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THE STATE OF WORLD FISHERIES AND AQUACULTURE

TOWARDS BLUE TRANSFORMATION

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THAILAND. Preparing the fishing nets on a boat.

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Food and Agriculture Organization of the United Nations
Rome, 2022

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FOREWORD

Despite significant previous progress, the world is off track to end hunger and malnutrition in all its forms by 2030. Degraded ecosystems, an intensifying climate crisis, and increased biodiversity loss are threatening jobs, economies, the environment and food security around the globe, all aggravated by the impacts of the COVID-19 pandemic, crises and other humanitarian emergencies. Today, 811 million people suffer from hunger and 3 billion cannot afford healthy diets.

This has elevated the calls to urgently transform our agrifood systems to ensure food security, improve nutrition and secure affordable healthy diets for a growing population, while safeguarding livelihoods and our natural resources.

Aquatic foods are increasingly recognized for their key role in food security and nutrition, not just as a source of protein, but also as a unique and extremely diverse provider of essential omega-3 fatty acids and bioavailable micronutrients. Prioritizing and better integrating fisheries and aquaculture products in global, regional and national food system strategies and policies should be a vital part of the necessary transformation of our agrifood systems.

The 2022 edition of *The State of World Fisheries and Aquaculture – Towards Blue Transformation –* builds on this narrative by presenting quantitative evidence of the growing role of fisheries and aquaculture in providing food, nutrition and employment. In 2020, fisheries and aquaculture production reached an all-time record of 214 million tonnes, worth about USD 424 billion. Production of aquatic animals in 2020 was more than 60 percent higher than the average in the 1990s, considerably outpacing world population growth, largely due to increasing aquaculture production. We are eating more aquatic foods than ever – about 20.2 kg per capita in 2020 – more than double our consumption rate 50 years ago. Globally, aquatic foods provide about 17 percent of animal protein, reaching over 50 percent in several countries in Asia and Africa. The sector employs an estimated 58.5 million people in primary production alone – approximately 21 percent women.

This report also highlights further changes needed in the fisheries and aquaculture sector to address the challenges of feeding the world effectively, equitably and sustainably. Its subtitle, *Towards Blue Transformation*, reflects the acceleration required to achieve a sustainable, inclusive and efficient sector able to meet expectations, the urgent need to integrate sustainably harvested aquatic foods into national food system policies and programmes, and opportunities to contribute to restoring aquatic habitats and biodiversity.

The State of World Fisheries and Aquaculture 2022 is underpinned by a significant policy context. First, the Declaration for Sustainable Fisheries and Aquaculture, unanimously endorsed in 2021 by the Thirty-fourth Session of the FAO Committee on Fisheries (COFI), concludes with a call to support "an evolving and positive vision for fisheries and aquaculture in the twenty-first century, where the sector is fully recognized for its contribution to fighting poverty, hunger and malnutrition." Second, this 2022 edition coincides with the implementation of three relevant United Nations Decades, namely the Decade of Action to deliver the Global Goals, the Decade of Ocean Science for Sustainable Development, and the Decade on Ecosystem Restoration. Finally, the report is launched as we approach the middle of the International Year of Artisanal Fisheries and Aquaculture 2022. The policy landscape could not be more ambitious and the moment more opportune to transform towards more efficient, more inclusive, more resilient and more sustainable aquatic food systems to help achieve the Sustainable Development Goals.

Since its first edition in 1995, *The State of World Fisheries and Aquaculture* has provided technical insight and evidence-based information on a sector crucial to societal success. It serves a wide audience – from policymakers, managers and scientists, to fishers and consumers – to demonstrate and enhance the vital role and contributions of fisheries and aquaculture to achieve better production, better nutrition, a better environment and a better life for all, leaving no one behind. I am confident that this edition will continue the tradition of making valuable contributions in helping us meet the challenges of the twenty-first century.

Qu Dongyu
FAO Director-General

METHODOLOGY

Preparation of *The State of World Fisheries and Aquaculture 2022* started in April 2021. It is the work of a 12-member editorial board representing the various teams of the FAO Fisheries and Aquaculture Division (NFI), guided by a core executive group of the NFI Information and Knowledge Management Team and a representative of the FAO Office of Communications. Chaired by the Director of NFI, the editorial board met regularly to develop and refine the structure and content, review progress and address emerging issues. This work benefited from wider consultation among the FAO teams in charge of the five FAO flagship publications.

Between May and June 2021, topics and contributors were proposed for consideration by the editorial board, which developed and refined the outline, involving virtually all officers in the division and some from other FAO divisions, with FAO decentralized officers contributing regional insights and stories. Notably, the board drew inspiration from high-level global events, starting from the recommendations of the Thirty-fourth Session of the FAO Committee on Fisheries, enshrined in its Declaration for Sustainable Fisheries and Aquaculture, which calls on Members "to support an evolving and positive vision for fisheries and aquaculture in the twenty-first century, where the sector is fully recognized for its contribution to fighting poverty, hunger and malnutrition."

The editorial board expanded the 2020 three-tiered structure of the publication, with a view to thoroughly addressing Blue Transformation. Under Parts 2 and 3, Blue Transformation anchors this edition at the centre of the FAO Strategic Framework 2022–2031 in the context of the 2030 Agenda for Sustainable Development, with a focus on the United Nations "Decades", namely the Decade of Action to deliver the Global Goals, the Decade of Ocean Science for Sustainable Development and the Decade on Ecosystem Restoration. Furthermore, preparation of the draft took place during a period of unprecedented challenges driven by the COVID-19 pandemic, which caused temporary and permanent structural changes in the sector. *The State of World Fisheries and Aquaculture 2022* attempts to address the changes that are likely to become mainstream as the fisheries and aquaculture sector emerges from the crisis.

With these ingredients in hand, the editorial board adopted a structure in four parts. Part 1, World Review, owing to its historical high readership, was maintained. Part 2, Towards Blue Transformation, focuses on issues coming to the fore in 2021–2022. It examines the key challenges of the three pillars underpinning Blue Transformation, namely expansion and intensification of aquaculture production to satisfy growing demand, improvement of fisheries management to deliver healthy stocks, and upgrading and innovation of fisheries and aquaculture value chains. Part 3 explores pathways for concrete actions during the decade – focusing on the relevant Sustainable Development Goal (SDG) targets, the need for scientific development and innovation, and the mainstreaming of ecosystem restoration and biodiversity – to enable Blue Transformation to effectively support achieving the Global Goals. Part 4 covers emerging issues and projections (outlook). In addition, this 2022 edition includes, for the first time, an Executive Summary, which covers the entire publication and not only the global trends.

On the basis of the revised structure, various editorial board members were assigned the leadership of a thematic section. Most contributions were prepared by FAO authors, in collaboration with external experts where appropriate (see Acknowledgements).

In July 2021, a summary was prepared with the inputs of all section leaders and revised based on feedback from the editorial board. The summary document was submitted to NFI's management, then to the FAO Deputy Director-General (Natural Resources and Sustainable Development stream) for approval in mid-July 2021. This document formed the blueprint guiding authors in the drafting of the publication.

Parts 2, 3 and 4 were drafted between September 2021 and January 2022 and edited for technical and language content. In Part 3, the SDG section was finalized in March to allow integration of the most recent data (February 2022) from the United Nations Statistics Division regarding the four SDG 14 indicators under FAO custodianship. In February–March, these parts were submitted in batches for translation into FAO's six official languages and for review by the FAO Fisheries and Aquaculture Division and the editorial board.

Part 1, World Review, is based on FAO's official fisheries and aquaculture statistics. To reflect the most up-to-date statistics available, drafting began in November 2021 and ended in February–March 2022 upon annual closure of the various thematic databases in which the data are structured. The statistics are the outcome of an established programme to ensure the most reliable information, including assistance to enhance countries' capacity to collect and submit data according to international standards. The process is one of careful collation, revision and validation. In the absence of national reporting, FAO makes estimates based on the best data available from other sources or through standard methodologies.

Developments in recent decades in fisheries and aquaculture, characterized by the sector's increasing role in food security, human nutrition and trade, have been accompanied by a major expansion of the associated terminology. This has necessitated a thorough review to ensure coherence throughout *The State of World Fisheries and Aquaculture 2022* and the use of clear and intuitive terms as defined by authoritative sources of FAO or others. A working group was set up to complete this task and a Glossary was elaborated to assist authors, editors and readers.

An advanced draft was externally reviewed in March 2022 by three well-known experts in the area of fisheries and aquaculture. A final draft was approved by the Office of the FAO Deputy Director-General (Natural Resources and Sustainable Development stream) and the Office of the FAO Director-General.

ACKNOWLEDGEMENTS

The State of World Fisheries and Aquaculture 2022 was prepared under the overall direction of Manuel Barange and an editorial board under his leadership, comprising Lahsen Ababouch, Vera Agostini, Marcio Castro de Souza, Ruth Duffy, Eszter Hidas, Alessandro Lovatelli, Ana Menezes, Rebecca Metzner, Marc Taconet, Gilles van der Walle, Stefania Vannuccini and Kiran Viparthi.

Authorship of each section was led and coordinated by a different editorial board member. The production process was overseen by Marc Taconet with support from Lahsen Ababouch (technical editing), Emmanuel Blondel (map production), Ruth Duffy (language editing and project management) assisted by Marianne Guyonnet (liaison), and Kiran Viparthi (informatics).

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PART 1

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Aquaculture production: Xiaowei Zhou (lead author)
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Employment in fisheries and aquaculture: Jennifer Gee (lead author) and Pierre Maudoux
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Consumption of aquatic foods: Adrienne Egger (lead author) and Molly Ahern
Trade of fisheries and aquaculture products: Adrienne Egger (lead author) and Felix Dent

PART 2

Blue Transformation: a vision for transforming aquatic food systems: Manuel Barange (lead author) and Carlos Fuentevilla

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Better management and production: Pedro Barros (lead author), Rebecca Metzner, John Valbo-Jørgensen, Felix Martinn, Alicia Mosteiro, Nicolas Gutierrez and Yimin Ye
Best practices, innovations and technologies for improving fisheries management: José Antonio Acuña Barros (lead author), Kim Stobberup, Raymon van Anrooy, Kristín von Kistowski, Javier Villanueva García-Benítez and Nicole Franz
Better lives: Social protection and decent work: Daniela Kalikoski (lead author), Birgitte Krogh-Poulsen, Uwe Barg, Daniella Salazar Herrera, Mariana Toussaint and Nicole Franz
Supporting fisheries management in data- and capacity-limited regions: Nicola Gutierrez (lead author), Simon Funge-Smith and Stefania Vannuccini

Innovating fisheries and aquaculture value chains (coordinators Marcio Castro de Souza and Gilles van de Walle):
Competitive value chains: Marcio Castro de Souza (lead author), Weiwei Wang, William Griffin, Nianjun Shen, Ansen Ward, Omar Riego Peñarubia, John Ryder, Esther Garrido Gamarro, Gilles van de Walle, Jogeir Toppe and Dimitar Taskov
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The International Year of Artisanal Fisheries and Aquaculture 2022 (coordinator Rebecca Metzner):
The purpose of the International Year: Nicole Franz (lead author), Lena Westlund and Alessandro Lovatelli
The IYAFA 2022 Global Action Plan: seven pillars contributing to achieving the SDGs: Nicole Franz (lead author), Molly Ahern, Jennifer Gee, Daniela Kalikoski, Alessandro Lovatelli, Graham Mair, Florence Poulain, Lena Westlund and Xinhua Yuan
Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development: Nicole Franz (lead author) and Lena Westlund
Small-scale fisheries and aquaculture: contributing to food systems and nutrition security: Molly Ahern (lead author)
Partnerships to advance the implementation of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries: Lena Westlund (lead author) and Nicole Franz

PART 3
Decade of Action to deliver the Global Goals (coordinator Marc Taconet):
The Sustainable Development Goals and fisheries and aquaculture: Audun Lem (lead author), Marc Taconet, Graham Mair, Diana Fernandez Reguera, Michael Griffin, Kim Friedman and Daniela Lucente
SDG Indicator 14.4.1 – quantifying fish stocks within biologically sustainable levels: Marc Taconet (lead author), Yimin Ye, Nicolas Gutierrez, Rishi Sharma and Anne-Elise Nieblas
SDG Indicator 14.6.1 – assessing degree of implementation of international instruments to combat illegal, unreported and unregulated fishing: Piero Mannini (lead author) and Giuliano Carrara
SDG Indicator 14.7.1 – measuring sustainable fisheries contributions to national economies: Marcio Castro de Souza (lead author), Weiwei Wang and Michael Griffin
SDG Indicator 14.b.1 – assessing degree of recognition and protection of access rights for small-scale fisheries: Nicole Franz (lead author), Stefania Savore and Giuliano Carrara

United Nations Decade of Ocean Science for Sustainable Development (2021–2030) (coordinator Vera Agostini):
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What is the Ocean Decade?: Joseph Zelasney (lead author), Merete Tandstad, Anton Ellenbroek, Marc Taconet and Vera Agostini
FAO and the Decade Actions: Joseph Zelasney (lead author), Merete Tandstad, Marc Taconet, Anton Ellenbroek, Vera Agostini and Nelson Rosas Ribeiro Filho

United Nations Decade on Ecosystem Restoration (coordinator Eszter Hidas):
Fisheries and aquaculture and the FAO–UNEP-led Decade on Ecosystem Restoration: Kim Friedman (lead author), Diana Fernandez Reguera and Vera Agostini
Fisheries and aquaculture and the Post-2020 Global Biodiversity Framework: Kim Friedman (lead author), Vera Agostini and Amber Himes-Cornell
Recovery actions for vulnerable species and habitats: Kim Friedman, Amber Himes-Cornell, Merete Tandstad, Anthony Thompson, John Valbo-Jørgensen and David Coates
Optimizing sustainable biodiversity use, including mitigating ecosystem impacts, through technology and innovation: Graham Mair, Johnathan Lansley and Amparo Perez Roda

PART 4
COVID-19, a crisis like no other: Florence Poulain (lead author), José Estors Carballo, Lionel Dabbadie, Alejandro Flores, Jennifer Gee, Kathrin Hett, Robert Lee, Daniela Kalikoski, Jon Lansley, Felix Marttin, Daniella Salazar Herrera, Jessica Sanders, Susana Siar and Martinus Van der Knaap
Fisheries and aquaculture adaptations to climate change: Xuechan Ma (lead author), Tarub Bahri, José Aguilar-Manjarrez, Diana Fernandez Reguera, Yacoub Issola (UNEP/Abidjan Convention), Florence Poulain and Fatou Sock
Advancing towards gender equality in fisheries and aquaculture: Jennifer Gee (lead author), Roxane Misk, Maria Grazie Cantarella, Matteo Luzzi and Omar Riego Peñarubia
Fisheries and aquaculture projections: Stefania Vannuccini (lead author) and Manuel Barange

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Translations were delivered by the Language Branch (CSGL) of the FAO Governing Bodies Servicing Division (CSG).

The Publications Branch (OCCP) in FAO's Office of Communications (OCC) provided editorial support, design and layout, as well as production coordination, for editions in all six official languages.

ABBREVIATIONS AND ACRONYMS

2030 Agenda	2030 Agenda for Sustainable Development
ABMT	area-based management tool
ABNJ	areas beyond national jurisdiction
AIS	Automatic Identification System
ALDFG	abandoned, lost or otherwise discarded fishing gear
AqGR	aquatic genetic resources for food and agriculture
AU	African Union
B2B	business-to-business
B2C	business-to-consumer
BBNJ	biodiversity beyond national jurisdiction
CBD	Convention on Biological Diversity
CDS	catch documentation scheme
CEM	Commission on Ecosystem Management
CFS	Committee on Food Security
CGIAR	CGIAR System Organization
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Code	Code of Conduct for Responsible Fisheries
COFI	Committee on Fisheries
COFI:AQ	COFI Sub-Committee on Aquaculture
COFI:FT	COFI Sub-Committee on Fish Trade
COP26	twenty-sixth session of the Conference of the Parties
COVID-19	coronavirus disease 2019
DHA	docosahexaenoic acid
EAA	ecosystem approach to aquaculture
EAF	ecosystem approach to fisheries
EATIP	European Aquaculture Technology and Innovation Platform
ECLAC	Economic Commission for Latin America and the Caribbean
EPA	eicosapentaenoic acid
EU	European Union
EUMOFA	European Market Observatory for Fisheries and Aquaculture Products
FBS	FAO Food Balance Sheets
FIAT	Fisheries Infrastructure Assessment Tool
FLW	food loss and waste
FPI	FAO Fish Price Index
GAF	Gender in Aquaculture and Fisheries Section
GCA	Global Conference on Aquaculture
GDP	gross domestic product
GESAMP	United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GGGI	Global Ghost Gear Initiative
GIES	Global Information Exchange System
GIS	geographic information system
GPS	global positioning system
GSA	Guidelines for Sustainable Aquaculture
GTA	gender-transformative approach
HIHI	Hand-in-Hand Initiative
HLPE	High-Level Panel of Experts on Food Security and Nutrition
HLPF	United Nations High-level Political Forum on Sustainable Development
HS	Harmonized Commodity Description and Coding System

ABBREVIATIONS AND ACRONYMS

IAA	integrated agriculture-aquaculture
IBAR	InterAfrican Bureau for Animal Resources
ICES	International Council for the Exploration of the Sea
ICT	information and communications technology
ICT4SSF	information and communication technologies for small-scale fisheries
IFAD	International Fund for Agricultural Development
IFFO	Marine Ingredients Organisation
IFOP	Institute of Fisheries Development
IFPRI	International Food Policy Research Institute
IHH	Illuminating Hidden Harvests
IIA	integrated irrigated-aquaculture
ILBI	international legally binding instrument
ILO	International Labour Organization
IMO	International Maritime Organization
IMTA	integrated multitrophic aquaculture
INFOFISH	Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region
INFOPESCA	Centre for Marketing Information and Advisory Services for Fishery Products in Latin America and the Caribbean
INFOYU	China Fish Marketing Information and Trade Advisory Service Center
IOC-UNESCO	Intergovernmental Oceanographic Commission
IPOA	International Plan of Action
IPCC	Intergovernmental Panel on Climate Change
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
IUCN	International Union for Conservation of Nature and Natural Resources
IUU fishing	illegal, unreported and unregulated fishing
IYAFA 2022	International Year of Artisanal Aquaculture and Fisheries 2022
KDE	key data element
LCA	life cycle assessment
LDC	least developed country
LOA	length overall
MCS	monitoring, control and surveillance
MEL	monitoring, evaluation and learning
MPA	marine protected area
MSY	maximum sustainable yield
NDC	nationally determined contribution
NGO	non-governmental organization
Norad	Norwegian Agency for Development Cooperation
NPOA	National Plan of Action
NPOA-SSF	National Plan of Action in support of the implementation of the SSF Guidelines
NTM	non-tariff measure
OECD	Organisation for Economic Co-operation and Development
OECM	other effective area-based conservation measure
OSPESCA	Central American Organization of the Fisheries and Aquaculture Sector
PMP/AB	Progressive Management Pathway for Improving Aquaculture Biosecurity

PPAs	programme priority areas
PSMA	Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (Port State Measures Agreement)
PUFA	polyunsaturated fatty acid
RFAB	Regional Fisheries Advisory Body
RFB	regional fishery body
RFMO	regional fisheries management organization
ROFTA	return on fixed tangible assets
ROI	return on investment
RTA	regional trade agreement
SDG	Sustainable Development Goal
SER	Society for Ecological Restoration
SICA	Central American Integration System
SIDA	Swedish International Development Cooperation Agency
SIDS	small island developing State
SME	small and medium enterprise
SOFIA	The State of World Fisheries and Aquaculture
SSF	small-scale fisheries
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
TBT	technical barriers to trade
TBTI	Too Big To Ignore
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNCTAD	United Nations Conference on Trade and Development
UN DESA	United Nations Department of Social and Economic Affairs
UNDOSSD	United Nations Decade of Ocean Science for Sustainable Development (2021–2030)
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNSD	United Nations Statistics Division
USGS	United States Geological Survey
VGCDS	Voluntary Guidelines for Catch Documentation Schemes
VGMFG	Voluntary Guidelines for the Marking of Fishing Gear
VME	vulnerable marine ecosystem
VMS	vessel monitoring system
WCO	World Customs Organization
WFP	World Food Programme
WGFTFB	Working Group on Fishing Technology and Fish Behaviour
WHO	World Health Organization
WTO	World Trade Organization

KEY MESSAGES

1. Global fisheries and aquaculture production is at a record high and the sector will play an increasingly important role in providing food and nutrition in the future.

Total fisheries and aquaculture production reached a record 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae, largely due to the growth of aquaculture, particularly in Asia. The amount destined for human consumption (excluding algae) was 20.2 kg per capita, more than double the average of 9.9 kg per capita in the 1960s. An estimated 58.5 million people were employed in the primary sector. Including subsistence and secondary sector workers, and their dependents, it is estimated that about 600 million livelihoods depend at least partially on fisheries and aquaculture. The international trade of fisheries and aquaculture products generated around USD 151 billion in 2020, down from the record high of USD 165 billion in 2018 mainly due to the outbreak of COVID-19.

2. Aquaculture has great potential to feed and nourish the world's growing population. But growth must be sustainable.

In 2020, global aquaculture production reached a record 122.6 million tonnes, with a total value of USD 281.5 billion. Aquatic animals accounted for 87.5 million tonnes and algae comprised 35.1 million tonnes. In 2020, driven by expansion in Chile, China and Norway, global aquaculture production grew in all regions except Africa, due to a decrease in the two major producing countries, Egypt and Nigeria. The rest of Africa enjoyed 14.5 percent growth from 2019. Asia continued to dominate world aquaculture, producing 91.6 percent of the total. Aquaculture growth has often occurred at the expense of the environment. Sustainable aquaculture development remains critical to supply the growing demand for aquatic foods.

3. The world's consumption of aquatic foods has increased significantly in recent years and will continue to rise.

Global consumption of aquatic foods (excluding algae) has increased at an average annual rate of 3.0 percent since 1961, compared with a population growth rate of 1.6 percent. On a per capita basis, consumption of aquatic food grew from an average of 9.9 kg in the 1960s to a record high of 20.5 kg in 2019, while it slightly declined to 20.2 kg in 2020. Rising incomes and urbanization, improvements in post-harvest practices and changes in dietary trends are projected to drive a 15 percent increase in aquatic food consumption, to supply on average 21.4 kg per capita in 2030.

4. Fishery resources continue to decline due to overfishing, pollution, poor management and other factors, but the number of landings from biologically sustainable stocks is on the rise.

The fraction of fishery stocks within biologically sustainable levels decreased to 64.6 percent in 2019, 1.2 percent lower than in 2017. However, 82.5 percent of the 2019 landings were from biologically sustainable stocks, a 3.8 percent improvement from 2017. Effective fisheries management has been proven to successfully rebuild stocks and increase catches within ecosystem boundaries. Improving global fisheries management remains crucial to restore ecosystems to a healthy and productive state and protect the long-term supply of aquatic foods. Rebuilding overfished stocks could increase fisheries production by 16.5 million tonnes and raise the contribution of marine fisheries to the food security, nutrition, economic growth and well-being of coastal communities.

5. Reduction of the global fishing fleet size continues, but more needs to be done to minimize overcapacity and ensure sustainability in fishing operations.

The total number of fishing vessels in 2020 was estimated at 4.1 million, a reduction of 10 percent since 2015, reflecting efforts by countries, in particular China and European countries, to reduce the global fleet size. Asia still had the largest fishing fleet, at about two-thirds of the global total. However, reductions in fleet size alone do not necessarily guarantee more sustainable outcomes, since changes in fishing efficiency can offset the sustainability gains of fleet reductions.

6. Aquatic animal production is forecast to grow another 14 percent by 2030. It is vital this growth goes hand in hand with safeguarding ecosystems, reducing pollution, protecting biodiversity and ensuring social equity.

FAO's outlook for fisheries and aquaculture to 2030 projects an increase in production, consumption and trade, albeit at slower growth rates. Total production of aquatic animals is expected to reach 202 million tonnes in 2030, thanks mainly to sustained growth of aquaculture, projected to reach 100 million tonnes for the first time in 2027 and 106 million tonnes in 2030. World capture fisheries is projected to recover, increasing by 6 percent from 2020 to reach 96 million tonnes in 2030, as a result of improved resource management, underfished resources, and reduced discards, waste and losses.

7. Millions of lives and livelihoods are supported by aquatic food systems. Yet, many small-scale producers, especially women, are vulnerable with precarious working conditions. Building their resilience is key to sustainability and equitable development.

Of the 58.5 million people employed in the primary fisheries and aquaculture sector in 2020, 21 percent were women, rising to about 50 percent for those employed in the entire aquatic value chain (including pre- and post-harvest). Although they occupy critical roles in fisheries and aquaculture, women constitute a disproportionately large percentage of the people engaged in the informal, lowest paid, least stable and less skilled segments of the workforce, and often face gender-based constraints that prevent them from fully exploring and benefiting from their roles in the sector.

8. Aquatic food systems are a powerful solution. Blue Transformation can meet the twin challenges of food security and environmental sustainability.

FAO is committed to Blue Transformation, a visionary strategy that aims to enhance the role of aquatic food systems in feeding the world's growing population by providing the legal, policy and technical frameworks required to sustain growth and innovation. Blue Transformation proposes a series of actions designed to support resilience in aquatic food systems and ensure fisheries and aquaculture grow sustainably while leaving no one behind, especially those communities that depend on the sector. Climate- and environment-friendly policies and practices, as well as technological innovations, are critical building blocks for Blue Transformation.

9. Blue Transformation requires a commitment from the public and private sectors if we are to achieve the United Nations 2030 Agenda, particularly since the COVID-19 pandemic has reversed previously favourable trends.

Blue Transformation requires a commitment from governments, the private sector and civil society to maximize the opportunities that fisheries and aquaculture offer. Blue Transformation seeks to promote sustainable aquaculture expansion and intensification, effective management of all fisheries, and upgrading of aquatic value chains. Proactive public and private partnerships are needed to improve production, reduce food loss and waste and enhance equitable access to lucrative markets. Furthermore, inclusion of aquatic foods in national food security and nutrition strategies, together with initiatives to improve consumer awareness on their benefits, is needed to increase availability and improve access.

EXECUTIVE SUMMARY

Over the last two decades, the fisheries and aquaculture sectors have been increasingly recognized for their essential contribution to global food security and nutrition. Expanding this role requires scaling up transformative changes in policy, management, innovation, and investment to achieve sustainable, inclusive and equitable global fisheries and aquaculture. *The State of World Fisheries and Aquaculture 2022*[1] presents updated and verified statistics[2] of the sector and analyses its international policy context and selected high-impact actions undertaken to accelerate international efforts in support of the Sustainable Development Goals (SDGs). The report looks at the impact and implications of the COVID-19 pandemic on fisheries and aquaculture production,[3] utilization, and trade and provides a future outlook for the sector.

1. WORLD REVIEW

Total fisheries and aquaculture production reached an all-time record of 214 million tonnes in 2020, comprising 178 million tonnes of aquatic animals and 36 million tonnes of algae,[3] a slight increase (3 percent) from the previous 2018 record (213 million tonnes). The limited growth is mainly caused by a 4.4 percent decline in capture fisheries due to reduced catches of pelagic species, particularly anchoveta, a reduction in China's catches, and the impacts of the COVID-19 pandemic in 2020. This decline was compensated for by a continued growth of aquaculture, albeit at a slower yearly rate in the last two years.

For aquatic animal production, this general trend masks significant variations between continents, regions, and countries. In 2020, Asian countries were the main producers accounting for 70 percent of the total, followed by the Americas, Europe, Africa and Oceania. China remained the first major producer with a share of 35 percent of the total. The expansion of aquaculture in recent decades has boosted the overall growth of aquatic animal production in inland waters, from 12 percent of total production in the late 1980s to 37 percent in 2020.

In 2020, global **capture fisheries production** (excluding algae) was 90.3 million tonnes, with an estimated value of USD 141 billion, including 78.8 million tonnes from marine waters and 11.5 million tonnes from inland waters – a fall of 4.0 percent compared with the average of the previous three years. Finfish represent about 85 percent of total marine capture production, with anchoveta once again the top species harvested. In 2020, catches of the four most high-value groups (tunas, cephalopods, shrimps and lobsters) remained at their highest levels or declined marginally from peak catches recorded previously.

Despite a decrease of 5.1 percent from 2019, global catches in inland waters, estimated at 11.5 million tonnes, remained at a historically high level and benefited from improved reporting by the producing countries. Asia produced almost two-thirds of total inland fisheries, followed by Africa – inland catches are important for food security in both these regions. For the first time since the mid-1980s, China was not the top inland fisheries producer, overtaken by India at 1.8 million tonnes.

Global **aquaculture production** in 2020 reached a record 122.6 million tonnes, including 87.5 million tonnes of aquatic animals worth USD 264.8 billion and 35.1 million tonnes of algae worth USD 16.5 billion. Around 54.4 million tonnes were farmed in inland waters and 68.1 million tonnes came from marine and coastal aquaculture.

All regions, except Africa, experienced continued aquaculture growth in 2020, driven by expansion in Chile, China and Norway – the top producers

1 Note that this 2022 edition of *The State of World Fisheries and Aquaculture* includes for the first time a Glossary which reflects the ongoing expansion of the terminology resulting from the sector's increasing role in food security, human nutrition and trade.

2 In Part 1 World Review, if not expressly indicated, the statistical analysis on production, utilization, consumption and trade is carried out separately for aquatic animals (excluding aquatic mammals and reptiles) and algae. Detailed coverage of species and specific sectorial exclusions are indicated in the Glossary.

3 For algae, and fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

in their respective regions. Africa experienced a decrease in the two major producing countries, Egypt and Nigeria, while the rest of Africa enjoyed 14.5 percent growth from 2019. Asia continued to dominate world aquaculture, producing over 90 percent of the total.

The contribution of aquaculture to the global production of aquatic animals reached a record 49.2 percent in 2020. Aquaculture of fed aquatic animals continues to outpace that of non-fed aquatic animals. Despite the great diversity in farmed aquatic species, only a small number of "staple" species dominate aquaculture production, particularly grass carp for global inland aquaculture and Atlantic salmon for marine aquaculture.

FAO continues to report on **the status of fishery resources**. The Organization's long-term monitoring of assessed marine fishery stocks confirms that marine fishery resources have continued to decline. The fraction of fishery stocks within biologically sustainable levels decreased from 90 percent in 1974 to 64.6 percent in 2019, with maximally sustainably fished stocks at 57.3 percent and underfished stocks at 7.2 percent.

Nevertheless, despite worsening trends by number, in 2019, biologically sustainable stocks accounted for 82.5 percent of the landings of aquatic products,[4] a 3.8 percent increase from 2017. For example, on average, 66.7 percent of the stocks of the ten species most landed in 2019 – anchoveta, Alaska pollock, skipjack tuna, Atlantic herring, yellowfin, blue whiting, European pilchard, Pacific chub mackerel, Atlantic cod and largehead hairtail – were fished within biologically sustainable levels in 2019, slightly higher than in 2017. This demonstrates that larger stocks are managed more effectively.

Rebuilding overfished stocks could increase marine capture fisheries production by 16.5 million tonnes and thus contribute to the food security, nutrition, economies and well-being of coastal communities. Scientifically assessed and intensively managed stocks have, on average, seen increased abundance at proposed target levels; in contrast, regions with less developed fisheries management have much greater harvest rates and lower abundance. This highlights the urgent need to replicate and re-adapt successful policies and regulations in fisheries that are not managed sustainably, and implement innovative, ecosystem-based mechanisms that promote sustainable use and conservation around the world.

Many of the important inland fisheries lie within least developed and developing countries, where limited human and financial resources to monitor and manage such fisheries represent a major obstacle. Even in some developed countries, the low profile of inland fisheries means that stock assessment and monitoring may be a relatively low priority in relation to other competing needs. In 2016, FAO began developing a global threat map for inland fisheries to provide a baseline metric to track changes in major basins and improve inland fisheries. Preliminary results indicate that across all major basins 55 percent of inland fisheries are under moderate pressure and 17 percent under high pressure.

With regard to the **fishing fleet**, the total number of fishing vessels in 2020 was estimated at 4.1 million, a reduction of 10 percent since 2015, reflecting efforts by many countries, in particular China and European countries, to reduce the global fleet size. Asia still has the largest fishing fleet, at about two-thirds of the global total. The global total of motorized vessels has remained steady at 2.5 million vessels, with Asia having almost 75 percent; about 97 percent of the world's non-motorized vessels are spread between Asia and Africa.

Regarding **employment in fisheries and aquaculture**, in 2020, an estimated 58.5 million people were engaged in the primary production sector as full-time or part-time workers. Some 35 percent were employed in aquaculture, a figure which has flattened in recent years, while the global number of fishers has contracted. In 2020, 84 percent of all fishers

4 For aquatic products, see Glossary, including Context of SOFIA 2022.

and fish farmers were in Asia. Overall, women accounted for 21 percent of those engaged in the primary sector (28 percent in aquaculture and 18 percent in fisheries), but they tend to have more unstable employment in aquaculture and fisheries, representing only 15 percent of full-time workers in 2020. However, when considering the available data for the processing sector only, women accounted for just over 50 percent of full-time employment and 71 percent of part-time engagement.

Utilization and processing of fisheries and aquaculture production have changed considerably in past decades. In 2020, 89 percent (157 million tonnes) of world production (excluding algae) was used for direct human consumption, compared with 67 percent in the 1960s. The remainder (over 20 million tonnes) was used for non-food purposes – the vast majority for fishmeal and fish oil, with the rest for ornamental fish, bait, pharmaceutical applications, pet food, and direct feeding in aquaculture and raising of livestock and fur animals. Live, fresh or chilled forms still represented the largest share of aquatic food[5] (excluding algae) for direct human consumption, followed by frozen, prepared, and preserved and cured. In Asia and Africa, the share of aquatic food production preserved by salting, smoking, fermentation or drying is higher than the world average. A growing share of by-products is used for food and non-food purposes. For example, over 27 percent of the global production of fishmeal and 48 percent of the total production of fish oil were obtained from by-products.

Global **consumption of aquatic foods** (excluding algae) increased at an average annual rate of 3.0 percent from 1961 to 2019, a rate almost twice that of annual world population growth (1.6 percent) for the same period, with annual per capita consumption reaching a record high of 20.5 kg in 2019. Preliminary estimates point to a lower consumption in 2020 due to a COVID-19-driven contraction of demand, followed by a slight increase in 2021. Despite a few exceptions, the most notable being Japan, most countries saw a rise in their per capita aquatic food consumption between 1961 and 2019, with upper-middle-income countries experiencing the strongest annual growth. Globally in 2019, aquatic foods provided about 17 percent of animal proteins and 7 percent of all proteins. For 3.3 billion people, aquatic foods provide at least 20 percent of the average per capita intake of animal protein. In Cambodia, Sierra Leone, Bangladesh, Indonesia, Ghana, Mozambique and some small island developing States, aquatic foods contribute half or more of total animal protein intake.

International **trade of fisheries and aquaculture products** has grown significantly in recent decades, expanding over continents and regions. In 2020, world exports of aquatic products, excluding algae, were worth USD 151 billion – a 7 percent decline from the 2018 record high of USD 165 billion. The value of traded aquatic products accounted for 11 percent of total agricultural trade (excluding forestry) and about 1 percent of total merchandise trade in 2020. These shares are much higher in many countries, exceeding 40 percent of the total value of merchandise trade in Cabo Verde, Iceland, Kiribati and Maldives, for example. Nearly 90 percent of the quantity of traded aquatic products, excluding algae, consisted of preserved products, the majority of which were frozen. Other exports included USD 1.9 billion from algae, inedible aquatic by-products, and sponges and corals.

From 1976 to 2020, the value of trade in aquatic products increased at an average annual rate of 6.9 percent in nominal terms and 3.9 percent in real terms (adjusted for inflation). The faster rate of growth in value relative to quantity reflects the increasing proportion of trade in high-value species and products undergoing processing or other forms of value addition.

China remains the world's largest exporter of aquatic animal products, followed by Norway and Viet Nam, with the European Union the largest single importing market. The largest importing countries are the United States of America,

5 For aquatic food, see Glossary, including Context of SOFIA 2022.

followed by China and Japan. In terms of volume (live weight), China is the top importing country of large quantities of species not only for domestic consumption but also as raw material to be processed in China and then re-exported.

2. TOWARDS BLUE TRANSFORMATION[6]

The current Decade of Action to deliver the Global Goals[7] must accelerate actions to address food security while preserving our natural resources. Aquatic foods, forecast to increase by a further 15 percent by 2030, can provide a larger proportion of humanity's nutritious food requirements. **Blue Transformation is a vision for sustainably transforming aquatic food systems**, a recognized solution for food and nutrition security and environmental and social well-being, by preserving aquatic ecosystem health, reducing pollution, protecting biodiversity and promoting social equality.

Blue Transformation focuses on sustainable aquaculture expansion and intensification, effective management of all fisheries, and upgraded value chains. This requires holistic and adaptive approaches that consider the complex interaction in agrifood systems and support multi-stakeholder interventions using existing and emerging knowledge, tools and practices to secure and maximize the contribution of aquatic food systems to global food security and nutrition.

By 2030, aquatic food production is forecast to increase by a further 15 percent, mainly by **intensifying and expanding sustainable aquaculture production**. Such growth must preserve aquatic ecosystem health, prevent pollution, and protect biodiversity and social equality. Blue Transformation aims to: (i) increase the development and adoption of sustainable aquaculture practices; (ii) integrate aquaculture into national, regional and global development strategies and food policies; (iii) expand and intensify aquaculture production to meet the growing demand for aquatic food and enhance inclusive livelihoods; and (iv) improve capacities at all levels to develop and adopt innovative technology and management practices for a more efficient and resilient aquaculture industry.

Fundamental barriers facing aquaculture production systems, governance, investment, innovations and capacity building must be addressed. Improved aquaculture systems require further technical innovations – with a focus on genetic improvements in breeding programmes, feeds, biosecurity and disease control – coupled with coherent policies and appropriate incentives along the entire value chain. Focus priority areas for innovative aquaculture practices are aquafeeds and feeding, digitalization, and the promotion of efficient and pro-environment practices. Implementing these solutions requires adequate capacity and skills, training, research and partnerships, and can benefit from developments in information and communications technology and the wider access to mobile applications and platforms.

Good governance, based on sound and enforceable legal and institutional frameworks, is fundamental to create an enabling environment to attract investment in aquaculture expansion. A balanced mix of finance and insurance services is needed at all scales to improve infrastructure and support technological innovations and mechanisms, such as carbon or nitrogen credits and blue bonds to reward blue investment for environmental benefits and ecosystem services.

Effective management of all fisheries is a core objective of Blue Transformation. **Improving fisheries management** is essential to rebuild fishery stocks, increase catches and restore ecosystems to a healthy and productive state while managing exploited resources within ecosystem boundaries. This requires transformative changes to promote governance and policy reforms, effective management frameworks, innovative technologies and adequate social protection.

6 For Blue Transformation, see Glossary.

7 In 2019, the United Nations Secretary-General called for a decade of ambitious action to deliver the Sustainable Development Goals by 2030: the Decade of Action to deliver the Global Goals.

International instruments such as the United Nations Convention on the Law of the Sea, the Code of Conduct for Responsible Fisheries and related implementation tools, including the Port State Measures Agreement, should guide governance and policy reform worldwide to enforce management actions at the country and regional levels. Intergovernmental organizations (IGOs), non-governmental organizations (NGOs) and the private sector should intensify cross-sectoral collaboration and cooperation arrangements to further strengthen their complementary roles in addressing local, national and regional fisheries management issues.

Effective management should adopt the ecosystem approach to fisheries with due consideration of tenure, rights and co-management, taking into account the benefits and trade-offs of environmental, social and economic objectives of fishery resources and aquatic ecosystems. Through co-management mechanisms, relevant stakeholders should be involved in decision-making, supported by effective monitoring, control and surveillance (MCS), increased information exchange, enforcement and strengthened coordination.

Technological advances are instrumental for effective implementation of conservation and management measures, by improving data collection, analysis and dissemination, MCS, efficiency, environmental protection and safety at sea. Social protection programmes that account for decent work and human rights positively impact resource conservation and the protection of livelihoods.

Developing – especially least developed – countries have limited technical and institutional capacities to ensure effective fisheries management. They require tailored capacity development initiatives with approaches adapted to their financial and human capacity constraints.

Aquaculture expansion and effective fisheries management depend on **innovating fisheries and aquaculture value chains**, which in turn need public and private partnerships to support new technologies, increase availability of aquatic foods, enhance consumer awareness of their benefits, reduce food loss and waste (FLW), and improve access to lucrative markets. Reducing FLW entails the implementation of multidimensional actions integrating governance, technology, skills and knowledge, services and infrastructure, and market linkages. Access to lucrative markets requires the capacity to respond to market requirements, in particular the non-tariff measures addressing consumer, environmental and social protection and using transparent and reliable traceability systems.

The **International Year of Artisanal Fisheries and Aquaculture 2022** was declared by the United Nations General Assembly to enhance global awareness and understanding of small-scale artisanal fisheries and aquaculture; foster action to support its contribution to sustainable development; and promote dialogue and collaboration between and among actors and partners, engaging key public and private stakeholders to address challenges and opportunities for small-scale fisheries and aquaculture to contribute to achieving the Sustainable Development Goals (SDGs).

3. BLUE TRANSFORMATION TO ACHIEVE THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

With less than eight years to 2030, the world is not on track to end hunger and malnutrition and achieve the SDGs. The COVID-19 pandemic reversed previously favourable trends.
In line with the 2030 Agenda for Sustainable Development, the **Decade of Action to deliver the Global Goals** intends to strengthen the strategies of countries, IGOs, NGOs and civil society organizations to promote a fair, prosperous and sustainable world.

Fisheries and aquaculture contribute to most SDGs, in particular, SDG 14 (Life below water), which is dedicated to the ocean and its marine resources. FAO, as custodian of four

SDG indicators that concern the sustainable use of marine living resources, is leveraging and adapting existing global monitoring and reporting mechanisms to integrate national data. SDG Indicators 14.6.1 and 14.b.1 now reveal encouraging trends regarding levels of policy implementation. Recent and upcoming methodology enhancements are designed to address limited national capacities in many developing countries to measure the sustainability of marine fishery stocks (SDG Indicator 14.4.1), and to allow countries to better understand the importance of sustainable fisheries for their national economies (SDG Indicator 14.7.1). With regard to ocean environmental status (SDG Targets 14.1, 14.3 and 14.5), while some indicators reveal worsening trends and accelerating rates of pollution, there is clear progress and a strong political will to enact national legislation on protection of marine environments.

Most importantly, reporting the true contribution of fisheries and aquaculture to the 2030 Agenda is still hampered because the SDG 14 indicators cover mostly marine capture fisheries; the contribution of aquaculture has not always been clearly identified or communicated, and the contribution of inland fisheries and aquaculture to food and nutrition is absent from current SDG texts.

The **United Nations Decade of Ocean Science for Sustainable Development (2021–2030)** (UNDOSSD) recognizes that a strong science-policy interface is crucial to design sustainable solutions and ultimately enshrine decisions, agreements and actions in the best available evidence. The UNDOSSD Implementation Plan, a highly participatory and inclusive process, builds on existing achievements to deliver across geographies, sectors, disciplines and generations, address ten priority challenges and unite the Decade partners in collective action. To address the challenges relevant to fisheries and aquaculture, they seek to generate knowledge, support innovation, address inequalities in ocean science capacity and develop solutions to optimize the role of the ocean in food security under changing environmental, social and climate conditions.

The **United Nations Decade on Ecosystem Restoration**, co-led by FAO and the United Nations Environment Programme, calls for the global revival of ecosystems and their services by restoring habitats and species to ensure productive and resilient social-environmental systems in the face of ongoing and future challenges.

Restoring inland, coastal and marine ecosystems requires adequate governance and support to incorporate conservation and sustainable production actions by multiple actors, sectors and jurisdictions. The Decade represents an opportunity to build and link networks and partnerships across the globe, strengthening the restoration–science–policy nexus.

Restoring fisheries productivity requires the rehabilitation of mangrove forests, seagrass meadows and reefs, watersheds and wetlands, and effective management to rebuild fishery stocks and reduce adverse impacts of fishing on ecosystems. Actions in aquaculture aim to restore ecosystem structure and function to support food provisioning, while minimizing pollution, invasive alien species, waste and the emergence of diseases.

The Post-2020 Global Biodiversity Framework faces three important challenges: (i) to broaden its adoption and delivery outside the conservation community, widening ownership of challenges and solutions for biodiversity; (ii) to match resources for implementation of change to the ambition of its tasks; and (iii) to engage in a dynamic process that can be well measured and communicated.

To integrate these challenges into their plans of action, stakeholders must support strengthening the nexus between biodiversity restoration, economic benefit and livelihoods. Initiatives and actions – including those implemented by FAO – provide the required support for the recovery of vulnerable species and habitats, including characterizing of threatened species, National Plans of Action on sharks and seabirds, area-based fisheries management, and basin-based management of inland fisheries. Other actions aim at optimizing sustainable biodiversity use by addressing risks and mitigation associated with farmed aquatic diversity, reducing bycatch and the pollution caused by abandoned, lost and discarded fishing gear, and using selective fishing technology.

4. EMERGING ISSUES AND OUTLOOK

Since March 2020, the COVID-19 pandemic has swept through continents and countries causing unprecedented health, social and economic damage, including to fisheries and aquaculture. Worldwide, **COVID-19, a crisis like no other**, entailed lockdowns and closures of markets, ports and borders resulted in significant slowdown of trade, causing disruption in aquatic food production and distribution and loss of employment and livelihoods.

Fishing was disrupted and aquaculture struggled to maintain its planned production cycles. Supply chains dominated by small and medium enterprises were particularly vulnerable to COVID-19 restrictions. Vulnerable and marginalized people were disproportionately affected, with women enduring greater employment declines and loss of household livelihoods. Recovery was gradual by diversifying household income with other agricultural activities, streamlining business costs, targeting local markets and embracing online marketing and direct delivery.

Governments adopted diverse and complex health, social, economic, education and environmental support measures, depending on national priorities, capacity and resources. Countries with functioning social protection systems responded more efficiently to mitigate the impacts of the pandemic. Unfortunately, informal workers, numerous in the fisheries and aquaculture sectors, were often excluded.

The pandemic exposed the interconnectivity of markets and supply chains and the need for inclusive and shock-responsive national social protection systems. On the positive side, the crisis accelerated digitalization, and encouraged e-monitoring and enforcement, the use of green energy and clean technologies and the development of local production and markets.

Increased warming has caused irreversible changes requiring urgent ocean-based action to strengthen and accelerate climate mitigation and adaptation measures, increasing the urgency of **fisheries and aquaculture adaptations to climate change**. This calls for the explicit consideration of climate stressors in fisheries and aquaculture management by connecting adaptation plans and management or development actions, including local and context-specific indicators associated with climate stressors of fisheries and aquaculture.

Transformative adaptation plans are required at national and local levels, with particular attention to the most vulnerable using an inclusive and participatory approach and considering the needs and benefits of small-scale fisheries and aquaculture. These plans would benefit from adopting climate-informed spatial management approaches, integrating equity and human rights considerations and investing in innovation.

At the twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change in Glasgow (COP26), the key role of oceans was strengthened, opening opportunities for fisheries and aquaculture to expand its contribution to global efforts, sharing adaptation and mitigation solutions, and raising the profile of inland fisheries and aquaculture within the international climate discussions.

Advancing towards gender equality in fisheries and aquaculture is fundamental for sustainability and inclusiveness. Despite their significant role in the sector, women are mostly engaged in the informal, lowest paid, least stable and least skilled segments of the workforce. Because of social, cultural and economic contexts, they often face gender-based constraints that prevent them from fully realizing and benefiting from their roles in the sector. This is further complicated by limited access to information, services, infrastructure, markets, social protection and decent employment, decision-making and leadership positions.

The FAO Policy on Gender Equality guided the adoption of key FAO instruments and ways to promote gender transformative approaches that support the role of women as key agents of change to achieve Blue Transformation.

Based on economic, policy and environmental assumptions, FAO prepares an outlook for fisheries and aquaculture production, utilization, trade, prices and key issues that might influence future supply and demand. FAO **fisheries and aquaculture projections** to 2030 point to an increase in production, consumption and trade, albeit at slower growth rates. Total production of aquatic animals is expected to reach 202 million tonnes in 2030, with the main increase coming from aquaculture, contributing 106 million tonnes in 2030. World capture fisheries is projected to increase to reach 96 million tonnes, as a result of recovering stocks of certain species owing to improved resource management, growth in catches of underfished resources, and reduced discards, waste and losses.

In 2030, 90 percent of all aquatic animal production will be for human consumption, an overall increase of 15 percent compared with 2020. This means annual per capita consumption will increase from 20.2 kg in 2020 to 21.4 kg in 2030, a result of high demand due to rising incomes and urbanization, linked with the expansion of production, improvements in post-harvest operations and distribution and changes in dietary trends. Aquatic food supply will increase in all regions, while per capita consumption is expected to decline slightly in Africa, in particular in sub-Saharan Africa, raising concerns in terms of food security.

Trade in aquatic products will continue to expand, but at a slower pace than in the previous decade, reflecting the slowdown in production growth, higher prices restraining overall demand and consumption, and stronger domestic demand in some of the major producing and exporting countries, such as China. A stable share (36 percent) of total production will be exported in 2030 with an increasing contribution from aquaculture. In quantity terms, China will continue to be the major exporter of aquatic food, followed by Viet Nam and Norway. The European Union, Japan and the United States of America will account for 39 percent of total imported volumes of aquatic food consumption in 2030.

Prices of internationally traded aquatic products are estimated to increase by 33 percent in nominal terms in 2030. This increase will be driven by improved incomes, population growth, strong demand, reduced supply and increased production cost pressure from inputs such as feed, energy and fish oil. ■

GUYANA
Fishers on small vessels moored in an estuarine landing site – FISH4ACP improving value chains.
©FAO/Nieuw Image Media

PART 1
WORLD REVIEW

GLOBAL FISHERIES AND AQUACULTURE AT A GLANCE

The fisheries and aquaculture sectors have been increasingly recognized for their essential contribution to global food security and nutrition in the twenty-first century. Further expansion of this contribution requires the acceleration of transformative changes in policy, management, innovation and investment to achieve sustainable and equitable global fisheries and aquaculture. *The State of World Fisheries and Aquaculture 2022*[1] presents updated and verified statistics[2] of the sector (Box 1) and analyses its international policy context and selected high-impact initiatives and actions undertaken to accelerate international efforts to support achievement of the Sustainable Development Goals. It looks at the impact and implications of the COVID-19 pandemic on fisheries and aquaculture production,[3] utilization and trade.

Global production of aquatic animals was estimated at 178 million tonnes in 2020, a slight decrease from the all-time record of 179 million tonnes in 2018 (Table 1 and Figure 1). Capture fisheries contributed 90 million tonnes (51 percent) and aquaculture 88 million tonnes (49 percent). Of the total production, 63 percent (112 million tonnes) was harvested in marine waters (70 percent from capture fisheries and 30 percent from aquaculture) and 37 percent (66 million tonnes) in inland waters (83 percent from aquaculture and 17 percent from capture fisheries). The total first sale value of the global production was estimated at USD 406 billion, comprising USD 141 billion for capture fisheries and USD 265 billion for aquaculture. In addition to aquatic animals, 36 million tonnes (wet weight) of algae[3] were produced in 2020, of which 97 percent originated from aquaculture, mostly marine aquaculture.

Of the overall production of aquatic animals, over 157 million tonnes (89 percent) were used for human consumption. The remaining 20 million tonnes were destined for non-food uses, to produce mainly fishmeal and fish oil (16 million tonnes or 81 percent) (Figure 2).

Global apparent consumption[3] of aquatic foods[3] increased at an average annual rate of 3.0 percent from 1961 to 2019, a rate almost twice that of annual world population growth (1.6 percent) for the same period. Per capita consumption of aquatic animal foods grew by about 1.4 percent per year, from 9.0 kg (live weight equivalent) in 1961 to 20.5 kg in 2019. Preliminary data for 2020 point to a slight decline to 20.2 kg. In the same year, aquaculture accounted for 56 percent of the amount of aquatic animal food production available for human consumption. During recent decades, per capita consumption of aquatic foods has been influenced most strongly by increased supplies, changing consumer preferences, advancements in technology and income growth.

1 Note that this 2022 edition of *The State of World Fisheries and Aquaculture* includes for the first time a Glossary which reflects the ongoing expansion of the terminology resulting from sector's increasing role in food security, human nutrition and trade.

2 In Part 1 World Review, if not expressly indicated, the statistical analysis on production, utilization, consumption and trade is carried out separately for aquatic animals (excluding aquatic mammals and reptiles) and algae. Detailed coverage of species and specific sectorial exclusions are indicated in the Glossary.

3 For algae, apparent consumption, aquatic foods, and fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

BOX 1 MORE THAN SEVEN DECADES OF FAO FISHERIES AND AQUACULTURE STATISTICS: 1950–2020

Statistics are a core function of FAO. Since its foundation, FAO has been mandated to collect, compile, analyse and disseminate information relating to nutrition, food and agriculture through Article 1 of the FAO Constitution.[1] The FAO statistical system plays an essential role in the fields of agriculture and food, supporting countries' policies to eradicate hunger and promote the sustainable use of natural resources by making informed decisions through access to high-quality and comprehensive data. In particular, FAO provides the only source of global fisheries and aquaculture statistics, FishStat, which represents a unique global public good for sector analysis and monitoring. These statistics are structured within different data collections (production of capture fisheries and aquaculture, processing, trade, fleet, employment and consumption) freely accessible to users in different formats in a range of tools and products by country or country groups, species or species groups, harvest environment, etc. The year 2022 is a major milestone for FAO, as it marks the coverage of its fisheries and aquaculture statistics for the years 1950–2020 for the majority of its datasets – the longest time series of any statistical dataset published by FAO. A series of initiatives, including workshops and dedicated publications, will celebrate this major event, with the aim of improving interaction and engagement with Members and users in order to meet their needs.

FAO fisheries and aquaculture statistics are based primarily on data collected annually from national sources through questionnaires specific to each dataset and country data. Every year countries are requested to provide data for the latest year, as well as validate and revise data for the most recent years. The quality of the FAO statistics is highly dependent upon the accuracy and reliability of the data collected and provided by countries. FAO strives to validate and ensure the quality of official data received. These statistics are carefully analysed and cross-checked with different datasets and other available information. When anomalies or gaps in the data are identified, FAO interacts with countries to explore these issues and find ways to resolve them in collaboration with the countries concerned in order to ensure consistency in the dissemination of official data.

However, the process of resolving inconsistencies in the data is often slow and time-consuming. When necessary, FAO estimates are applied (marked with a flag "E") in the databases and disseminated data. This often encourages corrective action by the country and many countries have collaborated with FAO to address issues concerning the reliability of their fisheries and aquaculture statistics.

National statistics provided by the countries are the main, but not the only, source of data used by FAO to maintain its fisheries and aquaculture statistics databases. Statistics provided by national authorities are complemented, and in some cases replaced, by alternative and more reliable data. This is the case of catches disseminated by the regional fishery bodies (RFBs). The Coordinating Working Party on Fishery Statistics (CWP), at its eighteenth session in 1999,[2] recommended "its members should in general regard as the most reliable source of data those held by the regional body which has assessment responsibility for the stock" and which are considered to represent the "best scientific estimate". Based on this recommendation, FAO regularly compares the catch data received from national offices, in particular for tuna and tuna-like species, with those validated by RFBs.

When data are not reported or only partially reported, FAO implements estimates based on the best information available from alternative sources, including those from RFBs in the case of capture fisheries. As the leading agency/organization for collecting and disseminating global fisheries and aquaculture statistics, FAO is obliged to estimate data for all non-reporting countries as well as for countries reporting partial information, to enable meaningful aggregates at the global, regional and national levels. This is particularly important given FAO's key role in calculating Food Balance Sheets to assess the pattern of a country's food supply and monitor trends in food availability and food security.

Knowledge of the status and trends across the entire value chain is key for sound policymaking and to assess and track the performance of fisheries and aquaculture management. FAO is committed in its efforts to make major improvements in terms of coverage of detail by species and country. At the same time, the demand for more detailed and timely statistics by sector and at national and subnational level has increased significantly.

Limited availability of information often constrains policymaking and planning. Nevertheless, the last two decades have seen little significant improvement in the general availability of data in many countries because of human and financial resource constraints. This is particularly the case for statistics from small-scale and subsistence fisheries. Also, many key statistics are missing at the global level, such as economic and social data, discards and fishing capacity.

In addition to providing data for global monitoring, FAO is recognized for its fundamental role in providing technical assistance services and capacity development in fisheries statistics to many countries,

BOX 1 (Continued)

as well as developing methods and standards for fisheries and aquaculture statistics and facilitating global cooperation through the inter-agency CWP established in 1960 of which FAO is Secretariat. FAO strongly believes that working with countries is the only effective way to improve fisheries and aquaculture statistics, primarily to support policies that address national needs for food security and fisheries and aquaculture management, but also to meet the needs of RFBs and FAO. Still, FAO recognizes that improvements in major national data collection schemes require financial, human and technological resources for countries to build appropriate capacities to implement and maintain often complex and resource-intensive data collection, processing and reporting systems.

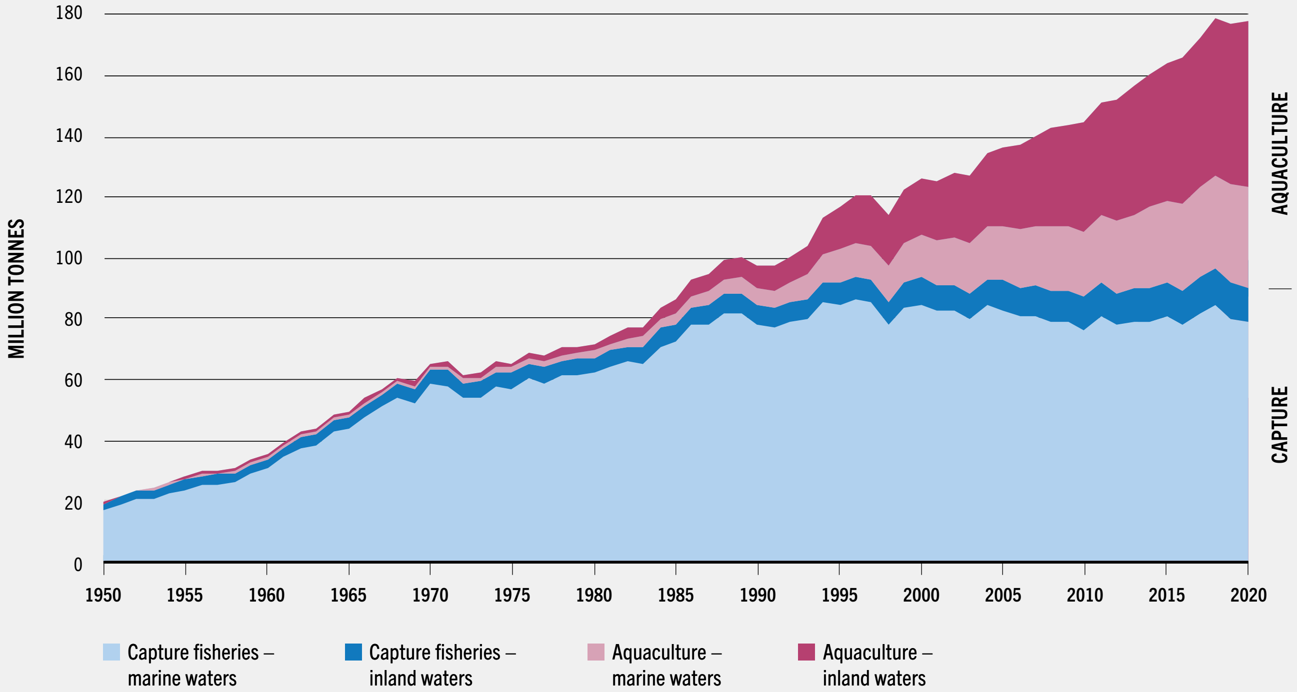
[1] FAO. 2017. *Basic texts of the Food and Agriculture Organization of the United Nations*. Volumes I and II, 2017 edition. Rome. www.fao.org/3/mp046e/mp046e.pdf
[2] FAO. 1999. *Report of the eighteenth session of the Coordinating Working Party on Fishery Statistics, Luxembourg, 6–9 July 1999*. FAO Fisheries Report No. 608. Rome. www.fao.org/3/x3554e/x3554e.pdf

TABLE 1 WORLD FISHERIES AND AQUACULTURE PRODUCTION, UTILIZATION AND TRADE[1]

	1990s	2000s	2010s	2018	2019	2020
	Average per year					
	Million tonnes (live weight equivalent)					
Production						
Capture:						
Inland	7.1	9.3	11.3	12.0	12.1	11.5
Marine	81.9	81.6	79.8	84.5	80.1	78.8
Total capture	**88.9**	**90.9**	**91.0**	**96.5**	**92.2**	**90.3**
Aquaculture:						
Inland	12.6	25.6	44.7	**51.6**	**53.3**	**54.4**
Marine	9.2	17.9	26.8	**30.9**	**31.9**	**33.1**
Total aquaculture	**21.8**	**43.4**	**71.5**	**82.5**	**85.2**	**87.5**
Total world fisheries and aquaculture	**110.7**	**134.3**	**162.6**	**178.9**	**177.4**	**177.8**
Utilization[2]						
Human consumption	81.6	109.3	143.2	156.8	158.1	157.4
Non-food uses	29.1	25.0	19.3	22.2	19.3	20.4
Population (billions)[3]	5.7	6.5	7.3	7.6	7.7	7.8
Per capita apparent consumption (kg)	14.3	16.8	19.5	20.5	20.5	20.2
Trade						
Exports – in quantity	39.6	51.6	61.4	66.8	66.6	59.8
Share of exports in total production	*35.8%*	*38.5%*	*37.7%*	*37.3%*	*37.5%*	*33.7%*
Exports – in value (USD 1 billion)	46.6	76.4	141.8	165.3	161.8	150.5

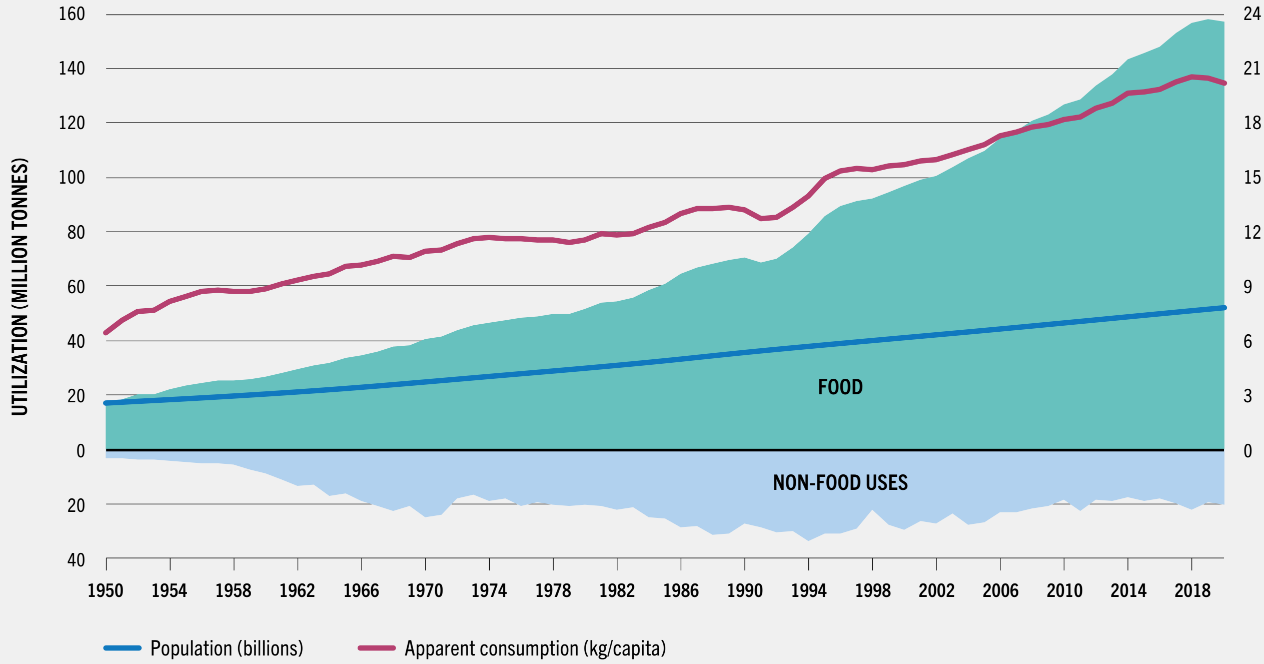
[1] Excluding aquatic mammals, crocodiles, alligators and caimans and algae. Totals may not match due to rounding.
[2] Utilization data for 2018–2020 are provisional estimates.
[3] Source of population figures: United Nations. 2019. 2019 Revision of World Population Prospects. In: *UN*. New York. Cited 22 April 2022. https://population.un.org/wpp
SOURCE: FAO.

FIGURE 1 WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

FIGURE 2 WORLD FISHERIES AND AQUACULTURE PRODUCTION: UTILIZATION AND APPARENT CONSUMPTION



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent. For algae and apparent consumption, see Glossary, including Context of SOFIA 2022. Source of population figures: United Nations. 2019. 2019 Revision of World Population Prospects. In: *UN*. New York. Cited 22 April 2022. https://population.un.org/wpp
SOURCE: FAO.

Aquatic foods remain some of the most traded food commodities in the world, with 225 states and territories reporting some trading activity of fisheries and aquaculture products[4] in 2020. World exports of aquatic products[4] in 2020, excluding algae, totalled about 60 million tonnes live weight, worth USD 151 billion (Table 1). This represents a major decline (8.4 percent in value and 10.5 percent in volume) from the record high of 67 million tonnes, worth USD 165 billion, reached in 2018. Overall, from 1976 to 2020, the value of global exports of fisheries and aquaculture products (excluding algae) increased at an average annual growth rate of 6.9 percent in nominal terms and 3.9 percent in real terms (adjusted for inflation), corresponding to an annual growth rate of 2.9 percent in terms of quantity over the same period. ■

TOTAL FISHERIES AND AQUACULTURE PRODUCTION[4]

Total fisheries and aquaculture production (excluding algae[4]) has significantly expanded in the past seven decades going from 19 million tonnes (live weight equivalent) in 1950 to an all-time record of about 179 million tonnes in 2018, with an annual growth rate of 3.3 percent. Production then declined marginally in 2019 (a fall of 1 percent compared with 2018), before increasing by a mere 0.2 percent to reach 178 million tonnes in 2020. The total first sale value of fisheries and aquaculture production of aquatic animals in 2020 was estimated at USD 406 billion, of which USD 265 billion came from aquaculture production.

The stagnation experienced in the last two years is mainly linked to a slight decline in capture fisheries, which decreased by 4.5 percent in 2019 compared with the 2018 peak of 96 million tonnes, and then by a further 2.1 percent in 2020. This decline was due to various factors, including fluctuating catches of pelagic species, particularly anchoveta, the recent reduction in China's catches and the impacts of COVID-19 on the sector in 2020 (see the sections Capture fisheries production, p. 10, and COVID-19, a crisis like no other, p. 195, and Box 2). Furthermore, aquaculture production (the main driver of the growth of total production since the late 1980s) continued to expand, albeit at a slower rate in the last two years (3.3 percent in 2018–2019 and 2.6 percent in 2019–2020 versus an average of 4.6 percent per year during the period 2010–2018) (see the section Aquaculture production, p. 26). These lower growth rates are due to a range of factors, including the impact of policy changes in China focused on environmental protection and various issues linked to COVID-19 in 2020 that not only impacted production for export markets, but also reduced availability of workers, supplies and inputs (including feed, fingerlings and ice), while disruption to transportation and marketing, plus sanitary measures, also left their mark. As aquaculture has grown faster than capture fisheries during the last two years, its share of total fisheries and aquaculture production has further increased. Of the 178 million tonnes produced in 2020, 51 percent (90 million tonnes) was from capture fisheries and 49 percent (88 million tonnes) from aquaculture (Figure 3). This represents a major change from the 4 percent share of aquaculture in the 1950s, 5 percent in the 1970s, 20 percent in the 1990s and 44 percent in the 2010s.

Of the total production, 63 percent (112 million tonnes) was harvested in marine waters (70 percent from capture fisheries and 30 percent from aquaculture) and 37 percent (66 million tonnes) in inland waters (83 percent from aquaculture and 17 percent from capture fisheries) (Figure 4). The expansion of aquaculture in the last few decades has boosted the overall growth of production in inland waters. In 1950, production in inland waters represented only 12 percent of the total fisheries and aquaculture production and, with some fluctuations, this share remained relatively stable until the late 1980s. Then, with the growth of aquaculture production, it gradually increased to 18 percent in the 1990s, 28 percent in the 2000s and 34 percent in the 2010s. Despite this growth, capture fisheries in marine waters still represent

4 For algae, aquatic products, fisheries and aquaculture production, and fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

BOX 2 IMPACTS OF COVID-19 ON GLOBAL FISHERIES AND AQUACULTURE PRODUCTION AND RELATED STATISTICS

The COVID-19 pandemic has had a profound impact on fisheries and aquaculture globally (see the section COVID-19, a crisis like no other, p. 195), driven by changes in consumer demand, market disruption and the logistical difficulties of ensuring stringent containment measures that prevented or hampered fishing and aquaculture activities, including lockdowns, curfews, physical distancing in operations and onboard vessels, and port restrictions.

In some countries, lockdowns caused drops in demand with a consequent decline in the prices of fisheries and aquaculture products. Many fishing fleets or aquaculture operations stopped running or reduced their activities, as their work became unprofitable, in particular during the 2020 pandemic waves. In some cases, fisheries quotas were not filled due to low demand, market closures and/or lack of cold storage capacity. Movement restrictions impacted professional seafarers, including at-sea fisheries observers and marine personnel in ports, thereby preventing crew changes and repatriation of seafarers. In aquaculture, unsold produce resulted in higher costs for feeding and increased mortality rate among aquatic animals. Fisheries and aquaculture production relying on export markets was more impacted than that serving domestic markets due to market closures, increased freight costs, flight cancellations and border restrictions. However, domestic fresh fish and shellfish supply was also severely impacted by the closure of food service sectors (e.g. hotels, restaurants and catering facilities, including school and work canteens).[1]

Globally, the impact varied with many countries reporting sharp drops in capture and aquaculture production during the first weeks and months of the crisis followed by improvements as the sector adapted. For example, at the height of the COVID-19 crisis in the United States of America, it is estimated that catches dropped by up to 40 percent across the country.[2] Similarly, reductions in fishing effort were noted in Africa, Asia, Europe and Oceania, particularly in the case of fleets relying extensively on export markets of higher-value species such as lobster or tunas.

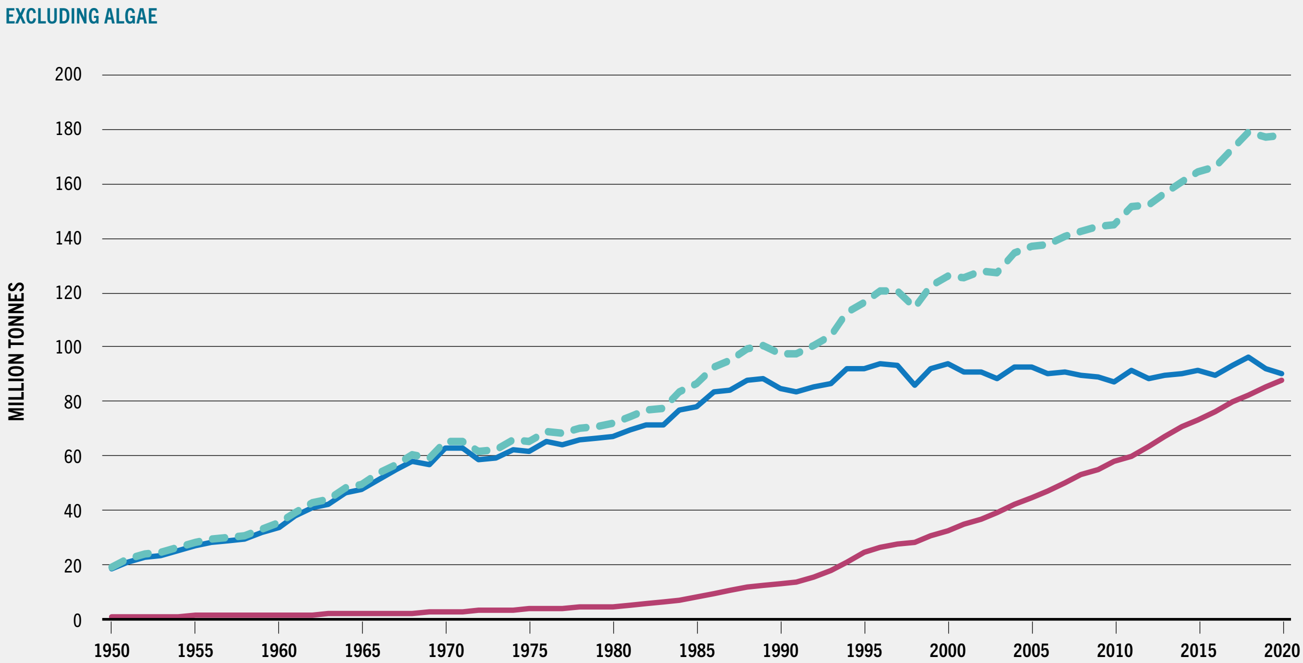
In some countries, the effective impact of the pandemic on the fisheries and aquaculture sector could not always be well monitored as the routine collection and processing of fisheries and aquaculture statistics was severely disrupted, also opening doors for illegal, unreported and unregulated fishing activities. Likewise, in many cases, surveys at sea stopped entirely, jeopardizing the collection of crucial data for stocks assessment across space and time. In other cases, scientific observers could not be deployed at sea due to difficulties ensuring sanitary measures (e.g. physical distancing between crew members at sea) or lack of necessary supplies (e.g. face masks and gloves). Collection of data from aquaculture facilities was also seriously affected.

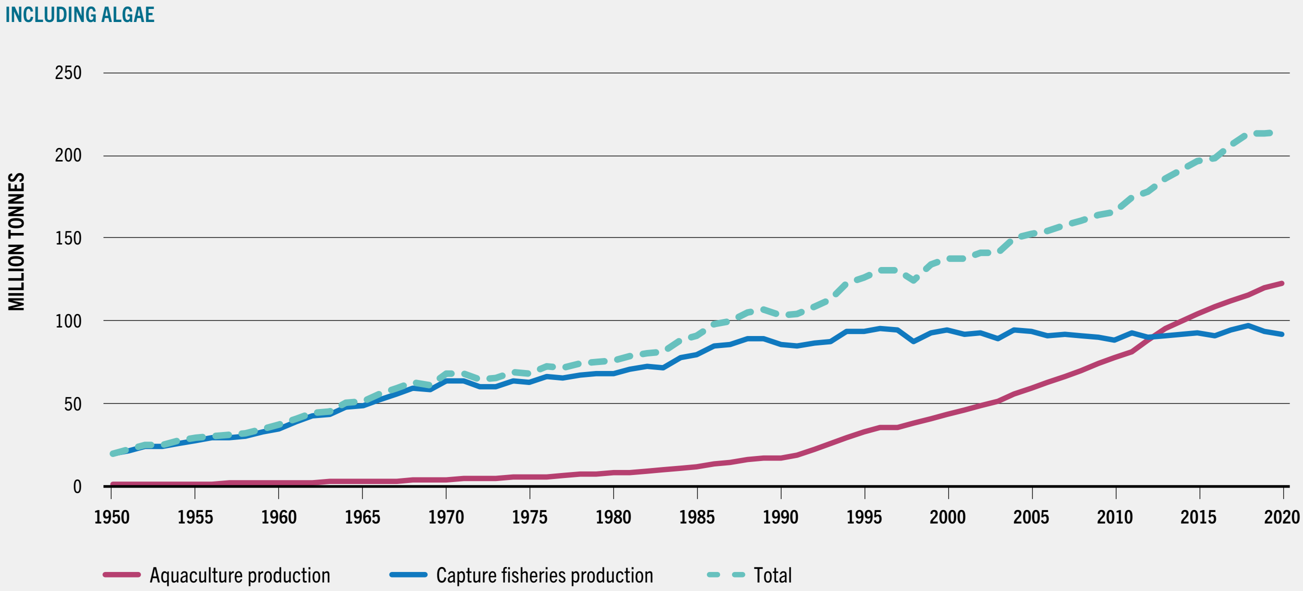
Traditional collection of fisheries and aquaculture data at landing sites was routinely suspended in many countries. This was also the case for household surveys and censuses that are important sources of information to assess the socio-economic dimension of the sector and its trends. Overall, COVID-19 brought a new set of challenges to national statistics systems and operations. These challenges were not homogeneous among countries or even within the same country, as some had better institutional, financial, technological and digital capacities to develop solutions. In some cases, alternative data collection approaches and methods were implemented, while in other countries data were not collected for several months or only partially collected. For some countries, there is a risk that the different approaches adopted or the partial coverage may have affected the quality and comparability of their data for 2020. In terms of the data reported to FAO, COVID-19 exacerbated ongoing issues of late or non-reporting of fisheries and aquaculture statistics in 2020 and 2021. In addition, data reported by a few countries included anomalous trends that necessitated direct follow-up with the countries concerned, as well as cross-checking with other sources to ensure the quality and consistency of the data disseminated by FAO.

[1] FAO. 2020. Novel Coronavirus (COVID-19). Q&A: COVID-19 pandemic – impact on fisheries and aquaculture. In: *FAO*. Rome. Cited 19 April 2022. www.fao.org/2019-ncov/q-and-a/impact-on-fisheries-and-aquaculture/en

[2] White, E.R., Froehlich, H.E., Gephart, J.A., Cottrell, R.S., Branch, T.A., Bejarano, R.A. & Baum, J.K. 2020. Early effects of COVID-19 on US fisheries and seafood consumption. *Fish and Fisheries*, 22(1): 232–239. https://doi.org/10.1111/faf.12525

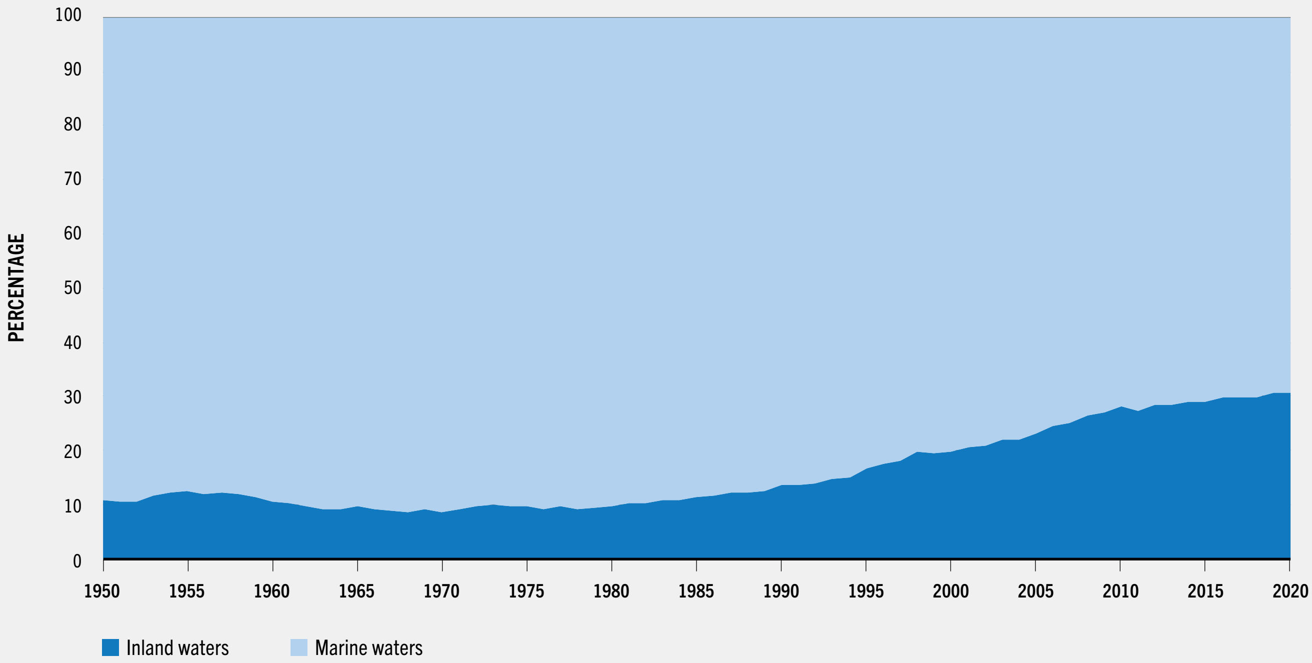
FIGURE 3 WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION (EXCLUDING AND INCLUDING ALGAE)





NOTES: Excluding aquatic mammals, crocodiles, alligators and caimans. Data expressed in live weight equivalent.
SOURCE: FAO.

FIGURE 4 SHARE OF WORLD TOTAL FISHERIES AND AQUACULTURE PRODUCTION BY INLAND AND MARINE WATERS

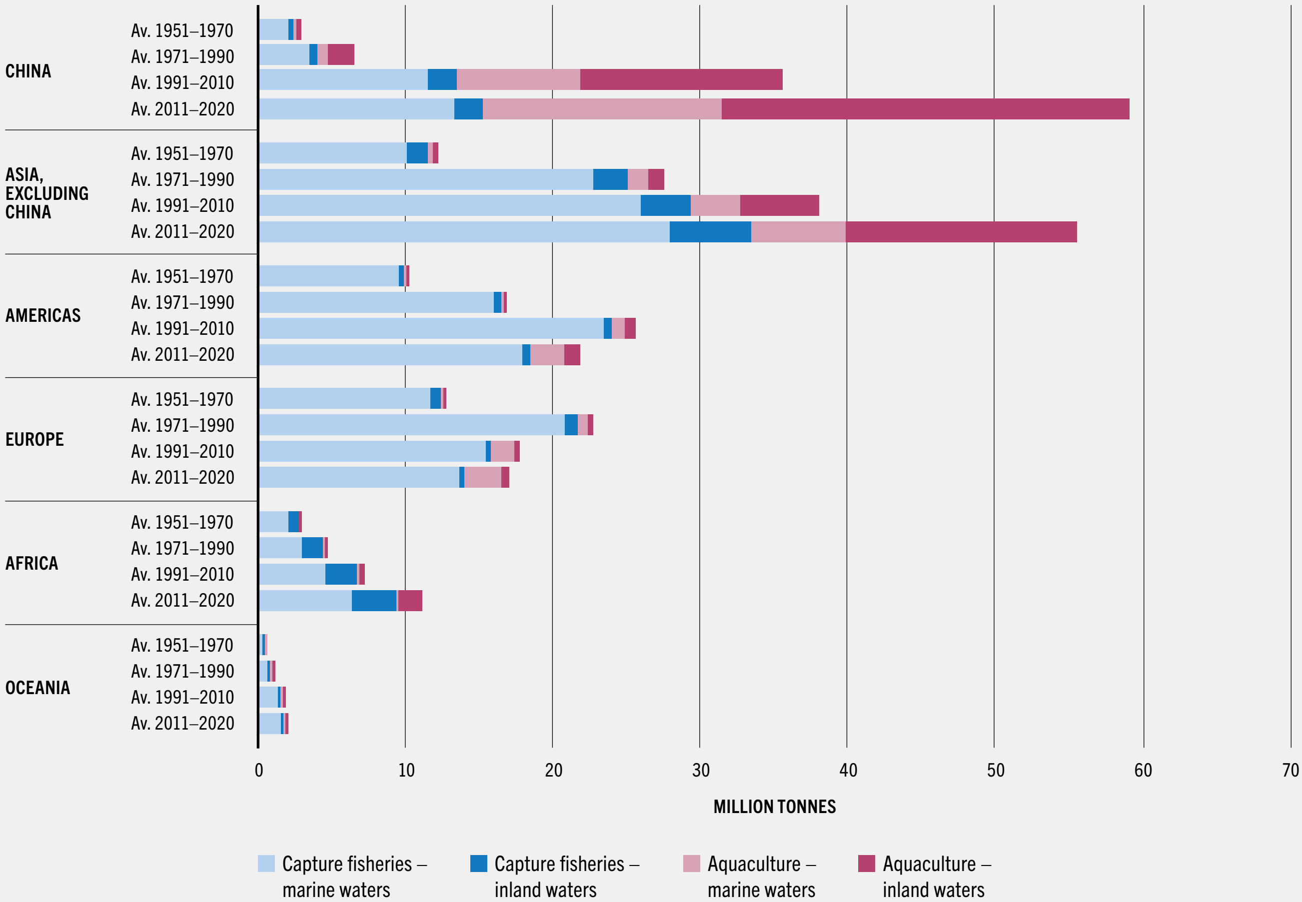


NOTE: Excluding aquatic mammals, crocodiles, alligators and caimans and algae.
SOURCE: FAO.

the main source of production (44 percent of total aquatic animal production in 2020, compared with about 87 percent in the 1950–1980 period) and the dominant method of production for several species. Following several decades of sustained growth, marine capture fisheries have remained fairly stable since the late 1980s at around 80 million tonnes, with some interannual fluctuations (up and down) in the range of 3–4 million tonnes.

This general trend masks considerable variations between continents, regions and countries. In 2020, Asian countries were the main producers, accounting for 70 percent of the total fisheries and aquaculture production of aquatic animals, followed by countries in the Americas (12 percent), Europe (10 percent), Africa (7 percent) and Oceania (1 percent). Overall, total fisheries and aquaculture production has seen important increases in all the continents in the last few decades (Figure 5). The exceptions are Europe (with a gradual decrease from the late 1980s, but recovering slightly in the last few years to 2018, to then decline again) and the Americas (with several ups and downs since the peak of the mid-1990s, mainly due to fluctuations in catches of anchoveta), whereas it has almost doubled during the last 20 years in Africa and Asia. Yet, compared with 2019, total production of aquatic animals in 2020 declined by 3 percent for African countries and 5 percent for countries in Oceania, most probably as a result of COVID-19. In 2020, China continued to be the major producer with a share of 35 percent of the total, followed by India (8 percent), Indonesia (7 percent), Viet Nam (5 percent) and Peru (3 percent). These five countries were responsible for about 58 percent of the world fisheries and aquaculture production of aquatic

FIGURE 5 REGIONAL CONTRIBUTION TO WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION



NOTES: Excluding aquatic mammals, crocodiles, alligators and caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

animals in 2020. Differences exist also in terms of the sector's contribution to economic development. In recent decades, a growing share of total fisheries and aquaculture production has been harvested by low- and middle-income countries (from about 33 percent in the 1950s to 87 percent in 2020). In 2020, upper-middle-income countries, including China, were the main producers, responsible for 49 percent of the total production of aquatic animals, followed by lower-middle-income countries (32 percent), high-income countries (17 percent) and, finally, low-income countries (2 percent).

Major differences can be noticed when analysing the data by FAO Major Fishing Area. In 2020, about 33 percent of the total production of aquatic animals was produced in inland waters in Asia, followed by 22 percent in the Pacific Northwest and 10 percent in the Western Central Pacific. Overall, in the 1950s, more than 40 percent of production was harvested in the Atlantic Ocean; in contrast, in 2020, the largest share of total production originated in the Pacific Ocean (40 percent) and just 13 percent in the Atlantic Ocean. Production differs from area to area depending on several factors, including the level of development of the countries surrounding those areas, the fisheries and aquaculture management measures implemented, the amount of illegal, unreported and unregulated (IUU) fishing, the status of fishery stocks, the availability and quality of the inland waters, and the composition of the species harvested. For example, for some fishing areas, capture fisheries can fluctuate more when catches comprise a high proportion of small pelagic fish, which are more prone to large fluctuations – linked, in some areas, to climatic variability, as is the case for catches of anchoveta in the Pacific Southeast in South America.

A large number of species are harvested every year, with the number and species varying from region to region. In 2020, finfish represented 76 percent of the total production of aquatic animals, with marine fishes representing 51 percent of the total finfish and 39 percent of the total aquatic animal production, followed by freshwater fishes, representing 43 percent of the total finfish and 33 percent of the total aquatic animal production[5] (Figure 6). Carps, barbels and other cyprinids represented the main group of species produced in 2020, with a share of 18 percent of the production of aquatic animals, followed by miscellaneous freshwater species and Clupeiforms such as herrings, sardines and anchovies. At the level of species, with 5.8 million tonnes, whiteleg shrimp (*Penaeus vannamei*) was the top species produced in 2020, closely followed by grass carp(=white amur; *Ctenopharyngodon idellus*), cupped oysters nei (*Crassostrea* spp.), silver carp (*Hypophthalmichthys molitrix*) and anchoveta(=Peruvian anchovy; *Engraulis ringens*).

In addition to the 178 million tonnes of aquatic animals, 36 million tonnes (wet weight) of algae were produced in 2020, of which 97 percent originated from aquaculture. Production of algae has experienced an impressive growth in the past few decades as it was at 12 million tonnes in 2000 and 21 million tonnes in 2010. However, it increased by only 2 percent in 2020 compared with 2019. Asian countries confirmed their role as major producers with a share of 97 percent of the total production of algae.

China alone as leading producer accounted for 58 percent of the overall total in 2020, followed by Indonesia (27 percent) and the Republic of Korea (5 percent).

If production of algae is added to that of aquatic animals, fisheries and aquaculture production reached an all-time record of 214 million tonnes in 2020, with an overall growth of only 0.4 percent compared with 2019 and of 0.3 percent compared with the previous record of 2018. Of this overall total, Asian countries produced 75 percent in 2020, followed by countries in the Americas (10 percent), Europe (8 percent), Africa (6 percent) and Oceania (1 percent). In the total fisheries and aquaculture production of aquatic animals and algae, aquaculture had already overtaken capture fisheries as the primary source of aquatic production in 2013, and its share in total production reached 57 percent in 2020 (Figure 3). ■

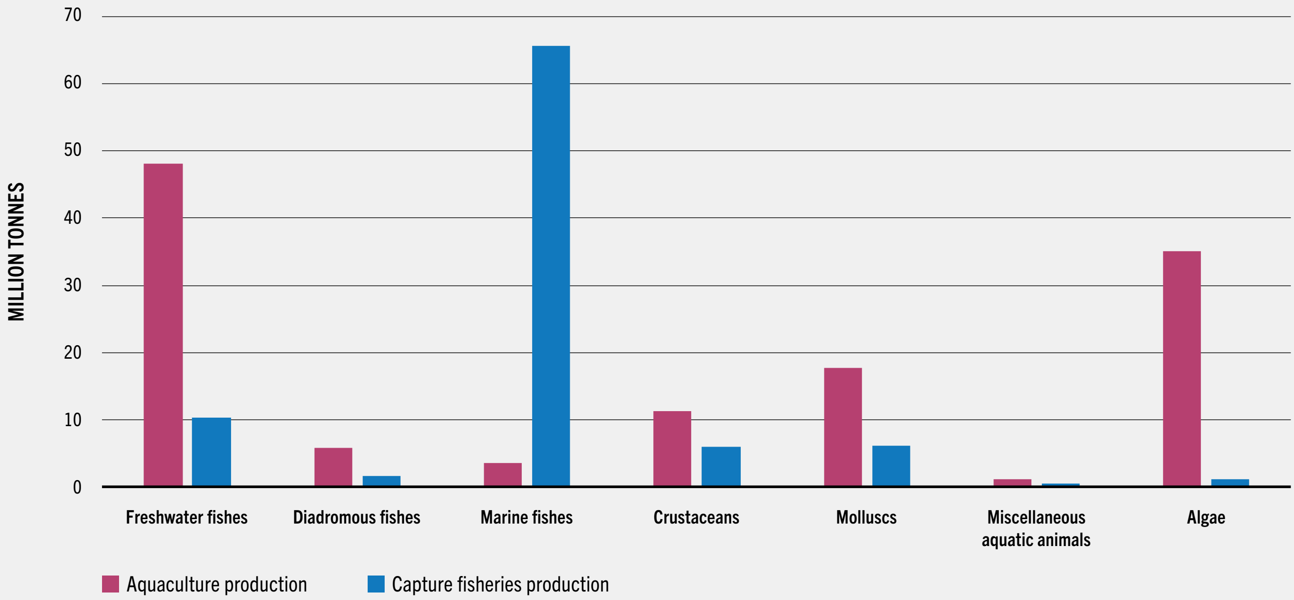
CAPTURE FISHERIES PRODUCTION

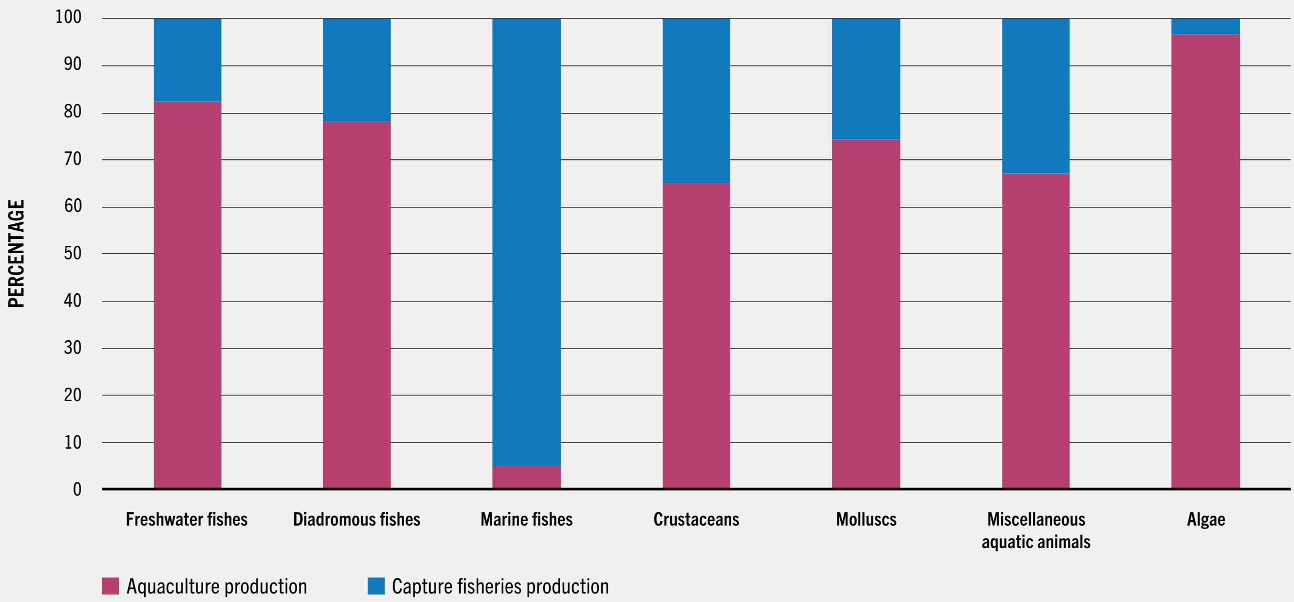
In 2020, global capture fisheries production (excluding algae[6]) was 90.3 million tonnes (Table 1) – a fall of 4.0 percent compared with the average of the previous three years. The decrease concerned both marine capture fisheries and inland waters (3.9 percent and 4.3 percent, respectively) and is most likely due to both the disruption in fishing operations because of the COVID-19 pandemic (Box 2) and the ongoing reduction in China's catches (10 percent lower in 2020 compared with the average of the previous three years). The 2017–2019 average was high because of the peak experienced in 2018 (96.5 million tonnes) due to relatively high catches of anchoveta (*Engraulis ringens*). However, the long-term trend in global capture fisheries continues to be relatively stable. Catches have generally fluctuated between 86 million tonnes and 93 million tonnes per year since the late 1980s (Figure 7).

5 The remaining 6 percent of finfish comprised diadromous species.

6 For algae, see Glossary, including Context of SOFIA 2022.

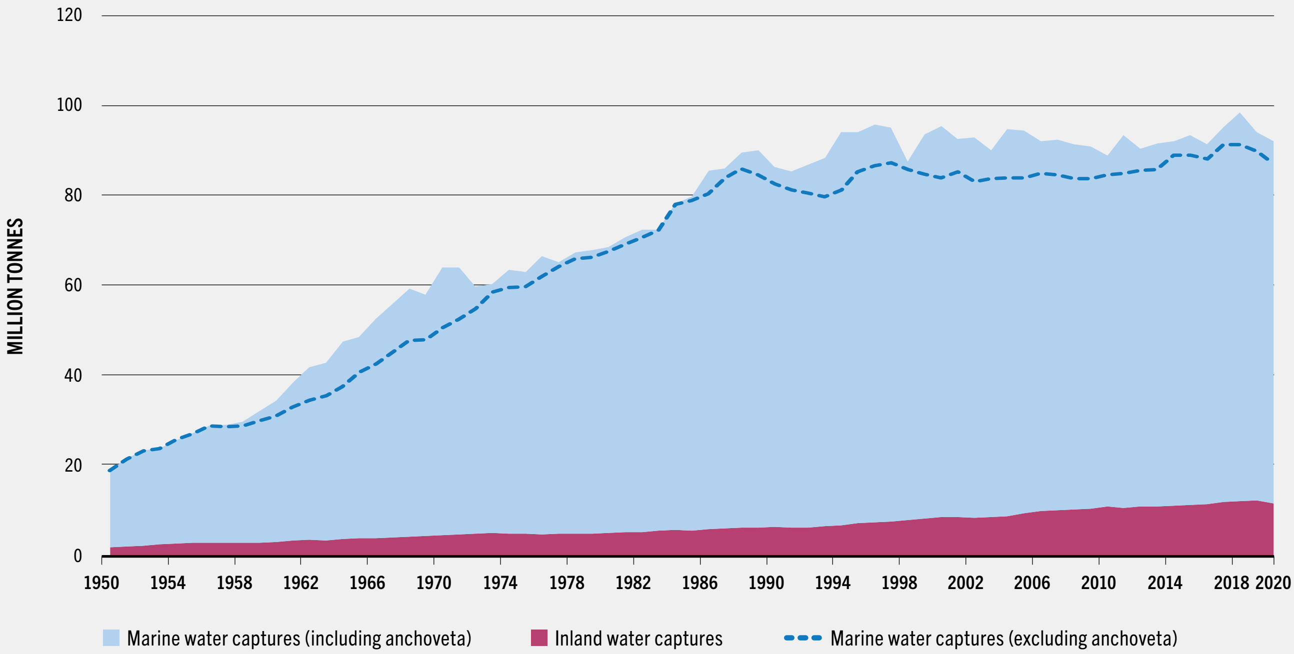
FIGURE 6 WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION BY ISSCAAP DIVISIONS, IN ABSOLUTE VALUES AND PERCENTAGE, 2020





NOTES: Excluding aquatic mammals, crocodiles, alligators and caimans. Data expressed in live weight equivalent. ISSCAAP = International Standard Statistical Classification of Aquatic Animals and Plants.
SOURCE: FAO.

FIGURE 7 **TRENDS IN GLOBAL CAPTURES**



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

China remains the top capture producer despite the downward revision of its catches for the period 2009–2016[7] and a decline of around 19.3 percent between 2015 and 2020. China accounted for almost 15 percent of global captures in 2020, more than the total captures of the second- and third-ranked countries combined. The top seven capture producers (China, Indonesia, Peru, India, Russian Federation, United States of America and Viet Nam) accounted for almost 49 percent of total global capture production (Figure 8), while the top 20 producers accounted for over 73 percent.

Catch trends in marine and inland waters, representing, respectively, 87.3 percent and 12.7 percent of the global production of capture fisheries in 2018–2020, are discussed further below.

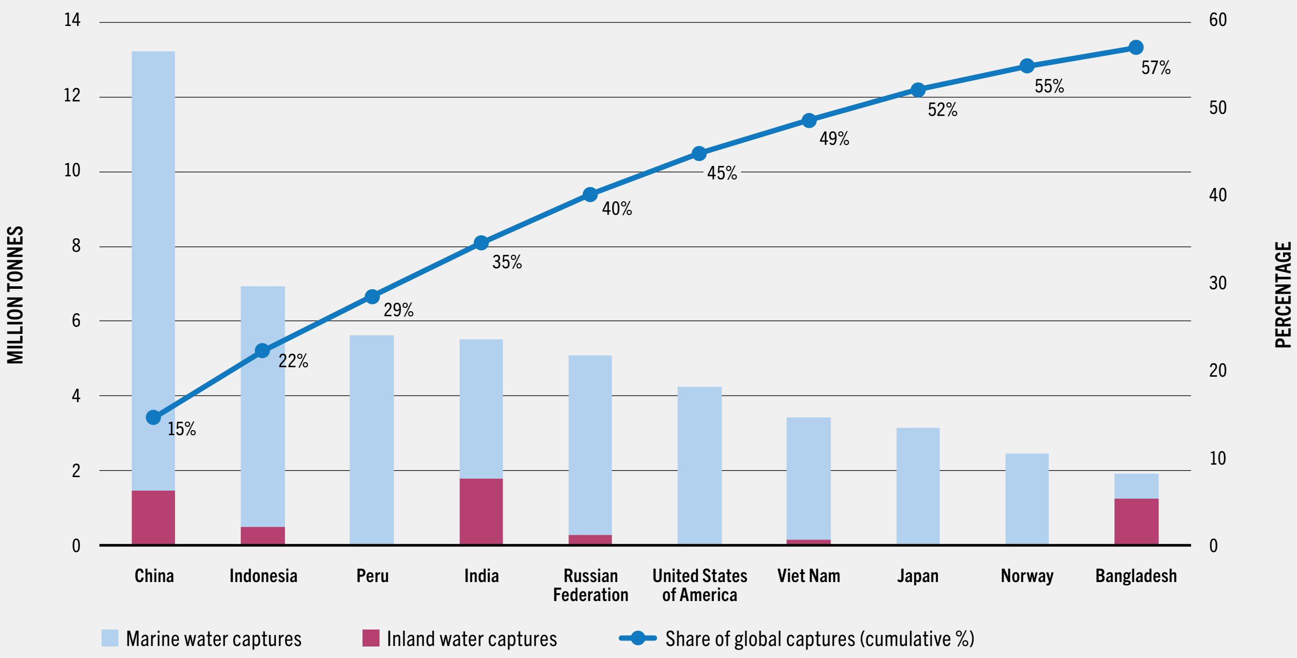
7 See Box 1 on p. 11 of *The State of World Fisheries and Aquaculture 2020* (FAO, 2020a).

Marine capture production

In 2020, global marine captures were 78.8 million tonnes, a decline of 6.8 percent from the peak of 84.5 million tonnes in 2018, when relatively high catches of anchoveta were reported by Peru and Chile (Table 2).

Marine captures were severely affected by the disruption to fishing operations caused by the COVID-19 pandemic during 2020. However, assessing the impact of the crisis on marine water catches is difficult and needs to be considered in the context of longer-term trends in the sector, including the ongoing reduction in catches reported by China in recent years. The abundance of species such as anchoveta, Pacific sardine (*Sardinops sagax*) and Pacific jack mackerel (*Trachurus symmetricus*), which are substantial but highly variable due to El Niño events and variations in oceanographic conditions, is also a major

FIGURE 8 TOP TEN GLOBAL CAPTURE PRODUCERS, 2020



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

influence on interannual changes in global marine captures.

Compared with 2019 (i.e. prior to the COVID-19 pandemic), global marine captures decreased by 1.6 percent in 2020, well within the limits of interannual fluctuations in previous years. Of the top ten producers for global capture production, most reported catches in 2020 were either at the same level as or higher than the catches for 2019 (e.g. Peru, India, Russian Federation and Norway).

Catches of major species have undergone marked variations over the years, as well as fluctuations in the catches among the top producing countries. A case in point is Indonesia, which reported an increase in marine catches from under 4 million tonnes in the early 2000s to over 6.7 million tonnes in 2018; these increases are in part explained by changes to the country's data collection, processing and open data access with the implementation of Satu Data (One Data) in 2016. Despite the initiatives to improve Indonesia's data collection, there are still major fluctuations in its marine catches, in addition to issues of late or non-reporting of data to FAO.

Global production of marine capture fisheries continues to be highly concentrated among a small number of producers (Figure 9a). In 2020, similar to previous years, the top seven producers accounted for over 50 percent of total marine captures, and China alone accounted for 14.9 percent of the world total (Table 2), followed by Indonesia (8.2 percent), Peru (7.1 percent), the Russian Federation (6.1 percent), the United States of America (5.4 percent), India (4.7 percent) and Viet Nam (4.2 percent).

While China remains the world's top producer of marine captures, its catches declined from 14.4 million tonnes in 2015 to 11.8 million tonnes in 2020, representing a decrease of 18.2 percent

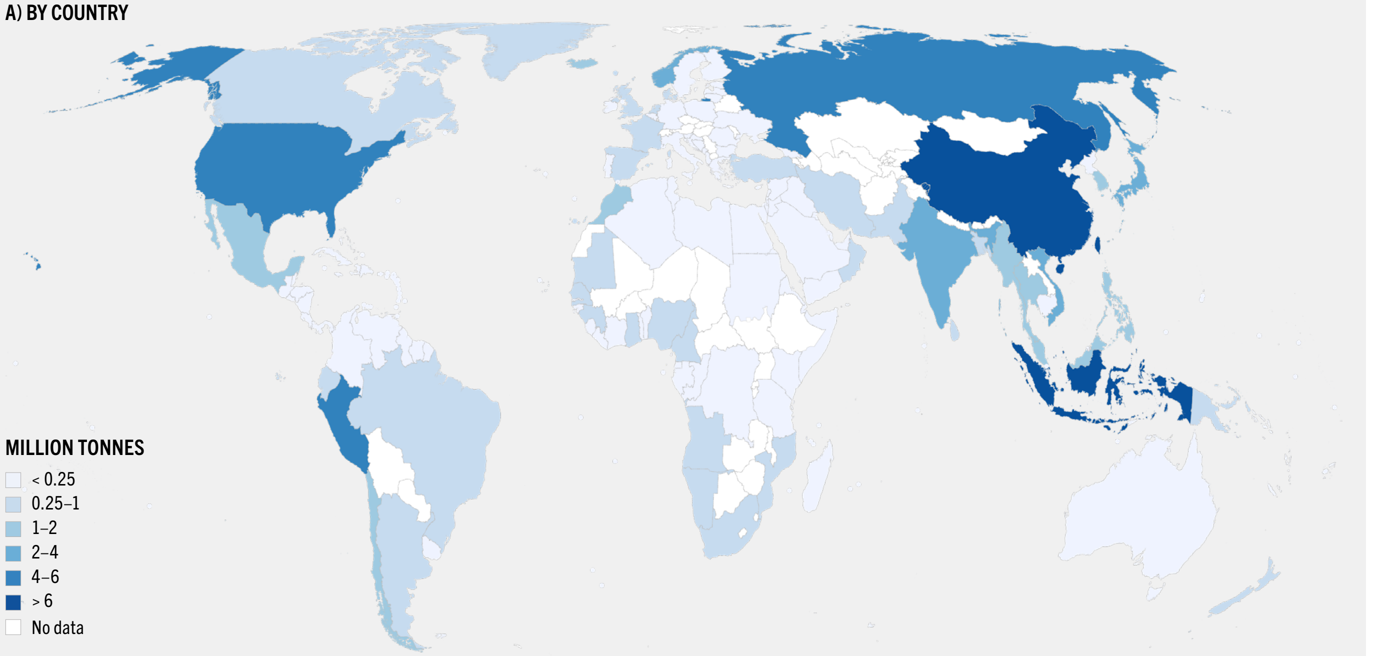
TABLE 2 MARINE CAPTURE PRODUCTION: MAJOR PRODUCING COUNTRIES AND TERRITORIES

Country or territory	Production (average per year)				Production				Percentage of total, 2020
	1980s	1990s	2000s	2010s	2017	2018	2019	2020	
	(million tonnes, live weight)								
China	3.82	9.96	12.43	13.24	13.19	12.68	12.15	11.77	15
Indonesia	1.74	3.03	4.37	5.98	6.56	6.71	6.56	6.43	8
Peru (total)	4.14	8.10	8.07	5.13	4.13	7.15	4.80	5.61	7
Peru (excluding anchoveta)	*2.50*	*2.54*	*0.95*	*1.01*	*0.83*	*0.96*	*1.29*	*1.22*	
Russian Federation	1.51	4.72	3.20	4.28	4.59	4.84	4.72	4.79	6
United States of America	4.53	5.15	4.75	4.89	5.01	4.77	4.81	4.23	5
India	1.69	2.60	2.95	3.55	3.94	3.62	3.67	3.71	5
Viet Nam	0.53	0.94	1.72	2.70	3.15	3.19	3.29	3.27	4
Japan	10.59	6.72	4.41	3.48	3.19	3.26	3.16	3.13	4
Norway	2.21	2.43	2.52	2.30	2.39	2.49	2.31	2.45	3
Chile (total)	4.52	5.95	4.02	2.16	1.92	2.12	1.98	1.77	2
Chile (excluding anchoveta)	*4.00*	*4.45*	*2.75*	*1.40*	*1.29*	*1.27*	*1.23*	*1.27*	
Philippines	1.32	1.68	2.10	1.92	1.72	1.65	1.67	1.76	2
Thailand	2.08	2.70	2.38	1.46	1.30	1.39	1.41	1.52	2
Malaysia	0.76	1.08	1.31	1.46	1.47	1.45	1.46	1.38	2
Republic of Korea	2.18	2.25	1.78	1.56	1.35	1.39	1.41	1.36	2
Morocco	0.46	0.68	0.97	1.28	1.36	1.36	1.44	1.36	2
Mexico	1.21	1.18	1.31	1.42	1.46	1.47	1.42	1.35	2
Iceland	1.43	1.67	1.66	1.20	1.18	1.26	1.04	1.02	1
Myanmar	0.50	0.61	1.10	1.15	1.27	1.15	1.06	1.01	1
Argentina	0.41	0.99	0.94	0.79	0.81	0.82	0.80	0.82	1
Spain	1.21	1.13	0.92	0.96	0.94	0.93	0.88	0.80	1
Oman	0.11	0.12	0.15	0.29	0.35	0.55	0.58	0.79	1
Denmark	1.86	1.71	1.05	0.73	0.90	0.79	0.63	0.73	1
Canada	1.41	1.09	1.01	0.83	0.81	0.81	0.75	0.71	1
Iran (Islamic Republic of)	0.11	0.23	0.31	0.55	0.69	0.72	0.73	0.70	1
Bangladesh	0.18	0.28	0.46	0.61	0.64	0.65	0.66	0.67	1
Total 25 major producers	**50.49**	**66.99**	**65.87**	**63.90**	**64.32**	**67.23**	**63.41**	**63.17**	**80**
Total all other producers	**21.61**	**14.86**	**15.72**	**15.89**	**17.16**	**17.27**	**16.69**	**15.62**	**20**
World total	**72.10**	**81.86**	**81.59**	**79.79**	**81.48**	**84.51**	**80.09**	**78.79**	**100**

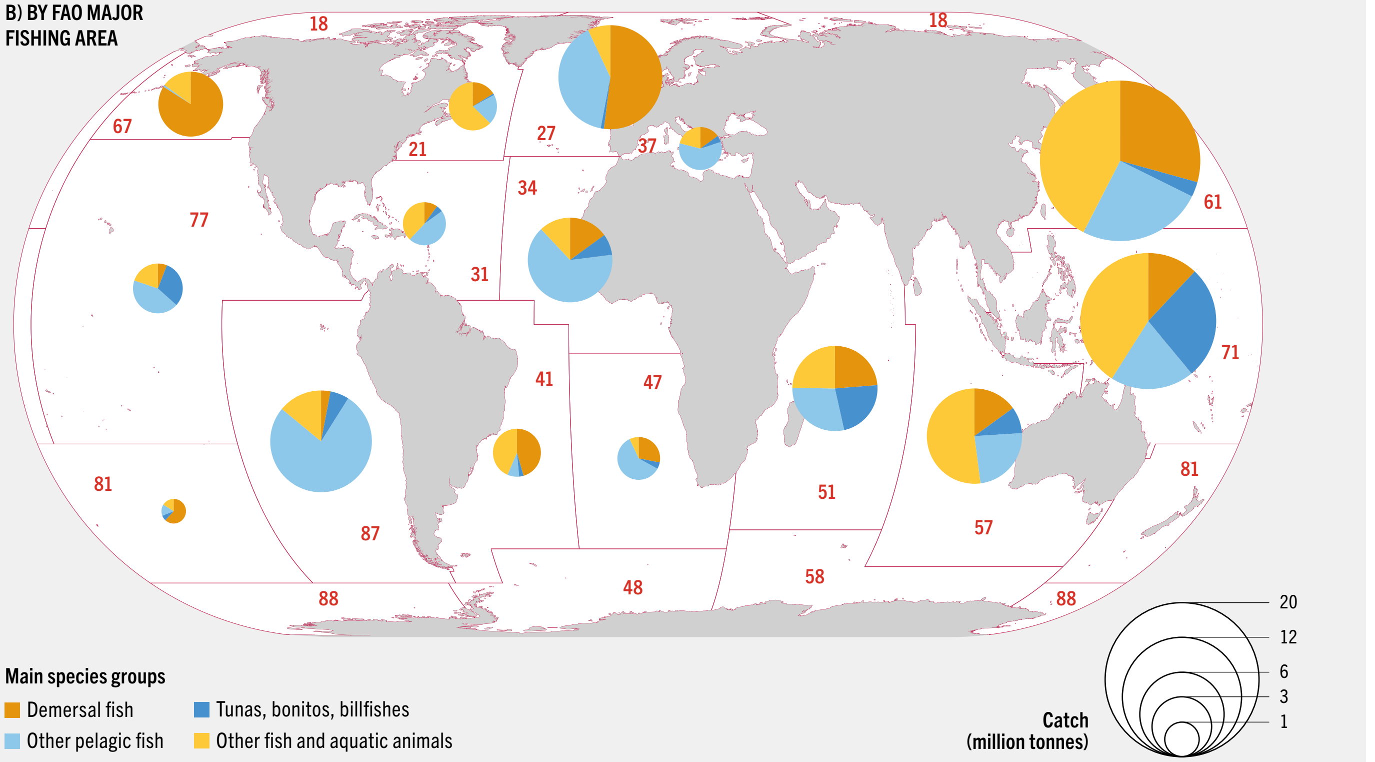
NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

FIGURE 9 MARINE CAPTURE PRODUCTION, AVERAGE 2018–2020

A) BY COUNTRY



B) BY FAO MAJOR FISHING AREA



The designations employed and the presentation of material on these maps do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

TABLE 3 MARINE CAPTURE PRODUCTION: MAJOR SPECIES AND GENERA

Species item	2007–2016	2017	2018	2019	2020	Percentage of total, 2020
	(thousand tonnes, live weight)					
Finfish						
Anchoveta, *Engraulis ringens*	5 548	3 923	7 045	4 249	4 896	7
Alaska pollock, *Gadus chalcogrammus*	3 072	3 489	3 396	3 495	3 544	5
Skipjack tuna, *Katsuwonus pelamis*	2 675	2 772	3 081	3 285	2 827	4
Atlantic herring, *Clupea harengus*	1 981	1 816	1 823	1 697	1 598	2
Yellowfin tuna, *Thunnus albacares*	1 278	1 521	1 547	1 555	1 569	2
Blue whiting, *Micromesistius poutassou*	904	1 559	1 712	1 517	1 487	2
Pacific chub mackerel, *Scomber japonicus*	1 404	1 514	1 554	1 417	1 360	2
European pilchard, *Sardina pilchardus*	1 130	1 434	1 604	1 496	1 331	2
Pacific sardine, *Sardinops sagax*	880	754	859	937	1 277	2
Scads nei,[1] *Decapterus* spp.	1 189	1 186	1 336	1 293	1 265	2
Largehead hairtail, *Trichiurus lepturus*	1 292	1 221	1 150	1 136	1 144	2
Atlantic cod, *Gadus morhua*	1 091	1 308	1 221	1 133	1 078	2
Atlantic mackerel, *Scomber scombrus*	948	1 219	1 047	869	1 049	2
Japanese anchovy, *Engraulis japonicus*	1 273	1 060	958	927	970	1
Others	41 623	44 142	43 671	42 608	41 341	62
Finfish total	**66 288**	**68 918**	**72 002**	**67 612**	**66 734**	**100**
Crustaceans						
Natantian decapods nei, Natantia	796	974	849	863	820	15
Antarctic krill, *Euphausia superba*	194	252	312	371	445	8
Gazami crab, *Portunus trituberculatus*	451	513	493	473	442	8
Fleshy prawn, *Penaeus chinensis*	127	181	223	216	367	7
Giant tiger prawn, *Penaeus monodon*	228	237	225	215	305	5
Marine crabs nei, Brachyura	289	343	307	323	290	5
Northern prawn, *Pandalus borealis*	321	223	249	251	255	5
Akiami paste shrimp, *Acetes japonicus*	567	453	439	402	251	4
Others	2 688	2 866	2 905	2 727	2 449	44
Crustaceans total	**5 662**	**6 043**	**6 002**	**5 841**	**5 625**	**100**
Molluscs						
Jumbo flying squid, *Dosidicus gigas*	866	763	892	914	877	15
Marine molluscs nei, Mollusca	763	644	658	707	600	10
Various squids nei, Loliginidae, Ommastrephidae	613	655	571	614	529	9
Cephalopods nei, Cephalopoda	412	433	322	425	424	7

TABLE 3 (Continued)

Species item	2007–2016	2017	2018	2019	2020	Percentage of total, 2020
	(thousand tonnes, live weight)					
Yesso scallop, *Mizuhopecten yessoensis*	304	247	316	351	357	6
Cuttlefish, bobtail squids nei, Sepiidae, Sepiolidae	303	395	347	365	353	6
Argentine shortfin squid, *Illex argentinus*	526	336	301	171	345	6
Others	2 785	2 486	2 549	2 624	2 438	41
Molluscs total	**6 572**	**5 960**	**5 956**	**6 171**	**5 923**	**100**
Other aquatic animals						
Jellyfishes nei, *Rhopilema* spp.	325	262	264	184	222	44
Aquatic invertebrates nei, Invertebrata	50	120	122	115	117	23
Sea cucumbers nei, Holothuroidea	26	38	48	48	43	9
Chilean sea urchin, *Loxechinus albus*	35	31	32	37	38	7
Cannonball jellyfish, *Stomolophus meleagris*	29	47	29	36	33	7
Sea urchins nei, *Strongylocentrotus* spp.	34	29	25	27	31	6
Others	24	28	24	23	20	4
Other aquatic animals total	**522**	**555**	**544**	**470**	**503**	**100**
Total all species	79 045	81 476	84 505	80 094	78 785	

[1] nei: not elsewhere included.
NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

from 2015 and 7.2 percent from 2018 (an average annual decrease of 3.9 percent). A continuation of a catch reduction policy beyond the Thirteenth and Fourteenth Five-Year Plans (2016–2020 and 2021–2025) is expected to result in further decreases in coming years.

While total catches for China in the FAO database are generally considered to be complete, improvements are needed to more accurately assign China's distant-water fishery catches by area and disaggregate catches by species.

Of the 11.8 million tonnes reported by China in 2020, a total of 2.3 million tonnes came under "distant-water fishery", with details on species and fishing area only provided for distant-water catches marketed in area 61, the Northwest Pacific. A portion of the remainder of China's distant-water fishery catches was attributed to other fishing areas through data available from the regional fisheries management organizations (RFMOs) and the remaining 1.8 million tonnes were entered in the FAO database under "marine fishes not elsewhere included" in area 61, possibly overstating the catches occurring in this area and the overall amount of unspecified marine fish caught by China.

The FAO global marine capture database includes catches for more than 2 600 species (including "not elsewhere included" categories); finfish represent about 85 percent of total marine capture production, with small pelagics as the main group, followed by gadiformes and tuna and tuna-like species. An overview of marine catch data by main species group and by FAO Major Fishing Area is shown in Figure 9b.[8]

8 For more information on FAO Major Fishing Areas, see www.fao.org/fishery/en/area/search

TABLE 4 INLAND AND MARINE CAPTURE PRODUCTION: FAO MAJOR FISHING AREAS

Fishing area code	Fishing area name	Production (average per year)				Production				Percentage of total, 2020
		1980s	1990s	2000s	2010s	2017	2018	2019	2020	
		(million tonnes, live weight)								
Inland water captures										
01	Africa – inland waters	1.47	1.89	2.33	2.87	3.01	3.02	3.24	3.21	28
02	America, North – inland waters	0.23	0.21	0.18	0.21	0.23	0.30	0.21	0.19	2
03	America, South – inland waters	0.32	0.33	0.39	0.36	0.36	0.34	0.35	0.34	3
04	Asia – inland waters	2.87	4.17	5.98	7.39	7.85	7.90	7.89	7.29	64
05	Europe – inland waters[1]	0.28	0.43	0.36	0.40	0.41	0.41	0.39	0.42	4
06	Oceania – inland waters	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0
07	Former Soviet Union area – inland waters	0.51	–	–	–	–	–	–	–	0
	Inland waters total	**5.70**	**7.05**	**9.26**	**11.26**	**11.88**	**11.99**	**12.09**	**11.47**	**100**
Marine water captures										
21	Atlantic, Northwest	2.91	2.33	2.22	1.84	1.75	1.73	1.73	1.54	8
27	Atlantic, Northeast	10.44	10.39	9.81	8.65	9.35	9.34	8.28	8.31	41
31	Atlantic, Western Central	2.01	1.83	1.56	1.38	1.46	1.51	1.39	1.25	6
34	Atlantic, Eastern Central	3.20	3.56	3.76	4.75	5.38	5.49	5.37	4.95	24
37	Mediterranean and Black Sea	1.84	1.50	1.54	1.31	1.35	1.29	1.39	1.19	6
41	Atlantic, Southwest	1.78	2.25	2.15	1.90	1.82	1.77	1.65	1.70	8
47	Altantic, Southeast	2.32	1.56	1.54	1.53	1.70	1.58	1.36	1.36	7
	Atlantic Ocean and Mediterranean total	**24.50**	**23.41**	**22.57**	**21.37**	**22.81**	**22.72**	**21.17**	**20.30**	**100**
51	Indian Ocean, Western	2.38	3.68	4.24	4.87	5.45	5.53	5.60	5.63	46
57	Indian Ocean, Eastern	2.67	4.13	5.48	6.42	7.10	6.74	6.77	6.59	54
	Indian Ocean total	**5.05**	**7.81**	**9.72**	**11.29**	**12.55**	**12.27**	**12.36**	**12.22**	**100**
61	Pacific, Northwest	20.95	21.80	19.97	20.62	20.26	20.25	19.54	19.15	42
67	Pacific, Northeast	2.74	2.98	2.79	3.06	3.40	3.11	3.19	2.86	6
71	Pacific, Western Central	5.94	8.51	10.80	12.51	12.76	13.33	13.33	13.26	29
77	Pacific, Eastern Central	1.62	1.44	1.81	1.84	1.74	1.70	1.85	1.69	4
81	Pacific, Southwest	0.57	0.82	0.69	0.53	0.47	0.46	0.47	0.43	1
87	Pacific, Southeast	10.23	14.90	13.10	8.31	7.21	10.33	7.80	8.40	18
	Pacific Ocean total	**42.06**	**50.45**	**49.16**	**46.87**	**45.84**	**49.19**	**46.17**	**45.80**	**100**

»

TABLE 4 (Continued)

Fishing area code	Fishing area name	Production (average per year)				Production				Percentage of total, 2020
		1980s	1990s	2000s	2010s	2017	2018	2019	2020	
		(million tonnes, live weight)								
18, 48, 58, 88	**Arctic and Antarctic areas total**	**0.48**	**0.19**	**0.14**	**0.27**	**0.27**	**0.33**	**0.39**	**0.46**	**100**
	Marine waters total	**72.10**	**81.86**	**81.59**	**79.79**	**81.48**	**84.51**	**80.09**	**78.79**	
Marine captures by major fishing area										
	Temperate areas	41.24	42.07	39.16	37.92	38.41	37.96	36.25	35.19	45
	Tropical areas	13.01	18.14	22.07	25.17	26.76	27.11	27.08	26.73	34
	Upwelling areas	17.37	21.45	20.21	16.44	16.03	19.11	16.38	16.41	21
	Arctic and Antarctic areas total	0.48	0.19	0.14	0.27	0.27	0.33	0.39	0.46	1
	Total marine waters: major fishing areas	**72.10**	**81.86**	**81.59**	**79.79**	**81.48**	**84.51**	**80.09**	**78.79**	**100**

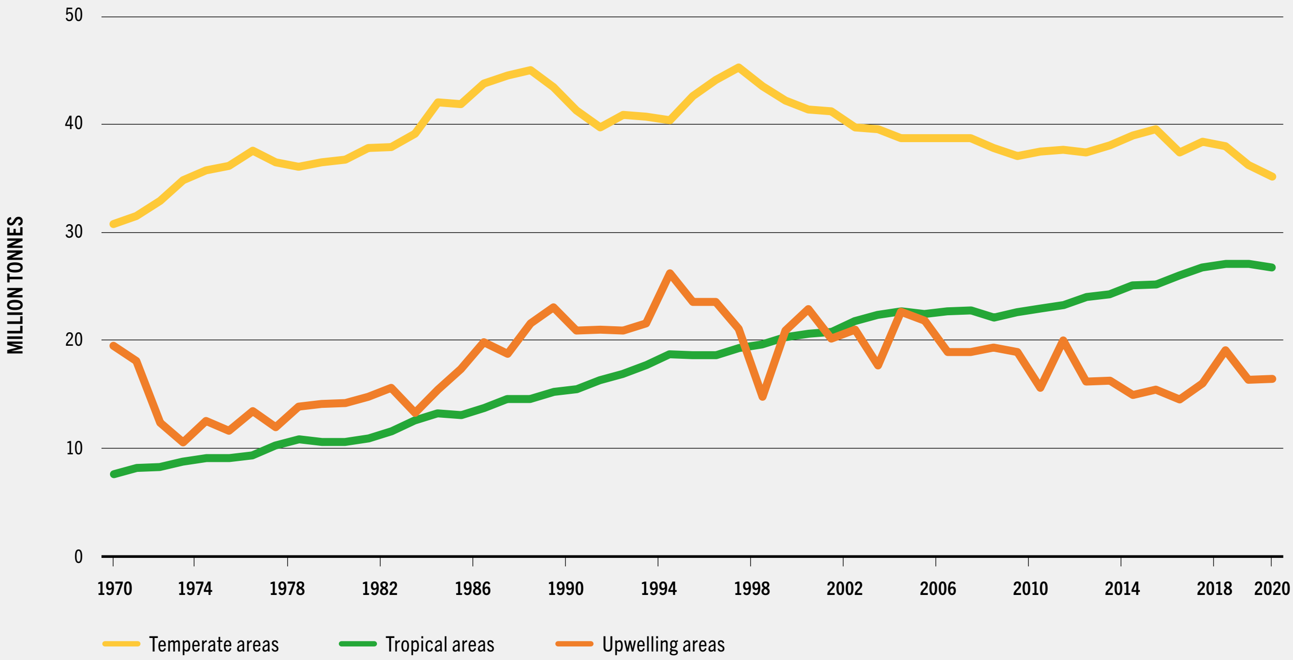
[1] Includes the Russian Federation.
NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

In 2020, catches of anchoveta once again made it the top species, at almost 4.9 million tonnes per year, albeit lower than the 2018 peak that exceeded 7.0 million tonnes. Alaska pollock (*Gadus chalcogrammus*) was second, at 3.5 million tonnes, while skipjack tuna (*Katsuwonus pelamis*) ranked third for the eleventh consecutive year, at 2.8 million tonnes (Table 3).

Despite measures implemented in 2020 to contain COVID-19 – which, in many cases, negatively impacted demand with restrictions on transportation and access to global markets, as well as closure of the food service sector – catches of four of the most highly valuable groups (tunas, cephalopods, shrimps and lobsters) remained at some of their highest levels in 2020 or declined marginally from peak catches recorded in the previous five years:

- Tuna and tuna-like species catches continued to reach some of the highest levels recorded, although catches decreased from 8.2 million tonnes in 2019 to 7.8 million tonnes in 2020 as fresh tuna exports and the sashimi market were impacted by COVID-19 restrictions. Most recent increases in catches have been in area 71, the Western Central Pacific, which increased from about 2.7 million tonnes in the mid-2000s to almost 3.8 million tonnes in 2019, with a decline of more than 5 percent in 2020 (3.6 million tonnes). Within this species group, skipjack and yellowfin tuna (*Thunnus albacares*) accounted for over 55 percent of catches.
- Cephalopod catches declined to between 3.5 million tonnes and 3.8 million tonnes following their peak catches of 4.9 million tonnes in 2014. Nevertheless, they remained at the relatively high levels that have marked their almost continuous growth over the last 20 years; in 2020, catches were 3.7 million tonnes. Cephalopods are fast-growing species highly influenced by environmental variability, which probably explains the fluctuations in their catches, including for the three main squid species – jumbo flying squid (*Dosidicus gigas*), Argentine shortfin squid (*Illex argentinus*) and Japanese flying squid (*Todarodes pacificus*).
- Shrimp and prawn catches recorded a new high in 2017 of almost 3.4 million tonnes, mostly due to the continued recovery in catches of Argentine red shrimp (*Pleoticus muelleri*), which offset declines in the other main shrimp species, notably akiami paste shrimp

FIGURE 10 MARINE CAPTURE PRODUCTION: TRENDS IN THREE MAIN CATEGORIES OF FISHING AREAS



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

(*Acetes japonicus*) and southern rough shrimp (*Trachysalambria curvirostris*). In 2020, catches were 3.2 million tonnes, continuing the trend of recent years with catches fluctuating between 3.1 million tonnes and 3.4 million tonnes per year.

- Lobster catches decreased to 255 000 tonnes in 2020 – the lowest level since 2009 – as lobster was one of the high-value species most impacted by COVID-19 restrictions and the closure of global export markets. As restrictions are eased, catches are expected to recover to the levels above 300 000 tonnes seen in recent years, particularly of American lobster (*Homarus americanus*), which accounts for over half of catches in this group.

Catch statistics by FAO Major Fishing Area for the last five years, as well as marine catches in recent decades, are presented in Table 4 for the following categories (Figure 10):

- 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);
- Arctic and Antarctic areas (areas 18, 48, 58 and 88).

In 2020, catches in temperate areas were 35.2 million tonnes, marginally lower than in previous years. Otherwise, catches have generally remained stable at between 36.2 million tonnes and 39.6 million tonnes per year since the early 2000s, following the two highest peaks in catches (about 45 million tonnes) in 1988 and 1997.

Area 61, the Northwest Pacific, recorded the highest production at 19.2 million tonnes, or 24 percent of global marine landings, in 2020. As stated above, catches for this area include a proportion of China's distant-water fishing fleet catches (recorded as "marine fishes not elsewhere included"), which are caught in other fishing areas but are assigned to area 61 in the absence of detailed information on where they were effectively caught.

Catches in other temperate areas have been mostly stable in the last ten years, with the exception of recent decreases in areas 41 and 81, the Southwest Atlantic and the Southwest Pacific, partly 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 tropical areas, catches in the Indian Ocean (areas 51 and 57) and the Western Central Pacific (area 71) reached their highest levels recorded at, respectively, 12.5 million tonnes (2017) and 13.3 million tonnes (2018). Catches have since decreased but remain only marginally below the peak catches of recent years.

In the Indian Ocean, catches have increased steadily since the 1980s, particularly in area 57, the Eastern Indian Ocean, with catches of small pelagics, large pelagics (tunas and billfish) and shrimps driving most of the increase.

Area 71, the Western Central Pacific, reported the second largest landings by area in 2020 with 13.3 million tonnes. Catches have also increased steadily since the 1950s, with tuna and tuna-like species accounting for most of the increase. Skipjack tuna in particular has increased from 1.0 million tonnes to almost 1.9 million tonnes in the last 20 years, while catches for the other main species groups have mostly remained stable.

In area 31, the Western Central Atlantic, catches have declined from the peak catches of 2.5 million tonnes in the mid-1980s, but have been relatively stable since the mid-2000s, fluctuating between 1.2 million tonnes and 1.6 million tonnes per year. Trends in total production are largely dependent on catches by the United States of America of Gulf menhaden (*Brevoortia patronus*), a clupeoid species that is processed into fishmeal and fish oil and accounts for over 30 percent of the total catches.

Catches in upwelling areas are characterized by high interannual variability. Their combined catches are highly influenced by catches in area 87, the Southeast Pacific, where El Niño oceanographic conditions strongly influence the abundance of anchoveta. Such catches account for 50–70 percent of total catches in area 87.

The long-term trend in area 87 has been one of declining catches since the mid-1990s, even taking into account the fluctuation in catches of anchoveta. Annual catches have decreased from over 20 million tonnes in 1994 to between about 7 million tonnes and 10 million tonnes in recent years – driven by decreasing catches of two of the main species: anchoveta and Chilean jack mackerel (*Trachurus murphyi*). However, high-value catches of jumbo flying squid have grown significantly since the early 2000s, partially offsetting the decline in catches of other species. Catches of jumbo flying squid grew from about 128 000 tonnes in 2000 to peak at 1 million tonnes in 2015, before fluctuating in subsequent years and reaching 880 000 tonnes in 2020.

In area 34, the Eastern Central Atlantic Ocean, catches have increased almost continuously, reaching 5.5 million tonnes in 2018, the highest catches recorded, before declining to 4.9 million tonnes in 2020. In area 47, the Southeast Atlantic, the opposite trend is recorded, with catches progressively decreasing from the peak of 3.3 million tonnes in 1978 to 1.4 million tonnes in 2020.

In area 77, the Eastern Central Pacific, catches have generally remained static, ranging from 1.6 million tonnes to 2 million tonnes per year.

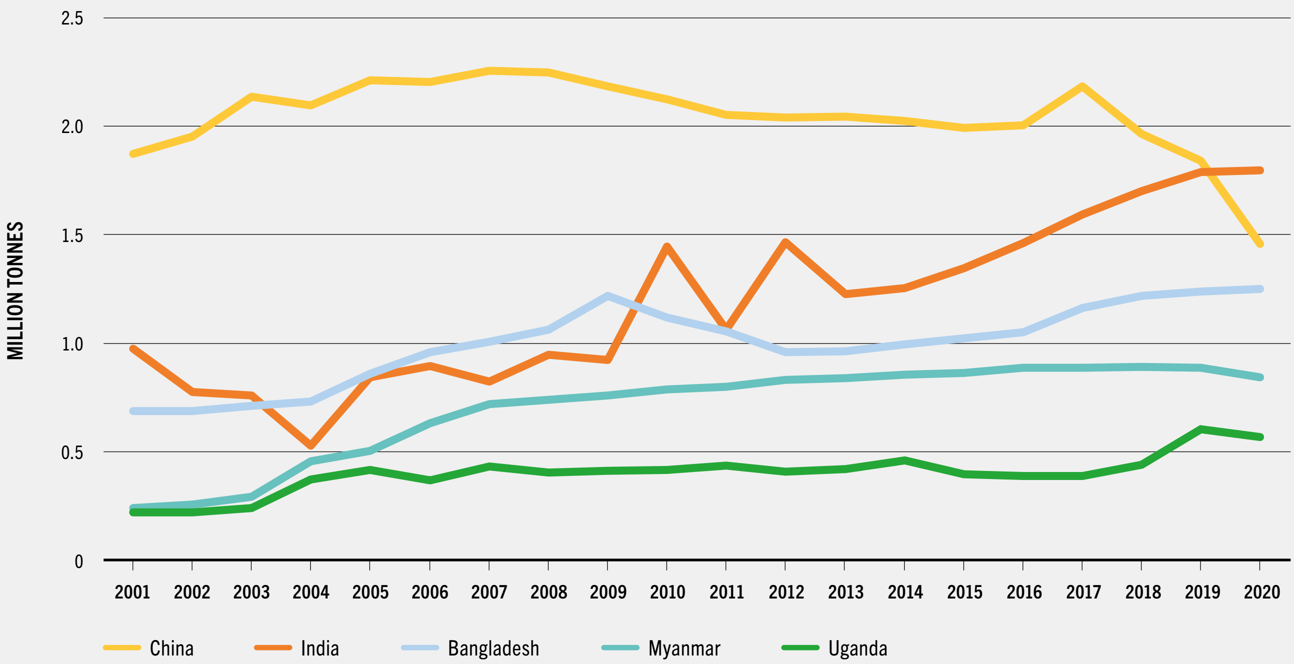
While total catches in Antarctic fishing areas (areas 48, 58 and 88) are relatively minor, catches have increased sharply in recent years, from 270 000 tonnes in 2017 to 462 000 tonnes in 2020, the highest catches since the early 1990s. Catches in the region are almost entirely driven by Antarctic krill (*Euphausia superba*), which increased from less than 100 000 tonnes in the late 1990s to 455 000 tonnes in 2020, following a decline in the early 1990s. Catches of the second-most important species, Patagonian toothfish (*Dissostichus eleginoides*), continue to be relatively stable at between 10 500 tonnes and 12 200 tonnes per year.

TABLE 5 INLAND WATERS CAPTURE PRODUCTION: MAJOR PRODUCING COUNTRIES AND TERRITORIES

Country	Production (average per year)				Production				Percentage of total, 2020
	1980s	1990s	2000s	2010s	2017	2018	2019	2020	
	(million tonnes, live weight)								
Top 25 inland water capture producers									
India	0.50	0.58	0.84	1.43	1.59	1.70	1.79	1.80	16
China	0.54	1.46	2.11	2.03	2.18	1.96	1.84	1.46	13
Bangladesh	0.44	0.50	0.86	1.08	1.16	1.22	1.24	1.25	11
Myanmar	0.14	0.15	0.48	0.85	0.89	0.89	0.89	0.84	7
Uganda	0.19	0.22	0.33	0.44	0.39	0.44	0.60	0.57	5
Indonesia	0.27	0.31	0.31	0.47	0.47	0.66	0.71	0.49	4
Cambodia	0.05	0.09	0.34	0.46	0.47	0.42	0.40	0.41	4
United Republic of Tanzania	0.25	0.29	0.30	0.31	0.33	0.31	0.38	0.41	4
Nigeria	0.10	0.10	0.21	0.35	0.42	0.39	0.37	0.35	3
Egypt	0.12	0.23	0.27	0.25	0.26	0.27	0.30	0.32	3
Russian Federation	0.09	0.26	0.22	0.27	0.27	0.27	0.25	0.28	2
Brazil	0.20	0.18	0.24	0.23	0.22	0.22	0.22	0.22	2
Democratic Republic of the Congo	0.13	0.17	0.23	0.22	0.23	0.23	0.23	0.21	2
Malawi	0.07	0.06	0.06	0.14	0.20	0.22	0.15	0.17	1
Mexico	0.10	0.11	0.11	0.15	0.17	0.22	0.16	0.15	1
Viet Nam	0.11	0.14	0.21	0.16	0.16	0.16	0.15	0.15	1
Pakistan	0.07	0.13	0.12	0.13	0.14	0.14	0.14	0.15	1
Philippines	0.26	0.19	0.15	0.18	0.16	0.16	0.15	0.15	1
Thailand	0.10	0.18	0.21	0.19	0.19	0.14	0.13	0.13	1
Mali	0.07	0.09	0.10	0.10	0.11	0.09	0.11	0.12	1
Chad	0.05	0.08	0.08	0.11	0.11	0.11	0.11	0.11	1
Zambia	0.06	0.07	0.07	0.09	0.10	0.10	0.10	0.11	1
Iran (Islamic Republic of)	0.01	0.09	0.07	0.09	0.10	0.11	0.10	0.10	1
Kenya	0.09	0.18	0.14	0.13	0.10	0.10	0.10	0.10	1
Mozambique	0.00	0.01	0.02	0.09	0.10	0.10	0.12	0.10	1
Top 25 producers	**4.02**	**5.86**	**8.07**	**9.95**	**10.52**	**10.64**	**10.74**	**10.13**	**88**
Total all other producers	**1.67**	**1.19**	**1.19**	**1.31**	**1.35**	**1.35**	**1.35**	**1.34**	**12**
All producers	**5.70**	**7.05**	**9.26**	**11.26**	**11.88**	**11.99**	**12.09**	**11.47**	**100**
Inland water captures, by region									
Asia	2.87	4.17	5.98	7.39	7.85	7.90	7.89	7.29	64
Africa	1.47	1.89	2.33	2.87	3.01	3.02	3.24	3.21	28
Americas	0.56	0.54	0.58	0.57	0.59	0.64	0.55	0.53	5
Europe	0.28	0.43	0.36	0.40	0.41	0.41	0.39	0.42	4
Oceania	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0
Others[1]	0.51	–		–	–	–	–	–	0
World total	**5.70**	**7.05**	**9.26**	**11.26**	**11.88**	**11.99**	**12.09**	**11.47**	**100**

[1] Includes the Union of Soviet Socialist Republics.
NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

FIGURE 11 TOP FIVE INLAND WATERS CAPTURE PRODUCERS



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

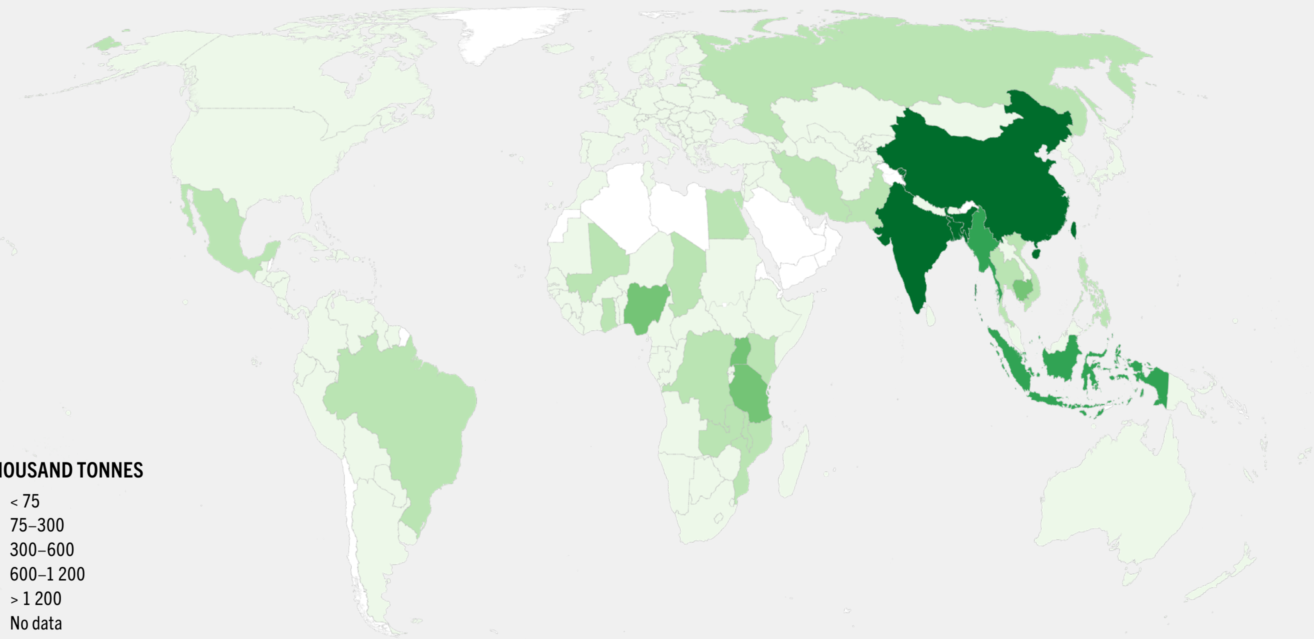
Inland waters capture production

In 2020, total global catches in inland waters were 11.5 million tonnes (Table 5), a decrease of 5.1 percent from 2019. As with marine capture production, fishing operations in inland waters were severely impacted by the COVID-19 pandemic during 2020, and this was compounded by the decline in China's catches. Despite the decrease in 2020, inland water catches remain at historically high levels and only marginally below the highest levels of 12.0 million tonnes recorded in 2019.

The long-term rising trend in inland fisheries production can partially be attributed to improved reporting and assessment at the country level. Nevertheless, many of the data collection systems for inland waters are still unreliable, or in some cases non-existent; furthermore, improvements in reporting may also mask trends in individual countries. Equally important, many countries do not report catches for inland fisheries, or they report only partial catches, while FAO estimates a proportionately higher amount of the total catches for inland waters compared with marine waters.

For the first time since the mid-1980s, China was not the top producer of inland water catches in 2020 and instead the highest catches were reported by India at 1.8 million tonnes. While China continues to be one of the largest producers of inland water capture fisheries, reported catches have decreased by over 33 percent from 2.2 million tonnes in 2017 to 1.5 million tonnes in 2020. This significant decrease is the result of recently introduced policies by China's Ministry of Agriculture and Rural Affairs, most notably a ten-year fishing ban in the waters of the Yangtze River, that aim

FIGURE 12 INLAND CAPTURE PRODUCTION BY COUNTRY, AVERAGE 2018–2020



The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

for conservation of living aquatic resources, with the underlying rationale that improvements in and expansion of inland aquaculture and culture-based fisheries can meet the increased demand for aquatic food[9] arising from the reduction in catches from inland capture fisheries.

With the exception of China, the increase in inland water catches continues to be driven by several major producing countries – notably India, Bangladesh, Myanmar and Uganda (Figure 11). Most of the countries reporting declining catches represent a relatively low contribution to global production of inland water captures, although some supply important quantities to national or regional diets – in particular, Cambodia, Brazil, Viet Nam and Thailand.

Inland water captures are more concentrated than marine captures among major producing nations endowed with important waterbodies or river basins (Figure 12). In 2020, 13 countries produced over 75 percent of total inland captures, compared with 20 countries for marine captures.

For the same reason, the top producers of inland water captures are also more concentrated geographically and are particularly important in terms of the contribution to total captures in Asia, where inland water catches provide an important food source for many local communities. Asia has consistently accounted

9 For aquatic food, see Glossary, including Context of SOFIA 2022.

for around two-thirds of global inland water production since the mid-2000s, while the top four producers are all located in Asia and accounted for over 46 percent of total inland water catches in 2020.

At the global level, Africa accounts for over 25 percent of inland captures, which represent an important source of food security, particularly in the case of landlocked and low-income countries. The combined catches for Europe and the Americas account for around 8 percent of total inland captures, while in Oceania catches are negligible.

Three major species groups account for over 75 percent of total inland water catches. The first group, "carps, barbels and other cyprinids", has shown a continuous increase, rising from about 0.7 million tonnes per year in the mid-2000s to almost 1.9 million tonnes in 2020, and explains most of the increase in catches from inland waters in recent years. Catches of the second-largest group, "tilapias and other cichlids", have also started to increase in recent years from 0.7 million tonnes to 0.9 million tonnes per year. Catches of the third-largest group, "freshwater crustaceans", have generally remained stable at between 0.4 million tonnes and 0.45 million tonnes per year; however, in 2020, catches fell to 0.3 million tonnes, mostly as a result of the decrease in China's inland water catches.

Data sources and quality of FAO capture statistics

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 FAO statistics is highly dependent on the accuracy, completeness and timeliness of the data collected by national fisheries institutions and reported annually to FAO.

Often, the data submitted are incomplete, inconsistent or do not comply with international reporting standards, and FAO works to curate the data in collaboration with countries to improve their data collection and reporting, expanding to cover more species. As a result, the species breakdown (an indicator of quality and coverage in reported catches) more than doubled between 1996 (1 035 species) and 2020 (2 981 species). However, a significant proportion of catches are still not reported at the species level, particularly for groups such as sharks, rays and chimaeras in marine capture. In the case of inland water captures, the category of freshwater fishes nei (Actinopterygii) accounts for around 50 percent of global inland water captures in recent years.

The quality and completeness of data also vary considerably between marine and inland water captures, with marine catches having generally more complete data available by species than do inland captures.

Alternatively, FAO informs users of the countries where the long-term official catch series may be subject to inconsistencies due to breaks in the time series as a result of changes in the data collection. While improvements in national data collection and reporting systems are always welcome, unless accompanied by corrections to historical data, they can result in abrupt changes to the total national catch and, if species breakdown is also improved, to trends at the species level.

Issues of timeliness or the non-reporting of data to FAO affect the quality and completeness of FAO's estimates of total capture fisheries. The late submission of questionnaires makes it challenging for FAO to process, validate and review the capture fisheries statistics – in particular for the most recent year – prior to the official release of the data, usually in mid-March every year. In the absence of national reports or in the event of inconsistencies in the data, FAO may make estimates based on the best data available from alternative official data sources (including data published by RFMOs, or through standard methodologies).

FAO continues to express concern that a number of countries have not responded to FAO questionnaires in recent years or report incomplete data. These countries include some large capture producers such as Indonesia, Brazil, Mauritania and Cambodia. Issues regarding the timeliness or non-reporting of data to FAO were exacerbated in 2020 by the disruption in regular data collection activities caused by the COVID-19 pandemic.

Improvements in the overall quality of the catch data in 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 the national and regional levels (Box 1, p. 2). 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. ■

AQUACULTURE PRODUCTION

Overall production status and trend

Global aquaculture production retained its growth trend in 2020 amid the worldwide spread of the COVID-19 pandemic (see the section COVID-19, a crisis like no other, p. 195, and Box 2, p. 6), albeit with differences among regions and among producing countries within each region. The total aquaculture production comprised 87.5 million tonnes of aquatic animals mostly for use as human food, 35.1 million tonnes of algae[10] for both food and non-food uses, 700 tonnes of shells and pearls for ornamental use, reaching a total of 122.6 million tonnes in live weight in 2020 (Figure 13). This represents an increase of 6.7 million tonnes from 115.9 million tonnes in 2018. The estimated total farm gate value was USD 281.5 billion in 2020, an increase of USD 18.5 billion from 2018 and USD 6.7 billion from 2019.

World aquaculture production of animal species grew by 2.7 percent in 2020 compared with 2019, an all-time low rate of annual growth in over 40 years. However, the net increase of 2.3 million tonnes in the same period was comparable to some years in the last decade. Finfish farming remained steady with minimal fluctuation around 66 percent and accounting for the largest share of world aquaculture for decades. In 2020, farmed finfish reached 57.5 million tonnes (USD 146.1 billion), including 49.1 million tonnes (USD 109.8 billion) from inland aquaculture and 8.3 million tonnes (USD 36.2 billion) from mariculture in the sea and coastal aquaculture on the shore. Production of other farmed aquatic animal species reached 17.7 million tonnes of molluscs (USD 29.8 billion) mostly bivalves, 11.2 million tonnes of crustaceans (USD 81.5 billion), 525 000 tonnes of aquatic invertebrates (USD 2.5 billion) and 537 000 tonnes of semi-aquatic species including turtles and frogs (USD 5 billion).

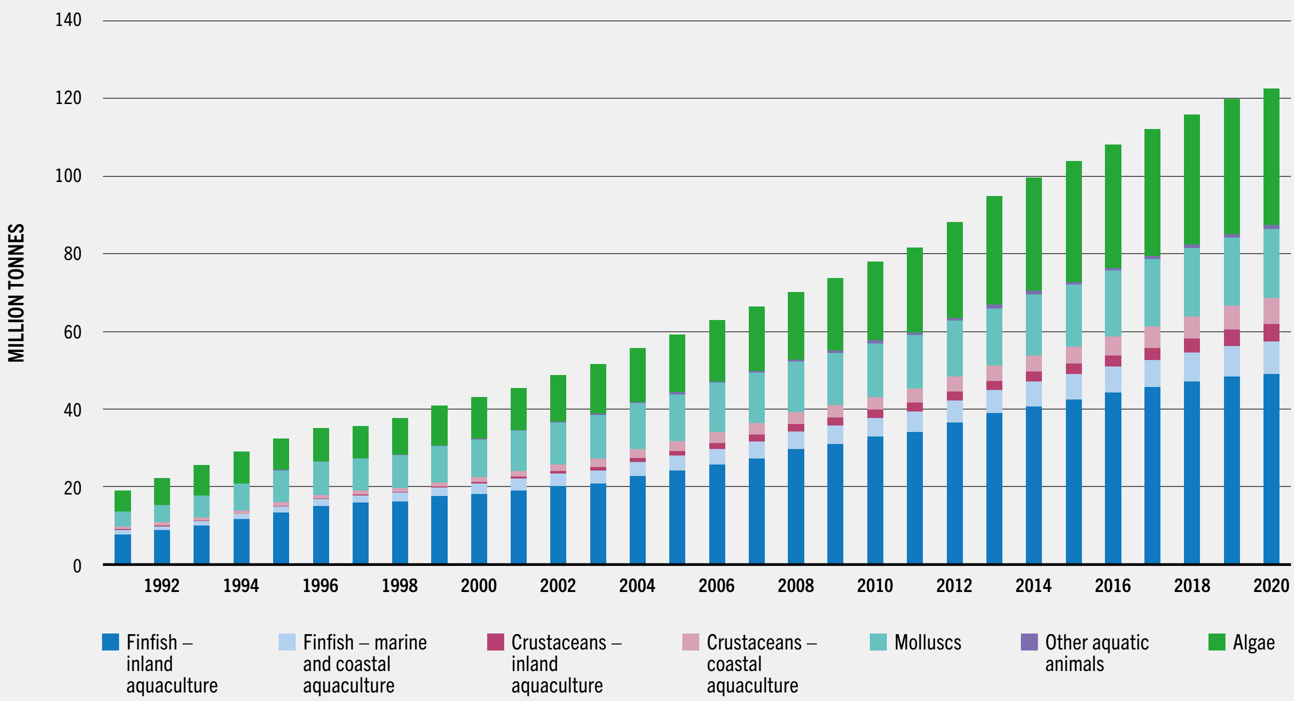
Global cultivation of algae, dominated by marine macroalgae known as seaweeds, grew by half a million tonnes in 2020, up by 1.4 percent from 34.6 million tonnes in 2019. Some major producing countries including China and Japan experienced growth in 2020, while seaweed harvests decreased in Southeast Asia and the Republic of Korea.

At the regional level, African aquaculture (excluding algae) suffered from a slight contraction in its annual output (down 1.2 percent in 2020 compared with 2019), mainly the result of the drop in production in Egypt, Africa's major producer. In Nigeria, the largest producer in sub-Saharan Africa, the declining trend since 2016 worsened in 2020 with a sharp decrease of 9.6 percent. Aquaculture in the rest of Africa enjoyed a double-digit growth of 14.5 percent reaching 396 700 tonnes in 2020 from 346 400 tonnes in 2019. All other regions experienced continued growth in 2020. Chile, China and Norway – the top producers in the Americas, Asia and Europe, respectively – all experienced growth in 2020, offsetting the decreased output that occurred in some countries in their respective regions.

In the period 1990–2020, total world aquaculture expanded by 609 percent in annual output with an average growth rate of 6.7 percent per year. The average annual growth rate had decreased gradually from 9.5 percent during the period 1990–2000 to 4.6 percent during 2010–2020. The growth rate reduced further to 3.3 percent per year in the most recent years (2015–2020). Next to the falling trend in growth rate in

10 For algae, see Glossary, including Context of SOFIA 2022.

FIGURE 13 WORLD AQUACULTURE PRODUCTION, 1991–2020



NOTES: Data exclude shells and pearls. Data expressed in live weight equivalent.
SOURCE: FAO.

relative terms, it is important to note the net increase in world production in absolute terms over three decades. Additional details of world aquaculture growth are presented in Table 6.

Aquaculture development has exhibited different fluctuating patterns in growth among regions. In the largest producing region, Asia, growth in the period 1990–2020 has been relatively steady in the major aquaculture countries, although with decreasing growth rates. Other regions have had relatively fluctuating growth in the same period, experiencing negative growth in some years (Figure 14).

Source of aquaculture data for analysis

As in past editions, the analysis of status and trends in aquaculture development relies on, though is not limited to, FAO's global aquaculture production data of 1950–2020 released in March 2022, including data adjustment for some back years for some countries as per routine standard statistical practices. The retroactive adjustments concern certain data-poor countries, but do not modify the conclusions on a global and regional scale reported in *The State of World Fisheries and Aquaculture 2020*.

For example, in 2020, FAO's aquaculture data on farmed animal species covered 207 countries and territories, including national data reported or retrieved from official sources for 122 of them (59 percent). However, total production data of these countries reached over 85.4 million tonnes, representing 97.6 percent of world production in 2020. At the species or species group level, to distinguish between inland and coastal aquaculture and to take into account the type of

TABLE 6 WORLD AQUACULTURE PRODUCTION AND GROWTH

	1990–2020	1990–2000	2000–2010	2010–2020	2015–2020
All aquaculture					
A. Starting annual output (million tonnes)	17.3	17.3	43.0	77.9	104.0
B. Ending year's annual output (million tonnes)	122.6	43.0	77.9	122.6	122.6
C. Accumulated increase in annual output (million tonnes)	105.3	25.7	34.9	44.6	18.6
D. Overall increase	609%	149%	81%	57%	18%
E. Average annual growth rate	6.7%	9.5%	6.1%	4.6%	3.3%
Aquatic animals					
A. Starting annual output (million tonnes)	13.1	13.1	32.4	57.8	72.9
B. Ending year's annual output (million tonnes)	87.5	32.4	57.8	87.5	87.5
C. Accumulated increase in annual output (million tonnes)	74.4	19.3	25.3	29.7	14.6
D. Overall increase	569%	148%	78%	51%	20%
E. Average annual growth rate	6.5%	9.5%	5.9%	4.2%	3.7%
Algae					
A. Starting annual output (million tonnes)	4.2	4.2	10.6	20.2	31.1
B. Ending year's annual output (million tonnes)	35.1	10.6	20.2	35.1	35.1
C. Accumulated increase in annual output (million tonnes)	30.9	6.4	9.6	14.9	4.0
D. Overall increase	736%	153%	90%	74%	13%
E. Average annual growth rate	7.3%	9.7%	6.7%	5.7%	2.5%

SOURCE: FAO.

water used, FAO corrected omissions in statistical details in official data that were questionable or available in highly aggregated form in line with internationally established standards of classification and identification.

Out of 61 producing countries and territories reporting algae cultivation, FAO collected official production data from 36 of them; their combined production was 34.7 million tonnes, or 98 percent of world production in 2020.

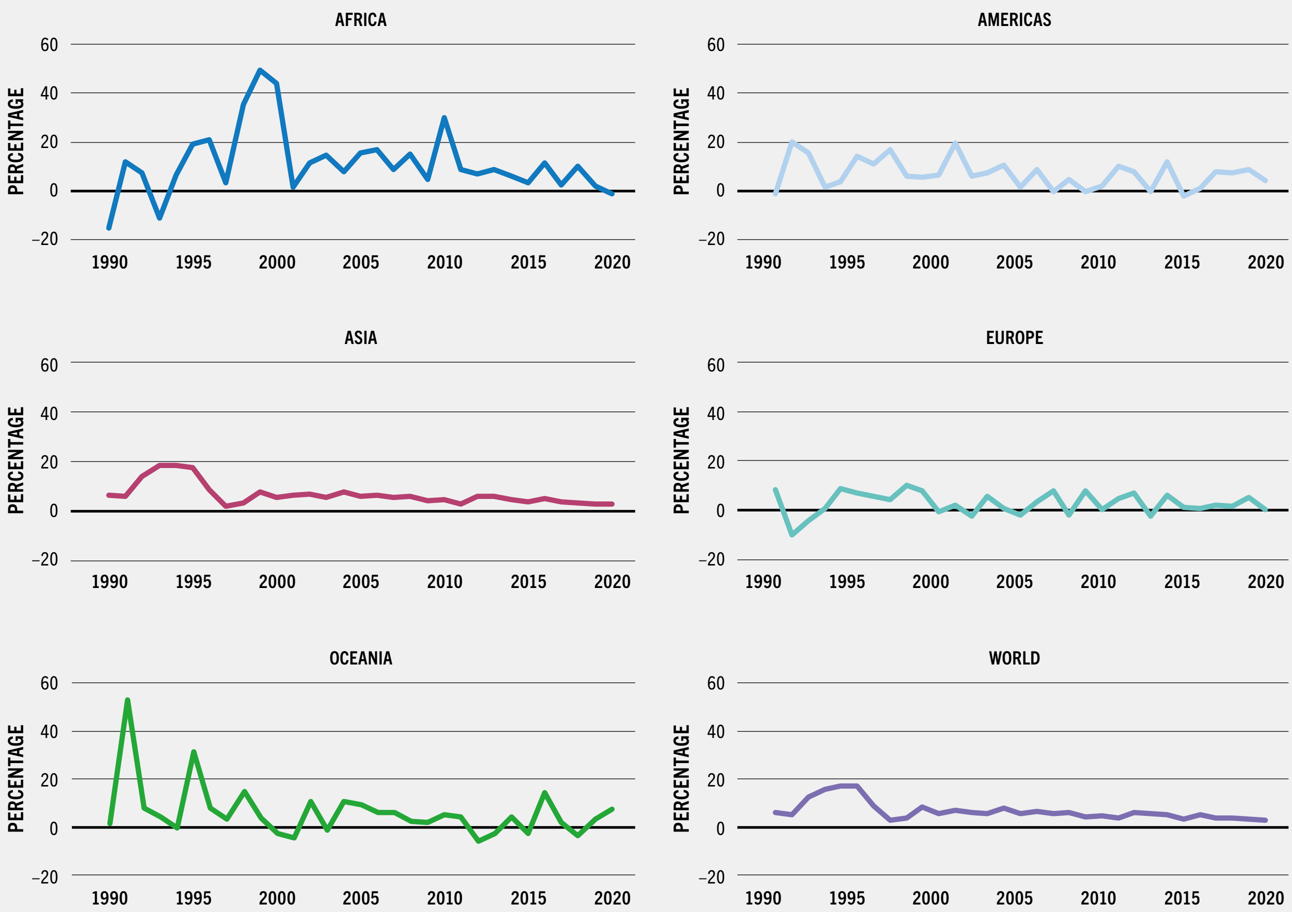
Production distribution and major producers

Asia has overwhelmingly dominated world aquaculture for decades, producing 91.6 percent of global aquatic animals and algae in 2020. However, there are huge differences in the level of aquaculture development between countries within Asia. Countries such as Mongolia, Timor-Leste and some countries in Central and West Asia are in need of accelerated aquaculture development to exploit their aquaculture potential.

The uneven distribution in aquaculture production and the disparity in aquaculture development status across regions and among countries in the same region have not shown significant improvement for decades. Many developing countries, in particular low-income countries, face great challenges to achieve their national aspirations of aquaculture development in support of national food production to feed and create jobs for their growing populations.

Data in Table 7 illustrate the global distribution of aquaculture production by region, reflecting the lingering situation of dominance by a small number of major producers at the global, regional and subregional levels. Since 1991, China

FIGURE 14 **ANNUAL GROWTH RATE OF AQUATIC ANIMAL AQUACULTURE PRODUCTION BY CONTINENT, 1990–2020**



SOURCE: FAO.

(mainland) has produced more farmed aquatic animals and algae than the rest of the world. Its share in world aquaculture production was 56.7 percent for aquatic animals and 59.5 percent for algal farming in 2020 – similar to recent years.

Production of the main groups of farmed species differs significantly across regions and countries. Some middle-income countries dominate inland aquaculture production of finfish species. Some such as Norway and Chile (endowed with large areas of fjords protected from rough sea), plus China from the middle-income group, dominate world mariculture of finfish species with sea cages. Atlantic salmon is representative of sea cage culture of coldwater species, while finfish produced by sea cage farmers in China are mostly warmwater species and their composition is more diverse. Figure 15 presents the distribution patterns among leading producers or subregions for comparison of selected main species groups.

Marine shrimps dominate the production of crustaceans from coastal aquaculture in

TABLE 7 WORLD AQUACULTURE PRODUCTION BY REGION AND SELECTED MAJOR PRODUCERS

Regions and selected countries		2010			2020		
		Animals	Algae	All species	Animals	Algae	All species
		(thousand tonnes, live weight)					
Africa		**1 286.1**	**138.3**	**1 424.4**	**2 250.2**	**104.1**	**2 354.3**
	(percentage in world)	***(2.23)***	***(0.69)***	***(1.83)***	***(2.57)***	***(0.30)***	***(1.92)***
Egypt		919.6		919.6	1 591.9		1 591.9
	(percentage in Africa)	*(71.50)*		*(64.56)*	*(70.74)*		*(67.62)*
Northern Africa, excluding Egypt		10.1		10.1	40.1	0.3	40.4
	(percentage in Africa)	*(0.78)*		*(0.71)*	*(1.78)*	*(0.27)*	*(1.72)*
Nigeria		200.5		200.5	261.7		261.7
	(percentage in Africa)	*(15.59)*		*(14.08)*	*(11.63)*		*(11.12)*
Sub-Saharan Africa, excluding Nigeria		155.9	138.3	294.2	356.5	103.8	460.3
	(percentage in Africa)	*(12.12)*	*(100.00)*	*(20.66)*	*(15.84)*	*(99.73)*	*(19.55)*
Americas		**2 514.6**	**12.9**	**2 527.6**	**4 375.2**	**25.3**	**4 400.5**
	(percentage in world)	***(4.35)***	***(0.06)***	***(3.24)***	***(5.00)***	***(0.07)***	***(3.59)***
Chile		701.1	12.2	713.2	1 485.9	19.6	1 505.5
	(percentage in Americas)	*(27.88)*	*(94.17)*	*(28.22)*	*(33.96)*	*(77.39)*	*(34.21)*
Rest of Latin America and the Caribbean		1 154.5	0.8	1 155.3	2 270.1	5.4	2 275.5
	(percentage in Americas)	*(45.91)*	*(5.83)*	*(45.71)*	*(51.89)*	*(21.43)*	*(51.71)*
North America		659.0		659.0	619.2	0.3	619.5
	(percentage in Americas)	*(26.21)*		*(26.07)*	*(14.15)*	*(1.19)*	*(14.08)*
Asia (excluding Cyprus)		**51 228.8**	**20 008.2**	**71 237.0**	**77 377.0**	**34 916.3**	**112 293.3**
	(percentage in world)	***(88.70)***	***(99.18)***	***(91.41)***	***(88.43)***	***(99.54)***	***(91.61)***
China (mainland)		35 513.4	12 273.3	47 786.7	49 620.1	20 862.9	70 483.1
	(percentage in Asia)	*(69.32)*	*(61.34)*	*(67.08)*	*(64.13)*	*(59.75)*	*(62.77)*
India		3 785.8	4.2	3 790.0	8 636.0	5.3	8 641.3
	(percentage in Asia)	*(7.39)*	*(0.02)*	*(5.32)*	*(11.16)*	*(0.02)*	*(7.70)*
Indonesia		2 304.8	3 915.0	6 219.8	5 226.6	9 618.4	14 845.0
	(percentage in Asia)	*(4.50)*	*(19.57)*	*(8.73)*	*(6.75)*	*(27.55)*	*(13.22)*
Viet Nam		2 683.1	18.2	2 701.3	4 600.8	13.9	4 614.7
	(percentage in Asia)	*(5.24)*	*(0.09)*	*(3.79)*	*(5.95)*	*(0.04)*	*(4.11)*
Bangladesh		1 308.5		1 308.5	2 583.9		2 583.9
	(percentage in Asia)	*(2.55)*		*(1.84)*	*(3.34)*		*(2.30)*
Rest of Asia		5 633.1	3 797.4	9 430.5	6 709.6	4 415.8	11 125.4
	(percentage in Asia)	*(11.00)*	*(18.98)*	*(13.24)*	*(8.67)*	*(12.65)*	*(9.91)*
Europe (including Cyprus)		**2 537.3**	**2.1**	**2 539.4**	**3 270.0**	**21.8**	**3 291.7**
	(percentage in world)	***(4.39)***	***(0.01)***	***(3.26)***	***(3.74)***	***(0.06)***	***(2.69)***
Norway		1 019.8		1 019.8	1 490.1	0.3	1 490.4
	(percentage in Europe)	*(40.19)*		*(40.16)*	*(45.57)*	*(1.54)*	*(45.28)*
European Union (27)		1 072.1	1.4	1 073.5	1 093.8	0.5	1 094.3
	(percentage in Europe)	*(42.25)*	*(70.17)*	*(42.27)*	*(33.45)*	*(2.38)*	*(33.24)*
Rest of Europe		445.5	0.6	446.1	686.1	20.9	707.0
	(percentage in Europe)	*(17.56)*	*(29.83)*	*(17.57)*	*(20.98)*	*(96.08)*	*(21.48)*
Oceania		**189.7**	**12.8**	**202.5**	**228.5**	**10.1**	**238.6**
	(percentage in world)	***(0.33)***	***(0.06)***	***(0.26)***	***(0.26)***	***(0.03)***	***(0.19)***
WORLD		**57 756.4**	**20 174.3**	**77 930.7**	**87 500.9**	**35 077.6**	**122 578.5**

SOURCE: FAO.

FIGURE 15 PRODUCTION DISTRIBUTION OF SELECTED MAIN SPECIES GROUPS AND TYPE OF AQUACULTURE, 2005–2020

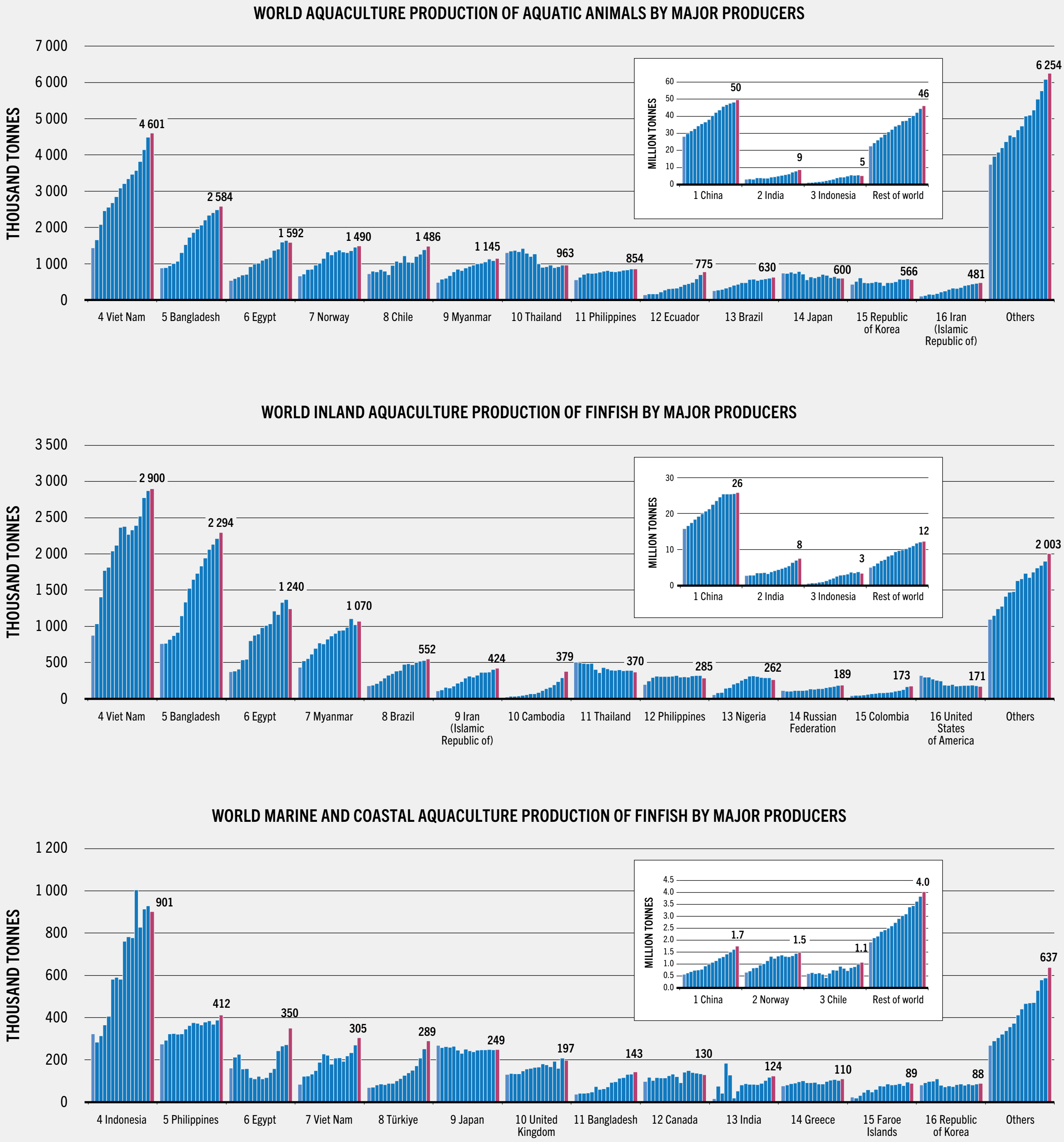
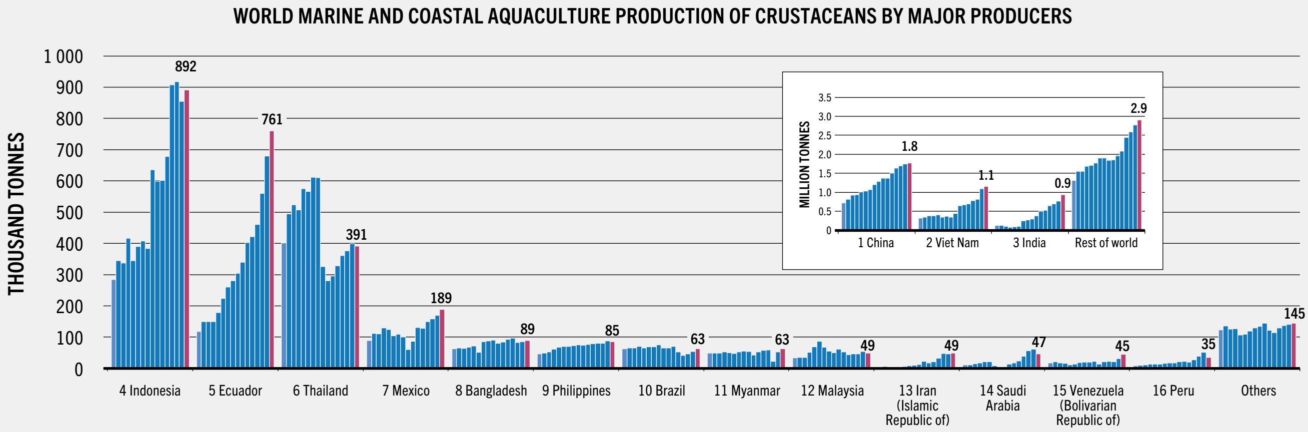
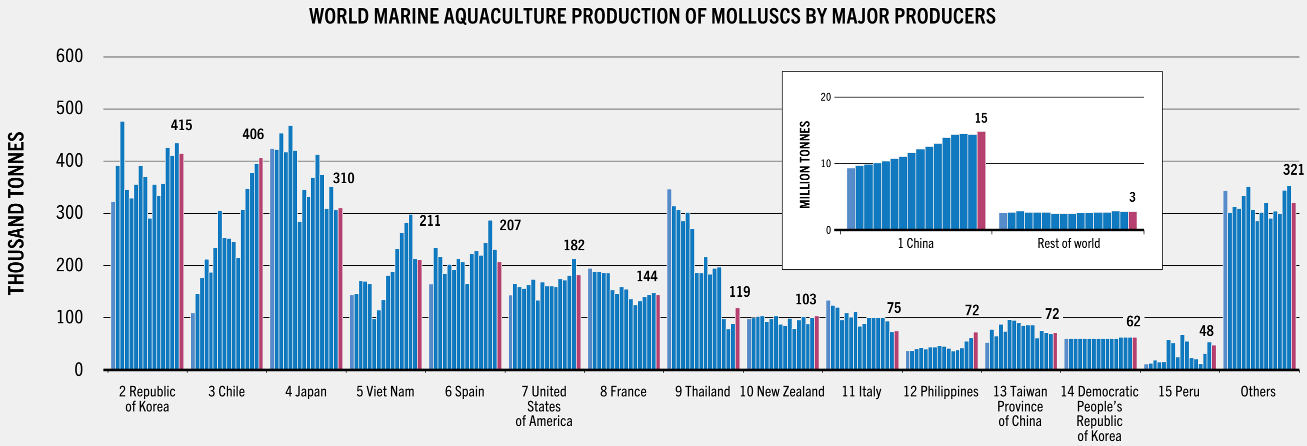
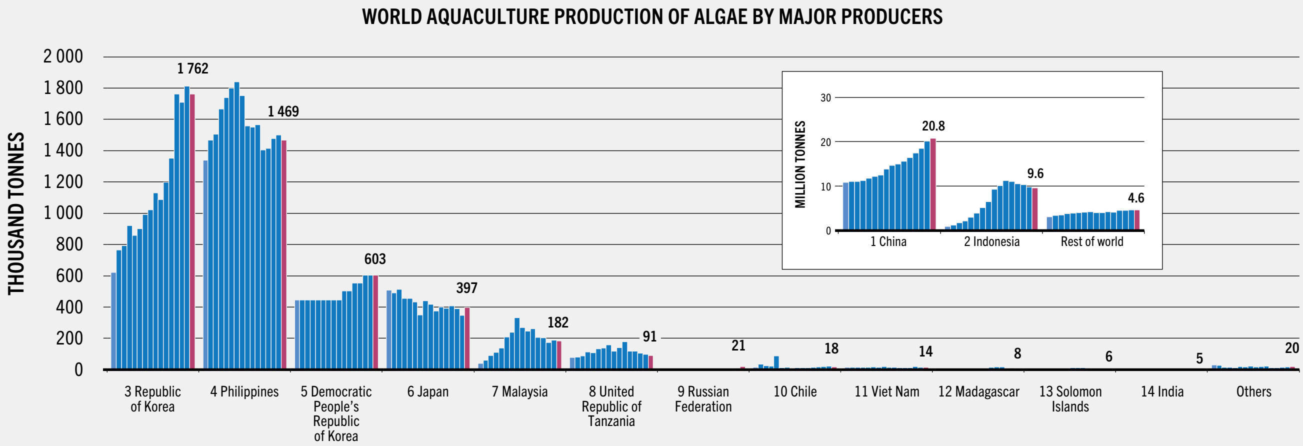


FIGURE 15 (Continued)







NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

brackish-water ponds. They are an important source of foreign exchange earnings for a number of developing countries in Asia and Latin America.

In terms of quantity, marine mollusc production in China by far outweighs that of all other producers combined. However, in some major producing countries, cultivation of marine bivalves accounts for a high percentage of total aquaculture production of aquatic animals. These countries include New Zealand (86.9 percent), France (75.4 percent), Spain (74.8 percent), the Republic of Korea (69.7 percent), Italy (61.6 percent) and Japan (51.8 percent), against a world average of 18.4 percent.

Aquaculture contribution to total fisheries and aquaculture production[11]

Most major aquaculture producing countries are highly populated developing countries where aquaculture contributes more than half of total fisheries and aquaculture production, benefiting half of the global population. These countries, such as Egypt in Africa, and Bangladesh and Viet Nam in Asia, set successful examples for aquaculture development in other countries with similar conditions and where potential exists for aquaculture development.

On a world scale, the contribution of aquaculture to total fisheries and aquaculture production (excluding algae) has climbed steadily, reaching 49.2 percent in 2020 on a par with capture, compared with just 13.4 percent in 1990. This contribution varies greatly among and within regions (Figure 16). Asia produces more from aquaculture (61.9 percent) than from capture, and when the top producer is excluded in each region, Asia still has a high aquaculture share of 44.7 percent. In contrast, if Egypt is excluded, Africa's contribution to world aquaculture production was a mere 6.6 percent in 2020, the lowest among regional and subregional groups represented in the figure.

Using the World Bank's income level classification, the period 1990–2020 witnessed rapid development in aquaculture in 51 of the lower-middle-income countries and 53 of the upper-middle-income countries reporting aquaculture production. In 2020, aquaculture contributed 61.7 percent to total production in upper-middle-income countries (2.76 billion population), up from 19.8 percent in 1990. The share of aquaculture in lower-middle-income countries (3.13 billion population) increased from 14.7 percent to 46.2 percent in the same period (Figures 17 and 18).

In the 67 high-income countries reporting aquaculture data (1.32 billion population), although aquaculture production more than doubled reaching 6.8 million tonnes in 2020 from 3.1 million tonnes in 1990, its contribution to total fisheries and aquaculture production was just 23 percent in 2020 (up from 7.6 percent in 1990). However, its contribution would be even lower without the 40.1 percent decrease in capture production in the same period (from 38.1 million tonnes to 22.8 million tonnes).

In the 26 low-income countries reporting aquaculture data (0.86 billion population), mostly in sub-Saharan Africa, aquaculture development has made limited progress in terms of its contribution to total fisheries production. In 2020, aquaculture accounted for just 8 percent of total production, a slight increase compared with 3.7 percent in 1990.

Inland aquaculture

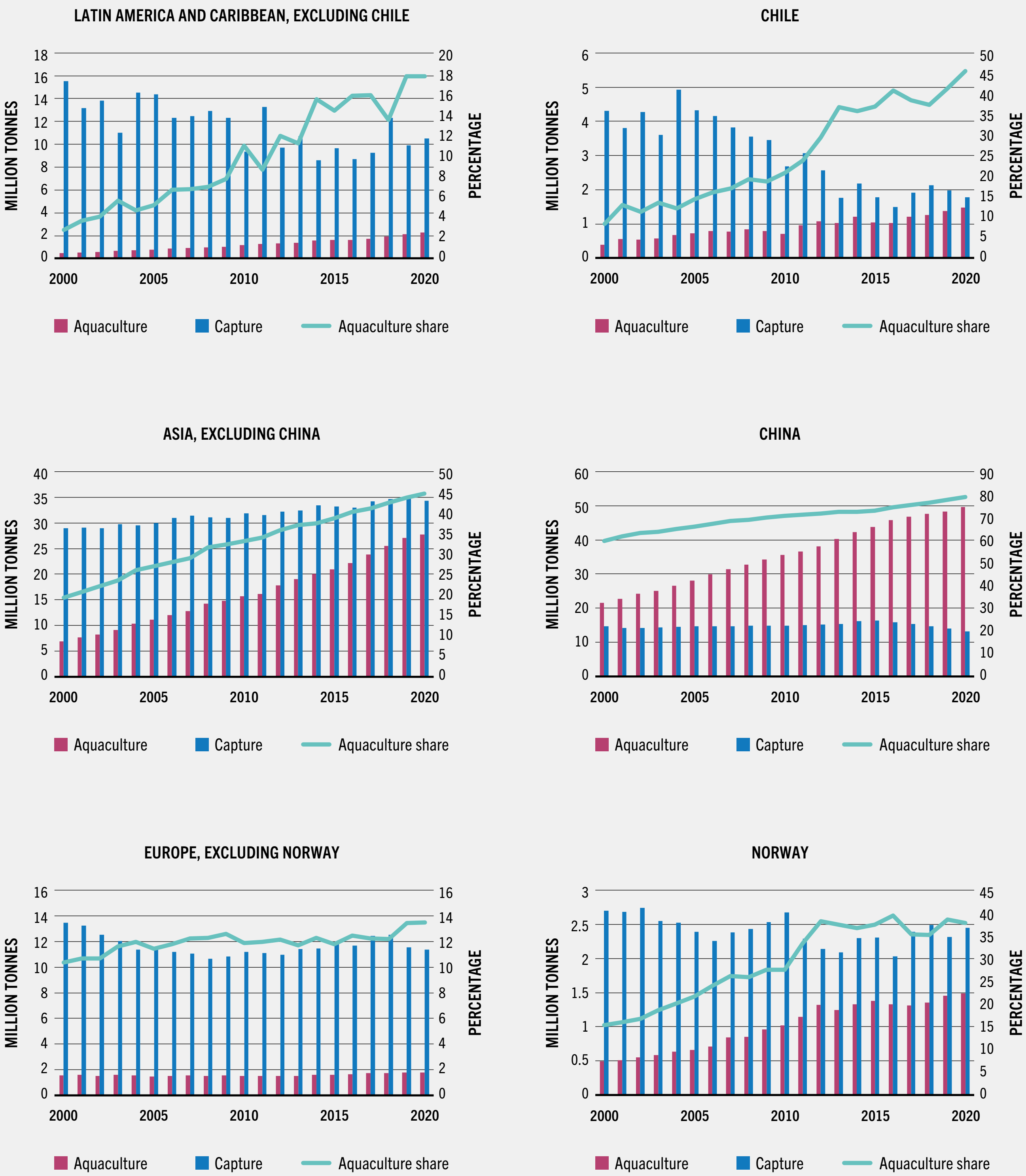
Because there are places in the world where natural or modified saline waters are used for aquaculture, *The State of World Aquaculture and Fisheries 2022* maintains the term "inland aquaculture", although another term, "freshwater aquaculture", is widely used when saline water is not a concern. Also, brackish-water aquaculture in constructed ponds on seashores in coastal areas – classified nationally or locally in some places as "inland aquaculture" – is treated in this report as coastal aquaculture.

In 2020, global inland aquaculture production was 54.4 million tonnes, accounting for 44.4 percent of the world total aquaculture production of animal species and algae, and inland farming of aquatic animal species represented 62.2 percent of

11 For fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

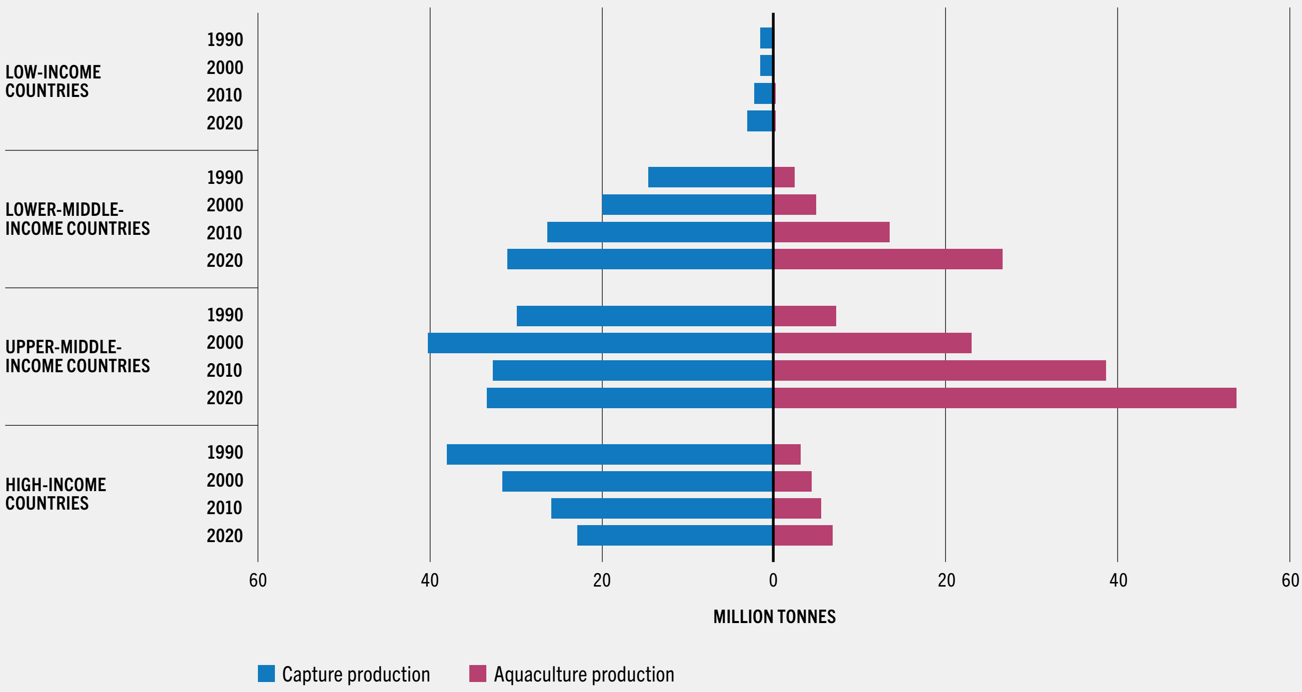
FIGURE 16 CONTRIBUTION OF AQUACULTURE TO TOTAL FISHERIES AND AQUACULTURE PRODUCTION (EXCLUDING ALGAE) BY REGION, 2000–2020

FIGURE 16 (Continued)



NOTE: Data in million tonnes expressed in live weight equivalent.
SOURCE: FAO.

FIGURE 17 FISHERIES AND AQUACULTURE GROWTH COMPARISON BY COUNTRY GROUP BY INCOME LEVEL (EXCLUDING ALGAE), 1990–2020



NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

total aquaculture production. Farming of finfish species dwarfs all other species groups in inland aquaculture at the regional and global levels (Table 8). However, the development status and composition pattern of non-finfish groups differ greatly from region to region.

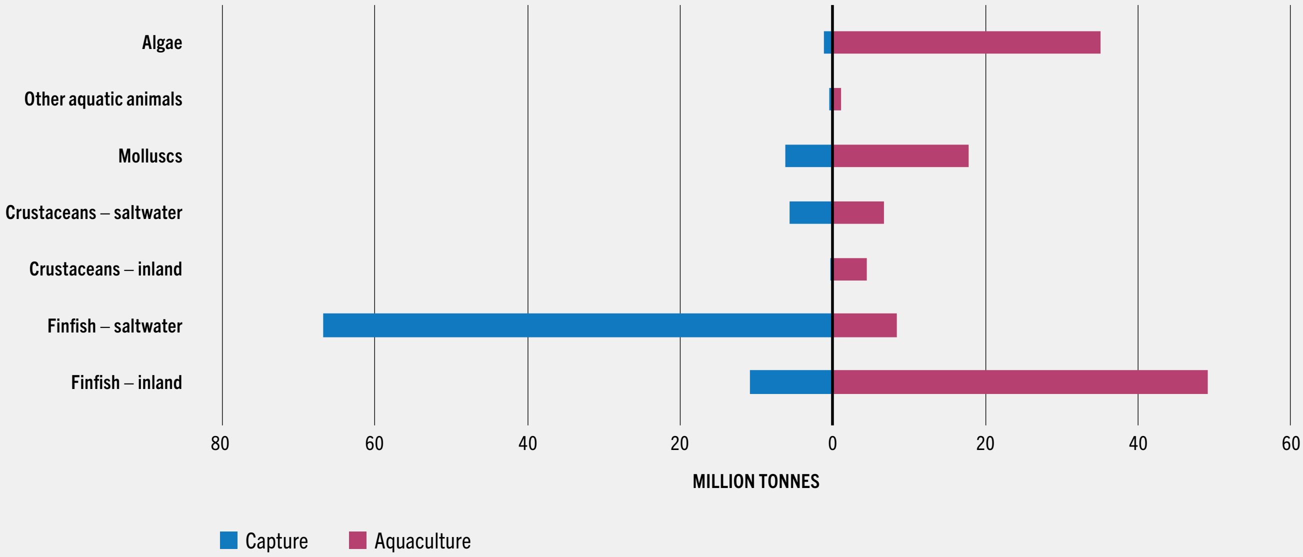
World inland aquaculture employs very diverse culture methods and facilities. The operation and practices vary greatly in terms of input intensity, level of technological and management sophistication and degree of integration with other farm activities. Globally, raising finfish and other species in constructed earthen ponds is by far the most widespread culture method.

Cage culture and, to a lesser extent, pen culture are also widely used in inland aquaculture, but their relative importance varies greatly among countries. Worldwide data on inland cage and pen culture are unavailable. Based on available data, Table 9 presents cage culture and pen culture production, in comparison with national total inland aquaculture production of finfish in selected countries.

National and local policy differs among countries in terms of control of access to and use of public open waterbodies for aquaculture, including cage and pen culture. With proper regulation, investing in cage culture in public open waterbodies has proved to be an effective and efficient approach to increase aquaculture production, along with pond culture and other methods.

In the Philippines and Indonesia, cage and pen culture (including enclosures) in rivers, lakes and reservoirs has been undergoing significant development for decades. In recent

FIGURE 18 SHARE OF AQUACULTURE IN TOTAL FISHERIES AND AQUACULTURE PRODUCTION BY MAJOR SPECIES GROUP, 2020



NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

years, authorities have started campaigns to reduce cage culture in some waterbodies. In China, one of the focuses of the Thirteenth Five-Year Plan (2016–2020) was to "green" natural resource-based economic activities in the country, including aquaculture, especially in inland areas. Implementation of the greening policy entailed locally coordinated clean-up plans together with a mitigation programme to protect the affected communities and individuals, and the vast majority of cages and pens were removed (Figure 19). Some provinces still grant a limited number of licenses based on the carrying capacity assessment of the waterbodies, but the permit process prioritizes environmental and conservation issues over the economic value of the remaining cage culture operations.

Mariculture and coastal aquaculture

Mariculture, or marine aquaculture, takes place in the sea for the entire cycle or only during the grow-out phase. In the first case, the production cycle takes place entirely in the seas for those species dependent on wild seeds from the sea, for example, sea mussels. Otherwise, mariculture refers only to the grow-out phase of the production cycle when a species is produced from a land-based hatchery and sometimes even in freshwater, as is the case for Atlantic salmon. Coastal aquaculture, typically practised in constructed ponds onshore or in intertidal zones, plays an important role in livelihoods, employment and economic development among coastal communities in many developing countries particularly in Asia and Latin America.

In 2020, global production of marine and coastal aquaculture was 68.1 million tonnes, including 33.1 million tonnes of aquatic animals and 35 million tonnes of algae. The picture of mariculture and coastal aquaculture production of the main species groups, disaggregated by region is presented in Table 8.

TABLE 8 INLAND AQUACULTURE AND MARINE AND COASTAL AQUACULTURE PRODUCTION BY REGION AND BY MAIN SPECIES GROUP, 2020

	Africa	Americas	Asia	Europe	Oceania	World	Share in world total (%)
			(tonnes, live weight)				
1. Finfish	1 857 209	1 179 727	45 526 599	551 802	5 124	49 120 461	90.2
2. Crustaceans	2	72 541	4 401 336	3 145	177	4 477 201	8.2
3. Molluscs	...	...	192 671	...	...	192 671	0.4
4. Other aquatic animals	...	370	593 161	176	...	593 707	1.1
(Aquatic animals subtotal)	*(1 857 211)*	*(1 252 638)*	*(50 713 767)*	*(555 123)*	*(5 301)*	*(54 384 040)*	*(99.9)*
5. Algae	150	1 321	62 670	349	...	64 490	0.1
Inland aquaculture	**1 857 361**	**1 253 959**	**50 776 437**	**555 472**	**5 301**	**54 448 530**	**100**
1. Finfish	379 322	1 240 969	4 502 888	2 121 867	95 587	8 340 633	12.2
2. Crustaceans	7 617	1 193 549	5 549 811	418	8 420	6 759 815	9.9
3. Molluscs	5 994	688 077	16 158 709	578 712	116 363	17 547 855	25.8
4. Other aquatic animals	60	...	459 185	6 495	2 844	468 584	0.7
(Aquatic animals subtotal)	*(392 993)*	*(3 122 595)*	*(26 670 593)*	*(2 707 492)*	*(223 214)*	*(33 116 887)*	*(48.6)*
5. Algae	103 941	23 994	34 853 646	21 443	10 065	35 013 089	51.4
Marine and coastal aquaculture	**496 934**	**3 146 589**	**61 524 239**	**2 728 935**	**233 279**	**68 129 976**	**100**
1. Finfish	2 236 531	2 420 696	50 029 487	2 673 669	100 711	57 461 094	46.9
2. Crustaceans	7 619	1 266 090	9 951 147	3 563	8 597	11 237 016	9.2
3. Molluscs	5 994	688 077	16 351 380	578 712	116 363	17 740 526	14.5
4. Other aquatic animals	60	370	1 052 346	6 671	2 844	1 062 291	0.9
(Aquatic animals subtotal)	*(2 250 204)*	*(4 375 233)*	*(77 384 360)*	*(3 262 615)*	*(228 515)*	*(87 500 927)*	*(71.5)*
5. Algae	104 091	25 315	34 916 316	21 792	10 065	35 077 579	28.6
Total aquaculture	**2 354 295**	**4 400 548**	**112 300 676**	**3 284 407**	**238 580**	**122 578 506**	**100**

NOTES: ... = no production or production data unavailable. Data exclude production of shells and pearls. Data may not match with totals due to rounding.
SOURCE: FAO.

It is relatively easy to separate mariculture and coastal aquaculture of crustaceans, molluscs and other marine invertebrates based on the biological characteristics of these species and the culture methods adopted to rear them. However, this is not the case for finfish and those countries that grow different finfish species in both systems, due to the aggregation in production data. Based on information and data from alternative sources, a general picture of mariculture and coastal aquaculture is presented herein for the first time, showing mariculture and coastal aquaculture separately; caution should be exercised in interpreting this preliminary information (Figure 20). In 2020, finfish from coastal aquaculture was 3.1 million tonnes, representing 37.4 percent of the combined production of 8.3 million tonnes from mariculture and coastal aquaculture. Crustaceans were almost entirely from coastal aquaculture. The share of coastal

TABLE 9 CONTRIBUTION OF CAGE AND PEN CULTURE TO INLAND FINFISH AQUACULTURE PRODUCTION IN SELECTED COUNTRIES

	2010			2015			2020		
	Total production (thousand tonnes, live weight)	Cage production (thousand tonnes, live weight)	Contribution (%)	Total production (thousand tonnes, live weight)	Cage production (thousand tonnes, live weight)	Contribution (%)	Total production (thousand tonnes, live weight)	Cage production (thousand tonnes, live weight)	Contribution (%)
Cage culture									
China (mainland)	19 913	1 131	5.7	24 642	1 379	5.6	25 864	321	1.2
Indonesia	1 332	121	9.1	2 955	191	6.5	3 390	650	19.2
Bangladesh	1 147	...	...	1 831	2	0.1	2 294	5	0.2
Egypt	920	160	17.4	1 175	173	14.7	1 592	201	12.6
Thailand	404	40	9.9	391	33	8.4	369	32	8.7
Philippines	308	103	33.3	303	95	31.2	285	74	26.0
Russian Federation	115	25	21.6	138	30	21.6	189	59	31.2
Colombia	68	23	33.5	93	19	20.8	173	30	17.5
Türkiye	79			101	70	69.0	128	100	78.0
	Total production (thousand tonnes, live weight)	Pen production (thousand tonnes, live weight)	Contribution (%)	Total production (thousand tonnes, live weight)	Pen production (thousand tonnes, live weight)	Contribution (%)	Total production (thousand tonnes, live weight)	Pen production (thousand tonnes, live weight)	Contribution (%)
Pen culture									
China (mainland)	19 913	523	2.6	24 642	482	2.0	25 864	37	0.1
Indonesia	1 332	309	23.2	2 955	577	19.5	3 390	24	0.7
Bangladesh	1 147	...	...	1 831	13	0.7	2 294	13	0.6
Philippines	308	63	20.3	303	61	20.1	285	40	14.0
Russian Federation	115	5	4.7	138	3	2.4	189	10	5.2

NOTES: ... = data unavailable, or no production. Pen culture production in China includes some Chinese mitten crab. For Egypt, total finfish production in inland aquaculture refers to total national aquaculture production.
SOURCE: FAO.

aquaculture was 19.4 percent for other aquatic animals, followed by marine algae (4.2 percent) and molluscs (0.5 percent).

Aquaculture production with and without feeding

Fed aquaculture production progressively outpaced that of non-fed species. The share of non-fed aquaculture in total farmed aquatic animal production continued to decline from over 40 percent before 2000 to 27.8 percent in 2020, although absolute production stayed relatively stable. In 2020, non-fed production of animal species was 24.3 million tonnes, comprising 8.2 million tonnes of filter-feeding finfish reared in inland aquaculture (mainly silver carp and bighead carp) and 16.2 million tonnes of aquatic invertebrates, mainly marine bivalves (Figure 21).

In multi-species polyculture systems practised in inland and coastal aquaculture, feeds intended for fed species also directly benefit filter-feeding species, especially when feeds in powder form are used or pellet feeds are low in water stability and

FIGURE 19 REDUCTION IN SCALE OF CAGE AND PEN AQUACULTURE IN INLAND WATERS IN CHINA (MAINLAND) IN RECENT YEARS

NOTE: Data in thousand tonnes expressed in live weight equivalent.
SOURCE: Ministry of Agriculture and Rural Affairs, China.

dissolve quickly. Therefore, the border between fed and non-fed species under certain conditions becomes less clear-cut.

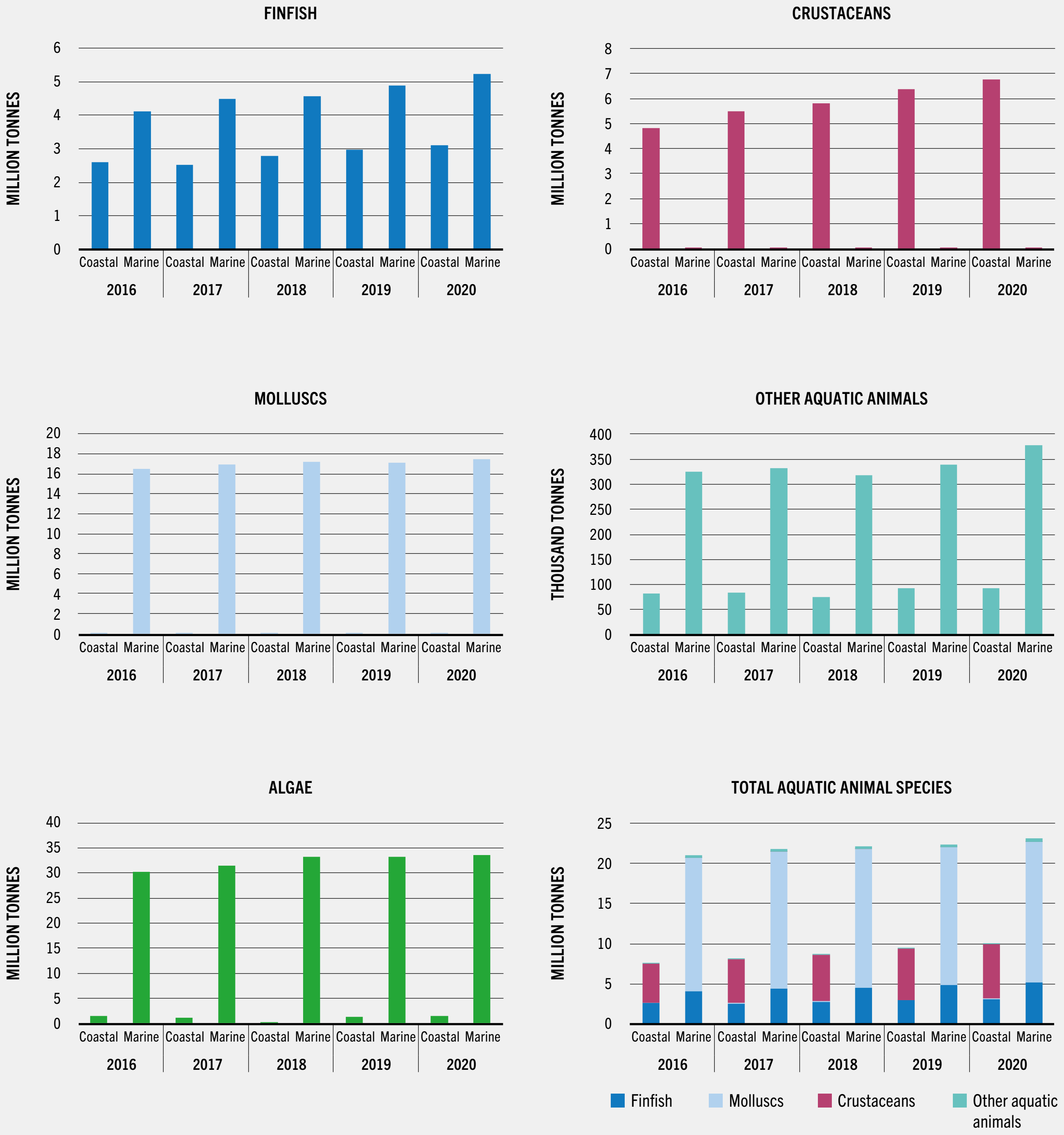
Regions such as Africa have not experienced aquaculture development of non-fed species. Although filter-feeding carps were introduced in some African countries in the 1950s and 1960s for aquaculture, they did not take off and faded before the arrival of the new millennium to be replaced by locally favourable tilapias and catfishes. It has proven difficult, if not impossible, to identify and develop native finfish species to play the role of filter-feeding carps in developing low-cost inland polyculture aquaculture with improved efficiency in harnessing natural productivity of the rearing water. However, in coastal areas in Africa, joint efforts (such as setting up internationally owned hatcheries) to accelerate development in marine molluscs farming represent a realistic option for increasing aquatic food[12] production.

Farmed aquatic species

Thanks to the vast range of conditions under which aquaculture is practised across the world, a richly diverse pool of aquatic species and

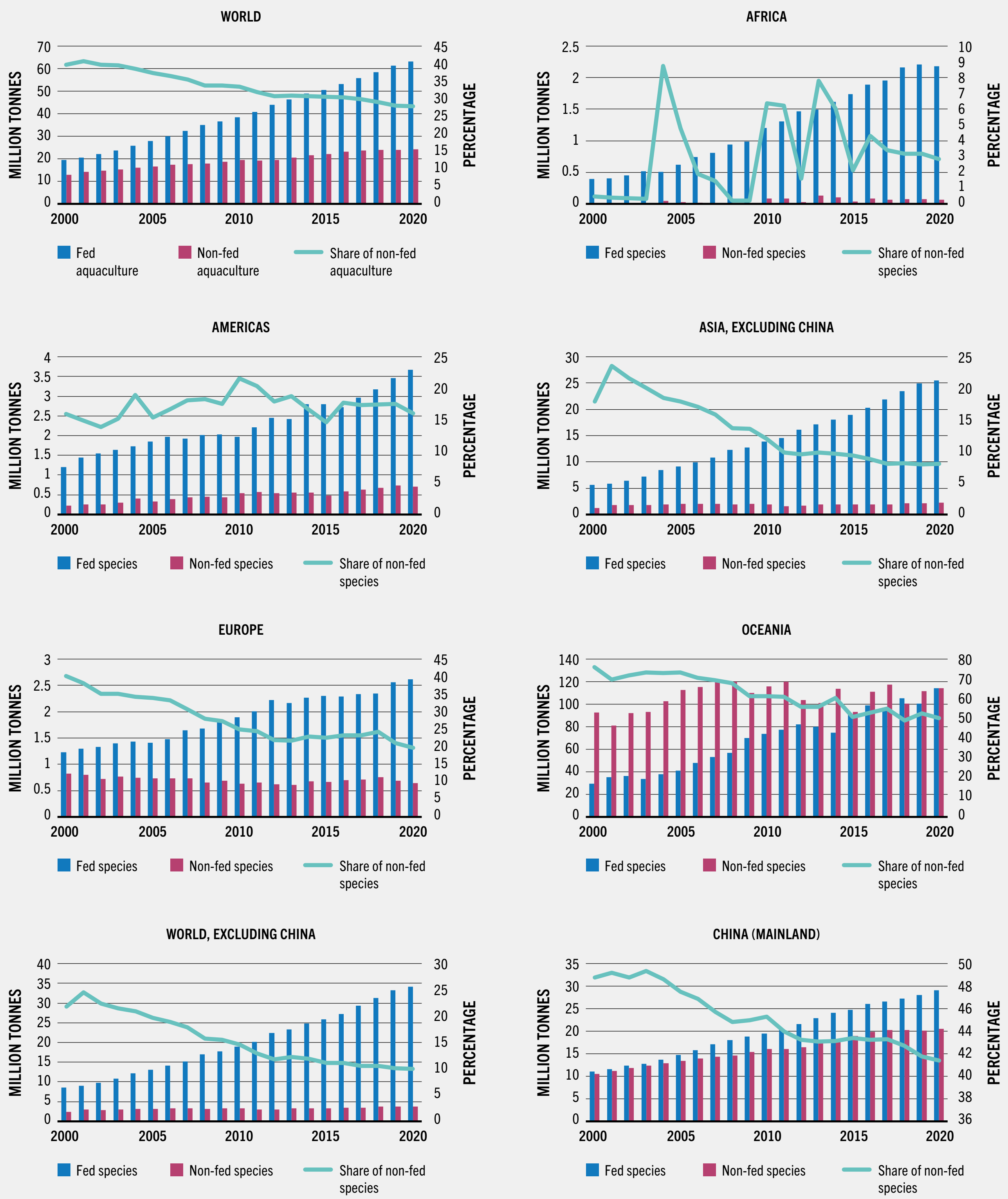
12 For aquatic food, see Glossary, including Context of SOFIA 2022.

FIGURE 20 COMPOSITION OF MARINE AND COASTAL AQUACULTURE PRODUCTION BY MAIN SPECIES GROUP, 2016–2020



NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

FIGURE 21 FED AND NON-FED AQUACULTURE PRODUCTION OF ANIMAL SPECIES BY REGION, 2000–2020



NOTE: Data in million tonnes expressed in live weight equivalent.
SOURCE: FAO.

TABLE 10 WORLD PRODUCTION OF MAJOR AQUACULTURE SPECIES (INCLUDING SPECIES GROUPS)

	2000	2005	2010	2015	2020	Percentage of total, 2020
			(thousand tonnes, live weight)			
Finfish in inland aquaculture						
Grass carp, *Ctenopharyngodon idellus*	2 976.5	3 396.6	4 213.1	5 315.0	5 791.5	11.8
Silver carp, *Hypophthalmichthys molitrix*	3 034.7	3 690.0	3 972.0	4 713.6	4 896.6	10
Nile tilapia, *Oreochromis niloticus*	1 001.5	1 721.3	2 637.4	4 000.9	4 407.2	9
Common carp, *Cyprinus carpio*	2 410.4	2 666.3	3 331.0	4 025.8	4 236.3	8.6
Catla, *Catla catla*	602.3	1 317.5	2 526.4	2 313.4	3 540.3	7.2
Bighead carp, *Hypophthalmichthys nobilis*	1 438.9	1 929.5	2 513.6	3 109.1	3 187.2	6.5
Carassius spp.	1 198.5	1 798.2	2 137.8	2 644.1	2 748.6	5.6
Striped catfish, *Pangasianodon hypophthalmus*	113.2	411.2	1 749.4	2 083.2	2 520.4	5.1
Roho labeo, *Labeo rohita*	733.9	1 435.9	1 133.2	1 785.3	2 484.8	5.1
Clarias catfishes, *Clarias* spp.	48.8	149.5	343.3	923.7	1 249.0	2.5
Tilapias nei, *Oreochromis* spp.	123.9	199.3	449.6	929.9	1 069.9	2.2
Wuchang bream, *Megalobrama amblycephala*	445.9	477.2	629.2	723.2	781.7	1.6
Rainbow trout, *Oncorhynchus mykiss*	340.4	360.0	464.7	546.5	739.5	1.5
Black carp, *Mylopharyngodon piceus*	149.0	280.7	409.5	541.2	695.5	1.4
Largemouth black bass, *Micropterus salmoides*	0.2	140.3	179.5	321.5	621.3	1.3
Subtotal of 15 major species	***14 618.2***	***19 973.5***	***26 689.7***	***33 976.3***	***38 970.1***	79.3
Subtotal other species	**3 546.6**	**4 260.1**	**6 337.7**	**8 535.7**	**10 150.4**	20.7
Total	**18 164.7**	**24 233.6**	**33 027.4**	**42 512.0**	**49 120.5**	100
Finfish in marine and coastal aquaculture						
Atlantic salmon, *Salmo salar*	895.7	1 266.6	1 433.8	2 380.2	2 719.6	32.6
Milkfish, *Chanos chanos*	429.7	542.9	750.5	1 012.3	1 167.8	14
Mullets nei, Mugilidae	92.4	173.7	102.7	129.2	291.2	3.5
Gilthead seabream, *Sparus aurata*	87.3	110.8	142.3	168.8	282.1	3.4
Large yellow croaker, *Larimichthys croceus*	0.0	60.9	83.3	142.4	254.1	3
European seabass, *Dicentrarchus labrax*	60.7	90.9	118.0	149.1	243.9	2.9
Groupers nei, *Epinephelus* spp.	7.6	57.1	77.2	149.2	226.2	2.7
Coho(=Silver) salmon, *Oncorhynchus kisutch*	108.6	115.1	124.8	140.7	221.8	2.7
Rainbow trout, *Oncorhynchus mykiss*	155.3	202.0	287.7	204.1	220.1	2.6
Japanese seabass, *Lateolabrax japonicus*	0.6	79.6	104.8	120.6	196.9	2.4
Pompano, *Trachinotus ovatus*	0.0	0.0	80.0	110.0	160.0	1.9
Japanese amberjack, *Seriola quinqueradiata*	136.8	159.7	138.9	140.3	137.1	1.6
Nile tilapia, *Oreochromis niloticus*	1.6	5.3	20.3	49.8	107.4	1.3
Barramundi(=Giant seaperch), *Lates calcarifer*	18.1	27.0	52.7	68.7	105.8	1.3
Red drum, *Sciaenops ocellatus*	2.1	42.4	53.0	71.3	84.3	1
Subtotal of 15 major species	***1 996.6***	***2 933.9***	***3 569.9***	***5 036.7***	***6 418.2***	77

TABLE 10 (Continued)

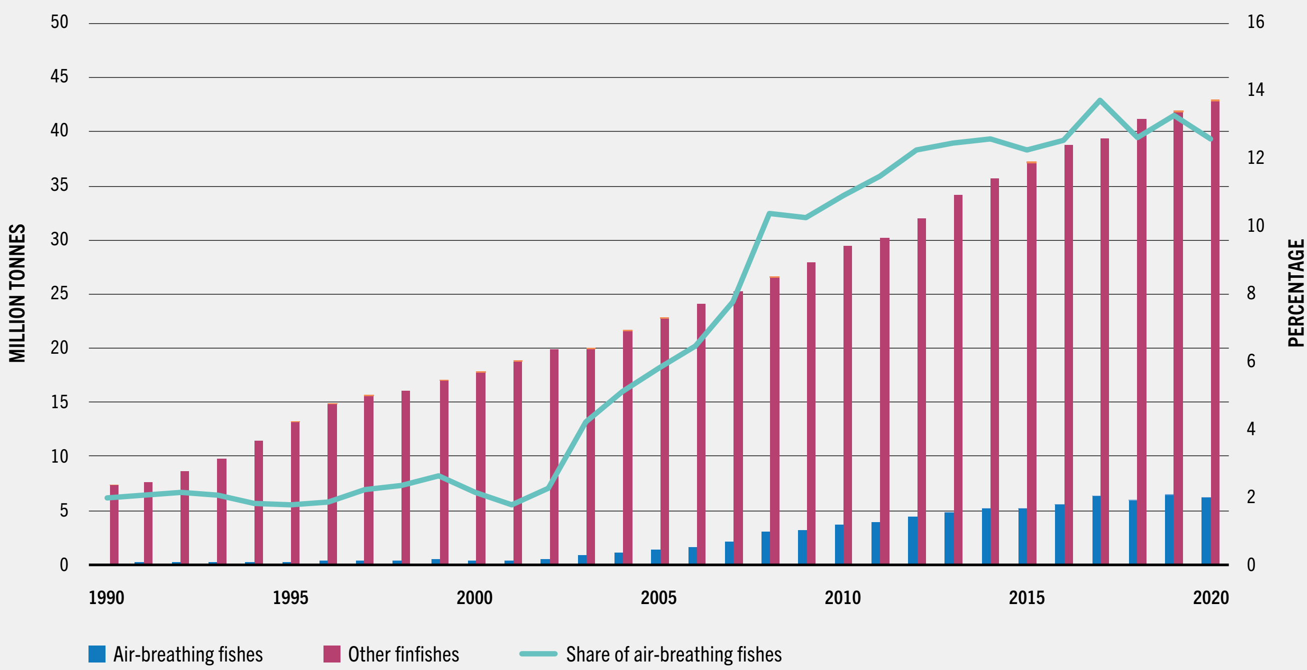
	2000	2005	2010	2015	2020	Percentage of total, 2020
			(thousand tonnes, live weight)			
Subtotal other species	**652.1**	**820.0**	**1 155.5**	**1 522.5**	**1 922.4**	23
Total	**2 648.7**	**3 753.9**	**4 725.4**	**6 559.2**	**8 340.6**	100
Crustaceans						
Whiteleg shrimp, *Penaeus vannamei*	154.5	1 678.4	2 648.5	3 803.6	5 812.2	51.7
Red swamp crawfish, *Procambarus clarkii*	9.9	114.3	599.3	723.1	2 469.0	22
Chinese mitten crab, *Eriocheir sinensis*	202.5	378.4	572.4	747.4	775.9	6.9
Giant tiger prawn, *Penaeus monodon*	631.0	665.5	562.9	735.2	717.1	6.4
Giant river prawn, *Macrobrachium rosenbergii*	130.7	195.9	193.1	202.5	294.0	2.6
Indo-Pacific swamp crab, *Scylla serrata*	10.7	11.7	37.0	83.6	248.8	2.2
Oriental river prawn, *Macrobrachium nipponense*	87.1	177.3	217.7	240.6	228.8	2
Green mud crab, *Scylla paramamosain*	0.0	97.5	112.4	135.1	159.4	1.4
Subtotal of 8 major species	***1 226.5***	***3 319.0***	***4 943.3***	***6 671.0***	***10 705.3***	95.3
Subtotal other species	**467.0**	**462.1**	**538.5**	**447.9**	**531.8**	4.7
Total	**1 693.4**	**3 781.0**	**5 481.8**	**7 118.9**	**11 237.0**	100
Molluscs						
Cupped oysters, *Crassostrea* spp.	2 922.6	3 377.5	3 570.7	4 408.3	5 450.3	30.7
Japanese carpet shell, *Ruditapes philippinarum*	1 504.3	2 590.8	3 500.2	3 880.2	4 266.2	24
Scallops nei, Pectinidae	811.5	906.3	1 366.6	1 710.1	1 746.4	9.8
Sea mussels, Mytilidae	719.8	834.1	871.4	1 055.8	1 108.3	6.2
Constricted tagelus, *Sinonovacula constricta*	487.7	624.4	693.3	760.2	860.3	4.8
Pacific cupped oyster, *Magallana gigas*	617.7	686.7	640.7	576.5	610.3	3.4
Blood cockle, *Anadara granosa*	286.6	385.3	456.7	425.9	457.9	2.6
Chilean mussel, *Mytilus chilensis*	23.5	87.7	221.5	208.7	399.1	2.2
Subtotal of 8 major species	***7 373.6***	***9 492.7***	***11 321.2***	***13 025.8***	***14 898.6***	84
Subtotal other species	**2 384.8**	**2 639.8**	**2 470.4**	**2 863.1**	**2 843.6**	16
Total	**9 758.4**	**12 132.5**	**13 791.5**	**15 888.9**	**17 742.2**	100
Other aquatic animals						
Chinese softshell turtle, *Trionyx sinensis*	85.0	163.3	261.1	313.7	334.3	31.5
Japanese sea cucumber, *Apostichopus japonicus*	0.0	57.2	126.6	198.0	201.5	19
Frogs, *Rana* spp.	0.1	71.2	79.6	82.1	147.8	13.9
Edible red jellyfish, *Rhopilema esculentum*	0.0	48.2	57.9	75.3	90.4	8.5
River and lake turtles, *Testudinata*	0.0	11.6	25.3	41.0	49.3	4.6
Subtotal of 5 major species	***85.0***	***351.5***	***550.4***	***710.1***	***823.3***	77.5
Subtotal other species	**70.8**	**76.8**	**243.3**	**140.8**	**239.0**	22.5
Total	**155.9**	**428.3**	**793.6**	**850.9**	**1 062.3**	100

TABLE 10 (Continued)

	2000	2005	2010	2015	2020	Percentage of total, 2020
			(thousand tonnes, live weight)			
Algae						
Japanese kelp, *Laminaria japonica*	5 380.9	5 699.1	6 525.6	10 313.7	12 469.8	35.5
Eucheuma seaweeds, *Eucheuma* spp.	214.3	983.9	3 472.6	10 182.1	8 129.4	23.2
Gracilaria seaweeds, *Gracilaria* spp.	55.5	933.2	1 657.1	3 767.0	5 180.4	14.8
Wakame, *Undaria pinnatifida*	311.1	2 439.7	1 505.1	2 215.6	2 810.6	8
Nori, *Porphyra* spp.	424.9	703.1	1 040.7	1 109.9	2 220.2	6.3
Elkhorn sea moss, *Kappaphycus alvarezii*	649.5	1 283.5	1 884.2	1 751.8	1 604.1	4.6
Fusiform sargassum, *Sargassum fusiforme*	12.1	115.6	97.0	209.3	292.9	0.8
Spiny eucheuma, *Eucheuma denticulatum*	85.3	174.5	265.5	280.8	154.1	0.4
Subtotal of 8 major species	***7 133.7***	***12 332.7***	***16 447.9***	***29 830.2***	***32 861.5***	93.7
Subtotal other species	**3 461.9**	**2 498.6**	**3 726.5**	**1 243.4**	**2 216.0**	6.3
Total	**10 595.6**	**14 831.3**	**20 174.3**	**31 073.5**	**35 077.6**	100

SOURCE: FAO.

FIGURE 22 **PRODUCTION OF AIR-BREATHING FISHES IN INLAND AQUACULTURE, 1990–2020**



NOTE: Data in million tonnes expressed in live weight equivalent.
SOURCE: FAO.

their hybrids are raised in different types of aquaculture farming systems using freshwater, brackish water, seawater or inland saline water.

The latest statistics compiled by FAO, based on national reports and estimates for non-reporting countries, cover all aquaculture productions worldwide in a 71-year period (1950–2020) under 652 units technically known as "species items" – an increase from the 622 reported in the 2020 edition of *The State of World Aquaculture and Fisheries*. They include 494 individual species, 7 finfish hybrids, 94 groups of species identified at genus level and 57 groups of species identified at family or higher levels. The 494 taxonomically recognized species ever farmed in the world include 313 species of finfish (in 186 genera), 88 species of molluscs, 49 species of crustaceans, 31 species of algae, 2 species of cyanobacteria, 6 species of marine invertebrates, 3 species of frogs (amphibians) and 2 species of aquatic turtles (reptiles).

The real number of aquatic species farmed in the world is much greater, and the present record of finfish hybrids is only a fraction of many hybrids of not only finfish, but also molluscs, frogs, aquatic turtles and seaweeds. Limitation in the process of data collection does not enable the FAO statistics to capture all the necessary details. Studies on aquatic genetic resources and biodiversity should consider these limitations when using FAO's aquaculture data, whose original purpose is to monitor aquaculture development as an economic sector of agriculture.

Despite the great diversity in farmed aquatic species, only a small number of "staple" species dominate aquaculture production, (Table 10). With 5.8 million tonnes produced in 2020, grass carp accounted for 11.8 percent of global inland aquaculture. Together with a further 23 individual species, they contributed 78.7 percent to total finfish production from inland aquaculture. Atlantic salmon and 21 other dominating species, such as milkfish, made up 75.6 percent of all finfish species of mariculture and coastal aquaculture. Atlantic salmon, with its production of 2.7 million tonnes in 2020, accounted for a high 32.6 percent of marine and coastal aquaculture of all finfish species.

Some finfish species living in freshwater or marine water are capable of bimodal respiration for oxygen uptake from the air, and the physiological mechanism varies. About 30 different air-breathing fishes and their hybrids are raised in inland aquaculture worldwide. Global production of air-breathing fish seldom exceeded 3 percent in total production of inland finfish farming until the mid-2000s when the share started to rise to reach about 13 percent in recent years. In 2020, the production of air-breathing fishes was 6.2 million tonnes and the share was 12.6 percent, a slight drop from 2019 due mainly to the drop in production in Viet Nam (Figure 22). Species from three families accounted for 83.9 percent of total production of air-breathing finfishes in 2020, including 47 percent from Pangasiidae (e.g. striped catfish, *Pangasianodon hypophthalmus*), 26.5 percent from Clariidae (e.g. North African catfish, *Clarias gariepinus*) and 10.5 percent from Channidae (e.g. snakehead, *Channa argus*). ■

THE STATUS OF FISHERY RESOURCES

Marine fisheries

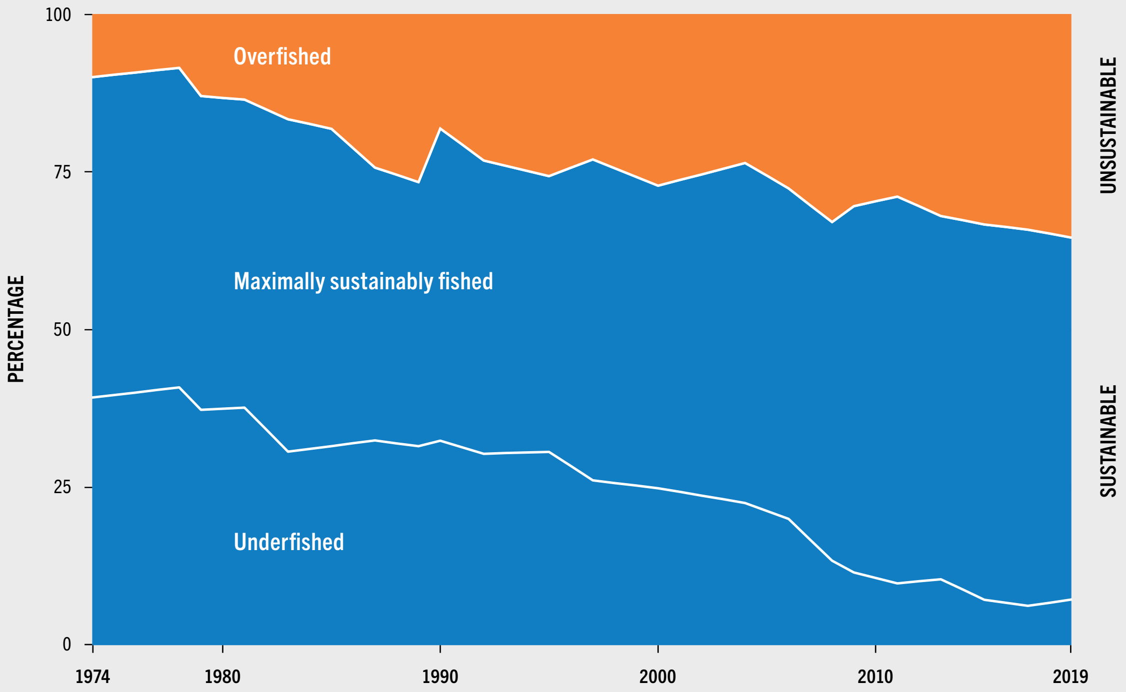
Status of resources

Based on FAO's assessment,[13] the fraction of fishery stocks within biologically sustainable levels decreased to 64.6 percent in 2019, that is 1.2 percent lower than in 2017 (Figure 23). This fraction was 90 percent in 1974. In contrast, the percentage of stocks fished at biologically unsustainable levels has been increasing since the late 1970s, from 10 percent in 1974 to 35.4 percent in 2019. This calculation treats all fishery stocks equally regardless of their abundance and catch. Biologically sustainable stocks account for 82.5 percent of the 2019 landings of assessed stocks monitored by FAO.

Biologically sustainable stocks consist of the maximally sustainably fished and underfished stocks, accounting for, respectively, 57.3 percent and 7.2 percent of the total number of assessed

13 For the methodology for the assessment, see FAO Fisheries and Aquaculture Technical Paper No. 569 (FAO, 2011a).

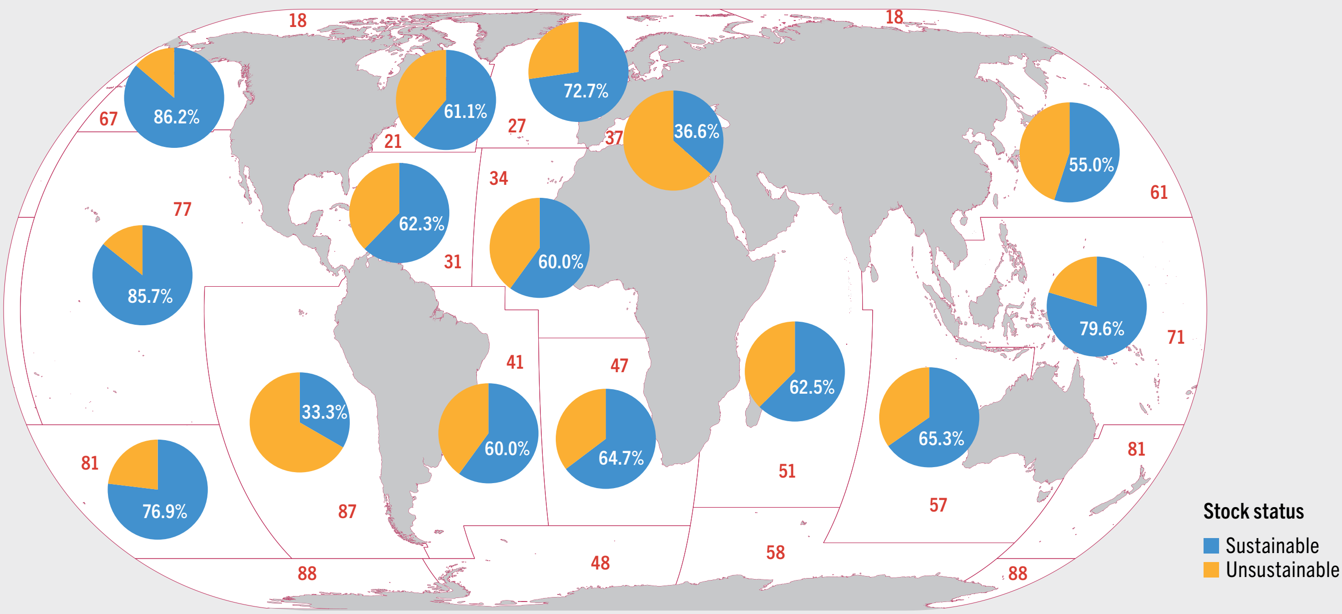
FIGURE 23 GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISHERY STOCKS, 1974–2019



SOURCE: FAO.

stocks in 2019. The underfished stocks maintained a decreasing trend over the entire period (bouncing back slightly during 2018 and 2019), whereas the maximally sustainably fished stocks fell between 1974 and 1989, to then increase, reaching 57.3 percent in 2019. In 2019, among FAO's 16 Major Fishing Areas, the Southeast Pacific (Area 87) had the highest percentage (66.7 percent) of stocks fished at unsustainable levels, followed by the Mediterranean and Black Sea (Area 37) 63.4 percent (Figure 24). In contrast, the Northeast Pacific (Area 67), Eastern Central Pacific (Area 77), Western Central Pacific (Area 71) and Southwest Pacific (Area 81) had the lowest proportion (13–23 percent) of stocks fished at biologically unsustainable levels. Other areas varied between 27 percent and 45 percent in 2019 (Figure 24). Landings of fish varied greatly among fishing areas (Figure 9b), and therefore, the significance of each area for global fishery sustainability may vary depending on its proportionate contribution to the global landings The temporal pattern of an area's landings often reveals information about its ecological productivity, fishery development stage, management and fishery stock status. In general, after excluding Arctic and Antarctic areas, which have minor landings, three groups of patterns can be observed (Figure 25): (i) areas with an overall declining landing trend following historical peaks; (ii) areas with catches oscillating around a globally stable value since 1990, associated with the dominance of pelagic, short-lived species; and (iii) areas with a continuously increasing trend in catches since 1950. The first group has the lowest percentage of biologically sustainable stocks (59.2 percent), the second group the highest (76.1 percent), while the third is in between (67.0 percent). When management intervention is not strong, an increasing trend of catch (the third group)

FIGURE 24 PERCENTAGES OF BIOLOGICALLY SUSTAINABLE AND UNSUSTAINABLE FISHERY STOCKS BY FAO MAJOR FISHING AREA, 2019



NOTE: The digital percentages represent the proportion of sustainable stocks.
SOURCE: FAO.

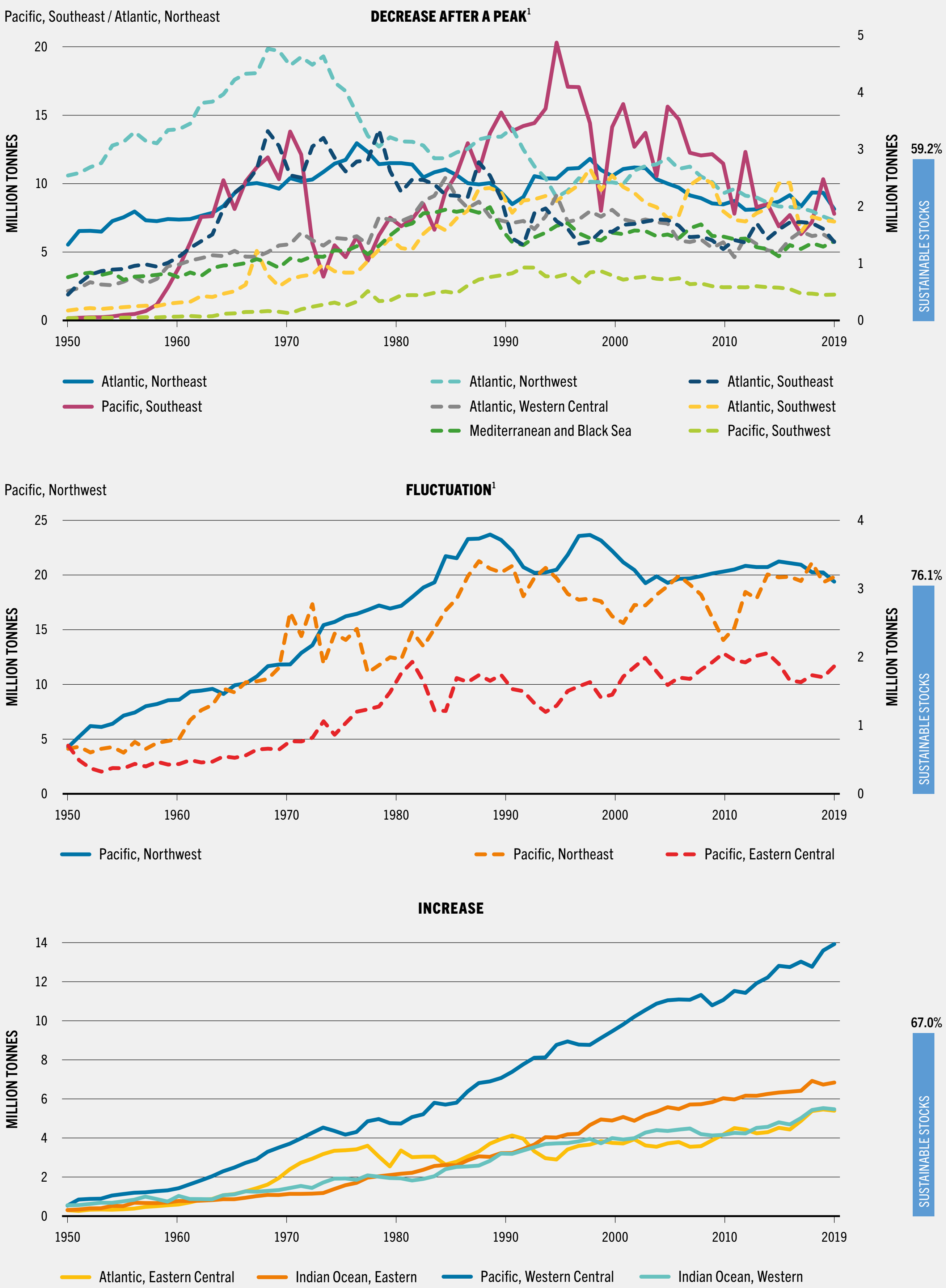
suggests development of fishing and lack of control, with resource sustainability most likely in good shape. However, when there is an increasing trend, stock assessment may involve great uncertainty and be unreliable due to the lack of contrast resulting from the one-way-trip pattern in catch or catch per unit of effort. In contrast, a decreasing trend in catch (the first group) usually suggests worsening sustainability of fishery stocks or implementation of strict regulations but lack of recovery. The highest level of sustainability (the second group) is likely to be associated with the full development of fisheries, mature management and effective regulation in fishing. However, other issues, such as environmental changes and social factors, can also influence catch trends. Box 3 illustrates the FAO plan to revise the current assessment methodology to better reflect the major changes that have occurred in the relative dominance of different fisheries resources.

Status and trends by major species

For the top ten species with the largest landings in 2019 – anchoveta (Peruvian anchovy) (*Engraulis ringens*), Alaska pollock (walleye pollock) (*Gadus chalcogrammus*), skipjack tuna (*Katsuwonus pelamis*), Atlantic herring (*Clupea harengus*), yellowfin tuna (*Thunnus albacares*), blue whiting (*Micromesistius poutassou*), European pilchard (*Sardina pilchardus*), Pacific chub mackerel (*Scomber japonicus*), Atlantic cod (*Gadus morhua*) and largehead hairtail (*Trichiurus lepturus*) – on average, 66.7 percent of these stocks were fished within biologically sustainable levels in 2019, slightly higher than the global average of 64.4 percent. European pilchard, Atlantic cod and Atlantic herring had higher than average proportions of overfished stocks.

Tuna stocks are of upmost importance because of their large volume of catches, high economic value and extensive international trade. Moreover, their

FIGURE 25 THE THREE TEMPORAL PATTERNS IN FISHERIES LANDINGS, 1950–2019



[1] Right vertical axis refers to the fishing areas not listed on the left vertical axis.
NOTES: Bars show the percentages of stocks at biologically sustainable levels in 2019 for the group of fishing areas listed under the graph. Data expressed in live weight equivalent.
SOURCE: FAO.

BOX 3 IMPROVING THE FAO PERIODIC ASSESSMENT OF THE STATE OF WORLD FISHERY RESOURCES

Since its first publication of the global review of marine fishery stocks in 1971,[1] FAO has been regularly assessing and monitoring the state of world marine fishery resources with results published biennially in *The State of World Fisheries and Aquaculture* (SOFIA) since 1995. The objective of the FAO assessment is to provide an overview of the global and regional state of marine fishery resources to help with policy formulation and decision-making for the long-term sustainability of these resources. As marine fisheries have developed, both the assessment methods and the relative data available have undergone significant change. The current methodology was revised in 2011[2] and has not been updated since. In order to continue providing a comprehensive and objective global analysis, FAO has decided to revise the methodology to better reflect the major changes that have occurred in the relative dominance of different fisheries resources, and to base the analysis on an updated and more comprehensive list of fishery stocks. The new methodology will update the list of stocks and provide a tiered and transparent approach to a new analysis with newer reporting formats. These changes are also expected to engage more directly with the growing community of assessment and management institutions and experts in Member Countries, and thus enhance transparency.

The revised plan to address these issues in future reports on the state of world marine capture fisheries is to adopt a regional strategy, where gaps in assessment can be narrowed over time by using a tiered approach linked to the level of information available. The initial and most important step is to update the list of stocks considered in the analysis in each region, thus better reflecting current realities in fisheries in different parts of the world. This will be done collaboratively with local experts, through regional workshops and new forms of consultations, such as the Sustainable Development Goal (SDG) Indicator 14.4.1 (Proportion of fish stocks within biologically sustainable levels) country-specific questionnaires. The tiered assessment approach depends on the quality of the data and supplementary information for each region:

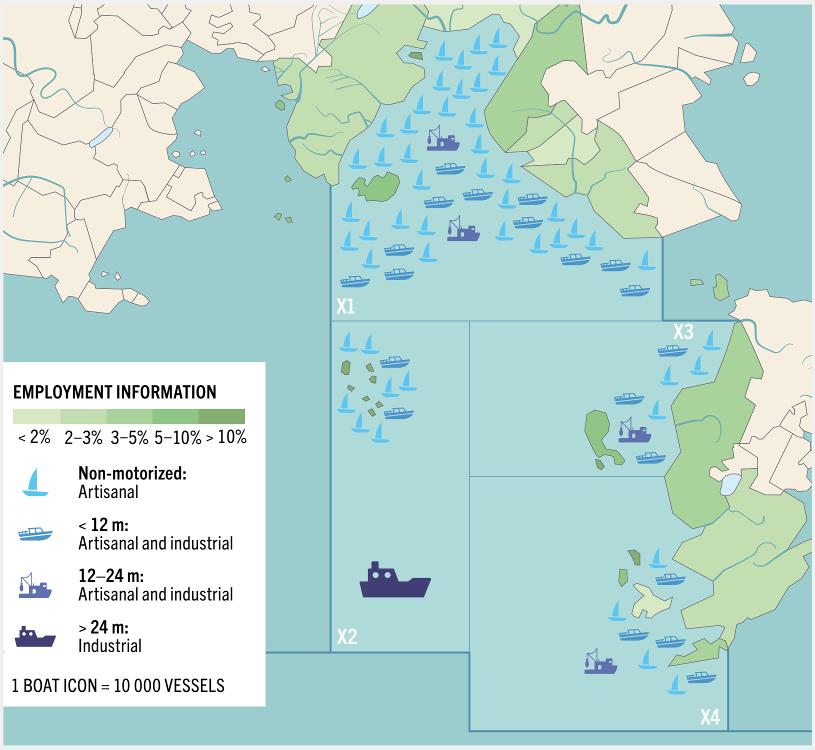
1. Tier 1 – Stocks for which traditional stock assessments are available and deemed reliable. Formal results are used as reported by the management agencies.
2. Tier 2 – Stocks for which no formal assessments are available, but for whom alternative approaches (such as Sraplus[3]) are viable, because supplementary information, such as external data on landings with abundance indices or expert-driven priors for depletion, is available to derive a state of the particular stock.
3. Tier 3 – If data are insufficient for either Tier 1 or Tier 2 approaches, then a weight-of-evidence[4] approach to categorize the status of the stock based on qualitative/semi-quantitative information will be used.[5]

To demonstrate the proof of concept of this tiered approach in a transparent SOFIA assessment framework, two FAO statistical areas (Area 31 and Area 37) will be piloted by FAO to present to the Thirty-fifth Session of the Committee of Fisheries (COFI) in 2022, comparing the current and new approach in terms of derived metrics. The pilot will document the data, workflow, analysis and reporting in a standardized format that is easily replicable. In addition, new infographics (see figure for a preliminary prototype example) will be developed to provide a more engaging communication format and present fisheries assessments in a wider context aligned with the ecosystem approach to fisheries management (EAFM).[6]

A detailed work programme to achieve the objectives of modernizing the SOFIA indicator on the status of marine resources will be proposed to the Thirty-fifth Session of COFI. If endorsed, examples of the tiered analysis and new visual communication approaches will be offered in the 2024 edition of *The State of World Fisheries and Aquaculture* with a full roll-out in most areas. A new edition of the FAO Technical Paper, *Review of the state of world marine fishery resources*, will subsequently be published describing the methodology in detail. The work programme also envisions a process to increase the capacity of national and regional fisheries institutions for assessing the state of the stocks. The programme will encourage greater participation and more active involvement in the global analysis by national institutions, empowering them to regularly present their analyses as inputs to the FAO flagship publication in conjunction with reporting on progress on SDG Indicator 14.4.1.

[1] Gulland, J.A. 1971. *The fish resources of the ocean*. West Byfleet, UK, Fishing News Books. www.fao.org/3/al937e/al937e.pdf
[2] FAO. 2011. *Review of the state of world marine fishery resources*. FAO Fisheries and Aquaculture Technical Paper No. 569. Rome. www.fao.org/3/i2389e/i2389e.pdf
[3] Stock reduction analysis + (Sraplus) includes options to estimate depletion based on external covariates.
[4] The weight-of-evidence approach was initially developed by the Australian Government:
Woodhams, J., Stobutzki, I., Vieira, S., Curtotti, R. & Begg, G.A., eds. 2011. *Fishery status reports 2010: status of fish stocks and fisheries managed by the Australian Government*. Canberra, Australian Bureau of Agricultural and Resource Economics and Sciences.
The approach aims to hypothesize alternative stock status based on different indicators (social, biological or economic). The weight of evidence would indicate the highest probability of a status using multiple approaches indicating the most likely outcome.
[5] Castro de Souza, M. & Barros, P. forthcoming. *Providing EAF-compliant management advice in data- and capacity-limited fisheries: A framework using the weight of evidence approach*. Rome, FAO.
[6] Staples, D., Brainard, R.,Capezzuoli, S., Funge-Smith, S., Grose, C., Heenan, A., Hermes, R. *et al*. 2014. *Essential EAFM. Ecosystem approach to fisheries management Training Course. Volume 2 – For Trainers*. RAP Publication 2014/13. Bangkok, FAO Regional Office for Asia and Pacific, Bangkok, Thailand. www.fao.org/3/i3779e/i3779e.pdf

DRAFT INFOGRAPHICS ON REGIONAL INFORMATION IN THE CONTEXT OF MULTIPLE INDICATORS RELEVANT TO FISHERIES MANAGEMENT AND ECOSYSTEM COMPLEXITY



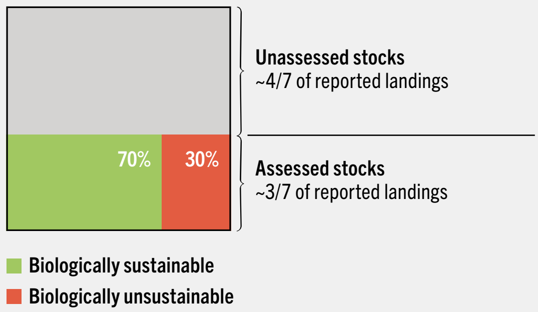
This illustrative map of sample area X shows the share of employment in the fisheries sector as a percentage of the total labour population in bordering countries, and the estimated size of the fleet components.

MAJOR FISHING AREA X
ILLUSTRATION PROTOTYPE

KEY ISSUES

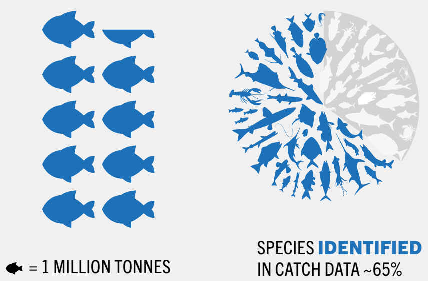
- **Data collection** remains a challenge in the region due to the small-scale and multispecies nature of the majority of its fisheries.
- The region is home to a large proportion of global fishers and **artisanal fleets**. Millions of people here depend on fisheries for livelihoods and food security.

STOCK STATUS



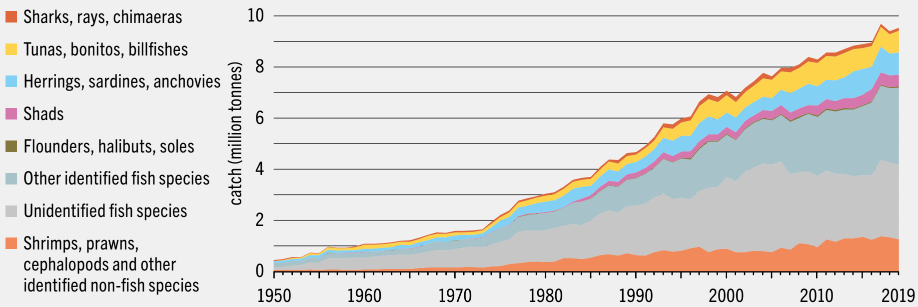
LANDINGS *Data source*

Reported landings ~ 9.5 million tonnes



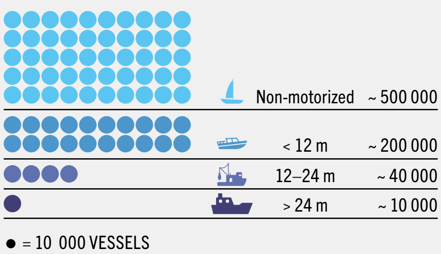
SPECIES COMPOSITION *Data source*

Composition of stocks by taxonomic group



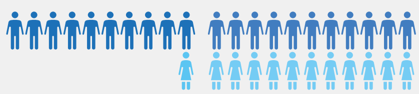
FLEET SIZE AND COMPOSITION *Data source*

~ 750 000 active vessels



EMPLOYMENT *Data source*

~ 33 million people employed[1]

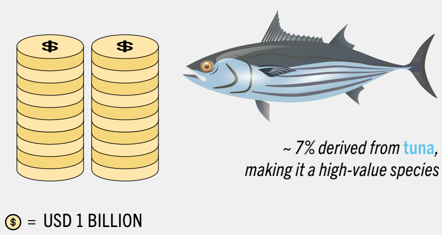


[1] *In fishing (primary); transporting, processing, preparing, selling (secondary).*

= 1 MILLION PEOPLE

ECONOMIC VALUES *Data source*

Estimated landings value: USD 20 billion



SOURCE: FAO.

management is subject to additional challenges owing to their highly migratory and often straddling distributions. At the global level, the seven species of tunas of principal commercial importance are albacore (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*) and three species of bluefin tuna (*Thunnus thynnus*, *Thunnus maccoyii*, *Thunnus orientalis*). The main commercial tunas contributed 5.7 million tonnes of catch in 2019, a 15 percent increase from 2017 but still 14 percent lower than the historical peak in 2014. On average, of the principal commercial tuna species, 66.7 percent of stocks were fished within biologically sustainable levels in 2019, slightly higher than the all-species average, but unchanged in comparison with 2017.

Tuna stocks are closely monitored and extensively assessed, and the status of the seven above-mentioned tuna species is known with moderate uncertainty. However, other tuna and tuna-like species remain mostly unassessed or assessed under high uncertainty. This represents a major challenge, as tuna and tuna-like species are estimated to account for at least 15 percent of the total global small-scale fisheries catch (FAO, Duke University and WorldFish, forthcoming). Furthermore, market demand for tuna remains high, and tuna fishing fleets continue to have significant overcapacity. Effective management, including better reporting and access to data and the implementation of harvest control rules across all tuna stocks, is needed to maintain stocks at a sustainable level and in particular rebuild overexploited stocks. Moreover, substantial additional efforts on data collection, reporting and assessment for tuna and tuna-like species other than the main commercial species are required.

Status and trends by fishing area

The Northwest Pacific has the highest production among the FAO Major Fishing Areas, producing 24.1 percent of global landings in 2019. Its total catch fluctuated between 17 million tonnes and 24 million tonnes in the 1980s and 1990s and was about 19.4 million tonnes in 2019 (Figure 25). Historically, Japanese pilchard (*Sardinops melanostictus*) and Alaska pollock used to be the most productive species, with peak landings at 5.4 million tonnes and 5.1 million tonnes, respectively. However, their catches have declined significantly in the last 25 years. In contrast, landings of squids, cuttlefishes, octopuses and shrimps have increased greatly since 1990. In 2019, two stocks of Japanese anchovy (*Engraulis japonicus*) were overfished, while for Alaska pollock two stocks were overfished and another sustainably fished. Overall, in 2019, about 55.0 percent of assessed stocks were fished within biologically sustainable levels, and 45.0 percent fished outside these levels, in the Northwest Pacific, a 10 percent increase compared with the last assessment in 2017.

In recent decades, catches in the Eastern Central Pacific have oscillated between 1.5 million tonnes and 2.0 million tonnes (Figure 25). Total landings in 2019 were 1.9 million tonnes, close to the maximum seen in history. A large proportion of the landings in this area are small and medium-sized pelagic fish (including important stocks of California pilchard (*Sardinops sagax*), anchovy and Pacific jack mackerel (*Scomber japonicas*), squids and prawns. The productivity of these stocks of short-lived species are naturally more susceptible to interannual variations in oceanographic conditions, which generate oscillations in catches despite sustainable exploitation rates. Catches of California pilchard in the Gulf of California stock have for instance recovered dramatically in the last three years, most likely in response to favourable environmental conditions. As noted in previous years, overfishing impacts selected coastal resources of high value, such as groupers, snappers and shrimps. However, the status of these stocks is considered highly uncertain due to the limited information available. The percentage of assessed stocks in the Eastern Central Pacific fished within biologically sustainable levels has remained stable since 2015 at 85.7 percent, the second highest among fishing areas.

The Southeast Pacific produced 7.8 million tonnes of aquatic animals in 2019, accounting for about 10 percent of global landings, with a clear decreasing trend since the 1990s (Figure 25). The two most productive species were anchoveta and jumbo flying squid (*Dosidicus gigas*), with landings of almost 5.0 million tonnes and 0.9 million tonnes, respectively. These species are considered to be within biologically sustainable levels, mostly due to a decrease in landings since the early 1990s as part of a more precautionary and effective fisheries management of anchoveta. Araucarian herring (*Strangomera bentincki*) was also harvested within sustainable levels. In contrast, South American pilchard (*Sardinops sagax*), South Pacific hake (*Merluccius gayi*) and Southern hake (*Merluccius australis*) continued to be overfished, and Patagonian toothfish (*Dissostichus eleginoides*) is currently being fished at unsustainable levels. Although the majority of the catch (approximately 95 percent) within this region comes from stocks at sustainable levels, overall, just 33.3 percent of the assessed stocks in the Pacific Southeast were fished within sustainable levels in 2019.

The Eastern Central Atlantic has seen an overall increasing trend in catches, but with fluctuations since the mid-1970s, reaching 5.4 million tonnes in 2019, the highest value in the time series (Figure 25). European sardine is the single most important species, with reported catches of about 1 million tonnes per year since 2014 and its stocks remain underfished. Round sardinella (*Sardinella aurita*) is another important small pelagic species. Its catches have been generally decreasing to about 184 000 tonnes in 2019, only about 50 percent of its peak value in 2001. The species is considered overfished. The demersal resources are known to be intensely fished in the region, and the status of the stocks varies – some are classified as sustainable and others as unsustainable. Overall, 60 percent of the assessed stocks in the Eastern Central Atlantic were within biologically sustainable levels in 2019.

In the Southwest Atlantic, total catches have varied between 1.8 million tonnes and 2.6 million tonnes (after an early period of increase that ended in the mid-1980s), reaching 1.7 million tonnes in 2019, a 5 percent decrease from 2017 (Figure 25). The species with the largest landings is the Argentine shortfin squid (*Illex argentinus*), representing 10–30 percent of the region's total catches historically. However, landings of this species decreased to 250 000 tonnes (14 percent) in 2019, and in contrast, Argentine red shrimp (*Pleoticus muelleri*) catch has grown significantly since 2005. Both were fished within biologically sustainable levels. In 2019, Argentine hake (*Merluccius hubbsi*) catch increased by 26 percent from 2017 and thus represents the most important species in terms of catch volumes for the region with 449 000 tonnes. One of the hake stocks had recovered to biologically sustainable levels in 2019 as a result of significant efforts to improve assessment and management, including reductions in fishing mortality. Moreover, Patagonian grenadier (*Macruronus magellanicus*) and whitemouth croaker (*Micropogonias furnieri*) have shown an increase in catches of about 70 percent and 20 percent, respectively, since 2017. Overall, 60.0 percent of the assessed stocks in the Southwest Atlantic were fished within biologically sustainable levels in 2019, a 20 percent improvement from 2017.

In 2019, landings in the Northeast Pacific remained at the same level as 2013, at about 3.2 million tonnes (Figure 25). Alaska pollock remains the most abundant species, representing about 50 percent of total landings. Pacific cod (*Gadus microcephalus*), hakes and soles are also large contributors to the catches. Most species except salmon stocks in this region are healthy and well managed, primarily due to the science-based advice from the North Pacific Fisheries Commission and North Pacific Fishery Management Council and to good governance that has helped reduce fishing pressure from distant water fishing nations. However, stocks of Pacific salmon (chinook, coho, sockeye and chum in southern parts of British Columbia in Canada, and the states of Washington, Oregon and California in the United States of America) were overfished in 2019. Overall, 86.2 percent of the assessed stocks in the area were fished within biologically sustainable levels in 2019, the highest among fishing areas.

The Northeast Atlantic is the third most productive area and had a catch of 8.1 million tonnes in 2019, a decline of 1.2 million tonnes from 2017. Its landings reached a peak of 13 million tonnes in 1976, then dropped, recovered slightly in the 1990s and have been decreasing since (Figure 25). Its fishery resources experienced extreme fishing pressures in the late 1970s and early 1980s. Since then, countries have managed better fishing pressure to rebuild overfished stocks. Recovery was seen in Atlantic mackerel (*Scomber scombrus*), turbot (*Scophthalmus* *maximus*), European plaice (*Pleuronectes platessa*), common sole (*Solea solea*), Arctic cod (*Boreogadus saida*) and Atlantic cod (*Gadus morhua*) in the 2000s, and common sole (*Solea solea*) and whiting (*Merlangius merlangus*) in the late 2010s. In the Northeast Atlantic, 72.7 percent of the assessed stocks were fished within biologically sustainable levels in 2019.

The Northwest Atlantic produced 1.7 million tonnes of aquatic animals in 2019 and continued a decreasing trend from its peak of 4.5 million tonnes in the early 1970s (Figure 25). The group of Atlantic cod, silver hake (*Merluccius bilinearis*), white hake (*Urophycis tenuis*) and haddock (*Melanogrammus aeglefinus*) has not shown a good recovery, with landings remaining at about 0.1 million tonnes since the late 1990s, only 5 percent of their historical peak value of 2.1 million tonnes in 1965. The reasons behind the poor recovery are environment-driven changes in productivity for some stocks, such as Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), winter flounder (*Pseudopleuronectes americanus*) and yellowtail flounder (*Limanda ferruginea*). Although catches may be very low and overfishing is not occurring, these stocks have still not recovered. In general, invertebrate fisheries are in a better state than finfish fisheries. Overall, 61.1 percent of the assessed stocks in the Northwest Atlantic were fished within biologically sustainable levels in 2019.

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 rebounded slightly to 1.4 million tonnes in 2019 (Figure 25). Small pelagic fishes, namely Gulf menhaden (*Brevoortia patronus*) and round sardinella are considered to be fully fished. Medium-sized pelagic fishes such as king mackerel (*Scomberomorus cavalla*) and Atlantic Spanish mackerel (*Scomberomorus maculatus*) appear to be fully fished, while the serra Spanish mackerel (*Scomberomorus brasiliensis*) appears to be overfished. Snappers and groupers are among the most highly valued and intensively fished in the region and, despite reductions in directed fishing effort thanks to management actions, some stocks continue to be overfished. Highly valued invertebrate species such as Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Lobatus gigas*) are considered fully fished. Penaeid shrimps are currently sustainably fished, as well as the Atlantic seabob (*Xiphopenaeus kroyeri*) along the Guianas-Brazil shelf. In the Western Central Atlantic, 62.2 percent of the assessed stocks were fished within biologically sustainable levels in 2019.

The Southeast Atlantic has shown a decreasing trend in landings since the late 1960s, from a total of 3.3 million tonnes to 1.4 million tonnes in 2019 (Figure 25). Horse mackerel and hake support the largest fisheries of the region and have recovered to biologically sustainable levels following good recruitment and strict management measures. The Southern African pilchard (*Sardinops ocellatus*) stocks are still very degraded, warranting special conservation measures from both Namibia and South Africa. The sardinella (*Sardinella aurita* and *Sardinella maderensis*) stocks, very important off Angola and partially in Namibia, remained at biologically sustainable levels. Whitehead's round herring (*Etrumeus whiteheadi*) was underfished. However, Cunene horse mackerel (*Trachurus trecae*) remained overfished in 2019, and perlemoen abalone (*Haliotis midae*), targeted heavily by illegal fishing, continued to deteriorate and remained overfished. Overall, 64.7 percent of the assessed stocks in the Southeast Atlantic were fished within biologically sustainable levels in 2019.

After reaching a historical maximum of about 2 million tonnes in the mid-1980s, total landings in the Mediterranean and Black Sea declined to a low of 1.1 million tonnes in 2014; since 2015, they have recovered slightly, with a catch of 1.4 million tonnes in 2019 (Figure 25). Most of the commercially important stocks regularly assessed continue to be fished outside biologically sustainable limits, including the stocks of hake (*Merluccius merluccius*), turbot (*Scophthalmus maximus*) and European pilchard. A decreasing trend in the level of overfishing of some of these stocks has been observed in past years but according to the General Fisheries Commission for the Mediterranean (GFCM), the overall fishing mortality for all resources combined is estimated at nearly 2.5 times higher than sustainable reference points. In 2019, 36.7 percent of the assessed stocks in the Mediterranean and Black

Sea were fished within biologically sustainable levels.[14]

The Western Central Pacific produced the second largest landings, 13.9 million tonnes (17 percent of the global total) in 2019, continuing the linear increasing trend since 1950 (Figure 25). Aquatic species are highly diversified, but catches are not always split by species, often recorded as "miscellaneous coastal fishes", "miscellaneous pelagic fishes" and "marine fishes not identified", which together constituted almost 50 percent of the region's total landings in 2019. Major species are tuna and tuna-like species, contributing about 21 percent of total landings. Sardinellas and anchovies are also significant in the region. Few stocks are considered to be 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 or through fishing down trophic levels of targeted species. The tropical and subtropical characteristics of this region and the limited data availability make stock assessment challenging with great uncertainties. Overall, 79.6 percent of the assessed fishery stocks in the Western Central Pacific were fished within biologically sustainable levels in 2019.

The Eastern Indian Ocean continues to show a steady increase in catches, with 6.8 million tonnes in 2019 (Figure 25). Stock status information is generally scarce and available only for a few coastal stocks in certain areas. Most of the stocks monitored by FAO are assessed based on catch trends and other ancillary information rather than analytical stock assessments or fishery independent data. Therefore, the state of stocks in the region is considered highly uncertain and should be treated with caution. Toli shad (*Tenualosa toil*), sardinellas (*Sardinella* spp.), Indian mackerel (*Rastrelliger kanagurta*) and Indian oil sardine (*Sardinella longiceps*) have highly fluctuating landings, most likely driven by the combined effect of fishing pressure and changing environment. Hilsa shad (*Tenualosa ilisha*) stocks are either fully fished or overexploited. Among the stocks considered within sustainable levels are anchovies, banana prawn, giant tiger prawn, squids and cuttlefish. Of the assessed stocks in the Eastern Indian Ocean, 65.3 percent were fished within biologically sustainable levels in 2019.

In the Western Indian Ocean, total landings continued to increase and reached 5.5 million tonnes in 2019 (Figure 25). Main Penaeidae shrimp stocks fished in the South West Indian Ocean, a main source of export revenue, continue to show clear signs of overfishing, prompting the countries concerned to introduce more stringent management measures. The stocks of sea cucumber across the region are considered overexploited. The Southwest Indian Ocean Fisheries Commission continues to update the assessment of the status of the main fished stocks in the region. The 2019 assessment estimated that 62.5 percent of the assessed stocks in the Western Indian Ocean were fished within biologically sustainable levels, while 37.5 percent were at biologically unsustainable levels.

Prospects of achieving the SDG target on fisheries

In 2019, 64.6 percent of the fishery stocks of the world's marine fisheries were fished within biologically sustainable levels. The significant continuous decreasing trend over time (Figure 25) is cause for alarm in the international community and among all relevant stakeholders, as urgent concrete plans and efforts are needed to achieve sustainable fisheries.

Overfishing – stock abundance fished to below the level that can produce maximum sustainable yield (MSY) – not only causes negative impacts on biodiversity and ecosystem functioning, but also reduces fisheries production, which subsequently leads to negative social and economic consequences. Rebuilding overfished stocks to the biomass that enables them to deliver MSY could increase fisheries production by 16.5 million tonnes and annual rent by USD 32 billion (Ye *et al*., 2013). It would also increase the contribution

14 With the main aim to support fisheries management, the GFCM provides a regional assessment of the status of priority commercial stocks in the Mediterranean and Black Sea. This assessment is based on analytical scientific assessments of management units (a combination of priority species and geographical subareas of interest) covering about 50 percent of the catches. The assessment also indicates that in 2018, a high proportion (75 percent) of priority commercial stocks assessed were considered outside sustainable fishing levels, in line with the results presented in the 2020 edition of *The State of World Fisheries and Aquaculture*, but also suggests that this percentage has decreased by about 10 percent since 2014 (FAO, 2020).

of marine fisheries to the food security, nutrition, economies and well-being of coastal communities. The situation seems more critical for some highly migratory, straddling and other fisheries resources that are fished solely or partially in the high seas. The United Nations Fish Stocks Agreement (in force since 2001) should be used as the legal basis for management measures of the high seas fisheries.

The United Nations Sustainable Development Goals (SDGs) set a clear target on fisheries (SDG Target 14.4): to end overfishing of marine fisheries by 2020. The world fisheries are now diverging away from this target. However, this global picture may mask regional and intra-country differences in progress. A recent study (Hilborn *et al*., 2020) shows that scientifically assessed and intensively managed stocks have, on average, seen abundance increasing or at proposed target levels and that in contrast, regions with less developed fisheries management have much greater harvest rates and lower abundance than assessed stocks. This highlights the urgent need to replicate and re-adapt successful policies and regulations in fisheries that are not managed sustainably and to create innovative mechanisms that promote sustainable use and conservation around the world.

Inland fisheries

Background

The productivity and resilience of inland water ecosystems is primarily driven by environmental factors, the most important of which include temperature, water flows and nutrient pulses driven by the seasonal expansion and contraction of aquatic systems. The species of these ecosystems have life strategies that allow them to take advantage of the inherent variability or stability of different systems depending on the location, whether they are arctic, montane, temperate or tropical, lakes, rivers, wetlands or floodplains.

The performance of fishery stocks or specific inland fisheries is intimately related to water quality and quantity and to the size and health of the habitats on which they rely to complete their life cycles and the connectivity between these. In tropical floodplains, which are home to some of the world's largest inland fisheries, and on which large numbers of people depend for their livelihoods, food security and nutrition, inter-annual variability in flooding decides survival and growth rates of the aquatic species and thus the size of the stocks capable of recovering from high levels of mortality. Fishing pressure in these systems can be significant but is not normally the principal driving factor that determines the status of the fisheries. Conversely, isolated stocks in temperate or Arctic lakes or streams may be very vulnerable to overfishing, although impacts on habitat, spawning grounds and connectivity may still be important or even overriding factors in determining the health of the stock.

The significant inland fisheries of the world's tropical basins may be further characterized by the large number of species present and the highly diversified fisheries which exploit them. As many of these important food fisheries lie within least developed or low-income food-deficit countries, there are limited human and financial resources to monitor and manage such fisheries. Given the highly dispersed nature of many of these fisheries, the use of traditional assessment methods (length frequency surveys, catch and effort surveys, fishery independent surveys, etc.) is time-consuming and expensive and hard to justify considering the limited options for deriving revenue from the landings and the low return on investment to the State. Even in some developed countries, the low profile of inland waters means that assessment and monitoring may be a relatively low priority or seen as an unwarranted expense when there are so many other competing needs.

The transboundary nature of catchments and river basins is another challenge to overcome, as basin boundaries do not necessarily follow convenient country borders, or those of their subnational jurisdictions. Few major river basins with important inland fisheries lie completely within the borders of a single country. In large continental and archipelagic countries, the national inland fishery landings are provided by the catch from several different basins, all driven by their own local pressures. In neither of these situations will an aggregate national catch figure provide an accurate or satisfactory or informative indicator of the status of the inland fisheries of a country. Importantly, the tendency in many countries is to monitor only the largest fisheries or landing sites and apply estimations or ignore other less intensive fisheries, further obscuring the understanding of the true state of inland waters and their fisheries.

Just how should we try to track the status of inland fisheries in these contexts, as part of our commitments to achieving the targets of SDG 1 (No poverty), SDG 2 (Zero hunger), indirectly SDG 14 (Life below water) and SDG 15 (Life on land) to inland waters?

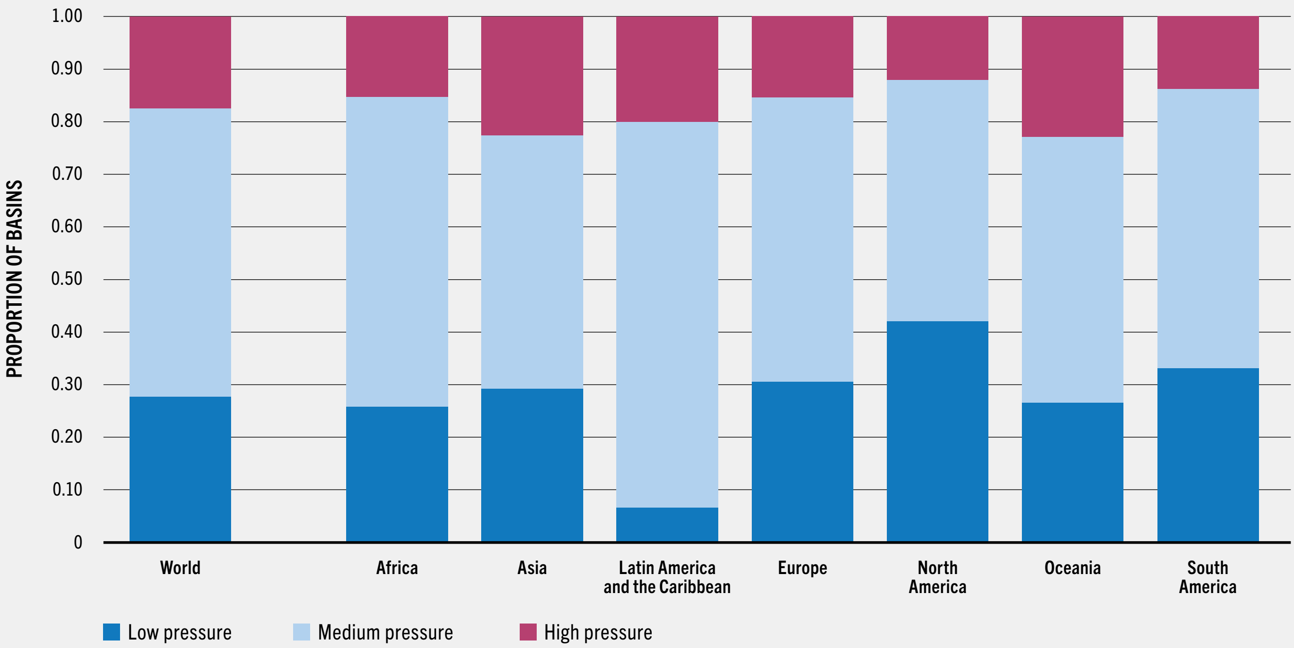
Without proper assessments, the impacts on inland fisheries for food and biodiversity caused by water development, agricultural and industrial environmental impacts, deforestation and land degradation go unaccounted for.

It has been recognized for some time that these limitations in national assessments and the basin nature of inland fisheries require a new assessment paradigm that can combine information from multiple sources, often collected remotely and using proxy measurements, but the tools and computer modelling power to do this have not been available. Starting in 2016, FAO initiated a process in collaboration with the United States Geological Survey (USGS) and selected fishery experts to develop a global threat map for inland fisheries that combined 20 identified anthropogenic pressures acting across catchments and basins to create a composite threat indicator. The relevant pressures on each basin and sub-basin that affect inland fisheries were weighted according to their importance in each basin. The initial results of this model were presented in the 2020 edition of *The State of World Fisheries and Aquaculture* (FAO, 2020a) with the intention of providing an update in the 2022 edition.

The threat assessment method has now been further refined by USGS and automates boosted regression model outputs from over 150 spatial data layers across the threat categories which affect inland fisheries. This was achieved by improving the weighting approach to make the spatial data meaningful and assign relative importance values. The approach combines weights from literature, boosted regression trees and expert opinions. More than 9 000 peer-reviewed articles on documented threats, responses and impacts from 45 basins most important to inland fisheries catch were reviewed. The results were complemented with a survey among 536 inland fisheries professionals from 79 countries with expertise on 93 basins, who were asked to apply threat scores at the local level to the fisheries with which they were most familiar. The threat assessment represents a fully transparent, reproducible framework that will permit an objective assessment of inland fisheries with a high level of confidence. An accompanying web portal will summarize assessment outcomes for fishery managers and other users.

Figure 26 summarizes threats by continent according to aggregated pressure categories. Criteria for pressure categories were evaluated on a numeric scale of one to ten, where "low pressure" was considered those with a score of 1–3, "moderate pressure" a score of 4–7 and "high pressure" a score of 8–10. Across all major basins important to inland fisheries, 28 percent of fisheries are estimated under low pressure, 55 percent under moderate pressure, and 17 percent under high pressure (left bar, "World"). Most regions follow a similar pattern of proportional distributions. These results call attention to the majority of basins with intermediate to high levels of degraded ecological attributes and can be used to improve inland fisheries by providing a baseline metric to track changes. There are several important considerations for these estimations. One is that in this figure each basin is represented equal to the other basins rather than relative across basins by size or fisheries catch. For example, basins that cover large geographic areas (e.g. Congo) are represented equal to those of small areas (e.g. Sepik). However, because the model can use data at different scales, basin and hydrological characteristics may be used to aggregate threats differently according to the metrics most relevant to fishery managers or users. It is also essential to note that in this figure, the number of basins vary across continents. For example, Asia and Africa have, respectively, 12 and 14 hydrological basins important to inland fisheries, while Oceania only has 2. To increase ease of use and interpretation, results from the assessment will be summarized

FIGURE 26 STATE OF MAJOR INLAND FISHERIES BY REGION



NOTE: Proportional threat status of the basins most important for inland fisheries and their catch (n=45 basins) is averaged by region and across regions.
SOURCE: Land and Water Lab, University of Florida.

across biogeographical realms, ecoregions and hydrological basins.

Analysis of individual basins

The threat mapping approach permits an evaluation of threats to inland fishery food production and biodiversity at different levels of resolution from the global level to the level of individual basins or sub-basins. The sub-basin disaggregation shows how different parts of a basin may contribute to its overall threat level and may show that not all parts of a basin are affected in the same way, and thus reveal where to focus conservation and ecosystem restoration efforts, and each part of the basin may support different fisheries and be subject to different threats. The vulnerability of the fisheries and their socio-economic characteristics will also vary according to their spatial distribution and will need to be considered. Linking an understanding of the state of the selected inland fisheries to the global threat map would also provide a baseline and a means to report meaningfully on progress on inland fishery stocks towards international goals such as the Aichi Targets, and support to the SDGs through recognition of the importance of inland fisheries to food security in some countries and subnational areas and how action on ecosystem restoration can sustain this. To develop a regular yet meaningful global assessment of inland fisheries will require commitment and additional resources to undertake assessments of the indicator fisheries on a routine basis and agreement to report into a common framework. This would enable FAO to collate a global assessment in a similar manner to that of the FAO marine stock status assessment.

The advantage of this approach is that it uses global, publicly available data, thus allowing coverage of countries that may have very limited capacity to collect and report data to FAO;

by selecting a number of indicator basins in each region, it will be possible to gain insight into the state of the fisheries in different parts of the world. However, for calibration and improved interpretation, the findings should be "ground-truthed" using locally available data, local knowledge and, where possible, collection of complementary data in the field; this is especially the case for large complex basins with several different fisheries in operation. Linking the threat maps to fishery data at a subnational level will enable more detailed national analysis and planning, especially pointing to areas where there is a need for greater understanding of primary threats and their relationship to fisheries production and biodiversity of aquatic species. This would enable national fishery agencies to identify important inland fisheries (or aquatic biodiversity) that are at risk and prioritize appropriate fishery monitoring and management interventions. Where there are several different fisheries operating in the same body of water that respond differently to the drivers or respond to different drivers (this could, for example, be fisheries for large predatory species and small pelagic fish taking place in the same water body or fishing for floodplain resident and migratory species in a major river), the outcomes require careful interpretation as different groups of stakeholders may be affected in different ways.

An additional step in developing a more detailed report could involve the selection and systematic tracking of a number of indicator fisheries in some of the most productive basins. Each of these fisheries would convey important information about what is happening in the basin of concern – information that may be translated into meaningful management actions. The data could also be reported into a common framework that would allow FAO to further refine the global-level assessment. Box 4 is an illustration of how such a basin assessment could be presented.

While information at the species level may not be essential, the number of species present in the catches contains an important message. Nevertheless, it is important to monitor different ecological guilds (e.g. migratory species, small pelagics, large-growing and long-living species, non-native species). These indicator fisheries are most likely directed at important species that are already monitored; however, this is not an actual requirement, provided the catches supply information about the status of all the species in the guild. ■

FISHING FLEET

Estimate of the global fleet and its regional distribution

The world had an estimated 4.1 million fishing vessels in 2020. This number has been on a downward trend in the last two decades, mainly driven by fleet reduction programmes in Europe and China, which started in 2000 and 2013, respectively, and were accounted for in a recent revision of FAO fleet data. The global fleet size was reduced by just under 10 percent between 2015 and 2020 and by just under 4 percent between 2019 and 2020. Asia hosts the world's largest fishing fleet, estimated at 2.68 million vessels or about two-thirds of the global total in 2020 (Figure 27). This proportion fell by 8 percent between 2015 and 2020. Africa's fleet has been increasing relative to the rest of the world, and now comprises 23.5 percent of the world's fishing vessels, up 10 percent from 2015. The Americas now account for under 9 percent of the world's fleet, down 1.5 percent from 2015. Europe and Oceania have retained a stable share of 2 percent and less than 1 percent, respectively, of the world's total.

At an estimated 564 000 vessels, China has the world's largest fishing fleet. This fleet is being scaled down and has been reduced by about 47 percent since 2013, when it totalled 1 072 000 vessels. This is motivated by the long-stated objective of reducing the size of the Chinese fishing sector (FAO, 2022a). The European Union, whose fleet totalled about 74 000 vessels in 2020 – a 28 percent reduction compared with 2000 – has implemented similar programmes through its common fisheries policy for the past two decades. Figure 28 and Figure 29 illustrate these changes in fleet sizes for China and the European Union. However, reductions in fleet size alone do not necessarily guarantee more sustainable outcomes, since changes in fishing efficiency can offset the sustainability gains of fleet reductions, as reported by Di Cintio

BOX 4 EXAMPLE OF A BASIN ASSESSMENT: LAKE MALAWI/NIASSA/NYASA

Figure A explores how a basin assessment could be done using the example of Lake Malawi/Niassa/Nyasa, one of the great East African rift lakes shared between Malawi, Mozambique and the United Republic of Tanzania. Population density and growth rate are high, especially in the Malawian part of the basin. Fishing is one of the most important sources of livelihood and at least 1.6 million people are dependent on it. Fish is an essential source of animal protein, providing 70 percent of animal protein in Malawi. The fisheries

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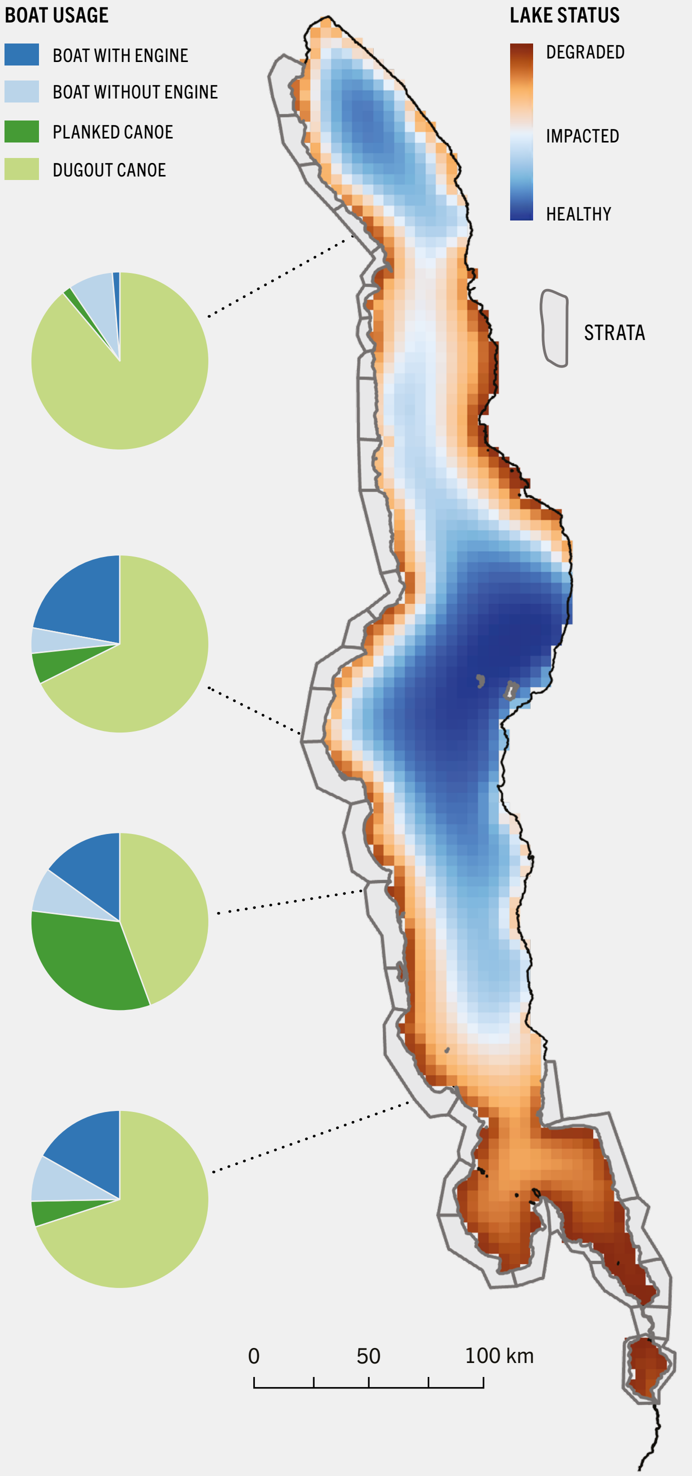
FIGURE A LAKE MALAWI/NIASSA/NYASA BASIN REPORT CARD



COUNTRIES
Malawi (68%), Mozambique (7%), United Republic of Tanzania (25%)

LAKE AREA
28 800–30 800 km²

LAND CATCHMENT AREA
97 750–98 700 km²

POPULATION ESTIMATED
20.9 million
(Malawi 55%, Mozambique 19%, United Republic of Tanzania 25%)

NUMBER OF FISH SPECIES
1 000

ANNUAL CATCH
44 000 tonnes (2010), 0.4% of global catches

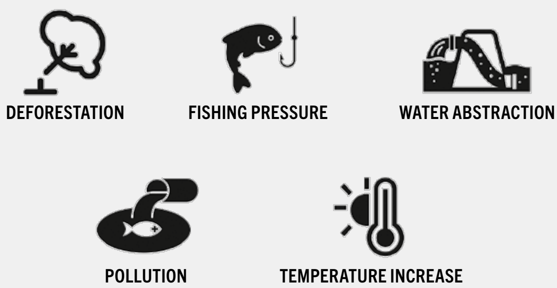
MAIN ECONOMIC ACTIVITIES
Agriculture, fishing

EMPLOYMENT
Fishers (60 000), fisheries-related activities (600 000)

FISHERIES-DEPENDENT POPULATION
1.6 million

DRIVERS OF CHANGE
Population growth, climate change

KEY PRESSURES

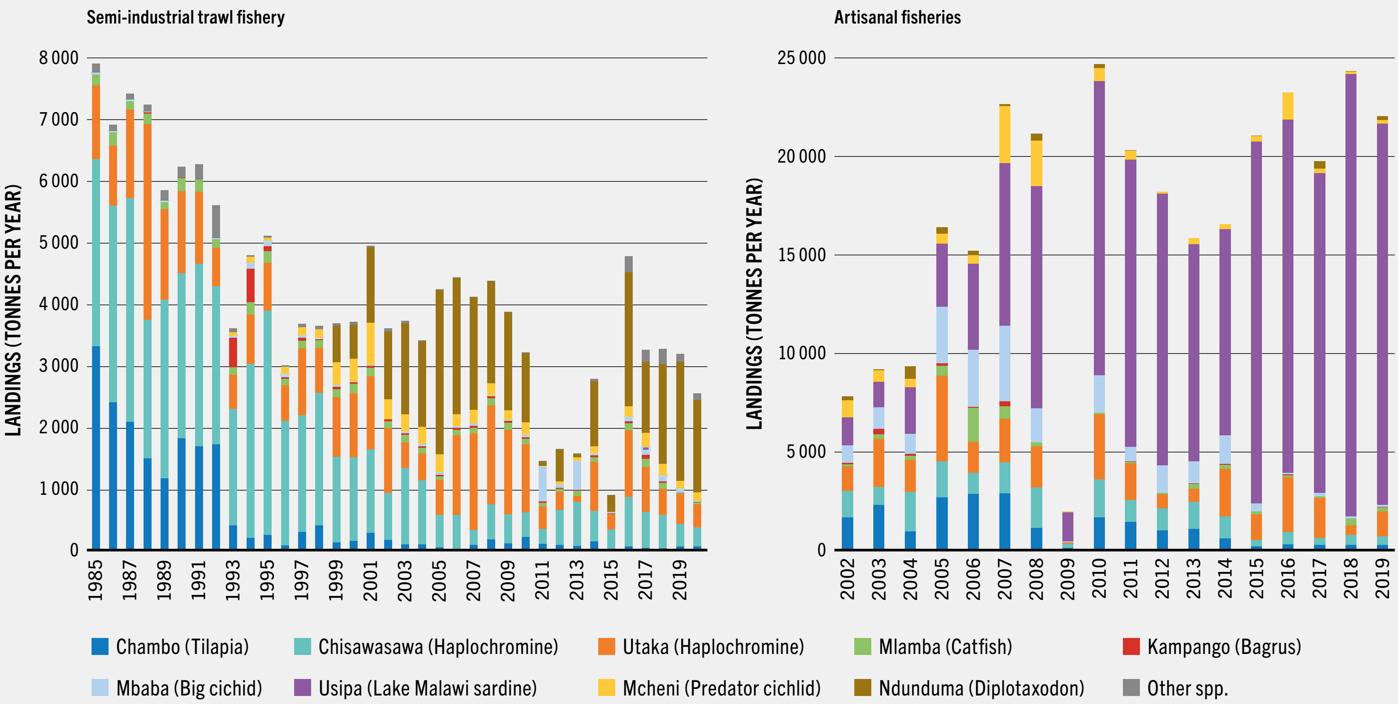


NOTE: Information in the box from Weyl, Ribbink and Tweedle (2010)[1] and Gumulira, Forrester and Lazar (2019).[2]
SOURCE: Land and Water Lab, University of Florida.

can be divided into semi-industrial (12 percent of landings), using 32 pair and 8 stern trawlers, and artisanal (88 percent of landings), using mostly dugout canoes. Common gear types include gillnets, open water seines with lamps as attraction lights, traps and mosquito nets. Malawi began systematic monitoring in their waters of semi-industrial fishery in 1976 and of artisanal fishery in 2002. There are no comparable datasets for the other two countries.

The trawl fishery of Lake Malawi/Niassa/Nyasa has been in decline since around 1990, while the landings in the artisanal fishery have grown since data collection started, mostly as a result of a larger number of fishers and higher fishing effort. There have been major shifts in the composition of the catches (Figure B). The artisanal fishery used to be rather diversified, but the lake Malawi sardine (*Engraulicypris sardella*) now contributes more than 90 percent of the artisanal catch, although with large interannual fluctuations. The trawl fishery mostly targets a number of cichlid species, of which the Chambo (*Oreochromis* spp.) collapsed in the early 1990s and never recovered, while the Chisawasawa (*Lethrinops* spp., demersal deep-water cichlids) has been in decline since the mid-2000s. Currently the trawl fishery mainly catches Ndunduma (*Diplotaxodon* spp., deep-water pelagic cichlids), for which there is limited competition with the artisanal fishery, and the catches remain fairly stable. Overfishing is generally believed to be responsible for the changes in fish catch composition observed. However, other factors including water abstraction, pollution, land-use change and climate change are most likely contributing factors. As in other lakes, fish production in Lake Malawi/Niassa/Nyasa is driven by nutrients originating from natural and anthropogenic sources in the basin's tributary rivers. In addition, there is recirculation of nutrients from the bottom layers due to upwelling. Upwelling varies according to the strength and direction of the prevailing winds, and the depth of the thermocline, which is determined by water temperature. The response to variations in nutrient inputs is typically immediately visible in small pelagic zooplanktivorous species such as the lake Malawi sardine.

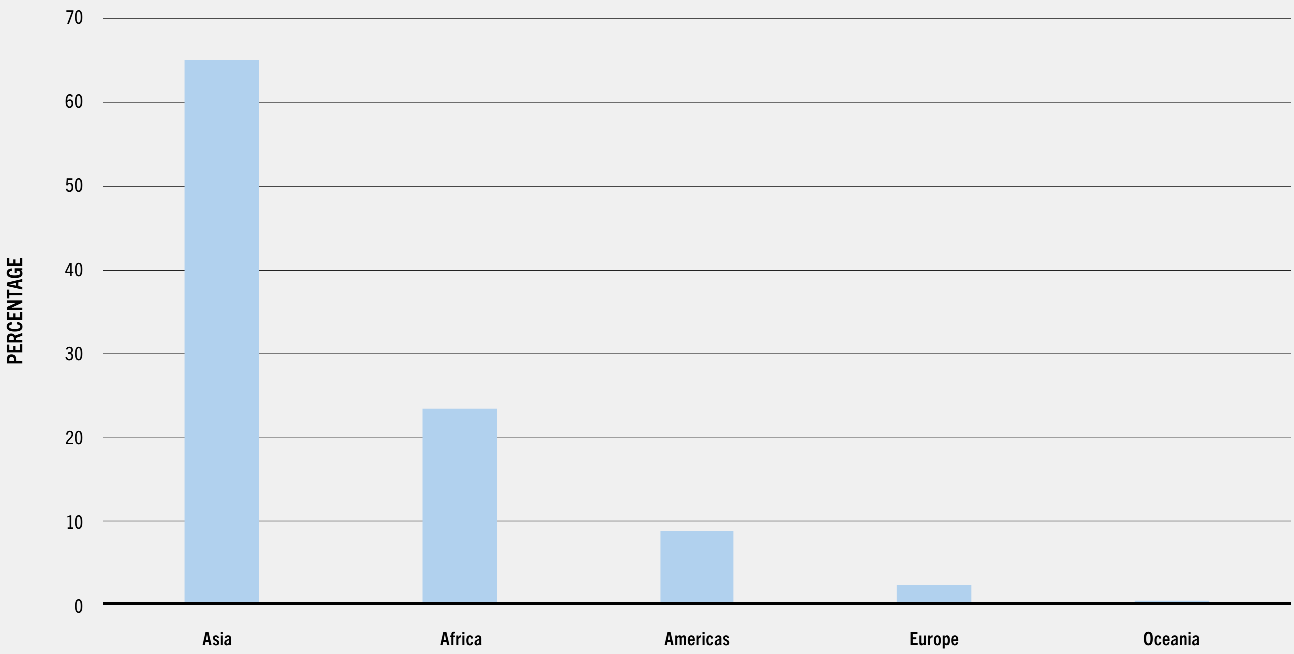
FIGURE B FISH LANDINGS IN THE ARTISANAL AND SEMI-INDUSTRIAL FISHERIES IN LAKE MALAWI/NIASSA/NYASA



[1] Weyl, O., Ribbink, A. & Tweedle, D. 2010. Lake Malawi: fishes, fisheries, biodiversity, health and habitat. *Aquatic Ecosystem Health and Management*, 13(3): 241–254.
[2] Gumulira, I., Forrester, G. & Lazar, N. 2019. Bioeconomic analysis of Engraulicypris sardella (USIPA) in South east arm of Lake Malawi. *International Journal of Fisheries and Aquaculture*, 11(4): 86–96.

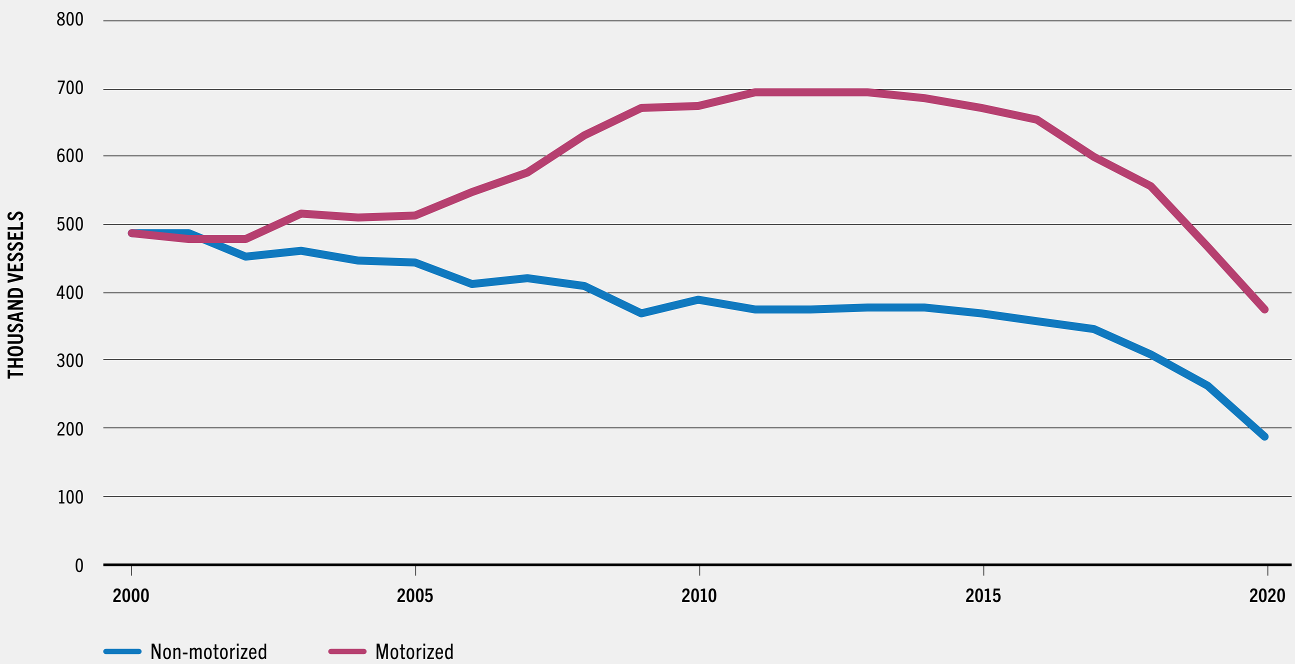
SOURCE: Department of Fisheries, Malawi.

FIGURE 27 DISTRIBUTION OF THE WORLD'S FISHING VESSELS BY CONTINENT, 2020



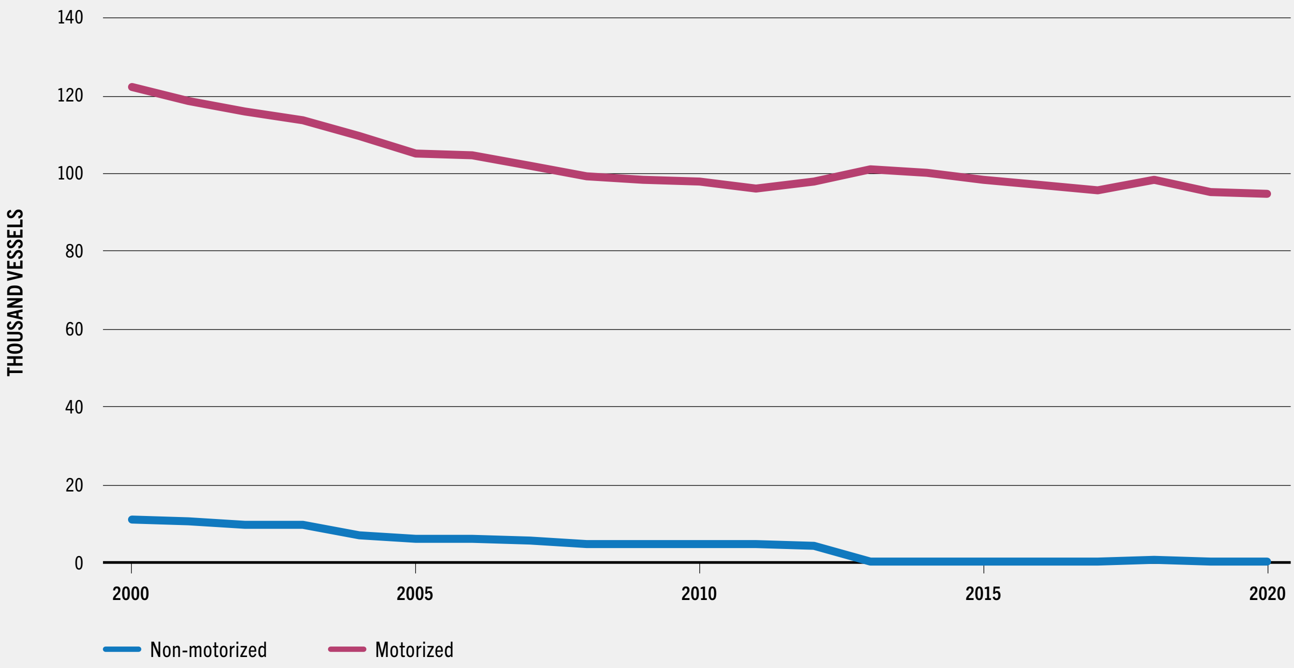
SOURCE: FAO.

FIGURE 28 FISHING FLEET SIZE BY MOTORIZATION STATUS, CHINA, 2000–2020



SOURCE: FAO.

FIGURE 29 FISHING FLEET SIZE BY MOTORIZATION STATUS, EU-27, 2000–2020



SOURCE: FAO.

et al. (2022) in Italy. A trend towards larger, more powerful vessels (Box 5) and more efficient fishing gears thus has the potential to jeopardize the sustainability of fishing, notwithstanding a decreasing number of vessels.

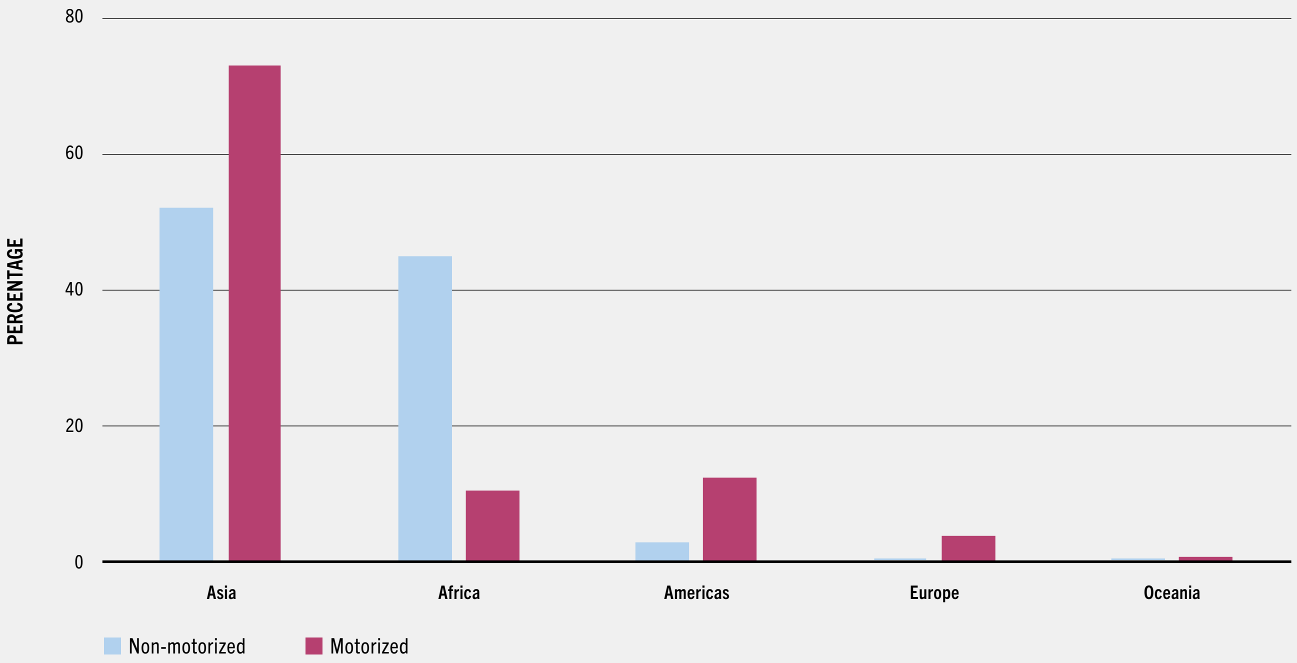
In terms of fleet motorization, the world has about 2.5 million vessels equipped with engines, making up 62 percent of the global fishing fleet. Figure 30 shows how motorized and non-motorized vessels are distributed across continents. The figure shows that the distribution for both types of vessels is uneven, with Asia having almost three-quarters (1.9 million) of the world's motorized vessels in 2020. The vast majority of the world's non-motorized vessels (about 97 percent) are spread between Asia and Africa, which are respectively estimated to have 815 000 and 702 000 such vessels. These non-motorized vessels are mostly categorized in the length overall (LOA) class of under 12 m, though many country reports continue to lack classification in terms of length, motorization status and vessel type. Importantly, the countries affected by this issue include some of the world's largest fishing fleets, representing a significant limitation of the data.

Size distribution of vessels and the importance of small boats

In 2020, around 81 percent of the world's motorized fishing vessels with known length classification were in the LOA class of under 12 m, the majority of which were undecked. Figure 31 shows that small vessels represent the largest share of motorized vessels in all continents. In absolute terms, most of these small, motorized vessels were in Asia, followed by the Americas (particularly Latin American and the Caribbean) and Africa. Large vessels (with an LOA of 24 m or more and usually associated with over 100 gross tonnage) were estimated at about 45 000 units across the world, representing under 5 percent of the world's motorized fishing vessels. The proportion of these large boats was highest in the Americas, Oceania and Asia in 2020. It is worth noting again that large vessels, though in small numbers, account for an estimated one-third of the total engine power of the global fishing fleet (Rousseau *et al.*, 2019).

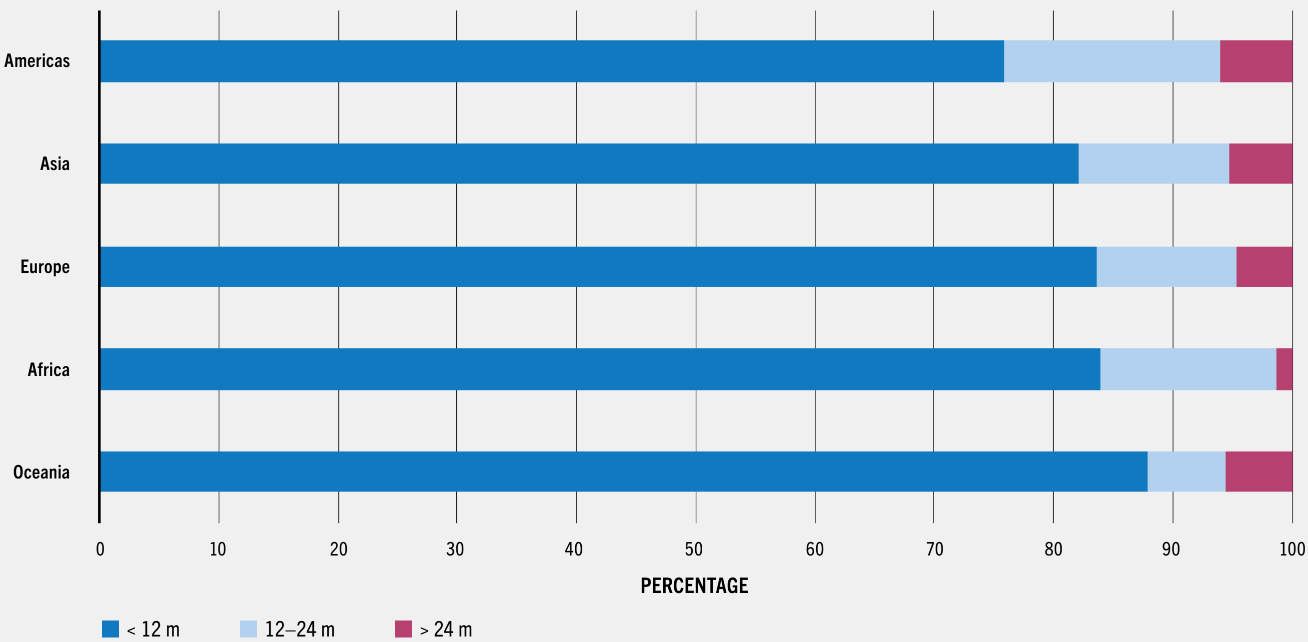
Figure 31 shows higher proportions of medium and large vessel sizes in 2020 compared with

FIGURE 30 PROPORTION OF GLOBAL FISHING VESSELS WITH AND WITHOUT ENGINE BY CONTINENT, 2020



SOURCE: FAO.

FIGURE 31 SIZE DISTRIBUTION OF MOTORIZED FISHING VESSELS BY CONTINENT, 2020



SOURCE: FAO.

BOX 5 GLOBAL FISHING FLEETS PERFORMANCE

FAO conducted a review of the techno-economic performance of the main global marine fishing fleets from 20 major fishing countries in Africa, Asia, Europe, North and South America.[1] Financial, socio-economic and technical information was collected from 103 major fishing fleet segments, representing approximately 240 000 fishing vessels. Taken as a whole, these fleets were responsible for an estimated 39 percent of marine capture fisheries production worldwide during the period 2016–2019.

The analysis of vessel characteristics reveals that there are substantial differences between fleet segments in marine fishing capacity (in terms of vessel length, tonnage and power). Comparing 16 fleet segments that also featured in a previous review in 2000, an increase in the gross tonnage of individual average vessels in all of these fleet segments was visible. Moreover, substantial increases in overall average vessel length and engine power were observed in several Asian fishing fleets. The age structure of the fishing fleets of (semi-) industrial fishing vessels in North and South America, Africa and Europe generally demonstrates an upward trend, while the age profile of most fishing fleet segments in Asia is younger, owing to the rejuvenation of fishing fleets in China, Bangladesh, India and Indonesia.

An analysis of the costs and earnings data of 98 fleet segments showed that labour and running costs were the two main cost components. The highest costs and earnings were found among purse seiner and trawler fleet segments targeting pelagic species.

The review showed that investments in (semi-) industrial fishing vessels and fishing operations are generally profitable, and that marine capture fishing continues to be a financially viable economic activity in all 20 fishing nations included in the review. Most fishing fleets surveyed realized sufficient income to cover depreciation costs, interest and loan repayments, and provide necessary financial resources for reinvestment. Of the 97 mostly (semi-) industrial fleet segments, 92 percent reported a positive net cash flow in the years they were surveyed between 2016 and 2019. Net profit margins (NPM) of 10 percent or more were realized by average fishing vessels in 73 percent of the fleet segments, while 88 percent reported positive results in terms of capital productivity, as their returns on fixed tangible assets (ROFTA) were positive. Returns on investment (ROI) of 10 percent or higher were realized by 61 percent of the fleet segments.

Profitability varied between vessels, fleet segments and years.[2] On average, purse seiners, gillnetters and squid jiggers presented very good results on the three major profitability indicators (NPM, ROFTA and ROI). Pelagic trawlers and large and medium-sized bottom trawlers also reported percentages that indicate profitable or highly profitable fishing operations. Four of the ten longliner fleet segments presented negative results, which affected the aggregated average performance of the grouped longliner segments.

The fishing technologies used continue to develop. Reducing fuel costs and saving energy have been key drivers for technological developments in semi-industrial fishing operations, vessels and gear. There have also been major developments in terms of increasing fishing efficiency, reducing the environmental impact of fishing, improving handling and enhancing product quality, in addition to improving safety at sea and the working conditions of fishers on board vessels. These developments – together with a general increase in prices of aquatic products, successful fisheries management in some areas, and improved fleet capacity management in Europe and North America – have all contributed to the positive financial and economic performance of the main global fishing fleets in recent years, before the COVID-19 pandemic.

[1] Van Anrooy, R., Carvalho, N., Kitts, A., Mukherjee, R., Van Eijs, S., Japp, D. & Ndao, S. 2021. *Review of the techno-economic performance of the main global fishing fleets*. FAO Fisheries and Aquaculture Technical Paper No. 654. Rome, FAO. https://doi.org/10.4060/cb4900en
[2] For the aggregated average performance of fishing fleet segments, grouped by gear type and vessel size (for bottom trawlers) in the years surveyed, see table available at: www.fao.org/3/cb4900en/cb4900en.pdf#page=85

previous years, mostly in Africa, the Americas and Asia. These data confirm the results of the review reported in Box 5, which underlines general increases in tonnage and length observed in fleets around the world. In the case of the Americas, an important update of the data for Brazil – a key player on the continent – resulted in a fleet characterized by more large vessels than previously reported. This partly explains the fact that the Americas now have the world's smallest proportion of motorized vessels under 12 m.

Table 11 summarizes the number of vessels by LOA class and motorization status for a selection of countries that highlight regional trends. The selected countries follow the global trend identified earlier with most vessels being smaller LOA; most non-powered vessels are in Asian and African countries, and only 8 of the 27 countries and territories shown in Table 11 have 200 or more vessels over 24 m LOA. Non-motorized vessels only represent a major component of the fleet in Benin and Malawi and – to a lesser extent – in Angola, Bangladesh, Sri Lanka and Tunisia, where they account for around 50 percent of the total.

While small vessels make up most of the world's fleets, the estimation of their numbers is particularly challenging. Indeed, while industrial vessels are usually subject to licensing and registration requirements, this is less often the case for small vessels. Additionally, small vessels may not always be reported in national statistics even when registries exist. Another challenge has to do with inland water fleets, for which reporting and data availability in local and national registries is rarely adequate, complicating further disaggregation and comparison between marine and inland water fleets. This highlights the need for FAO to accelerate its efforts to improve data quality and reporting in fisheries, with a major focus on small-scale fisheries around the world, also through dedicated capacity-building activities in fisheries statistics. Indeed, information on vessels (best collected through registries) is critical for countries because it allows them to assess the size of their fleets, supports fisheries management and constitutes a critical first step in recognizing and formalizing small-scale fishery activities and their actors.

The comprehensive revision conducted during the past few years by FAO has improved the FAO fleet data for the period 1995–2020, enabling adjustments in national and regional totals compared with previous issues of *The State of World Fisheries and Aquaculture*. It has also enabled the development and presentation of more than 20 years of historical data in more detailed form, by closely communicating with Members to revise historical data, uncover new data sources, control data errors and make imputations where necessary. This work on improving data collection and analysis will be expanded to include the historical data from 1950 to 1995. ■

EMPLOYMENT IN FISHERIES AND AQUACULTURE

This section covers the annual and trend data for employment in fisheries and aquaculture. Most of the dataset regards engagement in the primary sector of fisheries and aquaculture, while a smaller subset also includes data on post-harvest activities, primarily processing.

Employment in the primary sector

In 2020, an estimated 58.5 million were engaged as full-time, part-time, occasional or unspecified workers in fisheries and aquaculture, and of these approximately 21 percent were women. By sector, 35 percent were employed in aquaculture and 65 percent in capture fisheries (Table 12).

Total employment in the aquaculture sector has been flattening in recent years (Table 12), while the global number of fishers has contracted, particularly driven by trends in Asia. The impact of the COVID-19 pandemic on employment was felt throughout the value chains of fisheries and aquaculture (see the section COVID-19, a crisis like no other, p. 195). Fishing and aquaculture were disrupted by restrictions on mobility, non-essential activities and trade, causing disruption and shifts in markets and distribution. This varied depending on the country and period of the year, with the virus and its different variants moving from Asia to Europe and the Americas.

In 2020, 84 percent of all fishers and fish farmers were in Asia, followed by Africa (10 percent) and Latin America and the Caribbean (4 percent). More than 20 million were engaged in aquaculture, concentrated primarily in Asia (93.5 percent), followed by Africa (3.1 percent) and Latin America and the Caribbean (nearly 3 percent). Europe, North America and Oceania each had less

TABLE 11 REPORTED NUMBER OF VESSELS BY MOTORIZATION AND LOA CLASS IN FISHING FLEETS FROM SELECTED COUNTRIES AND TERRITORIES, 2020

	Non-motorized			Motorized		
	< 12 m	12–24 m	> 24 m	< 12 m	12–24 m	> 24 m
Africa						
Angola	6 563			4 694	186	256
Benin	40 869			578	10	17
Malawi	17 224			2 493		
Mauritius	260			3 605	33	6
Senegal	1 468	166		8 844	4 656	152
Sudan				1 120		60
Tunisia	6 506			5 469	1 198	303
Americas						
Bahamas				1 220	45	3
Chile	476			10 545	1 902	105
Guatemala				79	30	2
Guyana	10			712	806	
Mexico	13 612			61 294	1 690	246
Saint Lucia				482		
Suriname				418	587	63
Asia						
Bangladesh	34 810			32 859	33	205
Cambodia	32 002			85 724		
Korea, Republic of	725	32		54 832	8 866	1 289
Lebanon	88			1 852	90	
Myanmar	4 347			13 141	3 806	1 141
Oman	5 025	64	2	23 678	1 400	128
Sri Lanka	26 942			28 625	2 455	24
Taiwan Province of China	317		1	14 514	6 140	800
Europe						
Iceland				1 656	168	168
Norway				4 763	781	313
Poland				656	112	49
Oceania						
New Caledonia				752	16	3
New Zealand	5			571	415	69
Vanuatu				191	30	66

SOURCE: FAO.

TABLE 12 WORLD EMPLOYMENT FOR FISHERS AND FISH FARMERS BY REGION FOR SELECTED YEARS, 1995–2020

	1995	2000	2005	2010	2015	2020
	(thousands)					
Fisheries and aquaculture						
Africa	2 812	3 589	4 159	5 032	5 562	5 641
Americas	2 072	1 905	1 978	2 321	2 501	2 621
Asia	31 632	41 265	45 693	50 401	52 079	49 425
Europe	476	514	463	426	375	388
Oceania	466	475	478	482	481	474
Total	**37 456**	**47 748**	**52 770**	**58 662**	**60 999**	**58 549**
Fisheries						
Africa	2 743	3 395	3 906	4 671	5 057	5 007
Americas	1 793	1 605	1 679	1 981	2 156	2 015
Asia	24 205	28 335	30 476	31 994	31 833	30 102
Europe	378	418	380	333	286	294
Oceania	460	465	469	473	471	464
Total	**29 579**	**34 219**	**36 909**	**39 452**	**39 803**	**37 882**
Aquaculture						
Africa	69	194	252	361	505	634
Americas	279	301	299	340	345	606
Asia	7 426	12 930	15 217	18 407	20 246	19 323
Europe	98	96	83	93	89	94
Oceania	6	9	9	9	10	10
Total	**7 878**	**13 529**	**15 861**	**19 211**	**21 195**	**20 667**

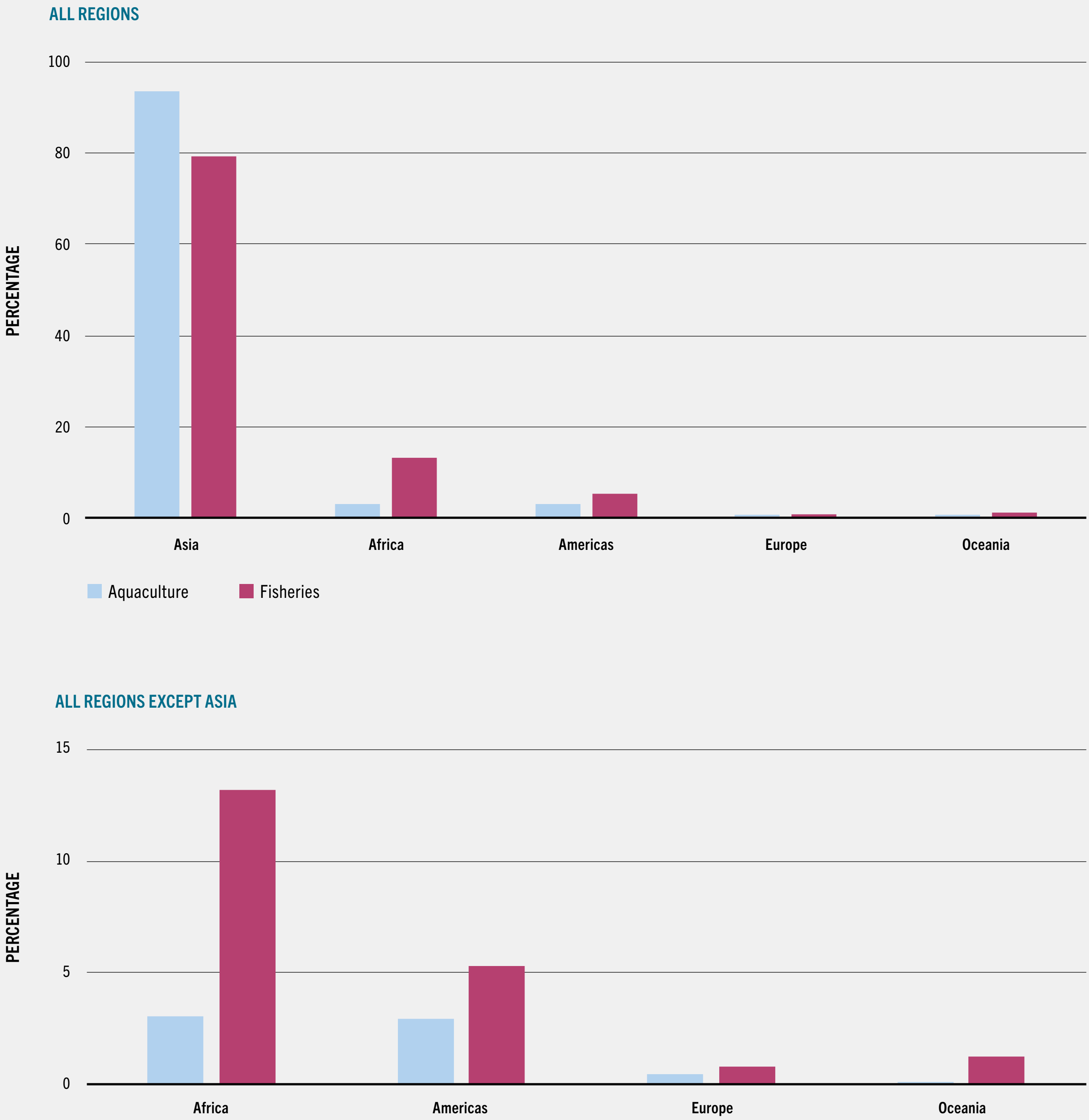
SOURCE: FAO.

than 1 percent of the global population engaged as fishers or fish farmers (Figure 32).

Nearly 80 percent of the 37.9 million fishers were from Asia, followed by Africa with 13 percent, the Americas with just over 5 percent (mostly accounted for by Latin America and the Caribbean), Oceania with just over 1 percent and Europe with just below 1 percent.

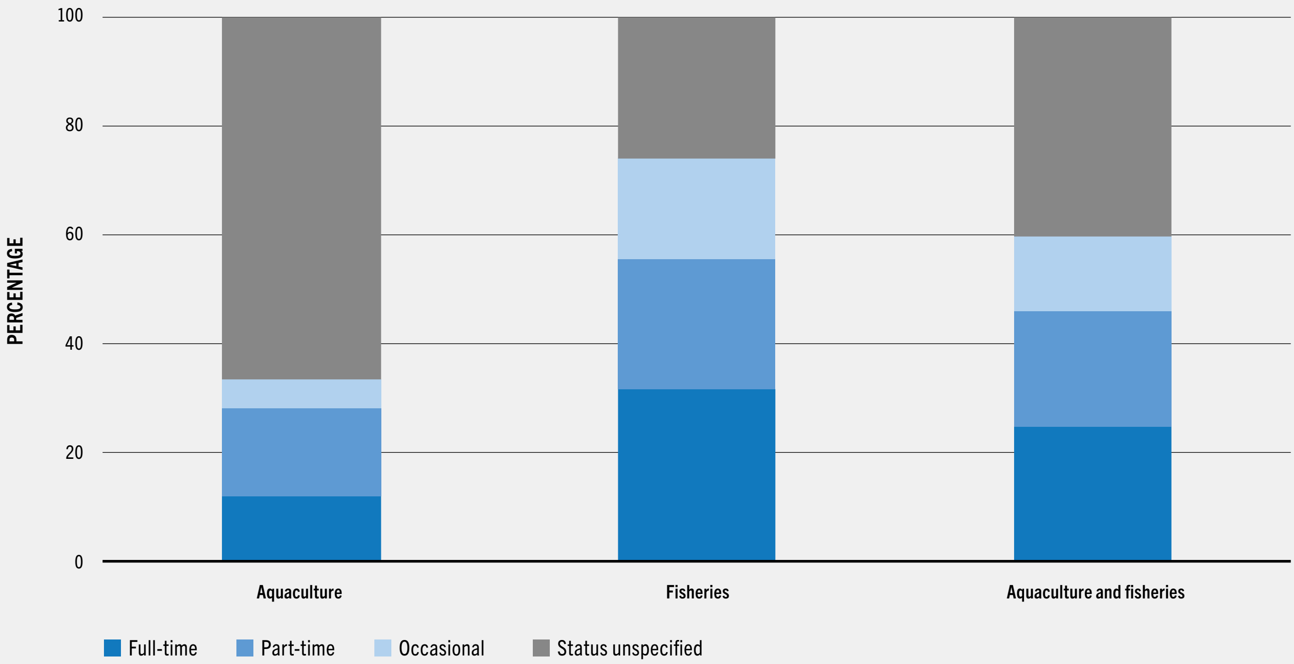
The trends in the number of people engaged as fishers or fish farmers vary by region. Europe and North America have experienced the largest proportional decreases in the number of both, particularly fishers (Table 12). Africa has experienced steady growth in the employment of fishers and fish farmers, most of which accounted for by fishing. Employment in aquaculture continues to increase in Africa but remains low compared with employment in the African fishing sector. In Asia, engagement in both aquaculture and fisheries is declining for the first time in decades. For fishers, the Chinese fleet reduction (see the section Fishing fleet, p. 59) and the impact of COVID-19 have been strong drivers of this decline. Fisheries employment decreased

FIGURE 32 SHARE OF EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY CONTINENT



NOTE: The second chart shows all continents except Asia for increased resolution.
SOURCE: FAO.

FIGURE 33 TIME USE CATEGORIES REPORTING IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE



SOURCE: FAO.

5.4 percent and aquaculture employment decreased 4.6 percent between 2015 and 2020 (Table 12). Oceania also displays a decrease in employment, with the number of fishers dropping while aquaculture workers remained steady between 2015 and 2020. Interestingly, until 2015, employment in Europe was declining in fisheries and aquaculture; however, during 2015–2020 there was 3 percent growth in fisheries and 5 percent growth in aquaculture.

Figure 33 presents employment data disaggregated into full-time, part-time, occasional and status unspecified. Because nearly 40 percent of the employment data are reported as status unspecified, the insights regarding contribution and time dedicated to employment are limited. The proportion of status unspecified is greater for aquaculture, as some of the countries with a high level of employment in aquaculture do not disaggregate data. Approximately 25 percent of employment was reported in the full-time category, 21 percent in part-time and the remaining 14 percent as occasional engagement. Of all female workers, the majority were reported as status unspecified (34 percent), followed by part-time (27 percent). Only 15 percent of the full-time workers were female, further reinforcing research that women tend to have more unstable positions within the value chains of aquaculture and fisheries. However, when considering the available data for the processing sector only, women are found to make up just over 50 percent of full-time employment and 71 percent of part-time engagement (Box 6).

Overall, it is estimated that in 2020, women accounted for just over 21 percent of all people directly engaged in the fisheries and aquaculture primary sector – 28 percent in aquaculture and 18 percent in fisheries (Figure 34). This higher proportion than previous estimations is a result

BOX 6 RELEVANCE OF SEX-DISAGGREGATED EMPLOYMENT DATA: THE CASE OF THE PROCESSING SECTOR

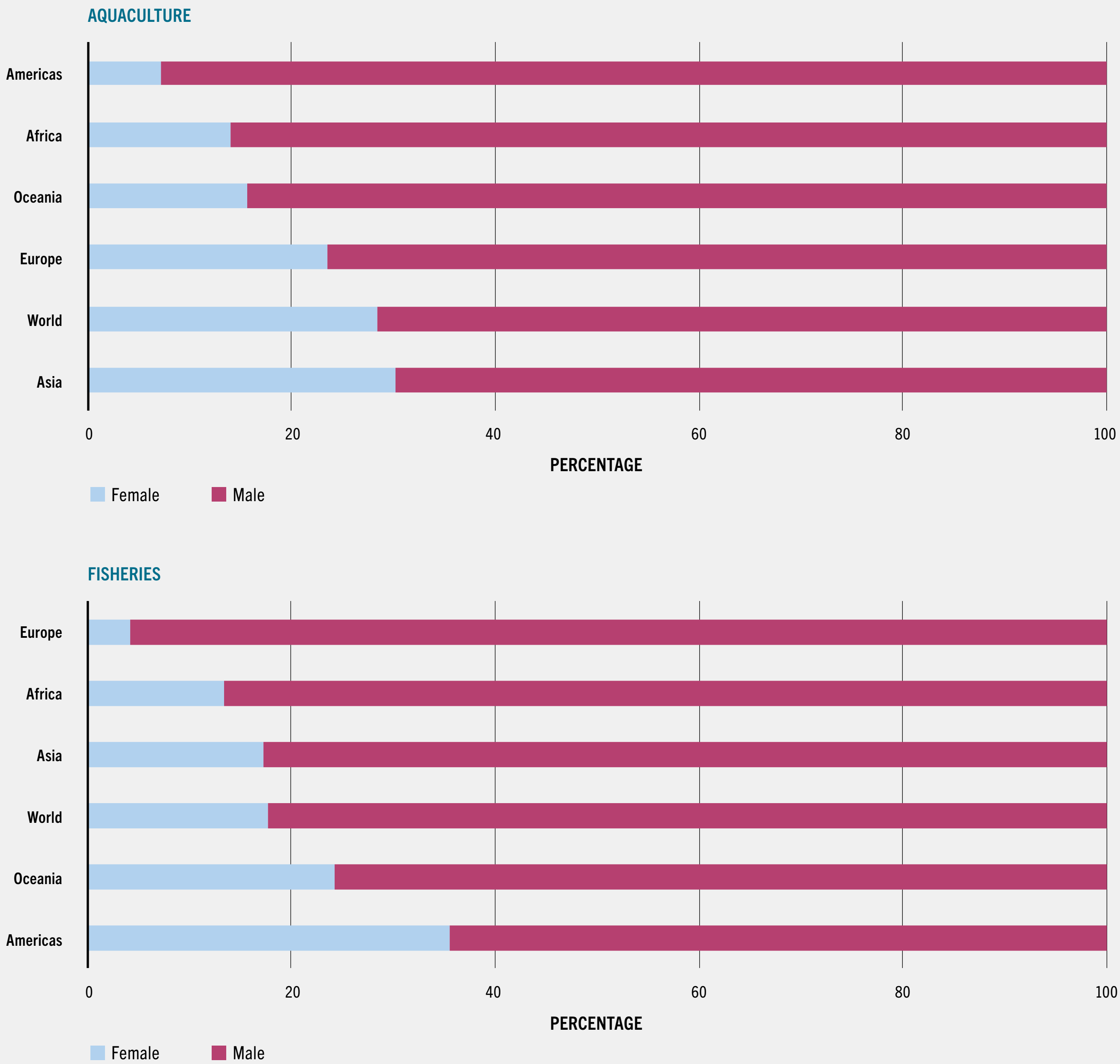
Processing of aquatic food is at the core of post-harvest activities in the fisheries and aquaculture sector, exerting a direct impact on local to global fisheries and aquaculture economies. Processing encompasses a variety of techniques aimed at the transformation and preservation of fisheries and aquaculture products, ranging from artisanal, small-scale methods to large-scale mechanized operations. In 2012, the World Bank[1] estimated that in certain segments of the processing sector worldwide, up to 85 percent of the employees were women. Further, the preliminary results of the recent Illuminating Hidden Harvests study[2] show half of the workers in the small-scale fisheries' post-harvest sector to be women. The high percentages of women engaged in processing can be viewed in light of a socialized space-dependent gendered division of labour in the fishery industry, with men having greater access to the sea and women mainly working on land.[3,4] High female employment in processing also relates to the perception that women are more compliant, flexible and meticulous and accept lower pay than men.[5] The latter set of gender norms leads to the poorly paid, unstable and low qualification positions of women in the secondary sector, with little to no recognition provided at the policy level.[6]

The recent collaboration between FAO and the Organisation for Economic Co-operation and Development (OECD) on a joint study across 49 countries enabled the annual collection of sex-disaggregated data for the fisheries and aquaculture processing sector for those countries. To date, the dataset holds 38 countries' statistics for employment in the processing sector. Of these, 22 are disaggregated by sex.[7] The resulting time series constitutes a promising example for other countries and is being followed by ten additional countries outside the FAO-OECD dataset. FAO encourages the remaining Members to also report their available processing datasets. Yet, data received so far clearly reveal major gaps to fill in national gendered employment statistics. Indeed, the lack of quantitative knowledge on women engaged in post-harvest activities mirrors the issue existing in the primary sector and impedes the achievement of gender equality worldwide, by limiting the adoption of evidence-based policies targeting unequal wages, health risks and gender-based discriminations in the workplace.[6] In addition to the reported data from Members, FAO has also conducted a round of work to expand the collection of national, regional and global time series on sex-disaggregated employment data in the processing sector, spanning from 1991 to 2021. The resulting time series are being examined prior to their merging with the reported dataset. The current estimate is that women represent just over 46 percent of the total workforce. Statistics from 117 countries and one regional body have been collected, 58 percent of which present at least one sex-disaggregated value in their time series.

Despite improvement of the latest dataset, processing-specific time series cover only industrial, organized and formal activities. Given the major role of women in artisanal and subsistence fisheries,[2] increasing focus should be placed on the collection of sex-disaggregated data in informal, unpaid, subsistence activities. More information on women's employment status in the post-harvest activities of aggregation and distribution is needed. Finally, the ancillary activities comprising the pre-harvest sector (boat and aquaculture pond maintenance, net mending, bookkeeping, food preparation for fishing trips etc.) are not yet included in the fisheries and aquaculture employment statistics, as they are mostly informal. To recognize the role of the fishery and aquaculture informal sector to support food security and ensure women's financial empowerment, these activities should be accounted for and the collection of sex-disaggregated data prioritized.

[1] World Bank. 2012. *Hidden harvest: The global contribution of capture fisheries*. Economic and Sector Work. Washington, DC. https://openknowledge.worldbank.org/bitstream/handle/10986/11873/664690ESW0P1210120HiddenHarvest0web.pdf?sequence=1&isAllowed=y
[2] FAO, Duke University & WorldFish. (forthcoming). *Illuminating Hidden Harvests: A snapshot of key findings into the contributions of small-scale fisheries to sustainable development*. Rome, FAO, Durham, USA, Duke University, and Penang, Malaysia, WorldFish.
[3] de la Torre-Castro, M., Fröcklin, S., Börjesson, S., Okupnik, J. & Jiddawi, N.S. 2017. Gender analysis for better coastal management – Increasing our understanding of social-ecological seascapes. *Marine Policy*, 83: 62–74. https://doi.org/10.1016/j.marpol.2017.05.015
[4] Alonso-Población, E. & Niehof, A. 2019. On the power of a spatial metaphor: Is female to land as male is to sea? *Maritime Studies*, 18: 249–257. https://doi.org/10.1007/s40152-019-00148-z
[5] Monfort, M.C. 2015. *The role of women in the seafood industry*. GLOBEFISH Research Programme, Vol. 119. Rome, FAO. www.fao.org/3/bc014e/bc014e.pdf
[6] FAO. 2020. *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. Rome. https://doi.org/10.4060/ca9229en
[7] See Table 13, p. 74.

FIGURE 34 SEX-DISAGGREGATED DATA ON EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY REGION, 2020



NOTE: The calculated ratio of females to males is based on reported figures, excluding those reported as unspecified.
SOURCE: FAO.

of more disaggregated reporting from countries and of FAO's ongoing effort (since 2019) to improve the quality of the employment data. This work has been conducted for the entire dataset from 1995 onwards and for 49 countries, in collaboration with the Organisation for Economic Co-operation and Development (OECD), harmonizing the employment datasets and streamlining data collection through a joint questionnaire on fisheries and aquaculture employment in the primary and secondary sector to eliminate a double reporting burden for Members.

Employment in post-harvest sector

Table 13 presents the data reported by selected Member States for employment in the post-harvest sector, particularly in processing. This is explored in further detail in Box 6, as processing is the sector where the largest proportion of women are employed. These figures are complemented by the Illuminating Hidden Harvests study (FAO, Duke University and WorldFish, forthcoming; see also the section Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development, p. 151). This study found that 39.6 percent of the actors (people employed and subsistence) throughout the small-scale fisheries value chain and 49.8 percent of post-harvest workers were women. The focus on small-scale actors is particularly important, because they have been overlooked in terms of data and yet they comprise a greater proportion of women workers. ■

UTILIZATION AND PROCESSING OF FISHERIES AND AQUACULTURE PRODUCTION[15]

Fisheries and aquaculture harvests are transformed into a wide range of products with different characteristics and flavour depending on the species, preservation method and product form. Major improvements in processing, refrigeration, ice production and use, freezing, storage and transportation have enabled extended shelf-life, distribution over long distances and across borders, and an increasing variety of products.

The proportion of fisheries and aquaculture production of aquatic animals used for direct human consumption has increased significantly from 67 percent in the 1960s to about 89 percent in 2020 (that is over 157 million tonnes of the 178 million tonnes of total fisheries and aquaculture production, excluding algae[15]) (Figure 35). The remaining 11 percent (over 20 million tonnes) was used for non-food purposes; of this, 81 percent (over 16 million tonnes) was reduced to fishmeal and fish oil, while the rest (about 4 million tonnes) was largely utilized as ornamental fish, for culture (e.g. fry, fingerlings or small adults for ongrowing), as bait, in pharmaceutical uses, for pet food, or as raw material for direct feeding in aquaculture and for the raising of livestock and fur animals.

In 2020, live, fresh or chilled aquatic food[15] continued to account for the largest share of fisheries and aquaculture production utilized for direct human consumption (44 percent), and it often represents the most preferred and highly priced form of fisheries and aquaculture products.[15] It was followed by frozen (35 percent), prepared and preserved (11 percent) and cured[16] (10 percent) products. Freezing represents the main method of preserving fisheries and aquaculture products for food purposes, accounting for 63 percent of all processed aquatic animal production for human consumption (i.e. excluding live, fresh or chilled).

These general data mask major differences. Utilization and processing methods differ significantly across continents, regions, countries and even within countries. In Asia and Africa, the share of aquatic food production preserved by salting, smoking, fermentation or drying is higher than the world average. Approximately two-thirds of the fisheries and aquaculture production used for human consumption is in frozen, prepared and preserved forms in Europe and North America. The share of fisheries and aquaculture production utilized for reduction into fishmeal and fish oil is highest in Latin America, followed by Asia and Europe.

Overall, in more developed economies, processing of aquatic food has diversified particularly into high-value-added products, such as ready-to-eat meals. In 2020, over 50 percent of the aquatic animal food production destined for human

15 For algae, aquatic food, fisheries and aquaculture production, and fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

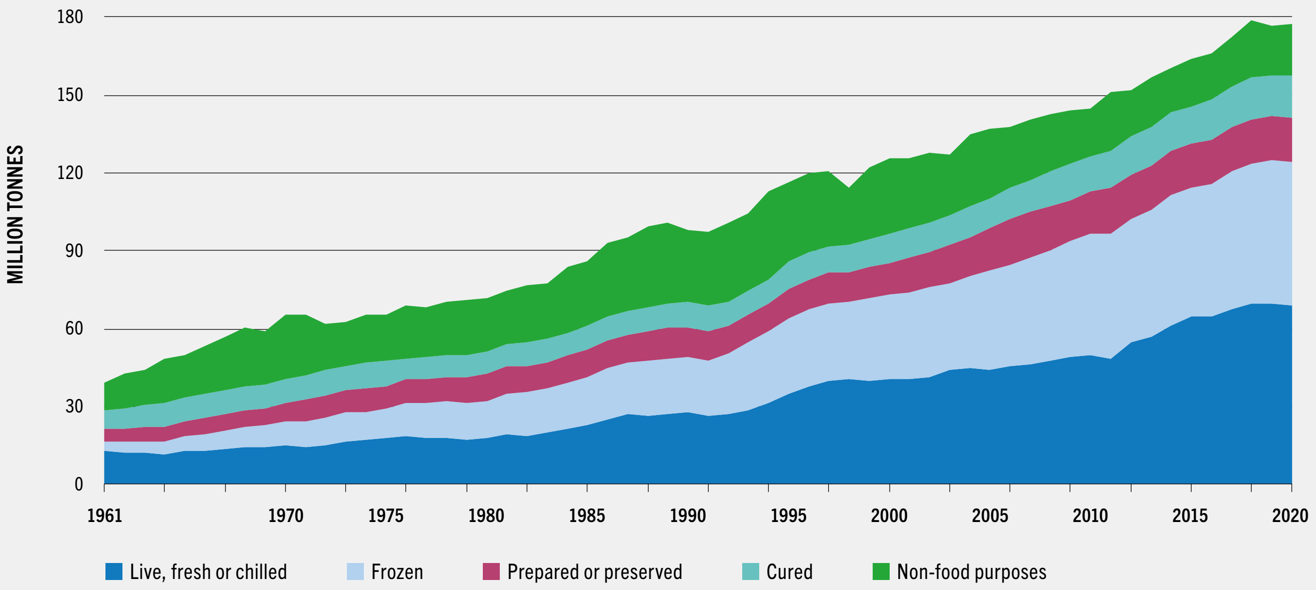
16 Cured means dried, salted, in brine, fermented, smoked, etc.

TABLE 13 EMPLOYMENT IN PROCESSING OF AQUATIC PRODUCTS BY COUNTRY FOR SELECTED YEARS, 1995–2020

Country	1995	2000	2005	2010	2015	2020
	(number of people)					
Argentina	6 226	5 849	8 005	9 005	8 142	10 778
Austria	218	218	267	125		153
Brunei Darussalam				311	311	433
Burkina Faso				3 020	3 020	3 080
Canada	21 540	32 058	24 158	21 067	23 136	19 716
Chile	39 090	39 090	39 433	42 752	49 984	40 537
Costa Rica	1 890	2 346	1 973	1 660	1 332	1 563
Czechia			133	135	150	203
Denmark	8 465	6 633	5 209	3 661	3 641	3 133
Estonia			2 507	1 772	1 931	1 400
Finland				1 796	1 873	1 704
France			15 672	15 633	17 523	14 767
Germany			7 584	7 206	7 091	7 393
Indonesia					63 534	78 126
Ireland	4 920	4 530	3 507	2 867	3 797	5 116
Israel						250
Italy	5 425	5 425	5 425	5 950	5 926	5 891
Korea, Republic of					37 455	43 167
Lithuania	3 640	3 970	4 547	4 379	5 668	5 199
Malawi					16 492	30 118
Mauritius					4 980	5 040
Morocco						109 440
Myanmar						12 212
Netherlands	6 500	3 750	2 600	2 506	2 800	2 470
New Zealand	6 890	6 890	6 790	5 650	4 960	5 150
Niger						38 388
Norway	12 474	14 341	10 772	10 591	11 209	12 416
Peru	26 986	30 965	33 664	36 796	34 313	31 707
Poland	12 654	12 654	12 654	16 971	19 156	18 234
Portugal			14 752	14 752	14 296	8 392
Russian Federation			54 342	60 607	49 919	40 801
Seychelles						2 352
Slovakia			1 049	849	715	614
Slovenia			250	266	209	302
Suriname						2 000
Sweden	1 890	2 064	1 941	2 007	2 171	1 955
Thailand					3 017	3 017
Trinidad and Tobago						9
Türkiye	2 000	3 500	4 990	5 833	6 200	6 500
United States of America	55 070	47 607	41 607	36 469	36 624	32 298
Viet Nam	85 400	133 650	189 340	222 749	251 706	253 934

SOURCE: FAO.

FIGURE 35 UTILIZATION OF WORLD FISHERIES AND AQUACULTURE PRODUCTION, 1961–2020



NOTES: Excluding aquatic mammals, crocodiles, alligators and caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

consumption in high-income countries[17] was in frozen form, followed by about 26 percent in prepared and preserved form, and 13 percent in cured form. In many developing countries, processing of aquatic products[18] has been evolving from traditional methods to more advanced value-adding processes, depending on the commodity and market value. However, there are significant differences depending on countries' infrastructure and cultural preferences. In 2020, about 20 percent of the aquatic food production of upper-middle-income countries was utilized in frozen form, 11 percent in canned form, and over 60 percent in live, fresh or chilled form. In contrast, for low-income countries, only 7 percent was in frozen form, more than 20 percent in cured form and about 70 percent in live, fresh or chilled form.

Aquatic products commercialized in live form are principally appreciated in East and Southeast Asia and in niche markets in other countries, mainly among immigrant Asian communities. In China and some Southeast Asian countries, live aquatic animals have been traded and handled for more than 3 000 years, and in many cases practices for their commercialization continue to be based on tradition and are not formally regulated. Commercialization of live aquatic animals has continued to grow in recent years also thanks to improved logistics and technological developments. Yet, marketing and transportation can be challenging, as they are often subject to stringent health regulations, quality standards and animal welfare requirements (notably in Europe and North America).

Overall, the ongoing expansion in consumption and commercialization of fisheries and aquaculture products (see the sections Consumption of aquatic foods, p. 81, and Trade of fisheries and aquaculture products, p. 91) has been accompanied by a significant development in food

17 The World Bank assigns the world's economies to four income groups: low, lower-middle, upper-middle, and high. More information is available at https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html

18 For aquatic products, see Glossary, including Context of SOFIA 2022.

quality and safety standards. In recent decades, the fisheries and aquaculture sectors have become more complex and dynamic, with developments driven by high demand from the retail industry, species diversification, outsourcing of processing, and stronger supply linkages between producers, processors and retailers. Expansion of supermarket chains and large retailers worldwide has increased their role as key players in influencing market access requirements and standards. To meet these food safety and quality standards and ensure consumer protection, increasingly stringent hygiene and handling measures have been adopted at the national, regional and international levels, based on the Codex Code of Practice for Fish and Fishery Products (FAO and WHO, 2020) and its guidance to countries on practical aspects of implementing good hygiene practices and the Hazard Analysis Critical Control Point (HACCP)-based food safety management system.

As aquatic products are highly perishable, particular care is required at harvesting and all along the supply chain. If not correctly treated after harvesting, they can soon become unfit to eat and possibly dangerous to health as a result of microbial growth, chemical change, breakdown by endogenous enzymes and cross-contamination leading to food safety risks. Proper handling, processing, preservation, packaging and storage measures are essential to extend shelf-life, ensure food safety, maintain quality and nutritional attributes and avoid loss and waste. Furthermore, improved utilization can help reduce the pressure on aquatic resources and foster sustainability of the sector.

Preservation and processing techniques are also essential to allow aquatic products to be distributed and marketed domestically and internationally. These techniques are based on temperature reduction (chilling and freezing), heat treatment (canning, boiling and smoking), reduction of available water (drying, salting and smoking) and changing of the storage environment (vacuum packaging, modified atmosphere packaging and refrigeration).

Nutritional attributes of aquatic food can vary according to the way in which it is processed and prepared. Heating (by sterilization, pasteurization, hot smoking or cooking) reduces the amount of thermolabile nutrients, including many vitamins. However, the concentration of some nutrients can increase with heating, which removes water.

Significant technological development in food processing and packaging is ongoing in many countries, with increases in efficient, effective and lucrative utilization of raw materials, and innovation in product diversification for human consumption as well as for production of fishmeal and fish oil and other purposes.

Products: fishmeal and fish oil

A significant but declining proportion of world fisheries production is processed into fishmeal and fish oil. Fishmeal is a protein-rich flour made by milling and drying fish or fish parts, while fish oil is obtained by pressing cooked fish and centrifuging the liquid extracted. Fishmeal and fish oil can be produced from whole fish, fish trimmings or other fish processing by-products. A number of different species are used as whole fish – mainly small pelagic fish, such as Peruvian anchoveta (accounting for the greatest proportion), menhaden, blue whiting, capelin, sardine, mackerel and herring.

Fishmeal and fish oil production fluctuates according to changes in the catches of those species, in particular anchoveta, dominated by the El Niño–Southern Oscillation, which affects stock abundance. Over time, the adoption of good management practices and certification schemes has decreased the volumes of unsustainable catches of species targeted for reduction to fishmeal. The amount utilized for reduction to fishmeal and fish oil peaked in 1994 at over 30 million tonnes and then declined to less than 14 million tonnes in 2014. In 2018, it rose to about 18 million tonnes due to increased catches of Peruvian anchoveta (see the section Capture fisheries production, p. 10) before declining in the subsequent two years to reach over 16 million tonnes in 2020. This corresponds to about 20 percent of capture fisheries in marine waters.

This progressive reduction in supply has been coupled with a surging demand driven by a fast-growing aquaculture industry, as well as by pig and poultry farming, and the pet-food and pharmaceutical industries. According to the estimates of the Marine Ingredients Organisation (IFFO), in 2020 about 86 percent of fishmeal was used in aquaculture, while 9 percent was destined for pig farming, 4 percent for other uses (mainly pet food) and 1 percent for poultry. In the same year, about 73 percent of fish oil was destined for aquaculture, 16 percent for human consumption and 11 percent for other uses (including pet food and biofuel) (Figure 36). The increasing demand for fishmeal and fish oil led to an increase in their prices. The fact that supply is lower than demand and the sector is a profitable one has led to pressure to find additional or alternative sources. While the majority of whole fish used in the production of fishmeal and fish oil originates from well-managed resources, the sustainability of some fisheries remains of great concern in some countries where fishmeal production is on the rise. This is the case in some countries in West Africa, where an increasing amount of catches are reduced into fishmeal for export purposes, rather than used for human consumption. In Senegal, for instance, whole fish used for decades for direct human consumption are now being redirected into production of marine ingredients. This not only increases the pressure on fishery resources, but it impacts food security and livelihoods. In these areas, it is essential to improve governance and fisheries management, while prioritizing the utilization of fish for human consumption (Thiao and Bunting, 2022).

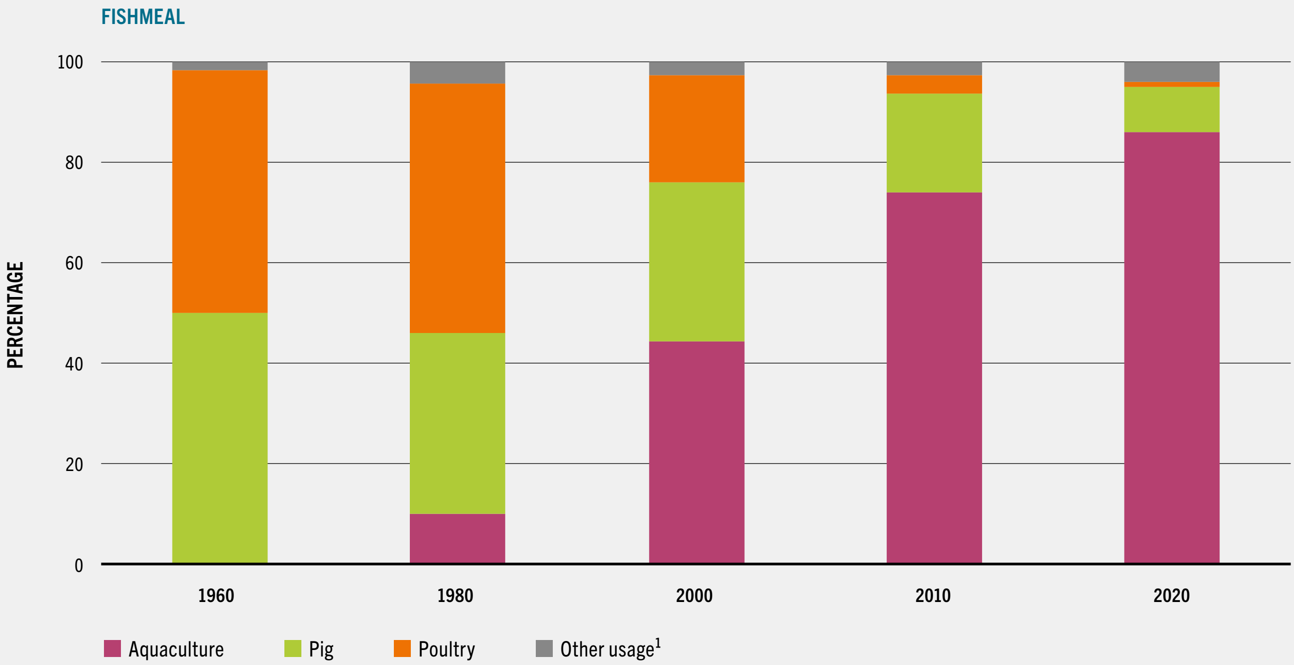
A growing share of fishmeal and fish oil is being produced using fish by-products from capture and aquaculture processing with a positive impact on waste reduction. With no major increases in raw material expected to come from whole wild fish (in particular, small pelagics), any increase in fishmeal production will need to come from fish by-products and other sources such as krill. Fishmeal from by-products has a different nutritional value, being lower in protein but richer in minerals in comparison with fishmeal obtained from whole fish. According to IFFO, in 2020, 27 percent of the global production of fishmeal and 48 percent of the total production of fish oil were obtained from by-products (IFFO, 2021; Figure 37).

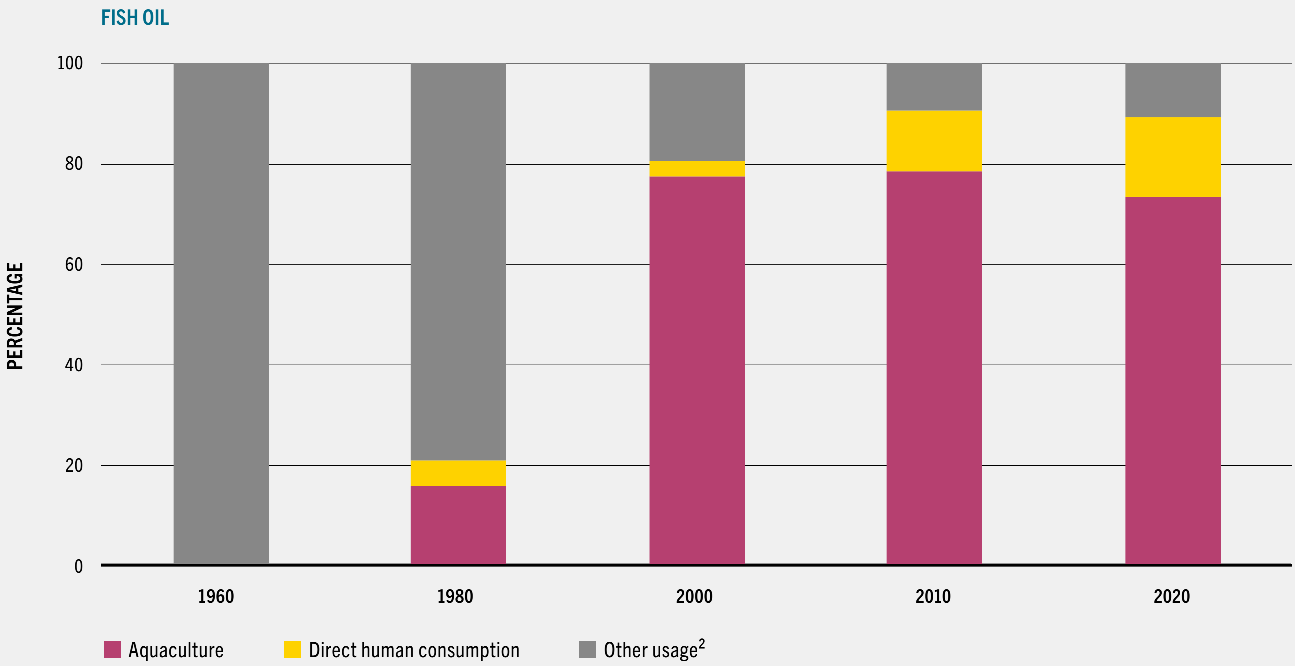
Nevertheless, fishmeal and fish oil are still considered the most nutritious and most digestible ingredients for farmed fish, as well as the major source of omega-3 fatty acids (eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) in animal diets. However, their inclusion rates in compound feeds for aquaculture have shown a clear downward trend, largely as a result of supply and price variation coupled with continuously increasing demand from the aquafeed industry. Fishmeal and fish oil are increasingly used selectively at specific stages of production, such as for hatchery, broodstock and finishing diets, and their incorporation in grower diets is decreasing. For example, their share in grower diets for farmed Atlantic salmon is now often less than 10 percent and there has been a continued reduction across all categories of species. With regard to direct human consumption, fish oil is a major natural source of the omega-3 long-chain polyunsaturated fatty acids (EPA and DHA), which perform a wide range of critical functions for human health.

Because of the fluctuations in fishmeal and fish oil production and associated price variations, many researchers are seeking alternative sources of polyunsaturated fatty acids (PUFAs). These include stocks of large marine zooplankton, such as Antarctic krill (*Euphausia superba*) and the copepod *Calanus finmarchicus*, although concerns remain over the impacts on marine food webs. Krill oil in particular is marketed as a human nutrient supplement, while krill meal is finding a niche in the production of certain aquafeeds. However, processing entails practical challenges – the fluoride content of the raw material needs to be reduced and the high cost of zooplankton products means that they cannot be included as a general oil or protein ingredient in fish feed. In addition to fish by-products, insect meals offer good potential as a protein feed input to aquafeeds (Hua *et al.*, 2019).

Fish silage, a rich protein hydrolysate that contains high amounts of essential amino acids, is a less expensive alternative to fishmeal and fish oil, and it is increasingly used as a feed additive, for example, in aquaculture and the pet-food industry. By using a technology such as fish silage, fish and parts of the fish not used as human food could easily be preserved and transformed into a valuable feed input for aquaculture (Toppe *et al.*, 2018).

FIGURE 36 UTILIZATION OF FISHMEAL AND FISH OIL





[1] Mainly pet feed.
[2] Pet food, biofuel, cooking oil in Viet Nam.
SOURCE: IFFO.

FIGURE 37 SHARE OF RAW MATERIAL UTILIZED FOR REDUCTION INTO FISHMEAL AND FISH OIL, 2020

SOURCE: IFFO.

By-product utilization

The expansion of processing of fisheries and aquaculture production has resulted in increasing quantities of by-products, which may represent up to 70 percent of processed fish, depending on the size, species and type of processing. The by-products are usually composed of heads (accounting for 9–12 percent of total fish weight), viscera (12–18 percent), skin (1–3 percent), bones (9–15 percent) and scales (about 5 percent). Historically, fish by-products were often diverted to the production of fishmeal or discarded as waste, resulting in economic losses and environmental problems. The processing of by-products often involves significant environmental and technical challenges due to the high microbial and enzyme load of the raw material and its susceptibility to rapid degradation unless processed or stored properly. Thus, timely collection and treatment of by-products is crucial for their further processing. The development of new ingredients or new products in various forms based on fish by-products provides a potentially valid alternative to increase the value added of products, avoid economic loss, reduce environmental impact, and supply consumers with nutritious, low-cost, and convenient food with a more stable shelf-life.

The fillets are the most valuable in terms of protein, but heads, frames, fillet cut-offs, belly flaps and parts of the viscera such as liver and roe are particularly good sources of nutrients such as long-chain omega-3 fatty acids, vitamins A, D and B12, as well as minerals such as iron, zinc, calcium, phosphorus and selenium. By applying processing technologies to parts of the fish traditionally not eaten, they can be converted into highly nutritious products at a low cost such as fish sausages, pâté, cakes, snacks, soups, sauces and other products for human consumption. If these products are tasty and locally acceptable, this could be an excellent opportunity to increase the nutritional impact from fisheries and aquaculture resources as well as reduce fish loss and waste.

Small fish bones with a minimum amount of meat are consumed as snacks in some countries. Furthermore, these by-products can be converted into flour and used as a flour substitute in breads, pastries, cakes and noodles to add nutrients such as protein and calcium. Gelatine made from skin and bones can be further processed into edible films and edible coatings for food applications. Fish gelatine is an alternative to bovine and porcine gelatine and can stabilize emulsions. Fish bones, in addition to providing collagen and gelatine, are also an excellent source of calcium and other minerals such as phosphorus, which can be used as feed or food supplements. Using simple low-cost technologies, fish by-products can also be converted into the above-mentioned fish silage.

In addition to their various uses in food, fish by-products are increasingly gaining attention in biotechnological and pharmaceutical applications as they offer a significant and sustainable source of high-value bio-compounds, due to the high content of collagen, enzymes, peptides, PUFAs and minerals (Coppola *et al*., 2021). Fish collagen is considered to be an alternative to collagen from bovines and pigs and has recently been recognized as a promising biomaterial with great potential in pharmaceutical and biomedical applications (Wijaya and Junianto, 2021). Enzymes and bioactive peptides can be isolated from fish viscera and can be used in a range of applications in leather, detergent, food and pharmaceutical industries, and in bioremediation processes. Fish oil contains a large quantity of long-chain PUFAs, which cannot be synthesized by the human body and provide a wide range of critical functions for human health.

By-products of crustaceans and bivalves can be used in many ways to increase their value while also addressing waste disposal issues. Chitin, a polysaccharide extracted from crustacean shell waste, is a potential source of antimicrobial substances. Its derivative, chitosan, has a wide range of applications, notably in the fields of wastewater treatment, cosmetics, toiletries, food, beverages, agrochemicals and pharmaceuticals. The shells of bivalves, such as mussels and oysters, can be turned into calcium carbonate or calcium oxide, two highly versatile chemical compounds with wide industrial applications. Shells can also be used in cosmetics and traditional medicines (pearl powder), as a calcium supplement in animal feed (shell powder), and for handicrafts and jewellery.

In addition, seaweeds are processed into food additives or food supplements and are a good source of iodine, fucoidan, fucoxanthin and phlorotannins (Cai *et al*., 2021). Seaweeds and microalgae generate socio-economic benefits for tens of thousands of households, primarily in coastal communities, making a contribution to human health, environmental benefits and ecosystem services. Generally rich in dietary fibre, micronutrients and bioactive compounds and with some species having high protein content, seaweeds are often viewed as a healthy, low-calorie food.

Aquatic food loss and waste

Despite major progress in processing, refrigeration and transportation, every year millions of tonnes of aquatic products are lost or nutritionally compromised. This does not only occur in the fisheries and aquaculture sectors, as global food loss and waste is a major issue and is the focus of Sustainable Development Goal (SDG) Target 12.3, which aims at halving wastage by 2030. In fisheries and aquaculture, it is estimated that up to 35 percent of the global fisheries and aquaculture production is either lost or wasted every year. In most regions of the world, total fish loss and waste is estimated to lie between 30 percent and 35 percent (FAO, 2011b). Wastage rates have been estimated to be highest in North America and Oceania, where about half of all aquatic animals caught are wasted at the consumption stage. In Africa and Latin America, fisheries production is mainly lost because of inadequate preservation infrastructure and expertise. Nevertheless, Latin America is the least wasteful region (under 30 percent of total production lost).

Fish losses, in quantity and quality, are driven by inefficiencies in value chains. Many developing countries – especially the least developed economies – still lack adequate infrastructure, services and know-how for adequate onboard and onshore handling and preservation. Inability to access electricity, potable water, roads, ice, cold storage and refrigerated transport represents a major handicap. Effective fish loss and waste reduction requires the application of a multidimensional and multi-stakeholder approach. Such a broad approach considers the factors affecting national capacities in loss prevention such as supportive policies and legislation as well as skills, knowledge, services, infrastructure and technology. Understanding how these different factors interact in a given context, influenced by factors related to location, species, climate and culture, is important in order to be able to design effective and sustainable solutions. This approach is promoted by the FAO Voluntary Code of Conduct for Food Loss and Waste Reduction (FAO, 2021a). It should be emphasized that reducing fish loss and waste can lead to a reduction in pressure on fishery stocks and contribute to improving resource sustainability as well as food and nutrition security.[19] ■

CONSUMPTION OF AQUATIC FOODS[20]

All aquatic food consumption statistics reported in this section are derived from FAO Food Balance Sheets (FBS) covering data from 1961. The FBS is a statistical framework, which estimates food available for human consumption (apparent consumption[20]) and not the actual quantity of food consumed (effective consumption).

Trends in aquatic food consumption[21]

Global consumption[22] of aquatic foods, excluding algae,[20] has increased significantly, with the world now consuming more than five times the quantity consumed nearly 60 years ago. In 2019, global aquatic food consumption was estimated at 158 million tonnes, up from 28 million tonnes in 1961.[23] Consumption increased at an average annual rate of 3.0 percent from 1961, compared with a population growth rate of 1.6 percent (Figure 38). Per capita consumption was influenced most strongly by increased supplies, changing consumer preferences, advancements in technology and income growth.

Of the 158 million tonnes of aquatic foods available for human consumption in 2019, Asia accounted for 72 percent of the total while its population represented 60 percent of the world population (Figure 39). As a comparison, in 1961, Asia consumed 48 percent of all aquatic foods available for food consumption. In parallel, the proportion of aquatic foods consumed in Europe and the United States of America decreased over time. The respective shares of Europe and the United States of America went from 32 percent and 9 percent in 1961 to 10 percent and 5 percent in 2019. The growing importance of Asian countries as consumers of aquatic products[20] is the result of a combination of factors. First, Asia became the main producer of aquatic products in 1993, mainly thanks to the development of aquaculture production. Second, the continent experienced significant economic growth in recent decades, which resulted in income growth, a larger middle class and the migration of rural populations to the cities where aquatic foods are more accessible. Finally, higher imports and a diversion of some exports towards the Chinese domestic market increased the diversity of aquatic foods available to Chinese consumers, further boosting their consumption.

Over the years, half or more of the aquatic food produced has been consumed by only a small number of countries. In 1961, the five largest consuming countries of aquatic foods (Japan, the former Union of Soviet Socialist Republics, China, the United States of America and the United Kingdom of Great Britain and Northern Ireland) accounted for half of global consumption. However, in 2019, the share of the five largest consuming countries (China, Indonesia, India, the United States of America and Japan) rose to 59 percent. This concentration reflects the emergence of major players such as China, which on its own, consumed 36 percent of all aquatic foods available for food consumption in 2019.

19 Food loss and waste (FLW) refers to the decrease in the quantity or quality of food. A reduction in quality usually leads to a reduction in nutritional value, economic value, or food safety issues (FAO, 2017a). Food waste is part of food loss. It occurs along the entire food supply chain and is the result of decisions and actions by primary producers, retailers, food service providers and consumers. An example of "waste" in fisheries is "discards", whereby captured aquatic species are thrown away at sea. Information on the food loss and waste in value chains of aquatic products can be found on an FAO web page devoted to this topic (FAO, 2020b).

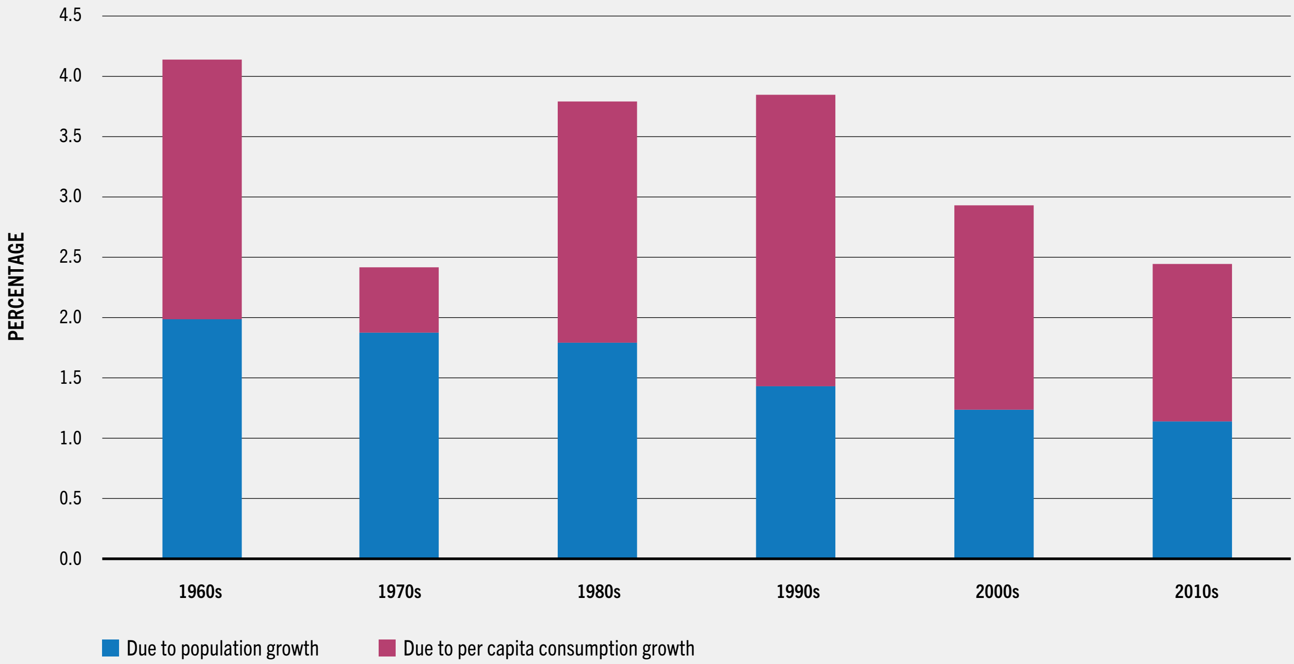
20 For algae, apparent consumption, aquatic foods and aquatic products, see Glossary, including Context of SOFIA 2022.

21 Consumption data for 2019 should be considered preliminary. These values could differ slightly from those to be released in the FBS section of the *FAO Yearbook of Fishery and Aquaculture Statistics 2020*, and in the FishStatJ workspace to be disseminated in late 2022. For the updated data, access: www.fao.org/fishery/en/statistics

22 All aquatic food consumption statistics reported in this section refer to apparent consumption.

23 Aquatic food consumption data are expressed in live weight equivalent.

FIGURE 38 AVERAGE ANNUAL GROWTH IN AQUATIC FOOD CONSUMPTION



SOURCE: FAO.

Per capita consumption of aquatic foods

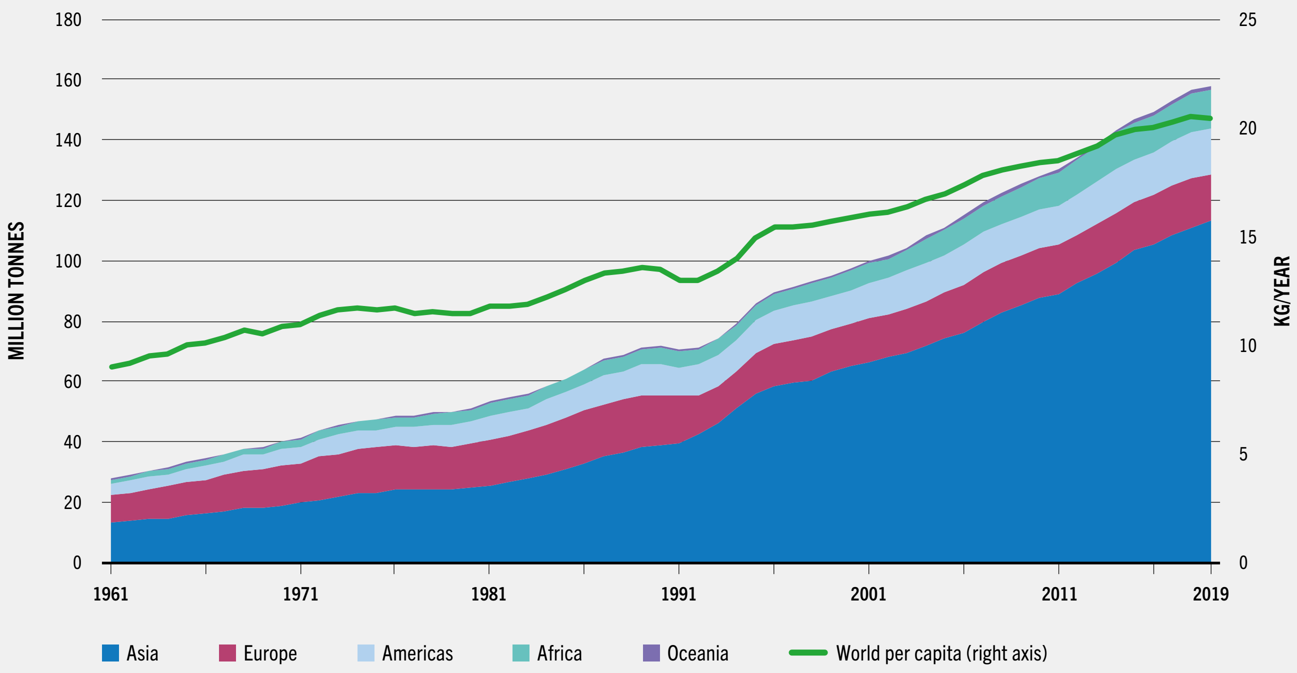
Global annual per capita consumption of aquatic foods grew from an average of 9.9 kg in the 1960s to 11.4 kg in the 1970s, 12.5 kg in the 1980s, 14.4 kg in the 1990s, 17.0 kg in the 2000s and 19.6 kg in the 2010s, with a record high of 20.5 kg in 2019. Preliminary estimates point to a lower consumption (20.2 kg) in 2020 due to a contraction of demand, followed by a slight increase in 2021.

Despite a few exceptions, of which the most notable is Japan, most countries saw a rise in their aquatic food consumption per capita during the period 1961–2019. However, the rate of change across countries was highly variable with upper-middle-income countries experiencing the strongest annual growth (3.2 percent). Among these, China was the main driver for growth also due to its major expansion in fisheries and aquaculture production[24] and increase in population. In 2019, China's population accounted for 56 percent of the total population of all upper-middle-income countries. In China, per capita consumption grew from 4.2 kg in 1961 to 40.1 kg in 2019. Lower-middle-income countries experienced slower annual growth (1.9 percent), but this was still higher than high-income countries (0.5 percent). The moderate growth observed in high-income countries mainly reflects already high levels of consumption of aquatic foods. Low-income countries experienced a negative growth, decreasing by 0.2 percent per year over the period 1961–2019.

In addition to a high variability in the growth rates, huge differences exist in aquatic food consumption per capita among countries. The quantities consumed vary between countries,

24 For fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

FIGURE 39 AQUATIC FOOD CONSUMPTION BY CONTINENT, 1961–2019

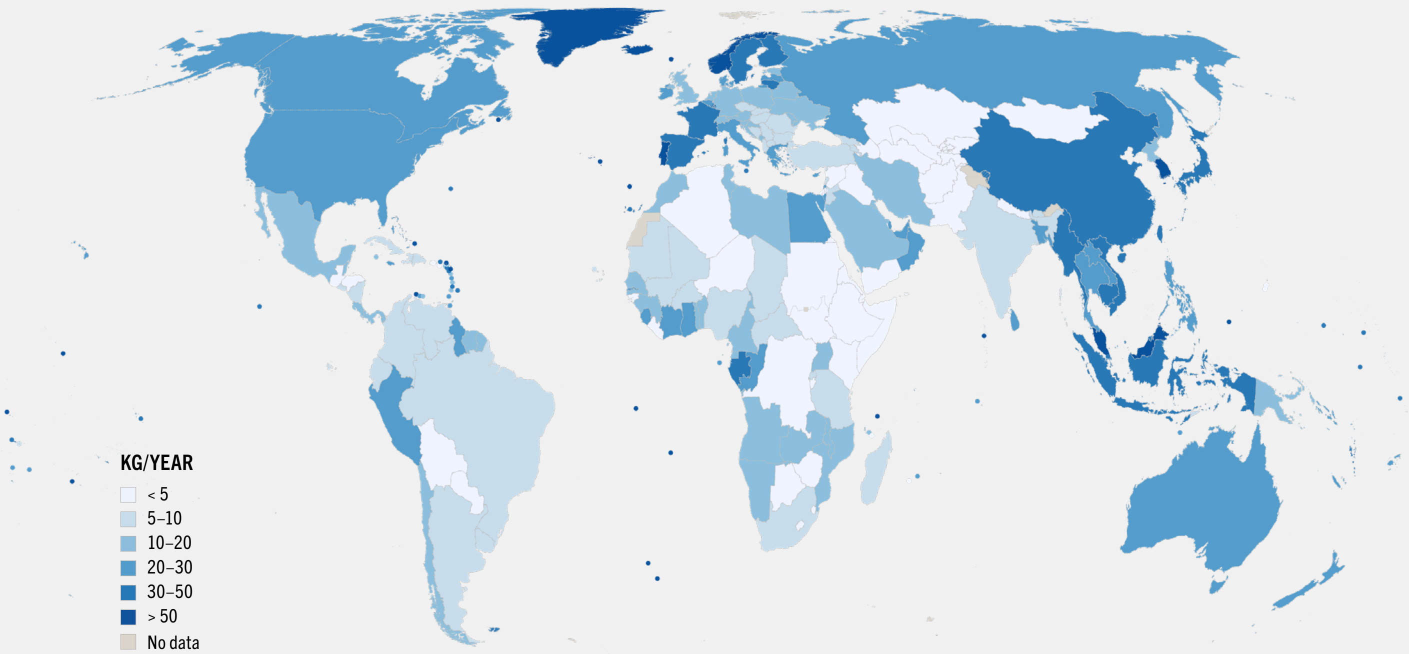


NOTE: Data in million tonnes expressed in live weight equivalent.
SOURCE: FAO.

reflecting the different levels of availability of both aquatic and other foods (including proximity and access to aquaculture facilities, fish landings and markets), as well as differences in price, income level, nutrition consciousness, food traditions and consumer preferences. It is important to note that differences also exist within countries, with higher consumption levels generally occurring in coastal areas. In 2019, of the 227 countries for which FAO estimated the per capita consumption of aquatic foods, 133 countries were below the world average and 94 countries above. In terms of population, those countries consuming less than the world average accounted for 54 percent of the world population in 2019. The countries where consumption is highest include Iceland, the Faroe Islands and Maldives, which consume over 80 kg of aquatic foods per capita per year (Figure 40). This is in stark contrast to countries consuming under 1 kg per capita per year, such as Afghanistan, Tajikistan and Ethiopia. In 2019, the world average per capita consumption was 20.5 kg. This varied from an average of 5.4 kg in low-income countries, to 15.2 kg in lower-middle-income countries, 28.1 kg in upper-middle-income countries and 26.5 kg in high-income countries (Table 14). However, if China is not included, the average consumption of upper-middle-income countries drops to 13.0 kg per capita.

Striking differences also exist by continent. Asia had the highest consumption of aquatic foods in 2019, with 24.5 kg per capita. Oceania followed with 23.1 kg, then Europe (21.4 kg), the Americas (14.5 kg) and Africa (10.1 kg). However, it should be stressed that actual values may be higher than indicated by official statistics, in view of the under-recorded contribution of subsistence fisheries, small-scale fisheries and informal cross-border trade. This could be particularly relevant for Africa and some countries in Asia.

FIGURE 40 APPARENT AQUATIC FOOD CONSUMPTION PER CAPITA, AVERAGE 2017–2019



The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

SOURCE: FAO.

Aquatic food consumption habits vary across Africa. Despite a low average consumption of aquatic foods in Africa, eleven countries had a higher consumption than the world average. These include some small island developing States (SIDS) in addition to Gabon, Congo, the Gambia, Sierra Leone, Ghana, Egypt and Côte d'Ivoire. For the remaining African countries, the relatively low consumption of aquatic foods is for a variety of reasons. These include: high population growth, which in most cases outpaces the growth of capture fisheries production; the relatively small aquaculture sector, which reduces the potential for increasing production in the near future; poor landing, road and market infrastructures, which limit the movement of good quality aquatic products across borders within the continent; and high post-harvest losses due to underdeveloped cold chains. Moreover, as described in the section Fisheries and aquaculture projections (p. 211), the situation is expected to worsen in Africa, with consumption per capita projected to decline in the next ten years. Were this to occur, it would represent a serious threat in terms of food security given the high prevalence of undernourishment in the region and the key role played by aquatic foods in terms of contribution to total intake of animal proteins across many African countries.

TABLE 14 TOTAL AND PER CAPITA APPARENT CONSUMPTION OF AQUATIC FOODS BY REGION AND ECONOMIC CLASS, 2019

Region/economic class	Total aquatic food consumption *(million tonnes, live weight equivalent)*	Per capita aquatic food consumption *(kg/capita/year)*
World	**157.7**	**20.5**
World, excluding China	100.3	16.0
Africa	**13.1**	**10.0**
Americas	**14.8**	**14.6**
North America	8.3	22.7
Latin America and the Caribbean	6.4	9.9
Asia	**113.1**	**24.6**
Europe	**15.8**	**21.1**
Oceania	**1.0**	**23.2**
High-income countries	**32.0**	**26.5**
Upper-middle-income countries	**72.2**	**28.1**
Lower-middle-income countries	**50.0**	**15.2**
Low-income countries	**3.5**	**5.4**

NOTE: Data are preliminary.
SOURCE: FAO.

Nutritional and environmental benefits of aquatic food consumption

Aquatic foods are important for a healthy and balanced diet (Box 7). Even small quantities of aquatic foods can have a significant positive nutritional impact by providing essential nutrients that are scarce in plant-based diets. Aquatic foods provide high-quality proteins and essential amino acids, vitamins (particularly A, B and D), phosphorus, and minerals such as iron, calcium, zinc, iodine, magnesium, potassium and selenium, and are a primary dietary source of heart-healthy omega-3 fatty acids. Depending on the species, aquatic foods can provide varying levels of nutrients. The most significant difference is fat content: species such as sardines, salmon and tuna are considered fatty, while cod and catfish are lean. The two omega-3 fatty acids found in aquatic species are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). The human body does not produce omega-3 fatty acids so they must be sourced through food. Omega-3 fatty acids are found in every kind of aquatic food, but are especially high in fatty species. Regular consumption of aquatic food helps maintain a healthy heart by lowering blood pressure and reduces the risk of stroke, depression, Alzheimer's disease, and other chronic conditions. Controlled trials and observational studies demonstrated that the omega-3 fatty acids in aquatic food are important for optimal development of a baby's brain and nervous system, and that the children of women who consume lower amounts of aquatic food or omega-3s during pregnancy and breastfeeding have evidence of delayed brain development.

Many non-high-income countries, including some SIDS, rely on subsistence fishing as a key source of food. Kiribati is a good example: the country is a SIDS yet has one of the highest levels of per capita consumption of aquatic foods worldwide. For these countries, proteins sourced from aquatic foods are essential in the diet, particularly when the total protein intake is low.

In addition, the share of proteins from aquatic foods in the diet of non-high-income

BOX 7 KEY FINDINGS OF REPORT ON ROLE OF AQUATIC FOODS IN NUTRITION

Current food systems often fail to deliver affordable, nutritious foods in an equitable manner and the cost of a healthy diet remains unaffordable for many people. While food system discourses often centre on terrestrial foods, as they supply most of the food consumed globally,[1] there is an increasing focus on aquatic foods for their unique role in providing essential fatty acids and micronutrients such as iron, zinc, calcium, iodine and vitamins A, B12 and D. Following calls for more environmentally sustainable diets,[2] "moderate" consumption of fish and other aquatic foods[1] was promoted as part of a sustainable healthy diet. At the same time, despite recognition of the importance of healthy diets that are environmentally, economically and socially sustainable, there is as yet no robust and well-defined narrative for "sustainable healthy diet". The UN Nutrition Discussion Paper, *The role of aquatic foods in sustainable healthy diets*,[3] aimed to partly fill the gap by presenting evidence to inform and steer policy, investments and research to leverage on the potential of aquatic foods in delivering sustainable healthy diets and supporting achievement of the Sustainable Development Goals (SDGs).

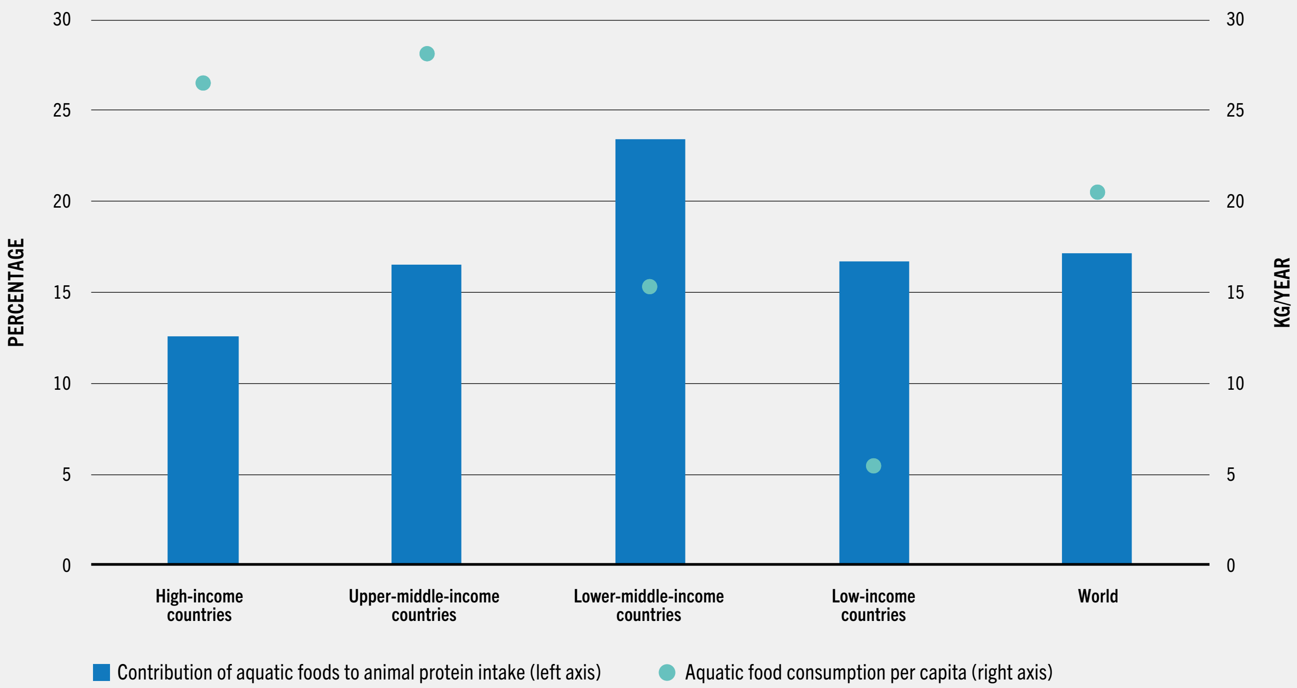
The paper highlighted that many studies have narrowly focused on a limited number of economically valuable finfish species, while the broader nutritional and cultural value of diverse aquatic foods is often not taken into account. Diverse aquatic foods – including animals, seaweed and microorganisms farmed in and harvested from water, as well as cell- and plant-based foods emerging from new food technologies – have an essential role in ensuring food and nutrition security, while providing livelihood benefits to people around the world. Aquatic foods hold the potential for a major contribution to global food security and nutrition, transitioning towards diets that are socially, economically and environmentally sustainable. Moderate consumption does not necessarily increase the negative environmental impacts of production, if supplied and consumed following the recommendations in the UN Nutrition paper. Aquatic foods can be part of the solution to building resilient food systems and healthy diets for all, given that they are available, accessible, affordable and acceptable. The UN Nutrition paper recommends to policymakers and other stakeholders to promote diversified consumption of aquatic foods through nutrition strategies and interventions, ensuring equitable and sustainable supply and production of aquatic foods, and democratizing knowledge, data and technologies to create meaningful knowledge and applicable innovations. Promoting changes in consumer behaviour and demand for more diverse and low-trophic aquatic foods will also play a role in putting aquatic foods on the table.

[1] FAO. 2022. FAOSTAT: Food Balances (2010-). In: *FAO*. Rome. Cited 14 April 2022. www.fao.org/faostat/en/#data/FBS
[2] Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T. *et al.* 2019. Food in the Anthropocene: The EAT–*Lancet* Commission on healthy diets from sustainable food systems. *The Lancet*, 393(10170): 447–492. www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(18)31788-4.pdf?utm_campaign=tleat19&utm_source=HubPage
[3] UN Nutrition. 2021. *The role of aquatic foods in sustainable healthy diets*. Discussion Paper. www.unnutrition.org/wp-content/uploads/FINAL-UN-Nutrition-Aquatic-foods-Paper_EN_.pdf

countries tends to be greater than in the diet of high-income countries (Figure 41). This reflects the fact that aquatic foods often represent an affordable source of animal protein, cheaper and more accessible than other animal protein sources, highly preferred and part of culinary traditions. Figure 41 also illustrates the mismatch between the per capita levels of aquatic food consumption and their relative contribution to animal protein intake. In 2019, aquatic food consumption per capita was much lower in low-income countries than in high-income countries. However, aquatic foods contributed to a greater share of animal protein intake in low-income countries than in high-income countries.

Globally, aquatic foods provided about 17 percent of animal proteins and 7 percent of all proteins in 2019 (Figure 42). In the same year in low-income countries, they provided 17 percent of animal proteins, in lower-middle-income

FIGURE 41 AQUATIC FOOD CONSUMPTION AND CONTRIBUTION TO ANIMAL PROTEIN INTAKE BY ECONOMIC CLASS, 2019



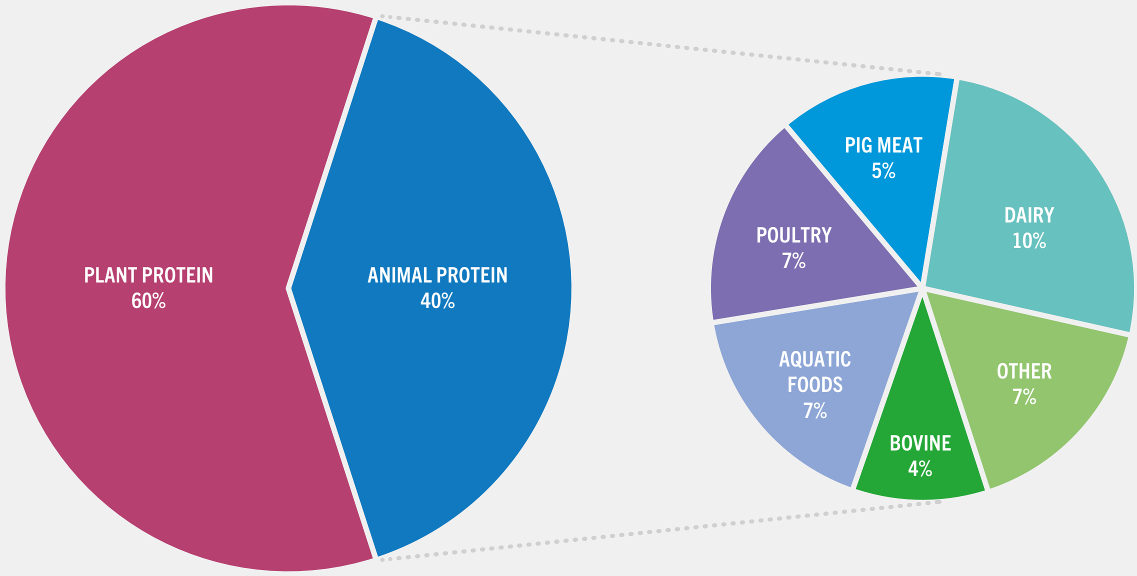
SOURCE: FAO.

countries 23 percent, in upper-middle-income countries 17 percent and in high-income countries 13 percent. Moreover, for 3.3 billion people, aquatic foods provided at least 20 percent of the average per capita intake of animal protein (Figure 43). In Cambodia, Sierra Leone, Bangladesh, Indonesia, Ghana, Mozambique and some SIDS, aquatic foods contributed 50 percent or more of total animal protein intake.

Trade and access to aquatic foods

As indicated above, geography plays a major role in explaining the differences in the levels of consumption of aquatic foods across countries. However, international trade contributed to reduce the impact of geographical location and limited domestic production, by allowing many countries to access larger quantities and wider diversity of aquatic foods that were not available domestically. Globally, the share of import volumes in total consumption of aquatic foods rose from 16 percent in 1961 to 32 percent in 2019. The reliance on imports is higher in richer countries where the supply chain infrastructures allow transportation of aquatic products in good condition and where consumers can afford species, particularly high-value ones, not locally produced. In the United States of America, for example, the share of imports in total consumption of aquatic foods rose from one-third in 1961 to nearly three-quarters in 2019. In contrast, in low-income countries, consumption of aquatic foods is mainly based on domestic production. For example, in Uganda, imports of aquatic products accounted for only 1 percent of total consumption of aquatic foods in 2019. The bulk of its supply is sourced from domestic production, mainly from freshwater sardines, perches and tilapias fished or farmed in Lake Victoria.

FIGURE 42 CONTRIBUTION OF PLANT AND ANIMAL PROTEINS TO GLOBAL AVERAGE DAILY PROTEIN INTAKE, 2019



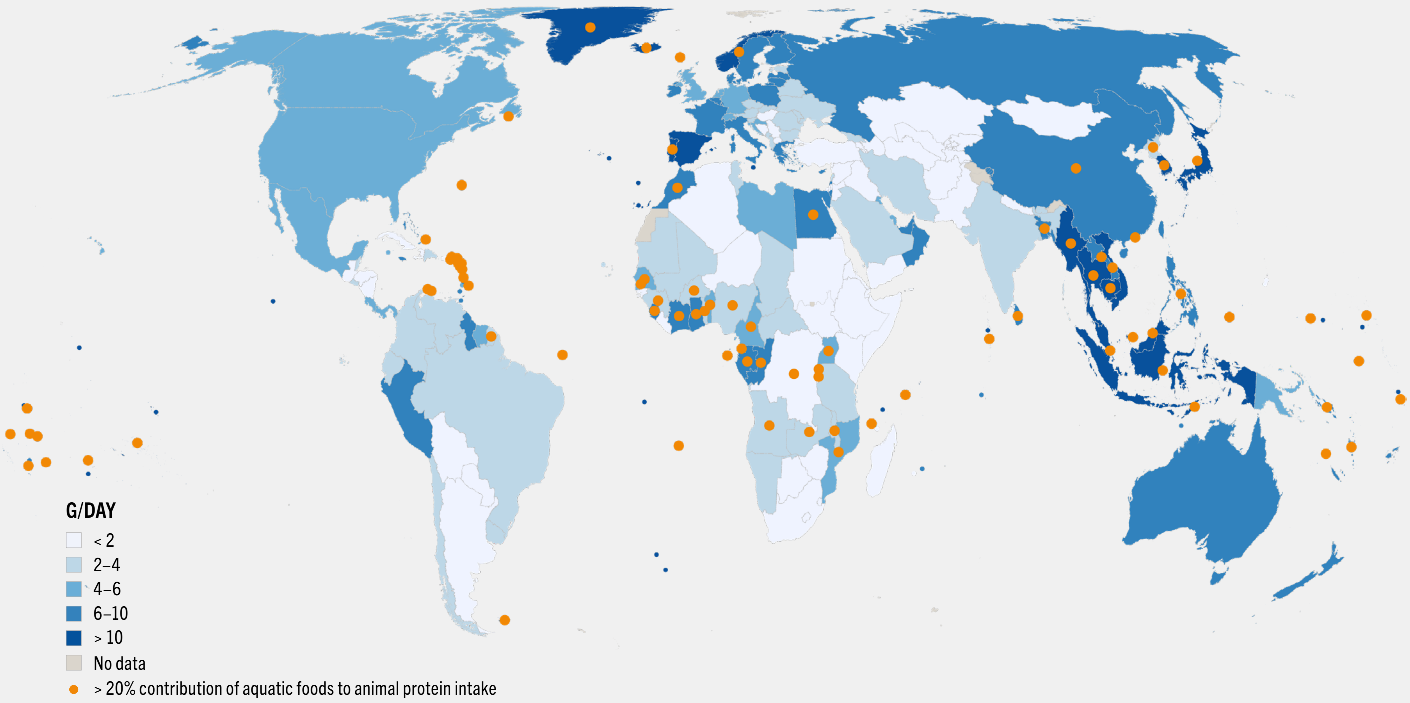
SOURCE: FAO.

From wild to farmed

The increase in aquatic food consumption has been mainly made possible by a significant rise in aquaculture production, while capture fisheries production has been rather stagnant since the end of the 1990s. The proportion of aquatic foods originating from aquaculture production rose from 6 percent in the 1960s to 50 percent in the 2010s. Preliminary estimates for 2020 indicate that this share further increased to 56 percent (Figure 44). It is also important to mention that these figures do not refer to the quantity effectively eaten, but to the food available to be consumed. Furthermore, taking into account only the edible amount (i.e. excluding shells and other inedible parts – noting that "inedible" varies among cultures), it is likely that capture fisheries are still the main source of aquatic foods eaten. This is due to the predominance of aquaculture in the production of bivalves and crustaceans, which comprise a relatively large proportion of inedible parts. However, the gap is narrowing. Once again, strong differences exist across countries with a higher share of farmed species being consumed by Asian countries, the main producers. Moreover, projections foresee an increase in the importance of farmed aquatic animals in global aquatic food consumption in the future (see the section Fisheries and aquaculture projections, p. 211). The significant rise in aquaculture production resulted in increased availability and a decline in prices, particularly for the species that became predominantly farmed rather than wild-caught. As a result, aquaculture contributed to increased food security in several developing countries, particularly in Asia, by making available for domestic consumption large volumes of some low-value freshwater species.

However, the rise in aquaculture production has not been homogenous across all species, with some species being easier to farm than others. In addition, the aquaculture sector is able to adapt more rapidly and efficiently to changing consumer preferences, as aquaculture producers have greater control over their production than

FIGURE 43 CONTRIBUTION OF AQUATIC FOODS TO ANIMAL PROTEIN SUPPLY PER CAPITA, AVERAGE 2017–2019



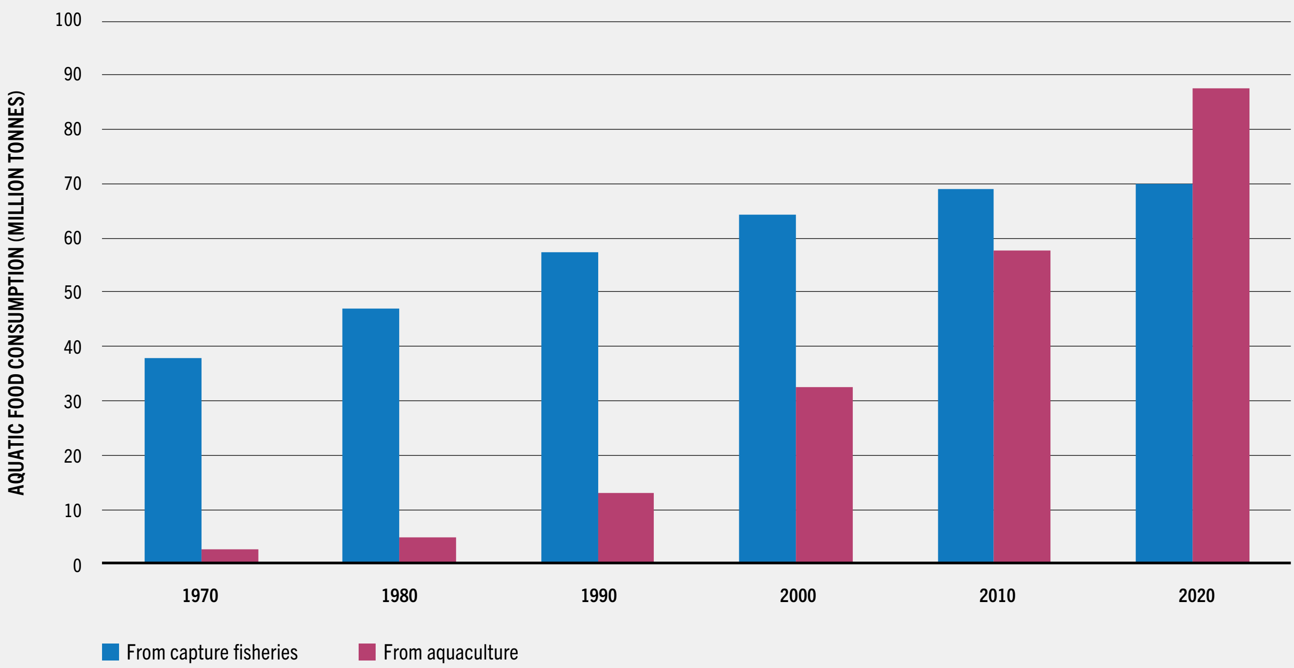
The designations employed and the presentation of material on this map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

SOURCE: FAO.

capture fisheries producers do. As a result, the species composition of global aquatic food consumption evolved significantly over time. The consumption of crustaceans used to be mainly concentrated in high-income countries due to their high price. However, thanks to a rise in the production of farmed shrimps and prawns and a fall in their price, the availability of crustaceans increased over fivefold, from 0.4 kg to 2.2 kg between 1961 and 2019. A similar trend was observed for molluscs (excluding cephalopods) whose consumption per capita rose from 0.6 kg in 1961 to 2.5 kg in 2019. Freshwater and diadromous fish saw the strongest growth in per capita consumption, increasing more than fivefold from 1.5 kg in 1961 to 8.2 kg in 2019. This reflected both the Asian appetite for some freshwater species and the strong demand for salmon and trout, particularly in Europe and North America, as well as tilapia in different countries. The demersal and pelagic fish groups did not show such strong variations, with their share in average world consumption stabilizing at about 2.7 kg and 3.0 kg per capita, respectively.

In 2019, of the 20.5 kg of per capita consumption, nearly 75 percent came from finfish and the remainder came from shellfish. Freshwater and diadromous species accounted for 40 percent of the aquatic food consumption per capita. Marine finfish species provided another 33 percent, of which 15 percent were pelagic

FIGURE 44 RELATIVE CONTRIBUTIONS OF AQUACULTURE AND CAPTURE FISHERIES TO AQUATIC FOODS AVAILABLE FOR HUMAN CONSUMPTION



NOTE: Data expressed in live weight equivalent.
SOURCE: FAO.

species, 13 percent were demersal species and 5 percent were unidentified marine fish. The remainder of the per capita consumption was composed of shellfish, of which 12 percent were molluscs (excluding cephalopods), 11 percent crustaceans and 2 percent cephalopods.

Demand for healthy and convenience food

Significant societal changes have influenced consumers' decisions, particularly in affluent economies. Healthy eating has become a dominant trend in food consumption in a context of rising numbers of overweight people and obesity-related diseases in many countries. As a result, demand for healthy and nutritious foods, such as aquatic foods, has increased in recent years. Furthermore, this has been accompanied by increasing attention of consumers and major distributors to the sustainability of aquatic food systems, in particular its environmental and social dimensions. As a result, producers and retailers rely on a range of certification schemes and labelling to meet consumer demand for sustainable aquatic food.

Besides healthy and sustainable aquatic products, consumers also want convenience, particularly in more advanced economies. Societal changes, including higher incomes, greater female participation in the workforce, urbanization, and decreasing family sizes, have increased the use of convenient food products. These products are pre-prepared and packaged commercially, requiring minimum preparation at home or by the food service industry, and are easy to order and deliver using online platforms. The widespread use of smartphones and mobile applications has made online ordering, home delivery, and click and collect more popular. Lockdowns and physical distancing requirements in the early stages of the COVID-19 pandemic gave a further boost to this trend. While exporters suffered from market and trade disruptions at the beginning of the pandemic, small and local suppliers of fisheries and aquaculture products thrived, highlighting the importance and resilience of local food systems.

Algae

Currently, seaweeds and other algae are not included in the FAO Food Balance Sheets for aquatic foods, reflecting the lack of available data collected on seaweeds and their uses in most countries. While seaweeds have for centuries formed part of the daily diet of some countries, particularly in East Asia, they are still underexplored as food in most countries. Seaweeds are considered a healthy, nutritive and low-calorie food. While the nutritional composition of seaweeds varies among species, seaweeds are generally low in fat and include a range of essential nutrients, such as omega-3 and omega-6 polyunsaturated fatty acids, vitamins (A, C, E and B12), iodine, dietary fibre and antioxidants. Besides being valuable from a nutritional point of view, seaweed consumption is associated with several health benefits, such as lowering blood pressure and preventing strokes (Fitzgerald *et al.*, 2011). In a context of a growing world population and environmental challenges, seaweed is also one of the several sustainable opportunities that can contribute to global food security, either as food or as feed including for aquaculture (Cai *et al.*, 2021). Seaweed can be farmed in seawater, thus not competing with arable land and freshwater. ■

TRADE OF FISHERIES AND AQUACULTURE PRODUCTS[25, 26]

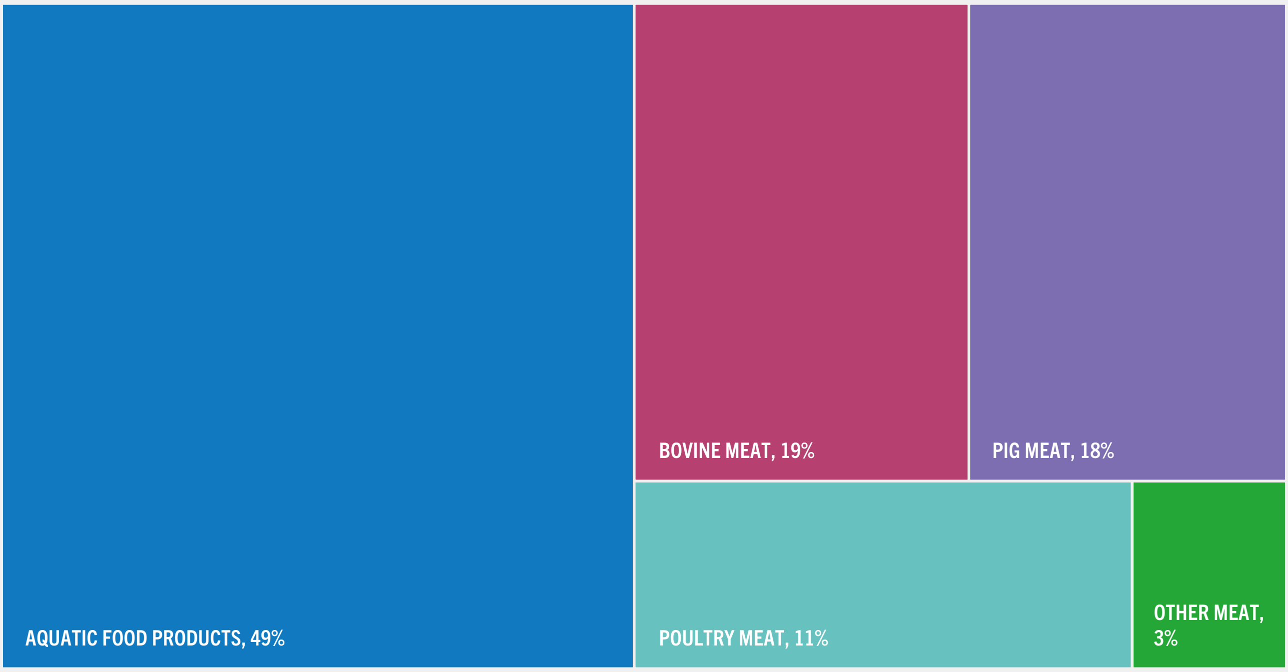
International trade of aquatic products[25] has grown significantly during recent decades, expanding over continents and regions. This expansion has been driven to a large extent by economic growth and cultural and technological advancement associated with globalization. Liberal trade policies, as well as logistical and technological innovations enabling globalized communications, have fostered economic interdependence and accelerated cultural dissemination, including food habits, across borders. Producers have been able to access increasingly distant markets, while consumers have seen their aquatic food options greatly diversified beyond the species caught or farmed in local waters. At the same time, income growth, a larger middle class and urbanization, particularly in low- and middle-income countries, have caused aggregate demand for traded aquatic food products to increase considerably. Today, trade in aquatic products plays an important role as a generator of export revenue, employment and value addition, and as a contributor to global food security, involving diverse and interlinked actors in shipping, processing, wholesale and retail. This is highly significant for several small island developing States where exports of aquatic products comprise a large proportion of the total value of merchandise trade and of total gross domestic product (GDP).

In 2020, 225 states and territories reported some trading activity of fisheries and aquaculture products. World exports of aquatic products, excluding algae,[25] totalled 59.8 million tonnes live

25 For algae, aquatic products, and fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

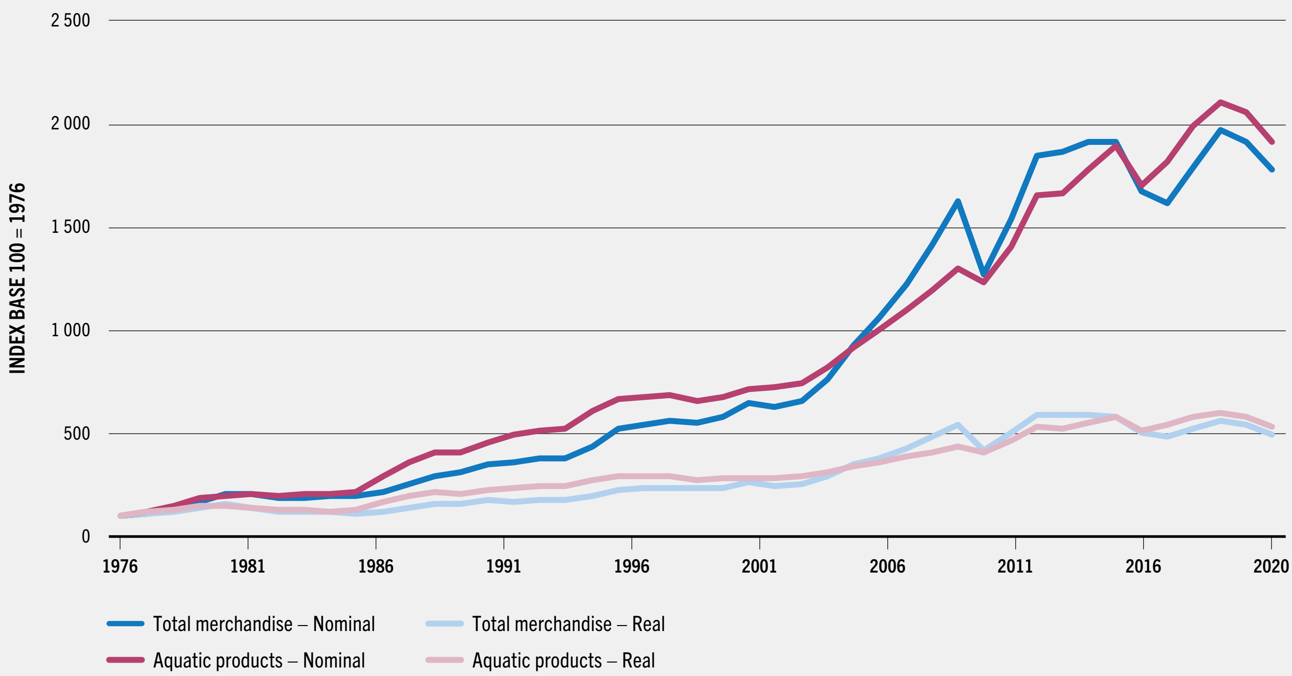
26 The trade statistical analysis is carried out separately for aquatic animals and algae, and other aquatic products.

FIGURE 45 GLOBAL EXPORT VALUE OF AQUATIC FOOD PRODUCTS AND TERRESTRIAL MEATS, 2020



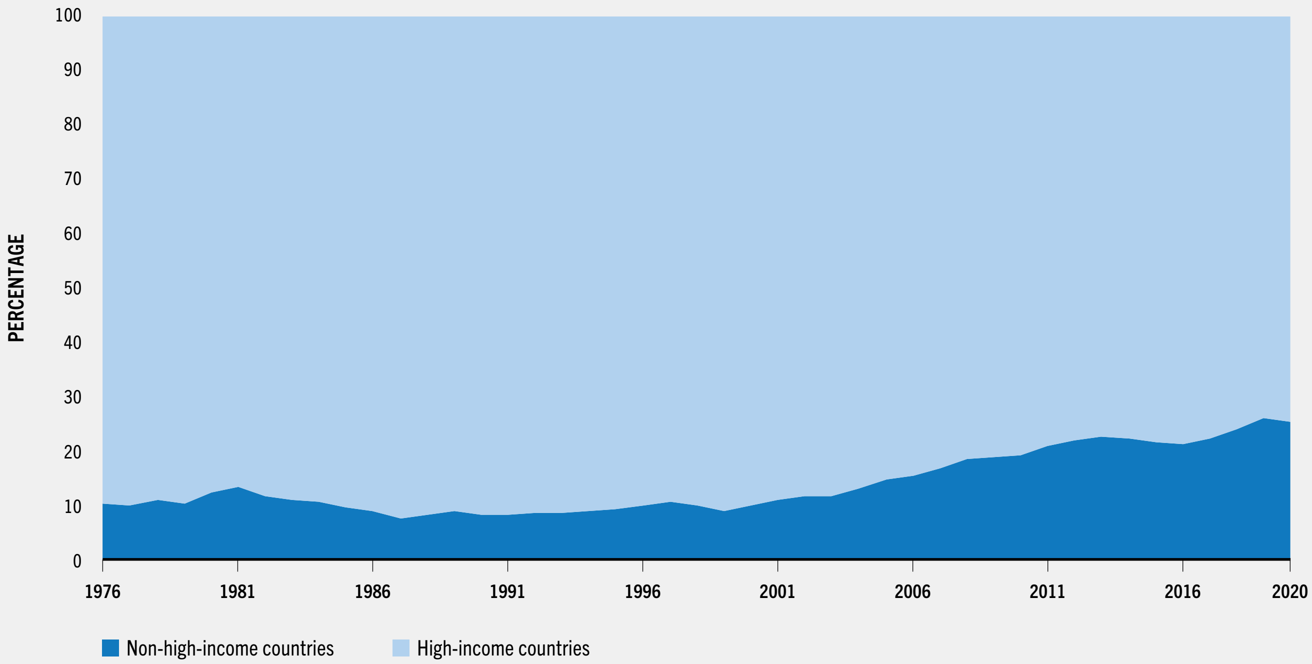
NOTES: Excluding algae.
SOURCE: FAO.

FIGURE 46 WORLD MERCHANDISE AND AQUATIC PRODUCT[1] EXPORT VALUE, FIXED-BASE INDICES (1976 = 100), 1976–2020



[1] Excluding algae.
SOURCE: FAO.

FIGURE 47 PERCENTAGE OF GLOBAL VALUE OF IMPORTS OF AQUATIC PRODUCTS[1] BY ECONOMIC CLASS, 1976–2020



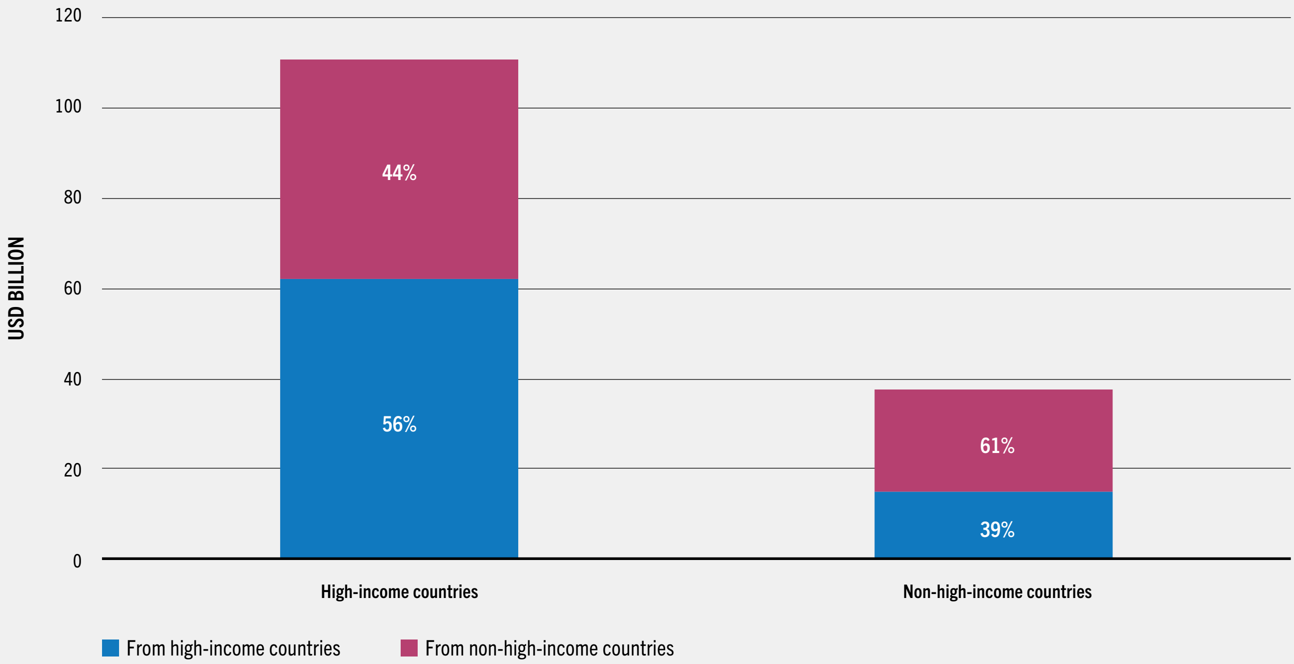
[1] Excluding algae.
SOURCE: FAO.

weight, worth USD 151 billion.[27] This represents the second consecutive decline, down from the record high of USD 165 billion reached in 2018. It is important to note that this figure covers trade in products only, meaning it does not capture the extent of trade in fisheries and aquaculture services, such as consulting, quality control, certification and labelling, trade promotion and marketing, maintenance and repair. The overall value generated by these services is not known, as it is usually recorded together with the value of services related to other activities. The value of traded aquatic products accounted for 11 percent of total agricultural trade (excluding forestry) and for about 1 percent of total merchandise trade in 2020. These shares are much higher in many countries, exceeding 40 percent of the total value of merchandise trade in Cabo Verde, Iceland, Kiribati or Maldives, for example. In 2020, the value of trade in aquatic food products was comparable to the total value of trade in all terrestrial meats (Figure 45). From 1976 to 2020, the value of trade in aquatic products increased at an average annual rate of 6.9 percent[28] in nominal terms and 3.9 percent in real terms. The nominal value of exports of aquatic products was nearly 20 times higher in 2020 compared with 1976 (Figure 46). This is comparable to the expansion of the value of global merchandise trade, which increased at a rate of 6.8 percent per year in nominal terms between 1976 and 2020, and by 3.7 percent in real terms (World Trade Organization, 2022). Meanwhile, the total quantity of aquatic products exported has increased at an average rate of 2.9 percent per year (live weight equivalent). The faster rate of growth in the value of trade of aquatic products relative to the quantity reflects the increasing proportion of trade volumes comprising high-value species and products undergoing processing or other forms of value addition. Other contributors include inflation and growth in demand, leading to price increases in the long term.

27 Trade data for 2020 should be considered preliminary as it refers to the information available as at March 2022. These values could differ slightly from those to be released in the Trade section of the FAO Yearbook of Fishery and Aquaculture Statistics 2020, and in the FishStatJ workspace to be disseminated in late 2022. The updated data will be available through the FAO website, available at: www.fao.org/fishery/en/statistics

28 Annual growth figures are expressed as a constant annual growth rate.

FIGURE 48 GLOBAL AQUATIC IMPORTS BETWEEN HIGH-INCOME COUNTRIES AND NON-HIGH-INCOME COUNTRIES BY VALUE, 2020



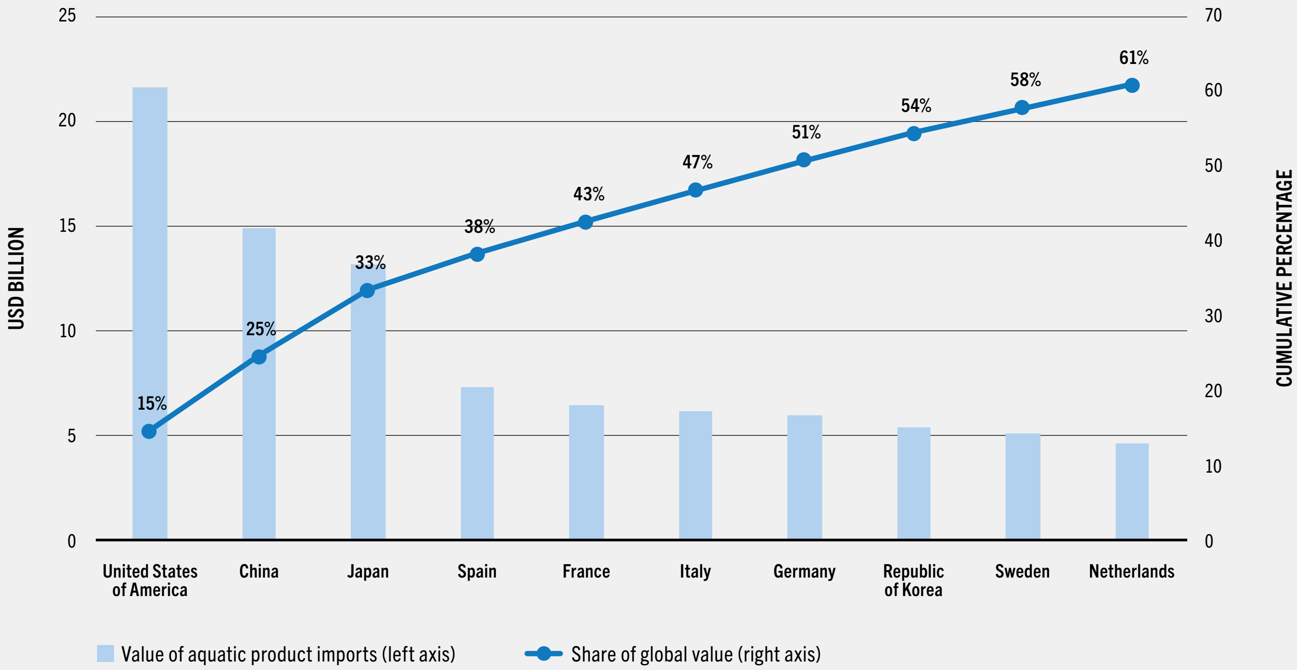
NOTES: Excluding algae.The "high from non-high" series shows the proportion of global aquatic imports that correspond to imports of high-income countries from non-high-income countries. The other series show similar flows within and across these country groups.
SOURCE: FAO.

In the last decade, several of the key trends characterizing the development of trade in aquatic products since the 1970s have either slowed or reversed. Growth rates in both value and volume have slowed, in absolute and per capita terms. This mirrors slower growth in global trade in general and marks a new phase of maturing global markets in which most aquatic products are traded along well-established routes between long-term trading partners, with relatively limited opportunities for new markets. In parallel, many aquatic food producers in non-high-income countries who have traditionally supplied markets in high-income countries are increasingly supplying a rising domestic demand.

Historically, an important feature of trade flows in aquatic products has been the role of non-high-income nations as suppliers to high-income countries. More developed economies have large populations of urbanized middle class with high levels of disposable income and insufficient domestic supply. This has historically meant that high-income countries have accounted for a large share of world imports of aquatic products (Figure 47). In 1976, high-income countries accounted for 90 percent of the global value of aquatic product imports. In contrast, in 2020, the share of high-income countries in the global value of aquatic product imports was 75 percent. This rise in the share of non-high-income countries reflects the fact that demand has increased at a faster rate in these countries than in high-income countries. This has been particularly true in East and Southeast Asian countries where the urbanized middle class has been expanding rapidly. Looking at the origin of imports in 2020, 56 percent of the value of imports of high-income countries originated from high-income countries (Figure 48), while 39 percent of the value of imports of non-high-income countries originated from high-income countries.

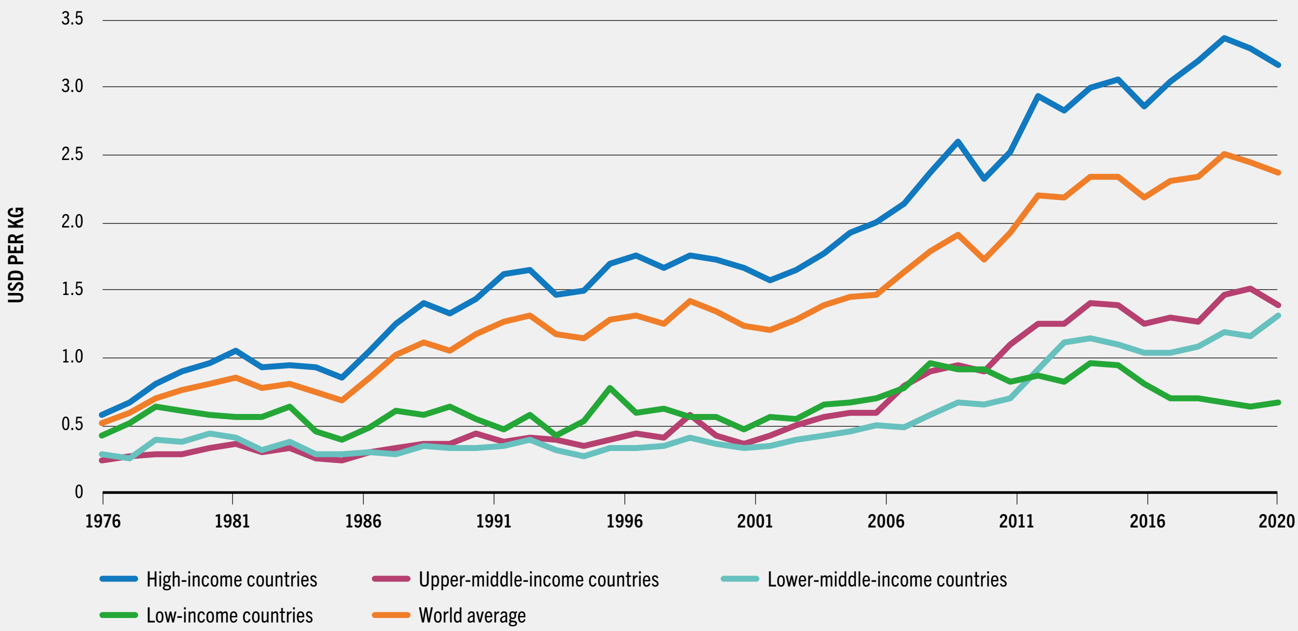
The European Union was the largest single market, accounting for 34 percent (and 16 percent, excluding intra-European Union trade) of the global value of aquatic imports in 2020. In terms of individual countries, the largest importing country in 2020 was the United States of America, accounting for 15 percent of world import value of aquatic products (Figure 49), followed by China (10 percent), Japan (9 percent), Spain

FIGURE 49 TOP TEN IMPORTING COUNTRIES OF AQUATIC PRODUCTS[1] BY VALUE, 2020



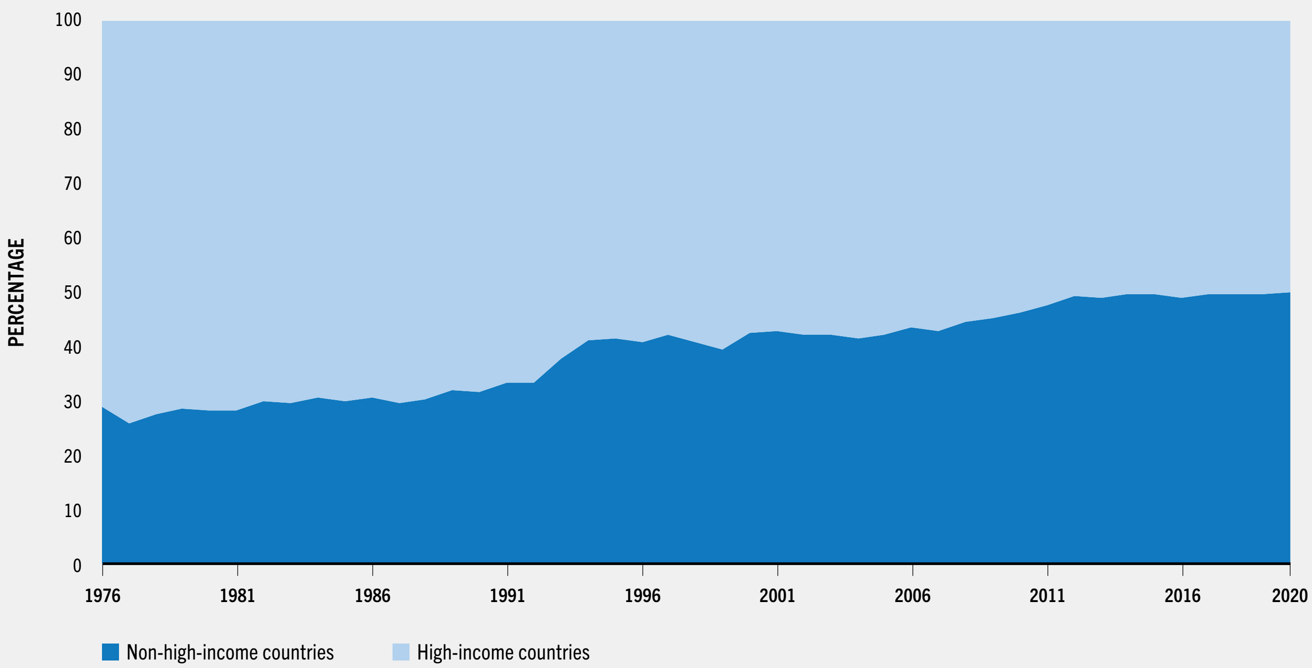
[1] Excluding algae.
SOURCE: FAO.

FIGURE 50 UNIT VALUE OF IMPORTS OF AQUATIC PRODUCTS BY ECONOMIC CLASS OF IMPORTERS, 1976–2020



NOTES: Excluding aquatic mammals, reptiles, amphibians, turtles, algae, sponges and corals and other non-food products. Data expressed in live weight equivalent.
SOURCE: FAO.

FIGURE 51 PERCENTAGE OF GLOBAL VALUE OF EXPORTS OF AQUATIC PRODUCTS BY ECONOMIC CLASS, 1976–2020



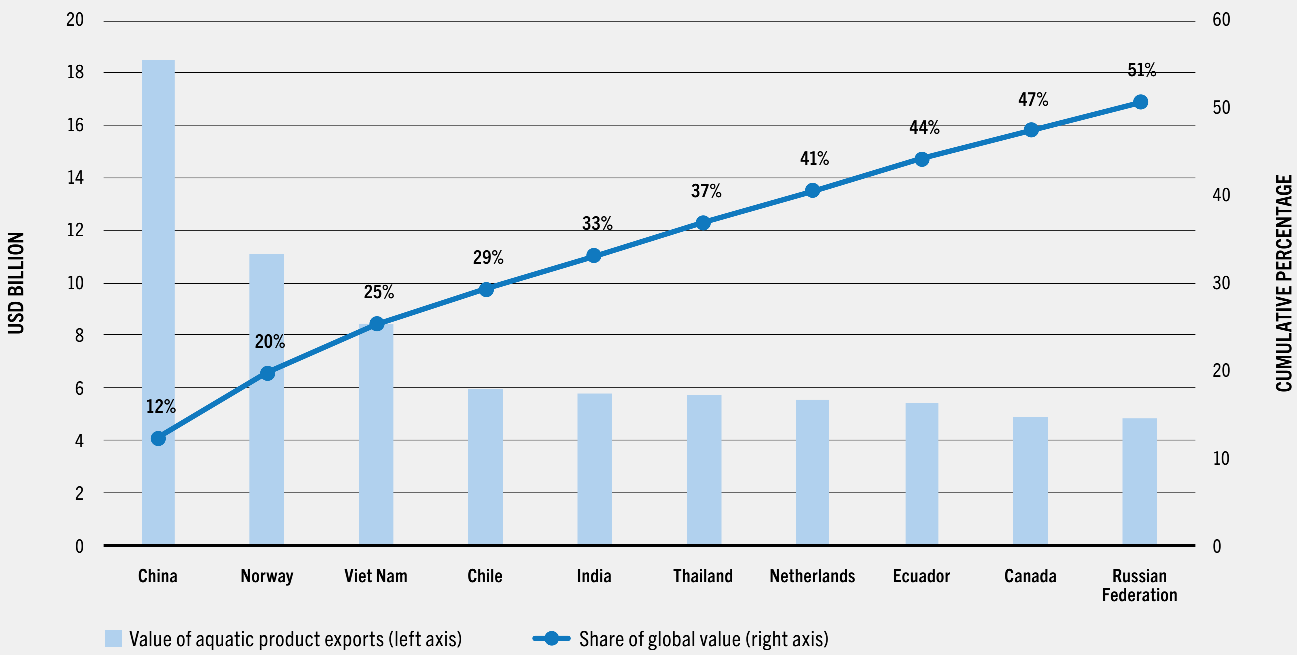
NOTE: Excluding aquatic mammals, reptiles, amphibians, turtles, algae, sponges and corals.
SOURCE: FAO.

(5 percent) and France (4 percent). However, it is worth mentioning that, in terms of volume (live weight), China is the top importing country of aquatic products, far ahead of the United States of America. China imports large quantities of species not locally produced, not only for domestic consumption but also as raw material to be processed in China and then re-exported.

Despite the rising importance of non-high-income countries as importers of aquatic products, significant differences in the average unit value of imports persist between high-income and non-high-income countries (Figure 50). It reflects the preference for high-value species and for more value-added products in high-income countries. In 2020, imports of high-income countries averaged USD 3.2 per kilogram (live weight equivalent) compared with USD 1.4 per kilogram for all remaining countries.

Even though emerging economies became larger importers of aquatic products, the dominant trend in global trade development since the 1970s is their increasing importance as exporters. In 1976, high-income countries accounted for 71 percent of the value of global exports of aquatic products, compared with 50 percent in 2020 (Figure 51). In quantity terms, the share of high-income countries has declined from 67 percent to 46 percent over the same period. The rising prominence of non-high-income nations has been supported by trade liberalization, strong growth in aquaculture production and significant investment in establishing the trading relationships, knowledge and infrastructure necessary for export market development. In addition to their role as global suppliers of aquatic products, non-high-income nations have also become increasingly important as supply

FIGURE 52 TOP TEN EXPORTING COUNTRIES OF AQUATIC PRODUCTS BY VALUE, 2020



NOTE: Excluding aquatic mammals, reptiles, amphibians, turtles, algae, sponges and corals.
SOURCE: FAO.

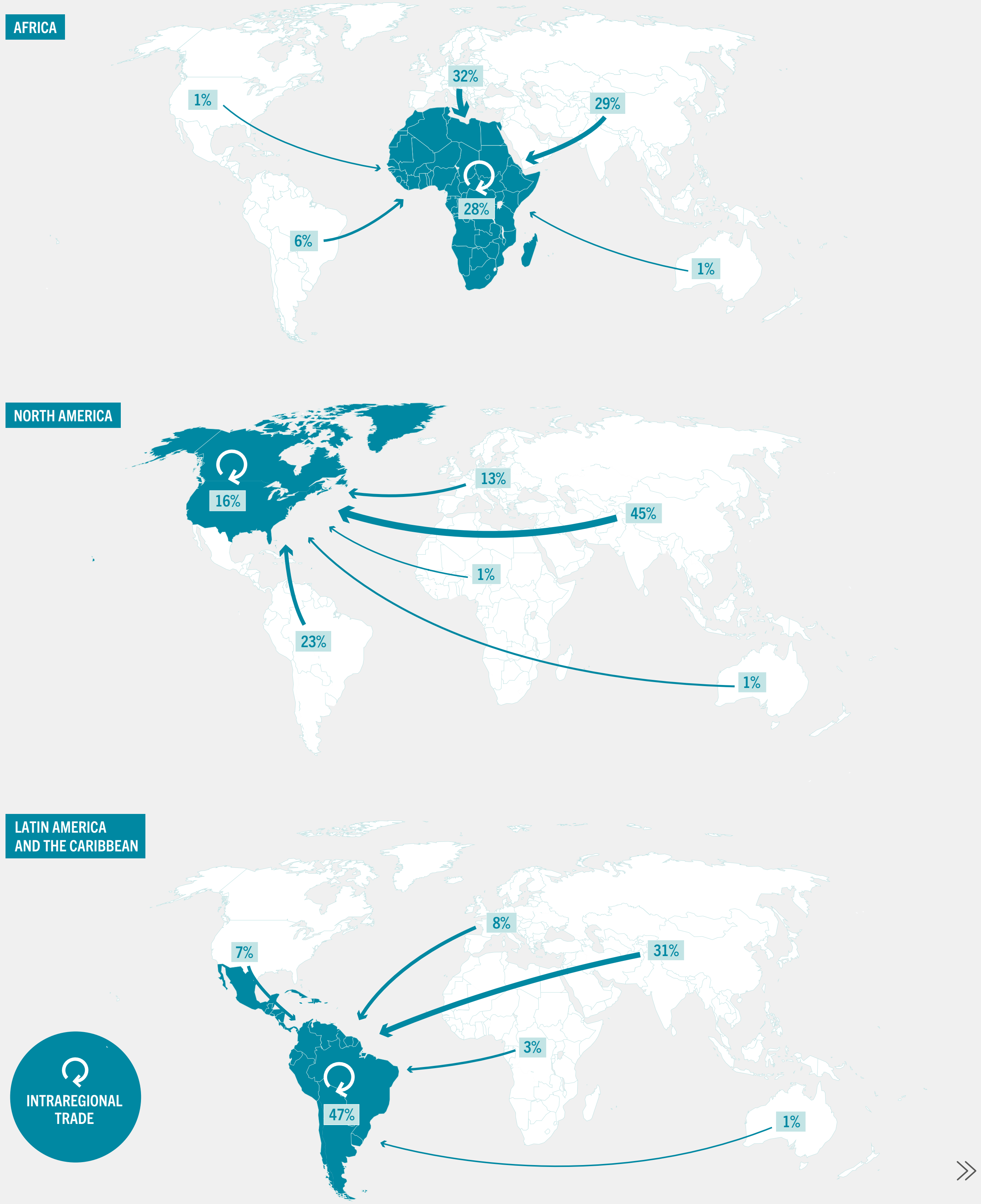
chain intermediaries, importing raw material and re-exporting processed or otherwise value-added products. While emerging economies have assumed increasingly important roles as international suppliers of aquatic products, some high-income countries remain significant exporters (Figure 52). Among the top five exporting countries of aquatic products in 2020, two were high-income countries (Norway and Chile), and the remainder non-high-income countries (China, Viet Nam and India).

China has risen to become the world's largest producer, exporter and processor of aquatic products. Its exports comprise both large quantities of domestically produced cephalopods, shrimp, tilapia and bivalve molluscs and processed whitefish such as Alaska pollock and cod. As indicated previously, a share of Chinese exports consists of processed aquatic products made from imported raw material.

In 2020, China exported USD 18 billion worth of aquatic products, accounting for 12 percent of the global total. Although this share has declined slightly from its 2015 peak, it remains well above historical levels. As a comparison, in 1976, China accounted for only 1.6 percent of the global exports of aquatic products in value. In 2020, China's top export destinations were Japan, the United States of America and the Republic of Korea, respectively accounting for 18 percent, 11 percent and 9 percent of China's total aquatic product export value.

Norway has been the second largest exporter of aquatic products since 2004. In 2020, Norway exported USD 11 billion worth of aquatic products, accounting for 7.4 percent of the global total. Norway is the world's largest producer of farmed Atlantic salmon, and it also records significant catches of small pelagics and groundfish species such as cod.

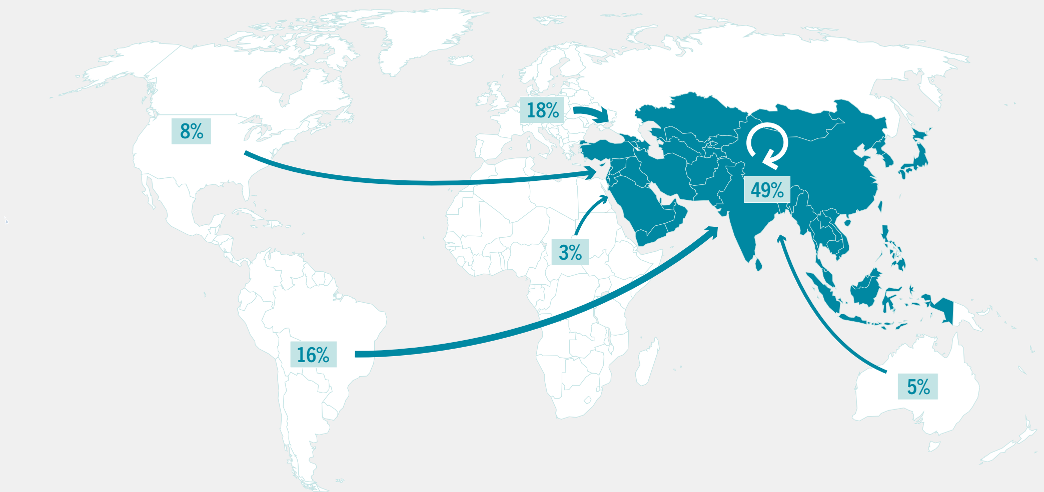
FIGURE 53 TRADE FLOWS OF AQUATIC PRODUCTS BY REGION (SHARE OF TOTAL IMPORTS, IN VALUE), 2020



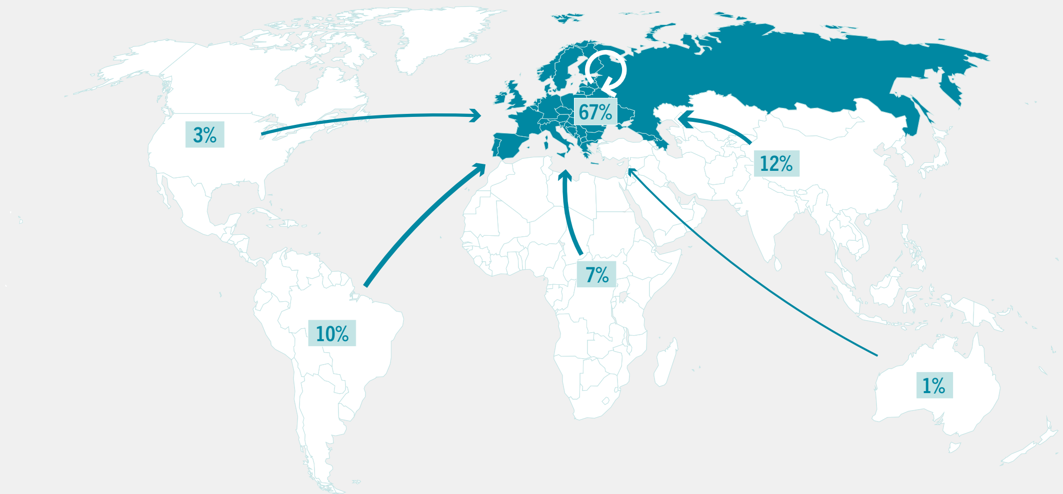
The designations employed and the presentation of material on these maps do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined. A dispute exists between the Governments of Argentina and the United Kingdom of Great Britain and Northern Ireland concerning sovereignty over the Falkland Islands (Malvinas).

FIGURE 53 (Continued)

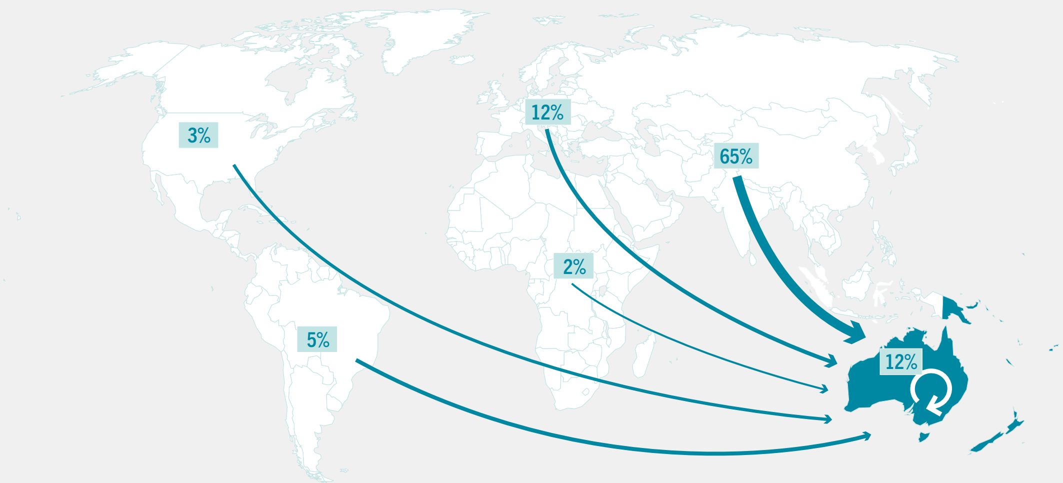
ASIA



EUROPE



OCEANIA



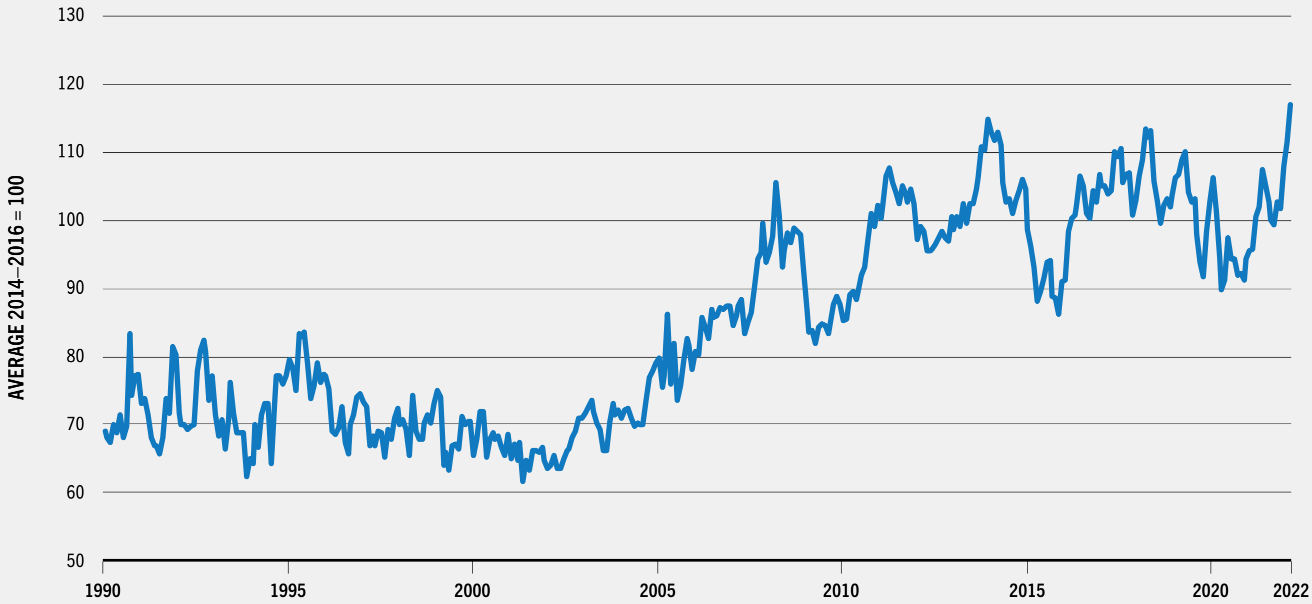
NOTES: Excluding aquatic mammals, reptiles, amphibians, turtles, algae, sponges and corals. Shares may not add up to 100 percent due to unspecified trading partners.
SOURCE: FAO.

The European Union is by far Norway's most important market, accounting for 60 percent of Norwegian export value. Viet Nam has been the third largest exporter of aquatic products since 2014 and has become by far the world's leading producer and exporter of farmed pangasius, supplemented by a large farmed shrimp industry and a significant processing sector. In 2020, Viet Nam exported USD 8.5 billion worth of aquatic products, accounting for 5.6 percent of the global total. Chile, the fourth largest exporter of aquatic products, has leveraged its geographical advantages to develop an extensive aquaculture industry, with the world's second largest salmonid production supplemented by smaller quantities of mussels. In 2020, Chilean exports of aquatic products totalled USD 5.9 billion, accounting for 3.9 percent of the global value. Supported by strong shrimp production growth, India had become the fourth major exporter in 2017. However, India was overtaken by Chile in 2020 as the value of India's exports has been on a downward trend since 2018. In 2020, the total value of India's exports of aquatic products reached USD 5.8 billion, down from USD 7.2 billion in 2017. Other major exporters include the European Union, Thailand, Ecuador, Canada and Indonesia. The European Union itself is the largest exporter in global terms, but the vast majority (78 percent of value) is intra-European Union trade. Moreover, a large proportion of these trade flows consist of re-exported products, either after processing or after initial entry into the European Union market from external sources. In Thailand, a large industry has been established around processing, with a particular focus on canned tuna produced from raw material landed directly in Thai ports by foreign long-distance fleets. Thailand has also built up a large shrimp aquaculture industry, but it has been badly affected in the last decade by disease outbreaks. Ecuadorian exports of aquatic products have increased significantly over the past decade, boosted by the surge in tuna and farmed shrimp production. Canada and the United States of America combined make up 6.4 percent of global export value, but much of this trade takes place between the two nations, with each representing the other's leading trading partner. Indonesia is also one of today's largest suppliers of farmed shrimp to the world market, while also playing a key role as a tuna and tilapia exporter.

Despite experiencing strong growth in the value of its aquatic product exports over time, Africa accounted for under 5 percent of the global export value in 2020. Morocco and Mauritania export significant quantities of cephalopods and small pelagics, mainly to the European and Japanese markets, but also to African countries. Several Western African nations also export substantial volumes of tuna, mainly canned, to Europe. As importers of aquatic products, African nations play a relatively small role in global terms, accounting for 3.3 percent of the total import value in 2020. African imports primarily consist of small pelagics of low unit values. However, it is worth noting that while Africa is a net exporter in terms of value, the continent is a net importer in terms of volume. Considering that many food-insecure nations are located in Africa (FAO *et al*., 2021), it is also important to recognize the role that trade may play in supporting food security. Trade can have an impact on food security via multiple channels, of which perhaps the most immediate is nutrient transfer. Imports of large volumes of small pelagic species of low unit value by African nations are nutritionally rich, in particular in terms of their high levels of micronutrients. The export of species with higher unit values, such as tuna, shrimp and cephalopods, in conjunction with the import of these nutritionally rich species, amounts to an advantageous exchange in nutritional terms. At the same time, the generation of export revenue has potentially positive implications for food security by contributing to employment and income generation. Income gains translate into increased food affordability which can reduce food insecurity and malnutrition via improved access to aquatic food and nutrition (FAO *et al*., 2021).

International trade has been accelerated by the creation of the World Trade Organization (WTO), and also within the context of multilateral, regional and bilateral trade agreements. These agreements, which establish preferential terms of trade between two or more trading partners, have become increasingly important in facilitating international trade by reducing or removing barriers including tariffs and technical barriers to trade (TBT). In particular, interregional trade has been enabled by regional trade agreements (RTAs), which have been increasing

FIGURE 54 FAO FISH PRICE INDEX



NOTE: Source of raw data: EUMOFA, INFOFISH, INFOPESCA, INFOYU and Statistics Norway.
SOURCE: FAO.

since the 1990s (Figure 53). However, it is worth noting that this trade is often not adequately reflected in official statistics, in particular for Africa and selected countries in Asia and Oceania. RTAs such as the European Union Customs Union, the North American Free Trade Agreement, the Association of Southeast Asian Nations, the Southern African Development Community and the Southern Common Market have been key drivers of global trade expansion in recent decades, and trade in fisheries and aquaculture products has benefited as part of this broader trend. RTAs often extend beyond trade terms and may also include provisions covering fisheries management and traceability, which can strengthen institutional oversight of shared resources and contribute to sustainable fisheries management.

Tariff policies have historically been used by governments to generate income from trade, to protect domestic industries from international competition and as punitive measures taken against other nations in the context of trade disputes. Aquatic products are classified as industrial goods by the WTO, meaning they are grouped under non-agricultural market access negotiations. Under the WTO principle of most-favoured nation, applied tariffs for fisheries and aquaculture products range from 0 percent to 30 percent, with an average of 14 percent (FAO, 2017b). Bound tariffs, which are effectively the maximum tariff in a given category under WTO rules, range from 0 percent to 60 percent, with an average of 35 percent. These figures point to the generally low level of applied tariffs on imports of fisheries and aquaculture products, despite some reintroduced tariffs and some concern over tariff escalation in the case of processed and value-added products. The large high-income importing countries, such as the European Union, the United States of America and Japan, apply reduced or zero tariffs on the majority of imports from countries qualifying for such treatment under the Generalized System of Preferences, which contributed to the rapid development of aquatic product exports in economically emerging countries. In contrast, many emerging countries still apply relatively high tariffs for fisheries and aquaculture products that can reflect fiscal policies or protective measures. Tariff escalation[29] continues to be a serious issue for many countries and products, particularly in accessing some high-income markets and expanding regional trade.

Technical barriers to trade are non-tariff barriers that can include any regulations, requirements or standards that impose an additional burden on trading parties. These may include both mandatory requirements or regulations and voluntary standards. Product standards, sanitary and phytosanitary measures, procedures for import licensing and rules of origin, and labelling requirements are all examples of TBTs applied to aquatic products. Traders of perishable aquatic products are also affected by customs and clearance procedures. The WTO TBT Agreement recognizes that these requirements, standards and procedures are necessary to protect human health, ensure product quality and safeguard the environment, but they should be non-discriminatory. In practice, TBTs can effectively block market access for countries lacking the necessary capacity, infrastructure, technology and technical knowledge to address them. TBTs are an important topic for fisheries and aquaculture products. In particular, the United Nations Conference on Trade and Development estimates there are on average 2.5 times more technical measures applied to fisheries and aquaculture products than to manufactured products.

Traceability and catch documentation are core components of compliance with food safety regulations and controls to combat illegal, unreported and unregulated fishing (IUU fishing). Ecolabels and certification schemes communicating to buyers and consumers that aquatic products are sourced from well-managed fisheries can impose additional burdens on exporters. Thus, it has become increasingly important to ensure that TBTs applied to aquatic products strike a fair balance between allowing market access and protecting both consumers and the resource. International cooperation in the design and assessment of TBTs, and subsequent efforts to facilitate compliance by streamlining procedures and harmonizing standards, are important prerequisites for achieving this balance. The FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing also contributes to protect both consumers and the resource, by allowing countries to impose trade restrictions at the port of entry in order to avoid the unloading of products originating from IUU fishing. The WTO Trade Facilitation Agreement that entered into force in February 2017 is expected to help overcome some of the challenges associated with customs procedures and expedite the movement, release and clearance of goods across borders.

Growth in trade of aquatic products in the long term is driven by trade policy shifts in addition to economic and demographic fundamentals, but over shorter time horizons, trade dynamics are dependent on a number of different factors. First, as for trade in general, trade in aquatic products is quite sensitive to economic conditions. Levels of aquatic food consumption correlate positively with income, meaning that periods of economic recession typically lead to a contraction in trade of aquatic products. Other important factors include geopolitical shifts, currency trends, logistical costs and delays, and major shocks to supply such as disease outbreaks or climatic events.

For example, in recent years, two significant developments have affected aquatic product trade. First, in 2018 new tarriff regimes between the United States of America and China, two of the world's largest trading partners, affected several heavily traded fisheries and aquaculture products, including lobster and tilapia. While new tariff regimes represent obstacles for existing suppliers, the new environment creates opportunities for alternative suppliers. An example is how the additional costs borne by China's tilapia sector,

29 Tariff escalation occurs when higher import duties are imposed on semi-processed products than on raw materials. Usually, even higher tariffs apply to finished products. This practice protects domestic processing industries and discourages the development of processing activity in the countries where raw products originate (definition based on WTO glossary).

traditionally the major supplier to the top market of the United States of America, have translated into a competitive advantage for the emerging Latin American tilapia export industry.

Another change affecting the dynamics of trade in fisheries and aquaculture products is the exit of the United Kingdom from the European Union. This transition has resulted in the introduction of new procedures for customs checks, food safety inspections and documentation, and product labelling. The additional administrative burden led to severe logistical bottlenecks for aquatic product traders of the United Kingdom in early 2021, disproportionally affecting small and medium businesses. Although progress has been made in streamlining these processes, uncertainties remain regarding the specifics of the framework under which trade will be conducted in the future.

The COVID-19 pandemic has brought an array of challenges for international trade of aquatic products. These impacts and their causes and implications are presented in the section COVID-19, a crisis like no other (p. 195) Furthermore, the pandemic caused an estimated 7.0 percent drop in the value of global aquatic product exports, falling to USD 151 billion in 2020. This followed on from a 2.1 percent decline in 2019 compared with the peak reached in 2018. In 2020, traded volumes fell by an estimated 10.1 percent, with declines in trade recorded across all regions. As fishing and aquaculture resumed and international markets opened, 2021 recorded a strong recovery in trade. In 2021, the total value of global exports of aquatic products went up 12 percent compared with 2020. Meanwhile, growth in traded volumes was more limited, due to the impact of conservative planning on aquaculture supply and continued logistical challenges. Prices went up in 2021. According to the FAO fish price index,[30] the average international fish prices were 7.2 percent higher in 2021 than in 2020, when prices were 7.2 percent lower than in 2019 (Figure 54). Estimates for the first two months of 2022 indicate that prices were 19 percent higher compared with the same period in 2021.

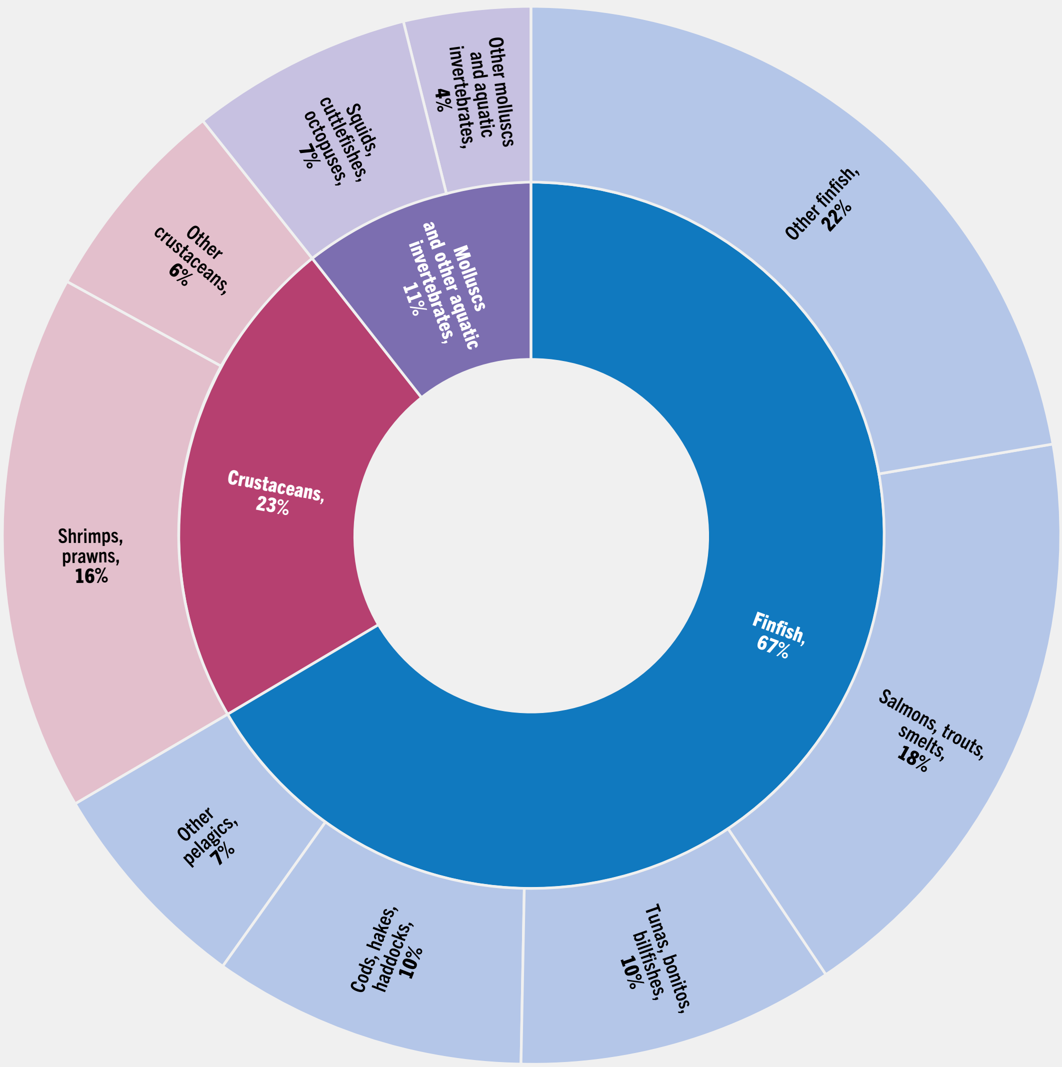
30 The FAO fish price index (FPI) is calculated across a range of prices for the major species groups. The FPI index value of 100 is the average price observed over the base period 2014–2016.

Main traded commodities

Traded fisheries and aquaculture products are diverse in terms of species, origin, product form, packaging and method of preservation. This creates challenges for gathering consistent and accurate trade statistics while underlining the importance of such statistics to understand a complex marketplace. Trade statistics are compiled by customs agencies and statistical bodies in the countries and territories participating in trade, within the coding and classification framework of the Harmonized Commodity Description and Coding System (HS). This framework is maintained by the World Customs Organization (WCO). At the highest level of disaggregation, this framework defines six-digit codes associated with specific product classifications that should be applied uniformly by all reporting bodies. Longer codes providing classifications at lower levels of aggregation may be introduced by individual countries and territories. The HS system is the foundation for tariff legislation in addition to collecting data to be consulted and used by trade analysts, academia, industry, governments, non-governmental organizations and intergovernmental organizations, offering valuable insight into trade and market trends and structure over time. To improve the utility of HS statistics, FAO worked with the WCO in 2012 and 2017 to revise the HS codes and classifications in order to better reflect the underlying features of the international trade of aquatic products. However, further disaggregation is necessary to distinguish wild-caught versus farmed aquatic animals in trade statistics. 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.

Nearly 90 percent of the quantity (live weight equivalent) of traded aquatic products consists of preserved products, the majority of which frozen. However, demand for fresh aquatic products and the advancement of packaging and logistical technologies have seen the proportion of fresh products in trade volumes increase

FIGURE 55 SHARE OF MAIN GROUPS OF SPECIES IN EXPORTS OF AQUATIC PRODUCTS BY VALUE, 2020



NOTE: Excluding aquatic mammals, reptiles, amphibians, turtles, algae, sponges and corals.
SOURCE: FAO.

over time. In 1976, fresh products accounted for 5.8 percent of the quantity (live weight) of trade of aquatic products compared with 11.1 percent in 2020. Airfreight has enabled the development of export of high-end fresh aquatic products, such as farmed salmon, or capture demersal finfish species. The COVID-19 pandemic temporarily reversed this trend, due to the shutdown of food services and a shift in the purchasing behaviour of consumers subject to lockdown restrictions. However, the surge in demand for products such as canned tuna observed in the early stages of the pandemic is now fading, and it is expected to return to its long-term trend.

Figure 55 shows the total value of internationally traded aquatic products broken down by key groups of species in 2020. Finfish accounted for 66.5 percent of the global value of exports of aquatic products (excluding algae) in 2020, followed by crustaceans (22.8 percent) and molluscs and other aquatic invertebrates (10.7 percent). Salmonids have been the most important commodity traded in value since 2013, accounting for about 18 percent of the total value in 2020. In the same year, the other main groups of exported species were shrimps and prawn with about 16 percent of the total, followed by tunas, bonitos and billfishes (9.7 percent), cods, hakes and haddocks (9.6 percent), and squids, cuttlefishes and octopuses (6.8 percent). A brief analysis of recent trends by some of the key groups of species is reported below.

Salmon and trout

Salmon, and particularly farmed Atlantic salmon, has been one of the major contributors to growth in global trade of fisheries and aquaculture products in recent decades. As a versatile and high-value species suitable for large-scale aquaculture, salmon occupies a strong competitive position in the world market. Growth in demand for salmon has outstripped other fish categories in almost every region and Atlantic salmon aquaculture has risen to become one of the most profitable and technologically advanced industries. The sector has also led the way in funding, coordinating and executing large-scale international marketing campaigns, and has successfully established logistical infrastructure to supply fresh aquatic foods to foreign markets via airfreight routes. In 2020, exports of salmon were worth USD 27.6 billion, led by Norway and Chile. Salmon and trout exports accounted for 18.4 percent of the value of all exported aquatic products in 2020, compared with 5.1 percent in 1976. Norway's primary market is the European Union, while Chile supplies Atlantic salmon to the United States of America and Brazil and farmed coho to Japan. Several wild Pacific species, caught by fleets of the Russian Federation and of the United States of America in the North Pacific, are also traded internationally. Salmon trade has been relatively resilient in the face of the challenges associated with the COVID-19 pandemic, despite an initial drop in prices and various logistical difficulties, reflecting the strength of underlying demand and the ability of the sector to adapt to changing conditions.

Shrimp

Shrimp and prawns have historically been some of the most heavily traded aquatic commodities. Currently produced primarily via intensive shrimp farming operations in Latin America and East and Southeast Asia, the majority of supply flows to consumers in high-income markets in North America, Europe and Japan. The markets of the United States of America and Japan are primarily supplied with warmwater species by major producers such as India, Indonesia, Thailand and Viet Nam. The European Union imports warmwater species from Asian and Latin American producers and sources coldwater species mainly from capture fisheries in Greenland. Today, emerging Asian economies such as China are absorbing an increasing proportion of global shrimp supply while the potential increase in per capita consumption in the mature traditional markets remains limited. Over time, shrimp and prawn exports have increased drastically but account for a relatively stable share of the total value of global exports of aquatic products. In 1976, exports of shrimps and prawns were worth USD 1.2 billion accounting for 15.4 percent of the value of global exports of aquatic products, whereas in 2020, they were worth USD 24.7 billion making up 16.4 percent of the total in value terms.

Groundfish and other whitefish

Whitefish covers a broad range of species, both wild-caught and farmed, such as cod, seabreams, groupers, Alaska pollock, tilapia, Nile perch and Pangas catfish (*Pangasius* spp.). These species are similar in taste and texture and, depending on the product, are substitutable for one another to a certain degree. The fleets of Norway, the European Union, Iceland, the Russian Federation and the United States of America account for most of the world's wild-caught groundfish production. The European Union is by far the top import market for wild-caught groundfish, while China plays an important role in the world market as a processor of raw material and re-exporter. Exports of groundfish and other whitefish account for about 17 percent of the total value of exports of aquatic products, although there are significant quantities of groundfish and other whitefish not explicitly identified as such in trade statistics and recorded under miscellaneous species. China has built up a large tilapia farming industry in its southern provinces and is now the largest exporter of tilapia. In parallel, alternative suppliers in Southeast Asia and Latin America have increased their exports to the United States of America, at the expense of China. While China remains the dominant tilapia supplier, the imposition of import tariffs by the United States of America on Chinese tilapia, combined with logistical challenges related to the COVID-19 pandemic and the repurposing of land in key production regions, means that this dominance is expected to continue to decline. Viet Nam accounts for the majority of global pangasius production and export. Historically, the most important pangasius export market has been the United States of America, but in recent years, China has risen to become Viet Nam's top export market.

Tuna

In 2020, global exports of tunas, bonitos and billfishes were worth USD 14.6 billion, the equivalent of 9.7 percent of the value of all exports of aquatic products. This proportion has remained relatively stable for many decades, as tuna's popularity has endured. Tuna trade consists of two broad groups of commodities; the first comprises processed and preserved tuna, and the second high-quality fresh tuna for the sushi and sashimi market. Bluefin and bigeye tuna are typically used for sashimi and sushi, while skipjack, albacore and yellowfin are used as raw material for processed products. Thailand has established a large tuna processing industry, supplied by raw material landed directly by fishing fleets in Thai ports, and it plays a key role in the international tuna trade. The United States of America is the primary destination for Thai processed tuna exports. Smaller but significant industries also exist elsewhere in Asia, Africa and Latin America, with Ecuador supplying the European Union market with large quantities of processed tuna and raw material for European processors. Tariff regimes and the implications of duty-free import quotas enforced by major markets are important determinants of tuna trade flows in the processed product market and remain a central issue in trade negotiations. The sashimi and sushi market is dominated by Japan, which is supplied primarily by whole tuna and loins from the fleets of Taiwan Province of China and of the Republic of Korea, and by re-exports from Thailand.

Cephalopods

Cephalopods are a class of molluscs that includes octopus, squid and cuttlefish. Cephalopods are almost entirely wild-caught, with the bulk of supply coming from China, India, Morocco and Peru. The most important import markets for cephalopods are China, the European Union, particularly Italy and Spain, Japan and the Republic of Korea. Octopus is a popular restaurant menu item and this popularity has increased in recent times in line with increased demand for Hawaiian poke and Spanish-style tapas cuisine. Squid and cuttlefish are also used as ingredients in these dishes and are sold in large quantities at retail, typically in preserved and processed form. In 2020, exports of cephalopods amounted to USD 10.2 billion, the equivalent of 6.8 percent of the total value of exports of aquatic products. Cephalopods' share of global trade has been increasing over time, but supplies are at risk due to poor management. This has led to steep price increases in recent years.

Bivalves

The most important bivalve mollusc species for international trade are scallops, clams, oysters and mussels. Today, the vast majority of the bivalve molluscs consumed are farmed, produced in a number of European countries, North America, China and Chile. The European Union, the United States of America, China and the Republic of Korea account for the bulk of import demand. Demand for bivalves has remained relatively steady over time, and the species have benefited from a positive perception among consumers as a healthy and sustainable food option. In 2020, global exports of bivalve molluscs totalled USD 4.3 billion, representing around 2.8 percent of the value of global exports of aquatic products.

Small pelagics and fishmeal and fish oil

Small pelagic species such as mackerel, herring, sardine and anchovy make up a significant proportion of the world's capture fisheries production. The European Union, China, Morocco, Norway, the United Kingdom of Great Britain and Northern Ireland, the Russian Federation and Japan all report substantial catch volumes and exports. Despite a low unit value, these species accounted for 6.7 percent of the total value in 2020. Small pelagic stocks may straddle multiple exclusive economic zones, and productivity in a specific region tends to be heavily dependent on climatic conditions, translating into high supply and price volatility. The most important markets are geographically dispersed and include China, Egypt, the European Union, Japan, Nigeria and the United States of America. Small pelagics are also used for fishmeal and fish oil production for export. Anchovies, particularly Peruvian anchoveta, are typically used as raw material for these products. Most demand for fishmeal comes from major aquaculture producers such as China.

Other products

The above-mentioned value of USD 151 billion for exports of aquatic products in 2020 does not include an additional USD 1.9 billion made from seaweeds and other algae (58 percent), inedible fish by-products (33 percent), and sponges and corals (9 percent). Trade in algae increased from USD 65 million in 1976 to USD 1.1 billion in 2020, with China, Indonesia 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 processing by-products of aquatic animals (see the section Utilization and processing of fisheries and aquaculture production, p. 73), trade in inedible by-products has also surged, up from USD 8 million in 1976 to USD 715 million in 2020. ■

CÔTE D’IVOIRE
Feeding tilapias on a farm in Padiegnan, a village included in the FISH4ACP project.
©FAO/Sia Kambou

PART 2
TOWARDS BLUE TRANSFORMATION

BLUE TRANSFORMATION:[1] A VISION FOR TRANSFORMING AQUATIC FOOD SYSTEMS

The prevalence of moderate to severe food insecurity has been rising since 2014, exacerbated by the COVID-19 pandemic. Over 800 million people now suffer from hunger and 2.4 billion people have severely limited access to adequate food. As we enter the Decade of Action to deliver the Global Goals,[2] the challenge to feed a growing population without exhausting our natural resources continues to increase. In this context, aquatic food[1] systems are increasingly in the spotlight for their potential to provide a larger proportion of humanity's nutritious food requirements.

Aquatic foods offer highly accessible and affordable sources of animal proteins and micronutrients, playing a vital role in the food and nutrition security of many, particularly vulnerable coastal populations. Their crucial role as suppliers of highly nutritious food, essential for physical and cognitive development, has been growing (UN Nutrition, 2021), even though less than half of public health nutrition policies currently identify their consumption as a key objective (Koehn *et al*., 2021). In addition, fisheries and aquaculture already support 58.5 million jobs in the primary sector, including part-time and occasional, and 600 million livelihoods, and the trade in aquatic products[1] provides an important source of hard currency and income for exporting countries and regions.

Unfortunately, production and distribution of aquatic foods are not without problems. Strategies to deliver healthy, sustainable and equitable food systems do not adequately include the critical long-term impacts of overfishing, habitat degradation and unequal access to resources and markets. In 2021, the FAO Committee on Fisheries (COFI) unanimously endorsed the COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021b). This Declaration recognized the contributions of the sector in combating poverty and hunger since the endorsement of the 1995 Code of Conduct for Responsible Fisheries.

Successful experiences of restoring healthy fishery stocks and securing livelihoods through proper management or expanding sustainably aquaculture operations continue to emerge. Our growing understanding of the impacts of climate change and other natural and human-made shocks may also help secure and expand the services provided by aquatic food systems. Considering this knowledge, the 2021 COFI Declaration identifies priority areas to further transform fisheries and aquaculture, thus developing a twenty-first century vision for the sector where successes from around the globe are shared and scaled to transform aquatic food systems from a perceived problem to a recognized solution for food and nutrition security and environmental and social well-being.

1 For aquatic food, aquatic products and Blue Transformation, see Glossary, including Context of SOFIA 2022.

2 In 2019, the United Nations Secretary-General called for a decade of ambitious action to deliver the Sustainable Development Goals by 2030: the Decade of Action to deliver the Global Goals.

Blue Transformation is the vision and the process by which FAO, its Members and partners can use existing and emerging knowledge, tools and practices to secure and maximize the contribution of aquatic (both marine and inland) food systems to food security, nutrition and affordable healthy diets for all.

Why do we need Blue Transformation?

In recent decades, policy development, public and private sector innovation and rising consumption have spurred significant evolution in aquatic food systems. In the 25 years following the endorsement of the Code of Conduct for Responsible Fisheries, capture fisheries production remained stable, but aquaculture production grew by 250 percent, enabling the sector to meet the increase in aquatic food demand and consumption which rose to 20.5 kg per person per year (a growth rate double that of the world population). The integration of aquatic foods in global and regional supply chains means that fisheries and aquaculture trade value is now 200 percent greater than in 1995, and the net trade value (exports minus imports) for aquatic food products by non-high-income countries is larger than that of all other food products combined.

Blue Transformation is a targeted effort to promote innovative approaches that expand the contribution of aquatic food systems to food security and nutrition and affordable healthy diets. Achieving the objectives of Blue Transformation requires holistic and adaptive approaches that consider the complex interaction between global and local components in food systems and support multi-stakeholder interventions to secure and enhance livelihoods, foster equitable distribution of benefits and provide for an adequate use and conservation of biodiversity and ecosystems.

Through Blue Transformation, aquatic food systems can:

- support the provision of sufficient aquatic food for a growing population in an environmentally, socially and economically sustainable manner;
- ensure the availability and accessibility of safe and nutritious aquatic food for all, especially vulnerable populations, and reduce food loss and waste;
- ensure that aquatic food systems contribute to improving rights and incomes of dependent communities to achieve equitable livelihoods; and
- support resilience in aquatic food systems, which are highly influenced by dynamic human and environmental processes, including from climate change.

Objectives of Blue Transformation

Blue Transformation has three core objectives:

1. Sustainable aquaculture expansion and intensification – to support global food security targets and satisfy global demand for nutritious aquatic food and equitable distribution of the benefits.
2. Effective management of all fisheries – to deliver healthy stocks and secure livelihoods.
3. Upgraded value chains – to ensure the social, economic and environmental viability of aquatic food systems, and secure nutritional outcomes.

In the next ten years, aquaculture must expand sustainably to satisfy the gap in global demand for aquatic foods, especially in food-deficit regions, while generating new or securing existing sources of income and employment. This requires updating aquaculture governance by fostering improved planning, legal and institutional frameworks and policies. FAO and its partners must focus on the urgent demand for the development and transfer of innovative technologies and best practices to generate efficient, resilient and sustainable operations. The continued transformation of aquaculture applies to most regions but is particularly critical in food-insecure regions; the aim is to increase global production by between 35 percent and 40 percent by 2030, according to national and regional contexts.

Effective management of all fisheries is a non-negotiable objective of Blue Transformation. Where effective management exists, fishery resources have been rebuilt and are increasingly sustainable. To achieve this objective, FAO and its partners must apply and share effective fisheries management systems that restore ecosystems to a healthy and productive state, while managing exploited resources within ecosystem boundaries. Actions to achieve this objective include building global capacity to regularly collect, analyse and evaluate data that support decision-making and consider trade-offs, particularly in regions with limited data and poor capacity. This objective also strengthens social outcomes, applying actions and initiatives that promote equitable livelihoods, and co-management systems, securing access of small producers to resources and services.

Through upgraded value chains, public and private actors, including consumers, reduce food loss and waste, enhance transparency, improve access to lucrative markets and adopt emerging digital tools. Aquatic food value chain actors increasingly adopt these practices, which have seen a significant expansion and uptake because of the challenges presented by the COVID-19 pandemic. Upgraded value chains also add and create value to extract more wealth and food from the sector's productive capacity. The promotion of healthy diets in an inclusive manner is also critical and requires programmes and initiatives that improve consumer awareness and increase the availability of healthy, safe and nutritious aquatic foods, including in areas with low food and nutrition security.

Towards Blue Transformation

Part 2, Towards Blue Transformation, discusses emerging and existing knowledge, tools and practices that have been driving sectoral transformation over the past 25 years, providing examples that are already delivering the outcomes envisioned by Blue Transformation. It describes how Blue Transformation can support FAO Members and the international community at large to maximize the contribution of aquatic food systems to the Sustainable Development Goals. FAO projects that if properly supported, aquatic food systems can sustainably provide a 25 percent growth in per capita aquatic food consumption by 2050. FAO is committed to working with FAO Members, partners and stakeholders to implement Blue Transformation in support of the food security and nutrition of a world population expected to reach 10 billion in 2050. This section opens a small window on how those interactions may succeed. ■

INTENSIFYING AND EXPANDING SUSTAINABLE AQUACULTURE PRODUCTION

Objectives and targets

Aquaculture has undeniably established its crucial role in global food security and nutrition, reducing the supply-demand gap for aquatic food.[3] The sector's positive impact on livelihoods and employment is expected to grow through enhanced productivity and modernization, intensification, and increased economic and geographic access to farmed aquatic products.[3] By 2030, aquatic food production is forecast to increase by a further 15 percent (OECD and FAO, 2021a) and it is widely acknowledged that this growth will come mainly from aquaculture. Such growth must not come at the cost of aquatic ecosystem health, increased pollution, animal welfare, biodiversity or social equality. This requires new, sustainable and equitable aquaculture development strategies.

The development of aquaculture must therefore become a top priority, particularly in those regions where the growth potential of the sector remains largely untapped. Blue Transformation[3] – launched by FAO following the 2021 COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021b) – is a priority programme area of FAO under its Strategic Framework 2022–2031. Likewise, the Shanghai Declaration emphasizes the key role of aquaculture, reflecting the outcomes of the Global Conference on Aquaculture (GCA, 2021) organized by FAO, the Network of Aquaculture Centres in Asia-Pacific and the Chinese Ministry of Agriculture and Rural Affairs. These timely declarations recognize the need to intensify efforts to make full use of opportunities while

3 For aquatic food, aquatic products and Blue Transformation, see Glossary, including Context of SOFIA 2022.

addressing outstanding development challenges facing aquaculture to deliver sustainably and to its full potential.

Blue Transformation aims to: (i) increase development and adoption of sustainable aquaculture systems; (ii) ensure that aquaculture is integrated into national, regional and global development strategies and food policies; (iii) ensure that aquaculture production meets the growing demand for aquatic food and enhances inclusive livelihoods; and (iv) improve capacities at all levels to develop and adopt innovative technology and management practices for a more efficient and resilient aquaculture industry.

This section critically examines some of the fundamental challenges that need to be addressed to deliver on the commitments of Blue Transformation in aquaculture (Box 8) production systems, governance frameworks, innovations and capacity-building needs.

Better production systems

Expansion of sustainable aquaculture will require further technical innovations, policy support and incentives along the entire value chain. These include access to water, optimization of carrying capacity, identification and allocation of aquaculture zones, streamlining of licencing procedures in association with good environmental practices and monitoring, availability of trained and skilled labour, production of quality seed and feeds, regulation on the use of chemicals and antibiotics, and stringent biosecurity protocols. Following are examples of selected policy and technical efforts currently undertaken by FAO to ensure Blue Transformation and better aquaculture production systems.

Guidelines for Sustainable Aquaculture

Following a request by the Ninth session of the Sub-Committee on Aquaculture of the FAO Committee on Fisheries (COFI:AQ), FAO has been working since 2017, through global and regional consultative processes, on the identification of successful initiatives in support of sustainable aquaculture and their compilation into Guidelines for Sustainable Aquaculture (GSA). This process has taken into consideration policy and scientific developments, technological innovations and the lessons learned in different regions, countries and contexts. Existing national and international guidelines have been reviewed to identify gaps and ensure that information is up to date, while recognizing the specific constraints, needs and expectations of individual states. The aim of the GSA is to help countries improve implementation of the Code of Conduct for Responsible Fisheries (the Code) and in particular Article 9 (Aquaculture Development), while engaging and enabling the sector to effectively participate in the implementation of the 2030 Agenda and build collectively the future of sustainable aquaculture.

Furthermore, to meet the request of COFI Members to provide practical guidance to support sustainable aquaculture development, building on the wealth of information and expert reports generated for the preparation of the GSA, the COFI:AQ Secretariat prepared the document Transforming Aquaculture for Greater Contribution to Achieve the SDGs: Key Interconnected Actions to Guide Decision Makers and Practitioners. This is a practical guide intended for use by policymakers and aquaculture practitioners working throughout the aquaculture value chain in pre-farming, grow-out and post-harvest activities. It is intended as a live document to be adapted by countries to meet their specific needs and priorities. It should be updated regularly to reflect scientific developments, technological innovations and lessons learned. The GSA and the practical guide are expected to be submitted to the Eleventh session of COFI:AQ for FAO Members' review and further guidance.

Genetic improvement in breeding programmes

Genetic improvement of farmed species represents a powerful means to increase aquaculture's production efficiency and decrease its environmental footprint (Houston *et al.*, 2020), for example by reducing feed, land and water requirements per unit of production. Aquaculture species, across multiple taxa, tend to share two key features: high levels of intraspecific genetic diversity and high fecundity. These features permit high selection intensities to be applied generating major genetic gains for commercially important traits (FAO, 2019a). However, aquaculture, being a relatively young food industry, lags far behind other food production sectors (livestock and crops) where

BOX 8 TRANSFORMATION OF ASIAN AQUACULTURE

The South, Southeast and East Asian regions collectively produced 88 percent of global aquaculture in 2021, excluding algae, with small-scale enterprises contributing over 80 percent of this volume, requiring its timely consideration within the global food systems policy development and transformation.

In recent decades, there have been significant advances in Asian aquaculture research, technology, biosecurity, spatial planning, digitalization, education and training. The growth of Asian aquaculture is the result of government policy to support infrastructure development, strong business linkages, and constructive collaboration of stakeholders and partners. However, there are also lessons to be learned from examples of unregulated development, unsustainable intensification and weak regulatory policies in the region, and challenges lie ahead. Asian aquaculture must rise to the challenges of feeding growing populations against a backdrop of natural resource constraints and biodiversity loss. It must also adapt to the pressures of climate change and enhance system resilience. Demographic changes

PRIORITY AREAS FOR THE TRANSFORMATION OF ASIAN AQUACULTURE

Theme	Examples
Governance and policy reforms	Zoning and regulation reduce conflicts, improve efficiency and enhance environmental performance. National policy reforms promote fish consumption for improved diets and health.
Socio-economic dimension of aquaculture	Social protection and insurance schemes make farmers more resilient. Innovative financing enables farms to adopt environmentally and economically sustainable innovations.
Biosecurity and disease control	Stocking of post-larval shrimp sourced from specific pathogen-free broodstock reduces disease impacts.
Environmental control and regulation	Heterotrophic farm systems, low and zero water exchange systems and increased use of closed farm recirculation systems improve carbon and environmental footprint, and reduce the impacts of nutrients, solids and plastic on coastal and freshwater ecosystems.
Feed ingredients and feeding technologies	Innovative feed additives improve digestibility and nutrient bioavailability. Substitution with novel ingredients reduces dependence on fishmeal (and such feeds are now appearing commercially). Probiotics increase animal resistance to pathogen challenges. Monitoring and improvement of nutrient content of farmed aquatic products results in better nutritional outcomes.
Genetic improvement and diversification	Asian aquaculture systems and practices are highly diversified with over 425 cultured aquatic species. Breeds such as WorldFish's genetically improved farmed Tilapia (GIFT) continue to be improved with the faster growing generation and breeding of Tilapia lake virus-resistant GIFT.
Digital technologies and intelligent systems	Digital platforms using automatic water quality sensors, hydroacoustics, artificial intelligence and biosecurity sensors lower food conversion ratios, improve aquatic stock health and reduce stress in aquaculture production systems.
Value chain efficiency	Repurposing, reuse and recycling, and the valorization of waste products all contribute to improved performance following circular economy principles. Simple integrated fish–livestock or fish–crop systems through to complex commercial waste streams (e.g. fish processing and crop milling) provide feeds. Improved practices during harvesting, storage and transport reduce spoilage, food loss and waste.
Climate change impacts and opportunities	Development of species tolerant to temperature and salinity variation enables use of saline waters and lands. Changes in system management mitigate impacts of reduced water availability.

SOURCE: FAO.

BOX 8 (Continued)

mean that aquaculture will need to address an ageing rural workforce and urban drift by attracting and engaging a new generation of skilled and technology-smart youth.

Balancing societal outcomes and ecological sustainability will be a key challenge for the transformation of aquaculture in Asia. Many innovations currently target only high-value species, but to ensure equity and that no one is left behind, innovations must also target low-trophic and lower-priced aquatic species. Aquaculture specialists have tended to concentrate on technologies, but value chain and socio-economic dimensions – such as insurance or social protection for the most vulnerable – require additional focus in Asia. The transformation of aquaculture in Asia can be clustered into nine priority themes (see table).

FAO has established a Regional Technical Platform on Aquaculture in Asia to showcase some of the innovations that can contribute to the upscaling of the transformation of aquaculture in Asia and thus contribute to Blue Transformation globally.[1]

[1] For further details: www.fao.org/asiapacific/perspectives/rtp-aquaculture/en

the regular integration of genetics into breeding programmes and seed supply systems has led to the development and production of thousands of improved breeds and varieties. The wider adoption of genetic tools in aquaculture seed supply systems is hindered by various factors, for example: poor understanding of the properties, risks and benefits of both traditional and new generation (molecular) technologies; limited overall capacity for their application due to lack of infrastructure, investment and/or human resources; deficiency of scientifically informed, well-managed and long-term selective breeding programmes; and lack of broader private sector engagement. Addressing these challenges should be paramount in the development of national and regional seed supply strategies and policies. Accelerating the development and uptake of genetic improvement of aquaculture farmed types with a focus on selective breeding is one of the four priority areas in a global plan of action for aquatic genetic resources for food and agriculture (AqGR) developed by FAO (Box 9).

Biosecurity and disease control

The intensification of aquaculture and the globalization of trade in aquatic products have led to the emergence and re-emergence of infectious diseases representing a significant economic and environmental challenge to society. Given the sector's reliance on imported (as well as locally produced) seed and the failure of health certification, border inspection and other risk-based controls to protect aquatic populations, a paradigm shift has been necessary to manage aquatic health and biosecurity. The Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB), endorsed and welcomed by the Tenth session of the COFI Sub-Committee on Aquaculture (FAO, 2019b), is risk-based, collaborative and progressive and builds on management capacity using bottom-up and top-down approaches (Box 10). It is evidence-based and supported by transparent and ongoing review, adaptable to respond to the diversity of aquaculture systems, species, production scope and objectives, and to environmental and anthropogenic changes that impact aquaculture production (FAO, 2020c).

The adoption of "critical control point thinking" and a "risk mindset" along the value chain is important to identify the hazards and understand and manage the risk at every stage of production from seed source and grow-out operations to market. A ten-point biosecurity best practice provides a broad biosecurity landscape: know your species, know your system, know your pathogens, know your contamination pathway, source healthy seed, maintain good husbandry, use antimicrobials prudently, respect food safety requirements, respect the environment and have a biosecurity plan.

BOX 9 A GLOBAL PLAN OF ACTION FOR AQUATIC GENETIC RESOURCES FOR FOOD AND AGRICULTURE

In 2019, the Commission on Genetic Resources for Food and Agriculture (CGRFA) requested FAO to prepare a Global Plan of Action (GPA) for the conservation, sustainable use and development of aquatic genetic resources for food and agriculture (AqGR) in response to the needs and challenges identified in the first ever global assessment of the status of AqGR.[1] The GPA is a framework that aims to optimize the contribution of AqGR to food security and alleviation of poverty at the local, national and international scale, through rational and sustainable management of this key resource. The GPA should be voluntary and collaborative, implemented in line with the needs and priorities of FAO Members.

The GPA was prepared in consultation with FAO Members, the CGRFA and the Committee on Fisheries, and their relevant subsidiary bodies. The final GPA was presented to and endorsed by the Eighteenth Regular Session of the CGRFA in September 2021 and subsequently adopted by the FAO Council in December 2021.

Aquatic and terrestrial genetic resources have different priorities. Based on the specific characteristics of AqGR identified by the global assessment, the GPA identifies four priority areas (see figure).

Each priority area has a long-term goal and several strategic priorities; each strategic priority comprises a goal and several specific actions to be undertaken. Overall, the GPA identifies 21 strategic priorities and nearly 100 associated actions.

While the main responsibility for implementing the GPA rests with the countries, FAO will play a critical role in providing technical support in its implementation and will coordinate the monitoring of progress towards its goals. Monitoring should be primarily based on quantifiable indicators, many generated through AquaGRIS, FAO's global information system on AqGR.[2] Broad implementation of country-relevant actions in the GPA, underpinned by the latest information available through AquaGRIS, can be truly transformative for the long-term management of farmed species. The development and adoption of these instruments and associated guidelines and tools is timely to promote key interventions for ensuring the conservation of AqGR as well as a more sustainable use and accelerated development of these crucial resources.

THE FOUR PRIORITY AREAS OF THE GLOBAL PLAN OF ACTION FOR AqGR

1. INVENTORY, CHARACTERIZATION AND MONITORING
Establish and strengthen national and global characterization, monitoring and information systems for AqGR

2. CONSERVATION AND SUSTAINABLE USE OF AqGR
Promote the conservation and sustainable use of cultured and wild relative AqGR

3. DEVELOPMENT OF AqGR FOR AQUACULTURE
Accelerate the development and uptake of genetic improvement of aquaculture farmed types, with a focus on the expansion of selective breeding programmes

4. POLICIES, INSTITUTIONS AND CAPACITY BUILDING
Promote the development of AqGR-related policies, support the development of stakeholder institutions and build capacity to support the management of AqGR

[1] FAO. 2019. *The State of the World's Aquatic Genetic Resources for Food and Agriculture*. FAO Commission on Genetic Resources for Food and Agriculture assessments. Rome. www.fao.org/3/CA5256EN/CA5256EN.pdf
[2] FAO. 2021. AquaGRIS – a global information system for aquatic genetic resources. In: *FAO*. Rome. Cited 30 March 2022. www.fao.org/fishery/aquagris/home
SOURCE: FAO.

BOX 10 PROGRESSIVE MANAGEMENT PATHWAY FOR IMPROVING AQUACULTURE BIOSECURITY

The Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB) is a ground-breaking initiative that FAO and partners started in 2018. It was developed as an extension of the progressive control pathway (PCP) approach, which has been internationally adopted to assist countries to develop systematic frameworks for planning and monitoring risk reduction strategies for diminution, elimination and eradication of major livestock and zoonotic diseases. This stepwise approach enables realistic disease control objectives to be defined and achieved.

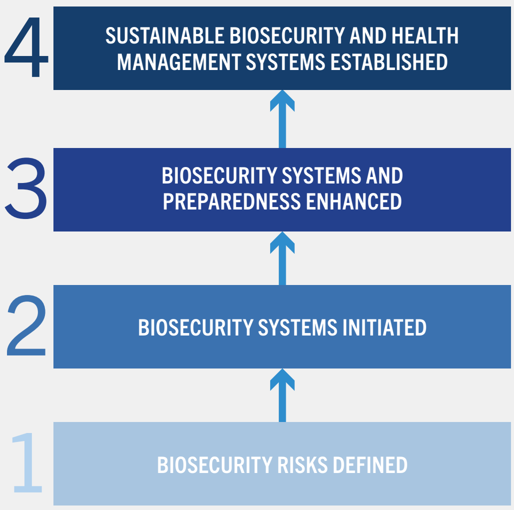
The PMP/AB aims to enhance aquaculture biosecurity capacity by building on existing frameworks, capacity and appropriate tools using risk-based approaches and public–private partnerships. In the context of the PMP/AB, biosecurity refers to "the cost-effective management of risks posed by pathogenic agents to aquaculture through a strategic approach at enterprise, national and international levels with shared public-private responsibilities."[1] The PMP/AB has four stages (see figure) and each stage has an objective, key outcomes and indicators.

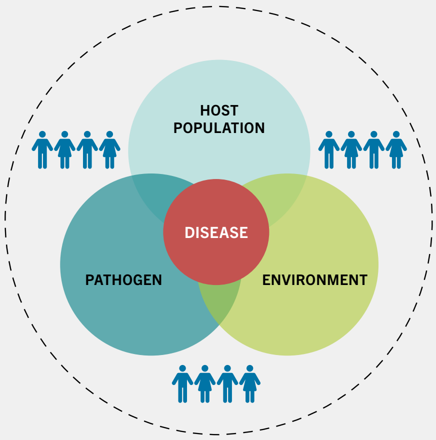
Countries, at whatever stage of industry development (advanced or just starting), will have the opportunity and flexibility to initiate the PMP/AB. For example, one or more of the following scenarios may apply:

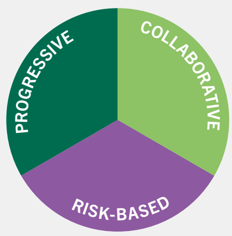
- **Scenario 1:** Country with no national aquaculture biosecurity strategy in place, but an aquaculture sector exists or is in the early stages of development.
- **Scenario 2:** Country with a national aquaculture biosecurity strategy in place with some level of implementation.
- **Scenario 3:** Country with an advanced national biosecurity strategy in place with full implementation.

THE FOUR STAGES OF THE PMP/AB

The **PMP/AB** follows the principles of being **risk-based**, **collaborative** and **progressive** and a good understanding of the epidemiological triad showing the relationship between pathogen and susceptible aquatic population in a suitable environment that allows transmission of the pathogen and development of disease in the population.







SOURCE: FAO.

BOX 10 (Continued)

- **Scenario 4:** Countries sharing waterbodies or transboundary watersheds where a regional or subregional aquaculture biosecurity strategy exists or is in development.

The PMP/AB can guide countries towards achieving sustainable biosecurity in aquaculture and health management systems through risk-based, progressive and collaborative processes at the regional, national, local sector and enterprise levels. It promotes strong stakeholder engagement, helps improve aquatic health and production, and supports prevention or reduction of the spread and impact of listed diseases.

The PMP/AB is intended to be flexible, adaptable and inclusive to account for the diverse and complex nature of the aquaculture sector. The approach can be applied by a country – to manage risks in any aquaculture sector, no matter the species, environment, production system, management strategy or operation size – or by a farm to achieve a certain aquaculture biosecurity grade for a specific species.

[1] **FAO.** 2020. *Report of the Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB): First Technical Working Group Meeting, Rome, 20–22 March 2019.* FAO Fisheries and Aquaculture Report No. 1322. Rome. www.fao.org/documents/card/en/c/cb0582en

Stakeholder engagement (including with small-scale producers) supports the principle of collaboration. Fisheries and veterinary authorities (including aquaculture health and veterinary experts) must communicate and jointly manage the health of aquatic species. Risk management[4] ownership is thus widely shared with active engagement and long-term commitment. The four stages of the PMP/AB enable each country and/or aquaculture sector to assess risk and priorities for their industry; countries can decide how far and how fast it is appropriate to progress.

One of the key messages of the Global Conference on Aquaculture 2020 is the old adage: "prevention is better than cure." Focusing on prevention – including of antimicrobial resistance – is a sign of a maturing industry. Use of clean seed with good husbandry practices and biosecurity strategies in a less stressful and healthier aquatic environment are basic actions. Biosecurity measures implemented proactively and preventatively are much less expensive than reactionary responses to outbreaks and they should be integrated in aquaculture development by all producing countries. Effective biosecurity, best husbandry practices, good genetics and quality nutrition are important for producing healthy, nutritious and resilient farmed organisms (FAO, 2020d).

4 For risk management, see Glossary.

Good governance for aquaculture expansion

Blue Transformation in aquaculture must be underpinned by adequate governance frameworks. The importance of governance is underlined in Article 9.1.1 of the Code, which requires States to "establish, maintain and develop an appropriate legal and administrative framework to facilitate the development of responsible aquaculture."

Good aquaculture governance is necessary to enhance the sector's contribution to the achievement of related Sustainable Development Goals (SDGs) by producing more nutritious aquatic food; generating employment and livelihoods, providing increased revenues to public treasury in the form of taxes and foreign exchange earnings; increasing its share of national economies (directly through GDPs and indirectly through its impacts on other economic sectors); and supporting better environmental stewardship through reducing the pressure on wild fishery stocks and promoting responsible use and protection of natural resources such as land, water, coastal habitats and aquatic living resources.

In recent decades, several countries have implemented good aquaculture governance through predictable, transparent, equitable and easily enforceable legal and institutional frameworks covering aquaculture along the entire value chain. Economic incentives that encourage best practices, assisting farmers to elaborate, support and enforce self-regulating management practices, and fostering sustainability-conducive production systems, have promoted good aquaculture governance (Hishamunda, Ridler and Martone, 2014; FAO, 2017c). Furthermore, access to lucrative international and domestic markets has also motivated an increasing number of farmers to comply with market access requirements and standards, including implementation of aquaculture certification schemes (Curtis *et al.*, forthcoming).

Despite improvement in several countries, aquaculture governance remains problematic in others. Lack of or limited accountability by the public and private sectors, inadequate law enforcement (where regulations exist), poor planning (causing conflicts over farming sites and leading to disease outbreaks and ecosystem deterioration), and failure to address the negative environmental and public welfare impacts of some aquaculture systems result in a tarnished image and public mistrust of the industry. This is exacerbated by the lack of aquaculture-specific governance frameworks. Aquaculture governance instruments are often piecemeal constructs adapted from different departments such as fisheries, agriculture, water, forestry, environment, trade or marine affairs. Governance through fragmented policies and regulations and multiple institutions leads to inefficiency, little or no enforceability and thus ineffective governance mechanisms. Moreover, the rapid growth of the sector challenges countries' institutional and legal frameworks to keep abreast of development or in some jurisdictions, limited attention is paid to aquaculture governance owing to the sector's modest importance in economies and social lives. Furthermore, the high costs borne by farmers conforming to regulations and requirements, including consumer standards, have become a governance issue leading to non-compliance in some instances, particularly among small-scale producers.

Policymakers must consider how to develop strong legal and institutional frameworks that recognize aquaculture as a distinct economic sector. Compliance is fundamental, and rules and regulations must therefore be implementable and affordable for farmers and other players. Likewise, licensing systems need to be efficient and transparent, and aquaculture must be factored into resource use and development plans. Moreover, the safety and quality of aquaculture products must meet national, regional and global standards. Finally, it is essential to improve aquaculture management, fostering expansion and sustainable growth, while preventing harmful impacts (Curtis *et al.*, forthcoming) and enhancing aquaculture's contribution to achieving the SDG targets. These considerations are particularly important given that the last decade's improvement in governance standards – resulting in enhanced productivity and product quality – has been accompanied by a decline in the aquaculture production growth rate.[5]

The significant contribution of small- and medium-scale producers to sustainable growth of aquaculture production must increase further if the sector is to enhance its relative contribution to achieving the SDGs; small- and medium-scale producers should be encouraged and enabled to intensify and expand production.

Aquaculture intensification and expansion require substantial funding and investment (see the section Aquaculture investments for Blue Transformation, p. 119). Governance should address the constraints to funding and investment by creating an enabling environment and promoting incentives attractive for investors and lending institutions. Aquaculture expansion also requires additional natural resources, mainly land and water, which may result in or exacerbate environmental and social conflicts arising from competing uses. Zoning and integrated coastal planning are effective tools for collaboration among competing users, helping to avoid or lessen conflicts while allowing the sector to grow. In countries with limited land, freshwater and coastal resources for inland and marine aquaculture expansion, growth depends on the acquisition of technological innovations such as onshore, recirculating and offshore

5 From 5.9 percent in 2001–2010 to 4.3 percent in 2011–2020.

farming systems. Diversification is also vital to lessen risks of crop failure and enhance farm sustainability. Moreover, aquaculture producers should take advantage of developments in digitalization, information and communications technology (ICT) and robotics (see the section Digitalization in aquaculture: governance and technologies, p. 122).

Aquaculture investments for Blue Transformation

Adequate and sustainable investment is necessary to support and facilitate aquaculture development, intensification and expansion. Only with adequate investment in the aquaculture value chain can the sector's potential be unlocked (Aquatic Network, 2021), especially in less aquaculture-developed regions, such as sub-Saharan Africa, Latin America and the Caribbean and Southern Asia. Where the aquaculture sector is mature (e.g. Eastern and South-Eastern Asia), substantial investment is mostly needed to make aquaculture more eco-friendly and increase its resilience against climate, biological and financial risks.

Private investment is key for improving farm production and productivity, and post-harvest practices, but it requires easily accessible financial services, including bank loans, which remain limited and complex in several developing countries. Recurring problems include lack of collateral, excessively high interest rates, the perception (among bankers) that aquaculture carries a particularly high risk of failure, lack of knowledge (among borrowers) of the modalities of applying for loans and limited information (among lenders) on successful aquaculture enterprises. Governments need to address these and other constraints for investors to optimize profits and banks to minimize the risks of lending. Some countries successfully adopted "no-collateral" strategies (e.g. group lending and village banks), public–private partnerships, alternative collaterals (e.g. titled land, often indicating the need for legal reforms) and government loan guarantees. Indeed, government loan guarantees as well as incentivized interest rates, reduce the problem of high interest rates and lower the risk of lending for financial institutions.

Strategic, shock-resilient, climate-smart, sustainable and financially viable investments in aquaculture expansion for Blue Transformation will require effective and supportive governance mechanisms at all levels. A key component of these mechanisms is an efficient policy and regulatory framework to create an enabling environment for investments in an environmentally and socially sustainable aquaculture that ensures economic profitability and fair distribution of benefits (see the section Good governance for aquaculture expansion, p. 117). Seaweed farming exemplifies the importance of such a framework. The industry has been receiving increasing attention as restorative aquaculture (The Nature Conservancy, 2021) that provides substantial ecosystem services and socio-economic benefits (Cai *et al*., 2021). Yet, investments in such nature-positive aquaculture have been hindered by often cumbersome bureaucratic licensing processes of aquaculture operations and poor recognition of the real ecosystem service value provided by seaweed farming activities.

For Blue Transformation of aquatic food systems, finance and insurance services are needed at local, national, regional and global scales. Innovative market-based mechanisms, such as carbon credits, nitrogen credits, blue bonds and green finance, are crucial to help reward blue investment for environmental benefits and ecosystem services provided by seaweed farming and other restorative aquaculture (Jones, 2021). With the aim of providing governmental, non-governmental, private and public stakeholders with information, resources and concrete pathways for obtaining financial services, FAO developed a set of Blue Finance Guidance Notes (FAO, 2020d), covering subjects such as insurance for small-scale fisheries and aquaculture, blue bonds, blended finance, impact investment and microfinance for small-scale fisheries.

While private investment is a key driver for global aquaculture development (Brummett, Cai and Marttin, 2017), public investment can help resource-poor farmers jump-start their aquaculture ambition (IFAD, 2018) and is crucial to address market failures such as inadequate private investment in public goods (e.g. infrastructure, improvement of genetic resources, biosecurity, technological innovation and market development). However, the lack of market mechanisms to guide public investments hinders their efficiency and effectiveness. Despite major investments worldwide in aquaculture infrastructure and services to support the growth objectives of the sector, the demands and needs of the stakeholders involved are often not met. Some infrastructures, particularly in markets and hatcheries, have ceased to function over time, remained idle or never operated at all, unable to meet the specific needs of sustainable aquaculture development.

Wealth creation from sustainable aquaculture ventures needs a full spectrum of resources and management. In addition to crucial biological and environmental aspects, sector development requires an economic and social enabling environment with access to basic infrastructures and services. Indeed, aquaculture in remote areas – without access to markets, roads and public transportation, lacking communication network, electricity, potable water, sanitation and healthcare – cannot succeed. At the same time, it is important to avoid conflict over resources, as communities/jurisdictions with more access to infrastructures may also become prone to various interest groups, especially those with better access to capital, potentially resulting in issues regarding distribution of costs and benefits. Planning and upscaling of investment for wealth creation should therefore include consultation of all stakeholders and a clear vision of who is investing and where, with full respect for the interests of the local communities (Menezes, Eide and Raakjær, 2011) (Box 11).

Building resilience of aquaculture and fisheries infrastructure against climate and other natural and human-made shocks has gained importance for Blue Transformation and, whether new facilities or upgraded existing ones, infrastructure needs to withstand storms, tidal waves, surges and floods. Aquaculture and fisheries infrastructure investments (seed production facilities, farm ponds, access routes, markets, etc.) must be strong and sustainable in the long term; therefore, to support the decision-making process, the World Bank and FAO developed the Fisheries Infrastructure Assessment Tool (FIAT). Applicable to investments (public or private) for enhancing and/or rehabilitating existing infrastructure as well as to new investments to support aquatic food value chains, FIAT is currently being tested in several countries.

Aquaculture innovative practices

Innovative aquafeeds and feeding

The expansion of aquaculture over recent decades, and any further growth as part of global Blue Transformation actions, need to be underpinned by innovations in nutrition of aquatic animals and the development of extruded feeds. Fed aquaculture has continued to contribute a large and increasing share of the sector's output, highlighting feed's crucial role in the industry (see the section Aquaculture production, pp 26). Feed cost consistently ranks top among the farming inputs of many fed fish species and crustaceans. Furthermore, life cycle assessment (LCA) studies have indicated that aquafeeds are often the dominating contributor to undesirable environmental impacts associated with commercial aquaculture activities. High-value aquaculture species (e.g. salmon, seabass and shrimp) require high-protein diets, which traditionally have relied on fishmeal and fish oil extracted from wild pelagic fish resources, which are also important for food security.

By 2050, aquaculture is projected to expand and intensify further, almost doubling its current production. To sustain such production levels, large volumes of feed will be needed in terms of affordable protein, essential amino acid, additives, omega-3 fatty acids, key minerals, vitamins and energy sources. This will require the sourcing of additional raw materials that are currently either not available or otherwise used.

Considerable research has focused on the replacement of fishmeal and fish oil with cheaper and potentially less environmentally burdensome ingredients, such as plant by-products, algae (micro- and macro-),[6] insects, fish and land animal by-products, and single-cell proteins (including from bacteria and yeast). Furthermore, progress has been made in the usage of fisheries and aquaculture

6 For algae, see Glossary, including Context of SOFIA 2022.

BOX 11 OFFSHORE AQUACULTURE

With increasing competition for coastal sea space, there is growing interest in the potential for expansion of offshore aquaculture[1] in deeper waters, further from the shore, with generally stronger currents.[2] Expansion offshore of commercial aquaculture has already begun for high-value marine fish and salmonids in established aquaculture nations such as Norway, Türkiye and China, as well as in less advanced aquaculture nations such as Panama and the United States of America. Offshore farming systems offer potential to achieve better economies of scale. Properly sited operations have much lower impacts on water quality, the substrate and associated benthic organisms living on or within bottom sediments and entail lower operational risks associated with farming activities. This requires, however, careful assessment.

Participation in offshore aquaculture remains limited due to the high capital investment needed for equipment and sufficient feed to meet the requirements of the large quantities grown offshore. Properly structured financing is thus necessary to support growth of the industry. Furthermore, the increasing role of technology in offshore cages reduces the labour requirements per tonne of production compared with coastal or nearshore aquaculture. This in turn decreases the employment opportunities for unskilled or semi-skilled workers. However, offshore culture of non-fed aquaculture species in nutrient-rich waters, such as seaweeds and bivalves, could be more inclusive of medium- and small-scale operators, because no outlay is required for feed and farming structures are less expensive.

Industry and regulatory agencies should ensure that environmental and social impacts from offshore fish farming are properly monitored[3] and managed. Further analysis is needed, not only to appreciate the effects of increasing scale of operations in deeper water sites, but to improve predictive modelling of impacts. It is also imperative to fully understand the benefits of cultivating non-fed species, through nutrient or particulate uptake, absorption of carbon, or increased biodiversity through the provision of adequate offshore farming structures.

Expansion of offshore aquaculture could make a significant contribution to achieving global food production goals, increasing the availability of aquatic products to consumers and lowering production costs and, therefore, possibly market prices. This can then provide broad societal benefits through improved nutrition, decreased pressure on wild fishery stocks and reduced reliance on terrestrial livestock to support growing animal protein needs.

[1] Aquaculture is considered “offshore” when, *inter alia*, it is over 2 km from the coast, in water over 50 m deep, and with waves at least 5 m high, variable winds and strong currents, and where there is a requirement for remote operations.
For a full definition: Lovatelli, A., Aguilar-Manjarrez, J. & Soto, D., eds. 2013. *Expanding mariculture farther offshore: Technical, environmental, spatial and governance challenges*. FAO Technical Workshop, 22–25 March 2010, Orbetello, Italy. Rome, FAO. www.fao.org/3/i3530e/i3530e00.htm
[2] Gentry, R.R., Froehlich, H.E., Grimm, D., Kareiva, P., Parke, M., Rust, M., Gaines, S.D. & Halpern, B.S. 2017. Mapping the global potential for marine aquaculture. *Nature Ecology and Evolution*, 1: 1317–1324. https://doi.org/10.1038/s41559-017-0257-9
Kim, J.K., Stekoll, M. & Yarish, C. 2019. Opportunities, challenges and future directions of open-water seaweed aquaculture in the United States. *Phycologia*, 58(5): 446–461. https://doi.org/10.1080/00318884.2019.1625611
[3] Welch, A.W., Knapp, A.N., El Tourky, S., Daughtery, Z., Hitchcock, G. & Benett, D. 2019. The nutrient footprint of a submerged-cage offshore aquaculture facility located in the tropical Caribbean. *Journal of the World Aquaculture Society*, 50: 299–316. https://doi.org/10.1111/jwas.12593

by-products to produce fishmeal as well as in the use of agricultural protein sources to replace fishmeal and fish oil extracted from wild pelagic resources. While these novel alternative ingredients introduce their own challenges to feed supply chains, the future sustainability of the fed aquaculture sector nevertheless remains intimately dependent on the sourcing of new and nutritionally balanced feed components that lessen these impacts.

To be considered economically and environmentally viable, alternative protein sources need to meet several criteria: (i) nutritionally adequate (i.e. digestible, and not significantly impairing the physiological functions, growth and health status of the farmed species); (ii) palatable to the farmed organism; (iii) obtained from sustainable production scalable to commercial levels; (iv) physically stable; (v) easily handled and stored; and, more crucially, (vi) nutritious and with lower environmental and life cycle impacts.

Expansion of the fed aquaculture sector requires the development of additional, cost-effective ingredients to meet the rising demand for feed and rely less on traditionally sourced marine ingredients. As demand grows, competition for feed ingredients intensifies, as does awareness of the sustainability of feed production. Indeed, producers of feed ingredients are increasingly required to demonstrate sustainability and traceability, including through certification schemes such as those of the Aquaculture Stewardship Council (ASC), the Marine Stewardship Council (MSC) and Marin Trust.

Given the limited availability of freshwater, declining amounts of arable land and lack of essential nutrients such as phosphates, and considering the intense competition for most currently used plant protein resources (for both human consumption and terrestrial animal feed), land crop products are not the only answer. On the contrary, it is vital to develop alternative, non-traditional protein and oil sources, such as seaweed, algae and microalgae, single-cell proteins, microbial biomass and insects, and to recycle food waste, to meet future aquaculture feed demand (Glencross *et al*., 2021) and aid the sustainable growth of aquaculture (Cottrell *et al*., 2020).

In terms of good feeding practices, precision feeding and adoption of formulated feeds based on the life stages of the farmed aquatic animals and their nutritional attributes will further help lower feed costs and reduce wastage, thus ensuring energy and resource efficiency in transformed aquaculture systems. Furthermore, in order to meet future global food demand for aquatic food, the sector should also work towards improving feed for species such as carps and tilapia, which account for the largest proportion of aquafeeds.

Digitalization in aquaculture: governance and technologies

With the expansion of digital technologies – platforms, software and infrastructure – digital applications are increasingly deployed in aquaculture (albeit at a slower pace in many developing countries), particularly to improve business planning and siting, farm stock management, environmental monitoring, risk prevention, biosecurity and intelligent automation of routine farm activities.

Digital technologies can be used to tackle many of the production challenges faced by the sector and to set up early warning systems to alert producers about critical intrinsic and extrinsic events affecting a production facility. On-farm precision technologies lead to lower feed usage and waste, better water quality and reduced labour costs, thereby enhancing the environmental and economic sustainability of farms. Off-farm access to aquaculture technologies using ICT (e.g. mobile phones and other electronic devices), e-commerce platforms and digital payment systems shorten supply chains and reduce transaction costs throughout the value chain.

Aquaculture spatial planning and siting has improved thanks to digital technology. For example, the availability of satellite images and accessibility to oceanographic, hydrological and meteorological data (e.g. water temperature, precipitation patterns, salinity levels, storm frequencies) through remote sensing over long periods of time, combined with the use of digital imaging drones, have not only improved planning quality and speed, but have enabled a more comprehensive application of the ecosystem approach to aquaculture (EAA).[7] Geographic information system (GIS) applications have facilitated the identification and allocation of opportunity aquaculture areas, particularly in shared waterbodies.

The deployment of digital technology (e.g. sensors, robots and cameras) in aquaculture production operations provides real-time and distant monitoring of farmed organism and culture facilities, significantly improving labour efficiency, feeding precision, aeration, water quality and pathogen monitoring. These technological advances enable an increasingly rapid response to adverse farming conditions, reducing production costs thanks to

7 For ecosystem approach to aquaculture, see Glossary.

efficient use of input resources and to reduced losses due to mismanagement or human error.

However, technical and financial support is essential to kick-start or advance the above technologies, while conducive governance frameworks are crucial. For example, an electronic platform for interactive discussion, planning, information generation and transfer data sharing and certification can facilitate product and information flows throughout the supply chain and prevent conflicts between users arising from information asymmetry; however, governance to develop and manage such a platform is of paramount importance. Moreover, harmonization of national and international rules and standards is necessary to increase transparency, improve cybersecurity and reduce the digital divide.

Integrated multitrophic aquaculture

In integrated multitrophic aquaculture (IMTA) systems, nutrients from uneaten feed and excreted waste of fed species become food for extractive species, hence reducing nutrient release into the environment while enhancing overall productivity. There is growing interest in IMTA as part of Blue Transformation programmes, which however requires significant architecture of facilities and equipment to combine multiple species into an integrated system (e.g. seaweed farming and bivalve mollusc culture combined with finfish cage farming) and entails additional management to produce and market the multiple crops. IMTA as a system for bioremediation at sea offers a potential solution to address the concerns of marine fed aquaculture releasing organic and inorganic wastes into the environment.

Integrated agriculture-aquaculture (IAA) production systems, where two or more aquaculture and agricultural activities take place concurrently or sequentially, have existed for centuries in East Asia and since the 1960s in Latin America and Africa, albeit on a smaller scale. IAA includes livestock–fish (e.g. pig rearing and fish), bird–fish (duck rearing and fish) and rice–fish/shrimp production systems. These systems are usually extensive or semi-intensive; agricultural waste is introduced into a fish stocking system – either by adding manure or by housing livestock in enclosures directly above the pond – to boost water fertilization and improve secondary growth of phytoplankton and zooplankton as food for the fish. In integrated irrigation-aquaculture (IIA) systems, on the other hand, the plant tends to be the primary crop and fish the secondary crop providing nutrient-rich effluent benefiting plant growth. Likewise, in aquaponics – a more recent form of IAA – the plant element is the main commercial crop. These systems bring important environmental advantage: optimal use of water resources as well as of dissolved nutrients that would otherwise be lost in the effluents of an aquaculture system.

All integrated production systems remain an area of great interest globally, particularly in small- and medium-scale production systems when technically feasible, and provide an economic benefit to the entrepreneur. The need to make effective use of the resources available without negatively affecting the environment is the driving force behind the adoption of such farming systems.

Bivalve aquaculture

Bivalve aquaculture can have an important role in aquatic "nutrition-sensitive" food systems – i.e. systems embedded in society, which provide a diverse and nutritionally complete set of foods and contribute to sustainable livelihoods – as bivalve molluscs provide a balance of bio-accessible nutrients for a healthy and active lifestyle, while farming enhances the livelihoods of coastal communities. Furthermore, there is growing recognition of the wider ecosystem benefits of bivalve aquaculture in coastal waters, including its regulating services such as carbon sequestration, nutrient remediation and coastal protection.

The developmental potential of bivalve aquaculture subsectors remains significant, particularly in the marine environment. Bivalve mollusc aquaculture is certainly important in the Americas, Europe, Asia and Oceania. In Africa, on the other hand, bivalve production remains negligible, although interest is steadily increasing where FAO projects have focused on transferring farming technologies (e.g. clam farming in Djibouti, mussel farming in Morocco) and on product diversification and the expansion of local consumption (e.g. oyster farming in Senegal).[8] Harvesting wild bivalves has been practised for centuries by marine coastal communities in Africa, particularly by women. Unfortunately, the wild stocks have been overexploited in many locations and aquaculture is considered key to reduce the pressure on wild stocks and secure the livelihoods of women and coastal communities.

As extractive culture species, bivalves are ideal for aquaculture: they do not require artificial feeds and the investment burden and running costs are significantly lower than for operations farming carnivorous finfish species. Nevertheless, the development of molluscan aquaculture at the global level is slow, in part due to the strict sanitary requirements to access international markets, requiring monitoring of harvesting waters and attainment of product safety standards. Moreover, while bivalve farming technology is often accessible and affordable, access to spat is complex and biosecurity requirements are often very stringent particularly if export markets are targeted.

In the past two decades, global finfish production has nearly tripled, while farming of bivalve molluscs has barely doubled; there is, therefore, good potential for expansion through Blue Transformation initiatives. Cupped oysters and Japanese carpet shell dominate bivalve production, followed by scallops and mussels (see the section Aquaculture production, p. 26). The reliance on wild spat for farming bivalve molluscs is still high for many regions and species globally. In recent decades, hatchery design and technology have seen major advances in terms of conditioning, spawning, larval care and setting, accompanied by higher survival rate of the animals. Phytoplankton production in hatcheries has similarly advanced with computer-aided monitoring and metering of feed to larval shellfish, again enhancing survival and growth. Development of improved setting procedures and equipment have allowed growers to produce seed aimed at their specific needs, while better handling of materials has enabled advances in large-scale setting and planting, especially of oysters. Furthermore, shellfish aquaculture has benefited from selective breeding and the development of disease-resistant and fast-growing strains and varieties with unique shell colours. Further research and technology development on bivalve culture presents a new frontier to support sustainable aquaculture expansion worldwide, with particular attention to the prevention of harmful algal blooms and their impacts on fisheries, aquaculture and food safety.

Capacity development, research and partnerships in aquaculture

The recently prepared draft Guidelines for Sustainable Aquaculture (GSA) also assessed the need for capacity building as a key component for ensuring an enabling environment and supporting implementation of the GSA (Jolly and Menezes, forthcoming). The draft guidelines support the overall aquaculture principles and provisions of the Code of Conduct for Responsible Fisheries and the implementation of the SDGs through Blue Transformations in the subsector. A desk review conducted in 2021 on the enabling environment for aquaculture development, particularly on aspects relevant to capacity development, extension and research, indicates that: (i) human and institutional capacities, critical technical skills (at the farmer and the extension/trainer level) and financial resources need to be significantly improved; (ii) extension education is required to transfer technical information to farming communities and to cover the needs of operators; (iii) low levels of digitalization persist with less than 50 percent of educators having competencies in ICT literacy; (iv) many institutions are unable to support extension services through ICT; (v) smallholder farms still have limited Internet accessibility; and (vi) aquaculture has expanded without sufficient knowledge based on scientific information derived from research. Given these challenges, knowledge and skills of public administrations, research institutions, extension services and labour need to improve significantly in the coming decade.

Training capacity and services, including extension, vary from country to country and include formal and informal education channels. In important aquaculture countries

8 For further details, see the FISH4ACP Project: www.fao.org/in-action/fish-4-acp/en

BOX 12 AQUACULTURE FIELD SCHOOLS IN AFRICA: THE IMPACT ON YOUTH AND WOMEN

The Aquaculture Field School (AFS) approach is an adaptation of the innovative, participatory and interactive learning approach, the so-called Farmer Field School (FFS), developed by FAO in Southeast Asia starting in the late 1980s. It proved to be remarkably successful and quickly expanded to other countries in Asia, Africa, the Near East and Latin America. The demand for FFS programmes is thus increasing, and in several countries, the approach has been institutionalized in national extension systems.

Based on the principle of FFS, the fish farming sector has expanded the methodology to increase the involvement of youth and women in aquaculture. The AFS aims to give a voice to rural women, youth and vulnerable persons and contribute to their social and economic empowerment by improving their skills in fish farming, entrepreneurship and aquaculture business management and increasing their access to aquaculture services and resources such as farm inputs and credit facilities.

FAO provides technical assistance to governments interested in the AFS approach by training master trainers, trainers and facilitators. Each facilitator then trains a group of 25–30 persons to tutor women and youth in leadership capabilities for decision-making in aquaculture. The beneficiary communities select the members of the group who will participate in the AFS.

In various countries in East Africa, an important spillover effect has emerged: many non-AFS members, witnessing the successes of aquaculture, have developed an interest in AFS activities and requested assistance to form new groups. The participatory approach to learning new or improved fish farming activities has paid off in many cases with participants generating financial resources from the sale of their produce; they have thus been able to invest the extra income in house repairs and construction, pay school fees for their children, etc. At the end of the production cycle there is a graduation ceremony during which diplomas are awarded to the participants. The AFS (or FFFS – Fish Farmer Field School) has a key role to play in the further development of the aquaculture sector in rural areas. The success of the approach should lead to upscaling and further promotion of FAO's work in the sector.

FAO in close collaboration with government institutions continues to implement various AFS-inspired Technical Cooperation Programme projects with encouraging results. For example, in Kenya, 36 groups across the country were targeted and 80 groups eventually formed (with approximately 2 000 direct beneficiaries). A subregional project in Burundi, Rwanda and Ethiopia focuses on producing fish in rice paddy fields; in addition to increased production of rice and fish for better nutrition, there are also social, environmental and financial benefits.

of Asia, Europe and the Americas, aquaculture education is well established at undergraduate and graduate levels. In Africa, some educational institutions offer dedicated aquaculture courses. However, across the globe, recruiters emphasize that both subject-specific knowledge and a range of generic skills are needed for graduates to perform efficiently (Pita *et al.*, 2015) and spearhead Blue Transformation. Challenges include insufficient graduates and/or specializations that fail to meet employers' requirements (Blue Earth Consultants, 2020; Engle, 2021).

Vocational training remains an important mechanism in human capacity development. Asia has made significant investments in this area to train individuals in specialized skills. The European Commission's Europe 2020 strategy for smart, sustainable and inclusive growth focuses on two key elements: student mobility and an agenda for new skills and jobs to attract and retain youth in various sectors, including aquaculture. In sub-Saharan Africa, FAO has collaborated with various institutions, including the Centre of Excellence in Aquaculture and Fisheries Science in Malawi and universities in Kenya, Nigeria and the United Republic of Tanzania, WorldFish, Norwegian Agency for Development Cooperation (NORAD) and local governments, to provide vocational capacity-building, extension services and research.

Capacity development needs to be planned and implemented in close association with the development of national multidisciplinary research programmes to improve competitiveness, production efficiency, economic viability and long-term social and environmental sustainability of the sector, and to make advances in genetics, nutrition, health and technology development. It is also important to support the creation of functional applied research (Little, Newton and Beveridge, 2016) consortiums and development systems at the national and regional levels. State-owned and private aquaculture research facilities are encouraged to focus on the adoption and dissemination of international protocols and best farming practices and proper utilization of water and local species resources. Research should focus on applied spatial planning, breeding and genetics, feed production and digital technology applications for higher efficiency in farming operation and management. To help identify problems and design research solutions, scientists should use field and traditional knowledge from farmers and communities, who in exchange would benefit from the results and improved technology through the extension process.

National aquaculture extension programmes should continue promoting proven aquaculture models and production technologies. Aquaculture extension information is dynamic and should evolve and generate changes in farmer behaviour to enhance sustainable production. In most cases, the government is the primary supplier of extension services. Other extension service providers include international governmental organizations (IGOs), non-governmental organizations (NGOs), the private sector (mainly equipment, seed and feed suppliers), farmer-to-farmer extension programmes and self-education (e.g. study tours and farmer field schools) (De, Saha and Radheyshyam, 2013) (Box 12).

Although still far from sufficient, the use of ICT is increasingly reducing the gap in access to information and improved management skills of smallholder farmers (Trendov, Varas and Zeng, 2019; Qiang *et al.*, 2012). Some digital initiatives across Africa and Asia support the delivery of extension services (Costopoulou, Ntaliani and Karetsos, 2016; Tsan *et al.*, 2019).

With the development of digital technology, FAO is establishing a regional technology platform for aquaculture. The online academy (FAO, 2020e) aims at improving accessibility to and inclusion in aquaculture practices, as well as facilitating policy dialogue across the board. Many governments have also established digital platforms (EATIP, 2021) on aquatic biosecurity surveillance, launched mobile apps on farm-level management and product traceability, as well as a cooperative platform for farmers, such as the shrimp farmers' dashboard (g-nous, 2020).

Partnerships are essential in Blue Transformation capacity-building efforts. In recent decades, IGOs, international financial agencies, civil societies and the various regional aquaculture networks of Asia-Pacific, Africa, Central and Eastern Europe, the Americas, and in small island developing States, have made strides to incorporate and adapt aquaculture capacity-building programmes (FAO Committee on Fisheries, 2015; Ahonen and Pirhonen, 2018). More partnerships are needed to encourage technology transfer and exchange among countries (Box 13). ■

IMPROVING FISHERIES MANAGEMENT

Objectives and targets

With less than ten years to achieve the Sustainable Development Goals (SDGs), accelerated transformative action is essential along the triple bottom line of ecological, economic and social sustainability. Blue Transformation[9] offers significant opportunities to improve fisheries management to:

- achieve secure equal rights to access resources, services and infrastructure, decent work and economic growth (SDGs 1, 8, 12, 14);
- secure both nutritious foods and livelihood opportunities, with equal access to fisheries for women and men and reduced inequalities through social, economic and political inclusion of all (SDGs 2, 5, 10, 14); and

9 For Blue Transformation, see Glossary.

BOX 13 INTELLIGENT PARTNERSHIPS: POWERFUL PLANNING AND DELIVERY MECHANISMS IN TIMES OF CRISIS – EXAMPLE OF A PROJECT IN MOZAMBIQUE

Partnerships can be valuable tools for delivering projects and introducing good practices during crises. In June 2020, at the peak of the COVID-19 pandemic, as rural communities in Mozambique faced various challenges, FAO responded to a request from a ground-based national organization, Fundação para o Desenvolvimento da Comunidade (FDC), to improve the traditional subsistence integrated aquaculture–agriculture practices for building resilient livelihoods against climate and health-related shocks. The FAO–FDC partnership promoted improved practices to enhance food production and nutritional security, while empowering women and youth.

Project activities included:

- re-introduction of traditional agricultural farming systems at a small- and medium-scale enterprise level, with fish farming as the core activity;
- application and adoption of integrated fish farming with emphasis on efficient utilization of available resources, recycling waste and saving energy, while maintaining ecological balance; and
- implementation of capacity-building programmes for youth and women.

After just one year, the Integrated Aquaculture Initiative on the Chilembene Historic Site project had provided employment and on-the-job training to many people; conducted research and development activities, including fish value chain assessments in various districts; renovated farm facilities; produced 16 tonnes of fish and sizeable quantities of chickens and rabbits; planted 8.5 ha of maize, beans and sweet potatoes; and was progressing to pig and duck farming.

The project highlights three important lessons:

1. Strong partnerships require all partners to commit to pursuing common goals and sharing risks, but the major building block is mutual trust.
2. Stakeholder partnerships, such as FAO–FDC, have the power to entice expertise and resources from both sides to build on challenges and turn them into opportunities for national and local economies.
3. With commitment and accountability on all sides, difficulties can be surmounted, success can be achieved and development can be accomplished – in any sector. Aquaculture is just one example!

Youth and women develop skills in aquaculture and agriculture best practices to increase resilience and diversification of livelihoods, Chilembene, Mozambique. ©FAO/Telcinia Nhantumbo
For further information, see: www.youtube.com/watch?v=XfrJEKLR3OE

» ▸ attain the sustainable and efficient use of inland and marine aquatic resources for responsible consumption and production (SDG 12).

To achieve these objectives, fisheries management must be science-based, context-specific, based on inclusive, transparent and multidisciplinary policies, and resulting in plans and actions developed in equitable ways. Managers must use targets based on both biological and social science parameters and, wherever possible, draw on local knowledge to establish management objectives and regulations, to collect, analyse and evaluate data, and to monitor fisheries management effectiveness. In coming sections, the necessary principles and transformative changes to improve fisheries will be discussed, including governance and policy reforms, effective management protocols, incorporation of innovative technologies and strong social protection systems.

Better governance and policy reform

The international community has adopted a legal framework for sustainable fisheries, recognizing the sector's important role for food security and nutrition, economic development, protection of the environment and the well-being of people. The basic international instrument is the United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982, which provides the legal framework for all maritime activities, including conservation and utilization of living marine resources.

In the early 1990s, the international community developed new approaches to fisheries and aquaculture management, embracing conservation and environmental as well as social and economic considerations. Under the auspices of FAO, several global instruments for fisheries management have been established. The Code of Conduct for Responsible Fisheries (the Code), adopted in 1995, provides detailed provisions for the responsible and sustainable management and use of living aquatic resources, with due respect for the ecosystem and biodiversity (FAO, 2021c). Voluntary in nature, the Code is probably the most cited, high-profile and widely diffused and used global fisheries instrument after UNCLOS. In its framework, four international plans of action and six international guidelines for responsible fisheries management have been developed, and two FAO legally binding agreements have been adopted addressing the issues of: (i) flag State responsibility in the high seas (the FAO Compliance Agreement); and (ii) port State responsibilities to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing (the Port State Measures Agreement).

In 2021, FAO Members called for FAO to develop Voluntary Guidelines for Transshipment to ensure that all movements of fishery catches are sufficiently regulated, monitored and controlled to prevent IUU harvests being laundered into the supply chain (Box 14); the Guidelines will build on the primary responsibility of the flag State to implement regulations.

Based on a biennial questionnaire, FAO monitors progress in the implementation of the Code and its related instruments. The self-reporting by FAO Members reveals informative trends along the themes of the Code; however, varying numbers of respondents over the years make detailed analysis challenging. While there has been progress, effective implementation of the Code and related instruments is hampered by limited budgetary means and human resources, incomplete policy and legal frameworks, and inadequate scientific research and information, particularly for developing States.

The success of global instruments and normative processes depends on regional efforts; they must be implemented and translated into actions at the country and regional levels, as appropriate. The United Nations Fish Stocks Agreement, an implementing agreement under UNCLOS, contains fisheries management principles and focuses on regional cooperation within regional fisheries management organizations (RFMOs) and regional fisheries advisory bodies (RFABs), collectively referred to as regional fisheries bodies (RFBs). RFBs play a central role in fisheries management, cooperating to ensure common approaches on various cross-cutting issues, at both the global and regional levels and on specific technical matters. Some RFBs are under the FAO constitutional framework, but FAO also supports other RFBs, including through the Regional Fishery Body Secretariats' Network, which fosters cooperation and facilitates consultation

BOX 14 REGULATION, MONITORING AND CONTROL OF TRANSSHIPMENT TO REDUCE THE RISK OF IUU-CAUGHT FISH ENTERING THE MARKET

Transshipment – the transfer of catch from one fishing vessel to either another fishing vessel or a carrier vessel – is widely practised in all regions to reduce fishing operating costs and maximize fishing opportunities. The international community has for some time expressed concerns about the risks that transshipment represents in supporting illegal, unreported and unregulated (IUU) fishing operations and related criminal activities. IUU fishing undermines national and regional efforts to manage fisheries sustainably and conserve marine biodiversity. IUU fishing distorts competition, puts legitimate fishers at an unfair disadvantage, and negatively impacts the well-being and food security of people in coastal communities, particularly in developing States and small island developing States.

An FAO in-depth study on transshipment,[1] called for by the Thirty-third Session of the Committee on Fisheries (COFI, July 2018) and presented at its Thirty-fourth Session (February 2021), concluded that transshipment, if insufficiently regulated, monitored and controlled, can increase the risk of IUU-caught fish entering the food supply chain, and the analysis of transshipment practices showed that significant risks exist that transshipment contributes to laundering IUU-caught fish into the market.

The Thirty-fourth Session of COFI welcomed the study and called on FAO to proceed with developing draft voluntary guidelines for transshipment. The objective of these guidelines is to provide assistance for the development of transshipment regulations or the review of existing ones, with a view to integrating these within the broader regulatory framework, and to ensure compliance with existing regulations through standards for effective monitoring, control and surveillance. The FAO Secretariat has elaborated draft guidelines for this purpose, building on the primary responsibility of the flag State to implement transshipment regulations. The current draft introduces transshipment declarations and landing declarations, ensuring that all movement of fish is documented.

An expert consultation that brought together the best technical, operational and legal expertise from all regions was held in October 2021 to review the draft guidelines. A technical consultation is planned for 2022 to negotiate the voluntary guidelines for transshipment with a view to their adoption before submitting these to the Thirty-fifth Session of the Committee on Fisheries for review and endorsement.

[1] FAO. 2020. *Transshipment: a closer look – An in-depth study in support of the development of international guidelines*. Rome. www.fao.org/documents/card/en/c/cb2339en

and sharing of experiences. FAO supports and oversees these processes and developments and assists with the strategic reorientation processes of some of its RFABs.

In areas beyond national jurisdiction (ABNJ), sustainable utilization of fisheries resources requires the conservation and sustainable use of biodiversity, which is the aim of the ongoing negotiations for a new international legally binding instrument (ILBI) under UNCLOS for the conservation and sustainable use of biodiversity beyond national jurisdiction (BBNJ). FAO provides fisheries information and guidance on issues related to FAO's mandate, and RFMOs assume a key role in supporting the implementation of the ILBI, particularly concerning area-based management tools and environmental assessments. In addition, the World Trade Organization (WTO) agreed during its twelfth Ministerial Conference on disciplines addressing fisheries subsidies with a focus on overfished stocks and IUU fishing. The associated WTO fisheries funding mechanism in support of the implementation of the new rules foresees a specific role for FAO to contribute with technical expertise.

In a time of challenges caused by overexploitation of natural resources, continued food insecurity and poverty, and changing climate, the international community increasingly recognizes the importance of regional and international cross-sectoral collaboration and cooperation in facilitating achievement of the objectives set out by the 2030 Agenda for Sustainable Development. The outbreak of COVID-19 has strongly reaffirmed this and reasserted the central role of cross-sectoral cooperation to address the challenges of global fisheries governance. Initiatives to enhance cross-sectoral collaboration among regional seas organizations and RFBs, to further strengthen their complementary roles in supporting local, national and regional implementation, are ongoing with the concerted support of FAO, the Convention on Biological Diversity (CBD) Secretariat, the United Nations Environment Programme (UNEP), the International Labour Organization (ILO) and the International Maritime Organization (IMO). These organizations need to strengthen further their collaboration, including through the Joint Working Group on IUU fishing and related matters.

Better management and production

Ecosystem considerations

The ecosystem approach to fisheries (EAF) was adopted in 2003 by the FAO Committee on Fisheries (COFI) as the overarching framework for fisheries management and development and it laid out several significant principles:

- First, all fisheries should be managed and, to do that, they should be assessed.
- Second, management should be precautionary and tailored to the specific characteristics of each fishery system.
- Finally, both fisheries assessment and management should be participatory, based on best available knowledge, and should cover, in an explicit and balanced way, the ecological, social and economic dimensions of fisheries.

These principles – and the need to consider the interactions and interdependencies between multiple components of the ecosystem and to balance ecological, economic and social benefits – have been widely accepted by most organizations and fora dealing with fisheries management. However, implementation of the EAF has yet to fully transform fisheries management, and imbalances remain in the way ecological, social and economic dimensions of fisheries are considered across regions and countries.

Managing a fishery in accordance with the EAF requires identification of the relevant elements in an ecosystem and the linkages between them. This is doable in the case of highly developed large-scale fisheries, but it is a daunting task in the context of data-poor, multispecies fisheries, in particular small-scale fisheries. Although the information needs are much broader under the EAF than in conventional fisheries management and assessment, new skills and tools and multidisciplinary approaches can provide the basis for a sound analysis and management.

Management outcomes can be measured using simple indicators (preferably developed with the participation of stakeholders) (Box 15). Fishers and other fishery stakeholders have a wealth of knowledge and experience that can be directly applied in fisheries management. The responsible entities should focus on facilitating participatory and collaborative approaches and governance processes such as co-management or citizen science, in order to empower stakeholders by developing their capacities and reducing conflicts while facilitating adaptive management. This is an efficient way to achieve sustainability – ecological, social and economic – in a changing environment.

Tenure, rights and co-management

There are numerous societal objectives that can be met by fisheries resources and aquatic ecosystems to improve human well-being and equity between various stakeholders while ensuring that the systems that sustain these services are not irretrievably compromised. The EAF facilitates explicit and balanced consideration of the wide range of ecological, social and economic objectives that fisheries resources and aquatic ecosystems offer, and it requires engagement and co-management involving a broad range of stakeholders in the prioritization of objectives and management decision-making.

The Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security[10] and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context

10 Endorsed by the Committee on Food Security (CFS) in 2012 (FAO, 2012a).

BOX 15 MEASURING MANAGEMENT EFFECTIVENESS

Fisheries management encompasses a system of suitable, science-based objectives implemented through context-specific strategies, regulations and tools. This includes a system for encouraging compliance and monitoring to ensure that management can adapt and adjust to unforeseen deviations from the planned path. Effective management systems can achieve social and economic benefits while maintaining the sustainable production of fishery resources and the function and structure of the ecosystem they depend on. Where fisheries are effectively managed, fishery stocks are above target levels or rebuilding, ensuring the sustainable production of fisheries resources.[1]

However, assessing and measuring management effectiveness should go beyond simple metrics of whether stocks are at sustainable levels and should assess whether the main elements of such systems are well designed and effectively implemented. Although management systems are as diverse as the fisheries they target, effective fisheries management requires four basic processes: (i) a legal framework for a legitimate mandate to manage fisheries; (ii) an appropriate institutional arrangement; (iii) inclusive and participatory decision-making processes; and (iv) mechanisms to implement regulations, monitor their effectiveness and ensure accountability. Within each of these processes, there are actions and strategies that need to be tailored to the contextual (e.g. socio-economic, ecological and cultural) realities of the areas of operation of the fisheries.

Several attempts have been made in developing and implementing systems to measure fisheries management effectiveness, including management effectiveness in exclusive economic zones,[2] the Fisheries Management Effectiveness component of the Ocean Health Index[3] and the Fisheries Management Index.[4] These initiatives have both commonalities (e.g. similar elements of the management systems were identified as critical) and differences (e.g. some were specific to fishery stock while others were at the national level) and have had different degrees of success at generating high-level information on the effectiveness of management systems at a regional or global level. Yet, measuring effectiveness at more localized levels aimed at supporting national agencies to identify strengths and weaknesses in their management processes requires specific in-country efforts to capture information from multiple sources in a participatory, multi-stakeholder manner. Equally important, any system aimed at measuring management effectiveness needs to consider the different contexts in which the fishery systems are embedded. For instance, the EAF Implementation Monitoring Tool has been designed to help countries monitor progress and achievement in the implementation of the ecosystem approach to fisheries (EAF) as well as identify gaps and challenges where greater efforts are required to improve the country´s national fisheries management.[5]

Developing and monitoring a national system for measuring fisheries management effectiveness that includes both process (i.e. whether key elements and steps of fisheries management are in place) and outcome indicators (i.e. whether the intended social, economic and ecological objectives and targets are met) is critical in the quest for improving fisheries management globally. The effective implementation of these systems will entail additional efforts in improving data and information as well as inclusivity, accountability and transparency to provide a real-time participatory view of the performance of fisheries management goals, indicators and strategies.

[1] Hilborn, R., Amoroso, R.O., Anderson, C.M., Baum, J.K., Branch, T.A., Costello, C., de Moor, C.L. *et al.* 2020. Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences*, 117(4): 2218–2224.
[2] Mora, C., Myers, R.A., Coll, M., Libralato, S., Pitcher, T.J., Sumaila, R.U., Zeller, D., Watson, R., Gaston, K.J. & Worm, B. 2009. Management effectiveness of the world's marine fisheries. *PLoS Biology*, 7(6): E1000131 https://doi.org/10.1371/journal.pbio.1000131
[3] Halpern, B.S., Longo, C., Hardy, D., McLeod, K.L., Samhouri, J.F., Katona, S.K., Kleisner, K. *et al.* 2012. An index to assess the health and benefits of the global ocean. *Nature*, 488: 615–620.
[4] Melnychuk, M.C., Peterson, E., Elliott, M. & Hilborn, R. 2017. Fisheries management impacts on target species status. *Proceedings of the National Academy of Sciences*, 114(1): 178–183.
[5] FAO. 2021. *Ecosystem approach to fisheries implementation monitoring tool – A tool to monitor implementation of the ecosystem approach to fisheries (EAF) management. User manual.* Rome. www.fao.org/publications/card/en/c/CB3669EN

of Food Security and Poverty Eradication (SSF Guidelines)[11] support achieving the EAF triple bottom line. Both guidelines help to clarify who should engage in objective-setting and management decision-making and how and when – not only in fisheries, but also in a broader range of sectors operating around the same environment. In doing so, the interconnections and relations among persons, groups and entities with stakes in living aquatic resources – the webs of interest – become apparent, opening the way for constructive dialogue, collaboration and shared solutions.

Collaboration inevitably requires trade-offs, which means foregoing some aspects of a sector to accommodate others. Nonetheless, recognizing the tenure and the rights of access to and use of fisheries and fisheries-related resources by fisherfolk and their communities helps highlight the interactions and connections between human needs associated with better food, income and livelihoods (including fishing), sustaining better aquatic ecosystems and improving production.

Inland fisheries

Inland fisheries invariably take place in multiple-use environments and are often considered secondary activities to domestic water use, industry, hydropower generation and agriculture that abstract, store and pollute water, or degrade and disrupt natural aquatic ecosystems. Managing inland fisheries in this context is a challenge since fisheries authorities do not usually regulate activities beyond the fisheries sector, and relevant agencies can include, *inter alia*, departments and ministries responsible for water resources, agriculture, forestry, health, environment, tourism and other extractive uses.

As a result, collaborative efforts of varying scope are required at diverse levels and need to be interlinked. At the central level, an inter-agency arrangement may be established to address cross-sectoral issues of national interest such as food and nutrition security and achieving the SDGs. At the local end of the spectrum, a water management committee with the participation of farmers, fishers, foresters and local authorities may decide on actions to be taken regarding the regulation of local water resources and the equitable distribution of benefits and costs.

This holistic approach at several levels enables the recognition of larger-scale, longer-term issues and their viable solutions across sectors. It reduces conflicts, especially between different fishery sub-sectors and between fisheries and other sectors, because it requires clear articulation of the needs of inland fisheries for water and broader ecosystem health as well as the underlying economic, environmental and ecological justification for this. The role of fisheries managers will be to advocate for the sector to trigger support and access to financial resources from the government, donors, non-governmental organizations (NGOs) and the private sector.

Effective monitoring and enforcement

The success of the framework of binding and non-binding international instruments that guide responsible fisheries management (see the section Better governance and policy reform, p. 128) cannot be guaranteed without effective monitoring, control and surveillance (MCS), enforcement, strengthened national-level inter-agency coordination and increased information exchange.

Effective MCS needs to build a culture of compliance and law enforcement. In this regard, more attention needs to be given to: enforcement of MCS plans and protocols; regular capacity-building and training; use of risk analysis[12] to target actions; and sharing of MCS and enforcement information. Coordinated action is needed to support developing States in strengthening their MCS, and this coordination can be achieved through FAO's Global Capacity Development Portal (FAO, 2021c).

The need for inter-agency cooperation and coordination is often neglected, despite gaps repeatedly identified at the national level. Efforts need to focus on the establishment of formalized inter-agency mechanisms (FAO, forthcoming, a) that aim to: (i) identify the mandates and roles of respective agencies; (ii) identify the availability of pooled resources, assets and information; and (iii) establish clear

11 Adopted by COFI in 2014 (FAO, 2015a).

12 For risk analysis, see Glossary.

procedures for cost-effective implementation of the provisions of relevant international instruments that guide responsible fisheries management.

Finally, although recognized as essential for effective MCS and enforcement, information collection and exchange are often neglected. For effective fisheries management, the relevant authorities must have sufficient information to fulfil their mandates. Information, however, is often not available or not in a useful format or time frame. The international community is working to put together a framework for global information exchange that should obviate barriers built around confidentiality, proprietary use of data, security, lack of standardization and timeliness. Efforts are focused on developing international tools – such as the FAO Global Record of Fishing Vessels (FAO, 2021e) and the Port State Measures Agreement (PSMA) Global Information Exchange System (GIES, currently in the pilot phase) – upgrading or developing regional and national systems as required, and establishing links or synergies between these and the systems of other government institutions mandated to manage sectors using aquatic resources.

Best practices, innovations and technologies for improving fisheries management

Technological advances are becoming instrumental for the MCS of effective implementation of conservation and management measures. From personal mobile devices to satellites, cutting-edge technologies are more and more accessible and affordable to wider States' authorities, allowing for a transformational leap in fisheries management.

Innovations in fishing technologies are contributing to the economic performance and management of fishing fleets worldwide. However, while industrial and semi-industrial fleets in Europe, North America and East Asia are early adapters of new technologies, the uptake of innovations is slower in small-scale fisheries in developing countries. Technological innovations introduced in fishing fleets and fishing gears are reported in *The State of World Fisheries and Aquaculture 2020* (FAO, 2020a) and have been updated recently (Van Anrooy *et al*., 2021). Innovations that improve fisheries management include not only the use of global positioning system (GPS), vessel monitoring system (VMS), Automatic Identification System (AIS), e-logbooks and e-monitoring, but also other technologies that increase fishing efficiency, reduce the environmental impact of fishing, and improve safety at sea, the working conditions of fishers on board vessels and quality of aquatic products.[13]

Challenges to adoption of innovations in fisheries management include moving from paper-based approaches to digital tools and methods (Box 16), timeliness of reporting, and the need for cost-effective solutions to strengthen monitoring of small-scale fishing vessels, long-distance fishing fleets and transshipment operations. Solutions to these challenges are being found, with their adoption accelerated following the onset of COVID-19.

Conscious of the challenges ahead, numerous innovative solutions based on existing technologies have been developed to focus not only on the compilation of accurate information on fishing activities regardless of where they occur, but also on its timely accessibility by all stakeholders. Some of them use, *inter alia*, sophisticated satellites to provide images and close to real-time information on ships' movements and identities. Others use remote electronic monitoring tools that employ on-board cameras to compile independent and accurate information about commercial fishing activities. To the same end, new electronic recording and reporting system devices have been developed, and progress has been made in integrating artificial intelligence to assist in the analysis of the significant amount of fisheries-related data generated by the new technologies. The use of drones is an innovative and economical solution for enhanced fisheries control and surveillance capacity. Lastly, due to the importance of having access to timely and relevant information for international cooperation to combat IUU fishing and improve transparency, global information sharing tools such as the FAO Global Record

13 For aquatic products, see Glossary, including Context of SOFIA 2022.

BOX 16 INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMALL-SCALE FISHERIES (ICT4SSF)

The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) state that:

> All parties should promote the availability, flow and exchange of information, including on aquatic transboundary resources, through the establishment or use of appropriate existing platforms and networks at community, national, subregional and regional level, including both horizontal and vertical two-way information flows. Taking into account the social and cultural dimensions [of SSF], appropriate approaches, tools and media should be used for communication with and capacity development for small-scale fishing communities.[1]

Likewise, Sustainable Development Goal (SDG) Target 9c calls to significantly increase access to information and communications technology (ICT) and to strive to provide universal and affordable access to the Internet in least developed countries by 2020.

Digitalization is increasingly proving efficient as an innovative tool for inclusion of small-scale producers, including small-scale fisheries, in natural resource management processes and value chains. When ICTs are locally led or co-developed, taking into account the needs of end users and marginalized groups, or contribute to strengthening existing networks and inclusive technologies, the potential for positive impact is much higher.[2] There is little doubt that ICTs hold potential to improve the lives of small-scale fisheries actors, but to bridge the digital divide, ICT4SSF development should be ethical, transparent and orientated specifically to meet the needs of the poor and the marginalized. For example, in fisheries monitoring systems, co-generated and co-owned data foster transparency and accountability, and they enable small-scale fisheries actors to have an active role in decisions in resource governance. However, given the unequal accessibility to information between sexes, individuals, groups, communities or businesses, ICT development must be mindful of how to add value for small-scale fisheries actors to achieve SDG 10 (Reduced inequalities) and to ensure no one is left behind.

[1] FAO. 2015. *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*, para. 11.8. Rome. www.fao.org/3/i4356en/I4356EN.pdf

[2] FAO and WorldFish. 2020. *Information and communication technologies for small-scale fisheries (ICT4SSF) - A handbook for fisheries stakeholders. In support of the implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication*. Bangkok. www.fao.org/3/cb2030en/CB2030EN.pdf

and the GIES under the PSMA are increasingly recognized as essential to support effective MCS.

Better lives: social protection and decent work

Social protection and decent work have been recognized as priority issues in several international instruments[14] and regional consultations led by FAO. Recently, FAO, IMO and ILO have joined forces to shape the fisheries sector of tomorrow by promoting safety and decent work in fisheries through the application of international standards.[15] However, at the national level, most of these instruments are still not fully adopted or implemented.[16] The sector is still struggling with poor enforcement of labour legislation, infringements on small-scale fishers' rights, child labour and barriers to access social protection, including a lack of updated fishers and social registries.

Based on Chapter 6 of the SSF Guidelines, expert advice, wide consultations and policy dialogues among key stakeholders, FAO calls on Member countries to enhance social protection and decent work in fisheries by:

- implementing the United Nations Guiding Principles on Business and Human Rights (United Nations, 2011) through the development of national action plans, including the provision of access to remedy human rights violations,

14 SDG 1.3; ILO Social Protection Floors Recommendation, 2012 (No.202); ILO Work in Fishing Convention, 2007 (No. 188); SSF Guidelines (FAO, 2015a); the 2021 COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021b).

15 Available in English, as well as in Chinese, Dutch, French, Indonesian and Spanish: FAO, IMO and ILO (2020).

16 There is extremely low ratification of ILO Convention No.188 and little expansion of social protection to the fisheries sector.

TABLE 15 KEY ISSUES AND SOLUTIONS FOR STRENGTHENING FISHERIES MANAGEMENT CAPACITY IN DATA- AND CAPACITY-LIMITED CONTEXTS

Process	Problem	Solutions
Data and information gathering and processing	Inefficient or ineffective data and information collection, as well as non-accessible or unused available data due to lack of rigorous methodologies and suitable tools, insufficient human and financial resources, and weak technical capacities of institutions.	Develop tools and train staff in data management, exploration and curation (i.e. quality control) Develop cost-efficient data collection programmes to optimize limited human and financial resources. Promote and support participation of fishing communities in data gathering and interpretation. Facilitate technology and knowledge transfer in the collection of data and information. Ensure qualitative, expert-based information is rigorously collected and integrated.
Assessment and production of management advice	Need for fishery management plans to be highly participatory and consider the socio-economic, ecological and cultural contexts of fisheries and countries.	Develop tools and train staff in the use of suitable assessment approaches (e.g. data-limited, simple indicator-based methods). Support the development of practical management plans in line with the EAF and using co-management. Develop and promote the use of pre-agreed decision rules (e.g. harvest control rules). Improve decision-making through science–policy–industry dialogues.
Enforcement and monitoring of management measures	Weak enforcement and monitoring systems unable to ensure the effectiveness of management decisions.	Assess and strengthen technical capacities for compliance and enforcement Develop and promote innovative mechanisms for collecting compliance data, particularly for small-scale fisheries. Develop and implement monitoring processes to understand the social and economic implications of management actions.

NOTE: EAF = ecosystem approach to fisheries.
SOURCE: FAO.

as a basic standard to prevent, mitigate and remedy business-related human rights impacts;
- ratifying and implementing the ILO Work in Fishing Convention, 2017 (No. 188) to improve working and living conditions on board fishing vessels and assist the enforcement of other fishery agreements;
- encouraging relevant training and capacity-building with respect to labour laws and vocational skills of fishworkers to support fishers to build and strengthen their professional organizations and trade unions to empower their political participation in the sector and beyond;
- improving information and registry of fishers, in particular small-scale fishers, and fishworkers to ensure inclusion of the fisheries sector in the design of social protection schemes and access of fisherfolk to these programmes;
- ensuring coherence between fisheries policies and social protection policies and programmes; and
- taking into account the clear linkages between IUU fishing and decent work deficits and considering coordinated action and cooperation involving relevant administrations and organizations at the national and regional levels to address these deficits.

When aligned with fisheries management measures within the EAF, social protection programmes and fisheries management that account for decent work and human rights can positively impact both resource conservation and the protection of fisherfolks' livelihoods. For example, the results from an impact evaluation by Seguro Defeso (the unemployment insurance scheme in Brazil) during fishing closures showed that the greater the household exposure to the programme's benefits, the higher the percentage of children enrolled in school, the better the quality of the beneficiaries' housing and the lower the percentage of youth simultaneously out of school and out of work. The results also indicated that the programme mitigated the need to seek alternative employment and that in some communities, fishers who benefited from the insurance scheme were less likely to break the closed season bans (FAO, forthcoming, b).

Supporting fisheries management in data- and capacity-limited regions

Sustainable capture fisheries is a common goal for all countries and a major target of SDG 14 (Life below water), yet countries' capacity to take the necessary action differs considerably. There is currently a clear gap between developed and least developed countries in terms of technical and institutional capacities (Ye and Gutierrez, 2017) across the three main steps in fisheries management: (i) data and information gathering and processing; (ii) assessment and production of management advice; and (iii) enforcement, monitoring and reporting of management measures.

Capacity development initiatives are needed to cover all these processes. The importance of tailored approaches that can be implemented within the constraints of financial and human capacity limitations and the complex governance challenges for developing world fisheries cannot be overstated. For example, promoting complex models that are data-intensive and catered primarily to the developed world as the basis for catch allocations or determining fleet capacity has shown its limitations, being unrealistic for most of the world's fisheries, particularly inland and small-scale fisheries (Hilborn *et al.*, 2020). Fortunately, the past 50 years of capacity development in fisheries management have taught some valuable lessons about what sort of processes are fundamental to increase countries' capacity to achieve effective fisheries management (Table 15).

For several decades, FAO has been active in supporting countries in enhancing their fisheries management capacities through, for example, training in data collection and sampling protocols, data-limited stock assessment methods, design of management plans aligned with the EAF, and implementation of systems to monitor compliance of management measures. This support has evolved over time responding to new global and regional challenges and the needs of recipient countries, but additional support is needed for fishers' and fishworkers' organizations through training in fisheries management, negotiation skills, leadership and communications, among others, to ensure successful co-management (Gutierrez, Hilborn and Defeo, 2011). Moreover, capacity development within RFBs can be cost-effective to increase countries' technical and institutional capacities.

While specific projects or one-time interventions can assist countries in providing short-term solutions, capacity development programmes should be long-term and continuous in order to facilitate ownership of the necessary knowledge and provide lasting impacts in achieving effective management. Other obstacles outside the realm of capacity development initiatives include high turnovers of staff, political instability and shortages of funds. ■

INNOVATING FISHERIES AND AQUACULTURE VALUE CHAINS

Expansion and intensification of aquaculture and effective management of all fisheries are necessary but insufficient conditions for Blue Transformation.[17] In order to achieve its ultimate goals of enhancing the contribution of aquatic systems to secure food security and nutrition and sustain livelihoods, aquatic value chains require innovations to make them more efficient, transparent, responsive, inclusive and equitable.

Competitive value chains

Trade and market access

International trade in fisheries and aquaculture products[17] generates significant income and supports poverty reduction and food security, particularly for developing countries, where small-scale fishers, fish farmers and women are strongly represented in the associated value chains.

Traded fisheries and aquaculture products often face a complex set of market access requirements, partly due to the prevalence of non-tariff measures (NTMs), distortion associated with

17 For Blue Transformation, and fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

fisheries subsidies, and tariff escalation.[18] According to the United Nations Conference on Trade and Development (UNCTAD), NTMs affect fisheries and aquaculture products more than other products in terms of quantity and intensity, making it more complex for the sector to fulfil regulatory requirements (Fugazzi, 2017).

Furthermore, tariff escalation considerably limits the possibility of value addition for developing countries and small-scale producers. The import duty on many fisheries and aquaculture products differs substantially between raw and processed products, particularly in many traditional importing countries, with higher tariffs imposed on processed products, thus disincentivizing value addition and job creation, and reducing possibilities for greater value retention.

The number of trade agreements has been increasing in recent decades, as they play an ever greater role in dictating the rules for global trade flows. The 82regional trade agreements in force in 2000 had increased to 310 by 2020. One of the main objectives of trade agreements is to create preferential trade possibilities with reduced import duties for participating countries. However, trade agreements are becoming more complex, with increasingly intricate rules, covering more policy areas and focusing on NTMs such as trade facilitation, information sharing, and mutual recognition of standards and regulations. Some new trade agreements explicitly support sustainability by combining trade preferences with new clauses addressing illegal, unreported and unregulated (IUU) fishing, fisheries subsidies, port State and conservation measures, catch documentation schemes, and bycatch and discard mitigation.

Any product destined to benefit from preferential access must comply with rules of origin to attest that it was produced or substantially transformed in a participating country. To take account of maritime zone parameters determining wild capture criteria, many trade agreements may include additional requirements, potentially reducing preferential access for these products.

Within the Committee on Fisheries Sub-Committee on Fish Trade (COFI:FT) and through GLOBEFISH, FAO has been promoting an inclusive forum to debate and inform about market access, NTMs, preferential access and international trade compliance. In addition, FAO continues to conduct specific studies and analyses, develop knowledge products, and implement capacity-building and technical assistance activities, including in cooperation with UNCTAD and the World Trade Organization to reduce market access asymmetries.

Loss and waste

Food loss and waste (FLW) is a major concern in the fisheries and aquaculture value chain. It can occur at different stages of the chain, from production and harvest through to final consumption. The underlying causes and drivers of losses are the highly perishable nature of aquatic products[19] and inefficiencies in value chains, due to inadequate infrastructure and lack of knowledge and skills of the involved actors. Specific sociocultural, institutional and economic contexts may also be contributing factors.

Reducing FLW can lead to economic benefits, with positive impacts on food and nutrition security and natural resource-use efficiency, and can reduce pressure on fishery stocks and environmental impacts.

Food loss and waste varies significantly by income level. In middle- and high-income countries, food waste occurs primarily during distribution and consumption, and is usually associated with lack of coordination, consumer behaviour, aesthetics and retail standards (e.g. colour and size), labelling, and over-purchasing. In low-income countries, FLW is almost non-existent at the consumption level but occurs at production, and during transportation, processing, storage and sale (HLPE, 2014). More particularly, in least developed countries (LDCs), poor infrastructure – including lack of

18 Tariff escalation is when there are higher import duties on semi-processed products than on raw materials, and higher still on finished products. This practice protects domestic processing industries and discourages the development of processing activity in the countries where raw materials originate (WTO Glossary – WTO, 2021).

19 For aquatic products, see Glossary, including Context of SOFIA 2022.

access to electricity, potable water, roads, ice, cold storage, cured product storage and refrigerated transport – has the most significant impact on FLW.

Design of adapted solutions requires a correct understanding of the magnitude, impact and causes of FLW, and of the roles of the various actors. Any solution should reflect the complexity of the fisheries and aquaculture value chains and the interconnectivity of their different stages. Therefore, FLW solutions often require actions involving governance, technology, skills and knowledge, services and infrastructure, social and gender equity, and good linkages to and understanding of markets, with the engagement of the public and private sectors, civil society, non-governmental organizations (NGOs), research and academia. These requirements are delineated in the FAO Voluntary Code of Conduct for Food Loss and Waste Reduction.[20]

The variety of issues and possible solutions involved requires a multidimensional approach – one that embraces established and innovative techniques and takes account of the dynamic nature of fisheries and aquaculture value chains. FISH4ACP FAO project (Box 17) demonstrates how the potential of fisheries and aquaculture value chains can be unlocked.

Food safety

To feed a growing global population with safe and nutritious food, efficient and effective food control systems are vital for consumer protection and trade promotion of fisheries and aquaculture products.

Food control authorities face multiple challenges in many countries, often due to gaps in the food safety regulatory frameworks, lack of coordination among authorities with food control responsibilities, and inadequate resources, including workforce, equipment, infrastructure and reliable control technologies. Furthermore, access to production and processing locations can sometimes be challenging. Innovative and digital solutions are being implemented to overcome some of these challenges, particularly following the outbreak of COVID-19. Remote inspection[21] to ensure product safety has proven to be reliable to deliver the necessary sanitary certificates to operators. Electronic certification systems can improve traceability throughout the supply chains, reduce delays and costs, decrease food waste by speeding up the process, combat fraudulent practices by introducing electronic authentication methods, and build trust among trading partners. To improve current processes, Codex Alimentarius is currently revising its guidance to expand official certification to e-certification. In addition, food control e-notification portals provide authorities with an effective tool to exchange real-time information about measures taken when severe risks are detected, helping countries act more quickly and in a coordinated manner in response to health threats. In this regard, FAO is exploring possible solutions under the Digital Solutions in Support of Improved Official Food Control Services project, which focuses on strengthening national capacities to develop and implement e-notification portals, in addition to carrying out remote inspections, supporting distance learning on food safety management, and broadening data pools in support of continuous development of risk categorization frameworks and other risk-based decision-making instruments.

Digital solutions, including e-certification using e-notification portals, can support resource optimization and achieve more effective and efficient food control services that respond to crises and promote transparency among trading partners.

Like its application for the production of other foods (e.g. chicken, beef), cell culture-based aquatic products can be a "game-changing technology" for aquatic food[22] production (Rubio *et al*., 2019). Food safety and quality of novel foods

20 The Code of Conduct for Responsible Fisheries (FAO, 2021a), developed by FAO, provides a set of internationally recognized, nationally adaptable guiding principles and standards for responsible practices to effectively reduce FLW, while promoting sustainable and inclusive agricultural and food systems, hence aiding the achievement of sustainable development.

21 Remote inspection is a form of visual inspection which uses visual aids including video technology to allow an inspector to examine objects and materials from a distance due to access limitations for various reasons.

22 For aquatic food, see Glossary, including Context of SOFIA 2022.

BOX 17 FISH4ACP – UNLOCKING THE POTENTIAL OF SUSTAINABLE FISHERIES AND AQUACULTURE VALUE CHAINS IN AFRICA, THE CARIBBEAN AND THE PACIFIC

Fisheries and aquaculture production is expanding in many African, Caribbean and Pacific (ACP) countries. However, this growth has not only been slow, but also uneven between regions and countries, and the benefits do not always reach the communities that rely on them for livelihoods and food security. In addition, poor fisheries and aquaculture practices can place stress on the environments in which they operate.

The Organisation of African, Caribbean and Pacific States launched a major programme, FISH4ACP, to optimize economic returns and social benefits from value chains in 12 ACP countries while minimizing detrimental effects on natural habitats, biodiversity and aquatic resources, and tackling some of the underlying challenges in building sustainable fisheries and aquaculture sectors. The project is implemented by FAO with funding from the European Union and the German Federal Ministry for Economic Cooperation and Development.

Launched in 2020, the programme's first phase (2020–2022) is based on a thorough value chain analysis for the assessment of the social, environmental and economic sustainability of selected fisheries or aquaculture value chains in benefiting countries. This phase also comprises the development of an upgrading strategy and action plan for the coming years of project activities to enhance productivity and competitiveness, ensuring that economic improvements go hand in hand with environmental sustainability and social inclusiveness.

Specifically, the programme focuses on:

- helping actors to develop a good understanding of their value chains and of ways and means for their improvement;
- opening up new markets for micro, small and medium-sized enterprises and enhancing the business and regulatory environments;
- creating better working conditions along the value chain;
- making the value chains more environmentally sustainable and resilient to shocks; and
- helping fisheries and aquaculture businesses attract and access additional sources of finance and investment.

In 2021, FISH4ACP conducted a series of workshops to discuss the findings of these analyses. The main stakeholders were involved, including representatives from both the public and the private sectors, to inform the upgrading and development strategies that will guide project activities in each of the 12 countries from 2022 to 2025.

This stakeholder engagement is a key project component to ensure that actors are directly involved in strategic discussions and decision-making from the outset, with a multi-stakeholder platform established for each of the value chains to maximize the sustainability and impact of the project.

To learn more about FISH4ACP and the countries involved, please visit the following resources:

- www.fao.org/in-action/fish-4-acp/en
- www.fao.org/3/ca7966en/CA7966EN.pdf

must be given due consideration to address the specific implications for consumer protection, public health and trade. In this regard, FAO and the World Health Organization (WHO) are collaborating, including through the Codex Alimentarius, to identify and assess food safety hazards linked to the consumption of novel foods to provide the basis for further work for their control (Codex Alimentarius Commission, 2021).

Value addition

Consumer perception of the value of fisheries and aquaculture products can be associated with their tangible and non-tangible characteristics. Processing, which results in changing the product form or adding new tangible attributes, can increase product value. However, enhancing the non-tangible characteristics, which are not necessarily associated with the production process but rather with personal interaction, is a viable alternative to value addition.

In recent decades, consumers have shown an increasing interest in the origin of fisheries and aquaculture products. The provision of this information, including health benefits, the sustainability of the production methods and the livelihoods of the people involved along the value chain, can add this intangible value. Product information can be communicated through business-to-business (B2B) product certification or business-to-consumer (B2C) product labelling. For example, new e-commerce approaches help producers, including those from rural areas, to connect directly with new or existing customers and link an appealing story to the product.

Full-chain traceability systems can support the transmission of information along the value chain by providing knowledge about the product's journey, potentially increasing the product's perceived value if effectively utilized. Electronic traceability systems, including blockchain technology, are expanding to ensure transparency, data security and integrity, and rapid data transfer along the value chain.

The fashion industry's innovative and increased use of aquatic resources creates new opportunities (e.g. use of fish leather) for value addition in the fisheries and aquaculture sector. Despite the obstacles faced, such as scepticism towards fashion products of fish origin, unreliable supply of quality raw material and limited access to finance, there are examples of local communities that have launched successful ventures, creating alternative employment opportunities and proving that this value-adding opportunity can be a realistic option for those with an entrepreneurial mindset.

"Pescatourism" offers the opportunity to generate income streams for fishers, fish farmers and their communities while also protecting the environment and local cultural heritage. It encompasses fishing excursions, recreational fishing, tours of fish farms and fishing villages, food tasting of local delicacies, cookery courses, and even accommodation offered by local fishers. There are numerous opportunities for pescatourism in many developing countries, given the presence of natural and often unspoiled beauty spots.

Furthermore, the fisheries and aquaculture sector has the potential to create non-market value through positive externalities and thus provide broader benefits to society. Examples include regulating services, such as carbon sequestration and nutrient remediation in extractive forms of aquaculture (e.g. seaweed, bivalve molluscs), provision of habitat for other organisms and, not least, cultural services such as historical artisanal fisheries with public, educational, symbolic and spiritual benefits.

Fish-based fashion products, pescatourism and other innovative ways of enhancing economic returns to the fisheries and aquaculture sector offer viable alternatives to maximize value addition beyond the conventional options. The combination of traditional and innovative value addition paves the way for improving the sector's sustainability, including the livelihoods of small-scale operators and their communities. Value addition opportunities can also be generated by using renewable energy solutions (Box 18).

Transparent and responsible value chains

Traceability

Traceability systems, including their associated elements of transparency, represent a crucial concerted effort towards transparent and responsible value chains. They allow a product to be followed from its origin to the end market, informing about compliance with many fisheries regulations (Hosch and Blaha, 2017), as well as food safety and certification requirements (Figure 56).

However, given the globalized landscape in the trade of fisheries and aquaculture products, coupled with the inherent fragmentation of associated value chains, the implementation of efficient traceability systems at the governmental and private levels presents challenges. For example, industry, governments and even consumers may lack commitment to or awareness of the benefits of the traceability system principles, or there may be a lack of availability of the technology and standards necessary for its implementation (Borit and Olsen, 2016).

BOX 18 RENEWABLE ENERGY USE IN SMALL-SCALE FISHERIES AND AQUACULTURE VALUE CHAINS

The fisheries and aquaculture sector, from production through post-harvest processes, marketing and distribution, is highly dependent on energy, particularly from fossil fuels.[1]

Energy use varies widely among the different fisheries and aquaculture value chain stages. Energy is a crucial cost element over which the sector has limited control, generating considerable impacts on profits and livelihoods. Post-harvest processing activities, distribution and trade, whether in aquaculture or capture fisheries, are heavily dependent not only on fossil fuels and electricity, but also on wood for fish smoking. Moreover, the cold chain is fundamental for preserving and preventing the loss of highly perishable harvest. Access to reliable and affordable sources of energy is a major challenge in developing countries, due to non-availability of infrastructure and prohibitive costs, especially in rural areas, causing severe disruption of cold chains during storage and processing[2] and leading to significant loss of aquatic products.

For example, energy demand in African economies is expected to nearly double by 2040 as population grows and living standards improve.[2] Although many African countries are net importers of fossil energy, there are numerous developing communities in sub-Saharan Africa and Asia where renewable energy resources are available; their exploitation can foster the creation of new jobs, economic growth, and social and health benefits while mitigating climate change impacts.[3]

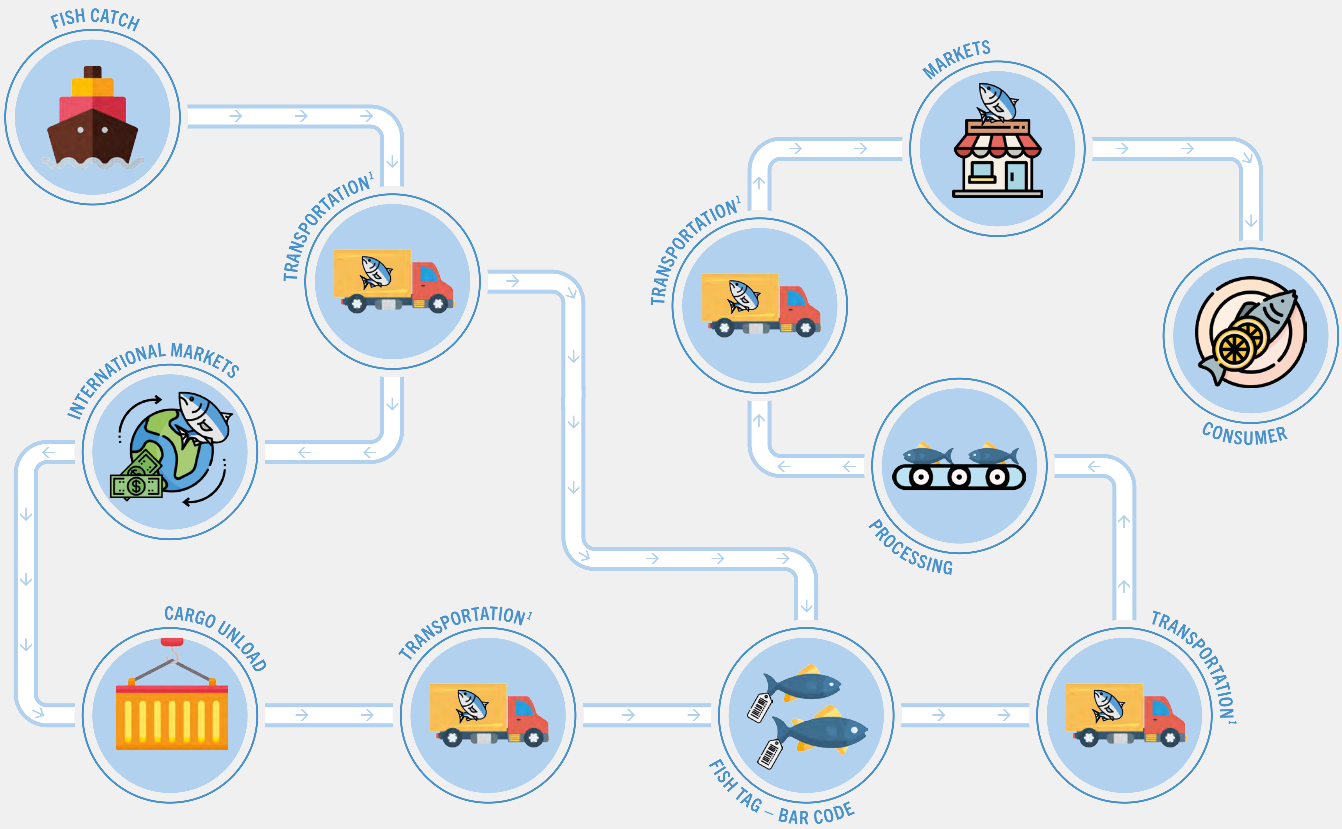
In particular, there is a significant rise in the use of solar energy for refrigeration and cold storage. Small-scale renewable infrastructure costs are often about the same as or lower than those for a large-scale centralized electricity grid.[2] Thanks to technological developments and incentives, the cost of electricity from solar photovoltaic (PV) decreased by 82 percent between 2010 and 2019, while the cost of onshore wind fell by 40 percent. In many countries, renewable energy is now at par or, in some cases, the least-cost option for new electricity generation.[3]

There is increasing scope for renewable energy and a need to promote it for applications at all stages of small-scale fisheries and aquaculture value chains. However, technologies are at different stages of maturity, and not all technologies are equally applicable and economically viable across countries and communities. Solar PV systems can be used to charge motors of fishing boats, power aquaculture equipment (feeders, pumps, aerators, security lighting), and run processing, ice-making, refrigeration and cold storage appliances, including during transport and retail. Biofuels can power aquaculture equipment, vending carts and distribution of aquatic products. Geothermal heat, available in many developing countries, can provide energy to warm water in aquaculture or for fish drying, while micro-hydroelectric systems can provide clean electricity for aquaculture.[4]

Renewable energy solutions could deliver clean energy and flexible options and provide opportunities for value addition to off-grid remote fishing and aquaculture communities struggling with access to reliable energy sources and the high and variable cost of fossil fuels. Seizing these opportunities will require strong political will together with policies to incentivize investment in building infrastructure for the efficient adoption of renewable energy.[3]

[1] FAO. 2015. Fuel and energy use in the fisheries sector: *Approaches, inventories and strategic implications*. FAO Fisheries and Aquaculture Circular No. C1080. Rome. www.fao.org/3/i5092e/i5092e.pdf
[2] FAO. 2016. *How access to energy can influence food losses: A brief overview*. Environment and Natural Resources Management Working Paper No. 65. Rome. www.fao.org/documents/card/en/c/86761a85-0e35-4b89-b2ac-691be59c714a
[3] IRENA. 2020. *The renewable energy transition in Africa. Country studies for Côte d'Ivoire, Ghana, South Africa, Morocco and Rwanda*. Abu Dhabi, IRENA, and Eschborn, Germany, GIZ.
[4] Micro-hydro turbines can be a very efficient and convenient form of small-scale renewable electricity to power electric heaters to maintain pond or tank water temperature and replace diesel generators in fish farms. For more information, refer to:
FAO. (forthcoming). *Renewable energy, post-harvest practices, and small-scale value chains: Current status and way forward*. Rome.

FIGURE 56 TRACEABILITY IN VALUE CHAINS OF AQUATIC PRODUCTS: A SIMPLE REPRESENTATION



[1] Note that other means of transportation – land, water and air – also exist.
NOTE: This infographic is a generic and simplified representation of a value chain and associated traceability, not containing all its linkages and related services. Traceability and value chains of aquatic products are a comprehensive, globalized and complex system.
SOURCE: FAO.

To overcome some of these challenges, FAO held an international seminar on Sustainable Seafood Value Chain: Traceability in November 2018 (FAO, 2018a); recommendations were proposed, including identification and documentation of the benefits and incentives of adopting traceability systems and reporting of success cases (Borit and Olsen, 2020).

Given the interconnectivity of fisheries and aquaculture value chains, collaboration at all stages is crucial for robust end-to-end traceability. Most current systems are fragmented and internal to individual companies; this creates information gaps throughout the supply chain and loss of operational efficiency. It is therefore key that supply chain partners agree to not only share some level of data but also increase interoperability (Blaha, 2017).

To facilitate and further promote this collaboration and considering the digital revolution transforming food systems, FAO supports strengthening of traceability systems to improve compliance (Hosch and Blaha, 2017), anchored on effectiveness, efficiency and interoperability.[23] To this end, online public (FAO, 2021f) and regional consultations were organized within the development framework of the draft guidance on advancing end-to-end traceability: critical tracking events (CTEs) and key data elements (KDEs) along capture fisheries and aquaculture value chains.

Catch documentation schemes

Catch documentation schemes (CDS) are an essential tool to combat IUU fishing.

23 Interoperability is defined as the ability to join up and merge data without losing meaning (Steele and Orrell, 2017).

CDS certificates and trade documents validated by national competent authorities establish that products have been legally sourced and accompany the harvested aquatic animals from fishing grounds to markets, certifying that the catch was sourced in compliance with all applicable requirements. In 2017, FAO Members adopted the Voluntary Guidelines for Catch Documentation Schemes (VGCDS) to assist in developing and harmonizing new and existing schemes.

To complement the VGCDS, FAO has been working on guidance (FAO, 2022b) to support national authorities to understand and implement CDS. In particular, the guidance aims to align and improve existing national monitoring, control and surveillance (MCS) tools and product tracking systems to meet internal and external demands for legal provenance documentation. During the development of the guidance, it was observed that while KDEs can vary quite substantially between schemes, the certifications underpinning a CDS (e.g. certifying the identity of the fishing vessel and whether it was operating legally) are often the same.

The guidance recommends that national authorities consider which KDEs must be verified and validated in their jurisdiction to certify the product's conformity with legal requirements. National authorities are encouraged to consider how existing verification systems or tools (e.g. vessel authorization and fishing license databases or traceability audits) can be more effectively used to strengthen validation processes for flag States, port States, market States and States which store, process or export fisheries products. Countries are also encouraged to ensure the traceability of legal provenance in order to avoid laundering uncertified fisheries products and maintain the integrity of the certified supply chain.

To ensure its practicality, the guidance was trialled in workshops involving fisheries and customs authorities in several countries resulting in the refinement of the document. Efforts to strengthen national processes for compiling and sharing legal provenance data within a CDS framework will continue under FAO's Global Programme to support the Implementation of the Port State Measures Agreement (PSMA) and Complementary International Instruments, Regional Mechanisms and Tools to Combat IUU Fishing.

Social responsibility

Fishing is one of the three most hazardous occupations according to the International Labour Organization (ILO). Decent working conditions along the fisheries and aquaculture value chain are key to mitigating risks for the numerous people relying on the sector for their income, livelihood or employment. Unsustainable practices may trigger different social problems at the various stages of the fisheries and aquaculture value chain, especially for vulnerable people such as migrant workers, women and children. For example, in IUU fishing, migrant workers are more exposed to modern slavery, bondage, forced labour and other abuses. The absence of social protection, social security or healthcare, the non-existence of formal working relationships (i.e. work contracts), and inadequate working conditions are all structural problems that persist throughout the fisheries and aquaculture value chain. In addition, environmental concerns, such as climate change and biodiversity loss, are likely to compound these social issues as coastal communities are often the most exposed to those risks.

There are various international instruments (conventions, guidelines, etc.) addressing human and labour rights aiming to ensure equitable social practices. However, their complexity and diversity create implementation challenges for stakeholders in the fisheries and aquaculture sector. In addition, since March 2020, the COVID-19 outbreak has disrupted supply chains and added new health hazards to already precarious employment conditions. Many employers could not invest the necessary resources to provide personal protective and sanitation equipment or reorganize the workspace to allow effective social distancing. Trade disruptions also led to reduced sales income affecting workers and employers alike, sometimes leading to bankruptcy and its social consequences.

In 2019, FAO conducted a multi-stakeholder consultative process worldwide to develop practical guidance on social responsibility in the sector involving representatives from the industry, governments, NGOs, trade unions, regional bodies, international organizations and academia, among others.

The guidance will cover the different fisheries and aquaculture value chain stages, consolidating existing relevant international instruments and tools in a voluntary, non-binding and practical document to assist policymakers and address this increasingly complex environment. It will adopt a human and labour rights due diligence approach when considering risk and development in the sector to foster equitable social practices. Although the guidance will focus on the private sector's responsibilities, it can also be relevant to other stakeholders interested in supporting and ensuring social responsibility compliance in fisheries and aquaculture value chains.

Integrated and resilient value chains

Blue fishing ports

A fishing port represents a vital link for many actors in the fisheries and aquaculture value chain (fishers, buyers, sellers, service providers, public and private institutions). It can play multiple social, economic and environmental roles from a local, regional, national and global angle. Fishing ports can promote sustainable fisheries and aquaculture, catalyse the reduction of waste and environmental pollution, foster the preservation of the nutritional attributes of aquatic food, ensure quality, and create incentives for fair prices and increased exports.

The FAO Blue Fishing Ports initiative is an innovative scheme to strengthen the role of ports as drivers of sustainable development in coastal cities and communities, maximizing data collection and enforcement, upgrading infrastructure and services, thus addressing national and global challenges of sustainable development in marine and coastal areas.

The initiative aims to leverage the strategic position of fishing ports in the fisheries and aquaculture value chains to promote positive and sustainable socio-economic growth while reducing their environmental impact. Having the proper infrastructure in place and how a port is managed and maintained are crucial considerations. In addition, the Blue Fishing Ports initiative also contributes to poverty alleviation and food security by strengthening food quality, reducing FLW, preserving natural resources, reinforcing the value chain, and enforcing labour rights and gender equality within the marine sectors (Figure 57).

The development of this FAO initiative was widely inclusive and participatory, initiated after the Thirty-third Session of the Committee on Fisheries in 2018, to engage the private sector around the principles of sustainable development of ocean economies. Governmental and non-governmental representatives from ports of Africa, Asia, America and Europe were brought together to share experiences, information and best practices during workshops and dedicated meetings. An FAO umbrella programme is being established with the collaboration of several ports and fisheries authorities worldwide and the support of regional and multilateral organizations. It aims to support fishing ports to design and implement sustainable Blue Transformation strategies that ensure a balance between social, economic and environmental dimensions.

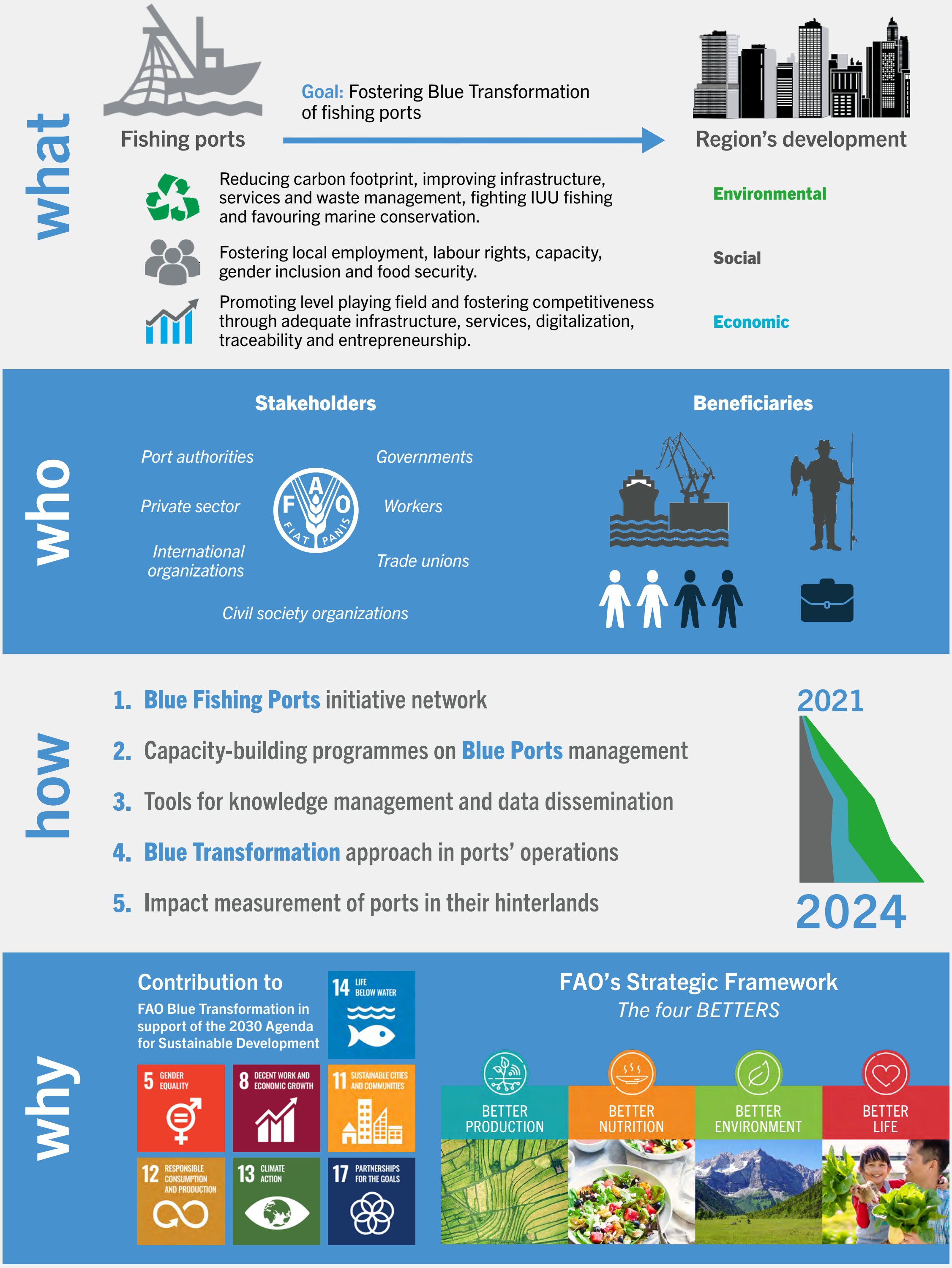
The Blue Fishing Ports initiative has started specific actions, including capacity-building, knowledge management and technical assistance, with the participation of 20 ports authorities, fisheries sector administrations and the cooperation of international organizations, in particular the Intergovernmental Oceanographic Commission (IOC-UNESCO), the World Bank, ILO and the International Maritime Organization (IMO).

In December 2021, IOC-UNESCO and FAO launched a capacity-building programme for port authorities to include the marine spatial planning approach as part of strategic and operational processes and to showcase good practices. In addition, global fishing ports and landing sites mapping will be carried out which will help to identify streamlining possibilities of maritime value chains development.

Consumer patterns

The significant increase in aquatic food production and availability in the last decade was fuelled by various factors, including higher demand for sustainable, diversified, affordable and nutritious fisheries and

FIGURE 57 FAO BLUE FISHING PORTS INITIATIVE



SOURCE: FAO.

BOX 19 FISH AND OTHER AQUATIC FOODS IN HEALTHY DIETS AND SUSTAINABLE FOOD SYSTEMS[1]

Fish and other aquatic foods from fisheries and aquaculture are recognized as a unique source of high-quality bioavailable animal proteins and unique micronutrients such as omega-3 fatty acids, vitamins and minerals, vital for physical and cognitive development, from foetal growth through infancy and childhood, and for maintaining good nutrition and health throughout adolescence and adulthood.

In order to meet the planetary health dietary recommendations of 28 g of fish per day per person,[2] the demand for fisheries and aquaculture products is high, estimated in 2019 at 10.2 kg per capita per year. Given the current sustainability constraints and supply options, availability of aquatic foods can be enhanced by reducing food loss and waste and developing innovative, nutritious and palatable products using non-targeted species, by-products and low-trophic aquatic foods. To reach this goal, these aquatic food products must be prioritized for human consumption and alternatives to their use in animal feeds should be explored.

Consumption of whole fish, where feasible, is highly recommended in both nutritional and environmental terms. In many areas of the world, small fish species are consumed whole, including head, eyes, bones and viscera – an essential source of micronutrients. This differs from the utilization ratio of tilapia, tuna or salmon fish fillets with only 30–70 percent of the fish consumed, while the remainder is discarded.[3] Existing simple processing technologies can convert heads and bones into nutritious and delicious products. The use of whole small fish or processed by-products has been shown to improve the nutrient content of meals while also reducing cost and increasing the availability of fish, particularly in school feeding programmes. For example, tuna frame powder was highly acceptable to schoolchildren in Ghana when added to traditional recipes in school meals,[4] while in Guatemala, heads and bones from tilapia were successfully processed and included in school meals, increasing the fish utilization ratio from as low as 30 percent to over 80 percent.[5]

The COVID-19 pandemic has exacerbated food insecurity and is expected to have long-term impacts in terms of greater prevalence of undernourishment and stunting.[6] In building back better, aquatic foods can play a crucial role in promoting health for people and the planet as part of a diet with other nutritious foods.

[1] See also Box 24, p. 170.
[2] Willet, W., Rockstrom, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T. *et al.* 2019. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *Lancet*, 393(10170): 447–492. https://doi.org/10.1016/S0140-6736(18)31788-4
[3] 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 and Technology*, 36(2): 144–151.
[4] Glover-Amengor, M., Ottah Atikpo, M.A., Abbey, L.D., Hagan, L., Ayin, J. & Toppe, J. 2012. Proximate composition and consumer acceptability of three underutilized fish species and tuna frames. *World Rural Observations*, 4(2): 65–70. www.sciencepub.net/rural/rural0402/011_9765rural0402_65_70.pdf
[5] FAO. 2018. Guatemala's school-feeding law prioritizes child nutrition and family farming. In: *FAO.* Rome. Cited 17 March 2022. www.fao.org/guatemala/noticias/detail-events/en/c/1103375
[6] FAO, IFAD, UNICEF, WFP & WHO. 2021. *The State of Food Security and Nutrition in the World 2021. Transforming food systems for food security, improved nutrition and affordable healthy diets for all.* Rome, FAO. https://doi.org/10.4060/cb4474en

aquaculture products. To access these markets, producers and processors must integrate in their strategies evolving demand and multiple consumer patterns and behaviours.

The supply and demand of fisheries and aquaculture products have been evolving in recent years, with an increasing impact of economic, environmental and social sustainability elements in addition to the conventional parameters of price and food safety.

The COVID-19 pandemic further affected consumer patterns. At the beginning of the pandemic and during its successive waves, household consumption of aquatic food shrank dramatically, fishing activities were suspended and fish markets were closed. Where and when restrictions were lifted, species traditionally directed to the hotel, restaurant and catering sector faced supply and distribution issues. The pandemic was also characterized by consumers rushing to stockpile long shelf-life foods such as canned aquatic products.

Confinement of citizens in their homes and temporary closure of the hospitality sector redirected fisheries and aquaculture products to supermarkets and other end-consumer distribution points. Many high-value species were incorporated into home-prepared meals for household groups who did not normally consume such species or only on specific occasions at restaurants. Online sales and home delivery of fisheries and aquaculture products increased.

Market requirements continue to evolve as NGOs and consumers increase their focus on the social and environmental responsibility aspects of fisheries and aquaculture production[24] and trade. Aquatic foods are also crucial in promoting healthy diets as illustrated in Box 19. ■

THE INTERNATIONAL YEAR OF ARTISANAL FISHERIES AND AQUACULTURE 2022

The purpose of the International Year

The United Nations designates specific days, weeks, years and decades as occasions to mark events or highlight topics to promote, through awareness and action, its developmental objectives.[25] In 2018, the United Nations General Assembly declared 2022 the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022) and nominated FAO as the lead agency for celebrating the year in collaboration with other relevant organizations and bodies of the United Nations (United Nations, 2018).

The world faces many complex challenges, including hunger, malnutrition and diet-related diseases, an ever-growing global population that needs sufficient and healthy food and must reduce food loss and waste, and over-exploitation of natural resources, in addition to the effects of climate change and other major issues such as the COVID-19 pandemic. IYAFA 2022 highlights the importance of small-scale artisanal fisheries and aquaculture for food systems, livelihoods, culture and the environment. Given that artisanal fishers, fish farmers and fishworkers produce a significant portion of aquatic food,[24] they can be key agents of transformative change for sustainable use and conservation of living aquatic resources – with positive ripple effects on food systems and nutrition security.

The objectives of IYAFA 2022 are to:

- enhance global awareness and understanding of small-scale artisanal fisheries and aquaculture, and foster action to support its contribution to sustainable development, specifically in relation to food security and nutrition, poverty eradication and the use of natural resources; and
- promote dialogue and collaboration between and among small-scale artisanal fishers, fish farmers, fishworkers, governments and other key partners along the value chain, as well as further strengthen their capacity to enhance sustainability in fisheries and aquaculture and improve their social development and well-being.

By elevating awareness of the role of small-scale fisheries and aquaculture, IYAFA 2022 aims to strengthen science–policy interactions, empowering stakeholders to take action including building and strengthening partnerships. It showcases the potential and diversity of small-scale artisanal fisheries and aquaculture and highlights the benefits of facilitating partnerships and cooperation with fishers, fish farmers and fishworkers to achieve sustainable development of living aquatic resources. By sensitizing public opinion and governments and fostering the adoption of specific public policies and programmes, these subsectors and their communities can secure their rights and acquire best practices to operate in a sustainable manner.

IYAFA 2022 also serves as a springboard to further implement the Code of Conduct for Responsible Fisheries and related instruments, in particular the Voluntary Guidelines for Securing

24 For aquatic food, and fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

25 For a comprehensive list of the international years currently observed by the United Nations, see www.un.org/en/observances/international-years

Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines; FAO, 2015a) and to take concrete actions towards achieving the Sustainable Development Goals (SDGs). IYAFA 2022 can also be a vehicle to support the 2021 Committee on Fisheries Declaration for Sustainable Fisheries and Aquaculture and the Shanghai Declaration, both of which recognize the critical importance of small-scale fisheries and aquaculture. As IYAFA 2022 falls within the United Nations Decade of Family Farming (2019–2028), the Year and the Decade will reinforce one another in providing greater visibility to small-scale artisanal fishers, fish farmers and fishworkers.

The global launch of IYAFA 2022 on 19 November 2021[26] was followed by events throughout the world such as the joint virtual launch of the three regional IYAFA 2022 committees for the Latin American and the Caribbean region. Uganda and Malawi held national launch events and a local launch took place in the United Republic of Tanzania. IYAFA 2022 encompasses many diverse initiatives, activities, actors and partnerships around the world and includes hundreds of activities and events[27] on small-scale fisheries and aquaculture – for example, conferences and forums,[28] journal special editions, webinar series, contests, and related communications materials (e.g. infographics and calendars) – to help achieve its objectives. The IYAFA 2022 support base is constantly growing, with leveraging partnerships and collaboration, diverse initiatives and actors.

The IYAFA 2022 Global Action Plan: seven pillars contributing to achieving the SDGs

The IYAFA 2022 Global Action Plan is structured around seven interconnected pillars addressing challenges and opportunities for small-scale artisanal fisheries and aquaculture to contribute to achieving the SDGs. It engages national administrations, fishers, fish farmers, fishworkers, non-governmental organizations (NGOs), civil society organizations (CSOs), private enterprises, development agencies and intergovernmental bodies (Figure 58).

Pillar 1 — Environmental sustainability: Use biodiversity sustainably for the longevity of small-scale artisanal fisheries and aquaculture

In line with SDG 2 (Zero hunger), SDG 6 (Clean water and sanitation), SDG 14 (Life below water), SDG 15 (Life on land), Chapter 5 (Governance of tenure in small-scale fisheries and resource management) of the SSF Guidelines and the Global Plan of Action for Aquatic Genetic Resources (Box 9), IYAFA 2022 highlights the stewardship role of fishers, fish farmers and fishworkers in ensuring the responsible management and sustainable use of living aquatic resources and their supporting ecosystems.

Activities contributing to validating the need to ensure the right to access to natural resources for those working in small-scale fisheries and aquaculture include:

- collection of case studies with the goals of providing advice to policymakers and increasing recognition of the role of small-scale fisheries actors in sustainable use and conservation;[29]
- development of a handbook on the environmental stewardship role of small-scale fishing communities;
- promotion of engagement and collaboration of fishworker organizations, CSOs and others working in the arena of small-scale fisheries and biodiversity[30] – such engagement facilitates inclusive processes that balance sustainable resource use with small-scale fishers' access and user rights (SDG Target 14.b);[31]
- development of AquaGRIS, a new global information system for aquatic genetic

26 See www.fao.org/artisanal-fisheries-aquaculture-2022/home/en

27 For a comprehensive list of IYAFA 2022 events, see www.fao.org/artisanal-fisheries-aquaculture-2022/events/events-list/en

28 Too Big To Ignore (TBTI) is organizing five regional congresses to celebrate IYAFA 2022. See: http://toobigtoignore.net/opportunity/4-world-small-scale-fisheries-congress
In September 2022, the General Fisheries Commission for the Mediterranean is hosting a regional IYAFA 2022 celebration: Spotlight on the future of the SSF sector in the Mediterranean and the Black Sea region. See: www.fao.org/gfcm/activities/fisheries/small-scale-fisheries/ssfforum/en

29 This work is being carried out by the Community Conservation Research Network hosted at Saint Mary's University in Canada.

30 The International Collective in Support of Fishworkers and the NGO Crocevia called for collaboration and engagement in the *Handbook on Convention of Biological Diversity (CBD) for small-scale fishing communities* (Rajagopalan, 2021).

31 SDG Target 14.b: Provide access for small-scale artisanal fishers to marine resources and markets.

FIGURE 58 KEY MESSAGES OF IYAFA 2022

ENVIRONMENTAL SUSTAINABILITY

RESOURCE STEWARDS

As custodians of shared resources, fishers, fishfarmers and fishworkers have a fundamental role in ensuring the responsible management and sustainable use of living aquatic resources and their supporting ecosystems.

ECONOMIC SUSTAINABILITY

VALUE FOR ALL

Access to markets, appropriate infrastructure and inclusive value chains enable fishers, fishfarmers and fishworkers to better provide affordable high-quality fish products, foster economic development and generate employment.

SOCIAL SUSTAINABILITY

LIVING WELL

Decent living and working conditions are essential for small-scale fishers, fishfarmers and fishworkers to secure livelihoods and maintain their social, cultural and physical well-being.

GOVERNANCE

NOTHING ABOUT US WITHOUT US

Effective participation, supported by comprehensive data and information, in decision-making processes ensures that traditional knowledge and voices of fishers, fishfarmers and fishworkers and their organizations shape laws and policies relating to small-scale artisanal fisheries and aquaculture.

GENDER EQUALITY AND EQUITY

WOMEN AND A CHANGING TIDE

Acknowledging the role women play in small-scale artisanal fisheries and aquaculture is essential to women's empowerment and sustainable development.

FOOD SECURITY AND NUTRITION

NOURISHING NATIONS

Small-scale artisanal fisheries and aquaculture have a fundamental role in contributing healthy, safe, affordable and nutritious aquatic foods and products as part of global and local food systems.

RESILIENCE

AWARE AND PREPARED

Fishers, fishfarmers and fishworkers are among the world's most vulnerable to environmental degradation, shocks, disasters and climate change. Policies and actions should support building resilience to these threats for the long-term continuity of the sectors.

SOURCE: FAO. 2021. *International Year of Artisanal Fisheries and Aquaculture 2022 Global Action Plan*. Rome. www.fao.org/3/cb4875en/cb4875en.pdf

resources, that can characterize and catalogue farmed types of aquatic resources used in small-scale aquaculture and act as a basis for developing equitable access and benefit-sharing measures; and

- development of technical farming manuals that enable the adoption of best farming practices to secure decent livelihoods while practising environmentally friendly farming.

Pillar 2 – Economic sustainability: Support inclusive value chains for small-scale artisanal fisheries and aquaculture

IYAFA 2022 highlights both the role that small-scale aquatic food producers play in achieving SDG 12 (Responsible consumption and production) and the ongoing challenges they face regarding economic performance, market access and social and environmental sustainability.

Enhancing the productivity and competitiveness of value chains and harnessing the potential of small-scale fisheries and aquaculture for sustainable development while ensuring that economic improvements go hand in hand with environmental sustainability and social inclusiveness is in line with Chapter 7 (Value chains, post-harvest and trade) of the SSF Guidelines and is at the core of the FAO FISH4ACP programme of the Organisation of African, Caribbean and Pacific States.

Pillar 3 – Social sustainability: Secure social inclusion and well-being of small-scale artisanal fisheries and aquaculture

SDG Target 1.3 calls on countries to implement nationally appropriate social protection systems, SDG 8 calls for decent work for all and SDG 10 calls for reduced inequality within and among countries. These are all issues that are highly relevant for people in the small-scale fisheries and aquaculture sector. Social protection policies and programmes have been proven to reduce poverty and food insecurity, stimulate investments in fishing and agriculture production, promote decent work, and positively impact local economies and communities.

COVID-19 has spotlighted the vital role of social protection in safeguarding the livelihoods and dignity of small-scale fishers, fish farmers and fishworkers and increasing their overall resilience (FAO, 2021g). Similarly, to advance decent work, FAO, the International Maritime Organization (IMO) and the International Labour Organization (ILO) joined forces to shape the fishery sector of tomorrow and promote safety and decent work in fisheries through the application of international standards (FAO, IMO and ILO, 2020). However, at the national level, most international instruments are not fully implemented, and the sector is still struggling with poor enforcement of labour legislation, infringement of small-scale fishers' rights, the existence of child labour and barriers to access social protection.

Pillar 4 – Governance: Ensure effective participation of small-scale artisanal fisheries and aquaculture in building and strengthening enabling policy environments

In line with SDG Target 10.3,[32] sustainable development of small-scale fisheries and aquaculture requires an enabling environment for ensuring equal opportunities and reducing inequalities as well as for achieving peaceful and inclusive societies for sustainable development (SDG 16).

IYAFA 2022 highlights the importance of establishing meaningful and transparent participatory processes for decision-making, resource management and market participation and ensuring secure access rights for small-scale fisheries and aquaculture to natural resources and services, especially as competition over such resources and power imbalances are increasing.

Pillar 5 – Gender equality and equity: Acknowledge that women and men in small-scale artisanal fisheries and aquaculture are equals

It is fundamental to recall that gender equality is not only a human right, but a key factor in attaining sustainable small-scale fisheries and aquaculture. Women make up 40 percent of the actors throughout the small-scale fisheries and aquaculture value chain in a variety of roles, yet they disproportionately hold the least stable and lowest-paid positions, do not have equal participation in organizations and decision-making processes, are not supported by legislation and policy for equality, and do not have equal access to and benefit from resources, markets, technologies and services.

IYAFA 2022 supports progress towards meeting SDG 5 (Gender equality) and Chapter 8 (Gender equality) of the SSF Guidelines by working to ensure women's empowerment through gender equality, improving the social and economic performance of the sector, and strengthening small-scale fishing and farming communities by fostering women's roles as agents of change.

Pillar 6 – Food security and nutrition: Promote the contribution to healthy diets from small-scale artisanal fisheries and aquaculture in sustainable food systems

In addition to direct contributions to sustaining food security and nutrition through provision of diverse aquatic foods to approximately 500 million people, small-scale fisheries provide livelihood opportunities and thus indirectly contribute to food security and nutrition, with the contribution even greater when considering also small-scale aquaculture.

IYAFA 2022 aims to raise the profile of the contribution of small-scale aquatic food producers to food systems and nutrition as small-scale fisheries and aquaculture produce around 40 percent of the global harvest and contribute an estimated 50 percent of the recommended nutrient intake of omega-3 fatty acids for nearly 1 billion women (FAO, Duke University and WorldFish, 2022).

Pillar 7 – Resilience: Increase the preparedness and adaptive capacity of small-scale artisanal fisheries and aquaculture to environmental degradation, shocks, disasters and climate change

SSF and aquaculture are experiencing an increasing number of risks. The United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement recognize that climate change may be catastrophic for small island developing States (SIDS), least developed countries (LDCs) and other vulnerable states where small-scale fisheries and farming communities are located.

32 SDG Target 10.3: Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.

SDG Target 1.5[33] focuses on resilience in the context of climate-related extreme events and other economic, social and environmental shocks and disaster. Resilience is also a core feature of SDG Target 13.1 (Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries).

IYAFA 2022 is advancing these SDG targets by promoting the implementation of the climate change and disaster risk elements of the SSF Guidelines and encouraging awareness-raising and capacity-building activities and job creation for SSF and aquaculture communities as part of COVID-19 recovery planning and building forward better. Cook, Rosenbaum and Poulain (2021) produced a guide to help policymakers, government agencies, development partners and CSOs design and implement fisheries-related policies and programmes addressing disaster risks and climate change in the context of human rights. Similarly, the online e-learning course, Fisheries and aquaculture response to emergencies (FARE),[34] offers similar support and prioritizes men and women who are small-scale fishers and fish farmers.[35]

Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development

IYAFA 2022's objective of enhancing global awareness, understanding and action to support the contribution of small-scale artisanal fisheries and aquaculture to sustainable development, food security and nutrition, poverty eradication and the use of natural resources requires the development of solid evidence highlighting the benefits, interactions and impacts of small-scale fisheries and aquaculture.

In preparation for IYAFA 2022, FAO, Duke University and WorldFish undertook the Illuminating Hidden Harvests (IHH) study (FAO, Duke University and WorldFish, forthcoming). The IHH study is based on a rigorous methodology and multidisciplinary approach that collected and synthesized information about small-scale fisheries. More than 800 experts contributed to 58 country and territory case studies covering 68 percent of global marine catch and 62 percent of global inland catch. A series of thematic studies address key topics such as environmental interactions, impacts of climate change, identity and indigenous peoples and small-scale fisheries, while the full research findings look holistically at small-scale fisheries by examining their environmental, social, economic and governance contributions while using gender as a cross-cutting theme.

Key findings (Figure 59) include:

- Small-scale fisheries catch is estimated to be 37 million tonnes – or 40 percent of total inland and marine capture fisheries production.
- About 90 percent of all those employed in capture fisheries operate in small-scale fisheries, including an estimated 21 million women.
- Taking into account also subsistence activities, about 94 percent of all those engaged in employment and subsistence activities in capture fisheries operate in small-scale fisheries, including an estimated 45 million women.
- Taking into account also household members, 492 million people depend at least partially on small-scale fisheries.
- Nutrient values vary substantially among fish types – small fish are especially nutritious. Small-scale fisheries could potentially provide 987 million women globally with 50 percent of the recommended daily intake of omega-3 fatty acids and 477 million women with 20 percent of the recommended daily intake of calcium, selenium and zinc.

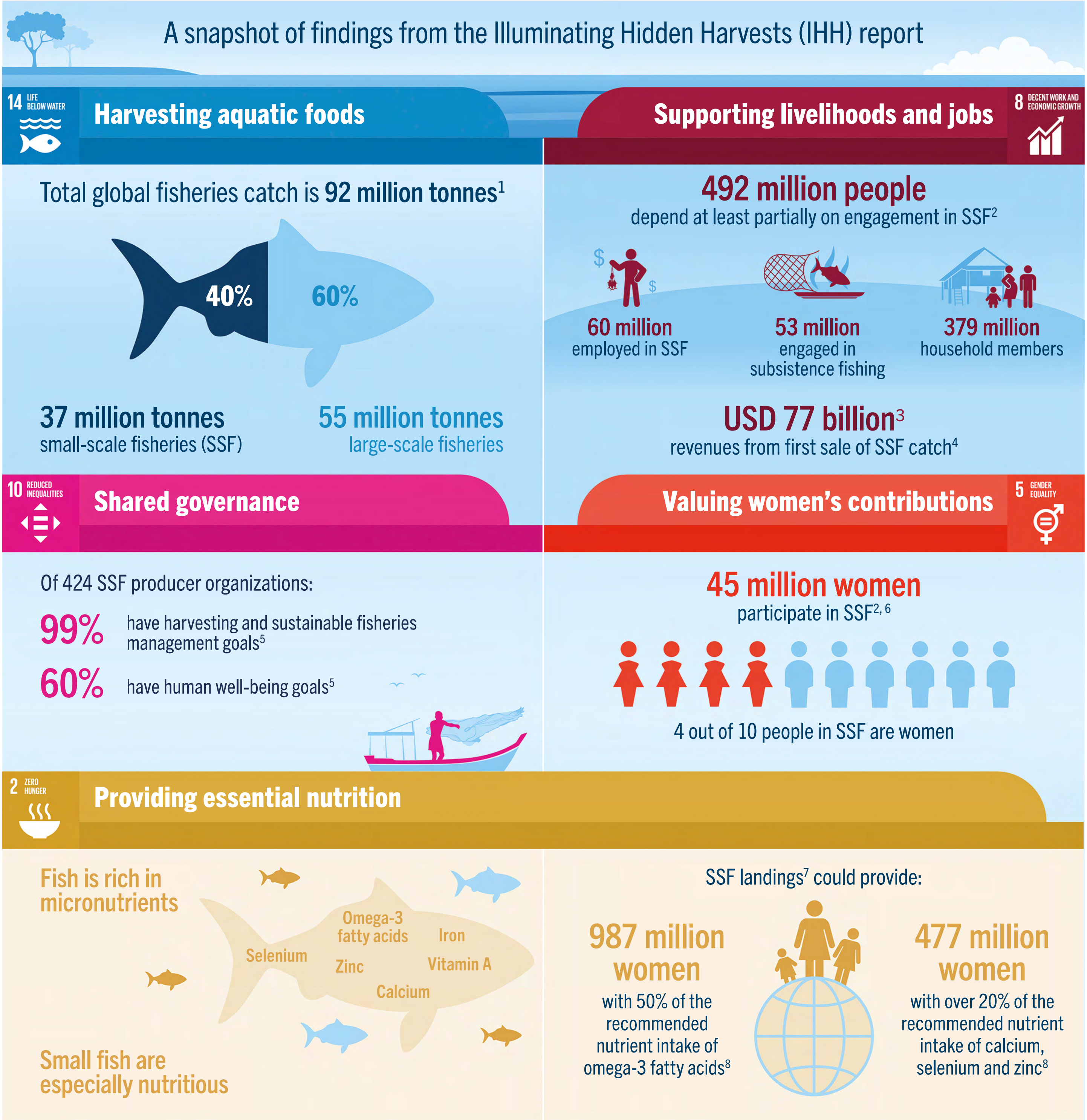
The IHH data collection and collation process revealed the wide variability in government data collection on small-scale fisheries and, in many cases, the lack of information to support policymaking and decisions about these fisheries. Where data were collected, the capacity to analyse and interpret them was not always available or prioritized.

33 SDG Target 1.5: By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.

34 Available at: https://elearning.fao.org/course/view.php?id=789

35 The course signposts to two sets of FAO guidance, best practice and standards as key resources: Cattermoul, Brown and Poulain (eds, 2014) and Brown and Poulain (eds, 2013).

FIGURE 59 THE CONTRIBUTIONS OF SMALL-SCALE FISHERIES (SSF) TO SUSTAINABLE DEVELOPMENT



[1] Average in 2013–17 extrapolated from 58 IHH country and territory case studies.
[2] Extrapolation from 78 national household-based surveys for 2016, including full- and part-time employment along the value chain (numbers rounded).
[3] Extrapolated from 58 IHH country and territory case studies.
[4] From first sale of SSF catch (2013–2017).
[5] Based on global IHH surveys of 717 SSF organizations.
[6] Supported by knowledge and insights of 28 gender advisors.
[7] Landings include only fish retained by fishers for consumption, sale or trade, whereas catch includes all fish caught.
[8] Based on predictive nutrient modelling by the IHH team and partners.

SOURCE: FAO, Duke University and World Fish. Funded by: Sida, Norad, OAK Foundation and CGIAR Research Program on Fish Agri-Food Systems.
www.fao.org/3/cb8233en/cb8233en.pdf

IYAFA 2022 and the IHH study results are triggers for transformational changes in the collection and analysis of data on small-scale fisheries. By building lasting in-country capacity for better data collection, analysis and dissemination in support of small-scale fisheries, the way fisheries and related livelihoods are monitored will better reflect the unique circumstances in which small-scale fisheries operate and help ensure that they are appropriately accounted for by policymakers.

Small-scale fisheries and aquaculture: contributing to food systems and nutrition security

It is well established that aquatic foods play a unique role in providing essential fatty acids, as well as a wider range of micronutrients and bioavailable animal proteins. They fill micronutrient gaps in the diets of many nutritionally vulnerable people in the developing world and contribute to lowering the risk of diet-related non-communicable diseases such as heart and cardiovascular disease, high blood pressure and cholesterol, stroke and diabetes. Consumption of aquatic foods improves the nutrient content of breastmilk and provides greater dietary diversity for pregnant and lactating women, improves cognitive development, and reduces stunting and severe acute malnutrition for infants and young children. Aquatic foods are also an integral part of healthy eating that is important in adolescence and adulthood (UN Nutrition, 2021).

Out of the seven priority areas for ending hunger and protecting the planet highlighted by the United Nations Secretary-General's call for the United Nations Food Systems Summit, protecting equality and rights, sustaining aquatic foods, and ending hunger and improving diets,[36] are highly relevant to IYAFA 2022. In this respect, small-scale fisheries and aquaculture can be key for sustainable and equitable food systems that deliver nutrition for all (Short *et al.*, 2021; Golden *et al.*, 2021; UN Nutrition, 2021).

36 For example, through school feeding programmes (von Braun *et al.*, 2021).

IYAFA 2022 provides a unique opportunity to showcase these critical messages in connection with the Committee on World Food Security and to protect dependent communities, balance agricultural and fisheries policies towards more nutrition-sensitive investment, and prioritize diversified aquatic foods to support public health, thereby ensuring the role of small-scale fisheries and aquaculture in sustainable and equitable food systems (UN Nutrition, 2021; Short *et al.*, 2021).

Partnerships to advance the implementation of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries

The SSF Guidelines provide comprehensive recommendations on fisheries management, and the livelihood functions of small-scale fishers while also recognizing the important linkages between small-scale fisheries and aquaculture. They address social and economic challenges and opportunities along the value chain in addition to tackling access to resources, tenure rights and fisheries management, climate change and disaster risks. Gender equality is a cross-cutting issue and the need to empower women and make their role more visible is a key concern. These interrelated dimensions require cross-sectoral collaboration by a vast number of partners to ensure policy coherence, information and institutional linkages to achieve the desired results and impacts (Figure 60).

Through IYAFA 2022, it is possible to share examples of how collaboration and partnerships can be key to securing sustainable small-scale fisheries and aquaculture, not only by illustrating what has been achieved but by inspiring new action for upscaling success stories (Box 13). Academics and research partners, regional organizations and NGOs, among others, are looking at ways and means to facilitate, connect, supplement, document and strengthen such efforts.

The role of governments

FAO Members have been creating the enabling environment for implementation of the SSF Guidelines, including the institutional and legal frameworks for participatory, inclusive and transparent processes for policy- and

FIGURE 60 UPTAKE OF THE SSF GUIDELINES PRIOR TO IYAFA 2022

About
1 100
articles and reports
published between 2014 and 2020 refer to the SSF Guidelines with an increasing trend – 279 items in 2020, compared with 61 in 2015 and 41 in 2014.[1]

More than **10**
global, regional and subregional small-scale fisheries social movements and civil society organizations,
including women's and indigenous peoples organizations, and representing many thousands of small-scale fishers and fishworkers, have been supported by FAO.[2]

A total of **50**
countries implement the SSF Guidelines
in various ways, with FAO support or through engagement with other projects, initiatives and organizations.[2]

Government representatives and other stakeholders from **80**
countries participated
in seven regional awareness-raising and consultation events on the SSF Guidelines organized by FAO (in collaboration with regional partners) in 2015–2018.[2]

Over
35 000
page views
of the SSF Guidelines web page on the FAO website in 2019 and 2020.[2]

[1] Based on a search of the SSF Guidelines in Google Scholar from 1 January 2014 to 31 December 2020.
[2] Information compiled from various FAO reports and web page analyses conducted in early 2021.
SOURCE: FAO. 2021. *SSF Guidelines uptake and influence: A pathway to impact.* Rome. www.fao.org/publications/card/en/c/CB7657EN

decision-making. IYAFA 2022 allows governments to demonstrate their commitments for responsible fisheries and aquaculture and overall socio-economic development.

Appropriate legislation and enforcement provide the strongest possible framework for inclusive, participatory fisheries governance and resource use and management. They can therefore be a tangible means to support small-scale fishers, fish farmers, fishworkers and their communities and foster their contribution to broader development goals, including the progressive realization of the right to food, poverty eradication, and sustainable resource utilization. Two guidance documents – a diagnostic tool for sustainable small-scale fisheries (ELI, 2020) and a guide to implementing the SSF Guidelines (FAO, 2020) – are available on how to appropriately amend or update legislation, supported by a related e-learning course. A new section in FAOLEX (FAO, 2022c) specifically devoted to small-scale fisheries is under development to inform and disseminate such reform processes.

Some FAO Members have adopted participatory processes led by multi-stakeholder national teams comprising representatives of governments, small-scale fisheries organizations, academia and NGOs to develop National Plans of Action in support of the implementation of the SSF Guidelines (NPOA-SSF). For example, the United Republic of Tanzania and Senegal have already launched their respective NPOA-SSF and have a coherent pathway towards more secure small-scale fisheries. Some countries are in the middle of consultations and assessments to facilitate such processes, while others have launched initiatives that focus on specific aspects of the SSF Guidelines. It is estimated that some 50 countries implement the SSF Guidelines in various ways, many with FAO support or through engagement with other projects, initiatives and organizations.

Partnerships among peers: small-scale fisheries organizations

Fishers and fishworkers, especially through their organizations, are main drivers of change and play a major role in the bottom-up and inclusive processes called for in the SSF Guidelines.

A key concept with respect to the effective participation of small-scale fisheries actors is empowerment: fishers and fishworkers – men and women, youth and vulnerable groups – need to have the capacity to take part in decision-making, access accurate information and know their rights. They also require structures where they are represented and have the space to participate in appropriate ways through collective action at the local, national, regional and global levels. For example, the Global Strategic Framework in support of the implementation of the SSF Guidelines includes a global Advisory Group with representatives from international small-scale fisheries organizations, and this has recently been complemented by regional advisory groups in key regions. Similarly, both the African Union's initiative to establish non-state actor platforms for fisher, fish farmer and fishworker representatives and the African Women Network of Fish Processors and Traders are examples of empowering achievements, while the efforts of the African Confederation of Professional Organizations of Artisanal Fisheries developed a specific action plan for IYAFA 2022.

These global and regional networks need to be backed up by strong local and national representation. In the United Republic of Tanzania, the Tanzanian Women Fish Workers Association was launched in 2019 and is being supported to create district-level chapters to ensure true bottom-up processes by empowering more women to take part in discussions and raise their voices, for example through direct participation in a review of the Tanzanian fisheries law.

Academia and research, non-governmental organizations and intergovernmental organizations

Many partnerships in research and academia are advancing the understanding of small-scale fisheries, providing invaluable input to the implementation of the SSF Guidelines. Between the 2014 endorsement of the SSF Guidelines and 2020, approximately 1 100 articles and reports were published referring to the SSF Guidelines. The global research network Too Big To Ignore (TBTI) remains a driving force: many of its members have published about efforts to implement the SSF Guidelines, while different partners are actively engaged in their implementation and/or contributing to the IYAFA 2022 celebrations (for example, through five regional TBTI congresses during the year).

An important role can be played by NGOs in supporting the implementation of the SSF Guidelines and promoting the sharing of information, experiences and good practices. For example, the Environmental Defense Fund, in collaboration with partners, established the Small-Scale Fisheries Resource and Collaboration Hub to provide an online space to share materials and engage.

Global and regional intergovernmental organizations and initiatives (including those outside the realm of fisheries) can reflect and call for the implementation of the SSF Guidelines in global and regional processes, thereby recognizing the positive contribution of the subsector to food security and nutrition, livelihoods and resource stewardship and promoting pathways for development that are more integrated and cross-cutting.

Monitoring for change

IYAFA 2022 marks the launch of a pilot monitoring, evaluation and learning (MEL) framework for the SSF Guidelines to assess progress towards the implementation of the SSF Guidelines' objectives and recommendations (paragraph 13.4) and the involvement of the small-scale fishing communities in these monitoring efforts (paragraph 13.5).

This MEL framework is intended not only to monitor progress of the implementation of the SSF Guidelines and highlight related gaps and challenges, but also to enable sharing of good practices, identify opportunities and inform future action. It is intended as a participatory tool to advance sustainable small-scale fisheries and the implementation of the SSF Guidelines. This will help to speed up collective learning, continue to build partnerships and realize the potential of small-scale artisanal fisheries while leaving no one behind. ■

UNITED REPUBLIC OF TANZANIA
Putting fresh sprat to sun-dry on the shore of Lake Tanganyika in Kigoma – FISH4ACP unlocking the potential of fisheries and aquaculture value chains.
©FAO/Luis Tato

PART 3
BLUE TRANSFORMATION TO ACHIEVE THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT

DECADE OF ACTION TO DELIVER THE GLOBAL GOALS

The Sustainable Development Goals and fisheries and aquaculture

The 2030 Agenda for Sustainable Development continues to shape the strategies of countries, international organizations and civil society, striving for a fair, prosperous and sustainable world. Its 17 Sustainable Development Goals (SDGs) and their related targets and indicators are central to the achievement of inclusive, sustainable economic growth that encompasses environmental, economic and social concerns.

The success of the SDGs rests to a large extent on an effective monitoring, review and follow-up process. The 2030 Agenda sets in place a global reporting structure that includes inputs at local, national and regional levels and culminates in the United Nations High-Level Political Forum on Sustainable Development (HLPF). SDG indicators are the foundation of this global framework for mutual accountability. A global indicator framework comprising 230 indicators to monitor the SDGs' 169 targets was set up by the United Nations Statistical Commission in March 2016. Reflecting the 2030 Agenda's guiding principle of "leaving no one behind", indicators are set to be disaggregated by gender, age, income, geography, occupation and other aspects of social identity (HLPF, 2022).

The interconnected nature of the SDGs makes them indivisible by nature, with progress in one area supporting and reinforcing progress in another. Hence there is a strong emphasis on integrated approaches to development, and results from related indicators must be jointly evaluated to allow a comprehensive analysis of the impacts and trade-offs between different development paths. This section reviews fisheries and aquaculture in the broader context of related indicators.

The 2030 Agenda acknowledges the key role of food and agriculture in combating hunger and food insecurity and alleviating poverty (FAO, 2022d). A focus on rural development, capacity building and investment in food production systems, including fisheries and aquaculture, is crucial to end poverty and hunger and bring about sustainable development. As the COVID-19 pandemic unfolds, progress unfortunately remains insufficient and urgent transformative actions are required. In this regard, given the relevance of all 17 SDGs for FAO's mandate, the Organization's Strategic Framework 2022–2031 has been fully aligned towards supporting achievement of the 2030 Agenda. This logically dovetails with FAO's role as the custodian agency for 21 SDG indicators[1] and as contributing agency to another 5 indicators, spanning SDGs 1, 2, 5, 6, 12, 14 and 15.

Fisheries and aquaculture is a key global food production system, and sustainable management of its resources is central to achieving development that safeguards food security, livelihoods, human dignity and natural resources. Regarding the sustainable use of marine living resources, the FAO Fisheries and Aquaculture Division builds on its global leadership to coordinate work on four indicators (SDG Indicators 14.4.1, 14.6.1, 14.7.1 and 14.b.1) under SDG 14 (Life below water). SDG 14 covers in principle both capture and aquaculture, but the currently defined indicators

1 To view the full list of these 21 SDG indicators, visit: www.fao.org/sustainable-development-goals/indicators/en

BOX 20 SDG TARGET 2.5 AS IT APPLIES TO GENETIC DIVERSITY OF AQUATIC RESOURCES

Sustainable Development Goal (SDG) 2 is widely known as the Zero Hunger Goal, but it is broader than this, encompassing the achievement of food security and the promotion of sustainable agriculture. Given that biodiversity underpins our food systems, its effective management is critical to our future food security, and this is recognized in SDG Target 2.5: By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species ... and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources .... .

While acknowledging that, compared with terrestrial farming, aquaculture is a young form of food production, biodiversity is as important to aquatic as it is to terrestrial food systems. Although not explicitly excluded in the wording of SDG Target 2.5, aquatic genetic diversity has not been included when assessing progress against the achievement of SDG Target 2.5, mainly because no specific indicators have been developed for this purpose. The indicators associated with SDG Target 2.5 relate only to the number of plant and animal genetic resources for food and agriculture secured in conservation facilities, and the risk status of livestock breeds. Such measures are quantified through existing information systems on plant and animal genetic resources (FAO's systems are WIEWS[1] and DAD-IS[2]).

As indicated in the first ever global assessment of aquatic genetic resources (AqGR) in 2019,[3] the information that could be used to develop indicators for the maintenance of genetic diversity in aquatic resources used for food and agriculture is currently unavailable or very limited in scope. FAO is addressing this critical knowledge gap through the development of AquaGRIS, a global information system for AqGR. The prototype[4] developed is currently being transformed into a fully functional information system which will include the capacity to generate as yet undefined indicators of the status of management of AqGR.

Together with 21 other SDG targets, SDG Target 2.5 expired in 2020 with relative progress unfortunately negligible.[5] Given the important role that aquatic food plays in human nutrition and food security, it is vital that aquatic diversity also be incorporated into the Post-2020 Biodiversity Framework currently being developed by the Parties to the Convention on Biological Diversity.

[1] WIEWS (World Information and Early Warning System on Plant Genetic Resources for Food and Agriculture): www.fao.org/wiews/en
[2] DAD-IS (Domestic Animal Diversity Information System): www.fao.org/dad-is/en
[3] FAO. 2019. *The State of the World's Aquatic Genetic Resources for Food and Agriculture*. FAO Commission on Genetic Resources for Food and Agriculture assessments. Rome. https://doi.org/10.4060/CA5256EN
[4] A prototype of AquaGRIS with data on a limited number of species is available at: www.fao.org/fishery/aquagris/home
[5] For further details, see: https://unstats.un.org/sdgs/report/2020/progress-summary-for-SDG-targets

mostly concern capture fisheries, however noting that SDG Indicator 14.b.1 also encompasses aquaculture. Work and progress under these four indicators, all classified at Tier I level, are dealt with in the following subsections (pp. 160–169).

For aquaculture development, almost all the SDGs are relevant. Despite this, aquaculture's role in contributing to the SDGs has not always been clearly identified or communicated. Although freshwater aquaculture is already contributing and likely to contribute more to food security than marine fisheries and mariculture does (Zhang *et al*., 2022), it is often implicit rather than explicit – for example under SDG 2 (Zero hunger) – resulting in limited inclusion in sustainability dialogues. At the recent Global Conference on Aquaculture in Shanghai, participants identified strategic priorities for accelerating sustainable aquaculture development and optimizing aquaculture's contribution to the SDGs. These priorities include specific targets and indicators requiring attention, not only through the follow-up and review framework of the 2030 Agenda led by the HLPF, but also through the Post-2020 Biodiversity Framework currently being developed by the Convention on Biological Diversity (Box 20).

Similarly, inland fisheries and the role of freshwater systems as providers of food and nutrition are absent from current SDG texts, despite their relevance to numerous SDGs, in particular SDG 2 (Zero hunger), SDG 6 (Clean water and sanitation), SDG 12 (Responsible consumption and production) and SDG 15

(Life on land). It is crucial to fully account the contribution of all aquatic food[2] production systems to achieving the 2030 Agenda, in particular by further integrating the development of aquaculture into national policies.

Six indicators of SDG 14 are under the custodianship of agencies other than FAO. The United Nations Environment Programme (UNEP) is the principal custodian for three of these (SDG Indicators 14.1.1, 14.2.1 and 14.5.1) and the Intergovernmental Oceanographic Commission (IOC-UNESCO) for two (SDG Indicators 14.3.1 and 14.a.1). For the indicators for which time series are available, those that measure environmental degradation (SDG Indicators 14.1.1 and 14.3.1) reveal worsening trends, accelerating the rates of pollution. The only SDG for which there has been clear progress relates to protection of marine environments (SDG Indicator 14.5.1), testimony of a strong political will to enact national legislation. In this regard, however, when evaluating whether to close access to marine waters, the needs of fishers and local communities should be fully considered in order to mitigate the impact on livelihoods and food supply. FAO contributes to these indicators, as described in Box 21.

Finally, the United Nations Secretariat is the custodian for SDG Indicator 14.c.1, which focuses on enhancing conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea. FAO provides inputs to SDG Indicator 14.c.1 in the form of methodological support for certain data elements. However, as only 2021 data are available for this indicator, it is not yet possible to comment on trends or progress. In general, it is difficult to ascertain the status of the indicators that are still classified as Tier II.

Regarding the status of progress on SDGs of relevance for fisheries and aquaculture (other than SDG 14), it is now evident that many of the goals set out in the 2030 Agenda are not on track to be realized within their time frames (United Nations, 2021a). While there has been progress in key areas, there has been regression in others. Moreover, the COVID-19 pandemic has reversed previously favourable trends, further delaying the achievement of targets and worsening more laggard indicators. The underlying threats from climate change, biodiversity loss and pollution, together with direct threats from human conflict, demand decisive action, but the advent of the pandemic and lack of progress in many areas of international development and cooperation have compounded the problem. Regarding SDG 1 (No poverty), consistent progress was being made and the global rate had fallen from 9.9 percent in 2015 to 8.2 percent in 2019 and was predicted to reach 6 percent in 2030. However, 2020 saw the first year-on-year rise in 20 years, with an additional 119 million people pushed into extreme poverty. As for SDG 2 (Zero hunger), global food security rates have been worsening since 2014: as many as 811 million people in the world faced hunger in 2020, with significant deterioration in sub-Saharan Africa and Latin America; and future projections predict increasing challenges as a result of conflicts, climate change and biodiversity loss. The pandemic has directly reduced incomes, disrupted supply chains, worsened nutritional status and brought suffering to many. Notably, the gap in food security between men and women increased from 6 percent in 2019 to 10 percent in 2020.

There are nevertheless some positive stories to be told. The world is generally a better place to live in now than it was at the turn of the century, with less poverty, greater access to education and lower child mortality. Access to safe drinking water has improved, maternal mortality is declining, albeit at a slower rate than needed, and HIV prevalence continues to diminish. In addition, the COVID-19 pandemic has revealed enormous community resilience, and workers in food supply chains have been appraised for their key role in society. Social protection schemes have been massively expanded while large parts of society have started to adjust to digital transformation. Awareness about adoption of cleaner energies and technologies has increased significantly. These advances, in addition to the success of vaccine development through international collaboration, have shown that together we can build back better and stronger and deliver on the 2030 Agenda for a more sustainable future for all.

2 For aquatic food, see Glossary, including Context of SOFIA 2022.

BOX 21 FAO CONTRIBUTIONS TO SDG 14 CONSERVATION INDICATORS ON BIODIVERSITY AND ECOSYSTEM FUNCTION

Sustainable Development Goal (SDG) 14 (Life below water) has seven targets (plus three means of implementation) dedicated to humanity's interactions with the ocean. Many of these cover actions directed at conservation and environmental health, but also concern issues of equity in access to resources and markets and knowledge sharing.

Much of the necessary knowledge is already available for taking the first steps to remove, adapt to or mitigate recognized impacts on the ocean environment. However, in many cases more work is needed to record change in the status and pressures around each issue and report on progress across developed and developing countries.

Beyond work directly focused on fisheries, FAO contributes to understanding and minimizing the impacts of ocean acidification and pollution, enhancing effective area management for the conservation of biodiversity, and strengthening implementation of global agreements on biodiversity and climate. These actions complement work on managing fisheries and synergize with international agreements on trade issues and strengthening of governance.

With regard to SDG Target 14.1 on preventing and reducing marine pollution, most excess outflow of nutrients and solid waste, such as plastics, originates from land. Nevertheless, FAO and partners are developing interventions to reduce waste in aquatic production systems through global initiatives such as the marking of fishing gears and are seeking novel approaches to understand and mitigate the impact of some forms of plastics (i.e. microplastics), in particular on aquatic animals and human health.

Regarding ocean acidification and climate change (SDG Target 14.3), FAO supports Members and the United Nations Framework Convention on Climate Change to monitor and report the rate, magnitude and extent of change, as well as the full impact of greenhouse gas pollution on ocean and fishery variables. The capacity to inform climate-related decisions at management-relevant scales is still a challenge, although efforts to enhance observations and share data and information are well underway.

To improve marine and coastal environmental management (SDG Target 14.2), including spatial management (SDG Target 14.5), FAO facilitates general understanding of how tenure, access, user rights and use of the newly defined other effective area-based conservation measures (OECMs) of the Convention on Biodiversity can bolster opportunities for reaching biodiversity goals that have a 2030 milestone for delivery. To achieve environmental objectives, FAO promotes the use of the full range of management tools to hand, including fisheries management ones, while mainstreaming considerations for biodiversity across all management, leveraging wide institutional cooperation where possible (e.g. between regional seas conventions and action plans and regional fishery bodies and large marine ecosystem projects).

Lastly, in terms of SDG 14 conservation-focused indicators, FAO supports increase of scientific knowledge and development of research capacity (SDG Target 14.a) to enable innovative, inclusive, effective and adaptive management action to face growing external pressures on marine and inland aquatic systems, as articulated in the 2021 COFI Declaration for Sustainable Fisheries and Aquaculture.[1]

[1] FAO. 2021. *2021 COFI Declaration for Sustainable Fisheries and Aquaculture*. Rome. https://doi.org/10.4060/cb3767en

SDG Indicator 14.4.1 – quantifying fish stocks within biologically sustainable levels

SDG Indicator 14.4.1 measures the sustainability of the world's marine capture fisheries by their abundance (FAO, 2022e). This indicator, well established since 1974 at the global and regional levels, has been regularly reported by FAO in its biennial publication *The State of World Fisheries and Aquaculture*. SDG Indicator 14.4.1 measures the sustainability of fish stocks and as such is an end measure of fisheries' biological sustainability – the most fundamental pillar of sustainability upon which eventually depend fisheries' economic and social sustainability. The indicator's temporal trend can show clearly changes and progress towards SDG Target 14.4[3] and facilitate

3 SDG Target 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.

the evaluation of the global effectiveness and efficiency of past fishery policies and management. Its horizontal comparisons between regions or among countries can help identify hotspots that lack progress and deserve more attention.

SDG 14 (Life below water) had a target of 100 percent of fish stocks within biologically sustainable levels by 2020. The latest assessment of the global indicator (see the section The status of fishery resources, p. 46) indicates that the 2020 target was not achieved (UNSD, 2022a). This failure calls for the world community to redouble its commitments and mobilize its efforts.

Under the 2030 Agenda, the country-led decision to expand the indicator to the national level comes together with a legitimate expectation, expressed at the Thirty-fourth Session of the Committee on Fisheries (February 2021), that the classic indicator of *The State of World Fisheries and Aquaculture* be revised so as to better consider national indicators. Indeed, FAO is currently revising its methodology for estimating regional and global indicators (see Box 3, p. 50). The adoption of the indicator at the national level is a unique opportunity for countries to integrate in their policy framework a tool to monitor the status of their fishery resources, using consistent and comparable approaches.

In 2019–2020, FAO piloted a first questionnaire call to facilitate harmonized and consistent reporting by countries on the indicator. Of the 164 countries with maritime coastlines, 98 (i.e. 60 percent) expressed interest in the indicator and 86 reported data that (for 84 of these) could be reviewed by FAO and quality assured for validation (Box 22) before being reported to the United Nations Statistics Division (UNSD) in March 2022. In the published results (UNSD, 2022b), the indicators were validated for 36 countries which passed both first and second levels of quality assurance. For the 29 countries which passed only the first level of quality assurance, the indicator was reported but flagged as unreliable. Finally, 18 countries failed to pass the first level of quality assurance and the indicator could therefore not be calculated. This first reporting exercise revealed the challenges faced by countries in determining stock status: deficiencies in fisheries data collection and management including lack of coordination among agencies involved; insufficient scientific expertise to effectively conduct stock assessment; and organizational and internal communication pitfalls resulting in poor consultation among stakeholders on the reporting process.

Indeed, SDG Indicator 14.4.1 is relatively complex and national reporting is hindered by limited national capacities. In its role as custodian agency of several SDG 14 indicators, FAO is committed to supporting countries to strengthen their capacities to collect data, conduct assessments and estimate SDG Indicator 14.4.1 at the national level. In this respect, FAO first invested in applying methodologies for assessment in data-limited situations and in developing methodologies for reporting on the national indicator (UNSD, 2022c). FAO then implemented a suite of capacity development tools and activities: the SDG Indicator 14.4.1 e-learning course was published in multiple languages (FAO, 2020f); the online FAO stock monitoring tool was developed enabling trainees to practise several data-limited methods; and a series of eight regional or language-based capacity development workshops, attended by more than 70 countries and 500 participants, were held face-to-face or online, between the end of 2019 and early 2022. Alongside, FAO and regional fishery bodies (RFBs) strengthen through the Fisheries and Resources Monitoring System the dissemination of available information on individual stock status and the framework for information and data exchange at various levels, with the goal to support the monitoring of SDG Indicator 14.4.1, and to facilitate RFBs' involvement in accompanying a progressive convergence between global–regional indicators and national estimates.

A new questionnaire dispatch is planned for 2022, with improvements based on countries' feedback and lessons learned from the first call.

A convergence of the two distinct processes of countries reporting their national indices and FAO estimating the regional indices is, to the extent possible, desirable but will need to follow

BOX 22 QUALITY ASSURANCE PROCESS FOR SDG 14.4.1 NATIONAL INDICATORS

The review of the questionnaires for quality assurance (QA) comprises two main steps: first, assessment of the completeness and quality of the information provided by participating countries (quality assurance level 1 or QA1); and second, assessment of the reliability, robustness and transparency of the data and information provided (quality assurance level 2 or QA2).

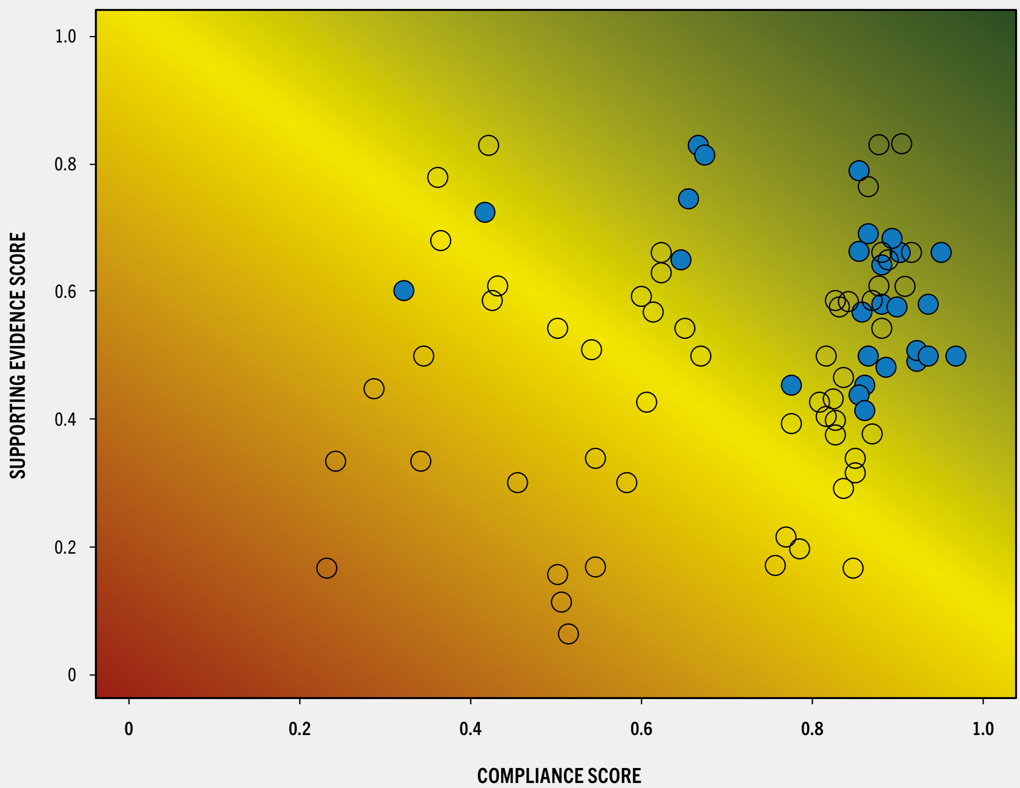
Upon receiving a country's questionnaire submission, it is reviewed for its compliance to guidelines and precision of content, specifically regarding inconsistent, incomplete or unclear entries, missing mandatory fields, or issues reporting the reference list of stocks. Feedback is given to each country, which has an opportunity to respond, edit and improve the questionnaire to the highest possible standard considering the data and human resources available.

Each questionnaire is then assessed relative to objective criteria to score its compliance with the monitoring guidelines and the potential of the supporting evidence for assessing the reliability of the reported content against existing, alternative information (see figure). This score represents the level of confidence attributed to the national reporting and is based on: (i) the availability of stock status information of the reference list of stocks (i.e. known vs unknown status); (ii) the reliability of the method (i.e. formal assessment; grey data or catch trend analysis; or black data and qualitative assessment/expert judgement forming the basis of the stock status classification); (iii) the existence and availability of reference sources to validate the assessment outputs; and (iv) the amount of data and information provided at the stock level.

The results of this QA1 can then be used to support onward QA2 analyses, which check the consistency of inputs with other known sources of information and may include: (i) checks on the assessment outputs against stock assessment reports that are publicly available or accessible to FAO; or (ii) a regional expert review to verify the reference list of stocks, provide knowledge on assessments performed (i.e. reliability of the assessment) or provide knowledge on data availability and quality. The results of the QA2 will also allow regional experts to provide insights into where to direct capacity development efforts in monitoring and reporting on SDG Indicator 14.4.1.

Upon validation, each stock is finally assigned a unique identifier in the Global Record of Stocks and Fisheries to facilitate data management, quality assurance and monitoring in future reporting rounds.

SDG INDICATOR 14.4.1 – QUALITY ASSURANCE PROCESS



NOTES: Quality assurance level 1 (QA1) scores of objective criteria for compliance (X axis) and supporting evidence (Y axis) provided in the questionnaires submitted by countries. Countries that passed QA2 are blue dots, and all other countries are open circles. Background colour gradient indicates low (red) to high (green) scores.
SOURCE: FAO.

a progressive pathway. The current regional and global estimates of sustainable fishery stocks cannot be aggregated from country data submitted through the questionnaire because of quality concerns, and this practice will remain for the foreseeable future. With the adoption of FAO's revised methodology (see Box 3, p. 50), and once FAO has gathered enough high reliability country estimates in the medium-to-long term, relevant data reported by countries can be combined with RFB data and other sources to adjust the regional estimates. This is expected to strengthen the reliability of FAO data and encourage more countries to report as they see their data being effectively used. As a result, disaggregation of regional and global estimates may become feasible by country, thus meeting the requirements set by UNSD.

SDG Indicator 14.6.1 – assessing degree of implementation of international instruments to combat illegal, unreported and unregulated fishing

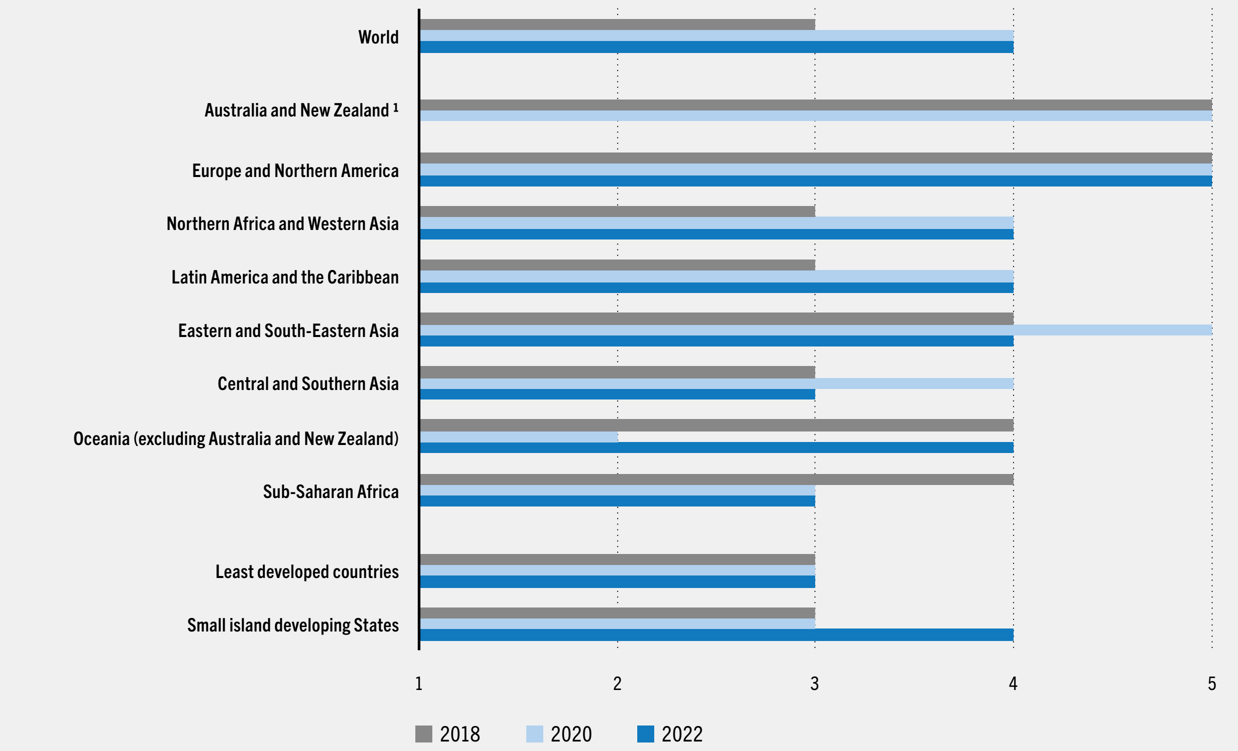
Illegal, unreported and unregulated (IUU) fishing remains one of the greatest threats to aquatic ecosystems and to fishers and communities who rely on their resources for nutrition and livelihoods. This is due to its potent ability to undermine national and regional efforts to manage fisheries sustainably and conserve marine biodiversity (FAO, 2022f).

Relevant international instruments are key to combating IUU fishing. In this regard, SDG Indicator 14.6.1 measures the degree of implementation by States of five of the principal instruments. The methodology (UNSD, 2022d), approved by States in April 2018 through the Inter-agency and Expert Group on SDG Indicators, aims to provide an effective and globally relevant indicator for measuring progress while minimizing the reporting burden placed on States. Questions used for this indicator were integrated into the longstanding Committee on Fisheries (COFI) questionnaire for monitoring the implementation of the Code of Conduct for Responsible Fisheries and related instruments. In line with guidance issued by COFI at its Thirty-second and Thirty-fourth Sessions, only scores validated by the respective countries are included within the submission to the United Nations Statistics Division (UNSD) and are considered in the following analysis.

Between 2018 and 2022, the average degree of implementation of international instruments to combat IUU fishing as measured by the indicator has improved across the world (UNSD, 2022b; Figure 61). In this period, the global aggregated indicator has risen from 3 to 4 (out of a maximum score of 5). Based on their reporting for SDG Indicator 14.6.1, States have thus made good overall progress in carrying out the recommended measures to combat IUU fishing, with close to 75 percent scoring highly in their degree of implementation of relevant international instruments in 2022 compared with 70 percent in 2018. Small island developing States, faced with specific challenges in fully implementing these instruments due to the large amounts of waters under their jurisdiction, registered an improvement from a medium level of implementation in 2018 and 2020 to a high level in 2022. In the case of least developed countries, which often face challenges to implement these instruments, implementation has remained at a medium level from 2018 through to 2022. In terms of regional groupings, fluctuation can be seen over the years in certain regions and no clear trend can be noted in the aggregate levels of implementation.

The global figures on SDG Indicator 14.6.1 are based on scores from approximately 50 percent of the total number of FAO Member States, with the exception of 2018 when reporting States reached 60 percent. While these figures reflect an overall improvement, differences in the number and composition of reporting States within a particular regional grouping could affect the indicator and explain the fluctuations observed in certain regional scores over the years. For example, Table 16 shows that between 2018 and 2022 there was a notable drop in the number of relevant States reporting on the indicator in Central and Southern Asia (from 7 to 2) and sub-Saharan Africa (from 18 to 9). To alleviate this limitation and allow for a more accurate trend analysis of progress made on SDG Indicator 14.6.1, it is necessary to increase the number of States reporting.

FIGURE 61 PROGRESS IN THE DEGREE OF IMPLEMENTATION OF INTERNATIONAL INSTRUMENTS AIMED AT COMBATING IUU FISHING BY REGION, 2018–2022 (SDG INDICATOR 14.6.1)



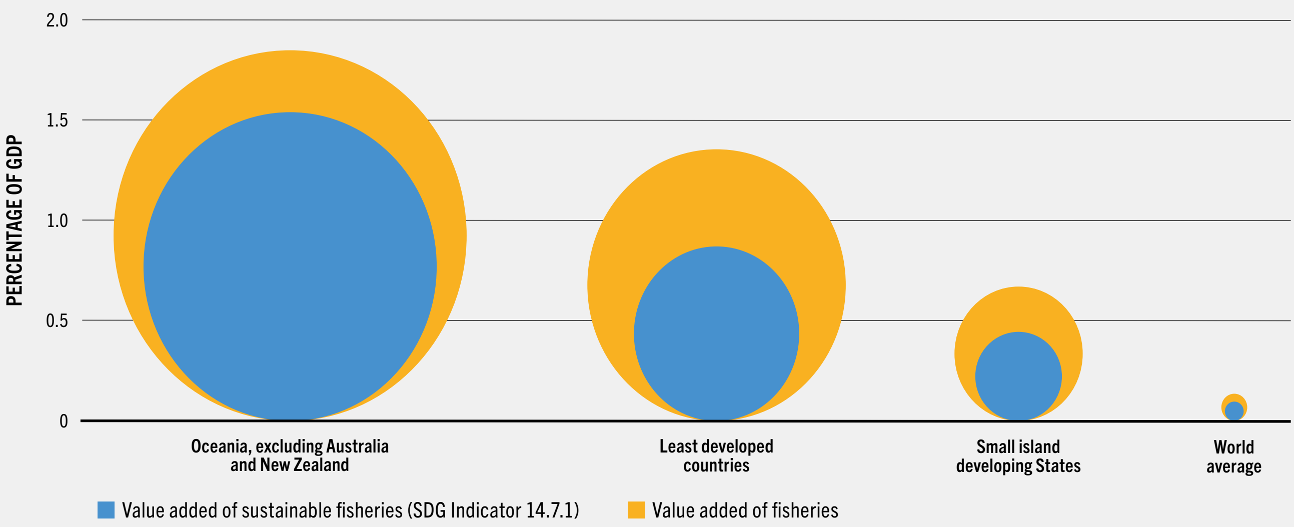
[1] Insufficient reporting States to create an aggregated score for this regional grouping in 2022.
NOTE: The chart shows the average level of implementation of the indicator by countries within each grouping, from the lowest level (1) to the highest level (5).
SOURCE: FAO.

TABLE 16 TRENDS IN THE RATE OF REPORTING BY FAO MEMBERS ON SDG INDICATOR 14.6.1 BY REGION, 2018–2022

Regions	Number of FAO Member States	Percentage of States reporting			Number of relevant States[1] reporting		
		2018	2022		2018	2020	2022
Latin America and the Caribbean	33	64	61	70	21	17	22
Europe and Northern America	45	80	69	80	33	28	36
Central and Southern Asia	14	64	36	36	7	3	2
Eastern and South-Eastern Asia	16	50	56	44	8	6	7
Northern Africa and Western Asia	23	48	43	30	8	6	6
Sub-Saharan Africa	48	50	25	27	18	11	9
Oceania	17	53	53	47	9	9	8
World	**196**	**60**	**49**	**51**	**104**	**80**	**90**

[1] Relevant States are those States which report and for which the indicator is considered applicable to their national context.
NOTE: Figures include FAO Associate Members.
SOURCE: FAO.

FIGURE 62 ECONOMIC CONTRIBUTION OF FISHERIES AND AQUACULTURE, 2019 (SDG INDICATOR 14.7.1)



NOTE: GDP = gross domestic product.
SOURCE: FAO.

SDG Indicator 14.7.1 – measuring sustainable fisheries contributions to national economies

Fisheries support the livelihoods of millions worldwide, providing an important source of income and food security. Ensuring that fisheries resources are appropriately safeguarded is inextricably linked to their continued contribution to economies and sustainable development, especially for least developed countries (LDCs) and small island developing States (SIDS).

SDG Indicator 14.7.1 (Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries) combines the value added of fisheries with the biological sustainability of regional stocks into a single, internationally comparable indicator that allows countries to better understand the importance of sustainable fisheries for their national economies (FAO, 2022g). In 2019 (UNSD, 2022b), sustainable fisheries accounted for just under 0.1 percent of gross domestic product (GDP) worldwide, 0.46 percent in SIDS and 0.88 percent in LDCs. The figure is far higher in some countries, such as the Comoros, which saw the value of its sustainable fisheries as a proportion of GDP grow from 4.5 percent in 2011 to 7 percent in 2019.

Central to estimating the value of sustainable fisheries is the biological sustainability of stocks. The sustainable management of fishery stocks remains critical for ensuring that fisheries continue to generate economic growth and support equitable development, meeting the needs of today without compromising future generations.

The production and the value added of the sector have expanded consistently in recent years, generating economic dividends and contributing to sustained economic growth (Figure 62). Yet these economic dividends can only be maintained into the future through prudent management of fishery stocks. Some regions are experiencing significant pressures on their stocks, with Oceania (excluding Australia and New Zealand) – the region where the contribution of sustainable fisheries to national GDP (1.54 percent) is the highest – seeing average sustainability levels falling across the board. This has led to a worsening overall trend for regions such as Eastern and South-Eastern Asia, where sustainable fisheries as a proportion of GDP fell from 1.06 percent in 2011 to 0.80 percent in 2019.

BOX 23 TOWARDS ENHANCED REPORTING AND EXPANDED COVERAGE ON SDG INDICATOR 14.7.1 THROUGH CAPACITY-BUILDING ACTIONS – COUNTRY EXAMPLES

A key characteristic of SDG Indicator 14.7.1, which measures the economic contribution of sustainable fisheries, is that it does not impose any additional reporting burden on countries. Increased reporting is often expensive and requires governments to weigh up costs and possible benefits. The baseline methodology developed for SDG Indicator 14.7.1 relies solely on information already available from national accounts systems to address these issues and ensure that it has the best global representation possible.

FAO is currently fine-tuning the analysis associated with the indicator methodology by checking the possibility of additional data being reported by countries based on their national context and needs. In partnership with the Secretariat of the Pacific Community, pilot trials are ongoing in Kiribati and Samoa. Like many small island developing States (SIDS), Kiribati and Samoa are both nations with rich fishing histories and where fishing continues to play a critical role in the livelihoods and economic well-being of the population. By collecting the necessary data – including demographic information, the economic value of subsistence fisheries and value addition at each step of the value chain – a better understanding of the true contribution of fisheries to overall GDP and to the livelihoods of different population groups may be formed. Analysing the contribution of women, rural communities and those employed in the sector can significantly enhance the usefulness of the information collected for the industry and policymakers.

Given the varying capacity and trade-off costs for SIDS and other developing countries to collect and provide additional information, any expansion of the current methodology would be done on a case-by-case basis. The experience and lessons learned in tailoring SDG Indicator 14.7.1 to the national context of these Pacific Island countries may serve as a benchmark for other countries facing similar challenges and willing to enhance their understanding of the contribution of fisheries within their national economies and its benefits to different population groups.

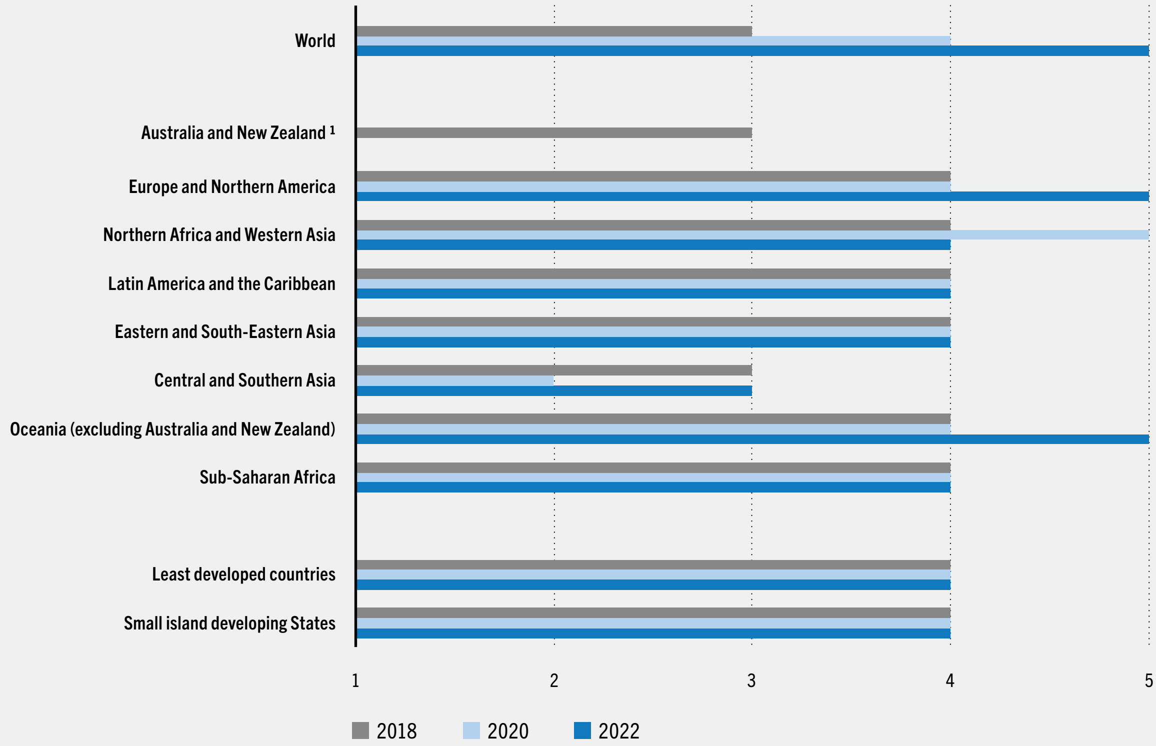
The current methodology for estimating SDG Indicator 14.7.1 provides an international baseline for assessing the sector (UNSD, 2022e). However, adjustments and parallel indicators may better reflect differing national contexts. Whereas currently the regular calculation for the majority of countries relies on the stock status by region, with more national data becoming available for SDG Indicator 14.4.1 (Proportion of fish stocks within biologically sustainable levels), calculation enhancements within SDG Indicator 14.7.1 can be implemented focusing on the multiplier for stock sustainability. Furthermore, there are ongoing country trials to enhance reporting on SDG Indicator 14.7.1 and adjust the indicator to measure GDP and the value of sustainable fisheries for different groups of the population such as women, subsistence fishers and rural workers (Box 23).

SDG Indicator 14.b.1 – assessing degree of recognition and protection of access rights for small-scale fisheries

The year 2022 confirms the importance for SDG Target 14.b of providing access for small-scale artisanal fishers to marine resources and markets. Indeed, 2022 is the International Year of Artisanal Fisheries and Aquaculture (IYAFA), which provides an enormously important platform to make progress in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries, as measured through SDG Indicator 14.b.1 (UNSD, 2022f).

Since 2015, most regions have expanded the adoption of regulatory frameworks supporting small-scale fisheries and promoting participatory decision-making processes (Figure 63). The average global score for SDG Indicator 14.b.1 reveals an

FIGURE 63 PROGRESS IN THE DEGREE OF APPLICATION OF A LEGAL/REGULATORY/POLICY/INSTITUTIONAL FRAMEWORK WHICH RECOGNIZES AND PROTECTS ACCESS RIGHTS FOR SMALL-SCALE FISHERIES BY REGION, 2018–2022 (SDG INDICATOR 14.B.1)



[1] Insufficient reporting States to create an aggregated score for this regional grouping in 2022.
NOTE: The chart shows the average level of implementation of the indicator by countries within each grouping, from the lowest level (1) to the highest level (5).
SOURCE: FAO.

increasing trend, for which reporting by countries has risen from 3 (out of a maximum of 5) in 2018 to 4 in 2020 and then to 5 in 2022 (UNSD, 2022b). At the regional level, overall scoring has remained stable or improved. However, Northern Africa and Western Asia scored lower in 2022 than in 2020.

While these figures reflect an overall improvement, it is important to also consider the reporting rate (Table 17). At the global level, the percentage of States reporting has remained relatively stable over the years, with 52 percent reporting in 2022 and 2020 compared with 63 percent in 2018 (FAO, 2022h). Within a particular regional grouping, differences in the number and composition of reporting States could affect the indicator and explain the fluctuations of regression or improvement observed in certain regional scores over the years. Average scores in 2022 for Central and Southern Asia, Northern Africa and Western Asia, and sub-Saharan Africa are the least likely to be representative of the region, considering the drop in the number of relevant States reporting between 2018 and 2022 within these regions, respectively, from 9 to 5, 10 to 7, and 26 to 13. It is thus clear that efforts need to be redoubled and there is no room for complacency.

The SDG Indicator 14.b.1 score relies on three main features. The first is the development and application of enabling frameworks, a fundamental

TABLE 17 TRENDS IN THE RATE OF REPORTING BY FAO MEMBERS ON SDG INDICATOR 14.B.1 BY REGION, 2018–2022

Regions	Number of FAO Member States	Percentage of States reporting			Number of relevant States[1] reporting		
		2018	2020	2022	2018	2020	2022
Latin America and the Caribbean	33	64	70	73	21	23	24
Europe and Northern America	45	80	68	80	32	29	33
Central and Southern Asia	14	64	43	36	9	6	5
Eastern and South-Eastern Asia	16	56	63	44	8	9	6
Northern Africa and Western Asia	23	48	43	35	10	6	7
Sub-Saharan Africa	48	60	27	29	26	12	13
Oceania	17	53	53	41	7	7	6
World	**196**	**63**	**52**	**52**	**113**	**92**	**94**

[1] Relevant States are those States which report and for which the indicator is considered applicable to their national context.
NOTE: Figures include FAO Associate Members.
SOURCE: FAO.

prerequisite. This requires, for example, that legislation is supportive of small-scale fisheries. A dedicated section on small-scale fisheries in the FAOLEX Legal Database will be released in 2022 to facilitate legal and regulatory reform in support of small-scale fisheries in the future, while guidance on legislating for sustainable small-scale fisheries (FAO, 2020g, 2022i) is available online. Some countries, such as Cabo Verde, are taking a lead in crafting such legislation, in which the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) are specifically included.

Second is the assessment of concrete action in support of small-scale fisheries. A number of countries are taking a strategic approach through the participatory development of National Plans of Action to implement the SSF Guidelines. This is happening for example in the United Republic of Tanzania, Namibia, Madagascar and Malawi (see the section Partnerships to advance the implementation of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries, p. 153).

Finally, the score depends on the measurement of the participation of small-scale fisheries actors in decision-making. It is important to recall that while SDG 14 refers only to marine fisheries, inland fisheries would equally benefit from better access to resources and markets. Results from the Illuminating Hidden Harvests (IHH) study (FAO, Duke University and WorldFish, forthcoming; see the section Illuminating Hidden Harvests: the contributions of small-scale fisheries to sustainable development, p. 151) provide new evidence in this respect. The study highlights the global recognition that co-management is necessary for effective and just governance. Indeed, 35–40 percent of catches from marine and inland small-scale fisheries from 58 IHH country and territory case studies originated from marine and inland fisheries formally governed with provisions for co-management. However, only about one-fifth of fishers in those marine or inland fisheries rate their effective participation as high. This is testimony that an enabling environment alone does not guarantee meaningful participation; it must be enacted also through capacity development and inclusive institutional set-ups.

In addition, the IHH study found that 22 countries (representing 48 percent of global marine capture fisheries production) exported on average almost 26 percent of their marine small-scale fisheries catch by volume in the period 2013–2017. In nine countries (representing 25 percent of global inland capture fisheries production), just over 16 percent on average of the inland small-scale fisheries catch was exported in the same period. This is a first attempt to assess the participation of small-scale fisheries in an increasingly globalized world.

There are numerous other actions in support of achieving SDG Target 14.b, for example, the Regional Plan of Action for Small-Scale Fisheries of the General Fisheries Commission for the Mediterranean (GFCM, 2022), support to the African Continental Non-State Actors Coordination Platform in Fisheries and Aquaculture (AU-IBAR, 2021) and the 2030 Latin America and Caribbean Regional Knowledge Management Platform (ECLAC, 2022). Nevertheless, countries still require much support in their progress towards achieving SDG Target 14.b and reporting on SDG Indicator 14.b.1. ■

UNITED NATIONS DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021–2030)

Science opportunities for fisheries and aquaculture management

Science is one of the key levers to accelerate progress in the transformation of food systems and achievement of the Sustainable Development Goals (SDGs) (United Nations, 2019), as scientific evidence is necessary to create sustainable solutions. A strong science–policy interface is crucial to help design these solutions and ultimately ensure that decisions, agreements and actions are based on the best available evidence. Several recent events facilitated by FAO specifically refer to and build on science. The International Symposium on Fisheries Sustainability (18–21 November 2019, Rome) was held to identify pathways to strengthen the science and policy interplay in fisheries production, management and trade, based on solid sustainability principles for improved outcomes on the ground. The symposium brought together a diverse group of experts and participants from around the world (around 1 000 attendees from more than 100 countries) and enabled an open dialogue and mutual understanding promoting science-based strategies for synergistic actions and supportive policies, at all levels. The discussions held resulted in a set of science-based recommendations and overarching actions to help achieve sustainable, equitable and resilient aquatic food[4] systems, while enhancing sustainable productivity to improve food security and nutrition and contribute to economic growth, raising living standards, and empowering women, youth and vulnerable communities (FAO, 2020h).

The Global Conference on Aquaculture Millennium +20 was the fourth in a series of decadal development and science-oriented conferences that have shaped global aquaculture. It attracted over 1 700 delegates from more than 100 countries and a diverse set of sectors. The conference identified key policy and technology innovations, scientific findings, investment opportunities and areas of cooperation that will promote the further development of sustainable aquaculture. It was informed by nine science-based thematic reviews, six regional reviews, and a global synthesis as well as over 100 academic posters. The Shanghai Declaration – a key output – took full account of the science-based information emerging from the thematic reviews and the conference to outline a common vision, key priorities and a call for actions for sustainable aquaculture.

With the increasing recognition of the importance of aquatic food comes the need to improve the scientific knowledge on its nutritional value and overall contribution to nourishing a growing population and addressing the objectives of the 2030 Agenda (Box 24). The outcomes of the above-mentioned events, as well as the dialogue on new research needs related to aquatic foods, should generate priority actions that will characterize science contributions to the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) and ultimately enhance the long-term sustainability of fisheries and aquaculture.

4 For aquatic food, see Glossary, including Context of SOFIA 2022.

BOX 24 POSITIONING AQUATIC FOODS FOR NOURISHING NATIONS BY 2030 AND BEYOND[1]

Sustaining aquatic foods was identified by the Scientific Group of the United Nations Food Systems Summit as one of seven science-driven priorities needed to accelerate the transformation to healthier, more sustainable, equitable and resilient food systems. Aquatic foods also emerged as a solution cluster to achieve specific Sustainable Development Goal (SDG) targets and contribute to possible solutions for transforming food systems.

In 2021, there were two major scientific initiatives for positioning aquatic foods towards achieving the SDGs: the UN Nutrition Discussion Paper, The role of aquatic foods in sustainable healthy diets,[2] and the peer-reviewed paper on aquatic foods to nourish nations by Blue Food Assessment.[3] These present the breadth of the current evidence and propose recommendations to steer policies, investments and research so that aquatic foods can better contribute to improving global food and nutrition security.

A shift in the global narrative from feeding to nourishing is necessary in order that the full benefits of aquatic foods as "superfoods"[4] can be recognized. Greater recognition and generation of data on the contribution of diverse aquatic foods – animals, plants and microorganisms – in providing multiple bioavailable micronutrients (e.g. calcium, iron, zinc, vitamin B12 and vitamin A) and essential fatty acids, as well as protein, are required. Further, research is needed to develop diverse, culturally acceptable, affordable and convenient aquatic food products, for use in the first 1 000 days of life in order that aquatic foods can contribute to improved health and nutrition in women, and cognition, development and growth in young children.

Huge gaps in disaggregated data on consumption patterns, diversity and abundance, environmental footprint, and sustainable production systems of diverse aquatic foods hinder the discourse, understanding and integration of aquatic foods in food system transformation. Multidisciplinary research on the benefits of aquatic foods for different population groups – for food and nutrition security, environmental resilience and sustainability – and socio-economic development, especially in low- and middle-income countries, must be prioritized.

A nutrition-sensitive aquatic food systems approach is needed to frame the scientific agenda for advancing aquatic foods as superfoods for nourishing nations. Research needs for this approach include:

- analysis of the nutrient composition and food safety of diverse aquatic foods, from inland and marine fisheries and aquaculture;
- development of innovations to reduce loss and waste;
- development of integrated production systems that include diverse aquatic foods as well as nutritious plant-source foods; and
- generation of the scientific basis for incorporating diverse aquatic foods in national food-based dietary guidelines.

In addition, attention should be given to the inclusion of low-trophic aquatic foods such as seaweed, jellyfish and sea cucumber.

The disruptions and risks caused by the growing climate crisis represent a mounting threat for aquatic food systems. The COVID-19 pandemic has further exposed the fragility of these systems, increasing the negative impacts on food and nutrition security, income and livelihoods, especially of small-scale actors. Research on the scale of the disruptions and vulnerabilities for different groups of actors, including consumers and the poor and vulnerable, is needed to ensure sustainability of aquatic food systems.

The United Nations declaration of 2022 as the International Year of Artisanal Fisheries and Aquaculture provides a strong platform to strengthen research efforts and better acknowledge the role of diverse aquatic foods as superfoods that can be harnessed to nourish nations.

[1] See also Box 19, p. 146.
[2] UN Nutrition. 2021. *The role of aquatic foods in sustainable healthy diets*. Discussion Paper. Rome, FAO. www.unnutrition.org/wp-content/uploads/FINAL-UN-Nutrition-Aquatic-foods-Paper_EN_.pdf
[3] Golden, C.D., Koehn, J.Z., Shepon, A., Passarelli, S., Free, C.M., Viana, D.F., Matthey, H. *et al*. 2021. Aquatic foods to nourish nations. *Nature*, 598: 315–320.
[4] "Superfoods" refer to (micro)nutrient-rich foods that have unique benefits for nutrition and health, and which must be given special attention in diets.

To foster integration of scientific advances and recognizing the achievements and challenges facing the sector since the endorsement of the Code of Conduct for Responsible Fisheries, the COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021b) was adopted unanimously at the Thirty-fourth Session of the Committee on Fisheries (COFI) in February 2021. The Declaration recognizes that challenges in implementing effective fisheries management measures are complex, region-specific and multidimensional, further complicated by climate change and ocean acidification, and are often due to insufficient data to support science-based decisions. It recognizes the need to address these challenges through innovative, inclusive, effective and adaptive fisheries management measures based on the best available scientific information. It also recognizes the key role of the ecosystem approach as an effective framework for integrating conservation and sustainable utilization objectives and the need to strengthen the scientific basis in support of fisheries and aquaculture management decisions. This entails the use of new information and communication technologies with recent technological advances, such as interoperable fisheries information systems, which offer new opportunities to better monitor fisheries and aquaculture and generate comprehensive multidisciplinary data and information underpinning science to inform management policy while engaging a multitude of stakeholders (Box 25). Also key is the promotion of international scientific cooperation, capacity building, education and training. Finally, the Declaration recognizes the potential of aquaculture for further growth, and the need for innovative practices which support environmental stewardship, with particular attention to food-deficit regions. It provides strategic orientation for enhancing the science–policy interface in support of fisheries management under the stewardship of COFI, the main global forum for discussions and decisions on fisheries and aquaculture-related issues, to further strengthen participatory and science-based solutions.[5]

5 For the list of commitments and priorities of the 2021 COFI Declaration for Sustainable Fisheries and Aquaculture: www.fao.org/3/cb3767en/cb3767en.pdf#page=10

What is the Ocean Decade?

The proclamation by the United Nations General Assembly in December 2017 of the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) (UNDOSSD) underscores the priority that United Nations Member States place on achieving ocean sustainability, and their conviction that science must play a central role in the process.

The Ocean Decade strives to stimulate "the science we need for the ocean we want" in order "to catalyse transformative ocean science solutions for sustainable development, connecting people and our ocean" (IOC-UNESCO, 2021, p. 17), and seeks to ensure that ocean science fully supports countries' actions to sustainably manage the ocean and to achieve the 2030 Agenda.

The Ocean Decade will be implemented based on a Plan (IOC-UNESCO, 2021), produced through a highly participatory and inclusive process led by the Intergovernmental Oceanographic Commission involving more than 1 900 stakeholders, including Member States, thematic experts, civil society and representatives from United Nations bodies, all making significant contributions.

The Implementation Plan provides a non-prescriptive framework for transformational action that will build on existing achievements and deliver across geographies, sectors, disciplines and generations. It focuses on addressing ten challenges, which articulate the immediate priorities for the Decade and aim to unite the Decade partners in collective action, thus ensuring that the whole of the Decade is greater than the sum of its parts.

UNDOSSD Challenge 3 is particularly relevant to the fisheries and aquaculture sector, as it seeks to generate knowledge, support innovation and develop solutions to optimize the role of the ocean in sustainably feeding the world's population under changing environmental, social and climate conditions.

The world will have an additional 2 billion people to feed over the next 30 years. Today the ocean makes a significant contribution to food security and nutrition, and it holds the potential to play an even bigger role in the global food system.

BOX 25 DIGITAL INNOVATION FOR SPECIES IDENTIFICATION

Technological innovations are transforming the way information and knowledge about living aquatic species are collected, distributed and made available to decision-makers. The application of machine learning and web-enabled handheld devices can for the first time bring the skills of taxonomists and fisheries scientists to fishers working in the sector and the general community.

The innovations offering scientific breakthroughs for sustainable development include advancements in the identification of marine organisms of actual and potential interest to fisheries and aquaculture. Such improvements facilitate access to species identification, and in so doing, enhance data quality across fisheries and aquaculture value chains.

To publicize advances and connect innovators working in this field, FAO held the global forum, Artificial Intelligence for a Digital Blue Planet, bringing together data scientists and analysts from marine research institutions, universities and the private sector to share their knowledge, skills and innovative ideas. The forum explored issues on how artificial intelligence can identify images of thousands of aquatic species and be utilized to determine size, number and life stage of aquatic life forms. Other topics focused on how global participants can work together in a virtual environment and seek solutions that can be further developed and deployed.[1]

Following the global forum, a webinar explored the use of still imagery and video to record deep-water shark and vulnerable marine ecosystem catches,[2] illustrating the advanced development stage of camera technologies to support on-board fishery observers, especially in the taxonomic classification of rarer species that are difficult for fisheries researchers to identify.

FAO will continue to play an important role in bringing together the various actors working on digital innovations in species identification and promoting the use of camera systems linked to machine learning across a wide range of fisheries globally. By providing guidance and technical advice on the identification of important target or bycatch species, FAO enables targeted interventions for the management and conservation of fisheries and aquaculture value chains.

[1] The Artificial Intelligence for a Digital Blue Planet forum was held on 28–30 June 2021 with the assistance of the Government of Japan. To view all presentations from the forum:
FAO. 2021. *Artificial Intelligence for a Digital Blue Planet* [video]. Cited 26 October 2021. www.youtube.com/playlist?list=PLzp5NgJ2-dK72rgBePlkQoD1gMTjNEJHs
To consult the playlist (in chronological order and following the original agenda):
FAO. 2021. *Artificial Intelligence for a Digital Blue Planet Forum agenda overview*. Cited 26 October 2021. www.fao.org/3/cb5356en/cb5356en.pdf
[2] The FAO virtual meeting, Use of Still and Video Cameras to Record Deepwater Shark and VME Indicator Catches by Scientific Observers, was held on 31 August 2021 with the assistance of the Government of Japan. To view the webinar content:
FAO. 2021. *Use of still and video cameras to record deepwater shark and VME indicator catches by scientific observers* [video]. Cited 26 October 2021. www.youtube.com/results?search_query=Use+of+still+and+video+cameras+to+record+deepwater+shark+and+VME+indicator+catches+by+scientific+observers

The Ocean Decade provides an opportunity to strengthen the fisheries–science–policy nexus and support the building of the networks and partnerships needed to operationalize the recommendations contained in the 2021 COFI Declaration.

FAO and the Decade Actions

Ocean Decade Actions are one of the prime vehicles for engagement with the Ocean Decade; these are tangible initiatives that will be carried out across the globe over the next ten years to overcome the challenges identified in the UNDOSSD Implementation Plan. The actions will focus on the advancement and application of knowledge to support the development of solutions and address inequalities in ocean science capacity and capabilities.

Ocean Decade Actions can be put forward and carried out by a wide range of proponents including, but not limited to, research institutes, governments, United Nations

FIGURE 64 DISCOVER, CONNECT, TAKE ACTION: THE UNITED NATIONS DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021–2030)

SOURCE: FAO.

entities, intergovernmental organizations, other international and regional organizations, business and industry, philanthropic and corporate foundations, non-governmental organizations, educators, community groups and individuals (e.g. via community-led science initiatives) (Figure 64).

FAO is working with partners to deliver targeted actions and help ensure that science and innovation contribute to sustainably feeding the world's population and ending poverty by promoting development of fisheries and aquaculture and informing policy responses to changing environmental, social and climate conditions. Two of the FAO-led actions endorsed by the Ocean Decade are outlined below.

EAF-Nansen Programme

The EAF-Nansen Programme (FAO, 2021h) is a long-standing partnership between Norway[6] and FAO. It builds on more than 45 years of experience and currently involves collaboration with 32 partner countries in Africa and Southeast Asia, regional fisheries organizations and other entities and institutions. The programme promotes sustainable use of marine resources through improved governance, science and knowledge generation and development of capacity in partner countries, which are at the core of the Decade initiative. Another important aspect, relevant to the principles of sustainable development, is the implementation of the ecosystem approach to fisheries (EAF) (FAO, 2003), promoting, among others, consideration of ecological, social and economic aspects of sustainability.

The programme aims to contribute to achieving the Sustainable Development Goals (SDGs), in particular SDG 14 (Life below water), and to promote gender equity to help achieve, among others, SDG 5 (Gender equality).

The programme comprises three main areas of work:

1. Improving knowledge of fisheries and marine ecosystems for use in decision-making and policy development.
2. Supporting sustainable management of fisheries by providing specific support to countries and regions in implementing the EAF.
3. Developing capacity of partner countries to improve their knowledge base to manage fisheries, by organizing specific workshops and training programmes.

A unique feature of the programme, closely aligned with the Ocean Decade, is its contribution to the collection of scientific data through missions of the research vessel *Dr Fridtjof Nansen* (FAO, 2019c). It is the only marine research vessel to currently fly the United Nations flag and be fully dedicated to international development work. Data and information are collected on marine ecosystems, including on fishery resources, biodiversity, nutritional attributes of aquatic foods, climate change and pollution impacts during research surveys carried out in African and Southeast Asian waters, and on the high seas.

In a normal year, the research vessel spends around 270 days conducting surveys; 2019 saw the participation of 215 scientists from 19 partner countries, making an important contribution to nurturing science and development collaboration across national borders. Research priorities for the activities of *Dr Fridtjof Nansen* are based on the programme's Science Plan (FAO, 2020i) and the needs of the national and regional partners in relation to their fisheries management priorities.

The programme supports the analysis and uptake of data and knowledge in decision-making at the national and regional levels, for example, through partner regional fisheries bodies such as the South East Atlantic Fisheries Organization, the Fishery Committee for the Eastern Central Atlantic and the Southwest Indian Ocean Fisheries Commission, and the cross-sectoral Benguela Current Commission. Countries are supported to develop, implement and monitor EAF-compliant fisheries management plans, policies and legislation and to establish fisheries management cycles. Finally, substantial efforts are made to address gender issues and promote equal participation of men and women in the governance of fisheries.

Digital innovation Hand-in-Hand with fisheries and ecosystem scientific monitoring

This programme (FAO, 2021i) aims to develop an atlas that uses open data and open science to describe ecosystems (including fisheries) and, where relevant, support monitoring of SDG targets and UNDOSSD outcomes. It draws from and enhances the FAO Hand-in-Hand Initiative (HIHI), which is an evidence-based, country-led and country-owned scheme to accelerate sustainable rural development to eradicate poverty and end hunger and all forms of malnutrition. HIHI prioritizes countries where national capacities and international support are most limited or where operational challenges, including natural or human-made crises, are greatest. The Initiative includes advanced geospatial modelling and analytics

6 The Programme is funded by the Norwegian Agency for Development Cooperation (Norad) and implemented in close collaboration with the Institute of Marine Research and with the support of the Directorate of Fisheries, Bergen, Norway.

to identify the most promising opportunities to raise the incomes and reduce the inequities and vulnerabilities of rural populations, which constitute the vast majority of the world's poor (Box 26).

The programme will leverage the HIHI Geospatial Platform and provide access to fisheries information and topical environmental maps built on select data generated by FAO (including catalogues of maps of regional fishery body [RFB] competence areas, species distributions, stocks and fisheries), as well as by UNDOSSD partners. It will allow countries and RFBs to disseminate comprehensive open data on the state, impacts and management of fisheries and ecosystems and support monitoring of their progress towards the SDGs and UNDOSSD outcomes. The programme will also: (i) promote collaboration, as countries and regions need to reach agreements on standards for the dissemination of open data; and (ii) help bridge the digital divide, as it will build on FAO's ongoing efforts to facilitate the co-design of fisheries information products with West and East African coastal States, Southeast Asian States, and small island developing States. ■

UNITED NATIONS DECADE ON ECOSYSTEM RESTORATION

Fisheries and aquaculture and the FAO–UNEP-led Decade on Ecosystem Restoration

The United Nations Decade on Ecosystem Restoration, adopted by the United Nations General Assembly in March 2019 and in effect from 2021 to 2030, is a global call for the revival of ecosystems and their services. The Decade foresees habitats and species, which are components of ecosystems, being restored to health so that social–environmental systems are productive and resilient in the face of ongoing and foreseen stresses (e.g. changing global climate, increasing pollution, habitat degradation and fragmentation, and market-related stress).

Ecosystem restoration is considered a foundational contribution for enabling delivery of the Sustainable Development Goals (SDGs) for poverty eradication and food security and the goals of the Rio Conventions. In June 2021, the United Nations Secretary-General's message for World Environment Day stated:

> The degradation of the natural world is already undermining the well-being of 3.2 billion people, or 40 percent of humanity. Luckily, the Earth is resilient. But she needs our help. We still have time to reverse the damage we have done. That is why … we are launching the United Nations Decade on Ecosystem Restoration (United Nations, 2021b).

FAO and the United Nations Environment Programme (UNEP) are tasked by the General Assembly to lead this decadal initiative in an inclusive, efficient and cost-effective manner. FAO and partners have begun by helping the global community define more clearly the outcome sought by this Decade, promoting a pragmatic vision for ecosystem restoration that is more inclusive of people and their actions to safeguard the planet's resources.

Restoration can be defined as a process of reversing the degradation of ecosystems, such as landscapes, wetlands and oceans, to regain their ecological functionality; in other words, setting up policies and supporting actions to improve the productive capacity of ecosystems to meet the needs of society, while maintaining their function for all of life. This can be achieved both by allowing the natural regeneration of overexploited ecosystems and via active interventions to facilitate recovery of nature through active and adaptive management.

Ecosystem restoration involves policy and practices beyond traditional rewilding to recreate pristine wilderness. It foresees ecosystem improvements in the places where people live, work and produce food, reframing traditional concepts to one that improves people's "joint venture" with the rest of nature. This is required as there is a growing need for food, set against a backdrop where people's footprint in nature

BOX 26 HAND-IN-HAND SPATIAL MULTI-CRITERIA DECISION ANALYSIS IN NIGERIA

FAO's Hand-in-Hand Initiative (HIHI) supports projects in more than 35 countries. One such project assessed the potential in Nigeria for African catfish and Nile tilapia.[1] The study was a pilot case for aquaculture Geographic Information Systems (GIS) that apply multi-criteria decision analysis (MCDA).

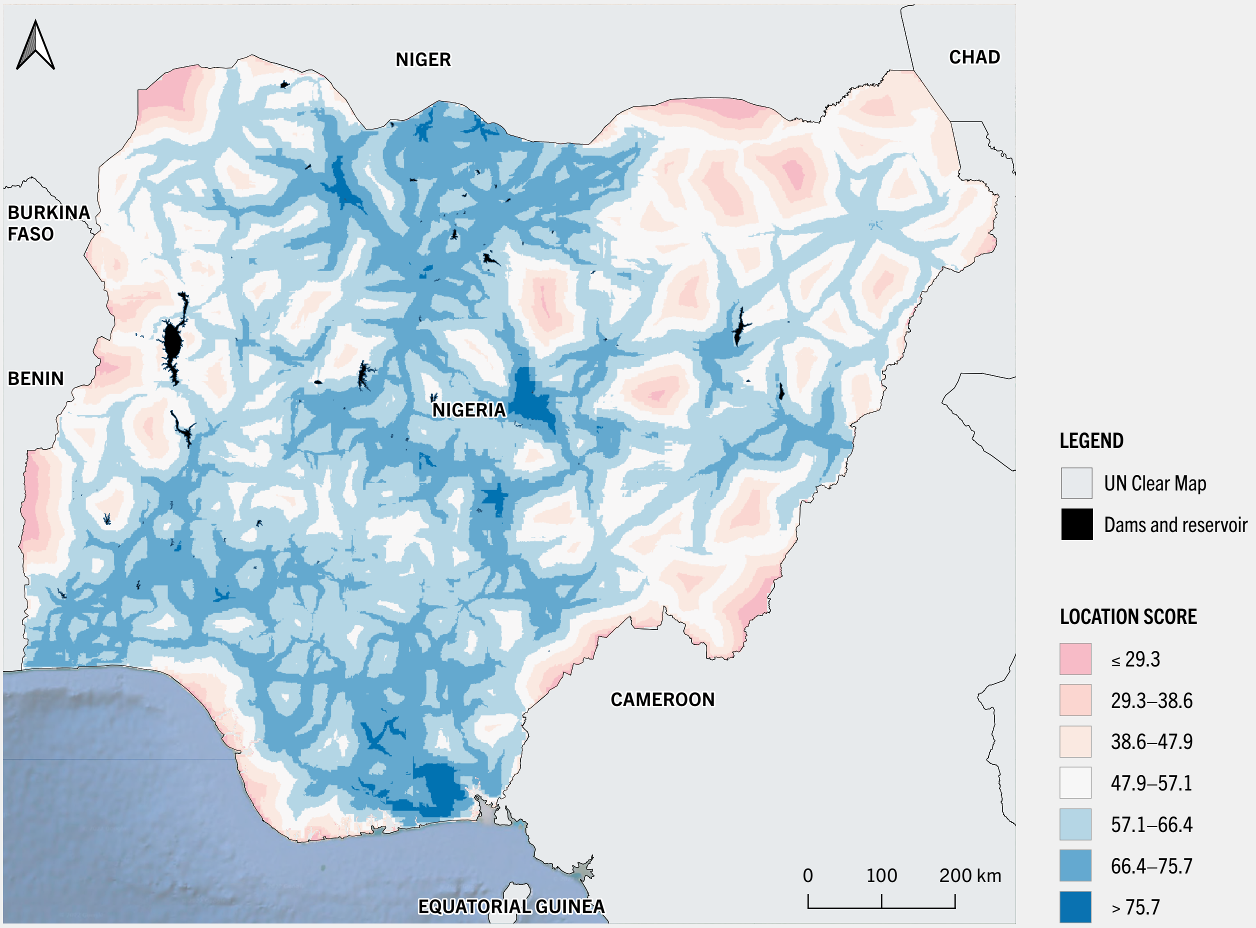
Hand-in-Hand supported the zoning methodologies to identify areas within the country that have good, yet most likely unrealized, aquacultural potential. The programme also coordinated inputs from various disciplines across FAO and country technical task forces, including through round tables to help define priorities. Based on modelling methodology earlier defined by FAO, the MCDA analysis used a GIS to delineate farming systems by weighing various factors, excluding – depending on the farming system – protected or heavily urbanized areas, large waterbodies and areas located an excessive distance from major roads.

The study resulted in a set of maps indicating areas suitable for intensive fish farming of both species, and suggested zones at regional and state scale directed at open non-intensive integrated pond systems, with high potential impact on poverty alleviation, improved nutrition and food security.

Based on optimal natural conditions and urban market access, the study results indicate significant growth potential for intensive fish farming systems in the southwest, southeast, and north-central regions of Nigeria, but also highlight the lack (or unreliability) of energy supply and the poor transport infrastructure as major limiting factors for the entire value chain in these regions. However, there is increasing potential for alternative photovoltaic energy generation from south to north, driving intensification opportunities in sites located in the north-central region. Nevertheless, the most promising locations remain in the southeast states.

Modelling of intensive tilapia cage systems in large waterbodies indicates significant untapped aquaculture potential promising high returns on investment in the southwest, centre and north (Figure A).

FIGURE A MODELLED FAVOURABLE LOCATIONS FOR TILAPIA INTENSIVE CAGE FARMING (LARGE WATERBODIES), NIGERIA



NOTES: The location score is the result of an arithmetic weighted sum of gridded location factor (criteria) normalized with values from 0 to 100, with 100 corresponding to the ideal location for intensive tilapia cage farming systems. Unsuitable locations are pink and suitable locations are blue. Identification of the most suitable locations finally leads to a shortlist of recommended dams or reservoirs with the best conditions for intensive tilapia cage farming systems (the shortlist is not presented here).
SOURCE: Adapted from Figure 16 in Ribeiro, N. 2021. *GIS Multicriteria Decision Analysis – Nigeria Fresh water fish farming*. Rome, FAO. Internal document. Cited 13 April 2022. https://sdlc.review.fao.org/confluence/download/attachments/4752761/MCDA_NGA_FishFarming_V1.4.pdf?api=v2

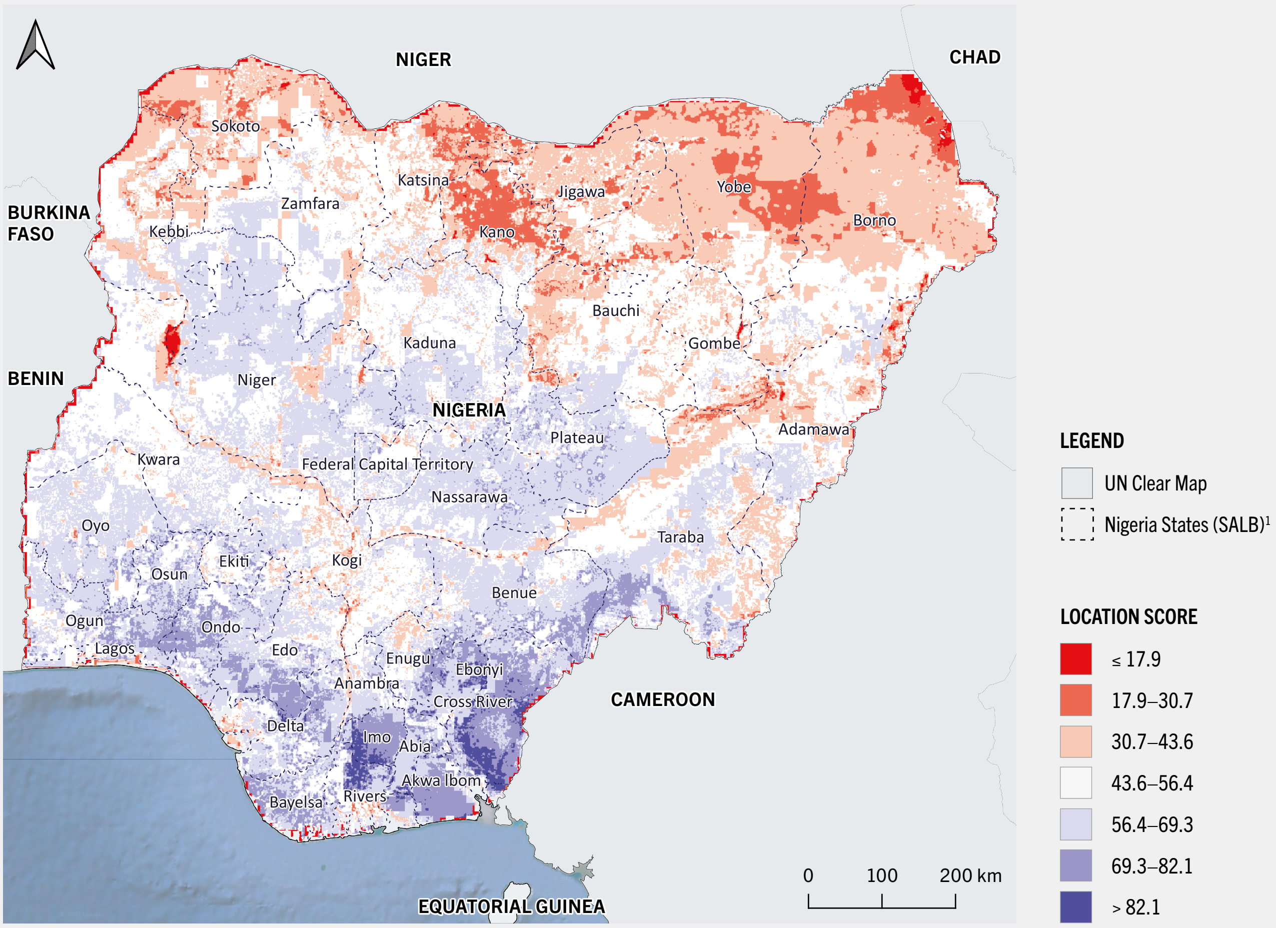
Development interventions focusing on integrated non-intensive farming systems (Figure B) capable of contributing to several Sustainable Development Goals, have extensive prospects, with limitations only in northern and northeast arid regions. With poverty set as a constraint, the central belt and parts of the north and northeast show high potential; these could be considered priority areas for aquaculture development.

While the HIHI study indicates potential, the integration of additional criteria would provide a fuller picture. For instance, the pilot study did not take into account environmental aspects that might impact long-term sustainability. Similarly, health and disease monitoring and management are likely to become more important as the sector develops. They should be considered in the future, along with environmental indicators from flood risks to longer-term climate risks.

In future, the implementation of any action in warm freshwater aquaculture should also recognize ethnic and cultural diversity and consider pre-existing resource competition issues in the country. It is important to note that the models discussed above provide working directions under the Hand-in-Hand Initiative, rather than turnkey solutions. Increased local collaboration to cover possible additions to the methodology – including value chain, socio-economic and fish farming production scenarios – would further enhance this study.

[1] Ribeiro, N. 2021. GIS Multicriteria Decision Analysis - Nigeria Fresh water fish farming. In: *GIS analysis documentation*. Cited 29 November 2021. https://sdlc.review.fao.org/confluence/display/GA/GIS+analysis+documentation
NOTE: The Hand-in-Hand Geospatial Analysis Team develops location analysis and suitability assessment modelling in support of interventions, design and planning in participating countries. It also assists in data publishing and training on the Hand-in-Hand Geospatial Platform.

FIGURE B MODELLED FAVOURABLE LOCATIONS FOR OPEN NON-INTENSIVE FARMING SYSTEMS (SMALL WATERBODIES), NIGERIA



[1] SALB = Second Administrative Level Boundaries (Committee of Experts on Global Geospatial Information Management: https://ggim.un.org).
NOTES: The location score is the result of an arithmetic weighted sum of gridded location factor (criteria) normalized with values from 0 to 100, with 100 corresponding to the ideal location for open, non-intensive farming systems (ponds and other small waterbodies). Unsuitable locations are red and suitable locations are purple.
SOURCE: Adapted from Figure 5 in Ribeiro, N. 2021. *GIS Multicriteria Decision Analysis – Nigeria Fresh water fish farming*. Rome, FAO. Internal document. Cited 13 April 2022. https://sdlc.review.fao.org/confluence/download/attachments/4752761/MCDA_NGA_FishFarming_V1.4.pdf?api=v2

is already ubiquitous (Plumptre *et al*., 2021). Healthier ecosystems, with richer biodiversity, yield greater benefits and are more resilient to change. In the case of aquatic systems, this means more productive waters, increasingly productive fisheries and larger storage of greenhouse gases. Such a framing of the task at hand is supported by a new set of ten guiding principles for ecosystem restoration developed by FAO, UNEP, the International Union for Conservation of Nature and Natural Resources (IUCN), the Commission on Ecosystem Management and the Society for Ecological Restoration (FAO *et al*., 2021), and well aligned with people's needs and aspirations.

FAO recognizes the monumental scale of the task to restore inland, coastal and marine ecosystems – a task which in some areas seeks to reverse long-term negative biodiversity change. In putting in place the policy framework and providing support for delivery of restoration, FAO needs to re-engineer the way restoration is approached across a broad variety of aquatic ecosystems. Noting the dynamic and interconnected nature of aquatic systems across terrestrial and marine sea- and landscapes, FAO is helping to link up polycentric governance approaches at all levels, to incorporate diverse conservation and sustainable production actions by multiple actors, sectors and jurisdictions. This is needed, as the challenge of improving people's relationship with the rest of nature can only be met if everyone – including international and national authorities, local governments, the private sector, academia and civil society – comes together to implement viable and durable solutions to reversing loss of ecosystem services.

So how will FAO and UNEP help improve the global community's relationship with the rest of nature so that ecosystems can support people in meeting the most pressing challenges faced by humanity today? Practical support starts with FAO and partners characterizing points of entry for restoration across aquatic systems so that activity reflects a continuum of restorative activities (FAO *et al.,* 2021, Principle 3). The Decade represents an opportunity to build and link networks and partnerships across the globe, strengthening the restoration–science–policy nexus. The United Nations partners will provide a forum to assist in linking up planned and ongoing restoration management, as part of FAO's effort to support countries' Blue Transformation[7] (see the section Blue Transformation: a vision for transforming aquatic food systems, p. 109). Through well-coordinated and effective restoration, it is suggested that the transformation to make aquatic systems more productive and sustainable can create millions of new jobs by 2030 and contribute to generating over USD 7 trillion every year to help eliminate poverty and hunger (United Nations, 2021b).

Aquatic food production often requires a broader focus on the restoration of the ecosystems supporting that production, including mangrove forests, seagrass meadows and reefs, as well as on the rehabilitation of terrestrial watersheds and wetlands. It is also necessary to improve management of living aquatic resources, themselves a major component of aquatic system biodiversity. Direct restorative actions in this context would include efforts to minimize impacts on ecosystems' structure and function by collateral effects of human activities. This includes rebuilding fish stocks (Box 27) and reducing adverse impacts of fishing on the environment. In the case of aquaculture, in which natural systems are often modified to maximize production, actions are centred on restoring ecosystem structure and function to support food provisioning, while minimizing impacts, pollution, waste and the emergence of aquatic animal diseases. In this respect, promoting aquaculture of extractive species or adopting innovative systems such as integrated multitrophic aquaculture represent promising solutions (see the section Bivalve aquaculture, p. 123).

During the coming decade, FAO needs to help in raising awareness and to support decision makers to acquire the scientific information and technical know-how for restoration of aquatic ecosystems in relation to fisheries and aquaculture production.[7] This involves sharing information on new technological advances, promoting cooperation, capacity-building, education and training, and ensuring that the best available scientific advice is used to inform

7 For Blue Transformation, and fisheries and aquaculture production, see Glossary, including Context of SOFIA 2022.

BOX 27 REBUILDING FISHERIES

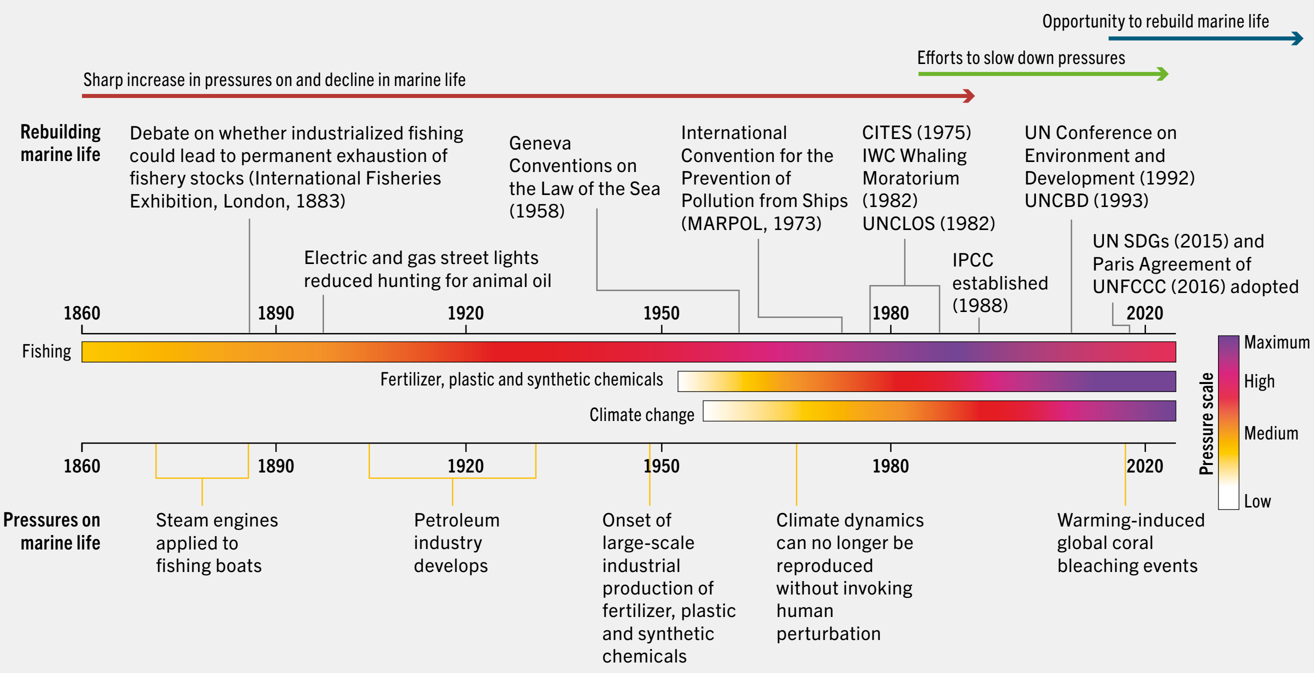
Fishery stocks are a major component of the living biomass of the planet and play a large role in the functioning of marine and freshwater ecosystems. In fact, fish comprise the greatest proportion of vertebrates on Earth, far outweighing all others, including humans, farm livestock and wild mammals.[1]

Successful rebuilding of depleted fish populations has been achieved at local and regional scales through investment in proven fisheries management, such as catch and effort reduction, regulation of fishing gear, temporal or spatial controls, and innovative and inclusive ways to share catches and management direction.[2] It has also been assisted by pollution control measures and actions to restore ecosystem structure, for example, in habitats that are nursery grounds for fish. Management interventions require detailed consideration of socio-economic and cultural circumstances, so that solutions can be tailored to the local context.

According to FAO's global assessments of fishery stocks – using basic fisheries science on about half of the reported global marine fish catch[3] – trends in abundance and harvest rate are increasing and at the proposed target levels. Hilborn *et al.* (2020)[4] assessed 882 fishery stocks worldwide (major stocks in the Americas, Europe, South Africa, Australia, New Zealand, Peru, Chile, Japan, the Russian Federation, the Mediterranean and Black Sea, and Northwest Africa) and reported that fishery stocks were being rebuilt, reversing previous declines on average. The study showed an increase in average fishing pressure accompanied by a decline in biomass until 1995, after which fishing pressure began to decrease (Figure A).

By 2005, a significant proportion of fishery stocks were rebuilding, and average biomass had started to increase (Figure B). By 2016, the biomass across all stocks reviewed was on average higher than the global standard for sustainability (maximum sustainable yield [MSY]), and fishing pressure was lower than that which would result in MSY. This was not seen across all fishery stocks assessed, and more work is needed to improve

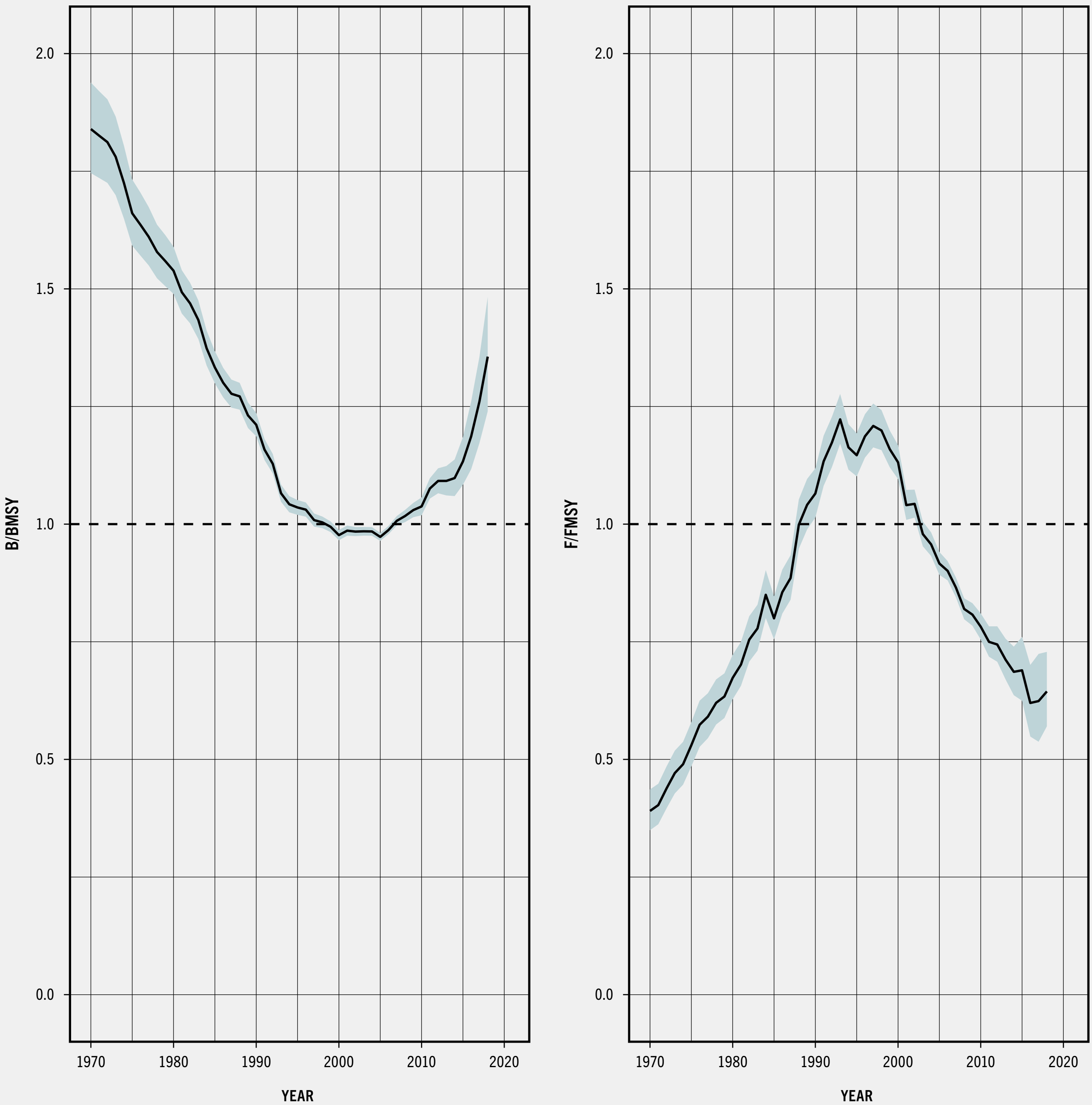
FIGURE A TIMELINE REPRESENTING CHANGE IN HUMAN PRESSURES



NOTE: Human pressures on fisheries commenced well before the Industrial Revolution, peaking in the 1980s and more recently slowing down (with great regional variation). Other pressures, such as pollution and climate change, are notable exceptions to this trend.
SOURCE: Adapted from Duarte, C.M., Agusti, S., Barbier, E., Britten, G.L., Castilla, J.C., Gattuso, J. & Fulweiler, R.W. 2020. Rebuilding marine life. Nature, 580: 39–51. https://doi.org/10.1038/s41586-020-2146-7

BOX 27 (Continued)

FIGURE B WORLDWIDE TRENDS IN RELATIVE BIOMASS (B/BMSY) OF ASSESSED FISH AND INVERTEBRATE STOCKS AND RELATIVE FISHING PRESSURE (F/FMSY) PREDICTED FROM A STATE–SPACE MODEL[1]



[1] BMSY = biomass at maximum sustainable yield; FMSY = fishing mortality sustainable yield.
NOTES: Solid line denotes the geometric mean, with shaded regions denoting 95 percent finite population-corrected confidence bounds. In years when all stocks are assessed, no uncertainty is considered.
SOURCE: Adapted from Hilborn, R., Amoroso, R.O, Anderson, C.M., Baum, J.K., Branch, T.A., Costello, C. & de Moor, C.L. 2020. Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences of the United States of America*, 117(4): 22182224. www.pnas.org/content/117/4/2218

BOX 27 (Continued)

management for 24 percent of stocks that accounted for 19 percent of the potential catch. The study by Hilborn *et al*. (2020) estimated that excess fishing pressure still results in about 3–5 percent loss of potential yield and there is room for more rebuilding.

So how long does it take to rebuild stocks to an internationally agreed level (MSY)? A previous review of more than 150 overfished stocks[5] showed that ten years was sufficient for recovery of stocks depleted below 0.5 biomass corresponding to maximum sustainable yield (BMSY), but not for stocks driven close to collapse (below 0.2 BMSY), which required longer and more variable recovery times. Improvements in the abundance of fishery stocks where rebuilding had occurred were directly linked to changes in legislation and subsequent implementation of fisheries management.

Rebuilding is not ubiquitous across all depleted fishery stocks, and the global community is still hamstrung by less reliable information on the status and trends of a large part of the world's fishery stocks, where the intensity of fisheries management is low and expert opinion suggests fisheries rebuilding is much needed. Better data collection and understanding of the status of change in these locations is required.

This presents the greatest challenge for future rebuilding where unassessed fisheries, often in tropical and subtropical regions, are dominated by highly diverse mixed fisheries that support some of the world's most dependent communities. This is further burdened by the need to remove harmful subsidies, combat illegal, unregulated and unreported fishing, and reduce the disruptive ecological impacts caused by some fishing practices. In addition, resources are needed to help fishing communities overcome the problems of poverty and lack of alternative employment opportunities.

Where fisheries science and management tools are still needed, for example in regions of South and Southeast Asia, and East Africa, significant investment is required in strong policy frameworks, fisheries management and livelihood diversification to promote rebuilding of fishery stocks. This investment is needed, not just to diminish recognized gaps in food production, but also to counterbalance a loss in ecosystem services which is leading to biodiversity conservation concerns.

[1] Bar-On, Y.M., Phillips, R. & Milo, R. 2018. The biomass distribution on Earth. *Proceedings of the National Academy of Sciences of the United States of America*, 115(25): 6506–6511. https://pnas.org/content/115/25/6506
[2] Birkenbach, A.M., Kaczan, D.J. & Smith, M.D. 2017. Catch shares slow the race to fish. *Nature*, 544(7649): 223–226.
[3] FAO. 2020. *The State of World Fisheries and Aquaculture 2020. Sustainability in action*. Rome. www.fao.org/3/ca9229en/ca9229en.pdf
[4] Hilborn, R., Amoroso, R.O, Anderson, C.M., Baum, J.K., Branch, T.A., Costello, C. & de Moor, C.L. 2020. Effective fisheries management instrumental in improving fish stock status. *Proceedings of the National Academy of Sciences of the United States of America*, 117(4): 22182224. www.pnas.org/content/117/4/2218
[5] Neubauer, P., Thorson, J.T., Melnychuk, M.C., Methot, R. & Blackhart, K. 2018. Drivers and rates of stock assessments in the United States. *PLoS ONE*, 13(5): e0196483. https://doi.org/10.1371/journal.pone.0196483

decision-making across the full value chain of aquatic systems in line with the local and land-/seascapes context of ecosystem restoration (FAO *et al.*, 2021, Principle 8).

Fisheries and aquaculture and the Post-2020 Global Biodiversity Framework

Efforts to maintain and restore social–environmental systems are gaining an international focus in 2022 and for the coming decade as Parties to the Convention on Biological Diversity (CBD) work together to define a work plan that will deliver into their vision for 2050: Living in harmony with nature. The Convention's three objectives – (i) conserve biological diversity; (ii) use biodiversity components sustainably; and (iii) ensure fair and equitable sharing of the benefits from genetic resources – share many elements with the 2030 Agenda.

Globally, with increasing population, life expectancy and per capita incomes, we have also experienced long-term declines in the status of biodiversity. Pressures of population growth, urbanization, unsustainable consumption and production patterns, pollution, spread of alien invasive species and climate change are all negatively impacting the ability of ecosystems to provide life-sustaining services.

MALTA
A variety of fish species swimming in a marine protected area in the Mediterranean Sea.
© FAO/Kurt Arrigo

Adopted in 1992, the CBD has played a coordinating role among multilateral environmental agreements (MEAs) to support countries in understanding and attempting to reverse declines in biodiversity through promoting the uptake and implementation of relevant policy and legislative instruments. This work has not been without challenges, as despite some bright spots, Parties to the CBD have largely failed to meet targets set for the last two decadal initiatives. In October 2021, the 193 Parties to the CBD were working to re-invigorate their work plans and finalize the formulation of a new set of CBD goals and targets for 2030: the Post-2020 Global Biodiversity Framework (Post-2020 Framework).[8]

The evolution of the Post-2020 Framework followed an extensive process of consultation among CBD Parties, academics, non-governmental organizations (NGOs) and civil society in defining its format and content[9] and outlining goals and targets for people's interaction with nature for the next decade. The consultative phase was followed by the final negotiation and adoption of the Post-2020 Global Biodiversity Framework at the United Nations Biodiversity Conference in Kunming, China (29 August – 11 September 2022).

It is hoped the Post-2020 Framework will catalyse a change from business as usual approaches in all sectors of society, including fisheries and aquaculture. The challenge facing the CBD in creating a global long-term vision for biodiversity conservation is threefold:

1. Broaden the adoption and delivery of the Post-2020 Framework outside its own conservation community, to encourage more general ownership of challenges and solutions for biodiversity.
2. Match resources for implementation of change to the ambition of the tasks outlined in the Post-2020 Framework.
3. Translate this ten-year initiative into something that becomes a live process that "learns from doing", can be well measured, ratchets up ambition and is well communicated!

During the webinar, COP15: Road to Kunming, Building a Shared Future for All Life on Earth, held on 21 May 2021, the United Nations Secretary-General stated:

> A healthy planet is critical for achieving the Sustainable Development Goals. Yet biodiversity is declining at an unprecedented and alarming rate, and the pressures are intensifying (United Nations, 2021c).

So how can the global community come together to deliver a better relationship for people and the rest of nature?

For fisheries and aquaculture, it is necessary to know the status of biodiversity in aquatic systems and define the key challenges and opportunities for action to maintain or recover biodiversity in a form that maintains its function. Ecosystem function is critical to the production of aquatic foods that support the livelihoods connected to fisheries and aquaculture value chains.

A recognized weakness in past CBD frameworks has been to not sufficiently promote the mainstreaming of biodiversity into all sectors, in those places where most interactions with biodiversity occur. To respond to issue (1) above, a primary challenge for production sectors such as fisheries and aquaculture is to elevate the consideration of biodiversity across all policies and actions. Importantly, the narrative of the Post-2020 Framework must reinforce the reality of people being part of, and not apart from, the rest of nature. In this framing, people and biodiversity are in a reciprocally beneficial relationship – where people's actions in delivering sustainable management can offer social–environmental systems resilience to ongoing human and natural pressures. At the Thirty-fourth Session of the Committee on Fisheries in 2021 (FAO, 2021j), it was recommended that negotiated ecosystem approach frameworks be promoted as part of the Post-2020 Framework, which will result in the adoption of a more holistic architecture in which to design and implement positive change in aquatic systems for people and the rest of nature.

8 The Post-2020 Global Biodiversity Framework is hereafter referred to as the Post-2020 Framework.

9 Technical committees (e.g. Subsidiary Body on Scientific, Technical and Technological Advice [SBSTTA] in November 2019; May–June 2021) and three open-ended working groups (Kenya, August 2019; Italy, February 2020; Colombia, August–September 2021).

To respond to issue (2), the global community needs to find funds to achieve the goals of the Post-2020 Framework, as an investment for their economic and social development. The CBD can assist by framing the increase in ecosystem services as a major benefit to society. This means strengthening the nexus between biodiversity restoration, economic benefit and livelihoods. To face the challenge of financial resource mobilization, Article 21 of the CBD provides for the establishment of a dedicated financial mechanism to support implementation of mainstreaming, while the Global Environment Facility that funds many environmental conventions has reached a ceiling that has not been increased. At the government level, countries can further rebalance the effects of harmful subsidies against more positive incentives, as subsidies that are potentially harmful to biodiversity receive five times more funds than do biodiversity-friendly instruments.[10] In addition, there are opportunities for greater use of public–private partnerships necessary for funding robust, enduring and ambitious ways to increase or turn around the loss of ecosystem services.

In response to issue (3), FAO recognizes that recovery from environmental degradation tends to be slow. Delivery of positive management change in fisheries and aquaculture requires transformation of new and varied sources of knowledge into policy, enabling new governance to be established and implemented (Rice, 2011). Correcting past mistakes typically incorporates multiple steps of change in local and central management approaches, and this requires bottom-up and top-down actions, often operating in combination. Maintaining and restoring nature relies heavily on the work delivered by innovators on the ground and by local people working on or close to the water offering practical and targeted solutions, respectful of local biocultural contexts. Therefore, the CBD needs a receptive, dynamic and flexible process that is adaptive to new inputs from on-ground practitioners over the coming decade. This will include work increasingly facilitated through information technology and artificial intelligence, supported by rapid development in machine learning and deep learning. FAO supports the fisheries and aquaculture community in the development and use of novel technologies as demonstrated by the forum on artificial intelligence, held 28–30 June 2021, and the webinar on recording deep-water shark and vulnerable marine ecosystem (VME) catches.[11] In order for the Post-2020 Framework to be more adaptive over the next decade, we can learn from the global community's response to the issue of climate, thanks to the five-year review process introduced by the Paris Agreement. The CBD currently lacks a formal review process which would serve to promote accountability for strong global leadership and ratchet up ambition in delivering progress on biodiversity.

Recovery actions for vulnerable species and habitats

FAO's work across multilateral environmental organizations working on characterizing and recovering threatened species

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which entered into force in 1975, is a multilateral treaty to protect endangered plants and animals from international trade that could threaten their survival in the wild. This is important as fisheries and aquaculture products[12] are among the most traded food commodities in the world, and trade keeps on growing. Species included in any of the three CITES Appendices are accorded varying degrees of protection. There are currently almost 2 400 marine species listed in CITES Appendices,[13] accounting for less than 10 percent of all CITES-listed species and around 40 percent of CITES-listed animal species.

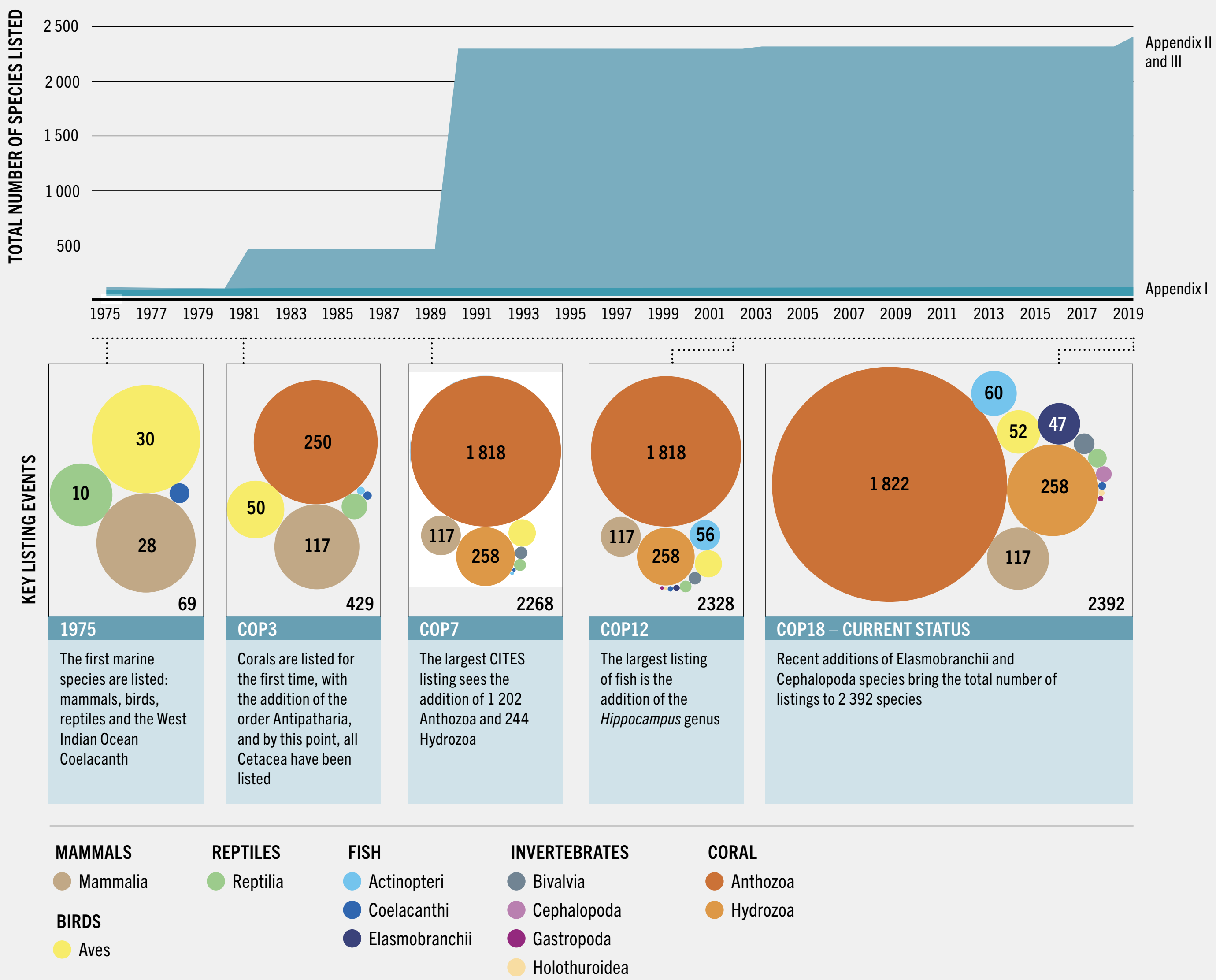
10 The Secretary-General of the Organisation for Economic Co-operation and Development (OECD) stated that there were USD 500 billion of potentially harmful subsidies compared with USD 78–91 billion of positive incentives a year, respectively.

11 The Artificial Intelligence for a Digital Blue Planet forum was held with the assistance of the Japanese Government. All the presentations from the forum are now available online on the FAO YouTube channel at: www.youtube.com/playlist?list=PLzp5NgJ2-dK72rgBePlkQoD1gMTjNEJHs The FAO virtual workshop, Use of Still and Video Cameras to Record Deepwater Shark and VME Indicator Catches by Scientific Observers, was held on 31 August 2021 with the assistance of the Japanese Government. www.youtube.com/results?search_query=Use+of+still+and+video+cameras+to+record+deepwater+shark+and+VME+indicator+catches+by+scientific+observers

12 For fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

13 Refer to Species+ (CITES, 2021a) and the CITES Checklist (CITES, 2021b).

FIGURE 65 NUMBER OF MARINE SPECIES LISTED IN CITES OVER TIME



SOURCE: Adapted from **Pavitt, A., Malsch, K., King, E., Chevalier, A., Kachelriess, D., Vannuccini, S. & Friedman, K.** 2021. *CITES and the sea: Trade in commercially exploited CITES-listed marine species*. FAO Fisheries and Aquaculture Technical Paper, No. 666. Rome, FAO. https://doi.org/10.4060/cb2971en

The number of aquatic species listed in CITES Appendices has grown markedly in recent decades, with most listings accepted into Appendix II, which regulates international trade of species that are or could become "threatened with extinction" due to market demands (Pavitt *et al.*, 2021). Species listed in Appendix II can be legally traded across international borders, but transactions require documented legality of trade and sustainability assurances to be lodged by the exporting country. Since 2003, new species added to Appendix II have included predominantly sharks and rays, with some mollusc and echinoderm species (Figure 65).

FAO and CITES continue to cooperate under a Memorandum of Understanding signed in 2006 that includes commitments to addressing scientific and technical issues relating to the listing and implementation of CITES provisions and facilitating capacity-building in countries for the promotion of sustainable trade.

To provide insights on what traded species are reported to CITES, when, how much and how often, FAO and partners including UNEP analysed direct export transactions reported by CITES Parties between 1990 and 2016. This review revealed a sevenfold increase in reporting of trade in CITES Appendix II marine species (Pavitt *et al*., 2021). FAO continues to work with CITES to identify successful control of trade in CITES-listed species and, where challenges remain, offer suggestions for their possible amelioration (Friedman *et al*., 2020, 2018; FAO, 2021k).

CITES Parties will again consider new species for inclusion in its Appendices at its Conference of the Parties (CITES COP19), scheduled for November 2022 in Panama. Aquatic species proposals are likely to be dominated by consideration of sharks and rays; however, eels, sea cucumbers, aquarium fish and other species groups are also under consideration. Notification of species proposed for listing amendments submission in COP19 will be made public 150 days prior to the CITES Parties' vote.

National Plans of Action on sharks and seabirds

The implementation of FAO International Plans of Action (IPOAs) and the development of National Plans of Action (NPOAs) are always very relevant for addressing directed fisheries for sharks and bycatch of both seabirds and sharks. States may consider developing NPOAs in line with the IPOA for the Conservation and Management of Sharks and the IPOA for Reducing Incidental Catch of Seabirds in Longline Fisheries.

To support Members in the development and implementation of NPOAs, FAO has created a database that regularly updates progress made by fisheries in conserving sharks, rays and chimaeras (FAO, 2020). This database provides a "one-stop shop" for those wishing to find shark-related management and guidance measures, instituted by CITES, the Convention on the Conservation of Migratory Species of Wild Animals, regional fishery bodies and national authorities, and it includes both binding and non-binding conservation and management measures, plans of action and national legislation.[14]

Area-based fisheries management in meeting global biodiversity targets

The need for integrating effective marine conservation measures into more holistic and synergetic ocean management strategies has never been greater, making marine conservation critical to any sustainable development effort. In particular, the establishment of marine protected areas (MPAs) and other area-based management tools (ABMTs) has received considerable attention globally for their ability to conserve biodiversity, restore ocean productivity and strengthen food security. The use of ABMTs in marine and coastal zones has been defined by global and regional agreements, and the commitment to use them has been reiterated in many international processes.

The 2030 Agenda stimulates national and regional action specifically via SDG 14 (Life below water). Target 14.5 calls for countries to conserve at least 10 percent of coastal and marine areas. Similarly, the Strategic Plan for Biodiversity 2011–2020 included Aichi Biodiversity Target 11, calling for the conservation of "at least … 10 percent of coastal and marine areas … through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures" (OECMs) by 2020 (CBD, 2021), therefore placing an important focus on the potential of using area-based management to achieve the dual objectives of conserving biodiversity and providing the resulting benefits to people. Interest in ABMTs is on the rise internationally, with the Parties to the CBD currently negotiating the Post-2020 Global Biodiversity Framework, including a draft target increasing MPAs and OECM coverage so that

14 These are free to download at: www.fao.org/ipoa-sharks/database-of-measures/en

BOX 28 OPERATIONALIZING OECMs IN THE FISHERIES SECTOR – HOW DO WE MAKE IT A SUCCESS?

Other effective area-based conservation measures (OECMs) are taking centre stage in many international fora and are the focus of an increasing number of publications[1] as countries try to reconcile the many goals and objectives agreed to in international conventions. OECMs offer many countries tangible prospects as they provide an opportunity to address the linkages between fisheries, aquaculture, biodiversity and other sectors and catalyse concrete actions towards coordinated management strategies and policies. Furthermore, given that the primary objectives of area-based fisheries management tend to not only concern biodiversity conservation, but are often related to fisheries sustainability, those that meet the OECM criteria are more likely to generate multiple benefits for species, ecosystems and fishing communities, as well as support social and economic development. Fisheries-related OECMs are, therefore, particularly relevant to food security, biodiversity conservation and sustainable development, as well as to several Sustainable Development Goals (SDGs) – SDG 1 (No poverty), SDG 2 (Zero hunger), SDG 12 (Responsible consumption and production) and SDG 14 (Life below water) – alongside the global biodiversity targets. Now that the Post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (CBD) is set to be adopted in late 2022 with an increase in the area-based management target, countries are increasingly recognizing OECMs and are seeking guidance about how to interpret and apply the OECM definition and criteria, particularly in the marine environment and the fisheries sector.

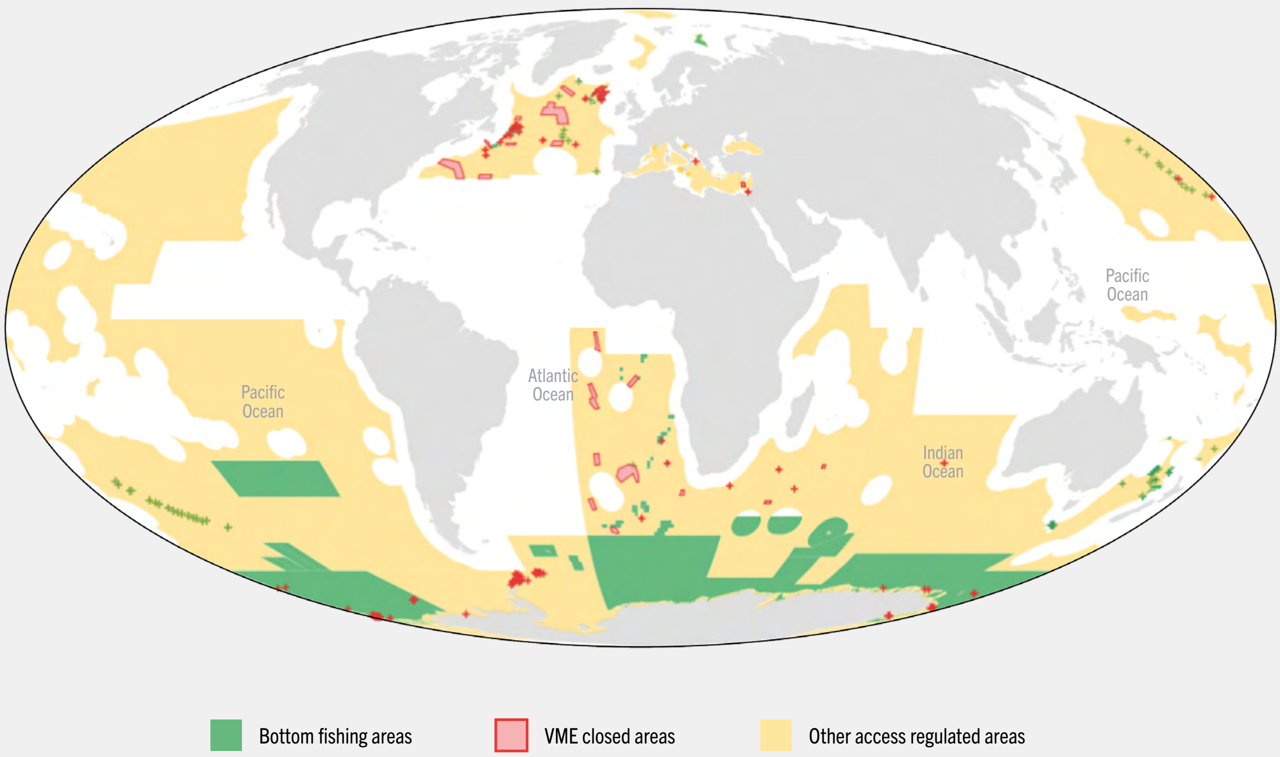
In February 2021, FAO Members discussed these challenges at the Thirty-fourth Session of the Committee on Fisheries (COFI). They noted the importance of considering multiple effective time- and area-based management tools, such as protected areas and OECMs for the conservation and sustainable use of biodiversity. COFI also noted the relevance of OECMs to support the achievement of several SDGs and global biodiversity targets, and requested that FAO produce and disseminate practical guidelines to support Members in their identification and implementation.[2]

As a result, FAO now has a mandate for developing and implementing OECM guidance. In cooperation with partners and FAO Member countries, the FAO Fisheries and Aquaculture Division is leading the development of this guidance and is actively moving forward to assist countries in assessing OECMs in the fisheries sector. In this context, it is committed to building the capacity of countries to report fisheries-related OECMs and document how the fisheries sector is contributing to area-based biodiversity conservation goals. It aims to develop specific guidance on applying the OECM criteria in the fisheries sector and assist its Members and regional fisheries bodies (RFBs) in assessing and identifying fisheries-related OECMs. For that purpose, the FAO Fisheries and Aquaculture Division will host a series of shared learning workshops on fisheries-related OECMs to provide the basis for a guidance document for the identification, establishment and management of OECMs in the fisheries sector that complements existing non-sectoral guidance.

Ultimately, both countries and RFBs will need to actively engage in promoting and supporting the identification and reporting of OECMs in order to maximize their potential in helping reach the new post-2020 CBD targets (undefined at the time of writing) and SDG Target 14.5 (by 2020, conserve at least 10 percent of coastal and marine areas, consistent with national and international law and based on best available scientific information). The availability of sector-specific guidance such as that being developed by FAO will be crucial to guide countries and RFBs as they navigate the application of the OECM criteria in different sectors.

[1] For example:
Gurney, G.G., Darling, E.S., Ahmadia, G.N., Agostini, V.N., Ban, N.C., Blythe, J., Claudet, J. *et al.* 2021. Biodiversity needs every tool in the box: use OECMs. *Nature*, 595: 646–649. https://doi.org/10.1038/d41586-021-02041-4
Jonas, H.D., Ahmadia, G.N., Bingham, H.C., Briggs, J., Butchart, D.H.M., Cariño, J., Chassot, O. *et al.* 2021. Equitable and effective area-based conservation: towards the conserved areas paradigm. *Parks*, 27(1): 71–84. https://doi.org/10.2305/IUCN.CH.2021.PARKS-27-1HJ.en
[2] Paragraphs 17d and 17e of:
FAO. 2021. *Report of the 34th Session of the Committee on Fisheries (Rome, 1–5 February 2021).* Forty-second Session of the FAO Conference, Rome, 14–18 June 2021. C 2021/23. www.fao.org/3/ne907en/ne907en.pdf

FIGURE 66 RFMO BOTTOM FISHERIES MANAGEMENT AREAS IN AREAS BEYOND NATIONAL JURISDICTION



NOTES: RFMO = regional fisheries management organization; VME = vulnerable marine ecosystem.
SOURCE: VME Database: FAO. 2021c. Vulnerable marine ecosystems. In: *FAO*. Rome. Cited 11 November 2021. www.fao.org/in-action/vulnerable-marine-ecosystems/en

30 percent of the oceans are managed through spatial controls by 2030 (Box 28).

The 2017 UN Ocean Conference Call for Action strengthened these goals and targets by calling upon all stakeholders "to conserve and sustainably use the oceans, seas and marine resources for sustainable development … on an urgent basis," including supporting "the use of effective and appropriate area-based management tools, including marine protected areas and other integrated, cross-sectoral approaches" (UNGA, 2017, pp. 3–4).

FAO Deep-sea Fisheries Guidelines – Actions to conserve and recover vulnerable marine ecosystems

The potential impact of deep-sea bottom fisheries on the seabed and its vulnerable species has been high on the global ocean agenda since the 1990s. In 2006, UNGA Resolution 61/105 Article 83 called for the protection of vulnerable marine ecosystems (VMEs, meaning fragile sessile benthic ecosystems such as corals, sponges and sea pens) from significant adverse impacts caused by bottom fishing. FAO adopted the International Guidelines for the Management of Deep-sea Fisheries in the High Seas in 2008 to promote integrated area-based management measures for bottom fisheries in the high seas. This completely changed the way these bottom fisheries were managed and stimulated the establishment of new regional fisheries management organizations (RFMOs) in the North and South Pacific and Indian Ocean. By 2015, most major bottom fisheries in the high seas were managed through legally binding mechanisms.

The North East Atlantic Fisheries Commission was the first to identify and close VMEs to bottom fishing in 2005 in the Northeast Atlantic, later followed by other RFMOs (Figure 66). This is one of a range of area-based measures to conserve ecologically representative and well-connected systems of protected areas. The measures comprise:

- identification of bottom fishing areas where fishing can occur according to agreed management measures (green areas);
- establishment of stringent exploratory protocols for fishing outside existing fishing areas (orange areas);
- closure of VME areas to bottom fishing (red areas); and
- adoption of encounter protocols to protect undiscovered VMEs (all areas).

These regulations directly support the CBD's draft Post-2020 Framework by ensuring that at least 30 percent of the wider seascape is managed effectively by area-based conservation measures (Targets 1, 3 and 4), and showcase the proactive elements of deep-sea fisheries in protecting and maintaining global biodiversity. In fact, in most RFMOs, 100 percent of the area has bottom fisheries measures in the high seas, and these are supported by other measures dealing with small pelagic and tuna fisheries. Hence, the Deep-sea Fisheries Guidelines (FAO, 2009) promote area-based measures that permit bottom fishing where impacts on biodiversity are low, but prohibit fishing in areas where biodiversity is fragile (e.g. on VMEs). The measures thus incentivize deep-sea fisheries to provide nutrition, income and employment while eliminating negative impacts on biodiversity, thus supporting sustainable use of fisheries resources as well as biodiversity conservation goals of the CBD.

Inland fisheries

Basin-based management to ensure sustainable inland fisheries

Inland fisheries are sustained by aquatic biodiversity, healthy key habitats such as spawning grounds, nursery areas and dry season refuges and connectivity between these habitats, and the maintenance of hydrological regimes. Although fishing pressure can be extremely high in inland waters, the main drivers of decline in inland fisheries usually arise outside the fisheries sector, for example, competition for water resources between sectors, land use change and pollution. To address these issues, the ecosystem elements requiring improvement must be identified, mapped – considering all phases in the life cycles of the fish – and restored. Restoration may include re-establishing riparian vegetation, re-profiling river channels, reintroducing habitat heterogeneity, recreating spawning grounds and reconnecting floodplains or backwaters with the river channel, as well as basin-wide measures to sustain environmental flows (Valbo-Jørgensen, Marmulla and Welcomme, 2008).

The sectoral approach to natural resources management has not benefited inland fisheries since fisheries authorities rarely have the mandate to regulate other water and land use activities affecting fisheries, effectively leaving them without the necessary tools to ensure sustainability. Mechanisms to ensure good governance in the water sector are often weak, and less powerful actors such as fishers are not always consulted regarding interventions that impact them. In large river basins, a subcatchment approach can be used whereby the basin is divided into ecologically appropriate units which can be managed at the appropriate levels by the appropriate parties. In international basins, basin organizations should balance costs and benefits and guide development in line with regional policies and international instruments (Valbo-Jørgensen, Marmulla and Welcomme, 2008) (Box 29).

Reconnecting inland aquatic habitats for biodiversity and fisheries

Restoring aquatic ecosystems for inland fisheries requires catering for the needs of fishes in both time and space – providing upstream (spawning) and downstream (feeding and refuge) habitats, ensuring the connectivity between them and considering the impacts of water management on the timing of hydrological events. These elements need to be agreed upon as part of any river basin or catchment area management plan. The growing number of mainstream dams in the world's major river basins and their potential impact on riparian communities has received a lot of attention in recent years. However, the proliferation of small dams, weirs, barrages and

BOX 29 INLAND FISHERIES

There are significant opportunities for ecosystem restoration to benefit inland fisheries in view of the degraded state of the habitats and environment that has contributed to the decline of such fisheries. Ecosystem restoration needs and benefits are nearly always multipurpose. There are important synergies among inland fisheries and other important high-value services, such as water quantity and quality regulation, disaster risk reduction, nutrient cycling and biodiversity conservation. Climate change adaptation interests are likewise closely aligned with those for inland fisheries through the mutual need to protect and restore inland water ecosystems in order to reduce disaster risks. Many ecosystem services can be converted to monetary values, making comparisons among them easier, but assessments should also include non-monetary values. The average values per unit area of aquatic ecosystem types on which inland fisheries depend – for example, rivers, lakes and wetlands – are orders of magnitude higher than for terrestrial ecosystems.

Reviews of ecosystem restoration for inland fisheries have tended to focus on North America and Europe, mainly for recreational fisheries and mostly for salmonid fish species, paying little attention to the food and nutrition components that are no longer very important in these fisheries. This contrasts with the situation in developing countries where the socio-economic status of the various stakeholders, winners and losers, should also be considered in the context of pro-poor sustainable development. Local communities in developing countries also tend to have high dependency on inland fisheries and are closely associated with the resource, usually living within it. This represents a potential management asset able to implement restoration measures, but which is now unavailable in developed countries. The local significance of inland fisheries is often best expressed not just through gross weights of catches, but through their contributions to the food and nutrition security and livelihoods of local communities, which can be very high and present a strong case for restoration. There are numerous examples showing that ecosystem restoration for inland fisheries can be a very cost-effective investment and, in many cases, particularly for community-based restoration efforts, costs can be minimal. The benefits of ecosystem restoration for inland fisheries can be achieved very quickly, with examples of local catches doubling or trebling within one to two years. When these are factored in, ecosystem restoration for inland fisheries can present a convincing business case.

NOTE: Summarized from: Coates, D. (forthcoming). *Ecosystem restoration and inland food fisheries in developing countries – opportunities for the United Nations Decade on Ecosystem Restoration (2021–2030).* FAO Fisheries and Aquaculture Circular No. 1231. Rome, FAO.

other obstacles for water storage or flood control can reduce downstream flooding and prevent fish from accessing productive floodplains that are an essential seasonal habitat for completing their life cycles, with considerable scope for re-engineering or better managing these smaller structures to improve fishery stocks and fisheries in a multipurpose landscape (FAO and IUCN, 2017). Experience has shown that there are considerable co-benefits for biodiversity when improving ecosystem conditions for inland fisheries: biodiversity conservation and inland fisheries are mutually supporting (Phang *et al*., 2019).

Appropriate annual hydrological patterns must also be maintained or restored, including their role in creating seasonal floodplain habitats, triggering migration, and distributing fish larvae and juveniles through passive drift. These requirements of fish and fisheries should be included in the calculation of environmental flows when negotiated with other users of water at the basin level.

Critical actions needed to seize opportunities stimulated by the United Nations Decade on Ecosystem Restoration 2021–2030 and the Post-2020 Global Biodiversity Framework include:

- recognizing the importance of inland fisheries for achieving food security and sustainable livelihoods in relevant policy and investments;

- building on the complementarities between inland fisheries and environmental and biodiversity goals by targeting interventions that enable inland fisheries-dependent communities to support environmental sustainability; and
- prioritizing ecosystem restoration investments for inland aquatic ecosystems because – although they and their biodiversity are the most highly degraded and threatened – they offer significant multipurpose gains, including inland fisheries and food security, water security and adaptation to climate change.

Optimizing sustainable biodiversity use, including mitigating ecosystem impacts, through technology and innovation

Risks and mitigation associated with farmed aquatic diversity

It is widely acknowledged that future increases in demand for aquatic food can only be adequately met through growth in aquaculture production; it is essential that this growth reflects best practice for sustainable aquaculture. Some aquaculture systems or practices can present significant risk to the biodiversity of aquatic systems in which they occur. The most recent global assessment of aquatic genetic resources for food and agriculture (AqGR; FAO, 2019a) identified a strong association between farmed and wild relative AqGR and showed that aquaculture can represent a threat to wild relative diversity through genetic interaction with escapees and deliberate introductions, or through habitat change related to fish and feed production. Threats are greatest from non-native and developed farmed types (Lorenzen, Beveridge and Mangel, 2012). The global assessment also noted the paucity of information on the properties of AqGR in aquaculture and the limited knowledge of ecosystem impacts of non-native and developed farmed types. Lucente *et al.* (2021) identified that 14 percent of cultured species are under threat in the wild, including some well-established aquaculture species. The Database of Introduced Aquatic Species (DIAS) (FAO, 2021l) indicates that most introductions of species occur for the purpose of aquaculture and provides access to information on introductions and their impacts on the environment. However, DIAS provides no indication of the relative scale of negative (e.g. harm to the environment) and positive (e.g. economic benefits from aquaculture) impacts.

There are various mechanisms to mitigate the impact of farmed types on wild relatives, including regulatory measures (e.g. aquaculture zoning) and actions of physical containment (creating barriers to prevent or minimize the interaction of cultured and wild resources) or biological containment (e.g. siting farms in environments outside the tolerances of species or using sterile or monosex seed).

Several key measures are available to transform the management of genetic diversity in aquaculture and reduce the potential risks associated with the further expansion of aquaculture production. These measures are incorporated into the Global Plan of Action for Aquatic Genetic Resources for Food and Agriculture adopted by FAO Members in late 2021. Greater availability of and access to information on the properties and use of aquatic diversity in aquaculture would enhance understanding and awareness of the associated benefits and risks of their use. FAO is addressing this through the development of AquaGRIS, a global information system on AqGR.[15] When populated with country data on farmed types, reports can be generated to support informed development of associated policies and strategies to effectively address the negative impacts of aquaculture, including the use of non-native species and developed farmed types.

Development, dissemination and adoption of guidelines and policies specific to responsible introduction and exchange of AqGR should also reduce the impacts from irresponsible introductions. These should be based on appropriate risk assessment[16] and mitigation and include a focus on non-native species and developed farmed types, incorporating the development and use of relevant material transfer agreements.

A potentially transformational future technological innovation is gene editing, which may offer the capability to generate selectively sterile farmed

15 A prototype of AquaGRIS with data on a limited number of species is available at: www.fao.org/fishery/aquagris/home

16 For risk assessment, see Glossary.

types. Widespread use of such technology could dramatically decrease the impacts of cultured farmed types on the receiving environment. However, in the near term, use of gene editing in commercial production systems remains contentious, and regulatory burdens are likely to limit the application of gene editing in many jurisdictions.

Responsible fishing technology

Innovations in fishing technologies can improve efficiency, increase effectiveness and reduce costs, saving energy use and reducing impacts on ecosystems. Such innovations are essential elements contributing to ecosystem restoration and SDG 14 (Life below water), particularly regarding components of the following targets:

- SDG Target 14.1 – prevent and significantly reduce marine pollution of all kinds, including marine debris.
- SDG Target 14.2 – sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts.

The Working Group on Fishing Technology and Fish Behaviour (WGFTFB), comprising fishing technology experts from around the globe and jointly supported by the International Council for the Exploration of the Sea (ICES) and FAO, regularly discusses and reviews research and practices of fishing technology and behaviour of aquatic species in relation to fishing gears, and provides guidance for management including the impacts of fishing gears on the environment. Details on the latest research and developments aimed at reducing the impacts of fishing operations on the marine environment, decreasing pollution and improving energy efficiency can be found in the WGFTFB report (ICES, 2021).

Bycatch mitigation

After the publication in 2021 of its Guidelines to Prevent and Reduce Bycatch of Marine Mammals in Capture Fisheries, FAO continues its efforts to assist States and RFMOs through technical advice and wide promotion of the Guidelines in several UN languages (FAO, 2021m). These guidelines are directed at decision makers, planners, managers and all those involved in developing and implementing policy and technical interventions which relate to the bycatch of marine mammals in fisheries (FAO, 2021n).

The five-year (2015–2020) FAO-GEF project, Sustainable Management of Bycatch in Latin America and Caribbean Trawl Fisheries (REBYC-II-LAC), improved bycatch management in shrimp trawl fisheries of six countries in Latin America and the Caribbean. A new phase, REBYC III, to include reducing bycatch from fishing gears other than trawls, is currently being developed.

Development and subsequent implementation of measures addressing bycatch issues will provide critical contributions to achieving the Post-2020 Global Biodiversity Framework vision of living in harmony with nature and regarding in particular SDG Target 4 (CBD, 2021) and Aichi Biodiversity Targets 6 and 12 (CBD, 2020).

Addressing pollution in the fisheries sector

Abandoned, lost or otherwise discarded fishing gear (ALDFG) is of increasing concern due to its negative environmental and economic impacts, including navigational hazards and associated safety issues. The ability of ALDFG to continue to capture aquatic animals in a non-controlled manner (i.e. "ghost fishing") is detrimental to fishery stocks with potential impacts on endangered species and benthic environments.

ALDFG is an internationally recognized problem within the global challenge of marine plastic litter, with many international organizations, activities and agreements focusing on marine debris and numerous national- and local-level initiatives implemented around the world. Within this context, the United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) Working Group 43, comprising independent scientists and co-chaired by FAO and the International Maritime Organization (IMO), has produced a report to provide updated information and build understanding of the extent of the impacts of sea-based sources of marine litter, in particular from the shipping and fishing sectors. The report includes a section on solutions for reducing sea-based sources of marine litter (GESAMP, 2021). The current Terms of Reference for GESAMP Working Group 43 are being updated to ensure that the latest scientific developments in this field and identified data gaps are considered when addressing the issue of marine plastic litter originating from the fishing and shipping sectors.

The 2021 FAO Committee on Fisheries (COFI) Declaration for Sustainable Fisheries and Aquaculture reiterates the importance of reducing the impact of ALDFG and marine litter. To fill data gaps identified by GESAMP Working Group 43 and to facilitate and standardize data collection on ALDFG, FAO designed questionnaires and is working with countries and partners such as the Global Ghost Gear Initiative (GGGI, 2021) to implement surveys and fill gaps. Data collated will provide an overview of the current status of the ALDFG issue across fisheries and geographies, support long-term trend analyses and monitoring of ghost fishing, and guide development and implementation of appropriate technologies and other mitigation measures.

Marking of fishing gear to enable the identification of the operator and/or owner of the gear is widely accepted as a key tool for reducing ALDFG and IUU fishing. To assist States to implement the Voluntary Guidelines on the Marking of Fishing Gear (VGMFG) (FAO, 2019d), FAO is developing a technical manual and a risk assessment framework that countries can use to assess the needs and requirements of a national system for marking of fishing gear.

Additionally, FAO is supporting the implementation of the GloLitter Partnerships Project (IMO, 2019a), funded by Norway and implemented in collaboration with the International Maritime Organization (IMO, 2019b).· GloLitter assists developing countries to implement the IMO Action Plan to Address Marine Plastic Litter from ships and the VGMFG at the national level. Through this project, FAO will develop and test gear modifications aimed at preventing ghost fishing in small-scale fisheries, which represent 90 percent of world fisheries employment (FAO, Duke University and WorldFish, forthcoming).

Collectively, these initiatives can synergistically contribute to addressing threats to biodiversity by reducing levels of pollution and discharge of plastic waste in accordance with the relevant 2030 Agenda SDG targets. ■

PHILIPPINES
Moving the catch of tulingan tuna (*Auxis rochei*) from the boat's hold to baskets to be carried to a local buyer in Initao. Fisher wearing face mask to comply with government guidelines to contain the spread of COVID-19.
©FAO/David Hogsholt

PART 4
EMERGING ISSUES AND OUTLOOK

COVID-19, A CRISIS LIKE NO OTHER

Introduction

In March 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) a global pandemic. Since then, the world has been shaken by a disease that has killed millions of people and rendered tens of millions ill.[1] In a matter of weeks, the world's economy suffered a sharp contraction as a result of the measures implemented in urgency to prevent the spreading of the virus. This led to major consequences for sectors highly dependent on trade, including fisheries and aquaculture. At the regional level, regional fishery bodies (RFBs) reported, *inter alia*, a negative impact on activities related to monitoring, control and surveillance (MCS) of fishing activities, fisheries and aquaculture research and management. Most countries and regions experienced severe declines in fishery and aquaculture production, employment and prices. Difficulties were reported for fisheries management decision-making and capacity-building owing to postponement of physical meetings, training sessions and workshops (FAO, 2021o). China, Europe, Japan and the United States of America, the four great major markets for aquatic foods,[2] were severely hit by the pandemic. Closed borders – with travel restrictions and disruption of imports – affected developing countries that rely on exports of aquatic products[2] for foreign exchange earnings.

FAO estimates that 3 billion people cannot afford a healthy diet, with an additional 1 billion if a shock were to reduce their income by one-third (FAO, 2020a). Indeed, the pandemic has posed major challenges to livelihoods, employment, food security and nutrition. Vaccination campaigns and policy responses to COVID-19 enabled global economic recovery in 2021, with an increase in production, trade and consumption of aquatic products (FAO, 2021p). The renewed interest in home cooking, food delivery services and digital retail channels driven by COVID-19 continues to expand (UNCTAD, 2022), although uncertainty remains as to how the sector will reorganize to adapt to a changing market and face the future, given the risk of new variants requiring subsequent restriction measures.

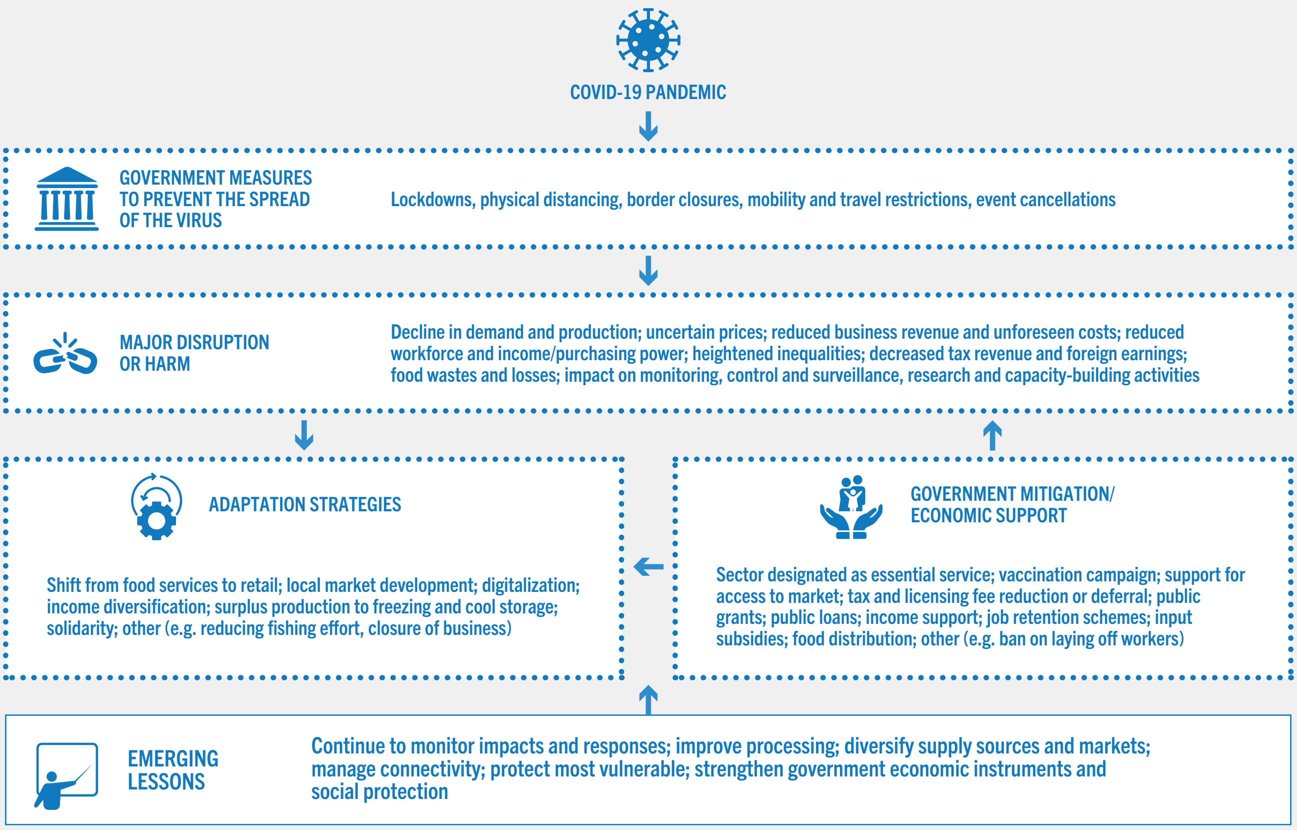
Supply chain disruption and related risks

The entire fisheries and aquaculture value chain was severely disrupted as a result of the lockdowns. An external shock such as the COVID-19 outbreak had never before arrived with such speed, and the impact on consumer behaviour and trade globally was unprecedented. The pandemic has revealed the fragilities of aquatic food systems on both the demand and supply sides (FAO and WorldFish, 2021). In European countries, in the short term, perishable food was sold off below cost and/or scrapped, while in the medium term, the capacity to restock was constrained by reduced production and transport capacity. There was a massive shift in sales from food services to retail, resulting in oversupply of food service products and shortages in retail with a subsequent impact on prices (Kent, 2021). In many countries, mobility restrictions totally disrupted the fisheries and aquaculture supply chain, at least during the first months of the pandemic before the sector was gradually recognized as essential, and initiatives were implemented to bring the industry back on track. Mobility restrictions meant that essential production inputs, such as feeds and seed, could not reach farms regularly. Shrimp and tilapia

1 At the time of writing (7 June 2022), the WHO reported 529 410 287 confirmed cases of COVID-19, including 6 296 771 deaths, at the global level (WHO, 2022).

2 For aquatic food and aquatic products, see Glossary, including Context of SOFIA 2022.

FIGURE 67 EXAMPLES OF DISRUPTIONS, ADAPTATION AND MITIGATION STRATEGIES, AND LESSONS EMERGING FROM THE COVID-19 CRISIS



SOURCE: FAO.

farmers in Central America witnessed a 75 percent drop in demand in both local and international markets. All this resulted in the paralysis of the industry, which experienced overstocking and unforeseen feeding and freezing costs with severe economic impacts, and some production units closed operations (OSPESCA and SICA, 2020).

The impacts of the pandemic on aquatic food systems have varied depending on species, markets and consumer demand, as well as labour force structure and adaptive capacity of both governments and the industry (Figure 67). In general, supply chains dominated by small and medium enterprises (SMEs) were particularly vulnerable to COVID-19 restrictions (FAO, 2021q). In Africa and South Asia in particular, prior to COVID-19, these supply chains were already constrained by insufficient cold storage and processing capacity, poor transportation infrastructure, disjointed input markets, and/or underfinanced suppliers. Large-scale vertically integrated supply chains, in contrast, have generally been less affected, as they are more able to control input and output delivery. The labour-intensive small-scale sector was vulnerable to restrictions on movement affecting workers and to disruptions in input provisioning and transportation (IFPRI, 2021). In South and Southeast Asia, preliminary findings from a survey conducted by FAO and INFOFISH show that the COVID-19 pandemic and lockdowns greatly impacted small-scale fisheries and aquaculture farmers across countries. The restrictions disrupted supply chains and markets, hampered business operations, affected employment, maintained certain inequalities such as that of gender participation, and contributed to fluctuating incomes for households, and to decreased tax revenue and foreign exchange earnings for governments (FAO and INFOFISH, forthcoming).

Operators and markets are slowly recovering, but rising freight costs, new border procedures, reduced availability of shipping containers, bottlenecks in big international harbours, and the risk of new variants dampen the medium-term outlook (FAO, 2021p). As a whole, the aquatic food system has managed to adapt and maintain flows of products and supply, but numerous enterprises have gone out of business or are in a precarious position (FAO and WorldFish, 2021).

Work, gender and food security

The pandemic has impacted work, income and associated purchasing power (FAO and WorldFish, 2021; Béné *et al*., 2021). Four in five workers worldwide have experienced partial or total unemployment or working from home (Tooze, 2021). It has exacerbated the lack of access to adequate food for millions of people, making their food security a huge and persistent problem. Vulnerability to such income shocks is particularly worrisome in low-income countries, where a diet meeting basic energy requirements is beyond the reach of many (FAO, 2021q).

Many studies concur that shocks disproportionately affect vulnerable and marginalized people, and the COVID-19 pandemic is no exception.[3] Low-income households, small operators, women, infants and young children, the elderly, persons with disabilities, indigenous populations, refugees, migrants, displaced people and minorities are at greater risk of suffering the adverse effects of the pandemic around the world. Small-scale fishers and fishworkers who rely on seasonal migration have been affected by prohibitions on travel and accommodation (Sowman *et al*., 2021). Crew change and reduced access to shore services have impacted seafarers, including migrant workers employed on long-distance industrial fishing vessels (Vandergeest, Marschke and MacDonnell, 2021). Many workers in the processing, harvesting and marketing industries have lost their jobs (Alam *et al*., 2022). Moreover, working on board fishing vessels and in post-harvest handling, packaging and processing has entailed increased risks of virus transmission and outbreaks of COVID-19 among workers because of reduced space and humidity (IFPRI, 2021).

Women's relatively high representation in the sectors hardest hit by lockdowns has translated into greater declines in women's employment than in men's (FAO and WorldFish, 2021). Yuan *et al*. (2022) investigated the impact on the livelihood of households engaged in the aquaculture value chain in China: family income decreased significantly due to lower wages and reduced business revenue (e.g. the income of all catfish seed producers fell by more than 50 percent), and the families of 30–40 percent of surveyed farmers encountered financial difficulties; furthermore, women faced the increased burden of caring for and educating children due to school closures and were under extra pressure to maintain the basic living conditions of the family. Women account for half the workforce when both primary and secondary fisheries and aquaculture sectors are considered (FAO, 2020a). Nevertheless, they are under-recognized in the industry, despite their crucial role throughout the value chain and in household livelihood and nutrition. Moreover, the secondary sector has been hit particularly hard by the pandemic and this is where most women work. On the other hand, it cannot be understated that women have also emerged as agents of change and leaders in the COVID-19 response (FAO, 2020j, 2021r; Misk and Gee, 2020). In many cases, solidarity has formed the foundation for women to develop coping strategies during the COVID-19 crisis and they have used their skills, knowledge and networks to develop innovative solutions and support each other (WorldFish, 2021). As in all sectors at a global level, concerted efforts are required within the fisheries and aquaculture sector to prevent the pandemic from turning back the clock on progress towards gender equality (Turquet and Koissy-Kpein, 2020). To this end, it

3 For further details: https://data.unwomen.org/features/covid-19-and-gender-what-do-we-know-what-do-we-need-know is vital to formulate appropriate gender-sensitive mitigation strategies that target economic and health aspects and enhance the resilience of people working in fisheries and aquaculture (FAO, 2020c).

Adaptation strategies

The entire world and the industry (at all scales) were not prepared for such a shock. Nevertheless, some businesses have managed to adapt over time and innovate. Some small businesses have been able to adjust and survive by using e-commerce platforms and modifying their business operations (Stoll *et al*., 2021; Witteven, 2021). Small-scale fisheries organizations throughout Latin America have adopted innovative approaches to commercialize their products. For example, they set up temporary selling points in spots located close to highly populated urban areas of Chile, Peru, Panama and Nicaragua, and small-scale fish farmers adopted e-commerce and home delivery to advertise and sell their products. Direct sales have developed as new and emerging markets in response to the closure of other markets. In Malaysia, online fish delivery intermediary, MyFishman.com, helped SMEs in fishing and aquaculture sell via fresh fish subscriptions and delivery services, thus avoiding wet markets and direct contact with consumers (IFPRI, 2021). Some changes seem here to stay and there are signs that COVID-19 may favour industry consolidation (Simeon, 2020).

In South and Southeast Asia, small-scale fishers, aquaculture operators and fisheries-based business operators responded in various ways depending on the level of restrictions in place, government support (or lack of), and their own resilience and innovation. Overall, their businesses experienced a general decline. However, resilience has been enhanced by diversifying or substituting household income with other agricultural activities, streamlining business costs to the necessary minimum, and embracing online marketing and direct delivery. This shift in business modus operandi is fostering new opportunities for small-scale fishers, aquaculture operators and fisheries-based business operators to have a closer and direct relationship with customers, enabling them to explore new markets and new products (FAO and INFOFISH, forthcoming).

Examples of mitigation strategies provided by RFBs include the rapid increase in the adoption of enhanced electronic monitoring tools for MCS activities, development of ad hoc fishing vessel boarding and inspection procedures, adoption of virtual meetings, establishment of online decision-making processes, online marketing of aquatic products and provision of support for the transition from fresh to value-added processed aquatic food products (FAO, 2021o). Countries such as China launched a national demand and supply platform to connect fisheries and aquaculture producers to processors and buyers, streamlining production with demand, directing surplus production to freezing and cold storage, and facilitating national and international trade (Alam *et al*., 2022; FAO, 2021s).

Government support measures

To contain the economic consequences of lockdowns and other restrictions, government support for households, businesses and markets took on dimensions not seen since the Second World War. Central banks responded to what the International Monetary Fund has called "a crisis like no other", with unprecedented interventions to sustain government debt and banks (Tooze, 2021).

The measures adopted to address the impacts of the pandemic were diverse and complex, reflecting the intricacy of the issues addressed, the order of priority and countries' capacity and resources. They included health, social, economic, education and environmental measures. According to Love *et al*. (2021), responses by aquatic food system actors and institutions mostly aimed to: (i) protect public health, including the health of fishery sector workers; (ii) support those whose enterprises, jobs and incomes were affected by COVID-19-related disruptions; and (iii) maintain supplies of aquatic products to consumers.

Government support in countries in Latin America ranged from availability of soft and interest-free loans for small-scale operators, tax and licensing fee relief, and fuel subsidies, to temporary suspension of credit obligations. In the United Kingdom of Great Britain and Northern Ireland, it took the form of income support, job retention schemes, bounce back loans and income tax deferral; there were also non-nation-specific measures, such as sea fisheries hardship funds in Scotland, support for the fishing industry in Northern Ireland and assistance from charities (e.g. The Seafarers' Charity) (Patience, Motova and Cooper, 2021).

Preliminary research in South and Southeast Asia reveals both positive and negative responses from governments. Survey results point to, *inter alia*, the need for customized and focused government intervention supported by proper regulations, improved gender participation, increased education and awareness on the potential of digital markets and online platforms, while maintaining quality produce and meeting consumer needs. Sustaining the livelihood of small-scale fishers, aquaculture operators and fisheries-based business operators requires concertation with all concerned stakeholders (FAO and INFOFISH, forthcoming).

However, in most countries, support was complicated by limited public funds. Moreover, the fiscal and monetary responses to support vulnerable groups will have important consequences for indebtedness, debt servicing capacity, and debt sustainability more broadly. For example, sub-Saharan Africa experienced a 4.5 percent increase in "pandemic debt"– the debt taken on above and beyond projections due to the COVID-19 crisis (Heitzig, Aloysius Uche and Senbet, 2021). This could have serious impacts on the governance and management of living aquatic resources.

Social protection

The COVID-19 responses show that countries with working social protection systems in place had greater flexibility and could respond by adapting social protection programmes to the impact of the pandemic (FAO, 2021g). Other countries were unable to respond to the needs of communities dependent on living aquatic resources, especially where informality was predominant (FAO, 2020l). Many workers in the fisheries and aquaculture sector are informal with no social protection coverage; they are not registered in mandatory social security schemes, are paid less than the legal minimum wage, do not have a written contract or are self-employed. These individuals include small-scale fishers, migrant fishworkers, ethnic minorities, crew members, harvesters, gleaners and vendors – especially women, who have been the most affected by the pandemic (FAO, 2021g).

Many people who lost their employment were also left without access to income support. Many countries implemented new schemes, while others expanded existing schemes, either horizontally or vertically, by, for instance, increasing the programme's coverage, relaxing access requirements, expanding the programme's duration or introducing extraordinary cash transfers. The most common interventions targeting the fisheries and aquaculture sector were temporary social assistance measures, ranging from one-off payment schemes to unconditional cash transfer programmes lasting three months, and including in-kind food transfers. However, financial support was also provided through, for example, fee waivers and input subsidies for baits, ice and fuel, as well as for the provision of seed for aquaculture purposes and the building of aquaculture farms; in addition, technical support was made available to generate jobs and rebuild the sector (FAO, 2021g).

Emerging lessons

The COVID-19 crisis is protracted; its effects are unfolding as new variants emerge. It is essential to continue monitoring, assessing and documenting both the impacts on and the responses of the fisheries and aquaculture sector, in order to inform short-, medium- and long-term strategies and be prepared for new waves.

Among the lessons learned, the COVID-19 pandemic has highlighted the interconnectivity of markets: the disruption of one or more stages of the aquatic supply chain can have impacts that span local, national and international boundaries. Market disruptions can lead to inflation risks (Kent, 2021). Key elements for building resilient aquatic food systems include improving processing, diversifying supply sources and markets, managing connectivity through more robust food transport network and logistics, and allowing a mix of different and heterogeneous suppliers (FAO, 2021q).

Recognizing that fisheries and aquaculture is an essential sector and integral part of the food system in many countries, it is vital to maintain the smooth functioning of all points of the supply chains, supporting food security, income and employment with special regard for the specific challenges faced by vulnerable groups including women and migrant workers (FAO and WorldFish, 2021).

COVID-19 has exacerbated pre-existing inequalities. Small-scale fisheries and aquaculture, SMEs, women and other vulnerable groups (e.g. informal and migrant workers) are increasingly marginalized and need to be properly protected.

The pandemic highlights the need to expand social protection coverage through a comprehensive and inclusive national social protection system that is shock-responsive and adequately covers the sector. Policy coordination and coherence between a range of line ministries at the national level are essential. Social protection programmes should use a gender-sensitive approach throughout the design, implementation and evaluation phases, because they can affect gender dynamics. Social protection schemes can enhance households' adaptive capacity to shocks and reduce negative coping strategies that would result in long-term detriment to their livelihoods. Social protection can contribute to improved welfare and fisheries management.

Economic support measures enacted by governments depend on the available resources and capacity. In most developing countries, the economic responses have important consequences for national debts because of the pre-COVID-19 debt level, debt servicing capacity and debt sustainability. This could have some impact on the governance and management of aquatic resources. Some recommend revisiting existing institutional mechanisms for debt sustainability and restructuring (Heitzig, Aloysius Uche and Senbet, 2021).

The emerging literature on COVID-19 and climate adaptation suggests that the pandemic impacts the Paris Agreement's goals of "enhancing adaptive capacity", "strengthening resilience" and "reducing vulnerability" to climate change, as countries are prioritizing health and economic recovery (UNEP, 2021). It is critical to embed social and environmental considerations (e.g. low carbon, climate resilience) into COVID-19 recovery plans through investment in activities that support blue economic recovery and build adaptive capacity (UNEP, 2021).

Furthermore, it is critical to prepare for multiple known or unknown risks. COVID-19 has added to diverse pre-existing pressures (e.g. fish/shellfish disease outbreaks, extreme weather events, chronic financial constraints), and fisheries and aquaculture management needs to address these through integrated risk management[4] approaches. Studying what types of measures and broader interventions have worked in different contexts and how systems have changed, and documenting both longer-term impacts and emerging lessons could help to build specific resilience to the COVID-19 pandemic and general resilience to future shocks or stressors (Love *et al*., 2021).

On the positive side, the crisis has accelerated the digitalization of the sector, encouraged the e-monitoring and enforcement of capture fisheries, advanced the use of green and clean energies, contributed to the development of local markets, driven fish farmers to better manage scarce production factors such as feeds and highlighted the importance of domestic production. ■

FISHERIES AND AQUACULTURE ADAPTATIONS TO CLIMATE CHANGE

Introduction

The Intergovernmental Panel on Climate Change (IPCC) reiterated the acceleration of global warming in the Sixth Assessment Report (IPCC, 2021), stressing that increased warming has caused irreversible changes. The Glasgow Climate Pact (UNFCCC, 2021) coming out of

4 For risk management, see Glossary.

BOX 30 HIGHLIGHTS OF THE GLASGOW CLIMATE PACT

The twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) – COP26 – was held from 31 October to 13 November 2021 in Glasgow, United Kingdom of Great Britain and Northern Ireland. The outcome document, the Glasgow Climate Pact,[1] addressed issues and challenges in seven action-oriented areas. It placed unprecedented emphasis on adaptation, highlighting the urgency of scaling up adaptation action. It also urged developed countries to significantly increase from the 2019 levels their collective provision of adaptation finance to developing countries by 2025. This is critical noting the current adaptation finance gap, which has been worsened by the increased indebtedness of developing countries as a consequence of the COVID-19 pandemic.

In terms of mitigation, the Glasgow Climate Pact recognized that limiting global warming to 1.5 °C requires rapid, deep and sustained reductions in global greenhouse gas emissions. It requested countries to revisit and strengthen the 2030 targets in their nationally determined contributions as necessary to align with the Paris Agreement temperature goal by the end of 2022.

Addressing loss and damage was another critical issue at COP26 and received particular attention from developing countries. The Glasgow Climate Pact urged developed countries to provide funds for technical assistance under the existing Santiago Network. It also established the Glasgow Dialogue to discuss funding arrangements for activities addressing loss and damage.

In the Glasgow Climate Pact, countries recognized the interlinkage between climate change and biodiversity loss and the critical role of protecting, conserving and restoring nature and ecosystems. There was a particular focus on the ocean, with COP 26 calling on the relevant work programmes and constituted bodies under the UNFCCC to consider how to integrate and strengthen ocean-based action in their existing mandates and work plans and to report on these activities within the existing reporting processes. Countries agreed to strengthen ocean-based action and continue annual ocean dialogues in 2022.

FAO was actively engaged in multiple events at COP26, ensuring fisheries and aquaculture were addressed under the UNFCCC. FAO also used the opportunity to reinforce its commitment to continue supporting countries to achieve sustainability and climate resilience collectively for fisheries and aquaculture, in collaboration with partners from the United Nations system, ocean community and private sector.

[1] UNFCCC. 2021. Decision -/CP.26 Glasgow Climate Pact. https://unfccc.int/sites/default/files/resource/cop26_auv_2f_cover_decision.pdf

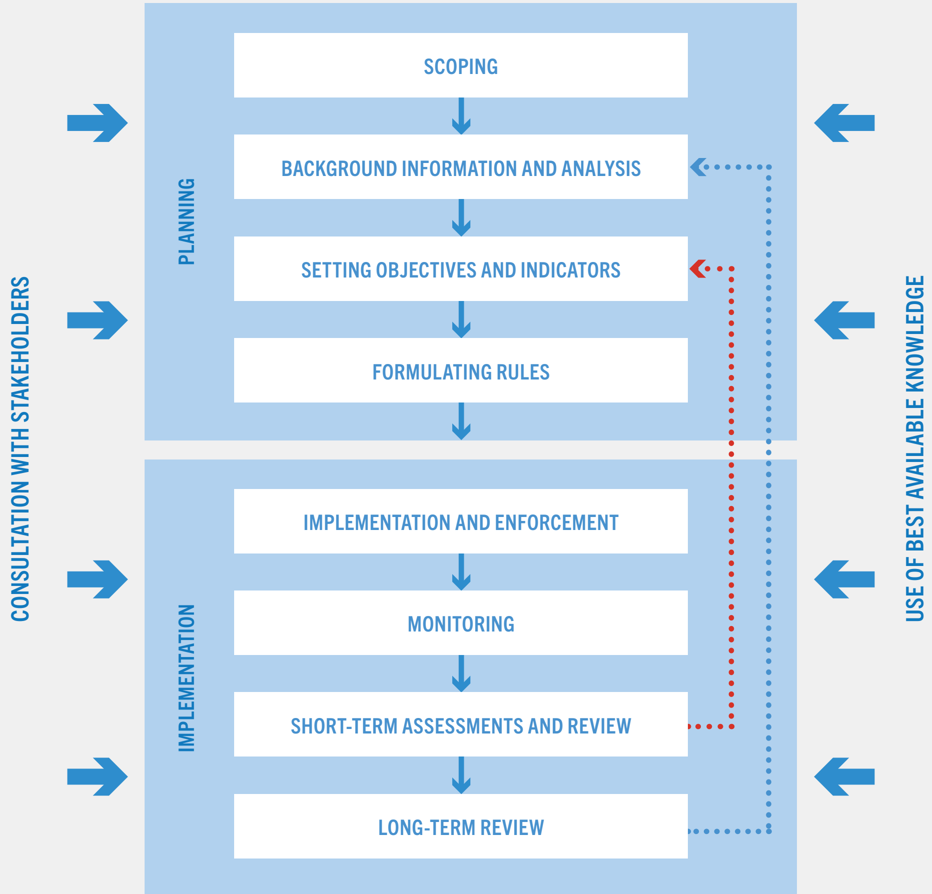
the twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP26) (Box 30) highlights the urgent need for ocean-based action, and the climate discussions reasserted the large capacity of aquatic ecosystems to store carbon. These recognitions call for strengthened and accelerated climate mitigation and adaptation in fisheries and aquaculture along the lines of developments that are progressively shaping up in the international climate dialogues. Over the years, global climate discussions relating to fisheries and aquaculture have been supported by FAO guidance on adaptation (Poulain, Himes-Cornell and Shelton, 2018); this section underscores five priorities for fostering on-the-ground actions on fisheries and aquaculture adaptation that can significantly contribute to Blue Transformation.[5]

Mainstreaming climate change into fisheries and aquaculture management

The increasing evidence of the impacts of climate change on aquatic ecosystems calls for the explicit consideration of climate stressors in fisheries and aquaculture management, as well as a better connection between adaptation plans and management or development actions. For this purpose, the sector would benefit from

5 For Blue Transformation, see Glossary.

FIGURE 68 ADAPTIVE MANAGEMENT CYCLES SHOWING AN ADDITIONAL FEEDBACK LOOP TO ADDRESS THE DYNAMIC NATURE OF CLIMATE CHANGE



NOTE: Additional feedback loop is indicated by dotted red line.
SOURCE: Adapted from FAO. 2003. *Fisheries management 2. The ecosystem approach to fisheries*. FAO Technical Guidelines for Responsible Fisheries. No. 4, Suppl. 2. Rome. www.fao.org/3/y4470e/y4470e.pdf

shifting to flexible and adaptive management approaches allowing for continuous adjustments as climate impacts are detected. Typically, management cycles as theorized in FAO guidance would need to include additional feedback loops to respond to changes in a timely manner and shorten the management cycle to allow for adaptation to changing conditions (Figure 68).

Environmental monitoring systems using a risk-based approach can trigger effective adaptation action if they include local and context-specific proxies and indicators associated with climate stressors that are known to have significant impacts on fisheries and aquaculture (e.g. temperature increase, changes in precipitation patterns, oxygen level in the water). In general, enhancing the reliance on risk-based approaches in fisheries and aquaculture

BOX 31 FOSTERING CLIMATE CHANGE ADAPTATION AND MITIGATION THROUGH IMPROVED COASTAL MANAGEMENT

Coastal fisheries are a vital provider of food and livelihoods to millions of people. Yet, there is growing pressure on the marine biodiversity of coastal areas. Climate change is among the main challenges endangering aquatic species and threatening coastal ecosystems, including mangroves.

In Sassandra (Côte d'Ivoire) and the Saloum Delta (Senegal), FAO and the United Nations Environment Programme/Abidjan Convention are working together with local communities to achieve sustainable mangrove management linked with improved fisheries governance and value chains, through the Coastal Fisheries Initiative project in West Africa funded by the Global Environment Facility.

In 2021, the project implemented mangrove restoration, assisting natural regeneration and safeguarding activities at a pilot scale of 700 ha, using a participatory and inclusive approach by involving local communities and non-governmental organizations.

The project also supports the operationalization of a coastal shrimp management plan in the Saloum Delta, and has carried out community capacity development, with a particular focus on women oyster processors and awareness raising through various media in local languages.

These interventions are leading to multiple benefits. They are enhancing the resilience of fisheries communities' livelihoods to climate-related risks and disasters and contributing to carbon sequestration, while addressing issues related to biodiversity.

NOTE: For further details, please visit: www.fao.org/in-action/coastal-fisheries-initiative/en

management optimizes risk reduction related to climate change, whether in the planning or implementation phase of management.[6] In addition, the spatial and temporal scale of management units of fishing or fish farming need to be properly designed so that they are aligned with the relevant climate mitigation and adaptation measures.

FAO initiated the analysis of case studies that successfully introduced flexibility in marine fisheries management (Bahri *et al.*, eds, 2021); however, further work is needed, documenting and learning from practical examples addressing the impacts of climate change in freshwater fisheries or aquaculture management to ensure continued productivity and resilience (Box 31).

6 See Aguilar-Manjarrez, Soto and Brummett (2017) for an example of aquaculture development.

Developing and implementing transformative adaptation plans

Fishers and fish farmers are already adapting to climate change by diversifying their livelihoods, adjusting to changes in the environment and modifying their fishing and fish farming techniques, but more rapid changes in institutions and management systems must be in place to foster autonomous adaptation[7] and avoid maladaptation. This requires transformative adaptation plans at the national, subnational and local levels; these plans must enable autonomous adaptation in the medium and long term to ease the transition of fisheries and aquaculture to a future resilient to climate change. In response to this need, FAO released guidelines (Brugere and De Young, 2020) intended for policymakers from ministries and

7 Autonomous adaptations are initiatives that occur naturally by private actors without intervention of public agencies; they are triggered by ecological changes in natural systems and by market or welfare changes in human systems and are referred to as spontaneous adaptation (Klein and Maciver, 1999).

institutions governing fisheries and aquaculture to actively take part in and contribute to the recognition, promotion and inclusion of the sector in national adaptation planning processes. Other stakeholders can also make use of these guidelines to understand how to engage in and initiate adaptation planning at the subnational and local levels.

While transformative adaptation plans will be required to encapsulate the needs of all scales of fisheries and aquaculture, particular attention must be given to the most vulnerable if the sector is to continue to contribute to meeting global goals of poverty reduction and food security. Therefore, the formulation and implementation of adaptation plans must follow an inclusive and participatory approach and consider the needs and benefits of small-scale fishing and fish farming communities in developing countries who are most impacted by climate change. One example is the development of 120 community-based integrated management plans in Myanmar, as part of the FAO FishAdapt project, to help increase the resilience of local fisheries and aquaculture communities and their livelihoods to climate change.

Adopting climate-informed spatial management approaches

Spatial management approaches provide a powerful framework for planning, adapting and mitigating the fisheries and aquaculture sectors to current and future climate risks and opportunities. In the absence of sound spatial management and planning, as oceans warm and acidify, geographic species distributions and habitats will shift, patterns of disease outbreak and spread will change, and social conflicts between inland waters or ocean users will worsen, among a myriad of other climate-induced changes.

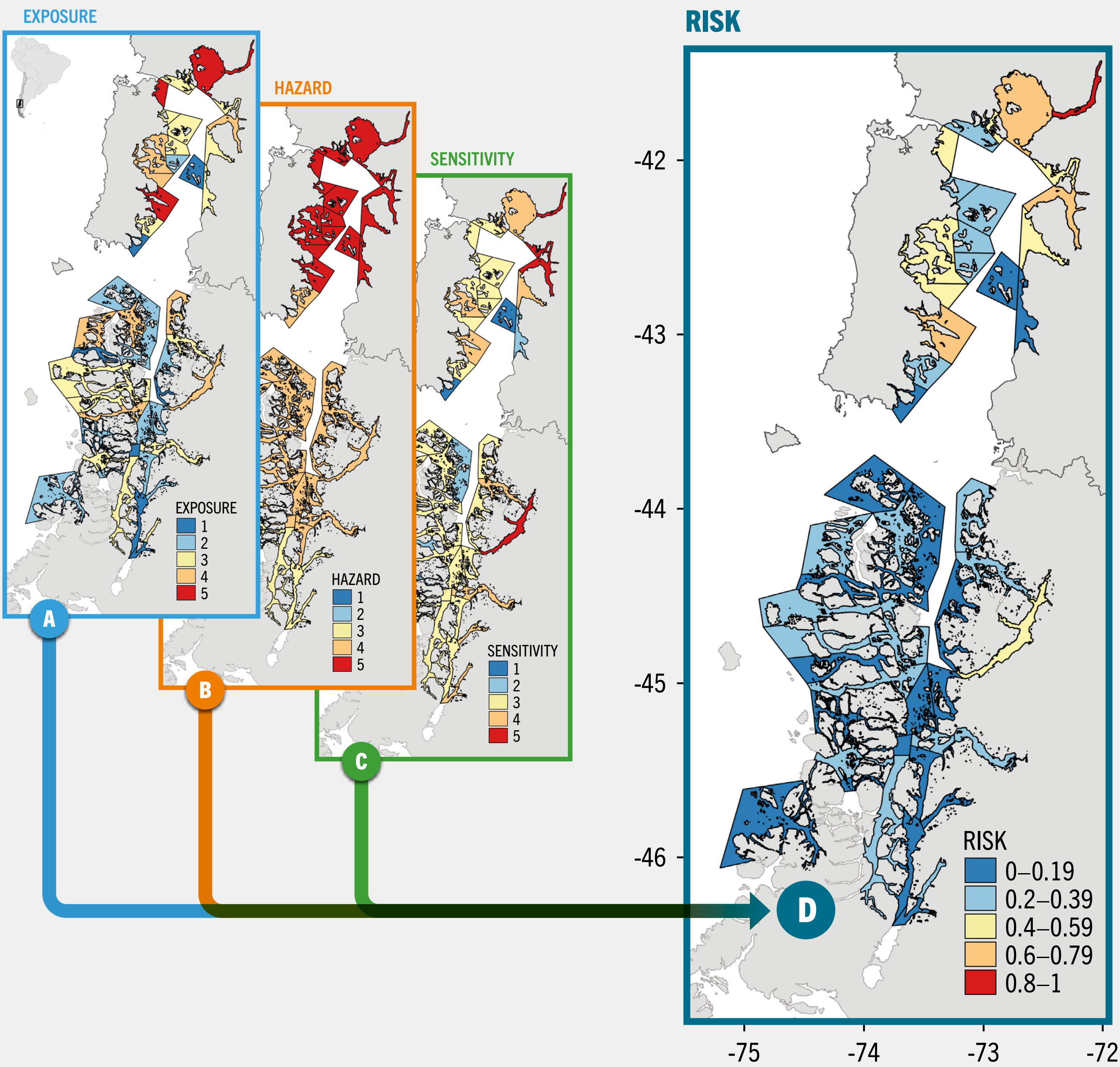
Spatial planning and management provide a solutions-focused pathway whereby spatial data and models can be used to better understand and predict how climate change could affect fisheries and aquaculture, as well as provide insights into variability between locations so that appropriate area-based adaptation strategies can be deployed. Good spatial planning and best management practices at the farm- and area-management levels, supported by spatial technology such as satellite remote sensing, aerial surveys, global positioning systems, geographic information systems, and information and communication technology, can reduce vulnerability to the risks of climate change and facilitate adaptation. For example, in Chile, climate change risk maps for aquaculture from the ARClim project developed under the Ministry of Environment are being used to generate science-based harmful algal bloom warnings to help reduce farmed salmon mortality (Figure 69).

Climate-informed spatial management mechanisms in fisheries and aquaculture may require adaptive shifts in governance frameworks, tailoring approaches for diverse stakeholder participation and engagement and integrating local science and knowledge in the design and implementation of innovative climate mitigation and adaptation strategies such as nature-based solutions. Furthermore, it is important to: develop diverse spatial databases that capture both ecological and socio-economic characteristics of the environment; strengthen oceanographic and climate-observing systems to provide local and real-time information; and develop national and regional capacities to implement early warning models and indicators that can support mitigation or adaptation of climate change impacts on fisheries and aquaculture.

Integrating equity and human rights considerations

The notion of equity should always be at the heart of climate discussions. Climate change may cause the most harm to those who have contributed the least to the climate crisis, such as small-scale fishing and fish farming communities, in particular those living in low-income countries and islands. Ultimately, equity is also about human rights. Climate change can affect people's right to food, access to drinking water, education, health and housing, with disproportionate impacts on individuals, groups and people who are in vulnerable situations such as women, children, older persons, indigenous peoples, minorities, migrants and the poor.

FIGURE 69 RISK MAPS OF LOSING SALMON BIOMASS DUE TO HARMFUL ALGAL BLOOMS UNDER CLIMATE CHANGE PROJECTIONS



NOTES: Polygons represent salmon farming concession areas (ACS) along latitudinal (Y) and longitudinal (X) axes. Colours in maps A to C represent scores for the components of Risk: Exposure (E), Hazard (H) and Sensitivity (S). Scores vary from 1 (minimum) to 5 (maximum) for each component. Map D represents Risk values, estimated as $R = (E \times H \times S)/125$. The denominator 125 refers to maximum possible values $(5 \times 5 \times 5)$, therefore risk varies between 0 (minimum risk) and 1 (maximum risk).
SOURCE: Adapted from Soto, D., León-Muñoz, J., Garreaud, R., Quiñones, R.A. & Morey, F. 2021. Scientific warnings could help to reduce farmed salmon mortality due to harmful algal blooms. *Marine Policy*, 132: 104705. https://doi.org/10.1016/j.marpol.2021.104705

The Voluntary Guidelines for Securing Sustainable Small-scale Fisheries, the 2021 FAO Committee on Fisheries Declaration for Sustainable Fisheries and Aquaculture and the Paris Agreement recognize the importance of equity and human rights. Climate change adaptation in the fisheries and aquaculture sector must integrate equity and human rights considerations in both processes and outcomes. Key process considerations include transparency, participation, access to justice and non-discrimination. Key outcome considerations include the right to life and the supporting rights to food, housing, water and livelihoods. The adaptation planning process needs to engage and empower vulnerable communities, including small-scale fishers and fish farmers. Countries should assess the vulnerabilities of the fisheries and aquaculture sector and act in line with equity and human rights considerations. This requires countries to be proactive, preparing for future events, whether extreme or slow-onset, ensuring access to resilient infrastructure and public services (including health services).

Investing in innovation

Climate change has been posing new challenges to fisheries and aquaculture urging the sector to innovate through a synergetic combination of technological, policy and market transformations. In this regard, FAO has supported the design and implementation of novel interoperable information systems that systematize and integrate country-level data on fisheries, aquaculture and climate change, providing information for users and decision-makers, as well as early warning systems that contribute to the reduction of incidents and fatalities and the provision of humanitarian support in climate-related extreme events. Examples include an already operative framework recently consolidated in Chile (IFOP, 2021), the implementation of social media technologies to facilitate real-time information and enhance compliance in Lake Malombe, Malawi (FAO, 2019e), and the enhancing of monitoring and assessment of climate change impacts to inform policy and planning and support the fisheries and aquaculture communities in Myanmar (FAO, 2021t).

Similar innovative approaches are deployed in other regions of the world. For example, ISDApp[8] in the Philippines converts collected localized weather data into simplified weather forecasts and sends them as text messages to the registered mobile numbers of fishers, even without a smartphone, while the Moana project[9] in New Zealand supports the combination of traditional knowledge and fisheries sector data with cutting-edge ocean sensing and advanced numerical modelling to provide reliable ocean forecast systems to support marine industries.

Fisheries and aquaculture make a minor contribution to global carbon emissions. Nevertheless, there are opportunities for decarbonization along the fisheries and aquaculture value chain, increasing its efficiency by reducing fish wastes and losses, including for small-scale fishers and fish farmers. Decarbonization technologies already exist; however, access and upscaling remain a challenge due to the high costs. Innovative financial schemes and multipronged approaches are needed to ensure access to credit by entrepreneurs and local communities, including women and youth, as well as incentivizing policies to support the adoption of clean technologies and energies along the fisheries and aquaculture value chain together with marked innovations to promote their benefits.

Conclusion

Countries are showing a growing interest in adaptation of fisheries and aquaculture to climate change. According to the latest FAO report on nationally determined contributions (NDCs), of the 85 new or updated NDCs submitted (between 1 January 2020 and 31 July 2021) by countries as part of their commitment to the Paris Agreement, 62 of the 77 (81 percent) with adaptation components referred to adaptation in fisheries and aquaculture, including ocean and coastal zone management (Crumpler *et al.*, 2021). The five priorities described above can provide very relevant guidance for countries in implementing their NDCs, to ultimately contribute to the achievement of the long-term adaptation goals of the Paris Agreement.

8 For additional information: www.isdapp.ph

9 For additional information: www.moanaproject.org

With COP26's decision that formally strengthens the ocean space within the UNFCCC discussions, it is important for fisheries and aquaculture to expand its contribution to global efforts, sharing adaptation and mitigation solutions that are pertinent to the sector, while progressively filling the important gap of insufficient attention to freshwater fisheries and aquaculture within the international climate discussions. ■

ADVANCING TOWARDS GENDER EQUALITY IN FISHERIES AND AQUACULTURE

The full and equal participation, engagement and benefit of women and men – in other words, gender equality – in the fisheries and aquaculture sector is fundamental for the achievement of sustainability and inclusiveness (FAO, 2020m).

Although women make up half of the overall workforce throughout the fisheries and aquaculture value chains, occupying critical roles, they constitute a disproportionately large percentage of the people engaged in the informal, lowest paid, least stable and least skilled segments of the workforce. In aquaculture, they account for 28 percent of the workforce in the primary sector; in fisheries 18 percent; and across the pre- and post-harvest components of the value chain an estimated 50 percent. In addition to being the backbone of rural economies (FAO, 2020m), women make significant contributions to household food security and nutrition while being responsible for household and care duties. The roles women engage in are most often strongly influenced by the social, cultural and economic contexts in which they live and they often face gender-based constraints that hinder their agency (i.e. their ability to make choices and act on them) and prevent them from fully benefiting from their roles in the sector.

Gender refers not to male and female (which is sex, or the biological characteristics that distinguish male/female/intersex), but to a social construction that is context- and time-specific. It refers to the social attributes and opportunities associated with being male and female. Thus, gender refers to the roles, behaviours, activities and attributes that a given society at a given time considers appropriate for men and women. In addition, it refers to the relationship between and among men and women and determines what is expected, allowed and valued in a woman or a man in a given context.

These gendered expectations largely drive the ways women and men engage and the degree to which they benefit from their engagement across the value chain of fisheries and aquaculture. A critical nuance to this understanding of role and benefit is informed by the concept of intersectionality. It must be considered that the intersections between different social dimensions (not only gender, but also class, age, ethnicity, race, caste, religion and sexual orientation), which represent the multiple components comprising identity, can result in intersecting and compounding inequalities not only between women and men but also among women and among men.

Intersectionality must be included in analysis, to inform the individuals' social location and their relative access to power or degree of oppression and vulnerabilities, which then help define the role they have in the fisheries and aquaculture sector (Williams *et al.*, eds, 2012). Failing to account for these intersections can lead to the unintended exclusion of the most vulnerable groups and risks entrenching and worsening inequities in fishing and aquaculture communities (Ferguson, 2021).

Just as women are not a homogenous group, the different roles of women throughout the fisheries and aquaculture sector vary widely, from harvesting shellfish and seaweed, small-scale fishing and net-mending, to processing and marketing of fisheries and aquaculture products[10] (Box 32). However, there is consistency in the gender dynamics that privilege men over women

10 For fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

BOX 32 SUCCESSFUL WOMEN'S ENTREPRENEURIAL ACTIVITIES

PHILIPPINES AQUACULTURE PROJECT: STRENGTHENING SMALL AQUACULTURE ENTREPRENEURS: THE CASE OF A WOMEN'S ASSOCIATION IN THE PHILIPPINES

In the Philippines, the Binmaley Rural Improvement Club (BRIC) – a small women's association specialized in milkfish farming and processing – became a key actor in the related value chain and the local economy. The association created the opportunity for women to organize themselves and is an effective example of female-led entrepreneurship in the aquaculture sector. FAO promoted this case study to support a training workshop on aquaculture value chain development and participation: by showcasing BRIC's activities and organization, it underlined how similar associations can empower women in economic terms, leading to community development and outstanding entrepreneurial results. Women's knowledge and skills were fundamental – both to develop a solid base for performing multiple tasks effectively and to produce excellent processed products from high-quality raw materials. On the entrepreneurial side, they strived for efficiency and profitability, using their cooking skills to produce value-added products from farmed fish and to diversify their offer, while also reducing food waste. In this way, women were empowered: they enhanced their leadership, providing additional income at the family level; at the same time, they contributed to the development of an aquaculture-based enterprise in the local sector and to gender equality in the longer term.

KENYA SEAWEED PROJECT: SUPPORT TO THE IMPLEMENTATION OF MARICULTURE IN KENYA WITHIN AN ECOSYSTEM APPROACH (TCP/KEN/3502): SELF-HELP GROUPS

In 2015, the call from the Government of Kenya for FAO technical assistance resulted in a project aimed at empowering small-scale farmers and training them to produce seaweed, mussels, oysters, crabs and milkfish. Kibuyuni Seaweed Women is one of five groups that benefited from the FAO project, which facilitated the construction of drying sheds with raised racks where the harvested crop could be spread to dry safely. The objective was to promote reduction in post-harvest losses and enhance crop quality with the aim of fetching higher market prices. The project also linked an international company that purchased the dried seaweed with the Kibuyuni Seaweed Women, which, at the end of the project cycle, counted 52 members and was registered with the Government of Kenya as a self-help group.

The story of Tima Mwalimu Jasho, a seaweed farmer who used part of her savings to build a one-bedroom house that she leases out, resonates strongly as the sale of 41 tonnes of seaweed brought in over USD 13 000 following an FAO training activity on seaweed culturing in Kenya. She stated: "We have been living in poverty unaware that we're sitting on something that could help our future."

The group's members have increased their benefits from seaweed farming thanks to the project training on seaweed best business management practices and on value addition. The group supplies seaweed to buyers in its raw form and earns additional income from a wide range of value-added products including juices, biscuits, cakes, vegetable salads, soap bars, liquid soaps and other cosmetic items. The income generated from the sale of raw seaweed and value-added products has gradually improved the standard of living of the communities, with most beneficiaries being women: they have put food on the table, built new houses, educated their children and purchased better building materials for their homes.

Although the project ended in 2017, the gains are still evident. The pilot initiative was successful for Kibuyuni Seaweed Women, which has since graduated from a self-help group to a cooperative society, the Kibuyuni Seaweed Farmers Association, registered as a savings and credit cooperative.

and the control exercised through gender-based roles (FAO, 2017d). While being encumbered with a triple work burden and frequently facing gender-based violence (Siles *et al*., 2019), women in the fisheries and aquaculture sector often:

- have limited access to information, extension and financial services, infrastructure, social protection and decent employment;
- have limited access to physical and capital resources;
- are excluded from decision-making and leadership positions;
- receive fewer benefits from their activities and have fewer rights and privileges; and
- have limited control over markets, how prices are set and interactions within value chains.

Gender-based discriminations not only impact women directly, but they also impose a significant penalty on the fisheries and aquaculture sector through productivity losses, inefficiencies and lost opportunities for innovation and women entrepreneurship.

Achieving gender equality is even more urgent in the context of the COVID-19 pandemic, which has proven to be a vector and revealer of inequalities, exacerbating the discrimination already existing in the sector. As schools have closed and health systems have been overburdened to contain the pandemic, the gendered division of unpaid care and domestic work binding women and girls as caregivers has intensified. In a further complication, women and girls have been facing constraints in accessing healthcare and sexual and reproductive health services. Moreover, an increase in domestic and gender-based violence, sexual abuse and exploitation has been observed around the world. Women are a vulnerable and at-risk population because they are traditionally and predominantly involved in post-harvest activities, including downstream activities such as processing of aquatic products,[11] fresh fish mongering, storage, packaging and marketing. Their vulnerability is reinforced by the need to continue their activities in order to maintain their income and feed their families (Misk and Gee, 2020).

11 For aquatic products, see Glossary, including Context of SOFIA 2022.

Gender mainstreaming in fisheries and aquaculture

The FAO Policy on Gender Equality sets a clear goal for "achieving equality between women and men in sustainable agriculture and rural development for the elimination of hunger and poverty" (FAO, 2015b). Simply defined, gender equality is a state in which women and men enjoy equal rights, opportunities and entitlements in civil and political life and its achievement can be supported using the FAO gender mainstreaming tool. This requires assessing the implications for women and men of any planned action, including legislation, policies or programmes, in all areas and at all levels. It enables making women's, as well as men's, concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality. This is embodied by SDG 5 – Achieve gender equality and empower all women and girls – which is an explicit stand-alone goal and a cross-cutting issue, as well as a driver of gender-sensitive sustainable development in all its dimensions. It is the reason why it is repeatedly stated that without a systematic incorporation of the gender lens in the implementation and monitoring of the SDGs, progress will inevitably falter and the 2030 Agenda will not be realized (UN Women, 2021).

The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty (SSF Guidelines) outline a clear commitment to gender equity and equality and set a precedent as the first fisheries instrument to directly address gender (GAF, 2018). In 2018, the Santiago de Compostela Declaration for Equal Opportunities in the Fishing Sector and Aquaculture made a clear call for the improvement of the situation of women working in fisheries and aquaculture by ensuring equal opportunities for women (Venugopalan, 2018). The following year, FAO hosted the International Symposium on Fisheries Sustainability (FAO, 2019f), which highlighted the role of women throughout the sector and underlined the need to improve and fully recognize this role and prioritize the achievement of gender equality. The year 2021 saw the release of a fundamental declaration: the FAO Committee on Fisheries (COFI) Declaration for Sustainable Fisheries and Aquaculture (see the section Science opportunities for fisheries and aquaculture management, p. 169; FAO, 2021b).

The COFI Declaration recognizes the critical role of women as key agents in the fisheries and aquaculture sector for achieving the SDGs. It includes a strong commitment from FAO Members to "ensure women's empowerment by enhancing women's full access to and equal opportunities in the fisheries and aquaculture sector through gender-based policies." The Shanghai Declaration, adopted by the participants of the Global Conference on Aquaculture Millenium+20, promotes gender equality and women's empowerment in aquaculture development. The Guidelines for Sustainable Aquaculture are currently being developed to guide FAO Members and all stakeholders in dialogue, policy processes and action for achieving sustainable and equitable aquaculture development. Gender equality and women's empowerment are included both as a thematic module and as a cross-cutting issue, reflecting the need to address these fundamental issues specifically and to mainstream them into all dimensions of aquaculture (FAO, 2022).

Gender-transformative approaches

Gender-transformative approaches (GTAs) have been designed as a tool that allows for the exposure of the underlying causes and extent of gender inequality and discrimination and then for these underlying causes to be addressed by redressing power imbalances at individual and societal levels. GTAs are a powerful tool to empower women and girls and to realize profound changes in fisheries and aquaculture communities. However, it must be underlined that these changes take place slowly and only with the engagement and contribution also of men and the entire family and community. This approach represents a way forward that can be and has been adapted to fisheries and aquaculture contexts to allow the sector to reach its full potential by way of the achievement of gender equality.

Women as agents of change

FAO's work on gender mainstreaming in fisheries and aquaculture follows the methods of the GTAs and is set in line with the four objectives set out by the FAO gender strategy (FAO, 2020):

- Women and men have equal voice and decision-making power in rural institutions and organizations to shape relevant legal frameworks, policies and programmes.
- Women and men have equal rights and access to and control over natural and productive resources, to contribute to and benefit from sustainable agriculture and rural development.
- Women and men have equal rights and access to services, markets and decent work and equal control over the resulting income and benefits.
- Women's work burden is reduced by enhancing their access to technologies, practices and infrastructure and by promoting an equitable distribution of responsibilities, including at the household level.

This work aims to foster the potential and capacity that exist in women in fisheries and aquaculture communities around the world while recognizing their role as key agents of change to achieve Blue Transformation.[12] As stated by the FAO Director-General:

> Women and girls can play a crucial role in the response to the COVID-19 pandemic and in particular in transforming our agri-food systems. We all need to work together to spark the necessary changes to empower women and girls, particularly those in rural areas (FAO, 2021u). ■

12 For Blue Transformation, see Glossary.

FISHERIES AND AQUACULTURE PROJECTIONS

Note: At the time of writing (March 2022), the Ukraine conflict adds another level of uncertainty to global value chains and trade. Prices of energy and inputs, including feed for aquaculture, have already started to soar. This is increasing operational costs resulting in higher prices of fisheries and aquaculture products.[13] *Flight cancellations and/or rerouting are placing pressure on cargo capacity and causing further supply chain disruptions and delays in deliveries. The conflict also risks causing profound geopolitical changes with effects on trade relations between the United States of America, Europe, China, the Russian Federation and the rest of the world. This is likely to have a considerable impact on the fisheries and aquaculture sector. The following projections consider only marginally the potential impact of the war. Adjustments will be introduced in future revisions of the projections as impact assessments become available.*

This section presents the medium-term outlook using the FAO fish model (FAO, 2012b, pp. 186–193), developed in 2010 to shed light on potential future developments in fisheries and aquaculture. The fish model has links to, but is not integrated into, the Aglink-Cosimo model used annually to generate the ten-year-horizon agricultural projections elaborated jointly by the Organisation for Economic Co-operation and Development (OECD) and FAO and published each year in the OECD-FAO Agricultural Outlook (OECD and FAO, 2021b). The FAO fish model uses a set of macroeconomic assumptions and selected prices to generate the agricultural projections. The fisheries and aquaculture projections presented in this section have been obtained through an ad hoc analysis carried out by FAO for the years 2021–2030.

The projections illustrated in this section depict an outlook for fisheries and aquaculture production,[13] utilization, trade,[14] prices and key issues that might influence future supply and demand. It is important to highlight that the projections are not forecasts, but rather plausible scenarios that provide insight into how these sectors may develop in the light of a set of specific assumptions regarding: the future macroeconomic environment; international trade rules and tariffs; the frequency of events and their effects on resources; the absence of other severe events such as tsunamis, tropical storms (cyclones, hurricanes and typhoons), floods and emerging diseases of aquatic species; improved fisheries and aquaculture management measures, including catch limitations; and the absence of market shocks. In view of the major role of China in the fisheries and aquaculture sectors, the assumptions consider continuation of the policy developments in China (FAO, 2018b, Box 31, p. 183) outlined in the Thirteenth (2016–2020) and Fourteenth (2021–2025) Five-Year Plans towards more sustainable and environmentally friendly fisheries and aquaculture. The future of the fisheries and aquaculture sectors will depend on many different factors of global, regional and local relevance. Population and economic growth, urbanization, technological developments and dietary diversification are expected to create an expansion in food demand, in particular for animal products, including aquatic food.[13]

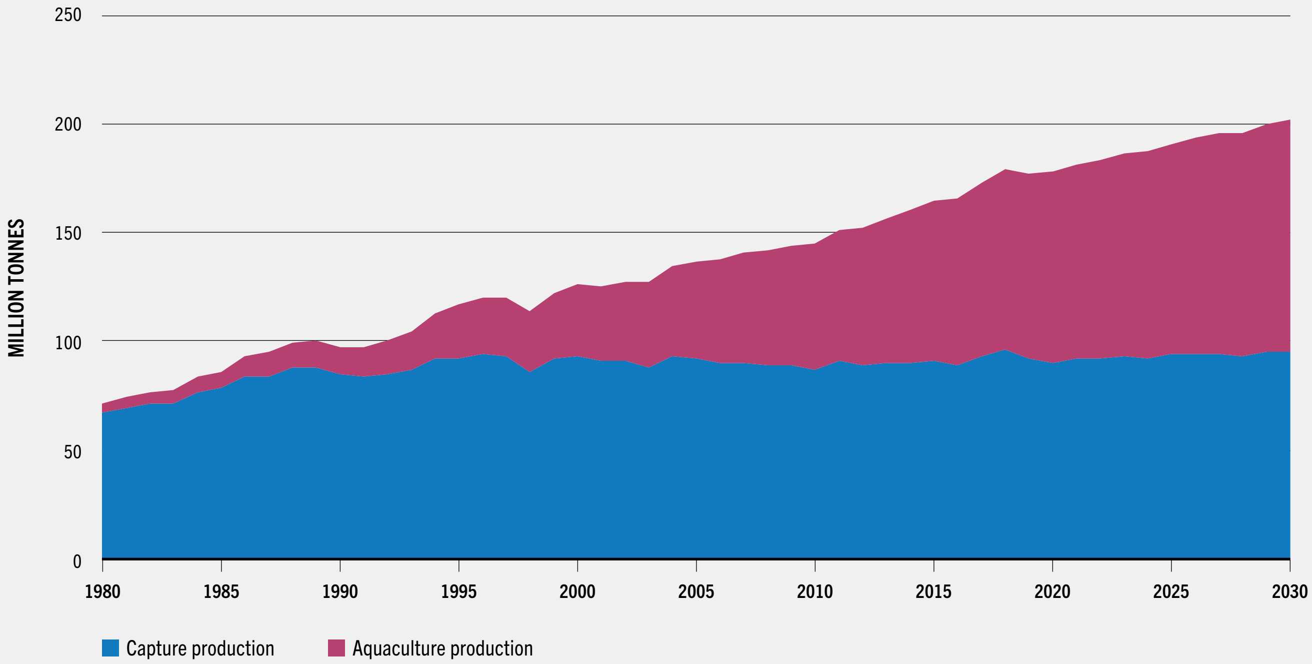
Production

On the basis of the assumptions used, total fisheries and aquaculture production (excluding algae[13]) is expected to expand further and reach 202 million tonnes in 2030 (Figure 70). This represents an increase of 14 percent relative to 2020 and an additional 24 million tonnes in absolute terms (Table 18). However, while the total quantity continues to increase, both the rate and absolute level of growth are expected to decline compared with the 23 percent growth (33 million tonnes) during the period 2010–2020. Most of the increase in world fisheries and aquaculture production will come from the aquaculture sector, where output should break the 100 million

13 For algae, aquatic food, fisheries and aquaculture production, and fisheries and aquaculture products, see Glossary, including Context of SOFIA 2022.

14 In the section Fisheries and aquaculture projections, the statistical analysis on production, utilization, consumption and trade only covers aquatic animals (excluding aquatic mammals and reptiles). Detailed coverage of species and specific sectorial exclusions are indicated in the Glossary.

FIGURE 70 WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION, 1980–2030



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

tonnes threshold for the first time in 2027. Aquaculture production is expected to increase to 106 million tonnes in 2030, with an overall growth of 22 percent or nearly 19 million tonnes compared with 2020. The share of farmed species in global fisheries and aquaculture production (for food and non-food uses) is projected to grow from 49 percent in 2020 to 53 percent in 2030 (Figure 71).

The average annual growth rate of aquaculture production should slow over the next decade to less than half the rate observed in the previous decade, dropping from 4.2 percent in 2010–2020 to 2.0 percent in 2020–2030 (Figure 72). A number of factors should contribute to this slowdown.[15] These include: broader adoption and enforcement of environmental regulations; reduced availability of water and suitable production locations; increasing outbreaks of aquatic animal diseases related to intensive production practices; and decreasing aquaculture productivity gains. In particular, Chinese policies are expected to account significantly for the overall reduced growth. Initiated in 2016, these policies are expected to continue the transition from extensive to intensive aquaculture, while at the same time integrating better production with environmental considerations through the adoption of ecologically sound technological innovations, with initial capacity reduction, followed by faster growth. Although China will remain the world's leading producer through to 2030, its aquaculture production is expected to increase by 21 percent in 2020–2030, nearly halving the 40 percent increase in 2010–2020. China accounted for 57 percent of global aquaculture production in 2020 and this is projected to decline slightly to 56 percent by

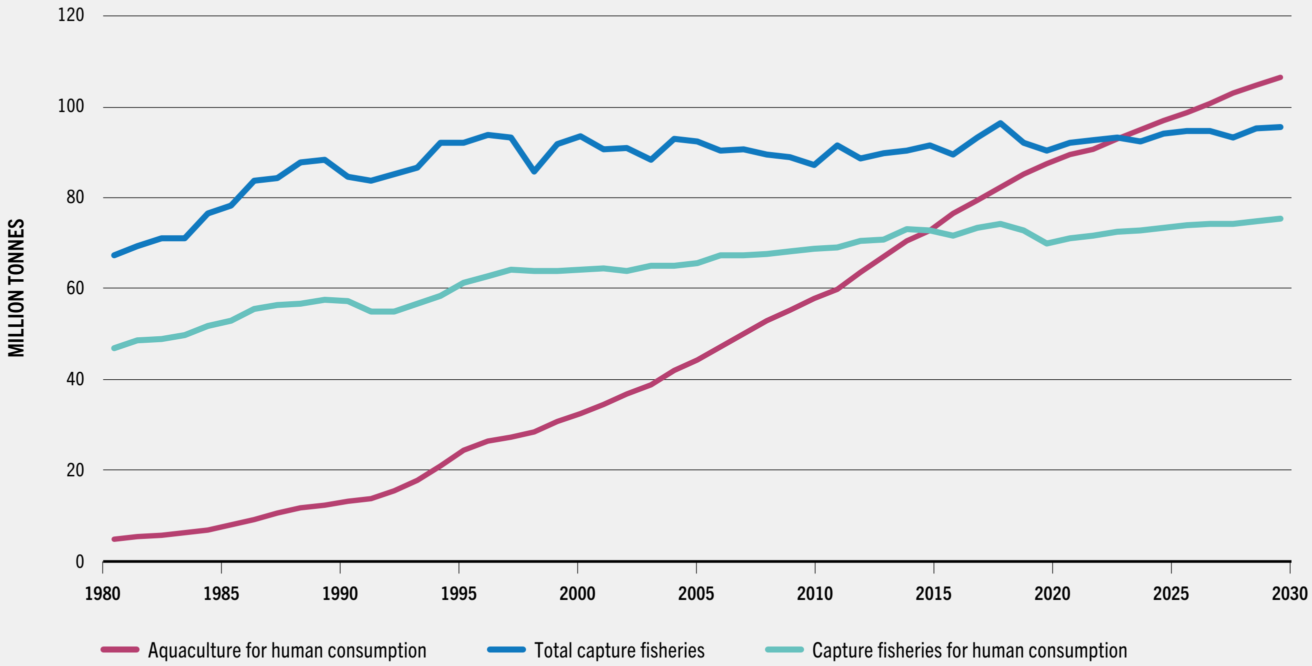
15 It is important to note that a reduction in growth rate does not indicate a decrease in production. Expressed in percentage terms, growth rates are usually higher when the calculation starts from a low base, and they decline as the size of the base grows.

TABLE 18 PROJECTED FISHERIES AND AQUACULTURE PRODUCTION TO 2030

	Production			Of which aquaculture		
	2020	2030	Growth of 2030 vs 2020	2020	2030	Growth of 2030 vs 2020
	1 000 tonnes (live weight equivalent)		*%*	*1 000 tonnes (live weight equivalent)*		*%*
Africa	**12 044**	**13 763**	**14.3**	**2 250**	**2 759**	**22.6**
Egypt	2 011	2 339	16.3	1 592	1 911	20.0
Nigeria	1 045	1 208	15.6	262	318	21.4
South Africa	602	522	-13.3	6	12	90.5
Americas	**21 903**	**24 499**	**11.8**	**4 375**	**5 623**	**28.5**
Argentina	840	896	6.7	2	2	10.3
Brazil	1 339	1 527	14.1	629	751	19.3
Canada	901	1 061	17.8	171	244	42.5
Chile	3 259	4 290	31.6	1 486	2 193	47.6
Mexico	1 780	1 910	7.3	279	296	6.2
Peru	5 770	6 210	7.6	144	184	28.2
United States of America	4 694	5 298	12.9	448	548	22.3
Asia	**124 960**	**143 182**	**14.6**	**77 384**	**94 095**	**21.6**
China	62 846	73 608	17.1	49 620	60 068	21.1
India	14 141	16 775	18.6	8 636	10 995	27.3
Indonesia	12 152	13 678	12.6	5 227	6 598	26.2
Japan	3 751	3 471	-7.5	599	684	14.1
Korea, Republic of	1 934	1 933	-0.1	566	633	11.7
Philippines	2 766	3 337	20.6	854	1 045	22.3
Thailand	2 618	2 763	5.5	962	1 113	15.6
Viet Nam	8 023	9 123	13.7	4 601	5 202	13.1
Europe	**17 096**	**18 696**	**9.4**	**3 263**	**3 704**	**13.5**
European Union[1]	5 026	5 555	10.5	1 094	1 256	14.9
Norway	3 941	4 012	1.8	1 490	1 612	8.2
Russian Federation	5 342	5 855	9.6	270	368	36.3
Oceania	**1 752**	**1 972**	**12.5**	**229**	**264**	**15.7**
Australia	284	305	7.4	106	129	21.3
New Zealand	482	541	12.1	119	131	10.3
World[2]	**177 757**	**202 112**	**13.7**	**87 501**	**106 445**	**21.7**

[1] Cyprus is included in Asia as well as in the European Union. [2] For 2020, the aggregate includes also 1 030 tonnes of not identified countries, data not included in any other aggregates.
NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

FIGURE 71 WORLD CAPTURE FISHERIES AND AQUACULTURE PRODUCTION, 1980–2030



NOTES: Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

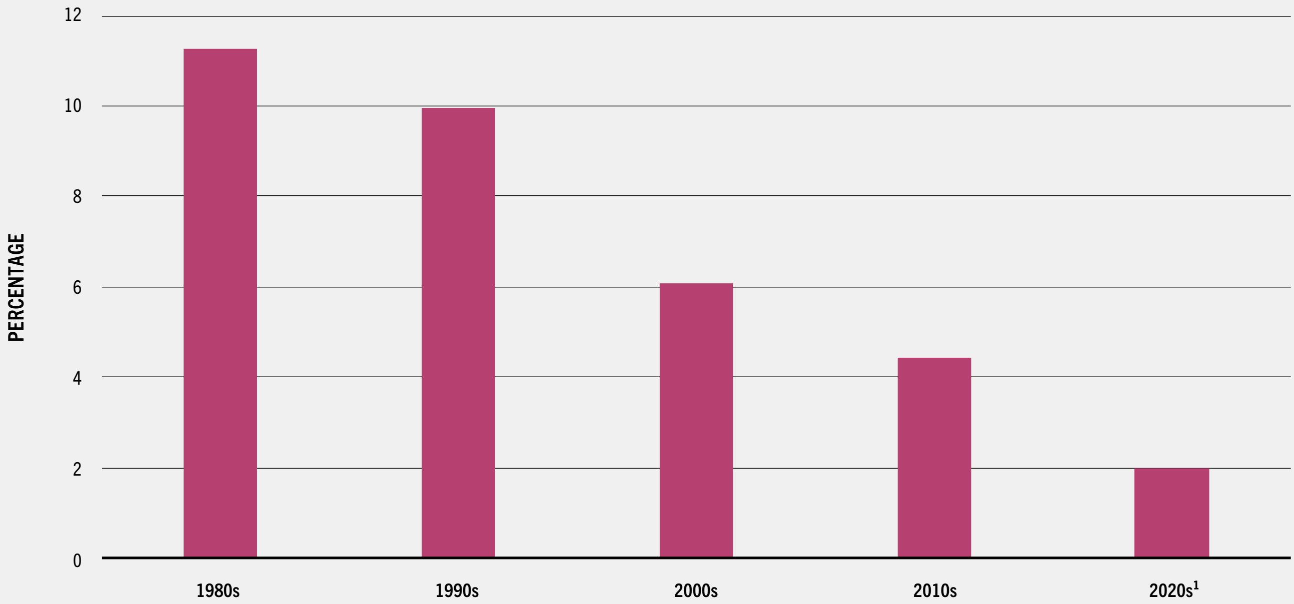
2030, despite aquaculture's contribution to total Chinese fisheries and aquaculture production as it increased from 79 percent to 82 percent in the same period. The projected deceleration of China's aquaculture production is expected to be partially compensated for by an increase in production in other countries.

Growth of aquaculture production is projected to continue on all continents, with variations in the range of species and products across countries and regions (Figure 73). The sector is expected to expand most in the Americas (up 29 percent from 2020), Africa (up 23 percent) and Asia (up 22 percent). The growth in Africa's aquaculture production will be driven by the additional culturing capacity put in place in recent years, as well as by national policies promoting aquaculture fuelled by rising local demand as a result of higher economic growth. However, despite this expected growth, overall aquaculture production in Africa will remain limited, at slightly more than 2.8 million tonnes in 2030, with the bulk (1.9 million tonnes) produced by Egypt. Asian countries should continue to dominate the aquaculture sector (maintaining their share of 88 percent of 2030 global aquaculture production) and be responsible for more than 88 percent of the increase in production by 2030.

All farmed groups of species, will continue to increase, but rates of growth will be uneven across groups and the quantitative importance of different species will change as a consequence. In general, species that require larger proportions of fishmeal and fish oil in their diets are expected to grow more slowly owing to expected higher prices and reduced availability of fishmeal.

In contrast to the slight decline experienced in 2019 and 2020, capture fisheries is projected to recover during the coming decades, resulting in

FIGURE 72 ANNUAL GROWTH RATE OF WORLD AQUACULTURE, 1980–2030

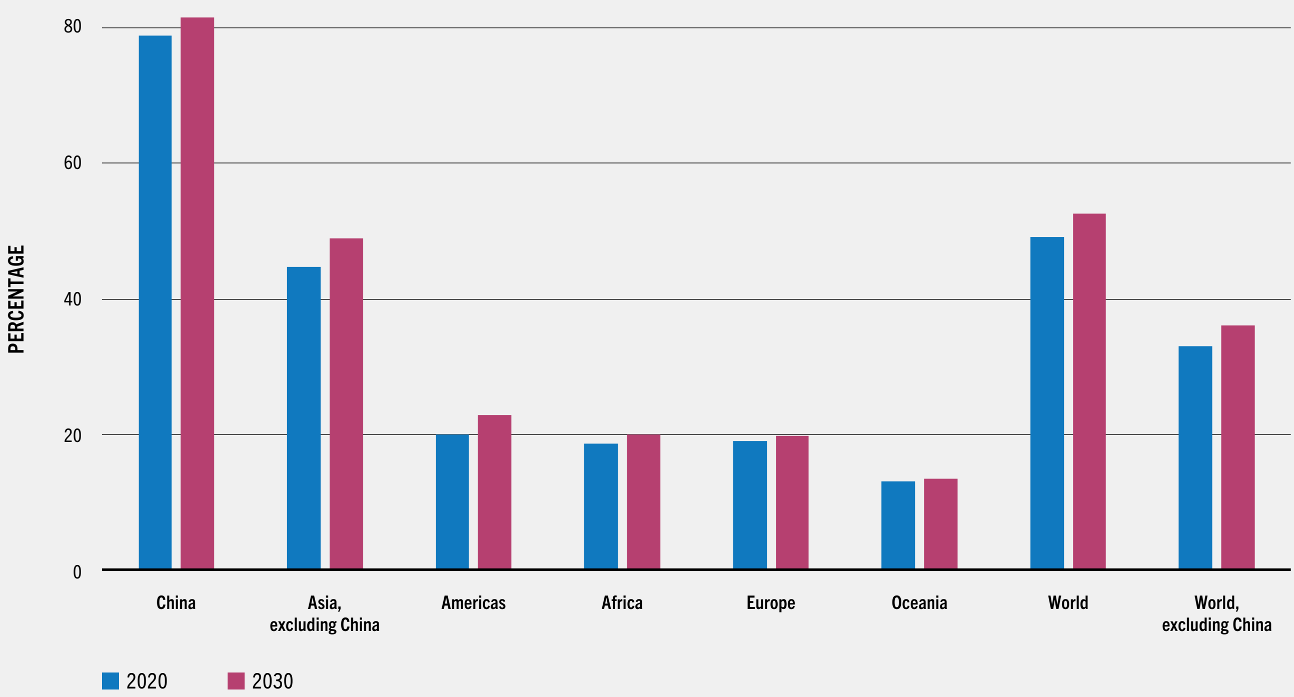


[1] 2030 included in 2020s.
NOTE: Excluding algae.
SOURCE : FAO.

world capture fisheries production at the end of the outlook period reaching 96 million tonnes, over 5 million tonnes more than in 2020, with an overall increase of 6 percent. However, some fluctuations are expected over the next decade, linked to the El Niño phenomenon, with reduced catches in South America, especially for anchoveta, resulting in an overall decrease in world capture fisheries production of about 2 percent in those years.[16] The overall increase in capture fisheries production is driven by different factors including: (i) increased catches in some fishing areas where stocks of certain species are recovering owing to improved resource management; (ii) growth in catches in waters of the few countries with underfished resources, where new fishing opportunities exist or where fisheries management measures are less restrictive; and (iii) improved utilization of the harvest, including reduced discards, waste and losses as driven by legislation or higher market prices of aquatic species for food and non-food products. China is expected to remain the major producing country, even if its capture fisheries production should remain at the levels reached in 2020, as it continues its environmental policies into the next decade. For capture fisheries, China's policies aim to reduce domestic catches through controls on licensing, reduction in the number of fishers and fishing vessels, and output controls. Other objectives include: modernization of gear, vessels and infrastructure; regular reduction of fuel subsidies; elimination of illegal, unreported and unregulated fishing (IUU fishing); and restoration of domestic fishery stocks through the use of restocking, artificial reefs and seasonal

16 The projections assume normal weather and production conditions, with the exception of the impact of the El Niño phenomenon set for selected Latin American countries to occur more strongly every five years, based on more recent trends. The years in which it will occur might not be exact, but they provide an indication as to the possible overall effects on both capture fisheries production and aquaculture. This climatic phenomenon reduces production of fishmeal and fish oil obtained from anchoveta and other small pelagic species in the affected region, with an impact on prices and input costs for aquaculture.

FIGURE 73 CONTRIBUTION OF AQUACULTURE TO REGIONAL FISHERIES AND AQUACULTURE PRODUCTION



NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

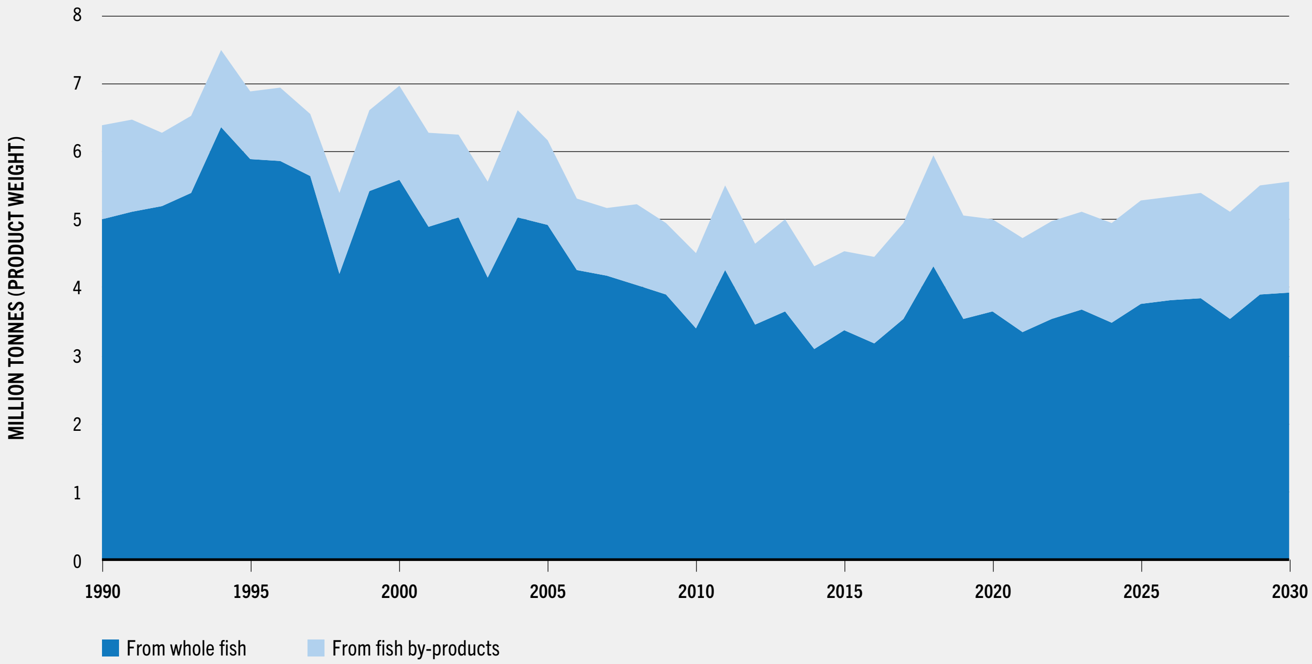
closures. However, this Chinese policy projects to compensate for the expected decline in domestic catches by an increase in distant-water fleet catches. In 2030, production of both fishmeal and fish oil is expected to increase over the outlook period by, respectively, 11 percent and 13 percent compared with 2020, although the share of capture fisheries production reduced into fishmeal and fish oil should decline slightly (17 percent by 2030 compared with 18 percent in 2020). The expected increase in fishmeal and fish oil production is due to the overall growth in capture fisheries production in 2030 compared with 2020, combined with the increase in fishmeal and fish oil production obtained from fish waste and by-products of the processing industry (Figure 74). Between 2020 and 2030, the proportion of total fishmeal obtained from fish waste is projected to increase from 27 percent to 29 percent, while the proportion of total fish oil is projected to slightly decline from 48 percent to 47 percent.

Consumption[17]

Most fisheries and aquaculture production will be utilized for human consumption and this share is expected to continue to grow from 89 percent in 2020 to 90 percent by 2030. Overall, by 2030, the amount of aquatic food for human consumption is projected to increase by 24 million tonnes compared with 2020, reaching 182 million tonnes. This represents an overall increase of 15 percent, a slower pace when compared with the 23 percent growth experienced in 2010–2020. This slowdown mainly reflects the reduced amount of additional fisheries and aquaculture production available, higher prices of aquatic foods in nominal terms, a deceleration in population growth and

17 As in the section Consumption of aquatic foods, consumption is expressed in live weight equivalent and refers to the apparent aquatic food consumption (for apparent food consumption, see Glossary, including Context of SOFIA 2022).

FIGURE 74 **WORLD FISHMEAL PRODUCTION, 1990–2030**



SOURCE : FAO.

saturated demand in some countries, particularly high-income countries, where aquatic food consumption is projected to show little growth (an average annual increase of 0.3 percent in 2020–2030).

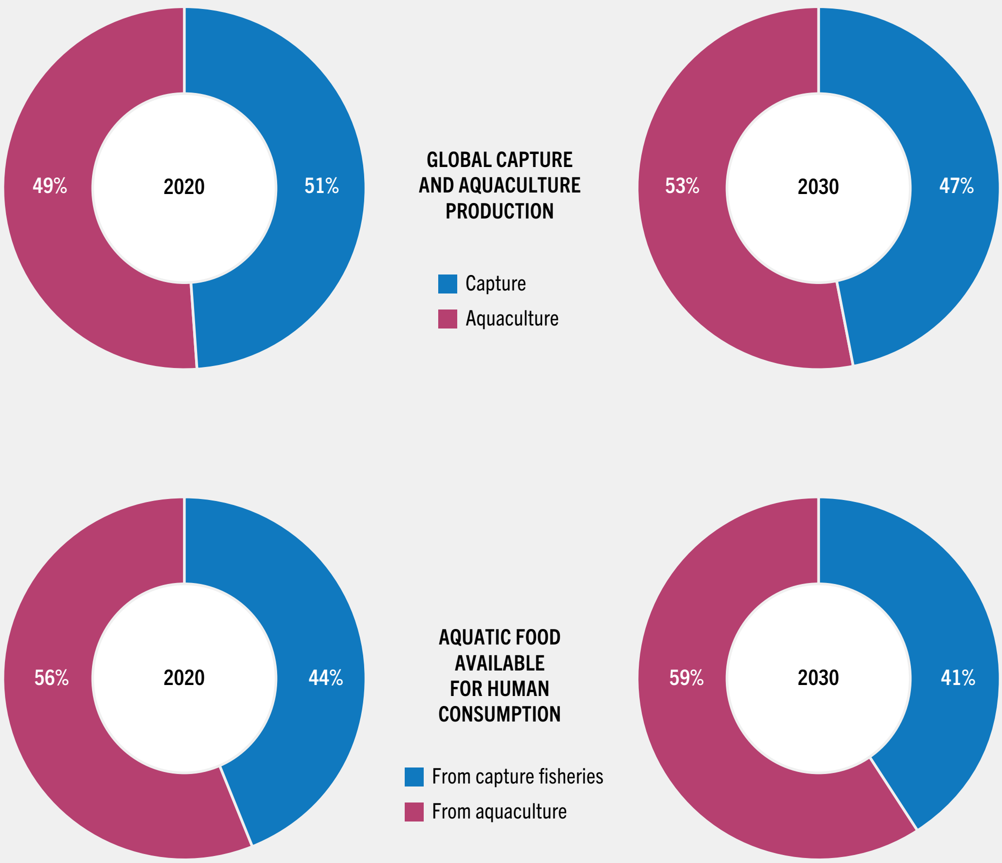
Overall, the main factors behind the increase in global consumption of aquatic food will be a combination of high demand resulting from rising incomes and urbanization, linked with the expansion of fisheries and aquaculture production, improvements in post-harvest methods and distribution channels expanding the commercialization of aquatic products.[18] Demand will also be stimulated by changes in dietary trends, pointing towards more variety in the typology of food consumed, and a greater focus on better health, nutrition and diet, with aquatic food playing a key role in this regard.

18 For aquatic products, see Glossary, including Context of SOFIA 2022.

Growth in demand will stem mostly from middle-income countries, which are expected to account for 82 percent of the increase in consumption by 2030 and to consume 73 percent of the aquatic food available for human consumption in 2030 (compared with 72 percent in 2020). About 72 percent of the world's fisheries and aquaculture production available for human consumption in 2030 will be consumed by Asian countries, while the lowest quantities will be consumed in Oceania. Total consumption of aquatic food is expected to increase in all continents by 2030 in comparison with 2020, with higher growth rates projected in Africa and Oceania (26 percent in both regions), the Americas (17 percent), Asia (15 percent) and Europe (6 percent).

In per capita terms, apparent consumption of aquatic food is projected to reach 21.4 kg in 2030, up from 20.2 kg in 2020. However, the average annual growth rate of per capita consumption

FIGURE 75 INCREASING ROLE OF AQUACULTURE



NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

of aquatic food will decline from 1.0 percent in 2010–2020 to 0.6 percent in 2020–2030. Per capita consumption of aquatic food will increase in all regions except Africa. The highest growth rates are projected for Oceania (12 percent), the Americas (9 percent), Asia (7 percent) and Europe (6 percent). Despite these regional trends, the overall tendencies in quantity and variety of aquatic foods consumed will vary among and within countries. In 2030, about 59 percent of the aquatic food available for human consumption is expected to originate from aquaculture production, up from 56 percent in 2020 (Figure 75).

In Africa, per capita consumption of aquatic food is expected to decrease slightly from 9.9 kg in 2020 to about 9.8 kg in 2030. The decline will be greater in sub-Saharan Africa (from 8.6 kg to 8.4 kg in the same period). Despite an expected overall increase in total supply of aquatic food due to increased production and imports, it will not be sufficient to outstrip the African population growth. One of the few exceptions will be Egypt, as the country is expected to further increase its already substantial aquaculture production (up 20 percent in 2030 compared with 2020). The projected decline in per capita consumption of aquatic food in Africa, in particular in sub-Saharan Africa, raises food security concerns because of the region's high prevalence of undernourishment (FAO *et al.*, 2021) and the importance of aquatic proteins in total animal protein intake in many African countries (see the section Consumption of aquatic foods, p. 81). The decline may also weaken the ability of countries that are more dependent on aquatic products to meet the nutrition targets of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture), SDG Target 2.1 and SDG Target 2.2.

Trade

The expansion of trade in aquatic products will continue over the outlook period, but at a slower pace than in the previous decade, reflecting the slowdown in production growth, higher fisheries and aquaculture prices (which will restrain overall demand and consumption of aquatic species), and stronger domestic demand in some of the major producing and exporting countries, such as China, which is expected to increase its aquaculture production for the domestic market. Trade will continue to play an important role in the fisheries and aquaculture sectors, notably in terms of food supply and food security. It is estimated that about 36 percent of total fisheries and aquaculture production will be exported in 2030 (31 percent, excluding intra-European Union trade) in the form of various products for human consumption or non-edible goods. Aquaculture will contribute to a growing share of international trade in aquatic food products. In quantity terms, China will continue to be the major exporter of aquatic food, followed by Viet Nam and Norway. The bulk of the growth in exports of aquatic food will originate from Asia, which will account for about 52 percent of the additional exported volumes by 2030. Asia's share in total trade of aquatic products for human consumption will increase from 47 percent in 2020 to 48 percent in 2030. High-income countries will remain highly dependent on imports to meet domestic demand. The European Union, Japan and the United States of America will account for 39 percent of total imports for aquatic food consumption in 2030, a slightly lower share than in 2020 (40 percent).

Trade of fishmeal and fish oil is expected to increase by 9 percent and 7 percent respectively. Peru and Chile will continue to be the main exporters of fish oil, while Norway and the European Union are the main importers, in particular for aquaculture production of salmonoids. Peru is also expected to remain the leading exporter of fishmeal, followed by the European Union and Chile, while China is the major importer.

Prices

The fisheries and aquaculture sectors are expected to enter a decade of higher prices in nominal terms. Factors driving this tendency include improved income, population growth and higher meat prices on the demand side; marginal increase in capture fisheries production, the slowing growth in aquaculture production and cost pressure from some crucial inputs such as feed, energy and fish oil on the supply side. In addition, the slowdown in Chinese fisheries and aquaculture production will stimulate higher prices in China, with repercussions on world prices. The highest increase is expected in the average price of traded products (33 percent higher in 2030 than in 2020) followed by the average price of aquaculture products (29 percent higher) that will be greater than that of captured products (19 percent, when excluding aquatic products for non-food uses). Prices of farmed aquatic species will also increase owing to higher fishmeal and fish oil prices, which are expected to increase by 11 percent and 1 percent, respectively, in nominal terms by 2030 as a result of strong global demand. High feed prices could also have an impact on the species composition in aquaculture, with a shift towards species requiring less feed, cheaper feed or no feed at all. The higher prices at the production level, coupled with high demand of aquatic food, will stimulate an estimated 18 percent growth in the average price of internationally traded aquatic products by 2030 relative to 2020.

In real terms, it is assumed that all prices, except those of aquaculture production and traded aquatic products, will decline slightly over the projection period, while remaining relatively high. For individual aquatic products, price volatility could be more pronounced as a result of supply or demand fluctuations. Moreover, because aquaculture is expected to represent a higher share of world fisheries and aquaculture supply, it could have a stronger impact on price formation in national and international markets of aquatic products. The major decreases are expected for fishmeal and fish oil prices. Yet, both prices are coming from rather historically high levels and by 2030 fishmeal prices will still be 28 percent higher than in 2005, the year major price increases began. This situation is even more pronounced for fish oil, where the real price in 2030 is expected to be 70 percent higher than that observed in 2005. Considered together, and all else remaining equal, this suggests that converting capture fisheries and fish waste to

BOX 33 POTENTIAL FISHERIES AND AQUACULTURE SCENARIOS TO 2050

FAO has recently conducted preliminary projections to 2050[1] producing three plausible fisheries and aquaculture scenarios for consideration and action. These projections are based on various expectations of sectoral growth, starting from the results of the FAO fish model included in the OECD-FAO Agricultural Outlook.[2] The scenarios are:

BUSINESS-AS-USUAL
This scenario follows trend paths similar to those obtained from the OECD-FAO projections to 2030, with a modest increase in capture fisheries (resulting mainly from improved management) and an important increase in aquaculture (despite slower growth rates compared with previous decades). The scenario points to a slight growth of marine and inland capture fisheries, partially due to better reporting systems for inland fisheries. The percentage of marine capture fisheries not used for direct human consumption should slightly decrease by 2050 compared with 2030 as a result of technological improvements.

LOW-ROAD
This scenario projects several failures in aquaculture expansion and continued use of unsustainable practices, leading to a deterioration in many new ventures, resulting in limited growth of aquaculture and a slight decline in capture fisheries. Capture fisheries, both marine and inland, see a continued deterioration of the resource base every year until 2050. The low-road scenario also foresees a 9.6 percent loss in the 2050 yield, consistent with Representative Concentration Pathway (RCP) 8.5 ("business-as-usual") projections of climate change impacts.[3] The proportion of marine capture fisheries not used for direct human consumption should remain at a similar level as expected in 2031, with no benefit from further technological innovation.

HIGH-ROAD
This scenario projects some positive outcomes, allowing the development and expansion of aquaculture in a sustainable manner. Growth rates are modest but significant, as production increases and reflects

PROJECTIONS OF FISHERIES AND AQUACULTURE PRODUCTION AND UTILIZATION BY 2050, AS PER THREE DISTINCTIVE SCENARIOS

	Business-as-usual	Low-road	High-road
	Million tonnes (live weight equivalent)		
Capture:			
Marine capture	85.4	65.8	95.5
Inland capture	13	10.1	13.5
Total capture	**98.3**	**75.8**	**109**
Aquaculture:			
Inland aquaculture	89.9	75.6	98.4
Marine aquaculture	50.1	45.3	62
Total aquaculture	**140**	**120.8**	**160.3**
Total fisheries and aquaculture production	**238.3**	**196.7**	**269.3**
Aquatic food for human consumption	217.4	180.5	248.2
	kg (live weight equivalent)		
Per capita consumption of aquatic food (kg/ year)	**22.3**	**18.5**	**25.5**

NOTE: Excluding aquatic mammals, crocodiles, alligators, caimans and algae.
SOURCE: FAO.

BOX 33 (Continued)

more extensive investment in mariculture. A number of positive outcomes are also expected for marine capture fisheries, with growth reaching towards the estimated maximum sustainable yield of oceans and seas and the ambitious target of 95.5 million tonnes by 2050. Inland capture fisheries are expected to grow to 13.5 million tonnes, reflecting better data collection systems and the implementation of management measures, which are currently lacking in many river basins. In addition, capture fisheries (both marine and inland) are subject to a 4.05 percent decrease in 2050 yield, consistent with RCP2.6 ("strong mitigation") projections for climate change impacts in capture fisheries.[3] The percentage of marine capture fisheries not destined for direct human consumption is expected to decrease as a result of technological improvements, including reduced loss and waste.

In terms of consumption, a business-as-usual scenario would allow the apparent per capita consumption of aquatic foods to rise to 22.3 kg by 2050, up from the 20.2 kg estimated in 2020, thus increasing the contribution of aquatic foods to the fight against hunger and malnutrition. Increased per capita consumption, as envisaged by the high-road scenario, reaching 25.5 kg, would theoretically be possible through innovative and intensive aquaculture development, combined with ambitious, effective management of all capture fisheries across the world. On the other hand, failure to address current overfishing patterns, and limited aquaculture growth would potentially result in

2020 VS 2050 IN PRODUCTION AND CONSUMPTION AS PER THE THREE SCENARIOS

NOTES: BAU = business-as-usual. Excluding aquatic mammals, crocodiles, alligators, caimans and algae. Data expressed in live weight equivalent.
SOURCE: FAO.

BOX 33 (Continued)

per capita consumption of aquatic food decreasing to 18.5 kg by 2050, a return to the pre-2012 levels, with a major impact on food security in particular for countries more dependent on aquatic foods in their diets.

The results of these projections are presented in the table.

The nature of these projections is not to predict the future, but to provide boundary conditions to enable appropriate action for achieving food and nutrition security (see figure). The business-as-usual scenario, in particular, is considered most plausible by FAO, as it attempts to extrapolate the medium trends estimated by the FAO fish model to 2050. The FAO model uses a set of macroeconomic assumptions and selected prices, and not just projections of growth, but these assumptions become more uncertain as time passes and they need regular adjustment. The low- and high-road scenarios, on the other hand, are designed to enable appreciation of the range of expected possibilities. This envelope of scenarios allows a conversation that acknowledges that the present is not necessarily a good prediction of the future, but also that decisions taken going forward will have significant and quantitative impacts on the contribution of aquatic products to food security and nutrition. The sector will remain crucial for feeding a world that may include 9.7 billion people by 2050, but this contribution may be more significant if the right policy decisions are taken.

[1] UN Nutrition. 2021. *The role of aquatic foods in sustainable healthy diets*. Discussion paper. Rome. www.unnutrition.org/wp-content/uploads/FINAL-UN-Nutrition-Aquatic-foods-Paper_EN_.pdf
[2] OECD (Organisation for Economic Co-operation and Development) & FAO. 2020. Chapter 8: Fish. In: *OECD-FAO Agricultural Outlook 2020–2029*. Paris, OECD Publishing. Cited 20 April 2022. www.oecd-ilibrary.org/docserver/4dd9b3d0-en.pdf?expires=1650400376&id=id&accname=guest&checksum=512B2A7A9D84422B9E01EEA8FB9E4E67
[3] Barange, M., Bahri, T., Beveridge, M.C.M., Cochrane, K.L., Funge-Smith, S. & Poulain, F., eds. 2018. *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. www.fao.org/documents/card/en/c/I9705EN

fishmeal and fish oil will remain a lucrative activity over the period projected.

Summary of main outcomes from the projections

The following major trends for the period to 2030 emerge from the analysis:

- World fisheries and aquaculture production, consumption and trade are expected to increase, but with a growth rate that will slow over time.
- World capture production is projected to grow moderately owing to increased production in areas where resources are properly managed.
- The world's growth in aquaculture production, despite its deceleration, is anticipated to fill most of the supply–demand gap.
- Aquatic food supply will increase in all regions, while per capita consumption is expected to slightly decline in Africa, in particular in sub-Saharan Africa, raising concerns in terms of food security.
- Trade in aquatic products is expected to increase more slowly than in the past decade, but the share of fisheries and aquaculture production that is exported is projected to remain stable.
- While prices will all increase in nominal terms, they are expected to decline in real terms, except those for aquaculture and trade.
- The new fisheries and aquaculture reforms and policies to be implemented by China as a continuation of its Thirteenth (2016–2020) and Fourteenth (2021–2025) Five-Year Plans are expected to have a noticeable impact at the world level, with changes in prices, output and consumption.

Main uncertainties

The projections presented in this section (see also Box 33, p. 220) rely on a series of economic, policy and environmental assumptions. A deviation of any of these assumptions would result in different fisheries and aquaculture projections. In the short term, major levels of uncertainty are linked to the COVID-19 pandemic and related effects as global value chains and trade are still recovering, and to the conflict between Ukraine and the Russian Federation. This ongoing conflict is likely to have multiple ramifications for trade, prices, logistics, production, investment, economic growth and livelihoods, causing significant food security repercussions far beyond Ukraine and with major impacts also on the fisheries and aquaculture sectors (Box 34).

Furthermore, the next decade is likely to see major changes in the environment, resource availability, macroeconomic conditions, international trade rules and tariffs, and market characteristics, which may affect production, markets and trade in the medium term. Climate variability and

BOX 34 UKRAINE: PRELIMINARY IMPACT OF THE CONFLICT ON THE FISHERIES AND AQUACULTURE SECTOR

BACKGROUND

Prior to the conflict, Ukraine's total fisheries and aquaculture production was around 87 200 tonnes, 26 700 tonnes from inland waters, 41 900 tonnes from marine waters and 18 600 tonnes from aquaculture. The country's fishing vessels operated in the Black Sea and the Sea of Azov within the exclusive economic zone of Ukraine and neighbouring countries and in distant waters, in particular in the Atlantic and the Pacific Antarctic. In 2020, the total catch in the Black and Azov Seas was about 20 800 tonnes, harvested by a total of 1 300 vessels.

Most of the 4 000 registered fish farms in Ukraine are small-scale, producing a range of species – predominantly carp, but also catfish, pike and trout – reared in artisanal ponds. Regarding aquaculture in marine areas, there have been no active farms since 2014, as the country's four shellfish farms and one turbot hatchery were located in the Autonomous Republic of Crimea and the city of Sevastopol, Ukraine, temporarily occupied by the Russian Federation.

Per capita consumption of aquatic food was about 12–13 kg per year, supplied mostly by imports from European countries. Recent years have seen imports increasing, albeit with some major fluctuations, with a peak at over USD 1 billion in 2021. In the same year, exports of aquatic products were valued at USD 66 million. Imports include salmonoids, mackerel, herrings and hakes, with almost one-third (31 percent) from Norway. Exports, on the other hand, comprise mainly salmon and cod fillets, with over one-half destined for several European countries.

IMPACT

According to information provided by the State Fisheries Agency in Ukraine, due to the ongoing conflict and related risks for fishers, all landing sites and ports located on the coast are closed, and marine fisheries activities have been halted. Inland fisheries have been seriously impacted, with activities running at no more than 30 percent of capacity. In some regions (such as Chernihiv, Kherson and Zaporizhzhia) they have stopped entirely, while in others they are ongoing in estuaries, reservoirs and lakes.

Likewise, fish farming in Ukraine has been severely disrupted as a result of the interruption in the supply of fingerlings, feed and other services, damaged infrastructure, and low demand. According to preliminary FAO estimates, should the conflict continue, the economic cost in 2022 would be at least USD 70 million for primary production and most likely three times this figure when including the post-harvest value, in addition to a net loss of USD 66 million previously generated by exports. Loss of imports has heavily impacted consumption of aquatic food. Infrastructure has been seriously affected and all commercial shipping in Ukrainian ports currently halted, with major repercussions for trade to and from Ukraine.

Outside Ukraine, marine fisheries in the Black Sea of neighbouring countries have also been severely impacted. Many fisheries research surveys, and monitoring, control and surveillance activities have been disrupted or completely stopped.

Overall, the conflict in Ukraine is seriously disrupting global markets of fisheries and aquaculture products. The Russian Federation fisheries sector (in 2020, the fifth largest producer of capture fisheries) is highly export oriented. In 2021, its exports of fisheries and aquaculture products reached USD 6.1 billion, up from USD 4.9 billion in 2020. These exports are currently severely disrupted and it remains to be seen what the impact will be in terms of their value and destination. Inflationary pressure on the world economy with rising costs of inputs and operations in major aquatic-food-producing countries are worsening access to investment in a sector already often considered risky for private and institutional investment.

change, including in the frequency and extent of extreme weather events, are expected to have significant and geographically differential impacts on the availability, processing and trade of aquatic products, making countries more vulnerable to risks. These risks can be exacerbated by: (i) poor governance causing environmental degradation and habitat destruction, leading to pressure on the resource bases, overfishing, IUU fishing, diseases and invasions by escapees and non-native species; and (ii) aquaculture issues associated with the accessibility and availability of sites and water resources and access to credit, seed and expertise. However, these risks can be mitigated through responsive and effective governance promoting stringent fisheries management regimes, responsible aquaculture growth and improvements in technology, innovations and research. In the long term, the implementation of these improvements and of proper management policies can have very positive impacts on total fisheries and aquaculture production as illustrated in the high-road scenario developed by FAO to 2050. In addition, market access requirements related to food safety, quality and traceability standards and product legality will continue to regulate international trade of fisheries and aquaculture products. ■

GLOSSARY

Developments over recent decades in fisheries and aquaculture, characterized by the sector's increasing role in food security, human nutrition and trade, have been accompanied by an expansion of the associated terminology creating the need for more precision and specificity of the terms used, to ensure coherence throughout *The State of World Fisheries and Aquaculture* (SOFIA).

This glossary reflects FAO's decision to review, revise and elaborate on some specific terms that required clarification. These terms are defined by authoritative sources of FAO or others and consider the singularities of data collection and collation, which often entail exclusions from the standard definitions.

The general definitions focus on the intuitive and common-sense meaning of the relevant term. Where necessary, an explanatory note provides details regarding its application to fisheries and aquaculture. The considerations in the column, Context of SOFIA 2022, address – among others – specific exclusions from the standard definitions in reporting and statistical analysis.

One critical example is the use of the term "fish", which was extensively used in previous editions to generally encompass all aquatic animal taxa in various contexts such as "fish production", "fish trade" or "fish consumption". However, in an evolving and multicultural global context, "fish" could be misleading or non-representative. This glossary takes into consideration these nuances.

Term	General definition	Context of SOFIA 2022
Algae	A highly diverse group of mainly aquatic, autotrophic, photosynthesizing organisms ranging from microscopic single-cell forms to multicellular forms, distinguished from vascular plants by the absence of structures such as true roots, stems, leaves and flowers. **Note:** Include multicellular macroalgae (e.g. seaweeds), unicellular microalgae (e.g. *Chlorella* spp.), and Cyanobacteria, not true algae but informally known as "blue-green algae" (e.g. *Spirulina* spp.).	Previous editions used the term "aquatic plants" predominantly to refer to micro- and macroalgae based on FAO's International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP). From this edition, the term algae is used to cover the aquatic organisms referred to in the Note.
Apparent food consumption	Proxy measure to indicate the supply of food available in a country for the indicated reference period. It refers to the amount available for human consumption and not to the effective food consumption, i.e. the actual quantity of food eaten, which can be measured through household or individual food consumption surveys. **Note:** Apparent food consumption refers to a country's total production plus food imports, and is adjusted to any change in stocks, minus food exports and minus non-food uses. Apparent food consumption per capita is obtained by dividing national consumption by population size. Apparent food consumption data are derived from FAO Food Balance Sheets and have been available on an annual basis at country level since 1961.	Other aquatic animals (e.g. mammals and reptiles) and algae are not included in reported figures and statistical analysis of aquatic food consumption. Statistical analysis of aquatic food is based on FAO Food Balance Sheet data.
Aquatic food	Food for human consumption grown in or harvested from water. **Note:** Includes all types of fish, crustaceans, molluscs, other aquatic animals and algae (e.g. seaweed).	Other aquatic animals (e.g. mammals and reptiles) and algae are not included in reported figures and statistical analysis of aquatic food consumption. Statistical analysis of aquatic food is based on FAO Food Balance Sheet data.
Aquatic products	Used as an equivalent and shorter term for fisheries and aquaculture products.	

Term	General definition	Context of SOFIA 2022
Blue Transformation	A set of actions, policies and strategies aimed at sustainably expanding and enhancing aquatic food systems and increasing their contribution to affordable and accessible healthy diets, while fostering equitable growth.	Under the FAO Strategic Framework 2022–2031, Blue Transformation provides guidance and direction to closely align the work of all programme priority areas (PPAs) that involve aquatic food systems (including the Blue Transformation PPA) to ensure a cohesive, effective and results-oriented approach.
Ecosystem approach to aquaculture	A strategy for the integration of the activity within the wider ecosystem such that it promotes sustainable development, equity, and resilience of interlinked social-ecological systems **Source:** FAO, 2010.	
Fisheries and aquaculture production	Animals, plants and microorganisms harvested through fisheries and aquaculture activities, whether marine or inland. **Note:** Includes all aquatic animals (fish, crustaceans, molluscs and other aquatic animals) and algae (macroalgae, microalgae, and Cyanobacteria).	Aquatic mammals and reptiles are excluded from reported figures and statistical analysis, as data are only available in numbers of individuals (not in weight). Moreover, analysis is carried out separately for aquatic animals and algae.
Fisheries and aquaculture products	The outputs of fisheries and aquaculture production intended for consumption, or domestic or international trade, presented whole or in parts, processed or unprocessed, in various product forms, regardless of their final utilization. **Note:** Include all aquatic animals (fish, crustaceans, molluscs, and other aquatic animals), algae (macroalgae, microalgae, and Cyanobacteria) and other aquatic products (e.g. corals and sponges). **Equivalent term:** Aquatic products.	FAO trade statistics of fisheries and aquaculture products do not include data on aquatic mammals, reptiles, amphibians, turtles, and miscellaneous aquatic products, (e.g. pearls and mother-of-pearl). The trade statistical analysis is carried out separately for aquatic animals and algae, and other aquatic products.
Risk analysis	A process consisting of three components: risk assessment, risk management and risk communication. **Source:** Codex Alimentarius Commission, 1997.	Food safety.
Risk assessment	1. The evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences; or the evaluation of the potential for adverse effects on human or animal health arising from the presence of additives, contaminants, toxins or disease-causing organisms in food, beverages or feedstuffs. **Source:** WTO, 1995. 2. A scientifically based process consisting of the following steps: (i) hazard identification, (ii) hazard characterization, (iii) exposure assessment, and (iv) risk characterization. **Source:** Codex Alimentarius Commission, 1997.	1. The Agreement on Sanitary and Phytosanitary Measures of the World Trade Organization was adopted to facilitate trade through the elaboration of sanitary and phytosanitary measures for plants, animals and foods. 2. Related to food safety as defined by the Codex Alimentarius.
Risk management	The process, distinct from risk assessment of weighing policy alternatives, in consultation with all interested parties, considering risk assessment and other factors relevant for the health protection of consumers and for the promotion of fair trade practices, and, if needed, selecting appropriate prevention and control options. **Source:** Codex Alimentarius Commission, 1997.	Food safety.

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THE STATE OF THE WORLD

2022 THE STATE OF WORLD FISHERIES AND AQUACULTURE

TOWARDS BLUE TRANSFORMATION

The 2022 edition of *The State of World Fisheries and Aquaculture* coincides with the launch of the Decade of Action to deliver the Global Goals, the United Nations Decade of Ocean Science for Sustainable Development and the United Nations Decade on Ecosystem Restoration. It presents how these and other equally important United Nations events, such as the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022), are being integrated and supported through Blue Transformation, a priority area of FAO's new Strategic Framework 2022–2031 designed to accelerate achievement of the 2030 Agenda for Sustainable Development in food and agriculture.

The concept of Blue Transformation emerged from the Thirty-fourth Session of the FAO Committee on Fisheries in February 2021, and in particular the Declaration for Sustainable Fisheries and Aquaculture, which was negotiated and endorsed by all FAO Members. The Declaration calls for support for "an evolving and positive vision for fisheries and aquaculture in the twenty-first century, where the sector is fully recognized for its contribution to fighting poverty, hunger and malnutrition." In this context, Part 1 of this edition of *The State of World Fisheries and Aquaculture* reviews the world status of fisheries and aquaculture, while Parts 2 and 3 are devoted to Blue Transformation and its pillars on intensifying and expanding aquaculture, improving fisheries management and innovating fisheries and aquaculture value chains. Blue Transformation emphasizes the need for forward-looking and bold actions to be launched or accelerated in coming years to achieve the objectives of the Declaration and in support of the 2030 Agenda. Part 4 covers current and high-impact emerging issues – COVID-19, climate change and gender equality – that require thorough consideration for transformative steps and preparedness to secure sustainable, efficient and equitable fisheries and aquaculture, and finally draws some outlook on future trends based on projections.

The State of World Fisheries and Aquaculture aims to provide objective, reliable and up-to-date information to a wide audience – policymakers, managers, scientists, stakeholders and indeed everyone interested in the fisheries and aquaculture sector.

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