations. However, research on women in fisher organizations is still scarce.

Case studies on fisher organizations in Barbados, Belize, Costa Rica, Indonesia and the United Republic of Tanzania (Siar and Kalikoski, 2016) revealed that women participate as members and leaders in fisher organizations, but much less than men. Ongoing FAO analyses focus on how women's participation and leadership in fisher organizations have an empowering effect on women and contribute to balancing the power relationships between men and women. Findings to date (Alonso-Población and Siar, 2018) indicate that the barriers to women's participation and leadership in fisher organizations include: »



KUA KUA, SAO TOME AND PRINCIPE
Women sun-drying fish
©FAO/Ines Gonsalves

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- lack of recognition of women's work and contribution in fisheries, particularly on the part of male fishers, and the notion that women do not fish;
- the lack of information on women's work and contributions due to the absence of gender disaggregation in many employment statistics;
- lack of integration of women's knowledge and experience into fisheries management;
- women's perception that fisher organizations are a male domain;
- personal barriers such as lack of time to participate, lack of confidence and paucity of formal education;
- a widespread bias in which women are seen primarily as mothers and wives while men are seen as breadwinners and leaders.

FAO (forthcoming) conducted gender-sensitive value chain analyses in Burkina Faso, Côte d'Ivoire, Ghana and Tunisia which portrayed significant gender inequities having negative impact on the performance of women and their livelihoods. For instance, in Tunisia in 2016, women clam collectors, who typically spend six to eight hours per day in the seawater, were earning four times less than intermediaries and only 70 percent of the legal minimum salary in the agriculture sector. Looking at the whole value chain, they were earning only about 12 percent of the final sale price. Strategies identified to address these issues include strengthening of technical, organizational and business management capacities of participating women; product differentiation; and fostering of networking, investment in infrastructure and access to financial services and markets, especially the rewarding international channels and institutional outlets (e.g. public procurement for school feeding programmes, hospitals and campuses).

Priority interventions identified in Tunisia led to significant results. Women were endowed with stronger bargaining power; advocacy at the policy level triggered more transparent marketing transactions; and a fair trade agreement was established among an association of women clam collectors, a clam depuration and export establishment and an international importer. Thanks to the fair trade agreement, in November 2017 women collectors were receiving 47 percent of the sale price, from which they pay 8 percent of the sale price to the transporter intermediary.

Decent work and social protection

Continued human rights abuses and labour exploitation in fisheries are raising concerns over irresponsible practices in fish supply chains. These include instances of human trafficking, fraudulent and deceptive recruitment, forced labour, physical, mental and sexual abuse, homicide, child labour, debt bondage, refusal of fair and promised pay, abandonment, discrimination, excessive working hours, poor occupational safety and health, and denial of freedom of association, collective bargaining negotiations and labour agreements.

In 2017 the ILO Work in Fishing Convention No. 188 entered into force, designed to ensure improved occupational safety and health for workers in the fishing sector. It contains provisions to ensure that workers at sea receive sufficient rest and medical care, the protection of a written work agreement, decent living conditions on board fishing vessels and the same social security protection as other workers. The standards of the Convention are supplemented by the accompanying Work in Fishing Recommendation (No. 199). In 2016 the ILO 2014 Protocol to the Forced Labour Convention, 1930 (P029) came into force, providing specific guidance on effective measures to be taken to eliminate all forms of forced labour.

COFI has stressed linkages among safety-at-sea issues, forced labour and IUU fishing (FAO, 2015b). On the occasion of World Fisheries Day (21 November) in 2016, the Holy See and FAO, together with ILO, fish industry representatives and trade unions, condemned illegal fishing and forced labour in fisheries and urged collective commitment to prevent human rights abuses in fisheries supply chains (FAO, 2016j). In 2017, the COFI Sub-Committee on Fish Trade discussed social sustainability issues including human and labour rights abuses in seafood value chains and their trade implications, urging FAO to strengthen its work programme and technical assistance in these areas (FAO, 2017u, 2017v). In 2016 and 2017 FAO continued to facilitate the Vigo Dialogue on decent work in fisheries and

BOX 24
SAFER DIVE FISHING IN NICARAGUA THROUGH SOUTH–SOUTH COOPERATION: A SUCCESS STORY

Apnea dive fishing (in which no breathing apparatus is used) has been practised along the islands and autonomous northern territories of Nicaragua for centuries. Reef fish, queen conch and lobster have always been part of the diet of Miskito indigenous communities. By the early 1970s, the Caribbean spiny lobster (*Panulirus argus*) became a commercially important species and began to be exported. Thus the fishing effort drastically increased, and the hookah dive system was introduced to enable fishers to dive in deeper waters. By 2013 some 9 200 people were part of the lobster fishery in this part of Nicaragua, of which 2 390 were dive fishers. Capture volume reached 4 000 tonnes and exports amounted to USD 45 million (INPESCA & FAO, 2014).

With the increasing number of hookah dive fishers, the number of diving accidents also increased, often resulting in death or permanent disability. According to the Nicaraguan Institute of Fisheries (INPESCA), by 2011, 1 100 divers had been affected by hyperbaric diseases, of which 528 had severe disability (INPESCA, 2011). The Government of Nicaragua requested FAO´s technical assistance in 2013 to formulate a strategy to reduce fatal diving accidents in fishing, while exploring opportunities to improve the sustainability of the country's lobster fishery.

FAO, in close collaboration with INPESCA, through the Mesoamerica Hunger-Free Program, developed an Action Plan for the Technological Conversion of the Caribbean Lobster Fishery and facilitated a South–South cooperation programme with Mexico´s National Institute of Fisheries and a Mexican fishing cooperative. A series of technical missions, hands-on training and pilot projects took place between 2013 and 2017. Thirty Nicaraguan fishers worked two weeks with their Mexican fisher counterparts, learning how to build and operate lobster aggregation devices (LADs) to use in shallower waters where apnea diving is feasible. Nicaraguan fishers also learned how to employ locally used, foldable lobster traps and disseminated the acquired knowledge among their peers.

Members of the Mexican fishing cooperative provided advice about site selection and construction of LADs, and FAO assisted INPESCA in recording lobster colonization processes and undertaking stock estimates. Lobster processors from both countries met and explored areas of collaboration.

The results so far have been highly encouraging: fishers are testing the use of LADs with the assistance of INPESCA, FAO and local universities. In 2015, 10 LADs were placed in a pilot operation. This number has increased to 50 to meet the requests of fishers who already perceive the advantages of higher lobster concentration and the greater safety of apnea dive fishing. In addition, the number of traps has increased more than 120 percent. All of these actions have resulted in at least a 45 percent reduction of fatal accidents (Asamblea Nacional de Nicaragua, 2016).

The South-South cooperation programme also stimulated exports. Two major processing plants have been adapted to process live lobster, as opposed to frozen lobster tails. Through this innovation, the overall export income of the country increased by USD 20 million per year, which represents an increment of 40 percent over the 2013 figure (INPESCA, 2014).

aquaculture, a multistakeholder forum held in Vigo, Spain each year since 2014.

An ongoing multi-country review by FAO and the International Union of Food, Agricultural, Hotel, Restaurant, Catering, Tobacco and Allied Workers' Associations (IUF) is addressing occupational safety and health (OSH) issues in aquaculture (see also Box 24). Multidisciplinary work on OSH issues in fish processing being carried out by FAO and partners in Côte d'Ivoire (FAO, 2017w), Ghana and Sri Lanka indicate that process optimization is at the heart of informed policy actions. In collaboration with government authorities and the private sector, FAO projects on aquaculture in East and West Africa are promoting creation of employment opportunities for youth and women, enterprise and value chain development, extension and collective cooperation, as well as livelihood diversification strategies.

OSH risks, diminishing aquatic resources, lack of user and access rights, exposure to climate and weather risks and political and social marginalization can lead fishing and aquaculture dependent communities – men and women – to become trapped in a vicious circle of poverty (Béné, Devereux and Roelen, 2015). Social protection, which includes social assistance in kind and in cash transfers, contributory social security and labour market policies (FAO, 2017x), has the potential to reduce vulnerabilities, prevent negative coping strategies and reduce market failures affecting fishers and fish workers. In addition to shielding and protecting the poorest and most vulnerable, social protection is also increasingly recognized as a tool for empowering communities, reducing rural poverty and contributing to broader rural development outcomes. FAO and GFCM are jointly organizing a study to explore the social protection systems available to small-scale fishing communities in Albania, Egypt, Lebanon, Morocco and Tunisia. This work will generate evidence that will be used to provide policy support and to foster policy and programme coherence at the country level.

FAO is also working in Cambodia and Myanmar, along with partners, to assess the state of social protection and poverty dimensions in the fisheries sector. The results will be used to design national social protection responses that adequately cover fishers, fish farmers and fish workers and take into account specificities such as fishing seasonality, high mobility, poor user and access rights and occupational hazards. ■

ITALY
Gilthead seabream (*Sparus aurata*) in a floating cage
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PART 4
OUTLOOK AND EMERGING ISSUES

PART 4

OUTLOOK AND EMERGING ISSUES

BLUE GROWTH IN ACTION

"Blue growth" is an innovative, integrated and multisectoral approach to the management of aquatic resources aimed at maximizing the ecosystem goods and services obtained from the use of oceans, inland waters and wetlands, while also providing social and economic benefits. Its objective is coordinated management resulting in inclusive growth that contributes to the three pillars of sustainable development (social, economic and environmental) and the alleviation of poverty, hunger and malnutrition (Burgess *et al.*, 2018).

Blue growth is anchored in the principle that ecosystem services provided by aquatic ecosystems are fundamental to human well-being – to the air we breathe, the food we consume, and the water we drink and use to grow food. Marine ecosystem services in particular provide more than 60 percent of the economic value of the global biosphere (Martinez *et al.*, 2007). Recognizing this value, the global community has been focusing more and more effort on the development of economic capacity to exploit aquatic ecosystems, and the services they provide, in a sustainable manner.

The use of an ecosystem for economic returns and social benefits must, however, take place in a way that minimizes environmental degradation. If an ecosystem and its services are not maintained, or in some cases restored, the natural capital is eroded and the system will not succeed; it will thus not contribute to improved food security and livelihoods or to achieving many SDG goals and targets.

Ecosystem services are generally divided into four categories (Box 25). While provisioning services provide direct inputs into a blue economy (e.g. fish, water, plants), regulating and supporting services are just as crucial, as they provide for healthy aquatic ecosystems that support the economic activities associated with provisioning services (Lillebø *et al.*, 2017). Equally important to blue growth are the cultural services that aquatic ecosystems provide, including tourism and educational opportunities as well as the cultural significance of the ecosystems for many coastal communities (Rodrigues and Kruse, 2017). Therefore, in the context of blue growth, aquatic resource management needs to consider and balance the importance and use of ecosystem services across all four categories. Achieving this balance is especially vital as the global community strives to achieve the SDG goals and targets – especially SDG 14 on oceans – and to ensure the long-term sustainability of aquatic ecosystem use.

An example of this balance is provided by Bann and Başak (2011), who estimated the economic value of Gökova Turkey Special Environmental Protection Area in Turkey at around USD 31.2 million per year. This value incorporates provisioning services (fish and salt marsh succulents for food), regulating services (carbon sequestration, erosion protection and waste treatment) and cultural services (tourism and recreation). The most economically significant of these services in the area is tourism and recreation, which accounts for approximately 55 percent of the total economic value, highlighting the need to manage the tourism industry sustainably.

Restoring habitat and preserving biodiversity can help to improve aquatic ecosystem services and provide numerous benefits in terms of food, revenue and jobs. For example, in Viet Nam, mangrove replanting by volunteers at the cost of USD 1.1 million saved USD 7.3 million annual

BOX 25

EXAMPLES OF THE FOUR TYPES OF ECOSYSTEM GOODS AND SERVICES WHICH ARE KEY TO BLUE GROWTH INTERVENTIONS

Provisioning

- Food (e.g. wild capture fisheries, aquaculture, drinking-water, marine salt)
- Raw materials (e.g. alginate industry, fish skin for fashion goods, sand, gravel)
- Biochemical and medical resources (e.g. fish skin for treatment of open wounds)
- Energy (e.g. macro- and microalgae, wind, wave and solar energy, oil and gas)

Regulating

- Biological control (e.g. herbivorous fish control of aquatic weeds, waste treatment)
- Regulation of water flow (e.g. protection by sand and mud flats, minimization of wind erosion from dunes and cliffs)
- Climate regulation (e.g. carbon sequestration and storage)
- Moderation of extreme events (e.g. protection of coastal infrastructure by mangroves and coral reefs)

Supporting

- Maintenance of life cycles (e.g. nursery grounds for target species and prey)
- Maintenance of genetic diversity

Cultural

- Recreation and tourism (e.g. recreational fishing, ecotourism, boating)
- Cognitive development (e.g. scientific advancement, educational enrichment)
- Inspiration for culture, art and design (e.g. role of fishing in a community's culture)
- Aesthetic value (e.g. peace felt from viewing the ocean)
- Spiritual experience (e.g. sense of place, spiritual interactions)

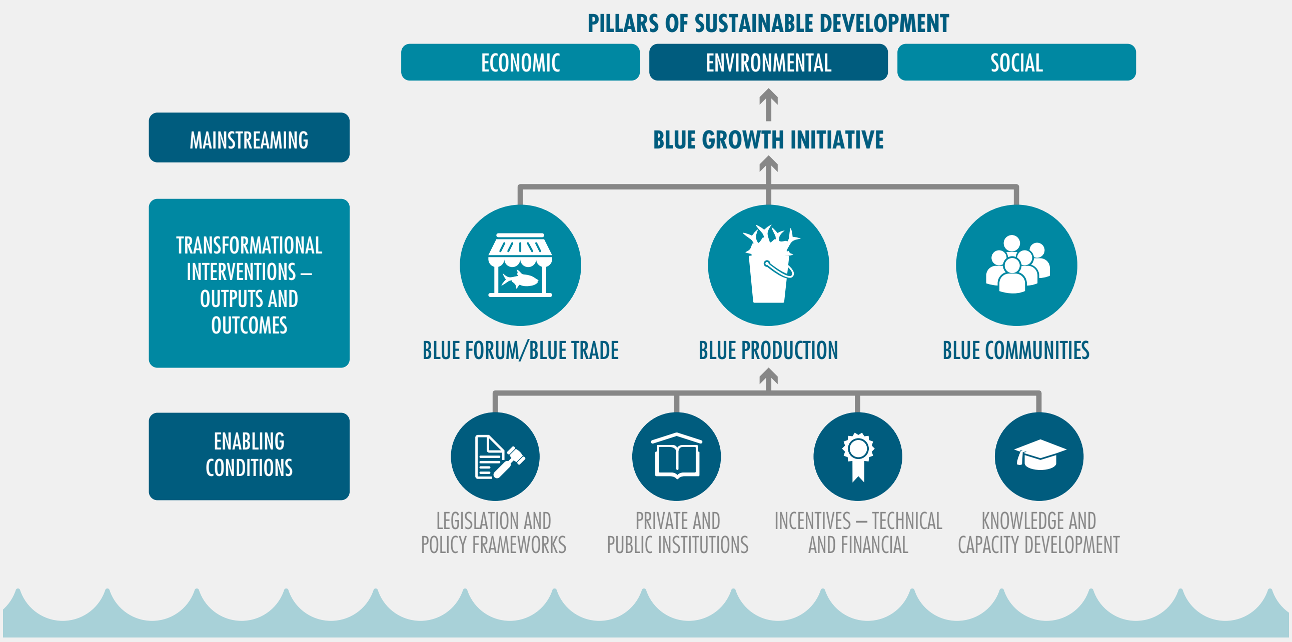
expenditure on dyke maintenance and benefited the livelihoods of an estimated 7 500 families in terms of labour and protection (IFRC, 2002). In Mexico, restoration of 50 ha of mangroves resulted in a sixfold increase in the daily income of fishers (Sánchez *et al.*, 2018).

Freshwater ecosystems can also provide extremely important ecosystem services. For example, flooding affects more people globally than any other natural hazard. In the European Union, large areas of riparian land are being set aside to help protect cities from flooding (Faivre *et al.*, 2017). Initiatives also include restoration of wetlands and floodplains, along with investment in blue or green infrastructure (e.g. floodplain restoration, natural flood defences and conservation of vegetated habitats which are highly effective in sequestering carbon). Restored habitat may also form essential refuges for wild fish (Peters, Yeager and Layman, 2015) and for other aquatic wildlife and birds or may provide opportunities for aquaculture (Rose, Bell and Crook, 2016). Management of recruitment-limited human-made freshwater bodies, for example enhancement or stocking to increase their fishery productivity or using them as space for aquaculture, can increase local availability of fish and open up economic opportunities in areas where their creation may have resulted in the loss of other livelihoods.

Blue Growth Initiative

FAO introduced the Blue Growth Initiative in 2013 to pursue blue growth through a holistic framework. The initiative strengthens the interactions among existing policies and aligns

FIGURE 45
BLUE GROWTH FRAMEWORK: HOW THE THREE BROAD PHASES OF THE BLUE GROWTH INITIATIVE CONTRIBUTE TO THE THREE PILLARS OF SUSTAINABLE DEVELOPMENT



with the Code of Conduct for Responsible Fisheries (FAO, 1995) and with the ecosystem approach to fisheries and to aquaculture, on which the initiative is based. It seeks to enhance the impacts of these guiding instruments through efficient use of limited resources, reduced carbon footprints, increased employment and decent working conditions.

The Blue Growth Initiative incorporates three main types of action based on a theory of change (Figure 45):

- **enabling:** putting in place the relevant conditions (e.g. legislation and sound financial incentives), capacity development and social mobilization;
- **transforming:** implementing demonstration or pilot projects to identify the most appropriate interventions and capture lessons;
- **mainstreaming:** scaling up and embedding appropriate policies, practices, incentives and technologies into public programmes and private-sector operations.

If the first two phases are effectively implemented, then mainstreaming will progress naturally as policy-makers, communities and the private sector recognize its economic and social benefits, such as improved market access, profitability and decent work opportunities for youth and women, and ultimately seek to embed blue growth in sector development.

The Blue Growth Framework can help to identify the connections among proposed interventions for blue growth, the necessary conditions for progress and the potential impacts (positive and negative) on the natural capital, as well as opportunities and limitations, for better-informed decisions on investments, policies and management measures. Key activities include promoting best practices based on the ecosystem approach to fisheries and to aquaculture and encompassing all stakeholders along the value chain, as well as promoting reductions in food loss and waste, energy efficiencies and innovation. This new approach is expected to

BOX 26
CABO VERDE: ADOPTING BLUE GROWTH POLICIES TO HARNESS THE POTENTIAL OF THE OCEAN

Cabo Verde is a small island developing State surrounded by ocean. Not surprisingly, the fisheries sector plays a key role in its economy, contributing to employment, livelihoods, food security and overall GDP. In 2015, the Government of Cabo Verde adopted a Blue Growth Charter to coordinate all blue growth policies and investments and to ensure that efforts cut across all ministries and sectors. Through this formal commitment to achieving blue growth, the country is working to create the necessary enabling conditions to begin targeted interventions and investments aimed at harnessing the potential of the ocean to promote economic growth and create employment for its population. In support of policy and institutional reforms, FAO is providing capacity building for the Strategic Intelligence Unit of the Ministry of Finance, which is responsible for implementing the transition strategy. With FAO assistance in developing an investment plan and a multi-annual programme for the transition, the Ministry of Finance has secured a USD 2.98 million funding grant from the African Development Bank Middle Income Country Technical Assistance Fund.

BOX 27
MANGROVE CONSERVATION AND ECONOMIC OPPORTUNITIES IN KENYA

To reverse trends in mangrove deforestation in Kenya's coastal areas, FAO helped to form community and youth groups involving 162 men and 120 women to raise awareness on the value of the ecosystem services provided by mangrove forests. Between 2015 and the end of the project in December 2017, target communities and youth groups planted over 335 000 seedlings in about 45 ha of degraded mangrove forests. The mangrove programme also developed a number of knowledge products to provide reliable information and strategic advice to government policy-makers, community stakeholders and potential donors. These include economic valuations for key coastal ecosystems, fish value chain appraisals of production and post-harvest conditions in selected sites, and marine spatial planning for mariculture. Furthermore, increased knowledge of the project area and its ecosystem have highlighted the potential for new activities in addition to mangrove restoration, such as fish processing and value addition, aquaculture, beekeeping and mariculture associated with ecotourism.

contribute to alleviation of poverty, hunger and malnutrition and sound management of aquatic resources while recognizing the need for inclusive growth.

FAO is now moving from concept to action, and shifting from normative work such as support to the Blue Growth Charter in Cabo Verde (Box 26) to practical community efforts such as community mangrove replanting in Kenya (Box 27), restoring productivity of freshwater fisheries in Malawi and implementing the fisheries and aquaculture component of the Global Action Programme (GAP) on Food

BOX 28
GLOBAL ACTION PROGRAMME (GAP) ON FOOD SECURITY AND NUTRITION IN SMALL ISLAND DEVELOPING STATES

The 52 territories that are classified as small island developing States have a combined population of over 50 million people. SIDS face particular challenges owing to their small size and isolated geographic position. Because of their lack of institutional and human capacity in both the public and private sectors, as well as their disadvantage in gaining influence and access to benefits from a range of regional and global processes, enabling partnerships are required for sustainable development of SIDS. The Small Island Developing States Accelerated Modalities of Action (SAMOA) Pathway (UN, 2014), an outcome document of the third International Conference on Small Island Developing States (Apia, 1 to 4 September 2014), articulates a joint vision from 42 States on issues affecting the sustainable development of SIDS, including their aspirations for fisheries and aquaculture.

As requested in Paragraph 61 of the SAMOA Pathway, FAO facilitated the development of an action plan to address the worsening food security and nutrition situation in SIDS, in collaboration with the United Nations Department of Economic and Social Affairs (UNDESA) and the Office of the High Representative for Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (OHRLLS). At the 40th session of the Conference of FAO in July 2017, the Global Action Programme on Food Security and Nutrition in Small Island Developing States (GAP), a multistakeholder and multisectoral programme, was launched to support the implementation of the SAMOA Pathway.

GAP is structured to facilitate and guide actions to achieve food security and improve nutrition in SIDS. It has three objectives:

- creation of enabling environments for food security and nutrition;
- promotion of sustainable, resilient nutrition-sensitive food systems;
- empowerment of people and communities for improved food security and nutrition.

Using FAO's Blue Growth Initiative as a holistic framework for implementing GAP in the marine sectors can help to address challenges such as unsustainable resource use, resource depletion from IUU fishing activity, youth unemployment and lack of access to international markets, and can help to identify new economic opportunities from SIDS ocean resources while progressing towards the targets of SDG 14.

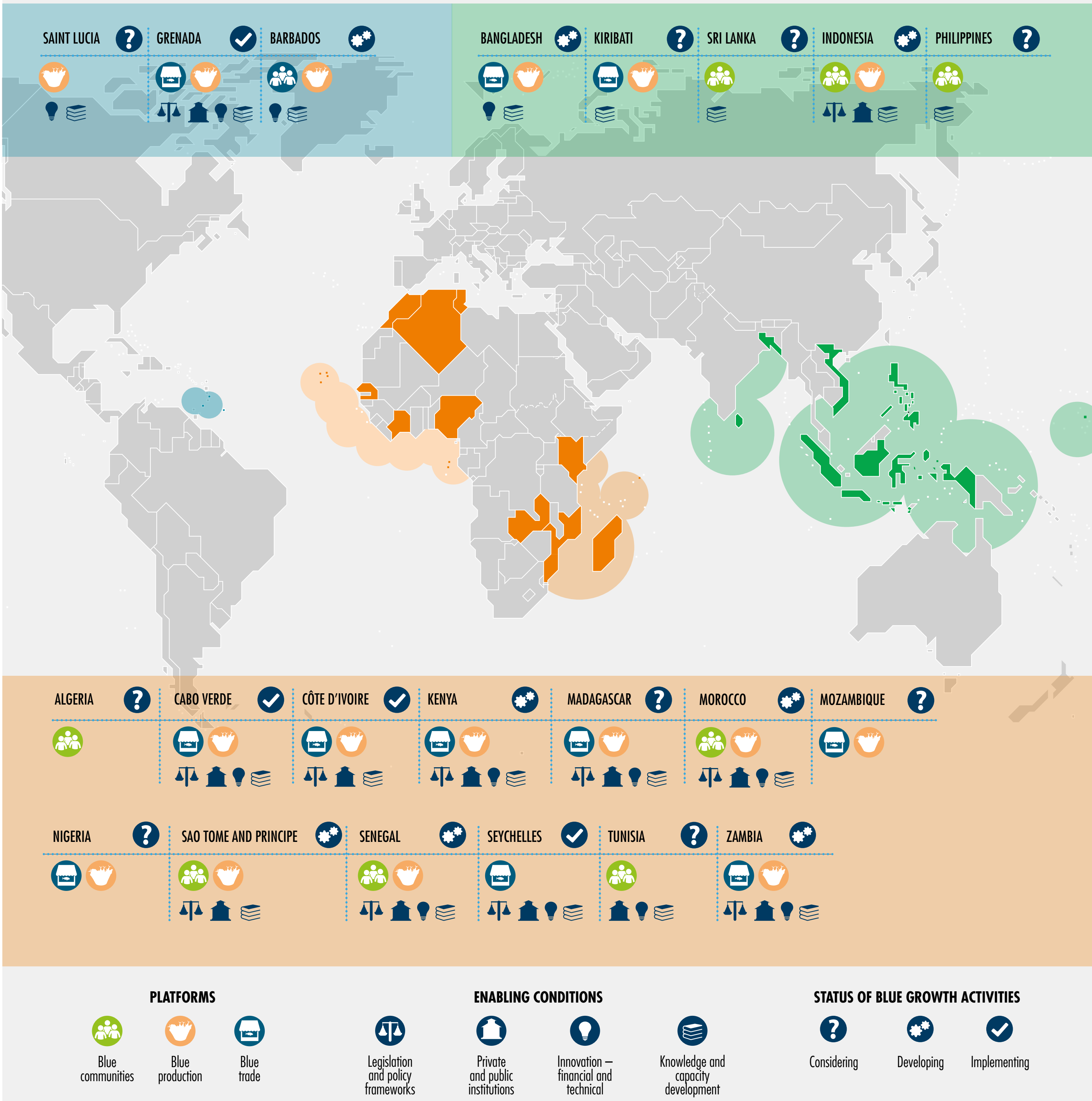
Security and Nutrition in Small Island Developing States (Box 28). FAO is currently applying this approach in 23 countries around the world (Figure 46).

Blue Forum

Blue growth will only be sustainable and long-lasting if it engages all stakeholder groups across fisheries and aquaculture and along the value chain. Finding solutions to global challenges must involve everyone in the sector working together in a comprehensive and coordinated way. To this end, FAO is developing the Blue Forum, a neutral platform enabling stakeholders from industry, civil society, NGOs, government and academia to discuss and seek solutions to contemporary issues that affect the sector and can threaten sustainable socio-economic development at the local, national, regional and global scales – IUU fishing, decent working conditions, human trafficking, sustainability issues and climate change, to name some of the most pressing – in addition to poverty and food insecurity.

The seeds of the Blue Forum were sown in 2013. It will be unique in giving each stakeholder group an equal voice and allowing stakeholders to reach consensus on best practices and methods to help to achieve FAO's objectives related to food security and nutrition and the SDGs. Stakeholders will network online through the Blue Forum website and meet when necessary. The Blue Forum is intended to be a catalyst for multisector »

FIGURE 46
GLOBAL DISTRIBUTION OF BLUE GROWTH INITIATIVE PROJECTS



NOTE: Final boundary between the Sudan and South Sudan has not yet been determined.
SOURCE: FAO, 2017y

» partnerships that drive direct social, economic and environmental action to promote the work of the stakeholders (private sector, CSOs, NGOs and governments) in transforming the fisheries and aquaculture sector. It will provide opportunities for identifying potential strategic alliances among initiatives of different sectors and actors and for creating synergy among them.

The Blue Forum is open to governments, CSOs and the private sector and encourages an inclusive approach. Blue Forum stakeholders will meet annually at an assembly to review progress on actions undertaken by the forum and to plan future work.

African Package for Climate-Resilient Ocean Economies

In the Mauritius Communiqué agreed in September 2016 at Towards COP22: the African Ministerial Conference on Ocean Economies and Climate Change, African Ministers requested that the African Development Bank (AFDB), the World Bank and FAO prepare a package of technical and financial assistance for developing their ocean-based economies. In response to that request, the African Package was presented at UNFCCC COP 22 in Marrakech, Morocco in late 2016. It provides the framework for the three agencies to deliver up to USD 3.5 billion in combined investments covering the marine sectors of fisheries, aquaculture, tourism, shipping, ocean energy, safety at sea, ports, hydrological and meteorological services, carbon sequestration, coastal protection and waste management (FAO, World Bank and AFDB, 2017).

The package is currently a work in progress, as the three agencies coordinate and develop its different components in various African countries. It is designed to be flexible enough for adjustment to the needs of African countries and other partners.

The package comprises five flagship programmes covering four coastal regions and the African SIDS over the period 2017–2020, and is designed to address their climate change priorities as identified in their Nationally Determined Contributions (see "Climate change impacts and responses" in Part 3). The approach supports commitments from the agencies such as the World Bank's Africa Climate Business Plan, AFDB's Ten Year Strategy (2013–2022) and High Fives, and FAO's Blue Growth Initiative. In each country the assistance is provided through new investments funded by the agencies as well as from the Green Climate Fund and GEF.

Within the African Package, FAO is working with the two banks in three major areas of assistance:

- development of blue economy strategies as the foundation for building an investment plan, e.g. in Morocco, Côte d'Ivoire and Sao Tome and Principe;
- technical assistance in the development or implementation of fisheries and aquaculture strategies with a blue economy or blue growth focus, e.g. in Côte d'Ivoire and Sao Tome and Principe;
- supporting countries in piloting blue growth approaches to strengthen coastal communities, e.g. in Algeria and Tunisia with a regional blue growth programme. ■

THE EMERGING ROLE OF REGIONAL COOPERATION FOR SUSTAINABLE DEVELOPMENT

A growing human population and growing per capita demand for food, nutrition and other goods and services means an expansion of fisheries and aquaculture activities in the oceans and inland water bodies and along the coasts, and increased pressure on the environment and on the use of other resources. Pressure on aquatic and coastal ecosystems is increasing even faster than the number of people on the planet (NOAA, 2013; Neumann et al., 2015). As awareness of this pressure rises, it becomes increasingly evident that sustainability can only be achieved through cooperation among all stakeholders, as recognized in SDG 17 (Revitalize the global partnership for sustainable development). The ecosystem approach to fisheries and to aquaculture (discussed in Part 2) includes a number of principles that recognize the interactive nature of sustainable development:

- **Wider effects:** Fisheries management must take into account the effects of fisheries on the wider ecosystem, as well as the effects of other human activities on fisheries;
- **Appropriate scale:** Fisheries must be managed on the appropriate geographical scale, taking account of the distribution and patterns of movement of the resources and other elements affecting or being affected by fisheries;
- **Participation and cooperation:** Management decisions and their implementation must involve the full participation of all stakeholders and cooperation with the necessary institutions and user groups.

Working at the appropriate scale in most cases requires cooperation at the regional level, as processes related to the exploitation of natural living resources usually involve at least several countries. In an increasingly connected world, regional fisheries bodies, and particularly regional fisheries management organizations, are gaining importance as international fora for discussion of issues related to fisheries management and sharing of living marine resources. RFBs have been intensifying their work to ensure that all possible mechanisms for cooperation are exploited in the development and management of fisheries and aquaculture.

FAO has been supporting this evolution through two parallel avenues: reinforcing the work of individual RFBs through the Organization's technical work on fisheries and aquaculture, and promoting and supporting linkages, exchange and mutual support among RFBs through the Regional Fishery Body Secretariats Network. RSN is hosted and supported by FAO and comprises 53 RFBs (including 25 RFMOs). Its purpose is to strengthen information sharing and to offer a framework for discussion among RFB secretariats and their partners on emerging issues related to fisheries management, research and aquaculture development in their regions and, in the case of RFMOs, regulatory areas. This two-pronged approach is contributing to rapid development in the capacity of RFBs to support the much-needed improvement in the planning and management of fisheries and aquaculture.

Considering wider effects means, however, that it is not sufficient to reinforce cooperation within the fisheries and aquaculture sector alone. As more and more demands are made on the use of the coastal and aquatic environment, by an ever-growing array of sectors, and as demand for fisheries and aquaculture products increases worldwide, the need for cooperation between fisheries management organizations and organizations that deal with the management of human activities in other sectors rises rapidly.

A few examples illustrate this need for collaboration in different domains. The fisheries and aquaculture sector is among the food production sectors most dependent on a healthy ecosystem. Aquatic organisms tend to have complex life cycles, requiring different types of environment for their development, and failure of only one such environment may endanger the sustainability of resources and the continuity of a fishery. In addition, most activities that use water or require it will have a direct impact on, and experience the impact of, fisheries and aquaculture activities. Fish and fish products are among the commodities most traded internationally, and trade routes and markets greatly influence the activities in fisheries and aquaculture worldwide.

To account for these extrasectoral effects, many international fora, including the recent United Nations Ocean Conference in June 2017, have highlighted the importance of strengthening cross-sectoral cooperation among diverse regional bodies and organizations, and RFBs have been multiplying their initiatives for cooperation with other regional organizations. Most notably, FAO and UNEP have facilitated discussions between RFBs and the corresponding regional seas organizations to strengthen collaboration on issues of common interest, taking into account their different mandates and roles. The two organizations also cooperate with CBD, within the framework of its Sustainable Ocean Initiative (SOI), to enhance cross-sectoral collaboration among RFBs and regional seas organizations in addressing issues such as the SDGs, the Aichi Biodiversity Targets, ecologically or biologically significant marine areas (EBSAs) and vulnerable marine ecosystems (VMEs).

RFBs and RFMOs have a crucial role to play in relation to the management of biodiversity beyond national jurisdiction (BBNJ). In its resolution 69/292 of 19 June 2015, the United Nations General Assembly decided to develop an international legally binding instrument under UNCLOS on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. The BBNJ process constitutes an important driver in the development of multisectoral governance in the high seas, where RFBs have a recognized role.

In 2014, the North East Atlantic Fisheries Commission (NEAFC) and the Convention for the Protection of the Marine Environment in the North East Atlantic (OSPAR) Commission adopted a collective arrangement for working together on particular areas outside national jurisdiction within the areas of their mandate. Both organizations deal with the protection of vulnerable marine ecosystems and biodiversity, but with different mandates. NEAFC's mandate is largely limited to management of fishing activities, which is explicitly excluded from OSPAR's legal competence. As some human activities that could affect the protected entities did not fall under the legal competence of either organization, OSPAR established wider cooperation and coordination among authorities with international legal competence in this context.

In the Mediterranean area, GFCM and the UNEP/Mediterranean Action Plan Secretariat to the Barcelona Convention (UNEP-MAP) signed a Memorandum of Understanding in 2012. Their collaboration has already achieved results, including:

- integration of environmental concerns in the context of social and economic development, especially in relation to fisheries and aquaculture;
- harmonization of existing criteria for identifying Specially Protected Areas of Mediterranean Importance and Fisheries Restricted Areas, in particular those located partially or wholly in areas beyond national jurisdiction;
- stronger coordination in the implementation of the SDG strategies of the two organizations.

The two bodies have also joined efforts on implementation of the ecosystem approach, particularly on linkages between EAF/EAA and wider environmental protection considerations.

FAO and UNEP are also supporting cooperation agreements in other areas of the world:

- In the Gulf and Sea of Oman, RECOFI and the Regional Organization for the Protection of the Marine Environment (ROPME) have been leading the initiative for cooperation. Although no Memorandum of Understanding has been signed yet, the seventh session of RECOFI (Tehran, Islamic Republic of Iran, 14 to 16 May 2013) and the regional workshop "Toward the Development of a Regional Ecosystem Based Management Strategy for ROPME Sea Area" (Dubai, United Arab Emirates, 4 to 7 April 2016) emphasized the value of effective and viable regional cooperation between ROPME and RECOFI, which have identical mandate areas and constituencies.
- In the Southwest Indian Ocean, SWIOFC and the Nairobi Convention have been discussing modes of cooperation, and a draft Memorandum of Understanding has been prepared to formalize it. The management bodies of both organizations support this cooperation.
- In the Central Eastern Atlantic, the Fisheries Committee for the Central Eastern Atlantic (CECAF) and the Abidjan Convention have developed a long-standing cooperative relation for supporting the sustainable use and conservation of marine living resources and their environment in the areas where the mandates of the two bodies overlap. The two bodies have developed a de facto collaboration through a number of joint projects and initiatives, such as the Canary Current Large Marine Ecosystem (CCLME) project. An agreement for cooperation is being prepared.

Moving across the Atlantic to the Western Central Atlantic, WECAFC cooperates with the United Nations Development Programme (UNDP) in supporting implementation of the Strategic Action Programme of the Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME+), a five-year project co-financed by GEF. On 27 July 2017, the Interim Coordination Mechanism for the

Sustainable Management, Use and Protection of the Caribbean and North Brazil Shelf Large Marine Ecosystems was formally established through the signature of a Memorandum of Understanding by five interregional governmental organizations: OSPESCA; the Central American Commission on Environment and Development (CCAD); the Caribbean Community (CARICOM) Secretariat; the Caribbean Regional Fishery Mechanism (CRFM); and the Organization of Eastern Caribbean States (OECS) Commission.

The importance of such efforts and the need to further enhance cooperation and coordination were recognized at the SOI Global Dialogue with Regional Seas Organizations and Regional Fisheries Bodies on Accelerating Progress Towards the Aichi Biodiversity Targets, held in Seoul, Republic of Korea, from 26 to 28 September 2016; they were specifically noted in the so-called "Seoul Outcome", an important landmark for the joint management of the oceans and their living resources.

Casting a wide net: cooperation among fisheries management, environmental protection and trade regulation

The efforts described above are important, but they are clearly insufficient. The 2030 milestone adopted by the nations of the world for the SDGs is only 12 years away. In those 12 years, the world is expected to number almost another billion people. Providing present and future generations with adequate food and livelihoods will require an approach that deviates from "business as usual". However, history has shown that human activities require other types of incentives to change than only the application of the precautionary principle.

The globalization process that has accompanied the growth of human population, and which is expected to continue to increase, presents its own unique challenges and opportunities for building a sustainable future. Fish and fish products are some of the most internationally traded commodities, and over 35 percent of the fish produced is traded internationally. Trade pressures and market demand and choices, especially in the most affluent societies, influence greatly the choices of fishery and aquaculture producers worldwide, even in very remote regions. Many large and important fisheries, both marine and inland, are driven mostly by export markets. While globalization is the source of important pressures for fishing and aquaculture, it also provides an opportunity for better and improved cooperation in fisheries management. Cooperation between organizations dealing with fisheries management and resource sustainability, such as FAO, and those that focus more specifically on issues of environmental health, such as UNEP, needs to be reinforced by greater cooperation with those concerned with regulating trade, such as WTO. Such triangular cooperation has the potential to be a game-changer for the sustainability of fisheries and aquaculture, as it can bring together the elements necessary for a real departure from "business as usual".

Environmental protection organizations, such as regional seas programmes or national environment ministries, can focus some of their aquatic environment interventions on those areas that can have the highest impact on keeping the balance and productivity of aquatic ecosystems, especially those related to international trade. They can get specialized sectoral information from the fisheries and trade organizations and can also delegate some direct interventions to these organizations, with impacts also on environmental quality.

Fisheries management organizations, mostly RFBs and national fisheries ministries, in cooperation with other State and non-State actors, may concentrate their management actions on reducing environmental impacts of fisheries and increasing the ecological, social and economic sustainability of the sector. They will be able to rely on more targeted and up-to-date information on the indirect impact of fisheries and aquaculture on the wider environment and on the trade dynamics related to fisheries and aquaculture for informing fisheries management decisions. On the implementation side, they will benefit from better upstream control of environmental quality directly relevant to fisheries and aquaculture, and from more targeted trade regulations that will support, rather than complicate, the necessary actions for the management of fisheries.

Properly managed, such cooperation may thus lead to a much more effective world system of management of aquatic production for inclusive environmental, social and economic sustainability in a rapidly changing world. Achieving it, however, will require a high level of awareness of leaders at all levels and a willingness to improve the sustainability of food production systems through cooperation and pursuit of agreed common goals. History has shown that these conditions are not always present when necessary, but the challenges of today's world – to human life and to the planet as a whole – are unlike any that have been experienced during the history of humankind. Cooperation is thus not only an option, but an absolute necessity. ■

THE ROLE OF REGIONAL FISHERY BODIES IN AQUACULTURE DEVELOPMENT

As noted elsewhere in this volume, aquaculture has been expanding significantly for the past four decades, with implications for food security and nutrition, income generation and employment, and trade. Some issues in aquaculture are of transboundary or regional concern – such as the introduction and transfer of farmed species; disease control; social, economic and environmental issues; impact on coastal, riparian and lacustrine environments and areas, land use, soil and water; and industrial development and practices – and must be addressed at the regional level.

The Code of Conduct for Responsible Fisheries (FAO, 1995), Article 9.2.4, promotes cooperation for aquaculture development at all levels, including regional and subregional, through appropriate mechanisms. Currently about one-third of existing RFBs, representing all regions, have mandates on aquaculture. Half of these, including advisory and regulatory bodies, were established under the Constitution of FAO. RFBs collaborate with regional aquaculture networks around the world: the Aquaculture Network for Africa (ANAF), the Micronesian Association for Sustainable Aquaculture (MASA), the Network of Aquaculture Centres in Asia-Pacific (NACA), the Network of Aquaculture Centres in Central-Eastern Europe (NACEE) and the Aquaculture Network for the Americas (RAA).

RFBs facilitate knowledge sharing, technical and institutional capacity development, management and governance and, in some cases, monitoring and evaluation of country compliance with the aquaculture-related provisions in the Code of Conduct for Responsible Fisheries (FAO, 2017z) (see example in Box 29). The FAO Regional Conferences are increasingly considering the work of RFBs in the aquaculture sector to define regional priorities and recommendations.

The membership of RFBs is diverse in terms of distribution of countries by income group. To achieve equitable development, FAO promotes cooperation among its Members to support RFBs in challenging areas, for enhanced food security, socio-economic development, resource management and sustainability.

As the fastest growing food-producing sector, aquaculture makes a notable contribution to food security. Most of the RFBs that address aquaculture thus link their strategies or work plans to food security. The following are some examples.

- The Community of Latin American and Caribbean States (CELAC) Plan for Food Security, Nutrition and Hunger Eradication has relevant aquaculture components, including school feeding programmes, and is being implemented with the support of RFBs in the region (the Commission for Inland Fisheries and Aquaculture of Latin America and the Caribbean [COPESCAALC], the Central American Integration System [SICA], OSPESCA).
- RFBs and RFMOs in Asia and the Pacific (APFIC, SEAFDEC) have increased collaboration to contribute to nutrition and food security in their member countries.
- In Africa, the Lake Victoria Fisheries Organization and FAO are supporting inclusive and sustainable aquaculture for human development, food and nutrition security, together with key players in the region.

BOX 29
SUPPORTING SUSTAINABLE AQUACULTURE DEVELOPMENT AT THE REGIONAL AND SUBREGIONAL LEVEL: THE EXAMPLE OF THE GENERAL FISHERIES COMMISSION FOR THE MEDITERRANEAN

The General Fisheries Commission for the Mediterranean is an RFMO established under the provisions of Article XIV of the FAO Constitution. Currently comprising 24 contracting parties (23 Member Countries and the European Union) and 3 cooperating non-contracting parties from the Mediterranean and the Black Sea, GFCM covers FAO major fishing area 37 (see FAO, 2017ab). GFCM has competence over fisheries and aquaculture, with the mandate to "ensure the conservation and sustainable use, at the biological, social, economic and environmental level, of living marine resources as well as the sustainable development of aquaculture in the Mediterranean Sea and the Black Sea".

GFCM plays a crucial role in fisheries and aquaculture governance in the region by bringing its Members together to develop and implement strategies and policies, ensuring that activities are managed in line with the Code of Conduct for Responsible Fisheries.

Recognizing the growing importance of the aquaculture sector in the region, GFCM has been working for several years towards creating an enabling framework for sustainable aquaculture development in the Mediterranean and the Black Sea, particularly through its Scientific Advisory Committee on Aquaculture (Cataudella, Srour and Ferri, 2017). The commission has made great strides in promoting consultation, cooperation and stakeholder participation, through, for example:

- the aquaculture multi-stakeholder platform, established in 2013, which addresses key priorities;
- the organization of high-level events such as the regional conference Blue Growth in the Mediterranean and the Black Sea: Developing Sustainable Aquaculture for Food Security (Italy, 2014) (Massa *et al.*, 2017) and the conference Towards Enhanced Cooperation on Black Sea Fisheries and Aquaculture (Romania, 2016).

Recently, reflection on how to facilitate aquaculture development while addressing regional and local specificities has led to a strategy for the sustainable development of Mediterranean and Black Sea aquaculture (FAO, 2017ac). Adopted at the forty-first session of GFCM (Montenegro, October 2017), this strategy is the fruit of an extensive consultative process involving experts and national focal points and considers good practices and lessons learned in addressing regional aquaculture challenges and priorities. The aquaculture strategy is structured around three main targets addressing key transboundary vulnerabilities and cross-cutting issues, in line with SDG 14 and FAO Strategic Objective 2 ("Make agriculture, forestry and fisheries more productive and sustainable"):

- target 1, Build an efficient regulatory and administrative framework to secure sustainable aquaculture growth;
- target 2, Enhance interactions between aquaculture and the environment while ensuring animal health and welfare;
- target 3, Facilitate market-oriented aquaculture and enhance public perception.

The work carried out in the preparation and development of the GFCM aquaculture strategy provides a clear example of regional cooperation to address country-level critical issues. Working in coordination with a regional network of partners and stakeholders and accounting for national and supranational aquaculture strategies are keys to fulfilling global commitments.

Threats to aquaculture, such as transboundary diseases and other aspects of animal health, are among the critical issues requiring attention and collaborative action by RFBs and RFMOs. These threats have particular consequences for aquaculture activities in developing countries, especially in areas where aquaculture is key for socio-economic development. For example, aquafarming of crustaceans, especially shrimp, has a major role in Asia and the Pacific, but shrimp production has suffered from serious disease outbreaks (Subasinghe, 2017). In response, NACA established the regional Quarterly Aquatic Animal Disease Reporting System. In the Near East, RECOFI has developed a Regional Strategy on Aquatic Animal Health (FAO, 2016k); held a regional training course on risk analysis for movements of live aquatic animals and a round-table meeting on regional aquatic biosecurity (FAO, 2017aa); and is promoting the implementation of spatial planning tools for marine capture fisheries and aquaculture (Meaden *et al*., 2016).

Aquaculture provides, globally, about 19 million jobs in the primary (production) sector. RFBs are supporting countries for increased employment generation, based on decent work and social protection, in initiatives involving areas such as technology transfer and innovation, sharing of aquaculture good practices for climate change adaptation, entrepreneurship and biosecurity. For example, improvement in the quality and performance of fish feed in cages at sea and the use of land-based technologies have permitted great diffusion of aquaculture in favourable coastal environments (Massa, Onofri and Fezzardi, 2017).

RFBs are the main regional mechanisms for developing regional aquaculture policies, coping with critical emerging issues and guiding aquaculture development. As they expand their work, policy and constituencies in the aquaculture sector, RFBs will need to take a strategic approach, in collaboration with interested stakeholders and partners including civil society, the private sector, academia, consumers and the media, to ensure that aquaculture development is sustainably managed and that its contribution to the SDGs is fully realized and valued at the national and regional levels (see also Hambrey, 2017). ■

DISRUPTIVE TECHNOLOGIES

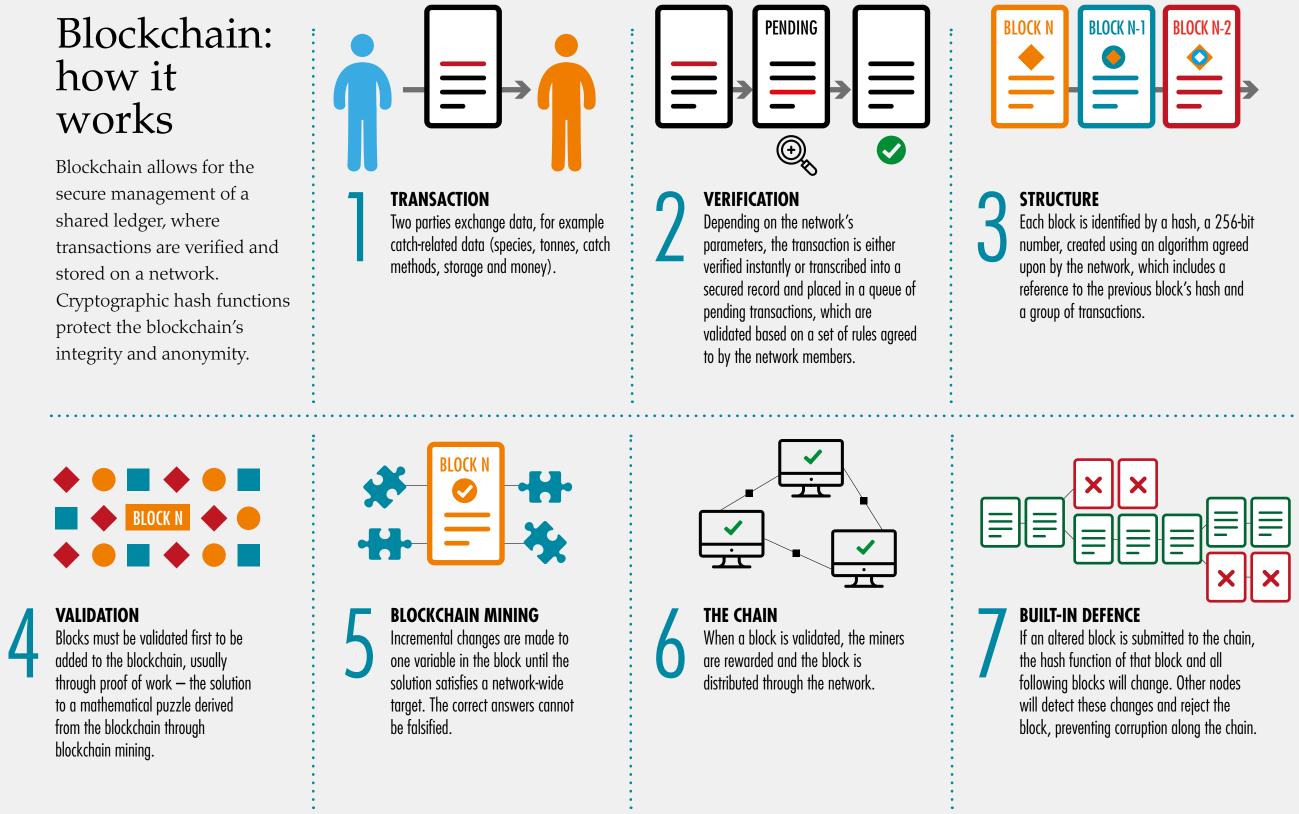
The term "disruptive technology" was coined to describe "new technologies that still lack refinement, often have performance problems, are just known to a limited public, and might not yet have a proven practical application" (Christensen, 1997). Disruption can mean drastic alteration or destruction of existing things or elements of society. Disruptive technologies therefore have the potential to change the way people work, do business and engage in the global economy. While innovation or incremental progress involves improving existing technologies and processes, disruptive technologies provide new ways to meet objectives. Personal computers, smartphones and light-emitting diode (LED) lights are recent examples of technologies that were disruptive when first implemented.

In the fisheries and aquaculture sector, disruptive technologies have the potential to change fishing activity by providing fishers with more information so that fishing is safer (e.g. weather forecasting), more precise (e.g. satellite positioning) and more predictable. Emerging technologies for gathering information and storing it safely have the potential to improve compliance with regulations and traceability, so that the sustainability and management of fish resources will improve substantially.

New disruptive technologies affecting the sector include mobile internet (e.g. providing real-time market prices for fish), advanced robotics (e.g. automatic fish filleting) and the "Internet of Things", or interconnectedness among systems, devices and advanced sensors (e.g. electronic fish tags). FAO encourages innovation and adoption of new technologies, including disruptive ones. Disruptive technologies can offer new ways for the fisheries and aquaculture sector to do business so that it is more sustainable and more resource and energy efficient while creating new decent work opportunities, including opportunities for women and youth.

Along the fish-food value chain, emerging disruptive technologies may change the way fisheries economies are organized, with consumers asking for sustainably caught fish from traceable and transparent sources, and fishers offering "on-demand" products from selective and safe fisheries. The disruptive technologies are becoming increasingly affordable and promise to change behaviour and the economy, even for small-scale fishers.

FIGURE 47
BLOCKCHAIN TECHNOLOGY



SOURCE: Adapted from Piscini *et al.*, 2018

The use of disruptive technologies in fisheries and aquaculture may not be widespread now, but a look at three disruptive technologies that were not on the sector's horizon a few years ago – blockchains, sensors and automatic identification systems (AIS) – demonstrates the potential of disruptive technology to change the processes, profitability and sustainability of the sector.

Blockchains

A blockchain is an information technology that acts as a shared ledger for digital storage and tracking of data associated with a product or service, from the raw production stage until it lands in the consumer's hand in real time (Figure 47). The product's activity is recorded as a block of information, with a unique time-stamp alphanumeric code that is accessible by all of the parties in the value chain. The ledger distributes the information (in blocks), but the information cannot be changed. The record of the transactions along the chain is in the form of an incorruptible ledger which can record all or part of the information associated with the transactions.

The interlinked system of blocks of information avoids vast record-keeping as well as complicated and time-consuming reconciliation of information. Since the information is distributed, there is no centralized repository of transactions and associated information, so the system is difficult to corrupt or hack; yet the information is still accessible and transparent to users. Since no single entity controls the blockchain, there is also no single point of failure.

The distributed ledger aspect of the blockchain technology improves transparency, traceability and trust among those involved in the transactions. The technology – now being trialed in fisheries and in the food safety sector – thus holds considerable potential to improve market access, especially for small-scale fishers and fish farmers. The difficulty of corrupting information in the block chain strengthens the traceability of fish products along the value chain, which will enable more fisheries, aquaculture farms and fish processing facilities to meet import requirements such as the country of origin and phytosanitary standards of many countries. Improved traceability will also make it possible to fulfil growing buyer demand for legally and responsibly sourced fish. In some fisheries and aquaculture farms, it will assist in meeting certification requirements.

The transparency of information and security in the blockchain distributed ledger also has the potential to improve business-to-business trust and consumer confidence. Consumers could have access to a range of information along the whole value chain, such as where and how the fish was caught; temperatures and times of handling and storage; transit and processing countries and the time in each country; and processing undertaken. This access to information will provide an incentive for actors along the value chain to drive for more sustainable, high-quality and safe fish.

Sensors

The size of the digital universe is expected at least to double every two years, well beyond 2020, largely because of the expanded use of sensors. Sensors, which now number in the billions (Gartner, 2017) – are found, for example, in multimillion-dollar satellites in space, on board vessels, deep in the ocean and in your smartphone. They enable services that were unimaginable a few years ago, such as near-real-time tracking of high seas fishing, contact with emergency services from artisanal vessels, or applications ("apps") for checking wave height before fishing. Satellites collect information on the condition of the sea and provide important near-real-time information to improve safety, such as wave height, winds and currents. These services are often free and are accessible to small-scale fishers, for instance through mobile apps.

On board vessels, cameras and other sensors can improve the monitoring of the catch, including (but not only) the deployment of gears and processing equipment. Images and videos are useful to identify species. The use of image recognition software to detect and classify caught species automatically, which is already being tested or used in selected fisheries, could result in disruptive improvement of on-board observations and catch reporting and much better understanding of stocks and fisheries.

With sensors placed on board vessels (such as acoustic sounders) and in the open waters (for example, on buoys or as autonomous drones), fish are now easier to detect and study. The information they provide, when combined with catch reports, can radically change the number and quality of environmental and stock assessments.

Analysis of the ocean of data provided by sensors involves a complex workflow which extends beyond traditional fisheries data centres. Cloud-based services are required to cope with much larger data storage needs at the point of creation. The prime examples of such "big data" are the huge datasets from satellites that monitor the environment, but video and data from mobile phones also require a software solution that can easily be adapted to an increasing volume of data or users. The big-data approach will change the understanding of natural and human processes, such as the growth and distribution of species or the spatial planning of fisheries and aquaculture. Through big data, new opportunities arise for tracing how and where vessels operate and for tracking products all the way to shops and consumers.

Automatic identification systems

The maritime automatic identification system (AIS) is an automatic tracking system used for collision avoidance on ships and by shore-side vessel traffic services (VTS). AIS transceivers automatically and at regular intervals broadcast information such as vessel identity, position, speed and navigational status via a built-in very high frequency (VHF) transmitter over public airwaves using unencrypted radio signals. These messages are then received, recorded and rebroadcast by communication stations including ships, shore stations and search-and-rescue aircraft. Although the maritime AIS system was primary developed to increase safety at sea, it also provides maritime authorities a better way to monitor water traffic and movements and to identify vessels.

The IMO International Convention for the Safety of Life at Sea (Regulation V/19) requires ships of a certain size (and all passenger ships) to carry AIS. Fishing vessels are exempt from this regulation, but those of a specific size may be required to carry AIS by national regulations (for example in Norway, the United States of America and the European Union).

Vessel monitoring systems (VMS), which rely on satellite communication, are also used in commercial fishing to allow environmental and fisheries regulatory organizations to track and monitor the activities of fishing vessels as an integral part of national and international monitoring control and surveillance programmes.

With the combination of AIS and VMS, a wide range of applications are being developed in the areas of collision avoidance, vessel traffic services, maritime security, aids to navigation, search and rescue, accident investigation, ocean current estimates, infrastructure protection, fleet and cargo tracking and fishing fleet monitoring and control.

Detection of AIS signals from space is also possible. Unlike traditional communication stations, satellites are not limited by the horizontal range of signals. They are able to relay AIS communications over vast distances. The number of satellites relaying AIS information has grown steadily over the years; it is estimated that at present more than 28 million messages are broadcast every day (ORBCOMM, 2018). Luckily, in parallel with vast advancements in cloud technology and infrastructure, various organizations are now able to process and analyse such immense amounts of data. In fisheries, the use of AIS data through applied machine learning and artificial intelligence provides new ways to estimate fishing effort, socio-economic indicators and fishing patterns. AIS may also open the arena for developing products in support of the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA).

Challenges and risks

New technologies in the fisheries sector offer opportunities for improved fishing practices (e.g. more selective targeting of species or reduced losses of fishing gear). However, if abused, they can also be used to facilitate IUU fishing or, if not taken into account in fisheries management, can increase fishing power in general and result in overexploitation of resources. This is a risk with blockchains, for example, as they make it possible to gather more information and to use it more efficiently and effectively, thus increasing predictive capacity. Some new technologies have also created barriers for fisheries that lack the capacity or financial resources to adopt them. These risks highlight the importance of ensuring that effective management is in place so that emerging technologies are used to improve rather than undermine the sustainability of fisheries. Similarly, it is essential to address barriers to fishers' and fish farmers' access to new technologies, and to build their capacity to take advantage of disruptive technologies. The machines will march on, and it is a great responsibility to keep the disruption of social and environmental networks in check. If well managed, disruptive technologies offer immense opportunities to enhance the technical and financial efficiency of the sector, to create new work opportunities, to improve food security and livelihoods and to contribute to the 2030 Agenda, especially SDG 14. ■

PROJECTIONS OF FISHERIES, AQUACULTURE AND MARKETS

The State of World Fisheries and Aquaculture has presented the results of specific fish projections in every edition since 2014. This section presents short-term fish demand and supply projections (Box 30) and medium-term projections obtained using the FAO fish model (see FAO, 2012d, pp. 186–193), a dynamic policy-specific partial equilibrium model developed in 2010 to gain insight on the potential path of development of the fisheries and aquaculture sector. The fish model has links to, but is not integrated into, the Aglink-Cosimo model used to generate the

BOX 30
SHORT-TERM FISH DEMAND AND SUPPLY PROJECTIONS FOR EVALUATING THE GROWTH POTENTIAL OF AQUACULTURE

FAO has developed a short-term projection model to assess and monitor potential fish demand and supply gaps over a five-year horizon, with the aim of facilitating evidence-based decision-making at the national, regional and global levels (Cai and Leung, 2017). The model includes:

- a demand-side component, which estimates the growth in fish demand;
- a supply-side component, which estimates the trend in aquaculture growth;
- a set of indicators that measure gaps between demand and supply.

Unlike the sophisticated models used to predict likely scenarios of fish production, trade, consumption and prices in the medium or long term, as reported in the main text of this section and included in publications such as *Fish to 2030* (World Bank, 2013) and the annual *OECD-FAO Agricultural Outlook* (OECD, 2018), the FAO short-term projection model estimates the potential change of a country's fish demand as driven by its expected income and population growth, with the assumption of no changes in fish prices in the country. The benchmark fish supply is projected over the same five-year horizon by assuming that the country's aquaculture production will follow the recent five-year trend while its capture fisheries production remains stable. Then the potential fish demand is compared to the benchmark fish supply, and the resulting fish demand–supply gap can be measured by the shortage or surplus of the potential demand compared to the potential supply; the share of the potential demand increase that can be covered by the potential supply increase; or the growth rate of aquaculture production needed to close the demand–supply gap.

The results indicate, for example, that for the five-year horizon between the mid-2010s and the early 2020s, aquaculture growth following the recent trend would be able to cover only 40 percent of the global hike in fish demand driven by income and population growth, leaving a fish demand–supply gap of 28 million tonnes in the early 2020s. According to this projection, global aquaculture would need to grow 9.9 percent per year in order to fill the world fish demand–supply gap.

In contrast with most projections on fish demand and supply, which focus mainly on regional and global results, the short-term FAO projection model estimates the potential demand–supply gaps for nearly 200 countries or territories, about 40 regions or country groups and the entire world. The results are presented in a disaggregated form for five basic species groups (marine fish, freshwater and diadromous fish, crustaceans, cephalopods and other molluscs) and for four more aggregated groups (molluscs [cephalopods + other molluscs], shellfish [crustaceans + molluscs], finfish [freshwater and diadromous + marine fish] and fish [finfish + shellfish]).

The detailed results (presented in the Annex of Cai and Leung, 2017) can be used to inform policy-making or business management at the national or industry level. For example, the results have been used to prepare a policy brief on aquaculture growth potential in Nigeria (see Allen, Rachmi and Cai, 2017) and to facilitate a review of the marine finfish industry in the Mediterranean (Represas and Moretti, 2017).

ten-year-horizon agricultural projections elaborated jointly by the Organisation for Economic Co-operation and Development (OECD) and FAO each year and published in the *OECD-FAO Agricultural Outlook* (OECD, 2018). The fish model uses the same macroeconomic assumptions and selected prices employed or generated to produce the agricultural projections. The fish projections presented here have been expanded to 2030.

The fishery and aquaculture projections depict an outlook for the sector in terms of potential production, use (human consumption, fishmeal and fish oil), prices and key issues that might influence future supply and demand. The model results are not forecasts, but rather plausible scenarios that provide insight into how the sector may develop in light of a set of specific assumptions regarding: the future macroeconomic environment; international trade rules and tariffs; the frequency and effects of El Niño phenomena; the absence of other severe climate effects and abnormal fish-related disease outbreaks; fisheries management measures, including catch limitations; longer-term productivity trends; and the absence of market shocks. The model also takes partial account of China's Thirteenth Five-Year Plan (Box 31), which is expected to substantially reduce Chinese capture fisheries and the growth rate of aquaculture production in the country.

Baseline projections

Production

Based on the assumption of higher demand and technological improvements, total world fish production (capture plus aquaculture, excluding aquatic plants) is expected to continue to expand

BOX 31

CHINA'S THIRTEENTH FIVE-YEAR PLAN: POTENTIAL IMPACT ON FISHERIES AND AQUACULTURE

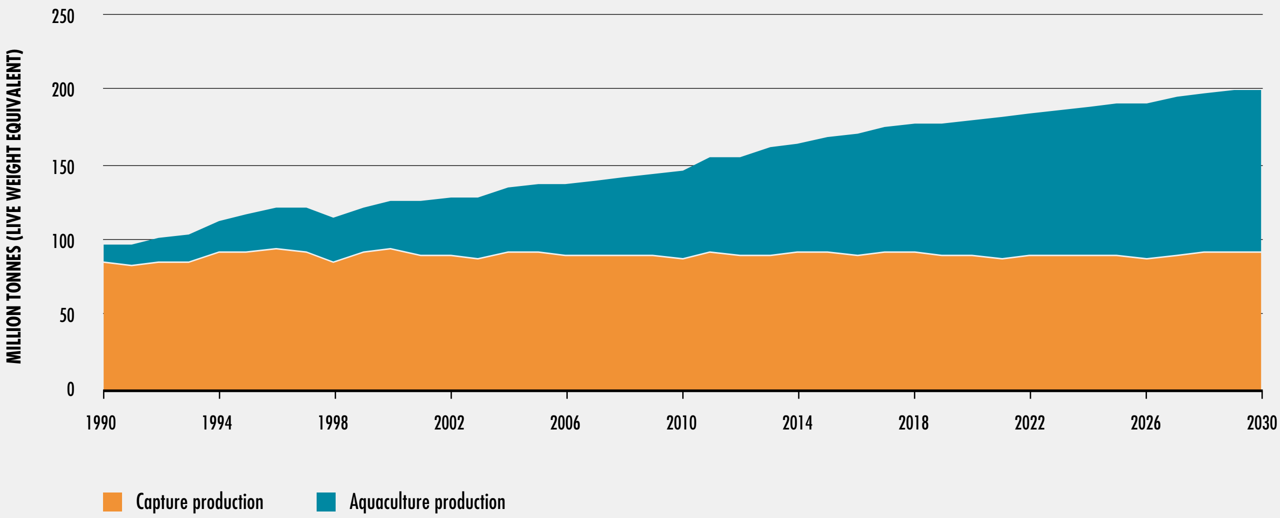
The Thirteenth Five-Year Plan for Economic and Social Development of the People's Republic of China (2016–2020) sets forth the country's strategic intentions and defines the major objectives, tasks and measures for its economic and social development. The plan includes goals and policies for transforming and upgrading the fisheries and aquaculture sector. It addresses current challenges such as scarcity of farming space, parcelling of aquaculture production among small-scale producers, a degraded resource base and excess capacity in the capture fisheries sector. The plan shifts away from the past emphasis on increasing production; it aims towards making the sector more sustainable and market oriented, with emphasis on improving the quality of the products and optimizing the industry structure, including the processing sector.

For aquaculture, the government policy aims to achieve sustainable, healthier production better integrated with the environment. Key elements include the adoption of ecologically sound technological innovations to facilitate the sustainable intensification of production; a shift from extensive to intensive aquaculture; and more energy-efficient production. For capture fisheries, the policy aims to constrain capacity and landings through licensing, output controls and reduction in the number of fishers and fishing vessels. Other objectives include the modernization of gear, vessels and infrastructure; regular reduction of the diesel fuel subsidy (e.g. a 40 percent reduction between 2014 and 2019); elimination of IUU fishing; the development of the distant-water fleet; and the restoration of domestic fish stocks through the use of restocking, artificial reefs and seasonal closures.

These measures should be followed by additional structural reforms and policies for the fisheries and aquaculture sector in the following years. If the plan and additional reforms are fully implemented and the goals are achieved, it is expected that the growth rate of China's aquaculture production will slow and its capture fisheries production will be substantially reduced.

SOURCE: OECD, 2017

FIGURE 48
WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION, 1990–2030



over the course of the projection period to reach 201 million tonnes in 2030 (Figure 48). This represents a growth of 18 percent over 2016, or 30 million tonnes (Table 22), at a lower annual growth rate (1.0 percent) than observed in the period 2003–2016 (2.3 percent).

In 2030 capture fisheries production is expected to reach about 91 million tonnes, slightly higher (by 1 percent) than in 2016. Factors influencing this limited growth include a 17 percent decrease of capture fisheries in China due to the implementation of new policies, compensated by increased catches in some fishing areas where stocks of certain species are recovering due to improved management; some increase in catches in waters of the few countries where there are underfished resources, where new fishing opportunities exist or where fisheries management measures are less restrictive; and enhanced use of fishery production, including reduced onboard discards, waste and losses as driven by legislation or higher market fish prices (for both food and non-food products). However, in some years (set in the model as 2021 and 2026 as one of the assumptions), the El Niño phenomenon is expected to reduce catches in South America, especially for anchoveta, resulting in an overall decrease of world capture fisheries production of about 2 percent in those years.

The major growth in production is expected to originate from aquaculture, which is projected to reach 109 million tonnes in 2030, with growth of 37 percent over 2016. However, it is estimated that the annual growth rate of aquaculture will slow down from 5.7 percent in 2003–2016 to 2.1 percent in 2017–2030 (Figure 49), mainly because of reduced growth of Chinese aquaculture production, partially compensated by an increase in production in other countries. Despite the lower growth rate, aquaculture will still continue to be one of the fastest growing animal-food sectors. The share of farmed species in global fishery production (for food and non-food uses), 47 percent in 2016, is projected to exceed that of wild species for the first time in 2020 and to grow to 54 percent in 2030 (Figure 50). »

TABLE 22
PROJECTED FISH PRODUCTION, 2030 (live weight equivalent)

Region/country	Fisheries and aquaculture			Aquaculture		
	Production (1 000 tonnes)		Growth, 2016 to 2030 (%)	Production (1 000 tonnes)		Growth, 2016 to 2030 (%)
	2016	2030		2016	2030	
Asia	**121 776**	**144 666**	**18.8**	**71 546**	**97 165**	**35.8**
China	66 808	79 134	18.4	49 244	64 572	31.1
India	10 762	13 407	24.6	5 700	8 212	44.1
Indonesia	11 492	15 158	31.9	4 950	8 253	66.7
Japan	3 872	3 427	−11.5	677	745	10.1
Philippines	2 821	3 229	14.4	796	1 085	36.3
Republic of Korea	1 894	1 831	−3.3	508	632	24.4
Thailand	2 493	2 757	10.6	963	1 305	35.6
Viet Nam	6 410	8 087	26.1	3 625	5 085	40.3
Africa	**11 260**	**13 556**	**20.4**	**1 982**	**3 195**	**61.2**
Egypt	1 706	2 657	55.7	1 371	2 302	68.0
Morocco	1 448	1 712	18.2	1	2	33.3
Nigeria	1 041	1 231	18.2	307	418	36.2
South Africa	618	590	−4.5	5	6	1.9
Europe	**16 644**	**17 954**	**7.9**	**2 945**	**3 953**	**34.2**
European Union	6 463	7 025	8.7	1 292	1 664	28.8
Norway	3 360	3 909	16.3	1 326	1 719	29.6
Russian Federation	4 932	5 244	6.3	173	291	67.9
North America	**6 703**	**6 470**	**−3.5**	**645**	**744**	**15.4**
Canada	1 063	1 099	3.5	201	249	24.2
United States of America	5 364	5 371	0.1	444	495	11.4
Latin America and Caribbean	**12 911**	**16 035**	**24.2**	**2 703**	**4 033**	**49.2**
Argentina	759	853	12.4	4	4	3.4
Brazil	1 286	1 885	46.6	581	1 097	89.0
Chile	2 535	3 665	44.6	1 035	1 309	26.4
Mexico	1 732	1 993	15.1	221	316	42.6
Peru	3 897	4 450	14.2	100	221	120.9
Oceania	**1 640**	**1 973**	**20.3**	**210**	**299**	**42.1**
Australia	269	289	7.3	97	151	55.7
New Zealand	532	560	5.3	109	143	31.0
World	**170 941**	**200 955**	**17.6**	**80 031**	**109 391**	**36.7**
Developed countries	**28 050**	**28 720**	**2.4**	**4 498**	**5 762**	**28.1**
Developing countries	**142 885**	**172 235**	**20.5**	**75 532**	**103 630**	**37.2**
Least developed countries	**12 978**	**14 434**	**11.2**	**3 749**	**5 487**	**46.3**

FIGURE 49
ANNUAL GROWTH RATE OF WORLD AQUACULTURE, 1980–2030

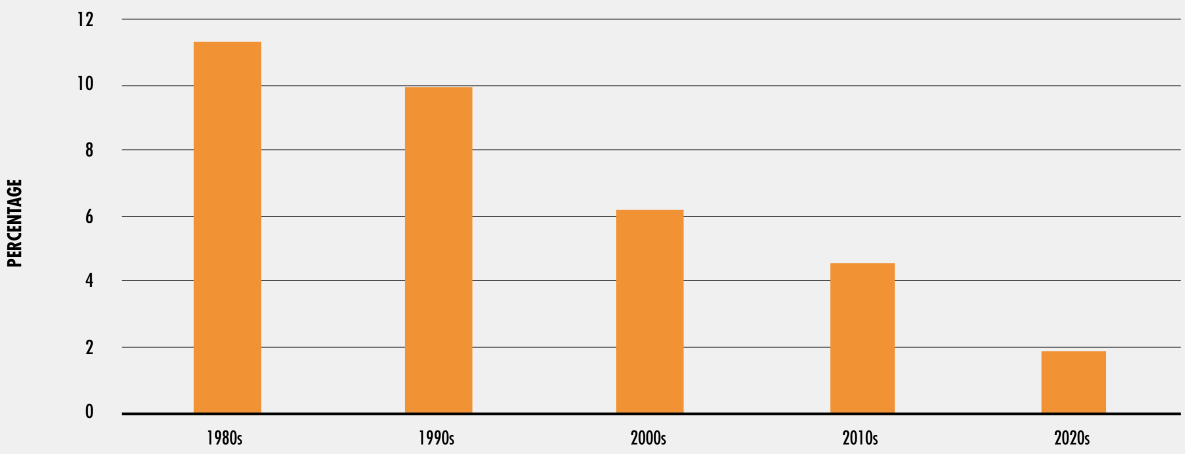


FIGURE 50
GLOBAL CAPTURE FISHERIES AND AQUACULTURE PRODUCTION, 1990–2030

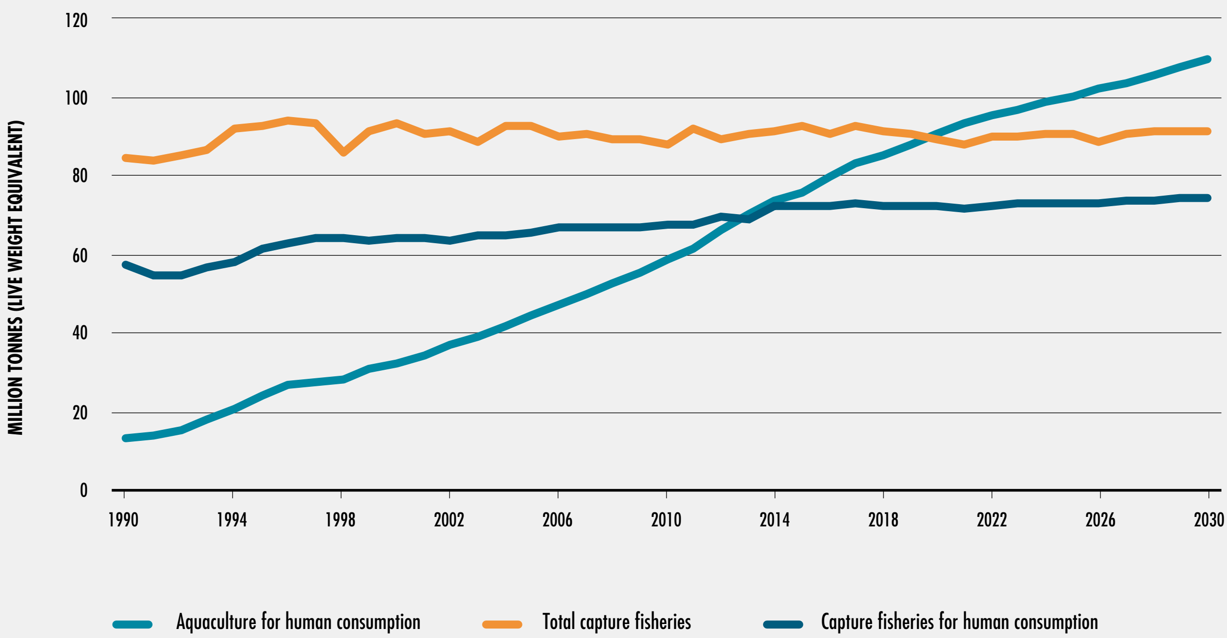
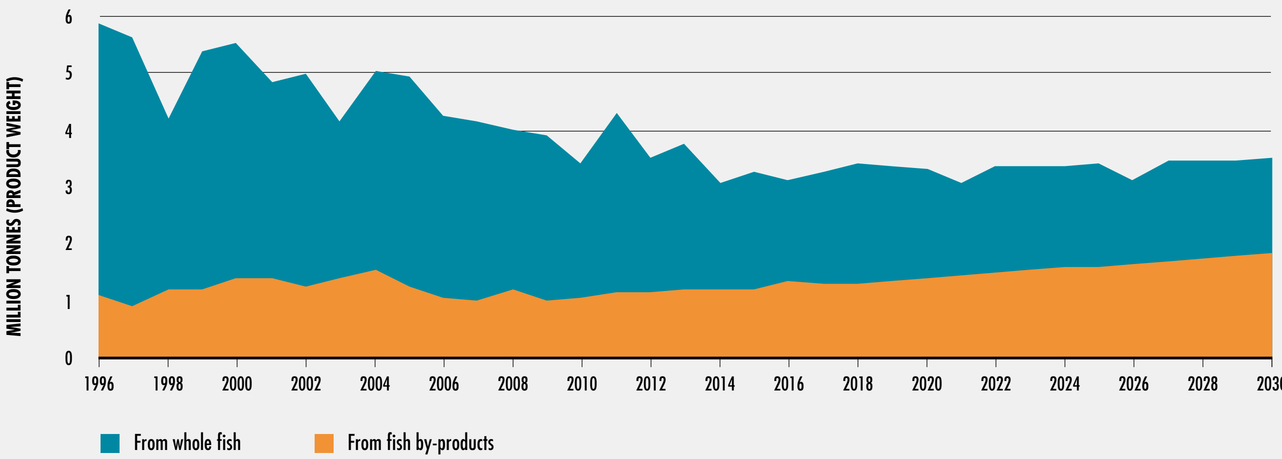


FIGURE 51
WORLD FISHMEAL PRODUCTION, 1996–2030



» Over 87 percent of the increase in aquaculture production in 2030 will originate from Asian countries. Asia will continue to dominate world aquaculture production, with a share of 89 percent in 2030. China will remain the world's leading producer, but its share in total production will decrease from 62 percent in 2016 to 59 percent in 2030. Aquaculture production is projected to continue to expand on all continents, with variations in the range of species and products across countries and regions. Major increases are expected in particular in Latin America (+49 percent) and in Africa (+61 percent). In Africa, the expansion is projected partly on the basis of the additional culturing capacity put in place in recent years, but also because of rising local demand from higher economic growth and local policies promoting aquaculture. Freshwater species, such as carp, catfish (including *Pangasius* spp.) and tilapia, are expected to represent about 62 percent of total world aquaculture production in 2030, as compared with 58 percent in 2016. Production of higher-value species, such as shrimps, salmon and trout, is also projected to continue to grow.

About 16 percent of capture fisheries yield will be used to produce fishmeal in 2030. The estimated fishmeal and fish oil production, in product weight, should reach 5.3 million tonnes and 1.0 million tonnes, respectively. In 2030, fishmeal production should be 19 percent higher than in 2016, but about 54 percent of the growth will derive from improved use of fish waste, cuttings and trimmings obtained from fish processing. Fishmeal produced from fish by-products will represent 34 percent of world fishmeal production in 2030, compared to 30 percent in 2016 (Figure 51). The fish model does not take into account the effects of the use of fish by-products on the composition and quality of the resulting fishmeal and/or fish oil. Possible effects include lower protein and increased ash (minerals) and small amino acids (e.g. glycine, proline, hydroxyproline) in comparison with products obtained from whole fish. This difference in composition may hinder increased use of fishmeal and/or fish oil in feeds used in aquaculture and livestock farming.

Prices

The sector is expected to enter a decade of higher prices in nominal terms. Factors driving this tendency include income, population growth and meat prices on the demand side; and the potential slight decline in capture fisheries production as a result of policy measures in China, the slowdown in growth of aquaculture production and cost pressure from some crucial inputs (e.g. feed, energy and crude oil) on the supply side. In addition, the slowdown in Chinese fisheries and aquaculture production will stimulate higher prices in China, with a domino effect on world prices. The increase in the average price of farmed fish (19 percent over the projection period) will be greater than that of captured fish (excluding fish for non-food use) (17 percent). These higher prices, coupled with high demand for fish for human consumption, will stimulate a 25 percent increase in the average price of internationally traded fish by 2030 relative to 2016. In addition, prices of fishmeal and fish oil are expected to continue trending upwards over the projection period, with growth of 20 percent and 16 percent, respectively, in nominal terms by 2030, as a result of strong global demand. High feed prices could have an impact on the species composition in aquaculture, with a shift towards those species requiring less expensive and/or lower quantities of feed or no feed.

In real terms, adjusted for inflation, it is assumed that all prices will decline slightly over the projection period but will remain high. For individual fishery commodities, price volatility could be more pronounced as a result of supply or demand swings. As aquaculture is expected to represent a higher share of world fish supply, aquaculture could have a stronger impact on price formation in the sector overall (both production and trade).

Consumption

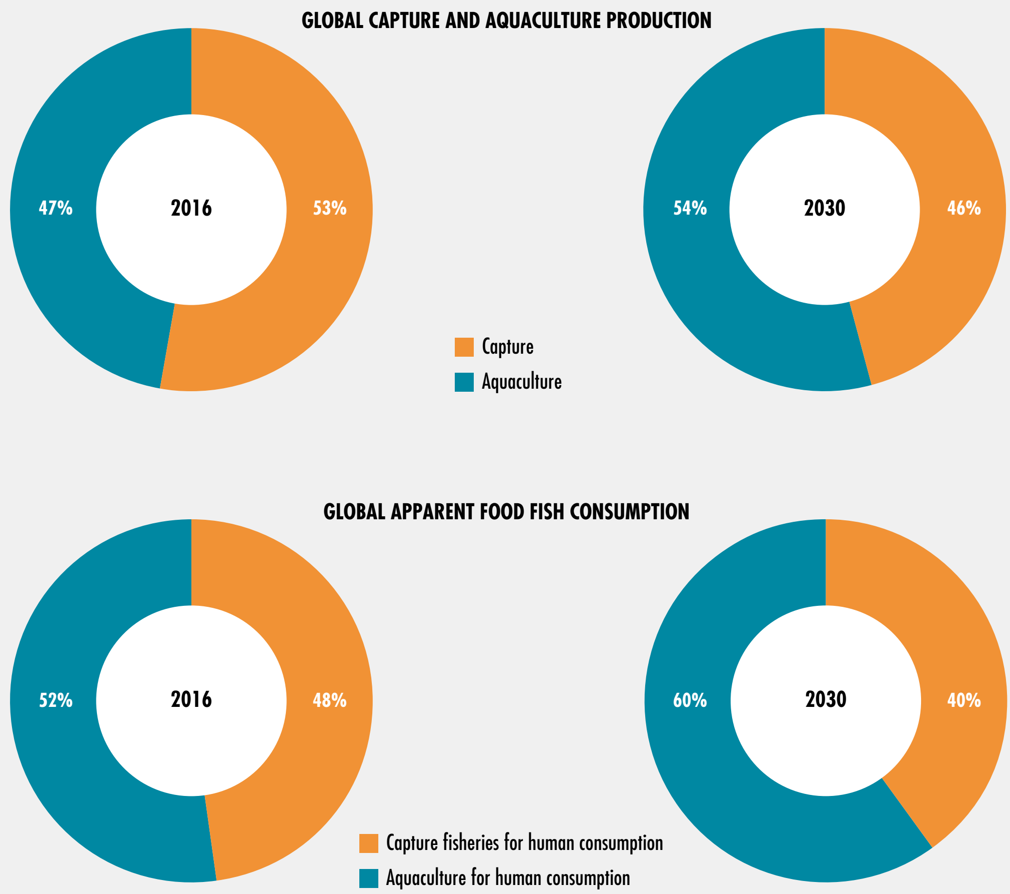
A growing share of fish production is expected to be destined for human consumption (around 90 percent). The driving force behind this increase will be a combination of rising incomes and urbanization, linked with the expansion of fish production and improved distribution channels. World food fish[19] consumption in 2030 is projected to be 20 percent (or 30 million tonnes live weight equivalent) higher than in 2016. However, it is predicted that its average annual growth rate will be slower in the projection period (+1.2 percent) than in the period 2003–2016 (+3.0 percent), mainly because of reduced production growth, higher fish prices and a deceleration in population expansion. About 71 percent of the fish available for human consumption (184 million tonnes) will be consumed in Asian countries, while the lowest quantities will be consumed in Oceania and Latin America. Total food fish consumption is expected to increase in all regions and subregions by 2030 in comparison with 2016, with major growth projected in Latin America (+33 percent), Africa (+37 percent), Oceania (+28 percent) and Asia (+20 percent).

In per capita terms, world fish consumption is projected to reach 21.5 kg in 2030, up from 20.3 kg in 2016. However, the annual growth rate of per capita food fish consumption will decline from 1.7 percent in 2003–2016 to 0.4 percent in 2017–2030. Per capita fish consumption will increase in all regions except Africa (–2 percent). The highest growth rates are projected for Latin America (+18 percent) and for Asia and Oceania (+8 percent each). Despite these regional trends, the overall tendencies in quantities and variety of fish consumed will vary among and within countries. Farmed species are expected to contribute to an increasing share of global fish food consumption, reaching about 60 percent of the total in 2030 (Figure 52).

In Africa, per capita fish consumption is expected to decrease by 0.2 percent per year up to 2030, declining from 9.8 kg in 2016 to 9.6 kg in 2030, as a result of population growth outpacing supply. The decline will more significant in sub-Saharan Africa (from 8.6 to 8.3 kg during the same period). Increasing domestic production (+20 percent over the period 2016–2030) and higher dependence on fish food imports will not be sufficient to meet the region's growing demand. The projected decline in per capita fish consumption in Africa raises food security concerns because of the region's high prevalence of undernourishment (FAO *et al.*, 2017) and the importance of fish in total animal protein intake in many African countries (see section on

19 Fish for food or for human consumption indicates fish production excluding non-food uses such as fish destined for reduction into fishmeal and fish oil, minus exports, plus imports, plus/minus stock data. Fish consumption data reported in this section refer to apparent consumption, which refers to the average food available for consumption, which, for a number of reasons (for example, waste at the household level), is not equal to edible food intake/edible food consumption.

FIGURE 52
INCREASING ROLE OF AQUACULTURE



consumption in Part 1). The decline may also weaken the ability of more fish-dependent countries to meet nutrition targets (2.1 and 2.2) of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture).

Trade

Fish and fish products will continue to be highly traded. It is projected that about 31 percent of total fishery production will be exported in 2030 (38 percent if trade within the European Union is included), in the form of different products for human consumption or non-edible purposes, traded at various stages of processing. In quantity terms, world trade of fish for human consumption is expected to grow by 24 percent in the projection period and to reach more than 48 million tonnes in live weight equivalent in 2030 (Table 23) (60.6 million tonnes if trade within the European Union is included). However, the average annual growth rate of exports is expected to decrease from 2.7 percent in 2003–2016 to 1.5 percent in 2017–2030, partly owing to increasing prices, slower growth of fish production and stronger domestic demand in some of the major exporting countries such as China. China will continue to be the major exporter of fish for human consumption (followed by Viet Nam and Norway), with its share in total fish exports for »

TABLE 23
PROJECTED FISH TRADE, 2030 (live weight equivalent)

Region/country	Exports (1 000 tonnes) 2016	Exports (1 000 tonnes) 2030	Growth, 2016 to 2030 (%)	Imports (1 000 tonnes) 2016	Imports (1 000 tonnes) 2030	Growth, 2016 to 2030 (%)
Asia	**19 349**	**24 062**	**24.4**	**15 974**	**17 606**	**10.2**
China	7 652	9 407	22.9	3 869	3 804	−1.7
India	1 072	1 727	61.2	44	35	−20.1
Indonesia	1 280	2 017	57.6	151	468	209.7
Japan	681	953	40.0	3 729	3 645	−2.2
Philippines	322	241	−25.3	461	597	29.3
Republic of Korea	620	387	−37.5	1 720	1 964	14.2
Thailand	1 916	2 392	24.8	1 702	1 917	12.6
Viet Nam	2 790	3 981	42.7	333	439	31.9
Africa	**2 782**	**2 304**	**−17.2**	**4 239**	**6 111**	**44.2**
Egypt	55	50	−9.0	545	486	−10.8
Morocco	644	648	0.6	76	130	71.6
Nigeria	14	15	6.6	661	1 034	56.4
South Africa	169	213	26.0	286	673	135.2
Europe	**8 640**	**11 937**	**38.2**	**10 354**	**12 649**	**22.2**
European Union	2 270	4 183	84.2	8 338	10 206	22.4
Norway	2 655	3 262	22.9	307	212	−31.0
Russian Federation	2 423	3 289	35.7	693	1 155	66.6
North America	**2 746**	**3 201**	**16.6**	**5 933**	**7 359**	**24.0**
Canada	854	598	−30.0	656	502	−23.6
United States of America	1 892	2 604	37.6	5 277	6 857	29.9
Latin America and Caribbean	**3 985**	**5 171**	**29.8**	**2 350**	**3 597**	**53.1**
Argentina	558	645	15.6	71	75	5.1
Brazil	43	51	16.5	637	969	51.9
Chile	1 368	2 133	55.9	127	200	56.9
Mexico	198	168	−15.4	523	947	81.1
Peru	504	469	−7.0	131	120	−8.7
Oceania	**1 040**	**1 155**	**11.0**	**678**	**775**	**14.2**
Australia	89	78	−13.0	469	587	25.3
New Zealand	409	415	1.6	51	50	−2.0
World	**38 802**	**48 096**	**24.0**	**39 517**	**48 096**	**21.7**
Developed countries	**12 570**	**16 590**	**32.0**	**20 719**	**24 508**	**18.3**
Developing countries	**26 232**	**31 506**	**20.1**	**18 797**	**23 588**	**25.5**
Least developed countries	**1 057**	**828**	**−21.6**	**1 085**	**1 470**	**35.5**

» human consumption remaining at 20 percent. The bulk of the growth in fish exports is projected to originate from Asian countries. This region will account for about 51 percent of the additional exports by 2030. Asia's share in total trade of fish for human consumption will remain at 50 percent in 2030. Advanced economies are expected to remain highly dependent on imports to fulfil their domestic demand. The European Union, Japan and the United States of America will account for 43 percent of total imports for food fish consumption in 2030, a slightly lower share than in 2016 (44 percent).

Scenarios: impacts of policy measures in China on global projections

The above results point to reduced growth of the sector relative to that projected in previous editions of *The State of World Fisheries and Aquaculture*, in large part because of the potential effects of China's Thirteenth Five-Year Plan for Fisheries Development and additional structural reforms (see Box 31, above). Because of China's prominence in fisheries and aquaculture, changes in terms of supply, consumption and pressure on prices could have major implications at the world level. However, as the practical implementation and eventual impacts of the Chinese policies are still subject to some uncertainty, their objectives were only partially factored into the model assumptions and are consequently not fully present in the baseline results discussed above. Therefore, two ad hoc scenarios were developed to compare the baseline results with the potential outlook in the absence of the plan and with full implementation of the plan (Table 24).

The difference between no or full implementation of the plan translates into a difference in China's total fish production of about 10 million tonnes in 2030. In the full-plan scenario, China's capture fisheries output would decrease by 29 percent, with aquaculture playing an increasingly important role in Chinese supply of fish products. The country's aquaculture production will continue to increase in all scenarios (by 2.2, 1.9 and 1.5 percent per year, respectively, for the no-plan, baseline and full-plan scenarios), albeit at a lower annual growth rate compared to the 5.3 percent per year of 2003–2016. In the full-plan scenario, the higher share of fish destined for human consumption (as a result of increased fish imports and new policies supporting waste reduction and production of species that meet market demand) will partly compensate for the greater reduction in overall production relative to the no-plan scenario.

The high domestic demand is expected to put pressure on prices. Overall, per capita food fish consumption in China will range between 48.0 kg (full-plan scenario) and 50.2 kg (no-plan scenario). In the full-plan scenario, the expected high prices in China and the reduced availability of fish originating from China in world markets will increase prices at the world level. This situation would also stimulate greater production in other countries, which would partly counterbalance the reduced production in China, particularly in aquaculture (Figure 53). World per capita fish consumption would range from 21.1 kg in the case of full implementation of the plan to 21.8 kg if the plan is not implemented.

Summary of main outcomes from the projections

The following major trends for the period up to 2030 emerge from the analyses:

- World fish production, consumption and trade are expected to increase, but with a growth rate that will slow over time.
- Despite reduced capture fisheries production in China, world capture fisheries production is projected to increase slightly through increased production in other areas if resources are properly managed.
- Expanding world aquaculture production, although growing more slowly than in the past, is anticipated to fill the supply–demand gap.
- Prices will all increase in nominal terms while declining in real terms, although remaining high.
- Food fish supply will increase in all regions, while per capita fish consumption is expected to decline in Africa, which raises concerns in terms of food security.
- Trade in fish and fish products is expected to increase more slowly than in the past decade, but the share of fish production that is exported is projected to remain stable.

TABLE 24
SCENARIOS FOR PRODUCTION, TRADE AND APPARENT CONSUMPTION DEPENDING ON IMPLEMENTATION OF CHINA'S THIRTEENTH FIVE-YEAR PLAN

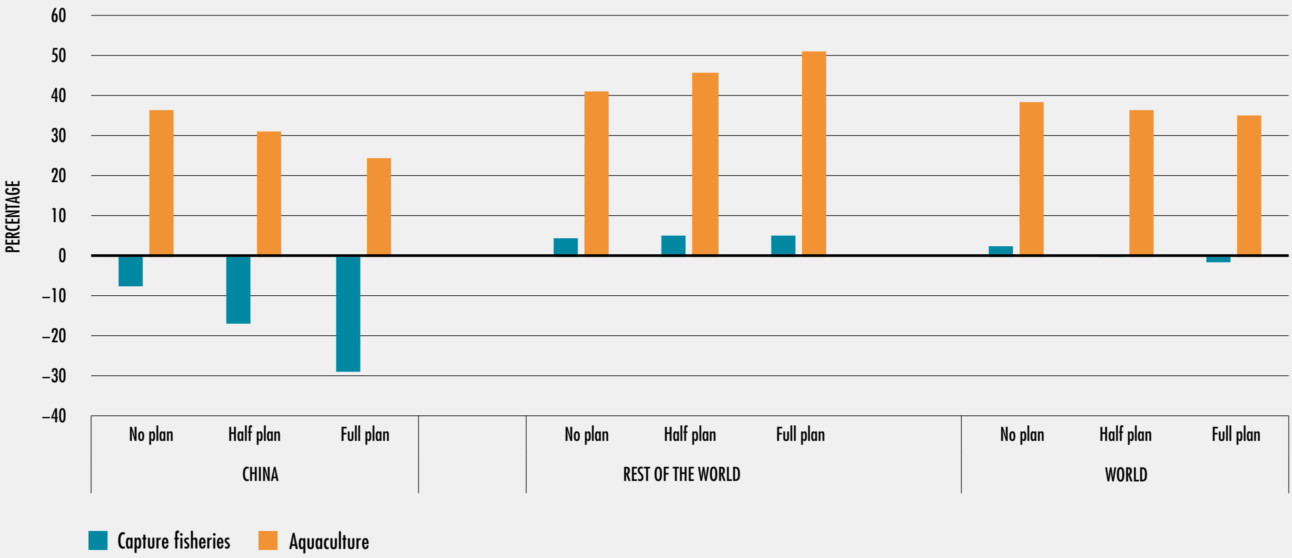
Category	1 000 tonnes (live weight equivalent)				% growth, 2016 to 2030		
	Base year 2016	No-plan scenario 2030	Baseline 2030	Full-plan scenario 2030	No-plan scenario	Baseline	Full-plan scenario
China							
Aquaculture production	49 244	67 206	64 572	61 391	36.5	31.1	24.7
Capture production	17 564	16 224	14 562	12 500	–7.6	–17.1	–28.8
Total fish production	66 808	83 430	79 134	73 891	24.9	18.4	10.6
Exports of food fish	7 652	11 302	9 407	7 370	47.7	22.9	–3.7
Imports of food fish	3 869	3 140	3 804	4 900	–18.8	–1.7	26.7
Per capita consumption *(kg)*	*41.2*	*50.2*	*49.2*	*48.0*	*22.0*	*19.6*	*16.6*
World, excluding China							
Aquaculture production	30 783	43 439	44 819	46 515	41.1	45.6	51.1
Capture production	73 346	76 772	77 003	77 290	4.7	5.0	5.4
Total fish production	104 128	120 210	121 821	123 803	15.4	17.0	18.9
Exports of food fish	31 151	37 103	38 689	40 683	19.1	24.2	30.6
Imports of food fish	35 648	45 265	44 292	43 154	27.0	24.2	21.1
Per capita consumption *(kg)*	*15.5*	*16.0*	*15.8*	*15.7*	*3.1*	*2.2*	*1.2*
World							
Aquaculture production	80 027	110 646	109 391	107 906	38.3	36.7	34.8
Capture production	90 910	92 996	91 565	89 790	2.3	0.7	–1.2
Total fish production	170 936	203 640	200 955	197 694	19.1	17.6	15.7
Exports/imports of food fish	38 802	48 405	48 096	48 053	24.7	24.0	23.8
Per capita consumption *(kg)*	*20.3*	*21.8*	*21.5*	*21.1*	*7.3*	*5.9*	*4.2*

- The new reforms and policies set by China for its capture fisheries and aquaculture sector are expected to have a noticeable impact at the world level, with changes in prices, output and consumption.

Main uncertainties

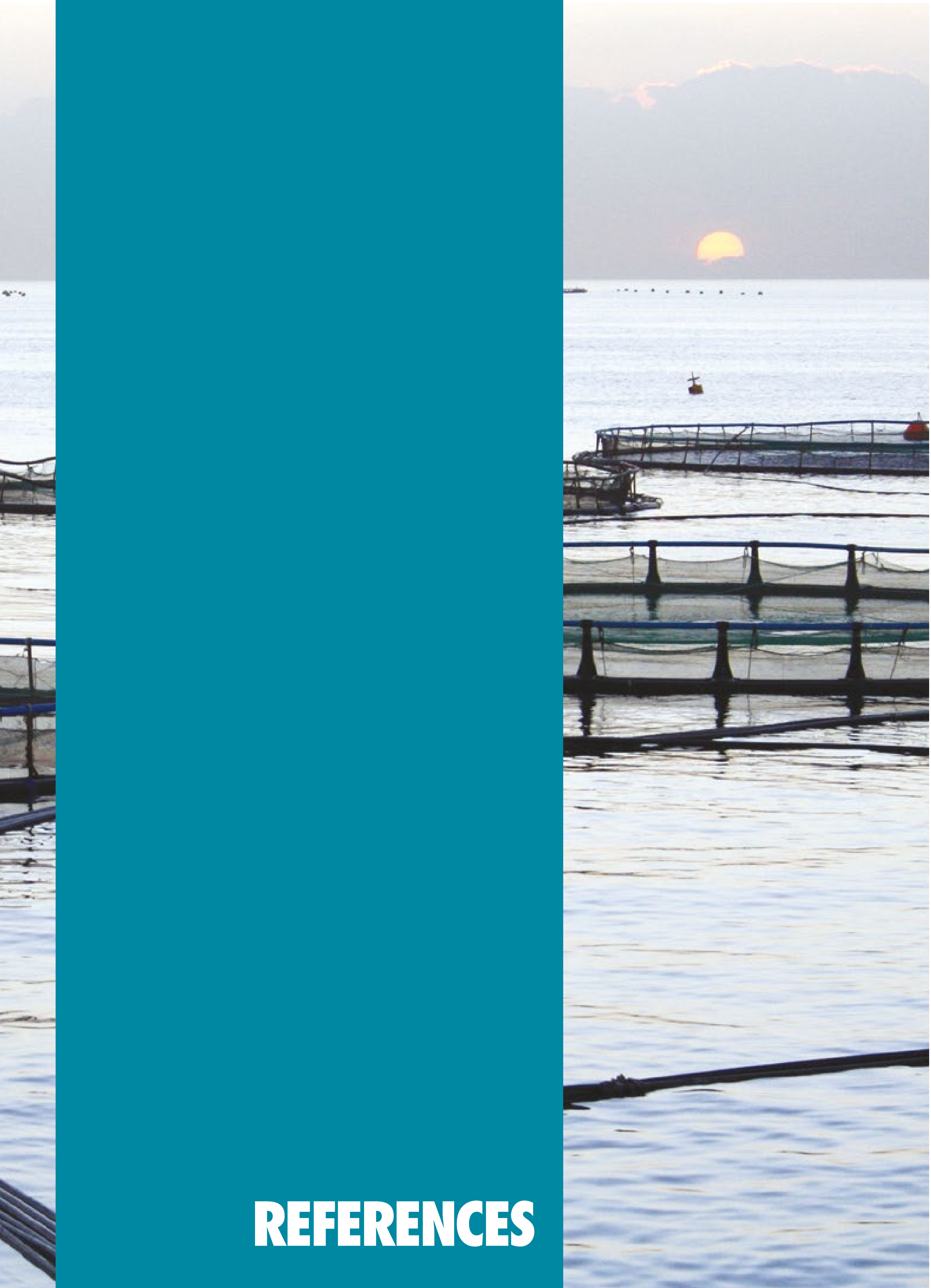
In addition to the new policies in China, many factors can affect the projections reported here. The next decade is likely to see major changes in the environment, resources, macroeconomic conditions, international trade rules and tariffs, market characteristics and social conduct, which may affect production and fish markets in the medium term. Influences include climate change, climate variability and extreme weather events, environmental degradation and habitat destruction, overfishing, IUU fishing, poor governance, diseases and escapes, invasion of non-native species; issues associated with

FIGURE 53
GROWTH IN FISH PRODUCTION FOR DIFFERENT SCENARIOS DEPENDING ON IMPLEMENTATION OF CHINA'S THIRTEENTH FIVE-YEAR PLAN, 2016–2030



accessibility and availability of sites and water resources and access to credit; as well as improved fisheries management, efficient aquaculture growth and improvement in technology and research. In addition, issues related to food safety and traceability, including the need to demonstrate that products are not derived from illegal and proscribed fishing operations, can have a relevant impact in terms of market access. ■

CYPRUS
Fish farming in floating cages
©GFCM/F. Massa



REFERENCES

REFERENCES

Ababouch, L., Taconet, M., Plummer, J., Garibaldi L. & Vannuccini, S. 2016. Bridging the science–policy divide to promote fisheries knowledge for all: the case of the Food and Agriculture Organization of the United Nations. In B.H. MacDonald, S.S. Soomai, E.M. De Santo & P.G. Wells, eds. *Science, information and policy interface for effective coastal and ocean management*, pp. 389–417. Boca Raton, Florida, USA, CRC Press.

ABALOBI. 2017. ABALOBI: a co-designed and fisher-driven mobile app suite to transform small-scale fisheries governance from hook to cook [online]. [Cited 5 December2017]. http://abalobi.info

Aguilar-Manjarrez, J., Soto, D. & Brummett, R. 2017. *Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture: a handbook*. Rome, FAO & World Bank.

Ainsworth, R.F & Cowx, I.G. 2018. Validation of FAO inland fisheries catch statistics and replacement of fish with equivalent protein sources. Unpublished report to FAO.

Akande, G. & Diei-Ouadi, Y. 2010. *Post-harvest losses in small-scale fisheries: case studies in five sub-Saharan African countries*. FAO Fisheries and Aquaculture Technical Paper No. 550. Rome, FAO.

Allen, K., Rachmi, A.F. & Cai, J. 2017. Nigeria: faster aquaculture growth needed to bridge fish demand–supply gap. *FAO Aquaculture Newsletter*, *57*: 36–37.

Allison, E.H., Delaporte, A. & Hellebrandt de Silva, D. 2013. Integrating fisheries management and aquaculture development with food security and livelihoods for the poor. Report submitted to the Rockefeller Foundation. Norwich, UK, School of International Development, University of East Anglia.

Alonso-Población, E. & Siar, S.V. 2018. *Women's participation and leadership in fisherfolk organizations and collective action in fisheries: a review of evidence on enablers, drivers and barriers*. FAO Fisheries and Aquaculture Circular No. 1159. Rome, FAO.

Arthur, J.R., Baldock, F.C., Subasinghe, R.P. & McGladdery, S.E. 2005. *Preparedness and response to aquatic animal health emergencies in Asia: guidelines*. FAO Fisheries Technical Paper No. 486. Rome, FAO.

Arthur, J.R. & Bondad-Reantaso, M.G. 2012. *Risk analysis for movements of live aquatic animals – an introductory training course*. Apia, FAO Subregional Office for the Pacific Islands.

Arthur, J.R., Bondad-Reantaso, M.G. & Subasinghe, R.P. 2008. *Procedures for the quarantine of live aquatic animals: a manual*. FAO Fisheries Technical Paper No. 502. Rome, FAO.

Asamblea Nacional de Nicaragua. 2016. Contexto sectorial en la exposición de motivos de la Iniciativa de Ley de Reforma al Art. 16 de la Ley No. 613 "Ley de Protección y Seguridad a las Personas dedicadas a la actividad del Buceo". Internal document. Managua.

Auchterlonie, N. 2018. The continuing importance of fishmeal and fish oil in aquafeeds. Presented at the Aquafarm Conference, Pordenone, Italy, 15–16 February [Cited 2 April 2018]. www.iffo.net/iffo-presentations

Balian, E.V., Segers, H., Leveque, C. & Martens, K. 2008. The Freshwater Animal Diversity Assessment: an overview of the results. In E.V. Balian, C. Leveque, H. Segers & K. Martens, eds. *Freshwater Animal Diversity Assessment*, pp. 627–637. Developments in Hydrobiology No. 198. Dordrecht, the Netherlands, Springer.

Bann, C. & Başak, E. 2011. *Economic analysis of Gökova Special Environmental Protection Area*. Project PIMS 3697, Strengthening the System of Marine and Coastal Protected Areas of Turkey. Technical Report Series 3. Ankara, Ministry of Environment and Urbanization & United Nations Development Programme (UNDP).

Barange, M., Merino, G., Blanchard, J.L., Scholtens J., Harle, J., Allison, E.H., Allen, J.I., Holt, J. & Jennings, S. 2014. Impacts of climate change on marine ecosystem production in societies dependent on fisheries. *Nature Climate Change*, 4: 211–216.

Bartley, D.M., De Graaf, G.J., Valbo-Jørgensen, J. & Marmulla, G. 2015. Inland capture fisheries: status and data issues. *Fisheries Management and Ecology*, 22(1): 71–77.

Basurto, X., Franz, N., Mills, D., Virdin, J. & Westlund, L. 2017. *Improving our knowledge on small-scale fisheries: data needs and methodologies*. Workshop proceedings, Rome, 27–29 June 2017. FAO Fisheries and Aquaculture Proceedings No. 56. Rome, FAO.

Batt, R.D., Morley, J.W., Selden, R.L., Tingley, M.W. & Pinsky, M.L. 2017. Gradual changes in range size accompany long-term trends in species richness. *Ecology Letters*. doi: 10.1111/ele.12812.

Bazigos, G.P. 1974. *The design of fisheries statistical surveys – inland water*. FAO Fisheries Technical Paper No. 133. Rome, FAO.

Beard, T.D. Jr., Arlinghaus, R., Cooke, S.J., McIntyre, P., De Silva, S., Bartley, D.M. & Cowx, I.G. 2011. Ecosystem approach to inland fisheries: research needs and implementation strategies. *Biology Letters*, *7*: 481–483.

Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., Derous, S., Holm, P., Horton, T., van Ierland, E., Marboe, A.H., Starkey, D.J., Townsend, M. & Zarzycki, T. 2007. Identification, definition and quantification of goods and services provided by marine biodiversity: implications for the ecosystem approach. *Marine Pollution Bulletin*, *54*(3): 253–265.

Bell, J.D., Johnson, J.E., Ganachaud, A.S., Gehrke, P.C., Hobday, A.J., Hoegh-Guldberg, O., Le Borgne, R., Lehodey, P., Lough, J.M., Pickering, T., Pratchett, M.S. & Waycott, M. 2011. *Vulnerability of tropical Pacific fisheries and aquaculture to climate change: summary for Pacific island countries and territories*. Noumea, New Caledonia, SPC.

Belton, B. & Thilsted, S.H. 2014. Fisheries in transition: food and nutrition security implications for the global South. *Global Food Security*, 3: 59–66.

Béné, C., Barange, M., Subasinghe, R., Pinstrup-Andersen, P., Merino, G., Hemre, G.-I. & Williams, M. 2015. Feeding 9 billion by 2050 – putting fish back on the menu. *Food Security*, *7*: 261–274.

Béné, C., Devereux, S. & Roelen, K. 2015. *Social protection and sustainable natural resource management: initial findings and good practices from small-scale fisheries*. FAO Fisheries and Aquaculture Circular No. 1106. Rome, FAO.

Beveridge, M.C.M., Thilsted, S.H., Phillips, M.J., Metian, M., Troell, M. & Hall, S.J. 2013. Meeting the food and nutrition needs of the poor: the role of fish and the opportunities and challenges emerging from the rise of aquaculture. *Journal of Fish Biology*, 83: 1067–1084. doi:10.1111/jfb.12187.

Biswas, N. 2017. *Towards gender-equitable small-scale fisheries governance and development – a handbook, in support of the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. Rome, FAO.

Bjorndal, T., Child, A. & Lem, A., eds. 2014. *Value chain dynamics and the small-scale sector: policy recommendations for small-scale fisheries and aquaculture trade*. FAO Fisheries and Aquaculture Technical Paper No. 581. Rome, FAO.

Blanchard, J.L., Watson, R.A., Fulton, E.A., Cottrell, R.S., Nash, K.L., Bryndum-Buchholz, A., Büchner, M., Carozza, D.A., Cheung, W.W.L., Elliot, J., Davidson, L.N.K., Dulvy, N.K, Dunne, J.P., Eddy, T.D., Galbraith, E., Lotze, H.K., Maury, O., Müller, C., Tittensor, D.P. & Jennings, S. 2017. Linked sustainability challenges and trade-offs among fisheries, aquaculture and agriculture. *Nature Ecology and Evolution*, 1: 1240–1249. doi: 10.1038/s41559-017-0258-8.

Bondad-Reantaso, M.G., McGladdery, S.E. & Berthe, F.C.J. 2007. *Pearl oyster health management: a manual*. FAO Fisheries Technical Paper No. 503. Rome, FAO.

Bondad-Reantaso, M.G., McGladdery, S.E., East, I. & Subasinghe, R.P., eds. 2001. *Asia diagnostic guide to aquatic animal diseases*. FAO Fisheries Technical Paper No. 402/2. Rome, FAO.

Bondad-Reantaso, M.G. & Prein, M., eds. 2009. *Measuring the contribution of small-scale aquaculture – an assessment*. FAO Fisheries and Aquaculture Technical Paper No. 534. Rome, FAO.

Branch, T.A., DeJoseph, B.M., Ray, L.J. & Wagner, C.A. 2013. Impacts of ocean acidification on marine seafood. *Trends in Ecology and Evolution*, 28: 178–186.

Branch, T.A., Jensen, O.P., Ricard, D., Ye, Y. & Hilborn, R. 2011. Contrasting global trends in marine fishery status obtained from catches and from stock assessments. *Conservation Biology*, 25: 777–786.

Brugère, C.& De Young, C. 2015. *Assessing climate change vulnerability in fisheries and aquaculture: available methodologies and their relevance for the sector*. FAO Fisheries and Aquaculture Technical Paper No. 597. Rome, FAO.

Brugère, C. & De Young, C. 2018. *Addressing fisheries and aquaculture in national adaptation plans: supplementary guidelines*. Rome, FAO (forthcoming).

REFERENCES

Burgess, M.G., Clemence, M., McDermott, G.R., Costello, C. & Gaines, S.D. 2018. Five rules for pragmatic blue growth. *Marine Policy*, 87: 331–339.

Burrows, M.T., Schoeman, D.S., Richardson, A.J., Molinos, J.G., Hoffmann, A., Buckley, L.B., Moore, P.J., Brown, C.J., Bruno, J.F., Duarte, C.M., Halpern, B.S., Hoegh-Guldberg, O., Kappel, C.V., Kiessling, W., O'Connor, M.I., Pandolfi, J.M., Parmesan, C., Sydeman, W.J., Ferrier, S., Williams, K.J. & Poloczanska, E.S. 2014. Geographical limits to species-range shifts are suggested by climate velocity. *Nature*, 507: 492–495. doi:10.1038/nature12976.

Cacaud, P., Cosentino-Roush, S., Kuemlangan, B., Kim, Y.J. & Koranteng, K. 2016. *A how-to guide on legislating for an ecosystem approach to fisheries.* FAO EAF-Nansen Project Report No. 27. Rome, FAO.

Caddy, J.F. & Bazigos, G.P. 1985. *Practical guidelines for statistical monitoring of fisheries in manpower limited situations.* FAO Fisheries Technical Paper No. 257. Rome, FAO.

Cai, J. 2017. Aquaculture growth potential: projections from short-term projection of fish demand. *FAO Fisheries and Aquaculture Newsletter*, 57: 48.

Cai, J. & Leung, P.S. 2017. *Short-term projection of global fish demand and supply gaps.* FAO Fisheries and Aquaculture Technical Paper No. 607. Rome, FAO.

Caribbean ICT Research Programme. 2014. mFisheries [online]. [Accessed 1 January 2018]. St. Augustine, Trinidad and Tobago, University of the West Indies. www.cirp.org.tt/mfisheries

Cataudella, S., Srour, A. & Ferri, N. 2017. Post-Rio+20 effective management for sustainability: the case of the General Fisheries Commission for the Mediterranean of the Food and Agriculture Organization of the United Nations. In P.A.L.D. Nunes, L.E. Svensson & A. Markandya, eds. *Handbook on the economics and management of sustainable oceans*, pp. 437–436. Cheltenham, UK, Edward Elgar Publishing Inc. & UNEP.

CBD (Convention on Biological Diversity). 2018. Sustainable Ocean Initiative [online]. [Cited 20 January 2018]. www.cbd.int/soi

CEB (United Nations System Chief Executives Board for Coordination). 2016. *Leaving no one behind: equality and non-discrimination at the heart of sustainable development: the United Nations System Shared Framework for Action.* New York, USA, UN.

Charles, A., Westlund, L., Bartley, D.M., Fletcher, W.J., Garcia, S., Govan, H. & Sanders, J. 2016. Fishing livelihoods as key to marine protected areas: insights from the World Parks Congress. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26(Suppl. S2): 165–184.

Cheung, W.W.L., Froelicher, T.L., Asch, R.G., Jones, M.C, Pinsky, M.L., Reygondeau, G., Rodgers, K.B., Rykaczewski, R.R., Sarmiento, J.L., Stock, C. & Watson, J.R. 2016. Building confidence in projections of the responses of living marine resources to climate change. *ICES Journal of Marine Science*, 73: 1283–1296.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J.L., Kearney, K., Watson, R., Zeller, D. & Pauly, D. 2010. Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change. *Global Change Biology*, 16: 24–35.

Christensen, C. 1997. *The innovator's dilemma: when new technologies cause great firms to fail.* Boston, Massachusetts, USA, Harvard Business Review Press.

CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). 2017. The CITES Appendices [online]. [Cited 5 December 2017]. https://cites.org/eng/app/index.php

Clark, M. & Tilman, D. 2017. Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters*, 12(6). http://iopscience.iop.org/article/10.1088/1748-9326/aa6cd5/meta.

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

Codex Alimentarius Commission. 2016. Code of Practice for Fish and Fishery Products. CAC/RCP 52-2003, updated 2016. Rome, FAO & WHO (also available www.fao.org/fao-who-codexalimentarius/codex-texts/codes-of-practice).

Codex Alimentarius Commission. 2017. Maximum residue limits (MRLs) and risk management recommendations (RMRs) for residues of veterinary drugs in foods. CAC/MRL 2-2017. Rome, FAO & WHO.

Coro, G., Large, S., Magliozzi, C. & Pagano, P. 2016. Analysing and forecasting fisheries time series: purse seine in Indian Ocean as a case study. *ICES Journal of Marine Science*, 73(10): 2552–2571. http://dx.doi.org/10.1093/icesjms/fsw131

Correa, M., ed. 2017. *Towards gender-equitable small-scale fisheries.* Proceedings of the Expert Workshop on Gender-Equitable Small-Scale Fisheries in the Context of the Implementation of the SSF Guidelines. FAO Fisheries and Aquaculture Proceedings No. 54. Rome, FAO.

Costello, C., Ovando, D., Hilborn, R., Gaines, S.D., Deschenes, O. & Lester, S.E. 2012. Status and solutions for the world's unassessed fisheries. *Science*, 338: 517–520.

Cowx, I.G., Arlinghaus, R. & Cooke, S.J. 2010. Harmonizing recreational fisheries and conservation objectives for aquatic biodiversity in inland waters. *Journal of Fish Biology*, 76(9): 2194–2215.

Curtis, L., Diei-Ouadi, Y., Mannini, P., Ward, A. & Anton, P. 2016. *Regional Conference on Food Security and Income Generation Through the Reduction of Losses and Waste in Fisheries*, Nouakchott, Mauritania, 15–17 December 2013. FAO Fisheries and Aquaculture Proceedings No. 43. Rome, FAO.

de Graaf, G., Bartley, D., Jorgensen, J. & Marmulla, G. 2015. The scale of inland fisheries, can we do better? Alternative approaches for assessment. *Fisheries Management and Ecology*, 22(1): 64–70.

de Graaf, G., Nunoo, F., Ofori Danson, P., Wiafe, G., Lamptey, E. & Bannerman, P. 2014. *International training course in fisheries statistics and data collection*. FAO Fisheries and Aquaculture Circular No. 1091. Rome, FAO.

de Graaf, G., Stamatopoulos, C. & Jarrett, T. 2017. *OPEN ARTFISH and the FAO ODK mobile phone application – a toolkit for small-scale fisheries routine data collection*. Computerized Information Series – Fisheries. Rome, FAO.

De Silva, S.S. & Soto, D. 2009. Climate change and aquaculture: potential impacts, adaptation and mitigation. In K. Cochrane, C. De Young, D. Soto & T. Bahri, eds. *Climate change implications for fisheries and aquaculture: overview of current scientific knowledge*, pp. 151–212. FAO Fisheries and Aquaculture Technical Paper No. 530. Rome, FAO.

Diei-Ouadi, Y., Sodoke, B.K., Ouedraogo, Y., Oduro, F.A., Bokobosso, K. & Rosenthal, I. 2015. *Strengthening the performance of post-harvest systems and regional trade in small-scale fisheries – case study of post-harvest loss reduction in the Volta basin riparian countries*. FAO Fisheries and Aquaculture Circular No. 1105. Rome, FAO.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.I., Knowler, D.J., Lévêque, C. & Sullivan, C.A. 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, 81: 163– 182.

Dunn, D.C., Maxwell, S.M., Boustany, A.M. & Halpin, P.N. 2016. Dynamic ocean management increases the efficiency and efficacy of fisheries management. *Proceedings of the National Academy of Sciences of the United States of America*, 113: 668–673.

EC (European Commission). 2017. *Our Ocean 2017 commitments*. Our Ocean, Malta, 5–6 October 2017.

ECESA Plus (Executive Committee on Economic and Social Affairs). 2017. 2017 HLPF thematic review of SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

ECOSOC (United Nations Economic and Social Council). 2017a. Ministerial Declaration of the 2017 High-Level Political Forum on Sustainable Development, convened under the auspices of the Economic and Social Council, on the theme "Eradicating poverty and promoting prosperity in a changing world". E/2017/L.29–E/HLPF/2017/L.2. New York, USA, UN.

ECOSOC. 2017b. Progress towards the Sustainable Development Goals – Report of the Secretary-General. High-Level Political Forum on Sustainable Development. E/2017/66. New York, USA, UN.

ECOSOC. 2017c. Statistical Commission. Report on the forty-eighth session (7–10 March 2017). E/2017/24-E/CN.3/2017/35. New York, USA, UN.

Ehler, C. & Douvere, F. 2009. *Marine spatial planning: a step-by-step approach toward ecosystem-based management*. IOC Manual and Guides No. 53, ICAM Dossier No. 6. Paris, UNESCO-IOC.

Environmental Defense Fund, Rare/Meloy Fund & Encourage Capital. 2018. *Principles for investment in sustainable wild-caught fisheries*.

European Parliament. 2013. Report on the food crisis, fraud in the food chain and the control thereof (2013/2091(INI)). Committee on the Environment, Public Health and Food Safety. A7-0434/2013.

Faivre, N., Sgobbi, A., Happaerts, S., Raynal, J.& Schmidt, L. 2017. Translating the Sendai Framework into action: the EU approach to ecosystem-based disaster risk reduction. *International Journal of Disaster Risk Reduction*. doi: 10.1016/j.ijdrr.2017.12.015.

FAO. 1995. *Code of Conduct for Responsible Fisheries*. Rome.

FAO. 1999a. *Guidelines for the routine collection of capture fishery data*. Prepared at the FAO/DANIDA Expert Consultation, Bangkok, Thailand, 18–30 May 1998. FAO Fisheries Technical Paper No. 382. Rome, FAO.

FAO. 1999b. *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries Circular. No. 942. Rome.

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

FAO. 2002. FAO's role in fishery statistics. In *The State of World Fisheries and Aquaculture 2002*, p. 6. Rome.

FAO. 2003a. *Review of the state of world fishery resources: inland fisheries*. FAO Fisheries Circular. No. 942, Rev.1. Rome.

FAO. 2003b. *Fisheries management 2. The ecosystem approach to fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome.

REFERENCES

FAO. 2007. *Aquaculture development. 2. Health management for the responsible movement of live aquatic animals.* FAO Technical Guidelines for Responsible Fisheries No. 5, Suppl. 2. Rome.

FAO. 2010a. *The State of World Fisheries and Aquaculture 2010.* FAO, Rome.

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

FAO. 2010c. Report of the FAO Expert Workshop on Indicators for Assessing the Contribution of Small-Scale Aquaculture to Sustainable Rural Development. Tagaytay, the Philippines, 6–8 August 2009. FAO Fisheries and Aquaculture Report No. 952. Rome.

FAO. 2011a. *Review of the state of world marine fishery resources.* FAO Fisheries and Aquaculture Technical Paper No. 569. Rome.

FAO. 2011b. *Fisheries management. 4. Marine protected areas and fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 4. Rome.

FAO. 2011c. *The Progressive Control Pathway for FMD control (PCP-FMD): principles, stage descriptions and standards.* Rome.

FAO. 2012a. *Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security.* Rome.

FAO. 2012b. *Recreational fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 13. Rome.

FAO. 2012c. Information and communications technology for small-scale fishers and fishing administrations. Lessons learned notes. Regional Fisheries Livelihoods Programme for South and Southeast Asia (RFLP).

FAO. 2012d. *The State of World Fisheries and Aquaculture 2012.* Rome.

FAO. 2014a. *Building a common vision for sustainable food and agriculture – principles and approaches.* Rome.

FAO. 2014b. *The State of World Fisheries and Aquaculture 2014.* Rome.

FAO. 2014c. Informe del Taller de validación del "Plan de gestión colaborativa de la pesca y la acuicultura con enfoque ecosistémico, en el Estero Real". Chinandega, Nicaragua, 13–14 March 2013. FAO Fisheries and Aquaculture Report No. 994/3. Rome.

FAO. 2015a. *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication.* Rome (available at www.fao.org/3/i4356en/I4356EN.pdf).

FAO. 2015b. Report of the 31st Session of the Committee on Fisheries, June, 2014. FAO Fisheries and Aquaculture Report, FIPI/1011. Rome.

FAO. 2015c. Report of the Expert Workshop to Estimate the Magnitude of Illegal, Unreported and Unregulated Fishing Globally. Rome, 2–4 February 2015. FAO Fisheries and Aquaculture Report No. 1106. Rome.

FAO. 2016a. *Food and agriculture – key to achieving the 2030 Agenda for Sustainable Development.* Rome.

FAO. 2016b. Report of the twenty-fifth session of the Coordinating Working Party on Fishery Statistics, Rome, Italy, 23–26 February 2016. FAO Fisheries and Aquaculture Report No. 1172. Rome.

FAO. 2016c. *The State of World Fisheries and Aquaculture 2016.* Rome.

FAO. 2016d. Report of the "Workshop on impacts of marine protected areas on fisheries yield, fishing communities and ecosystems", FAO, Rome. 16–18 June 2015. FAO Fisheries and Aquaculture Report No. 1136. Rome.

FAO. 2016e. Asia-Pacific countries work to protect and maintain trade in seafood while improving conservation of threatened species of aquatic life [online]. 22 April. [Cited 5 December 2017]. www.fao.org/asiapacific/news/detail-events/en/c/411644/

FAO. 2016f. Ten steps to responsible inland fisheries – outcomes from a global conference. In *The State of World Fisheries and Aquaculture 2016*, pp. 147–151. Rome.

FAO. 2016g. Panorama de la pesca continental y la acuicultura en America Latina y el Caribe. 14th Meeting of the Commission for Inland Fisheries and Aquaculture for Latin America and the Caribbean (COPESCAALC), Lima, Peru, 1–3 February 2016. COPESCAALC-XIV-3.

FAO. 2016h. FAO/INFOODS Global Food Composition Database for Fish and Shellfish Version 1.0 – uFiSh1.0. Rome. [Cited 19 January 2018]. www.fao.org/infoods/infoods/tables-and-databases/faoinfoods-databases

FAO. 2016i. *FAO Action Plan on Antimicrobial Resistance (2016–2020).* Rome.

FAO. 2016j. FAO and the Vatican condemn illegal fishing and forced labour on the high seas, urge collective action: groundbreaking international accords pave the way for wiping out human rights abuses in fisheries industry. News article [online]. 21 November. www.fao.org/news/story/en/item/453811/icode

FAO. 2016k. Report of the seventh meeting of the RECOFI Working Group on Aquaculture. Doha, Qatar, 26–28 April 2016. FAO Fisheries and Aquaculture Report No. 1156. Rome.

FAO. 2016l. *The State of Mediterranean and Black Sea Fisheries 2016.* General Fisheries Commission for the Mediterranean (GFCM). Rome.

FAO. 2017a. *Food and agriculture – driving action across the 2030 Agenda for Sustainable Development.* Rome.

FAO. 2017b. Report of the Sixteenth session of the COFI Sub-Committee on Fish Trade, Busan, Republic of Korea, 4–8 September 2017. FAO Fisheries and Aquaculture Report No. 1216. Rome.

FAO. 2017c. Aquaculture, the Sustainable Development Goals (SDGs)/ Agenda 2030 and FAO's Common Vision for Sustainable Food and Agriculture. COFI Sub-Committee on Aquaculture. Ninth Session, 24–27 October 2017. COFI:AQ/IX/2017/5. Rome.

FAO. 2017d. *Mid-term strategy (2017–2020) towards the sustainability of Mediterranean and Black Sea fisheries.* Rome.

FAO. 2017e. Port State Measures Agreement [online]. [Cited 15 December 2017]. www.fao.org/fishery/psm/agreement

FAO. 2017f. Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels [online]. [Cited 15 December 2017]. www.fao.org/global-record

FAO. 2017g. *FAO and the SDGs – indicators: measuring up to the 2030 Agenda for Sustainable Development.* Rome.

FAO. 2017h. E-learning Centre. SDG indicator 14.b.1 – Securing sustainable small-scale fisheries [online]. www.fao.org/elearning/#/elc/en/course/SDG14B1

FAO. 2017i. Coordinating Working Party on Fishery Statistics (CWP) [online]. [Cited 1 January 2018]. www.fao.org/cwp-on-fishery-statistics

FAO. 2017j. Report of the first meeting of the Parties to the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing. Oslo, Norway, 29–31 May 2017. FAO Fisheries and Aquaculture Report No. 1211. Rome.

FAO. 2017k. The impact of marine protected areas (MPAs) on livelihoods, trade, food fish supply and consumption. 16th session of the FAO Sub-Committee on Fish Trade, Busan, Republic of Korea, 4–8 September 2017. COFI:FT/XVI/2017/10. Rome.

FAO. 2017l. Update on CITES related activities. 16th session of the Sub-Committee on Fish Trade. Busan, Republic of Korea, 4–8 September 2017. COFI:FT/XVI/2017/9. Rome.

FAO. 2017m. Database of measures on conservation and management of sharks [online]. [Cited 5 December 2017]. www.fao.org/ipoa-sharks/database-of-measures

FAO. 2017n. Fisheries and aquaculture software. FishStatJ – software for fishery statistical time series [online]. [Cited 20 December 2017]. www.fao.org/fishery/statistics/software/fishstatj

FAO. 2017o. *The future of food and agriculture – trends and challenges.* Rome.

FAO. 2017p. Report of the 32nd Session of the Committee on Fisheries, Rome, 11–15 July 2016. Fortieth session of the Conference of FAO, 3–8 July 2017. C 2017/23. Rome.

FAO. 2017q. *Report of the International Emergency Fish Disease Investigation Mission on a Suspected Outbreak of Epizootic Ulcerative Syndrome (EUS) in the Democratic Republic of the Congo, 13 to 19 March 2015.* Rome, FAO.

FAO. 2017r. *FAO Strategy on Climate Change.* Rome.

FAO. 2017s. Climate-smart agriculture [online]. [Cited 30 October]. www.fao.org/climate-smart-agriculture/overview

FAO. 2017t. *Landscapes for life: approaches to landscape management for sustainable food and agriculture.* Rome.

FAO. 2017u. Social sustainability in fisheries value chains and the link to fish trade. COFI Sub-Committee on Fish Trade, 16th session, Busan, Republic of Korea, 4–8 September 2017. COFI:FT/XVI/2017/5. Rome.

FAO. 2017v. Social sustainability in fisheries value chains – some trends and challenges. COFI Sub-Committee on Fish Trade, 16th session, Busan, Republic of Korea, 4–8 September 2017. COFI:FT/XVI/2017/Inf.8. Rome.

FAO. 2017w. Réduction de l'impact environnemental et sanitaire des techniques de fumage traditionnel en Côte d'Ivoire [online]. 14 August. www.fao.org/cote-divoire/actualites/detail-events/fr/c/1032181.

FAO. 2017x. *FAO social protection framework – promoting rural development for all.* Rome.

FAO. 2017y. Blue Growth Initiative – Partnering with countries to achieve the Sustainable Development Goals. Brochure. Rome.

FAO. 2017z. Progress reporting on the implementation of the Code of Conduct for Responsible Fisheries (CCRF) provisions relevant to aquaculture and culture-based fisheries. Sub-Committee on Aquaculture, 9th session, 24–27 October 2017. COFI:AQ/IX/2017/3/Rev1. Rome.

FAO. 2017aa. Report of the introductory training course on risk analysis for movements of live aquatic animals for RECOFI members and the round-table meeting on RECOFI regional aquatic biosecurity, Muscat, Oman, 1–5 November 2015. FAO Fisheries and Aquaculture Report No. 1149. Rome.

REFERENCES

FAO. 2017ab. *FAO Yearbook of Fisheries and Aquaculture Statistics 2015.* Rome.

FAO. 2017ac. General Fisheries Commission for the Mediterranean. Report of the tenth session of the Scientific Advisory Committee on Aquaculture. Izmir, Turkey, 27–29 March 2017. Rome.

FAO. 2018a. Statistics – introduction [online]. [Cited 1 January 2018]. www.fao.org/fishery/statistics

FAO. 2018b. Report of the Workshop on Strategic Data Policies, Rome, 21–22 September 2015. FAO Fisheries and Aquaculture Report No. 1180. Rome.

FAO. 2018c. Fisheries and Resources Monitoring System (FIRMS) [online]. [Cited 1 January 2018]. http://firms.fao.org

FAO. 2018d. Fishery statistical collections: Consumption of fish and fishery products [online]. [Cited 31 March 2018]. www.fao.org/fishery/statistics/global-consumption/en

FAO. 2018e. Food Balance Sheets [online]. [Cited 31 March 2018]. www.fao.org/faostat/en/#data/FBS

FAO. 2018f. Multi-stakeholder Dialogue on Biodiversity Mainstreaming across Agricultural Sectors [online]. [Cited 14 May 2018]. www.fao.org/about/meetings/multi-stakeholder-dialogue-on-biodiversity

FAO. forthcoming. *Engaging agriculture, forestry and fisheries in the 2030 Agenda for Sustainable Development: guidelines for policy-makers.* Rome.

FAO. forthcoming. *Gender-related issues in small-scale fisheries in Burkina Faso, Côte d'Ivoire, Ghana and Tunisia: potential pathways towards strengthening livelihoods and women's roles.* Rome.

FAO & EU. 2017. Strengthening sector policies for better food security and nutrition results: fisheries and aquaculture. Policy Guidance Note 1. Rome.

FAO, IFAD, UNICEF, WFP & WHO. 2017. *The State of Food Security and Nutrition in the World 2017 – building resilience for peace and food security.* Rome, FAO.

FAO, IFAD & WFP. 2015. *The State of Food Insecurity in the World 2015 – Meeting the 2015 international hunger targets: taking stock of uneven progress.* Rome, FAO.

FAO & NACA (Network of Aquaculture Centres in Asia-Pacific). 2000. *Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy.* FAO Fisheries Technical Paper No. 402. Rome.

FAO & NACA. 2001. *Manual of procedures for the implementation of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals.* FAO Fisheries Technical Paper No. 402/1. Rome.

FAO, OIE (World Organization for Animal Health) & WHO (World Health Organization). 2010. *The FAO-OIE-WHO collaboration: Sharing responsibilities and coordinating global activities to address health risks at the animal-human-ecosystems interfaces.* A tripartite concept note.

FAO & WHO. 2006. *Food safety risk analysis – a guide for national food safety authorities.* FAO Food and Nutrition Paper No. 87. Rome.

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

FAO & WHO. 2016. *Toxicity equivalence factors for marine biotoxins associated with bivalve molluscs.* Technical Paper. Rome.

FAO & WHO. 2018. *Technical guidance for the development of the growing area aspects of bivalve molluscan sanitation programmes.* Rome.

FAO & World Bank. 2015. Aquaculture zoning, site selection and area management under the ecosystem approach to aquaculture. Policy brief. Rome.

FAO, World Bank & AFDB (African Development Bank). 2017. African Package for Climate-Resilient Ocean Economies. Brochure. Rome.

FRDC (Fisheries Research & Development Corporation). 2016. Status of Australian Fish Stocks Reports [online]. [Cited 11 January 2018]. http://fish.gov.au

Fugazza, M. 2017. *Fish trade and policy: a primer on non-tariff measures.* UNCTAD Research Paper No. 7. UNCTAD/SER.RP/2017/7. Geneva, Switzerland, UN.

Funge-Smith, S.J. 2016. How national household consumption and expenditure surveys can improve understanding of fish consumption patterns within a country and the role of inland fisheries in food security and nutrition. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme, eds. *Freshwater, fish and the future.* Proceedings of the Global Cross-Sectoral Conference, pp. 121–130. Rome, FAO, Michigan State University & American Fisheries Society.

Funge-Smith, S.J., ed. 2018. *Review of the state of the world fishery resources: inland fisheries.* FAO Fisheries and Aquaculture Circular No. 942, Rev. 3. FIAF/C942. Rome, FAO (forthcoming).

G20. 2017. G20 Action Plan on Marine Litter. 10 July. Hamburg, Germany.

Galgani, F., Hanke, G. & Maes, T. 2015. Global distribution, composition and abundance of marine litter. In M. Bergmann, L. Gutow, & M. Klages, eds. *Marine anthropogenic litter*, pp. 29–56. Cham, Switzerland, Springer International Publishing.

Garcia, S.M., Charles, A., Sanders, J. & Westlund, L. 2016. Interactions of marine protected areas with fishery livelihoods and food security: concluding discussion. In L. Westlund, A. Charles, S.M. Garcia & J. Sanders, eds. 2017. *Marine protected areas: interactions with fishery livelihoods and food security*, pp. 151–158. FAO Fisheries and Aquaculture Technical Paper No. 603. Rome, FAO.

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

Gartner. 2017. Gartner says 8.4 billion connected "things" will be in use in 2017, up 31 percent from 2016 [online]. Press release, 7 February. [Cited 17 January 2018]. www.gartner.com/newsroom/id/3598917

GESAMP (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). 2015. *Sources, fate and effects of microplastics in the marine environment: a global assessment*, ed. P.J. Kershaw. GESAMP Reports and Studies No. 90. London, IMO.

GESAMP. 2016. *Sources, fate and effects of microplastics in the marine environment: Part 2 of a global assessment*, ed. P.J. Kershaw & C.M. Rochman. GESAMP Reports and Studies No. 93. London, IMO.

Gillett, R. 2016. *Fisheries in the economies of Pacific Island countries and territories.* Noumea, New Caledonia, SPC.

Gilman, E., Chopin, F., Suuronen, P. & Kuemlangan, B. 2016. *Abandoned, lost or otherwise discarded gillnets and trammel nets: methods to estimate ghost fishing mortality, and the status of regional monitoring and management.* FAO Fisheries and Aquaculture Technical Paper No. 600. Rome, FAO.

Gjedrem, T. 2012. Genetic improvement for the development of efficient global aquaculture: a personal opinion review. *Aquaculture*, 344–349: 12–22.

Global Fishing Watch. 2018. Global Fishing Watch – sustainability through transparency [online]. [Cited 20 January 2018]. http://globalfishingwatch.org

GSI (Global Salmon Initiative). 2017. Sustainability report [online]. [Cited 30 October 2017]. http://globalsalmoninitiative.org/sustainability-report

Griliopoulos, D. 2014. New fish-drying method in Burundi boosts quality and incomes. *The Guardian*, 31 December [online]. [Cited 15 January 2018]. www.theguardian.com/global-development/2014/dec/31/new-fish-drying-method-in-burundi-boosts-quality-and-incomes

Gumy, A., Soto, D. & Morales, R. 2014. *Implementación práctica del enfoque ecosistémico a la pesca y la acuicultura del camarón en los países del sistema de integración centroamericana (SICA/OSPESCA).* FAO/OSPESCA workshop, San Salvador, 18–21 June 2012. FAO Fisheries and Aquaculture Proceedings No. 33. Rome, FAO.

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. 2011. *Global food losses and food waste – extent, causes and prevention.* Study conducted for the International Congress Save Food! Düsseldorf, Germany, 16–17 May 2011. Rome, FAO.

Gutierrez, N.L. 2017. Harnessing citizenry awareness and technology to improve fisheries information: the power of data. *Fisheries*, 42: 613–618.

Halwart, M. & Gupta, M.V., eds. 2004. *Culture of fish in rice fields.* Rome, FAO & Penang, Malaysia, The WorldFish Center.

Hambrey, J. 2017. *The 2030 Agenda and the sustainable development goals: the challenge for aquaculture development and management.* FAO Fisheries and Aquaculture Circular No. 1141. Rome, FAO.

Hanner, R., Becker, S., Ivanova, N.V. & Steinke, D. 2011. FISH-BOL and seafood identification: geographically dispersed case studies reveal systemic market substitution across Canada. *Mitochondrial DNA*, 22(Suppl. 1): 106–122. doi: 10.3109/19401736.2011.588217.

Hasan, M.R. 2017a. Feeding global aquaculture growth. *FAO Aquaculture Newsletter*, 56: ii–iii.

Hasan, M.R. 2017b. Keynote presentation: Status of world aquaculture and global aquafeed requirement with special notes on *Artemia*. In *Report of the FAO Expert Workshop on Sustainable Use and Management of Artemia Resources in Asia*, Appendix 4, pp. 16–17. Tianjin, China, 7–9 November 2016. FAO Fisheries and Aquaculture Report No. 1198. Rome, FAO.

Hasan, M.R. & New, M.B., eds. 2013. *On-farm feeding and feed management in aquaculture.* FAO Fisheries and Aquaculture Technical Paper No. 583. Rome, FAO.

Hasan, M.R. & Soto, S. 2017. *Improving feed conversion ratio and its impact on reducing greenhouse gas emissions in aquaculture.* Rome, FAO.

HLG-PCCB (High-level Group for Partnership, Coordination and Capacity-Building for Statistics for the 2030 Agenda for Sustainable Development). 2018. The Cape Town Global Action Plan for Sustainable Development Data [online]. [Cited 20 January 2018]. https://unstats.un.org/sdgs/hlg/Cape-Town-Global-Action-Plan

REFERENCES

HLPE (High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security). 2014. *Sustainable fisheries and aquaculture for food security and nutrition.* Rome.

HLPF (High-level Political Forum on Sustainable Development). 2017a. President's summary of 2017 High-level Political Forum on Sustainable Development. New York, USA, UN.

HLPF. 2017b. 2017 Voluntary National Reviews: compilation of main messages. New York, USA, UN.

Hoag, H. 2017. Nations agree to ban fishing in Arctic Ocean for at least 16 years. *Science* [online]. 1 December. [Cited 30 March 2018]. www.sciencemag.org/news/2017/12/nations-agree-ban-fishing-arctic-ocean-least-16-years

Hoegh-Guldberg, O., Cai, R., Poloczanska, E.S., Brewer, P.G., Sundby, S., Hilmi, K., Fabry, V.J. & Jung, S. 2014. The ocean. In *Climate change 2014: impacts, adaptation, and vulnerability.* Part B, *Regional aspects*, pp. 1655–1731. Contribution of Working Group II to the Fifth Assessment Report of IPCC, ed. V.R. Barros, C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L. White. Cambridge, UK & New York, USA, Cambridge University Press.

Hortle, K.G. 2007. *Consumption and the yield of fish and other aquatic animals from the Lower Mekong Basin.* MRC Technical Paper No. 16. Vientiane, Mekong River Commission.

ICSU (International Council for Science). 2017. *A guide to SDG interactions: from science to implementation.* Paris.

IFRC (International Federation of Red Cross and Red Crescent Societies). 2002. *World Disasters Report 2002.* London, Eurospan.

iMarine. 2018. iMarine Data e-Infrastructure Initiative for Fisheries Management and Conservation of Marine Living Resources [online]. [Cited 20 January 2018]. www.i-marine.eu

INPESCA (Instituto Nicaragüense de la Pesca y Acuicultura). 2011. *Plan de Reconversión Laboral, Técnica y Ocupacional para los Pescadores que Utilizan la Técnica del Buceo en la Pesca de Langosta.* Managua.

INPESCA. 2014. *Anuario Pesquero y Acuícola 2014.* Managua.

INPESCA & FAO. 2014. *Sistematización del intercambio de experiencias internacionales sobre procesos de transición tecnológica en la pesca de langosta (*Panulirus argus*) en la costa caribe de Nicaragua.* Managua.

INTERPOL/EUROPOL. 2016. *Report: Operation OPSON V 2015. Targeting counterfeit and substandard foodstuff and beverages.*

IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate change 2014: impacts, adaptation, and vulnerability.* Part A, *Global and sectoral aspects.* Contribution of Working Group II to the Fifth Assessment Report of IPCC, ed. C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea & L.L.White. Cambridge, UK & New York, USA, Cambridge University Press.

Jackson, A. & Newton, R.W. 2016. Project to model the use of fisheries by-products in the production of marine ingredients with special reference to omega-3 fatty acids EPA and DHA. Institute of Aquaculture, University of Stirling & IFFO, the Marine Ingredients Organisation.

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. & Law, K.L. 2015. Plastic waste inputs from land into the ocean. *Science*, 13 February: 768–771.

Jentoft, S., Chuenpagdee, R., Barragán-Paladines, M.J. & Franz, N., eds. 2017. *The Small-Scale Fisheries Guidelines: global implementation.* MARE Publication Series 14. Cham, Switzerland, Springer International Publishing AG.

Kalikoski, D.C., Jentoft, S., Charles, A., Salazar Herrera, D., Cook, K., Béné, C. & Allison, E.H. 2018. Understanding the impacts of climate change for fisheries and aquaculture: applying a poverty lens. In M. Barange, T. Bahri, M. Beveridge, K. Cochrane, S. Funge-Smith & F. Poulain, eds. *Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options.* FAO Fisheries and Aquaculture Technical Paper No. 627. Rome, FAO (forthcoming).

Karami, A., Golieskardi, A., Choo, C.K., Larat, V., Galloway, T.S. & Salamatinia, B. 2017. The presence of microplastics in commercial salts from different countries. *Scientific Reports*, 7. doi: 10.1038/srep46173.

Karttunen, K., Wolf, J., Garcia, V. & Meybeck, A. 2017. *Addressing agriculture, forestry and fisheries in national adaptation plans: supplementary guidelines.* Rome, FAO.

Kasprzyk, Z. & Rajaonson, C. 2013. *Handling of mud crab: illustrated operators' manual.* FAO SmartFish Publication No. 11. Mauritius, Indian Ocean Commission & FAO.

Kassam, L., Subasinghe, R. & Phillips, M. 2011. *Aquaculture farmer organizations and cluster management: concepts and experiences.* FAO Fisheries and Aquaculture Technical Paper No. 563. Rome, FAO.

Kawarazuka, N. & Béné, C. 2010. Linking small-scale fisheries and aquaculture to household nutritional security: an overview. *Food Security*, 2: 343–357.

Kelleher, K. 2005. *Discards in the world's marine fisheries: an update.* FAO Fisheries Technical Paper No. 470. Rome, FAO.

Khalil, C.A., Conforti, P., Ergin, I. & Gennari, P. 2017. *Defining small scale food producers to monitor target 2.3 of the 2030 Agenda for Sustainable Development.* FAO Statistics Division Working Paper Series ESS/17-12. Rome, FAO.

Kim, S.-E. & Mendis, E. 2006. Bioactive compounds from marine processing byproducts – a review. *Food Research International*, 39: 383–393.

Kolding, J., van Zwieten, P., Marttin, F. & Poulain, F. 2016. *Fisheries in the drylands of sub-Saharan Africa – "Fish come with the rains": building resilience for fisheries-dependent livelihoods to enhance food security and nutrition in the drylands.* FAO Fisheries and Aquaculture Circular No. 1118. Rome, FAO.

Koranteng, K.A., Vasconcellos, M.C. & Satia, B.P., eds. 2014. Preparation of management plans for selected fisheries in Africa – baseline reports. FAO EAF-Nansen Project Report No. 23. Rome, FAO.

Kurien, J. & López Ríos, J. 2013. *Flavouring fish into food security.* SF-FAO/2013/14. Ebene, Mauritius, FAO–SmartFish Programme of the Indian Ocean Commission.

Kwiatkowski, L., Bopp, L., Aumont, O., Ciais, P., Cox, P.M., Laufkötter, C., Li, Y. & Séférian, R. 2017. Emergent constraints on projections of declining primary production in the tropical oceans. *Nature Climate Change*, *7*: 355–358. doi: 10.1038/NCLIMATE3265.

Law, K.L. 2017. Plastics in the marine environment. *Annual Review of Marine Science*, 9: 205–229.

Le Blanc, D., Freire, C. & Vierros, M. 2017. Mapping the linkages between oceans and other Sustainable Development Goals: a preliminary exploration. DESA Working Paper No. 149. ST/ESA/2017/DWP/149. New York, UN.

Lebreton, L.C.M., van der Zwet, J., Damsteeg, J.-W., Slat, B., Andrady, A. & Reisser, J. 2017. River plastic emissions to the world's oceans. *Nature Communications*, 8. doi:10.1038/ncomms15611.

LEG (Least Developed Countries Expert Group). 2012. *National Adaptation Plans: technical guidelines for the national adaptation plan process*. Bonn, Germany, UNFCCC Secretariat (available at http://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/7279.php).

Lehane, L. 2000. Ciguatera update. *Medical Journal of Australia*, 172(4): 176–179.

Lentisco, A. & Lee, R.U. 2015. *A review of women's access to fish in small-scale fisheries.* FAO Fisheries and Aquaculture Circular No. 1098. Rome, FAO.

Liebezeit, G. & Liebezeit, E. 2013. Non-pollen particulates in honey and sugar. *Food Additives and Contaminants: Part A: Chemistry, Analysis, Control, Exposure & Risk Assessment*, 30: 2136–2140.

Liebezeit, G. & Liebezeit, E. 2014. Synthetic particles as contaminants in German beers. *Food Additives and Contaminants: Part A: Chemistry, Analysis, Control, Exposure & Risk Assessment*, 31: 1574–1578.

Lillebø, A.I., Pita, C., Rodrigues, J.G., Ramos, S. & Villasante, S. 2017. How can marine ecosystem services support the blue growth agenda? *Marine Policy*, 81: 132–142.

Little, D.C., Newton, R. & Beveridge, M.C.M. 2016. Aquaculture: a rapidly growing and significant source of sustainable food? Status, transitions and potential. Conference on 'The future of animal products in the human diet: health and environmental concerns', Symposium 3: Alternatives to meat, Nottingham, UK, 6–9 July 2015. *Proceedings of the Nutrition Society*, *75*(3): 274–286.

Lusher, A., Hollman, P. & Mendoza-Hill, J. 2017. *Microplastics in fisheries and aquaculture – Status of knowledge on their occurrence and implications for aquatic organisms and food safety.* FAO Fisheries and Aquaculture Technical Paper 615. Rome, FAO.

Lymer, D., Marttin, F., Marmulla, G. & Bartley, D. 2016a. A global estimate of theoretical annual inland fisheries capture fisheries harvest. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme, eds. *Freshwater, fish and the future.* Proceedings of the Global Cross-Sectoral Conference, pp. 63–75. Rome, FAO, Michigan State University & American Fisheries Society.

Lymer, D., Teillard, F., Opio, C. & Bartley, D.M. 2016b. Freshwater fisheries harvest replacement estimates (land and water) for protein and the micronutrients contribution in the Lower Mekong River Basin and related countries. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme, eds. *Freshwater, fish and the future: proceedings of the global cross-sectoral conference*, pp. 169–182. Rome, FAO, Michigan State University & American Fisheries Society.

Lynch, A.J., Cowx, I.G., Fluet-Chouinard, E., Glaser, S.M., Phang, S.C., Beard, T.D. Jr., Bower, S.D., Brooks, J.L., Bunnell, D.B., Claussen, J.E., Cooke, S.J., Kao, Y.-C., Lorenzen, K., Myers, B.J.E., Reid, A.J., Taylor, J.J. & Youn, S. 2017. Inland fisheries – invisible but integral to the UN Sustainable Development Agenda for ending poverty by 2030. *Global Environmental Change*, *47*: 167–173. www.sciencedirect.com/science/article/pii/S0959378017303965

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

REFERENCES

Macintyre, P.B., Reidy Liermann, C.A. & Revenga, C. 2016. Linking freshwater fishery management to global food security and biological conservation. *Proceedings of the National Academy of Science of the United States of America*, 113(45). doi: 10.1073/pnas.1521540113.

Marine Biotech. 2015. Examples of Marine Biotechnology successes [online]. www.marinebiotech.eu/wiki/Examples_of_Marine_Biotechnology_successes [Cited 13 March 2018].

Marko, P.B., Lee, S.C., Rice, A.M., Gramling, J.M., Fitzhenry, T.M., McAlister, J.S., Harper, G.R. & Moran, A.L. 2004. Fisheries: mislabelling of a depleted reef fish. *Nature*, 430(6997): 309–310.

Martínez, M.L., Intralawan, A., Vázquez, G., Pérez-Maqueo, O., Sutton, P. & Landgrave, R. 2007. The coasts of our world: ecological, economic and social importance. *Ecological Economics*, 63(2–3): 254–272.

Massa, F., Onofri, L. & Fezzardi, D. 2017. Aquaculture in the Mediterranean and the Black Sea: a Blue Growth perspective. In P.A.L.D. Nunes, L.E. Svensson & A. Markandya, eds. *Handbook on the economics and management of sustainable oceans*, pp. 93–123. Cheltenham, UK, Edward Elgar Publishing Inc. & UNEP.

Massa, F., Rigillo, R., Bourdenet, D., Fezzardi, D., Nastasi, A., Rizzotti, H., Emam W. & Carmignac, C. 2017. *Regional Conference Blue Growth in the Mediterranean and the Black Sea: developing sustainable aquaculture for food security*, Bari, Italy, 9–11 December 2014. FAO Fisheries and Aquaculture Proceedings No. 46. Rome, FAO.

Maxwell, S.M., Hazen, E.L., Lewison R.L., Dunn, D.C., Bailey, H., Bograd, S.J., Briscoe, D.K., Fossette, S., Hobday, A.J., Bennett, M., Benson, S., Caldwell, M.R., Costa, D.P., Dewar, H., Eguchi, T., Hazen, L., Kohin, S., Sippel, T. & Crowder, L.B. 2015. Dynamic ocean management: defining and conceptualizing real-time management of the ocean. *Marine Policy*, 58: 42–50.

McCauley, D.J., Pinsky, M.L., Palumbi, S.R., Estes, J.A., Joyce, F.H. & Warner, R.R. 2015. Marine defaunation: animal loss in the global ocean. *Science*, 347. doi: 10.1126/science.1255641

Meaden, G.J., Aguilar-Manjarrez, J., Corner, R.A., O'Hagan, A.M. & Cardia, F. 2016. *Marine spatial planning for enhanced fisheries and aquaculture sustainability – its application in the Near East.* FAO Fisheries and Aquaculture Technical Paper No. 604. Rome, FAO.

Mills, D.J., Westlund, L., de Graaf, G., Kura, Y., Willmann, R. & Kelleher, K. 2011. Under-reported and undervalued: small-scale fisheries in the developing world. In N.L. Andrew & R. Pomeroy, eds. *Small-scale fisheries management: frameworks and approaches for the developing world*, pp. 1–15. Wallingford, UK, CABI.

Molinos, G.J., Halpern, B.S., Schoeman, D.S., Brown, C.J., Kiessling, W., Moore, P.J., Pandolfi, J.M., Poloczanska, E.S., Richardson, A.J. & Burrows, M.T. 2016. Climate velocity and the future global redistribution of marine biodiversity. *Nature Climate Change*, 6: 83–88. doi:10.1038/nclimate2769.

Monfort, M.C. 2015. *The role of women in the seafood industry.* GLOBEFISH Research Programme Vol. 119. Rome, FAO.

Muthmainnah, D. & Prisantoso, B.J. 2016. Integrated swamp management to promote sustainability of fish resources: case study in Pampangan District, South Sumatra Province, Indonesia. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme, eds. *Freshwater, fish and the future: proceedings of the global cross-sectoral conference*, pp. 319–324. Rome, FAO, Michigan State University & American Fisheries Society.

Neumann, B., Vafeidis, A.T., Zimmermann, J. & Nicholls, R.J. 2015. Future coastal population growth and exposure to sea-level rise and coastal flooding - a global assessment. *PLoS ONE*, 10(3): e0118571. doi:10.1371/journal.pone.0118571.

Nilsson, M., Griggs, D. & Visbeck, M. 2016. Map the interactions between Sustainable Development Goals. *Nature*, 534: 320–322.

NOAA (National Oceanic and Atmospheric Administration, United States Department of Commerce). 2013. NOAA, U.S. Census report finds increases in coastal population growth by 2020 likely, putting more people at risk of extreme weather [online]. March 25. [Cited 4 January 2018]. www.noaanews.noaa.gov/stories2013/20130325_coastalpopulation.html

Ntona, M. & Morgera, E. 2017. Connecting SDG 14 with the other Sustainable Development Goals through marine spatial planning. *Marine Policy*, https://doi.org/10.1016/j.marpol.2017.06.020

Oceana. 2016. *Deceptive dishes: seafood swaps found worldwide.*

OECD. 2017. People's Republic of China. In *OECD review of fisheries: policies and summary statistics 2017*, pp. 107–116. Paris.

OECD. 2018. OECD-FAO Agricultural Outlook #AgOutlook [online]. www.agri-outlook.org [cited 9 March 2018]. Paris.

OECD & FAO. 2017. *OECD-FAO Agricultural Outlook 2017–2026.* Paris, OECD Publishing.

Oliveira, R.C., Bernardi, J.V.E, Wanderley, R., Almeida, R. & Manzatto, A.G. 2010. Fish consumption by traditional subsistence villagers of the Rio Madeira (Amazon): impact on hair mercury. *Annals of Human Biology*, 37: 629–642.

Olsen, R.L., Toppe, J. & Karunasagar, I. 2014. Challenges and realistic opportunities in the use of by-products from processing of fish and shellfish. *Trends in Food Science & Technology*, 36(2): 144–151.

O'Neill, J. 2014. *Antimicrobial resistance: tackling a crisis for the health and wealth of nations.* London, Review on Antimicrobial Resistance.

ORBCOMM. 2018. Networks: satellite AIS. Satellite AIS vessel tracking [online]. [Cited 11 January 2018]. www.orbcomm.com/en/networks/satellite-ais

Pacific Islands Forum Secretariat. 2011. Forum communique [online]. 42nd Pacific Islands Forum, Auckland, New Zealand, 7–8 September 2011. [Cited 7 February 2018]. www.forumsec.org/pages.cfm/newsroom/press-statements/2013/2011/forum-communique-42nd-pif-auckland-new-zealand.html

Pacific Islands Forum Secretariat. 2014. *The Framework for Pacific Regionalism.* Suva.

Pardo, M.A., Jiménez, E. & Pérez-Villarreal, B. 2016. Misdescription incidents in seafood sector. *Food Control*, 62: 277–283.

Pauly, D. & Zeller, D. 2016. Catch reconstructions reveal that global marine fishery catches are higher than reported and declining. *Nature Communications*, 7. doi:10.1038/ncomms10244.

Peters, J.R., Yeager, L.A. & Layman, C.A. 2015. Comparison of fish assemblages in restored and natural mangrove habitats along an urban shoreline. *Bulletin of Marine Science*, 91(2): 125–139.

Pinello, D., Gee, J. & Dimech, M. 2017. *Handbook for fisheries socio-economic sample survey – principles and practice.* FAO Fisheries and Aquaculture Technical Paper No. 613. Rome, FAO.

Pinsky, M.L., Worm, B., Fogarty, M.J., Sarmiento, J.L. & Levin, S.A. 2013. Marine taxa track local climate velocities. *Science*, 341(6151): 1239–1242. doi: 10.1126/science.1239352.

Piscini, E., Guastella, J., Rozman, A. & Nassim, T. 2016. Blockchain: democratized trust - distributed ledgers and the future of value [online]. Deloitte Insights, February 24. [Cited 11 January 2018]. www2.deloitte.com/insights/us/en/focus/tech-trends/2016/blockchain-applications-and-trust-in-a-global-economy.html

Poloczanska, E.S., Brown, C.J., Sydeman, W.J., Kiessling, W., Schoeman, D.S., Moore, P.J., Brander, K., Bruno, J.F., Buckley, L.B., Burrows, M.T., Duarte, C.M., Halpern, B.S., Holding, J., Kappel, C.V., O'Connor, M.I., Pandolfi, J.M., Parmesan, C., Schwing, F., Thompson S.A. & Richardson, A.J. 2013. Global imprint of climate change on marine life. *Nature Climate Change*, 3: 919–925. doi: 10.1038/nclimate1958.

Porter, M. 2012. Why the coast matters for women: a feminist approach to research on fishing communities. *Asian Fisheries Science*, 25S: 59–73.

Potts, J., Wilkings, A. Lynch, M. & McFatridge, S. 2016. *State of sustainability initiatives review: standards and the blue economy.* Winnipeg, Canada, International Institute for Sustainable Development (IISD).

Ramsar Convention. 2005. Resolution IX.4. The Ramsar Convention and conservation, production and sustainable use of fisheries resources. 9th Meeting of the Conference of the Parties to the Convention on Wetlands, Kampala, Uganda, 8–15 November.

Recuero Virto, L. 2017. Preliminary assessment of indicators for SDG 14 on "Oceans". Issue paper. 2017 Green Growth and Sustainable Development Forum: Greening the Ocean Economy, Paris, 21–22 November 2017. Paris, OECD.

Reilly, A. 2018. *Overview of food fraud in the fisheries sector.* FAO Fisheries and Aquaculture Circular FIAM/C1165. Rome, FAO.

Represas, I. & Moretti, A. 2017. Mediterranean marine fish hatcheries: update on progress and trends. Presented at LARVI 2017, Ghent, Belgium, 4–7 September. Dendermonde, Belgium, INVE Technologies. (available at www.inveaquaculture.com/download/presentation).

Rodrigues, J.G. & Kruse, M. 2017. Marine and coastal cultural ecosystem services: knowledge gaps and research priorities. *One Ecosystem*, 2.

Roos, N. 2016. Freshwater fish in the food basket in developing countries: a key to alleviate undernutrition. In W.W. Taylor, D.M. Bartley, C.I. Goddard, N.J. Leonard & R. Welcomme, eds. *Freshwater, fish and the future: proceedings of the global cross-sectoral conference*, pp. 35–43. Rome, FAO, Michigan State University & American Fisheries Society.

Rose, D., Bell, D. & Crook, D.A. 2016. Restoring habitat and cultural practice in Australia's oldest and largest traditional aquaculture system. *Reviews in Fish Biology and Fisheries*, 26(3): 589–600.

Rosenberg, A.A., Fogarty, M.J., Cooper, A.B., Dickey-Collas, M., Fulton, E.A., Gutiérrez, N.L., Hyde, K.J.W., Kleisner, K.M., Kristiansen, T., Longo, C., Minte-Vera, C.V., Minto, C., Mosqueira, I., Osio, G.C., Ovando, D., Selig, E.R., Thorson, J.T. & Ye, Y. 2014. *Developing new approaches to global stock status assessment and fishery production potential of the seas.* FAO Fisheries and Aquaculture Circular 1086. Rome, FAO.

Sachs, J., Schmidt-Traub, G., Kroll, C., Durand-Delacre, D. & Teksoz, K. 2017. *SDG Index and Dashboards Report 2017: global responsibilities – international spillovers in achieving the goals.* New York, USA, Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN).

REFERENCES

Sánchez, Á.S., Melchor, G.I.H., Cruz, J.M.Z., González, C.A.Z. & Galarza, J.L.S. 2018. Mangrove restoration an economical alternative for generating incomes. In W. Leal Filho, D.-M. Pociovalisteanu, P. Borges de Brito & I. Borges de Lima, eds. *Towards a sustainable bioeconomy: principles, challenges and perspectives*, pp. 307–317. Cham, Switzerland, Springer.

Sanchez-Jerez, P., Karakassis, I., Massa, F., Fezzardi, D., Aguilar-Manjarrez, J., Soto, D., Chapela, R., Avila, P., Macias, J. C., Tomassetti, P., Marino, G., Borg, J. A., Franičević, V., Yucel-Gier, G., Fleming, I.A., Biao, X., Nhhala, H., Hamza, H., Forcada, A. & Dempster, T. 2016. Aquaculture's struggle for space: the need for coastal spatial planning and the potential benefits of allocated zones for aquaculture (AZAs) to avoid conflict and promote sustainability. *Aquaculture Environment Interactions*, 8: 41–54.

Seggel, A., De Young, C. & Soto, D. 2016. *Climate change implications for fisheries and aquaculture: summary of the findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report.* FAO Fisheries and Aquaculture Circular No. 1122. Rome, FAO.

Senevirathne, M. & Kim, S.K. 2012. Development of bioactive peptides from fish proteins and their health promoting ability. *Advances in Food and Nutrition Research*, 65: 235–248. doi: 10.1016/B978-0-12-416003-3.00015-9.

Siar, S.V. & Kalikoski, D.C., eds. 2016. *Strengthening organizations and collective action in fisheries: towards the formulation of a capacity development programme.* Workshop report and case studies. Barbados, 4–6 November 2014. FAO Fisheries and Aquaculture Proceedings No. 41. Rome, FAO.

Simmance, F., Funge-Smith, S.J. & Gee, J. 2018. Gender dimensions of inland fisheries. In S.J. Funge-Smith, ed. *Review of the state of the world fishery resources: inland fisheries.* FAO Fisheries and Aquaculture Circular No. 942, Rev. 3. FIAF/C942. Rome, FAO.

Simonit, S. & Perrings, C. 2011. Sustainability and the value of the 'regulating' services: wetlands and water quality in Lake Victoria. *Ecological Economics*, 70: 1189–1199.

Sinclair, M. & Valdimarsson, G. 2003. *Responsible fisheries in the marine ecosystem.* Wallingford, UK, CAB International.

Singh, G.G., Cisneros-Montemayor, A.M., Swartz, W., Cheung, W., Guy, J.A., Kenny, T.-A., McOwen, C.J., Asch, R., Geffert, J.L., Wabnitz, C.C.C., Sumaila, R., Hanich, Q. & Ota, Y. 2017. A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Marine Policy*, https://doi.org/10.1016/j.marpol.2017.05.030

Singleton, R.L., Allison, E.H., Le Billon, P. & Sumaila, U.R. 2017. Conservation and the right to fish: international conservation NGOs and the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries. *Marine Policy*, 84: 22–32.

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

SPC (Secretariat of the Pacific Community). 2015. *A new song for coastal fisheries – pathways to change: the Noumea strategy.* Noumea, New Caledonia.

Stamatopoulos, C. 2002. *Sample based fishery surveys: a technical handbook.* FAO Fisheries Technical Paper No. 425. Rome, FAO.

Stentiford, G.D., Sritunyalucksana, K., Flegel, T.W., Williams, B.A.P., Withyachumnarnkul, B., Itsathitphaisarn, O. & Bass, D. 2017. New paradigms to help solve the global aquaculture disease crisis. *PLOS Pathogens*, 13(2). https://doi.org/10.1371/journal.ppat.1006160

Strohmaier, R., Rioux, J., Seggel, A., Meybeck, A., Bernoux, M., Salvatore, M., Miranda, J. & Agostini, A. 2016. *The agriculture sectors in the Intended Nationally Determined Contributions: analysis.* Environment and Natural Resources Management Working Paper No. 62. Rome, FAO.

Subasinghe, R. 2017. *Regional review on status and trends in aquaculture development in Asia-Pacific – 2015.* FAO Fisheries and Aquaculture Circular No. 1135/5. Rome, FAO.

Subasinghe, R.P., McGladdery, S.E. & Hill, B.J., eds. 2004. *Surveillance and zoning for aquatic animal diseases.* FAO Fisheries Technical Paper No. 451. Rome, FAO.

Suuronen, P., Siar, S., Edwin, L., Thomas, S.N., Pravin, P. & Gilman, E., eds. 2017. *Proceedings of the Expert Workshop on Estimating Food Loss and Wasted Resources from Gillnet and Trammel Net Fishing Operations*, Cochin, India, 8–10 April 2015. FAO Fisheries and Aquaculture Proceedings No. 44. Rome, FAO.

Tacon, A.G.J., Hasan, M.R. & Metian, M. 2011. *Demand and supply of feed ingredients for farmed fish and crustaceans: trends and prospects.* FAO Fisheries and Aquaculture Technical Paper No. 564. Rome, FAO.

Tantillo, G., Marchetti, P., Mottola, A., Terio, V., Bottaro, M., Bonerba, E., Bozzo, G. & Di Pinto, A. 2015. Occurrence of mislabelling in prepared fishery products in southern Italy. *Italian Journal of Food Safety*, 4(3): 5358. https://doi.org/10.4081/ijfs.2015.5358.

Thompson, B. & Amoroso, L., eds. 2014. *Improving diets and nutrition: food-based approaches.* Rome, FAO.

Thorpe, A., Zepeda C. & Funge-Smith, S.J. 2018. The economic value of inland fisheries. In S.J. Funge-Smith, ed. *Review of the state of the world fishery resources: inland fisheries.* FAO Fisheries and Aquaculture Circular No. 942, Rev. 3. FIAF/C942. Rome, FAO.

Troell, M., Joyce, A., Chopin, T., Neori, A., Buschmann, A.H. & Fang, J.-G. 2009. Ecological engineering in aquaculture – potential for integrated multi-trophic aquaculture (IMTA) in marine offshore systems. *Aquaculture*, 297: 1–9. https://doi.org/10.1016/j.aquaculture.2009.09.010.

Troell, M., Naylor, R., Metian, M., Beveridge, M., Tyedmers, P., Folke, C., Österblom, H., de Zeeuw, A., Scheffer, M., Nyborg, K., Barrett, S., Crépin, A.-S., Ehrlich, P., Lewin, S., Xepapadeas, T., Polasky, S., Arrow, K., Gren, Å., Kautsky, N., Mäler, K.-G., Taylor, S. & Walker, B. 2014. Does aquaculture add resilience to the global food system? *Proceedings of the National Academy of Sciences of the United States of America*, 111: 13257–13263. doi: 10.1073/pnas.1404067111.

Tveterås, S., Asche, F., Bellamare, M.F., Smith, M.D., Guttormsen, A.G., Lem, A., Lien, K. & Vannuccini, S. 2012. Fish is food – the FAO's Fish Price Index. *PLoS ONE*, *7*(5). https://doi.org/10.1371/journal.pone.0036731

Tzitzikas, Y., Marketakis, Y., Minadakis, N., Mountantonakis, M., Candela, L., Mangiacrapa, F., Pagano, P., Perciante, C., Castelli, D., Taconet, M., Gentile, A. & Gorelli, G. 2017. Towards a Global Record of Stocks and Fisheries. In M. Salampasis, A. Theodoridis & T. Bournaris, eds. *Proceedings of the 8th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2017),* pp. 328–340. Chania, Greece, 21–24 September 2017 (available at http://ceur-ws.org/Vol-2030/HAICTA_2017_paper39.pdf).

UN. 2002. Plan of Implementation of the World Summit on Sustainable Development. A/Conf.199/20. New York, USA.

UN. 2012. 66/288. The future we want. Resolution adopted by the General Assembly on 27 July 2012. 66th session. New York, USA.

UN. 2014. Resolution adopted by the General Assembly on 14 November 2014. 69/15. SIDS Accelerated Modalities of Action (SAMOA) Pathway. A/RES/69/15. New York.

UN. 2015a. *Transforming our world: the 2030 Agenda for Sustainable Development.* New York, USA.

UN. 2015b. *The Millennium Development Goals Report 2015.* New York, USA.

UN. 2015c. Paris Agreement (available at http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf).

UN. 2015d. *World urbanization prospects: the 2014 revision.* ST/ESA/SER.A/366. New York.

UN. 2015e. *World Population Prospects – the 2015 Revision.* New York.

UN. 2016. Report of the resumed Review Conference on the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, New York, 23–27 May 2016. A/CONF.210/2016/5. New York, USA.

UN. 2017a. Communities of Ocean Action: Implementation of Sustainable Development Goal 14 [online]. [Cited 19 December 2017]. https://oceanconference.un.org

UN. 2017b. *Sustainable Development Goals Report 2017.* New York, USA.

UN. 2017c. Agenda item 77(b). Oceans and the law of the sea: sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. 72nd session of the General Assembly. A/72/L.12. New York, USA.

UN. 2017d. Our ocean, our future: call for action [online]. Ocean Conference, New York, 5–9 June 2017. [Cited 25 January 2018]. https://oceanconference.un.org/callforaction

UN. 2018a. Methodology: standard country or area codes for statistical use (M49) [online]. [Cited 31 March 2018]. https://unstats.un.org/unsd/methodology/m49

UN. 2018b. United Nations World Ocean Assessment: Regular Process for Global Reporting and Assessment of the State of the Marine Environment Including Socioeconomic Aspects [online]. [Cited 20 January 2018]. www.worldoceanassessment.org

UNDG (United Nations Development Group). 2017a. Mainstreaming the 2030 Agenda for Sustainable Development: reference guide to UN Country Teams. March 2017 update. New York, USA.

UNDG. 2017b. *United Nations Development Assistance Framework guidance.* New York, USA.

REFERENCES

UNEP (United Nations Environment Programme). 2014. 1/6. Marine plastic debris and microplastics. United Nations Environment Assembly of the United Nations Environment Programme, 1st session, Nairobi, 27 June 2014. UNEP/EA.1/Res.6. Nairobi.

UNEP. 2016. 2/11. Marine plastic litter and microplastics. United Nations Environment Assembly of the United Nations Environment Programme, 2nd session, Nairobi, 23–27 May 2016. UNEP/EA.2/Res.11. Nairobi.

UNEP. 2017. Draft resolution on marine litter and microplastics. United Nations Environment Assembly of the United Nations Environment Programme, 3rd session, Nairobi, 4–6 December 2017. UNEP/EA.3/L.20. Nairobi.

United States of America. 2018. U.S. National Statistics for the UN Sustainable Development Goals. Indicator 14.4.1 – Proportion of fish stocks within biologically sustainable levels [online]. [Cited 11 January].

Vella, K. 2017. Press statement by Commissioner for Environment, Maritime Affairs and Fisheries, Karmenu Vella. AGRIFISH Council, 12 December 2017 [online]. https://ec.europa.eu/commission/commissioners/2014-2019/vella/announcements/agrifish-council-12-december-2017-press-statement-commissioner-environment-maritime-affairs-and_en [Cited 6 April 2018].

Waite, R., Beveridge, M.C.M., Brummett, R., Castine, S., Chaiyawannakarn, N., Kaushik, S., Mungkung, R., Nawapakpilai, S. & Phillips, M. 2014. *Improving productivity and environmental performance of aquaculture: Installment 5, Creating a sustainable food future.* Washington, DC, World Resources Institute.

Watson, R.A. & Tidd, A. 2018. Mapping nearly a century and a half of global marine fishing: 1869–2015. *Marine Policy*, 93: 171–177.

Welcomme, R. 2011. *Review of the state of the world fishery resources: inland fisheries.* FAO Fisheries and Aquaculture Circular No. 942, Rev. 2. Rome, FAO.

WCPFC (Western and Central Pacific Fisheries Commission). 2016. *Tuna Fishery Yearbook 2015.* Pohnpei, Federated States of Micronesia.

Westlund, L., Charles, A., Garcia, S.M. & Sanders, J., eds. 2017. *Marine protected areas: interactions with fishery livelihoods and food security.* FAO Fisheries and Aquaculture Technical Paper No. 603. Rome, FAO.

Wibowo, S., Utomo, B.S.B., Syamdidi, Ward, A.R., Diei-Ouadi, Y., Siar, S. & Suuronen, P. 2017. *Case studies on fish loss assessment of small-scale fisheries in Indonesia.* FAO Fisheries and Aquaculture Circular No. 1129. Rome, FAO.

World Bank. 2012. *Hidden harvest: the global contribution of capture fisheries.* Washington, DC, World Bank.

World Bank. 2013. *Fish to 2030: prospects for fisheries and aquaculture.* World Bank Report 83177-GLB. Washington, DC, USA.

World Bank. 2018. *Global Economic Prospects, January 2018: broad-based upturn, but for how long?* Advance edition. Washington, DC.

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

WTO (World Trade Organization). 2017. *World Trade Statistical Review 2017.* Geneva, Switzerland.

Ye, Y., Barange, M., Beveridge, M., Garibaldi, L., Gutierrez, N., Anganuzzi, A. & Taconet, M. 2017. FAO's statistic data and sustainability of fisheries and aquaculture: comments on Pauly and Zeller (2017). *Marine Policy*, 81: 401–405.

Ye, Y., Cochrane, K., Bianchi, G., Willmann, R., Majkowski, J., Tandstad, M. & Carocci, F. 2013. Rebuilding global fisheries: the World Summit goal, costs and benefits. *Fish and Fisheries*, 14(2): 174–185.

Ye, Y. & Gutierrez, N.L. 2017. Ending fishery overexploitation by expanding from local successes to globalized solutions. *Nature Ecology & Evolution*, 1: 0179. doi:10.1038/s41559-017-0179.

Yeshanew, S., Franz, N. & Westlund, L., eds. 2017. *Exploring the human rights-based approach in the context of the implementation and monitoring of the SSF Guidelines.* Workshop Proceedings, Rome, 24–26 October 2016. FAO Fisheries and Aquaculture Proceedings No. 53. Rome, FAO.

Ytrestøyl, T., Aas, S. & Åsgård, T. 2015. Utilisation of feed resources in production of Atlantic salmon (*Salmo salar*) in Norway. *Aquaculture*, 448: 365–374.

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