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THE STATE OF WORLD FISHERIES AND AQUACULTURE

BLUE TRANSFORMATION IN ACTION

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VIET NAM. Worker repairing a fishing net by hand.

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2024 THE STATE OF WORLD FISHERIES AND AQUACULTURE

BLUE TRANSFORMATION IN ACTION

Food and Agriculture Organization of the United Nations
Rome, 2024

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FOREWORD

Less than six years before 2030, there are major concerns that progress on most of the Sustainable Development Goals is either moving much too slowly or has regressed, shadowed in the face of intensified challenges. Conflict, climate extremes, environmental degradation and economic shocks combined with the high cost of nutritious foods and growing inequalities continue to threaten food security and nutrition. We know that over 3.1 billion people – more than 40 percent of the world population – cannot afford a healthy diet. Hunger and malnutrition occur unevenly across and within continents and countries, and current agrifood systems are highly vulnerable to shocks and disruptions arising from climate variability and extremes, exacerbating growing inequities.

Today, aquatic systems are increasingly recognized as vital for food and nutrition security. But more can be done to feed a growing and more urbanized population. Because of their great diversity and capacity to supply ecosystem services and sustain healthy diets, aquatic food systems represent a viable and effective solution that offers greater opportunities to improve global food security and nutrition today and for generations to come. However, if we want aquatic food systems to enhance their contribution to sustainable development, transformation is essential. In 2021, FAO adopted the Blue transformation, a Programme Priority Area anchored in the FAO Strategic Framework 2022–2031, aimed at maximizing the opportunities presented by aquatic food systems to enhance food security, improve nutrition, eradicate poverty and support the achievement of the 2030 Agenda for Sustainable Development. Furthermore, these objectives fully align with the key FAO strategies on climate change, innovation and biodiversity.

This edition of *The State of World Fisheries and Aquaculture* is devoted to "Blue Transformation in action". It illustrates how FAO effectively uses its resources, expertise and comparative advantage to promote collaborative efforts and initiatives involving Members, partners and key stakeholders. Implemented through the Blue Transformation Roadmap – presented at FAO Regional Conferences during 2024 – these efforts focus on priority actions to achieve three global objectives: sustainable aquaculture growth to meet the increasing demand for aquatic foods; effective fisheries management for healthier fishery stocks and equitable livelihoods; and upgrading of aquatic food value chains to guarantee their social, economic and environmental sustainability.

The State of World Fisheries and Aquaculture 2024 has benefited from significant improvements in data collection, analytical and assessment tools, and methodologies generating more reliable and expanded data on the state of world fisheries and aquaculture resources, and their exploitation and utilization. In 2022, fisheries and aquaculture production reached an all-time high of 223.2 million tonnes, worth a record USD 472 billion and contributing an estimated 20.7 kg of aquatic animal foods per capita. This constituted about 15 percent of the animal protein supply, reaching over 50 percent in several countries in Asia and Africa. While capture fisheries production has remained largely unchanged for decades, aquaculture has increased by 6.6 percent since 2020, contributing over 57 percent of aquatic animal products used for direct human consumption. The fisheries and aquaculture sector employs an estimated 62 million people in primary production alone. Where sex-disaggregated data are available, approximately 24 percent of the total workforce were women; of these, 53 percent were employed in the sector on a full-time basis, a great improvement since 1995, when only 32 percent of women were employed full time. Aquatic products continue to be one of the most traded food commodities, involving over 230 countries and territories and generating a record USD 195 billion in 2022 considering all aquatic products.

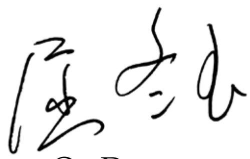
Despite these significant achievements, the sector still faces major challenges from climate change and disasters, water scarcity, pollution, biodiversity loss and other anthropogenic impacts. We need to accelerate efforts to ensure 100 percent of fishery stocks are placed under effective management, to reverse unsustainable practices, combat illegal, unreported and unregulated fishing, and reduce overfishing. An ecosystem approach should be at the centre of future aquaculture intensification and expansion, to minimize environmental impacts and secure animal health and food safety, with an efficient, diverse and sustainable use of inputs and resources, in particular water, land and feed, while improving yields and supporting livelihoods, especially for the most vulnerable communities and populations. Although significant improvements are reported in processing and utilization of aquatic foods, additional efforts are required to reduce loss and waste of aquatic products, upscaling successful FAO initiatives promoting innovative technologies, implementing circular economy solutions, facilitating access of producers, particularly small-scale ones, to regional and international markets and making aquatic foods available to all consumers.

The importance of fisheries and aquaculture for Sustainable Development Goal 14 – Conserve and sustainably use the oceans, seas and marine resources for sustainable development – highlights the responsibility of FAO, as custodian of four out of ten indicators of SDG 14, to accelerate the global momentum to secure healthy diets from healthy and productive oceans. This is being effectively implemented through activities aimed at improving the capacities of Members to implement, monitor and report progress and to inform on the challenges they face for achieving SDG 14 targets related to fisheries and aquaculture.

Recognition of the importance of fisheries and aquaculture in global fora is illustrated by the increasing inclusion of aquatic food systems in United Nations Food Systems Summit dialogues, United Nations Framework Convention on Climate Change negotiations and the Kunming-Montreal Global Biodiversity Framework, in addition to the adoption of the Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction, and the World Trade Organization Agreement on Fisheries Subsidies, as well as the upcoming international agreement on plastic pollution, including in the marine environment.

Our world population is projected to reach 8.5 billion by 2030 – many living in urban areas – with almost 600 million people remaining chronically undernourished. Providing sufficient food, nutrition and livelihoods for this growing population demands significant investments. As highlighted in this report, aquaculture has a major role to play, particularly in Africa where its great potential is not yet realized. We need to urgently explore all opportunities and take transformative action to make agrifood systems more efficient, more inclusive, more resilient and more sustainable. These transformative actions are needed to move forwards into a world with better production, better nutrition, a better environment and a better life, leaving no one behind.

The State of World Fisheries and Aquaculture, an FAO flagship publication, continues to provide evidence-based information, policy and technical insights on challenges and innovations shaping the present and future of the sector. I hope that this 2024 edition will meet the expectations of its expanding audience of policymakers, managers, scientists, fishers, farmers, traders, civil society and consumers to inform on the vital role and contributions of fisheries and aquaculture in addressing the challenges of the twenty-first century.



Qu Dongyu
FAO Director-General

METHODOLOGY

The preparation and production *of The State of World Fisheries and Aquaculture 2024* is a 15-month process which started in April 2023. The work was guided and supervised by an editorial board, chaired by the FAO Assistant Director-General and Director of the FAO Fisheries and Aquaculture Division (NFI), representing all the teams of the division, and steered by a core executive group of the NFI Information and Knowledge Management Team and a representative of the FAO Office of Communications.

The editorial board met regularly to design, develop and refine the structure and content of the report, then to review progress and address emerging issues brought by the core executive group. Based on the agreed structure, different senior editorial board members were assigned the leadership of a thematic section. Most contributions were prepared by FAO authors, including from FAO Decentralized Offices, in collaboration with external experts where appropriate (see **Acknowledgements**, p. xii). The work of the editorial board benefited from wider consultation among the FAO teams in charge of the FAO flagship publications.

Between April and June 2023, thematic section leaders coordinated proposals for a wide range of topics from the officers in the division, in consultation with officers from other FAO divisions and FAO Decentralized Offices. The proposals were reviewed by the editorial board to refine the outline ensuring it addressed current and emerging issues. The working outline took into consideration how ongoing FAO undertakings reflect Blue Transformation in action and align with the outcomes of high-level global and regional events and initiatives as well as concrete achievements on policies, norms and standards, technical innovation, partnerships and results at regional and country levels.

The longstanding Part 1 on world review, status and trends has benefited from improved data collection methodology, tools and analyses and has been extended to cover the regular monitoring of the SDG 14 indicators under FAO custodianship. Part 2 sets the scene for reporting and demonstrating Blue Transformation in action in global and regional fora, but also on the ground. Part 3 addresses outlook and contemporary issues, complementing the other two parts to inform stakeholders and to provide guidance to policy- and decision-makers in charge of fisheries and aquaculture. Following on from the 2022 edition, this report includes an executive summary, which covers the entire publication, and an expanded glossary. For the first time, *The State of World Fisheries and Aquaculture* features infographics to illustrate the key messages and executive summary.

In June 2023, a summary was prepared for each section and subsection, with inputs from section leaders, and revised based on feedback from the editorial board. The summary document was submitted to NFI management, then to the FAO Deputy Director-General for approval in July 2023. This document formed the blueprint guiding authors in the drafting of the publication.

Part 2 and most of Part 3 were drafted and edited for technical and language content between August 2023 and November 2023. Part 1 and the section on projections in Part 3 were drafted and edited between 1 January and 1 April 2024, because they are based on FAO's official fisheries and aquaculture statistics, which only become available upon annual closure of the thematic databases in which the data are structured. The process requires careful collation, cross checking, revision and validation. In the absence of national reporting, FAO makes estimates based on the best data available from other authoritative sources or through standard methodologies.

All parts were reviewed by a subgroup of the editorial board including managers of the FAO Fisheries and Aquaculture Division. In addition, Parts 2 and 3 (except projections) were submitted in December 2023 to a panel of three external experts covering respectively aquaculture, capture fisheries and value chains for their review and recommendations (see **Acknowledgements**, p. xii).

Based on an agreed schedule, the finalized English drafts of *The State of World Fisheries and Aquaculture 2024* were submitted in batches to the Language Branch for translation into FAO's other five official languages and to the Publications and Library Branch for copyediting, layout and processing.

Recent developments in fisheries and aquaculture have been accompanied by a major expansion of the associated terminology necessitating its thorough review to ensure coherence throughout the report. The glossary prepared in 2022 has been expanded for this edition, using definitions provided by authoritative sources of FAO or others. A Glossary Working Group was set up to complete this task and assist authors.

A final draft of *The State of World Fisheries and Aquaculture 2024* was submitted to the Office of the FAO Deputy Director-General and to the Office of the FAO Director-General for approval.

ACKNOWLEDGEMENTS

The State of World Fisheries and Aquaculture 2024 was prepared under the overall direction of the FAO Assistant Director-General and Director of the FAO Fisheries and Aquaculture Division, Manuel Barange and an editorial board under his leadership, comprising Lahsen Ababouch, Vera Agostini, Diana Fernandez Reguera, Carlos Fuentevilla, Marianne Guyonnet, Audun Lem, Alessandro Lovatelli, Felix Marttin, Marc Taconet, Jogeir Toppe, Stefania Vannuccini and Xinhua Yuan.

Authorship of each section was led and coordinated by an editorial board member. The production process was overseen by Marc Taconet with support from Lahsen Ababouch (project manager and technical editor), Emmanuel Blondel (map production) and Diana Fernandez Reguera (divisional support team), assisted by Marianne Guyonnet (liaison), Tamsin Vicary (Glossary) and Kiran Viparthi (informatics).

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PART 2 **Blue Transformation in action** (coordinator Manuel Barange)

Blue Transformation: a roadmap Manuel Barange (lead author) and Carlos Fuentevilla

Sustainable aquaculture in action (coordinators Xinhua Yuan and Alessandro Lovatelli)
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Managing shared fishery resources: the growing role of regional fishery bodies: Piero Mannini (lead author), Eszter Hidas, Kim Stobberup, Kathrin Hett, Stefania Savoré, Aureliano Gentile and Viktoria Varga Lencses
Managing marine fisheries for sustainability: a focus on the Code of Conduct for Responsible Fisheries: Nicolas Gutierrez (lead author), Felix Marttin, Merete Tandstad and Varun Tandon
Evolving the way we assess the status of marine fishery stocks: Rishi Sharma (lead author), Felix Marttin, Marc Taconet, Diana Fernandez Reguera and Anne-Elise Nieblas
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GLOBEFISH: 40 years of market monitoring and marketing intelligence: Audun Lem (lead author), Hasan Abdullayev and José Estors Carballo
FAO's standard setting on traceability and certification: Nada Bougouss (lead author), Aureliano Gentile, Nianjun Shen, Pedro Guemes and Ahmed Al Mazrouai
FISH4ACP: transforming aquatic food systems through a value chain approach: Gilles van de Walle (lead author), Greta Barbera and Maarten Roest
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Aquatic food safety: Esther Garrido Gamarro (lead author), Jogeir Toppe and Markus Lipp

PART 3 Outlook and contemporary issues (coordinators Manuel Barange and Vera Agostini)

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The key role of aquatic foods in climate action: Xuechan Ma (lead author), Diana Fernandez Reguera, Fernanda Garcia Sampaio, Jose Aguilar Manjarrez, Tarub Bahri, Angela Lentisco, Jeffrey Kinch, Jose Parajua, Florence Poulain, Felix Marttin, Jeffy Gomez, Vasco Schmidt and Iris Monnereau
Impacts of El Niño on marine fisheries and aquaculture: Iris Monnereau (lead author), Dimitri Gutiérrez (Peruvian Institute of Marine Research), Salvador Emilio Lluch-Cota (Biological Research Centre of the Northwest), Vera Agostini and Manuel Barange
Fisheries and aquaculture in the context of global biodiversity agreements: Kim Friedman (lead author), Piero Mannini, Amparo Perez Roda, Vera Agostini and Diana Fernandez Reguera
Fisheries and aquaculture projections, 2022–2032: Stefania Vannuccini (lead author) and Adrienne Egger

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The report was reviewed internally by Manuel Barange, Vera Agostini, Audun Lem, Xinhua Yuan and the editorial board, as well as by colleagues in other FAO technical divisions and units.

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

The Publications and Library 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

ABMT	area-based management tool
ABNJ	area beyond national jurisdiction
ACP	Africa, the Caribbean and the Pacific
ADC	aquaculture demonstrative centre
AI	artificial intelligence
AIS	Automatic Identification System
ALART	Aquaculture Legal Assessment and Revision Tool
ALDFG	abandoned, lost or discarded fishing gear
AMR	antimicrobial resistance
AqGR	aquatic genetic resources
AquaGRIS	global information system on aquatic genetic resources
BBNJ Agreement	Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction
BMSY	biomass corresponding to maximum sustainable yield
BPI	Blue Ports Initiative
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CCRF	Code of Conduct for Responsible Fisheries
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMM	conservation and management measure
COFI	Committee on Fisheries
COFI:AQ	COFI Sub-Committee on Aquaculture
COFI:FT	COFI Sub-Committee on Fish Trade
COP	Conference of the Parties
CPUE	catch per unit effort
CRFM	Caribbean Regional Fisheries Mechanism
CTE	critical tracking event
CWP	Coordinating Working Party
DHA	docosahexaenoic acid
dl-PCB	dioxin-like polychlorinated biphenyl
DRM	disaster risk management
DRR	disaster risk reduction
DSF	deep-sea fisheries
EAA	ecosystem approach to aquaculture
EAF	ecosystem approach to fisheries
EEZ	exclusive economic zone
ENSO	El Niño Southern Oscillation
EPA	eicosapentaenoic acid
EUMOFA	European Market Observatory for Fisheries and Aquaculture Products
EUROFISH	International Organisation for the Development of Fisheries and Aquaculture in Europe
EUROSTAT	Statistical Office of the European Union
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FBS	Food Balance Sheet
FFRC	Freshwater Fisheries Research Centre of Chinese Academy of Fishery Sciences
FIN	FISHINFONetwork
FIRMS	Fisheries and Resources Monitoring System
FLW	food loss and waste
FPI	FAO Fish Price Index
GBC	gender-based constraint
GBF	Kunming-Montreal Global Biodiversity Framework
GBV	gender-based violence

ABBREVIATIONS

GCA+20	Global Conference on Aquaculture Millennium +20
GCF	Green Climate Fund
GDP	gross domestic product
GDST	Global Dialogue on Seafood Traceability
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GIES	Global Information Exchange System
GIS	geographic information system
GRSF	Global Record of Stocks and Fisheries
GSA	Guidelines for Sustainable Aquaculture
GSAAP	Global Sustainable Aquaculture Advancement Partnership
GSSI	Global Sustainable Seafood Initiative
GST	Global Stocktake
GTA	gender-transformative approach
HACCP	Hazard Analysis Critical Control Point
HGSF	home-grown school feeding
IACG	Interagency Coordination Group
ICES	International Council for the Exploration of the Sea
IFFO	Marine Ingredients Organisation
IHH	Illuminating Hidden Harvests
ILO	International Labour Organization
IMO	International Maritime Organization
INFOFISH	Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region
INFOPÊCHE	Intergovernmental Organization for Marketing Information and Cooperation Services for Fishery Products in Africa
INFOPESCA	Centre for Marketing Information and Advisory Services for Fishery Products in Latin America and the Caribbean
INFOSAMAK	Centre for Marketing Information and Advisory Services for Fishery Products in the Arab Region
INFOYU	China Fish Marketing Information and Trade Advisory Service Center
IRCS	international radio call sign
ISSCAAP	International Standard Statistical Classification of Aquatic Animals and Plants
ISSF	International Seafood Sustainability Foundation
IUU	illegal, unreported and unregulated
IWRM	integrated water resources management
IYAFA	International Year of Artisanal Fisheries and Aquaculture
KDE	key data element
LDCs	least developed countries
LIFDC	low-income food-deficit country
LOA	length overall
MDS	multidimensional solutions
MoEWA	Ministry of Environment, Water and Agriculture (Saudi Arabia)
MPL	marine plastic litter
MSP	multistakeholder partnership
MSY	maximum sustainable yield
MU	management unit
NACA	Network of Aquaculture Centres in Asia-Pacific
NAOHS	National Aquatic Organism Health Strategy
NAP	National Adaptation Plan
NCT	nutrient conversion table

NDC	nationally determined contribution
Ne	effective population size
NFP	national focal point
NGO	non-governmental organization
NPOA-SSF	National Plan of Action for Small-Scale Fisheries
OACPS	Organisation of African, Caribbean and Pacific States
OECD	Organisation for Economic Co-operation and Development
PICTs	Pacific Island Countries and Territories
PMP/AB	Progressive Management Pathway for Aquaculture Biosecurity
PSMA	Port State Measures Agreement
RAE	retinol activity equivalent
RAOHS	Regional Aquatic Organism Health Strategy
QA	quality assessment
RE	retinol equivalent
RFAB	regional fisheries advisory body
RFB	regional fishery body
RFMA	regional fisheries management arrangement
RFMO	regional fisheries management organization
RTA	regional trade agreement
SDGs	Sustainable Development Goals
SIDS	Small Island Developing States
SoSI	FAO State of Stocks Index
SSF Guidelines	Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication
SST	sea surface temperature
SUA	Supply Utilization Account
TAB	terrestrial animal biosecurity
uFISH	FAO/INFOODS global food composition database for fish and shellfish
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFSA	United Nations Fish Stocks Agreement
UNFSS	United Nations Food Systems Summit
UVI	unique vessel identifier
VME	vulnerable marine ecosystem
WHO	World Health Organization
WOAH	World Organisation for Animal Health
WTO	World Trade Organization

KEY MESSAGES

1 World fisheries and aquaculture production hit a new high in 2022. Successful initiatives should be upscaled to consolidate the vital role of aquatic foods for global food security, nutrition and livelihoods.

- Global fisheries and aquaculture production surged to 223.2 million tonnes, with 185.4 million tonnes of aquatic animals and 37.8 million tonnes of algae.
- Of the total aquatic animal production, 89 percent was used for human consumption, equivalent to an estimated 20.7 kg per capita in 2022. The rest went on non-food uses, mostly fishmeal and fish oil.
- An estimated 61.8 million people were employed in the primary production sector, mostly in small-scale operations. Sex-disaggregated data indicate that 24 percent of fishers and fish farmers were women compared with 62 percent in the post-harvest sector.
- Over 230 countries and territories were involved in the international trade of aquatic products, reaching a record value of USD 195 billion – a 19 percent increase from pre-pandemic levels in 2019.
- In low- and middle-income countries, the total net trade (exports minus imports) of aquatic animal products reached USD 45 billion – greater than that of all other agricultural products combined.
- Further transformative and adaptive actions are needed to strengthen the resilience of aquatic food systems and consolidate their role in addressing hunger, malnutrition and poverty.

2 Aquaculture can meet the rising global demand for aquatic foods. Future expansion must prioritize sustainability and benefit regions and communities most in need.

- In 2022, global aquaculture production reached 130.9 million tonnes, valued at USD 312.8 billion, 59 percent of global fisheries and aquaculture production.
- Inland aquaculture contributed 62.6 percent of farmed aquatic animals, marine and coastal aquaculture 37.4 percent.
- For the first time, aquaculture surpassed capture fisheries in aquatic animal production with 94.4 million tonnes, representing 51 percent of the world total and a record 57 percent of the production destined for human consumption.
- Aquaculture remains dominated by a small number of countries, with many low-income countries in Africa, Asia and Latin America and the Caribbean not exploiting their full potential.
- Out of some 730 farmed species items, 17 staple species represent about 60 percent of global aquaculture production, while other species are important at local level.
- Targeted policies, technology transfer, capacity building and responsible investment are crucial to boost sustainable aquaculture where it is most needed, in particular in Africa.

3 Global capture fisheries production remains stable, but sustainability of fishery resources is a cause for concern. Urgent action is needed to accelerate fishery stock conservation and rebuilding.

- Global capture fisheries production of aquatic animals has fluctuated between 86 and 94 million tonnes per year since the late 1980s.
- In 2022, the sector produced 92.3 million tonnes, valued at about USD 159 billion and comprising 91.0 million tonnes of aquatic animals – 79.7 million tonnes caught in marine areas and 11.3 million tonnes in inland waters – in addition to 1.3 million tonnes of algae. With a share of 43 percent, marine capture fisheries remain the major source of global aquatic animal production.
- The fraction of marine stocks fished within biologically sustainable levels decreased to 62.3 percent in 2021, 2.3 percent lower than in 2019.
- When weighted by their production level, an estimated 76.9 percent of the 2021 landings were from biologically sustainable stocks. Effective fisheries management leads to stock recovery, and urgent action is needed to replicate successful policies and reverse declining sustainability trends.

4 Global demand for aquatic foods is projected to increase further. Expansion of sustainable production is vital to ensure healthy diets from healthy oceans, lakes and rivers.

- In 2022, global apparent consumption of aquatic animal foods reached an estimated 165 million tonnes, increasing at nearly twice the annual rate of the world population since 1961.
- Global annual per capita apparent consumption of aquatic animal foods rose from 9.1 kg in 1961 to an estimated 20.7 kg in 2022.
- Aquatic animal foods provide high-quality proteins – 15 percent of animal proteins and 6 percent of total proteins worldwide – and key nutrients including omega-3 fatty acids, minerals and vitamins.
- The potential of aquatic foods to contribute to food security, nutrition and poverty reduction is increasingly recognized in major global fora such as the UN Food Systems Summit and the UN Framework Convention on Climate Change.
- Efforts must continue to promote aquatic foods for healthy diets from healthy oceans, lakes and rivers.

5 Aquatic animal production is expected to increase by 10 percent by 2032. The Blue Transformation Roadmap aims to ensure sustainable fisheries and aquaculture growth while promoting equitable benefits and environmental conservation.

- Aquatic animal production is expected to increase by 10 percent by 2032, driven by aquaculture expansion and capture fisheries recovery. It will reach 205 million tonnes – 111 million tonnes from aquaculture and 94 million tonnes from fisheries.
- Up to 90 percent will be destined for human consumption, at a rate of about 21.3 kg per capita. Consumption per capita is expected to grow in all continents, but will likely decline in Africa, particularly sub-Saharan Africa, where many people rely on aquatic foods for nutrition.
- Exports of aquatic animal products will grow, involving 34 percent of the total production in 2032, down from 38 percent in 2022.
- The FAO Blue Transformation Roadmap paves the way for sustainable growth, promoting equitable benefits and reversing environmental degradation.

6 Small-scale fisheries are a vital source of nutrition and livelihoods for millions of people. Greater global recognition and action are needed to support and empower these communities.

- Small-scale fisheries contribute an estimated 40 percent of the global catch and support 90 percent of the capture fisheries workforce, with women representing 40 percent of all those engaged in the aquatic value chain.
- Some 500 million people rely on small-scale fisheries for their livelihoods, including 53 million involved in subsistence fishing – 45 percent of whom are women.
- The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries were endorsed a decade ago, yet the vital role of small-scale fisheries is not sufficiently recognized.
- Enhancing the recognition and governance of small-scale fisheries through co-management approaches remains crucial to secure sustainable exploitation, equitable socioeconomic development and equal opportunities for all.

7 Efforts to improve data collection and analysis must be strengthened. They are key to evidence-based policymaking and the effective management of fisheries and aquaculture.

- FAO, in coordination with Members and partners, has invested significant resources to strengthen capacity, and improve data collection, analytical tools and methodologies for managing fisheries and aquaculture effectively.
- Enhanced fishery stock assessments, revised socioeconomic and technical data, and digital innovations provide more accurate insights and bolster "Blue Transformation in action".
- Improved data and analysis inform global policy debates and guide FAO's initiatives for effective fisheries and aquaculture management at national, regional and global levels.

8 Efforts to achieve the Sustainable Development Goal targets related to fisheries and aquaculture must accelerate. FAO urges the international community to step up actions to support implementation of the Blue Transformation Roadmap.

- Progress in implementing the 2030 Agenda for Sustainable Development remains slow and uneven.
- The indicators on combating illegal, unreported and unregulated fishing and supporting small-scale fisheries show increasing uptake of international guidelines and policies. However, the indicator on increasing the economic benefits from sustainable marine fisheries is lagging, while the percentage of fishery stocks within biologically sustainable levels continues to drift from the target.
- FAO encourages countries to implement the Blue Transformation Roadmap to catalyse change in aquatic food systems and achieve sustainable aquaculture growth, effective fisheries management and upgraded value chains.

EXECUTIVE SUMMARY

Combating hunger, malnutrition and poverty remains essential for achieving the goals and targets of the 2030 Agenda for Sustainable Development. Aquatic systems are increasingly recognized for the multiple solutions they offer to improve food security and nutrition, alleviate poverty and boost socioeconomic development, particularly for the many coastal and riparian communities around the world, while maintaining a low environmental footprint.

The State of World Fisheries and Aquaculture 2024 analyses the status, trends and projections of global fisheries and aquaculture. It features "Blue Transformation in action", illustrating how FAO is leading collaborative efforts and initiatives in close coordination with Members, partners and key stakeholders to guide global policy processes and disseminate best practices to support sustainable aquaculture intensification and expansion, effective fisheries management and upgraded aquatic food value chains.

WORLD REVIEW

Total fisheries and aquaculture production reached an all-time record of 223.2 million tonnes in 2022, 185.4 million tonnes (live weight equivalent) of aquatic animals and 37.8 million tonnes (wet weight) of algae, a 4.4 percent increase from 2020. Sixty-two percent of aquatic animals were harvested in marine areas (69 percent from fisheries and 31 percent from aquaculture) and 38 percent in inland waters (84 percent from aquaculture and 16 percent from capture fisheries). Asian countries produced 70 percent of the aquatic animals, followed by countries in Europe and Latin America and the Caribbean (9 percent each), Africa (7 percent), Northern America (3 percent) and Oceania (1 percent). China remained the major producer (36 percent), followed by India (8 percent), Indonesia (7 percent), Viet Nam (5 percent) and Peru (3 percent).

World aquaculture production reached a new record of 130.9 million tonnes in 2022, valued at USD 313 billion and comprising 94.4 million tonnes of aquatic animals and 36.5 million tonnes of algae. Asia contributed 91.4 percent of the overall total, followed by Latin America and the Caribbean (3.3 percent), Europe (2.7 percent), Africa (1.9 percent), Northern America (0.5 percent) and Oceania (0.2 percent). Ten leading countries (China, Indonesia, India, Viet Nam, Bangladesh, Philippines, Republic of Korea, Norway, Egypt and Chile) produced 89.8 percent of the total.

In 2022, production of animal species from aquaculture (51 percent) surpassed for the first time that from capture fisheries, with inland aquaculture producing 62.6 percent of total farmed aquatic animals. The overall increase (7.6 percent) from 2020 was largely in Asia (87.9 percent of the increase), followed by Latin America and the Caribbean (7.3 percent), Europe (3.5 percent) and Africa (0.8 percent). This increase occurred mainly in finfish aquaculture (58.1 percent), followed by crustaceans (24.6 percent) and molluscs (15.6 percent).

World capture fisheries produced 92.3 million tonnes in 2022, 91.0 million tonnes of aquatic animals and 1.3 million tonnes of algae. China remained the top capture fisheries producer (14.3 percent), followed by Indonesia (8.0 percent), India (6.0 percent), Peru (5.8 percent), the Russian Federation (5.4 percent), the United States of America (4.6 percent), Viet Nam (3.9 percent) and Japan (3.2 percent).

With 80 million tonnes of aquatic animals produced in 2022, **marine capture fisheries** remain the principal source (43 percent) of global aquatic animals. About 85 percent of total marine fisheries production was finfish, mainly anchoveta (4.9 million tonnes), Alaska pollock (3.4 million tonnes) and skipjack tuna (3.1 million tonnes). Catches of valuable species groups continued to increase, reaching a record 8.3 million tonnes for tunas and tuna-like species, 3.9 million tonnes for cephalopods and 3.3 million tonnes for shrimps and lobsters. **Inland fisheries** produced 11.3 million tonnes, harvested mainly in Asia (63.4 percent) and Africa (29.4 percent), where they are important for food security. Lead producers were India (1.9 million tonnes), Bangladesh (1.3 million tonnes), China (1.2 million tonnes), Myanmar (0.9 million tonnes) and Indonesia (0.5 million tonnes). Inland fisheries figures are likely underestimated due to the difficulties most countries face in collecting these data.

Concern over the **state of marine fisheries resources** continues despite noticeable improvements in several regions. The fraction of marine fishery stocks within biologically sustainable levels decreased to 62.3 percent in 2021, 2.3 percent lower than in 2019. When weighted by their production levels, an estimated 76.9 percent of the 2021 landings from FAO-monitored stocks were from biologically sustainable stocks, significantly higher than the world average of 62.3 percent. Likewise, 86 percent across major tuna stocks were within biologically sustainable levels. These examples confirm that effective fisheries management leads to stock recovery and increased catches, calling for urgent action to expand its enforcement to reverse the declining trend.

Inland fishery stocks can recover rapidly from elevated mortality levels. Fishing pressure can be high because of the many people involved, but environmental factors play a greater role in productivity and resilience. Furthermore, lack of national capacity and resources and the low priority given to inland fisheries are major obstacles to monitoring and managing such fisheries. Recent FAO data indicate that 47 percent of major basins important to inland fisheries are under "low pressure", 40 percent under "moderate pressure" and 13 percent under "high pressure". These results can help inform the prioritization of interventions in the context of integrated water resources management.

The **world fishing fleet** was estimated at 4.9 million vessels in 2022, two-thirds of which were motorized. Asia hosts the world's largest fishing fleet (71 percent of the total), followed by Africa (19 percent), Latin America and the Caribbean (5 percent), Northern America and Europe (2 percent each), and Oceania (less than 1 percent). Asia hosts the largest fleets of motorized (80 percent) and non-motorized (54 percent) vessels and Africa hosts the second-largest non-motorized fishing fleet. Many fishing nations (e.g. China, Japan and European Union Member States) continue their strategy of reducing fishing vessels.

In 2022, the **primary sector of fisheries and aquaculture employed** around 61.8 million people, compared with 62.8 million in 2020, with 54 percent engaged in fisheries and 36 percent in aquaculture, while the subsector was not specified for 10 percent of the workforce. Asia provided 85 percent of these jobs, followed by Africa (10 percent) and Latin America and the Caribbean (4 percent), with Europe, Oceania and Northern America combined accounting for just 1 percent. Most aquaculture workers were in Asia (95 percent), followed by Africa (3 percent) and Latin America and the Caribbean (2 percent). In fisheries, 77 percent of the global workforce was in Asia, 16 percent in Africa and 5 percent in Latin America and the Caribbean. Where data are disaggregated by sex (66 percent of the data), women accounted for 24 percent of fishers and fish farmers (28 percent in inland fisheries) and 62 percent of processing workers. Fifty-three percent of women were employed on a full-time basis, compared with 57 percent of men. However, gender inequalities remain, including difference in wages, insufficient recognition of women's contribution to the sector and gender-based violence.

Utilization and processing of aquatic products continue to improve, making available for human consumption 89 percent of the aquatic animal production in 2022. The remaining volume was used for non-food purposes, mainly to produce fishmeal and fish oil (83 percent). The largest share (43 percent) of aquatic animal foods was distributed in live, fresh or chilled form, followed by frozen (35 percent), prepared and preserved (12 percent), and cured (10 percent). Overall, in high-income countries, aquatic foods are mostly processed, and traditional methods of preservation are increasingly replaced by more value-adding processes in many other countries. By-products traditionally discarded as waste are increasingly used to prepare food and non-food products. For example, in 2022, by-products accounted for 34 percent and 53 percent of the total production of fishmeal and fish oil, respectively.

Global apparent consumption of aquatic animal foods was 162.5 million tonnes in 2021, bringing the average annual growth to 3 percent per year since 1961, exceeding that of all terrestrial meats combined, estimated at 2.7 percent per year over the same period. Asia accounted for 71 percent of this apparent consumption, followed by Europe (10 percent), Africa (8 percent), Northern America (5 percent), Latin America and the Caribbean (4 percent) and Oceania (1 percent). Per capita consumption increased from 9.1 kg per year in 1961 to 20.6 kg per year in 2021.

From 1961 to 2021, consumption of aquatic animal foods in Europe, Japan and the United States of America combined decreased from 47 percent to 18 percent of the total. Meanwhile, the shares of China, Indonesia and India increased from 17 percent to 51 percent for the same period, with China alone absorbing 36 percent of this total. Globally, aquatic animal foods provided 15 percent of animal proteins and 6 percent of all proteins in 2021. They contributed at least 20 percent of the per capita protein supply from all animal sources to 3.2 billion people. Non-high-income countries generally rely more heavily on proteins from aquatic animal foods compared with high-income countries. This reflects the affordability, availability and accessibility of aquatic foods, making them a staple of choice in many culinary traditions of non-high-income countries.

Global trade of aquatic products continues to grow, involving over 230 countries and territories and generating a record USD 195 billion in 2022**.** It represented over 9.1 percent of total agricultural trade (excluding forest products) and about 1 percent of total merchandise trade value. In countries and territories such as the Faroe Islands, Maldives and Seychelles, however, it accounted for over 30 percent of total merchandise trade.

Exports of aquatic animals increased from USD 7.9 billion in 1976 to 192 billion in 2022 at an average annual growth rate of 7.2 percent in nominal terms and 4.0 percent in real terms, facilitated by the liberalization of trade policies, reduced transportation costs, and improved technology, logistics and storage. China remains the main exporter of aquatic animal products (12 percent in value), followed by Norway (8 percent), Viet Nam (6 percent), Ecuador (5 percent) and Chile (4 percent). The European Union was the largest single market importing USD 62.7 billion of aquatic animal products, including USD 29.5 billion of intra-European Union trade. The largest single importing country was the United States of America (17 percent), followed by China (12 percent), Japan (8 percent), Spain (5 percent) and France (4 percent).

The most traded aquatic animal products in 2022 were finfish (65 percent of the total value), crustaceans (23 percent), and molluscs and other aquatic invertebrates (11 percent). By species groups, salmonids remain the most valuable (20 percent in value), followed by shrimps and prawns (17 percent), cods, hakes and haddocks (9 percent), tunas, bonitos and billfishes (9 percent), and cephalopods (7 percent).

FAO supports its Members and other actors to **work towards achieving several SDG targets**, in particular the targets of SDG 14 (Life below Water) relevant to fisheries and aquaculture, measuring and reporting progress through the SDG indicator framework.

Overall, there has been good progress in the adoption of the SDG 14 monitoring and reporting framework by countries across the biological, social and economic sustainability dimensions covered by the four fisheries indicators under FAO custodianship. FAO has successfully supported the development of the indicators, their monitoring and reporting methodologies and the related capacity development.

Significant progress towards the adoption of instruments to combat illegal, unreported and unregulated fishing (Indicator 14.6.1) and to support small-scale fisheries (Indicator 14.b.1) has been achieved. This testifies to the general uptake of international policies and guidelines by countries. However, there remains much to do in terms of implementation on the ground. On the other hand, the indicator on increasing the economic benefits from sustainable marine fisheries (Indicator 14.7.1) is lagging, while the percentage of fishery stocks within biologically sustainable levels (Indicator 14.4.1) continues to drift from its target.

Full implementation and reporting by Members are works in progress and challenges remain, especially for developing countries. Moreover, the good reporting by certain countries should not distract attention from those countries still unable to report, including many least developed countries and Small Island Developing States. FAO encourages countries to implement the Blue Transformation Roadmap to catalyse change in aquatic food systems and achieve sustainable aquaculture growth, effective fisheries management and upgraded value chains.

BLUE TRANSFORMATION IN ACTION

Blue Transformation: a roadmap

In 2021, FAO launched the **Blue Transformation vision,** aimed at maximizing the opportunities presented by aquatic food systems to enhance food security, improve nutrition, eradicate poverty and support the achievement of the 2030 Agenda for Sustainable Development. In line with the FAO Strategic Framework 2022–2031 and its corporate strategies,[a] the Blue Transformation Roadmap proposes clear objectives, concrete priority actions and quantifiable targets to guide, monitor and report on global efforts to achieve this vision.

Sustainable aquaculture in action

FAO collaborates with Members and a global network of practitioners and experts to support initiatives and disseminate innovations and technology, aiming to achieve healthier, more efficient and safer aquaculture production. Examples of initiatives deployed include development of the Guidelines for Sustainable Aquaculture, a negotiated global document that will guide sustainable aquaculture expansion and intensification into the future; implementation of the Global Plan of Action for the Conservation, Sustainable Use and Development of Aquatic Genetic Resources for Food and Agriculture for rational and effective management of aquatic genetic resources; promotion of the global information system on aquatic genetic resources; adoption and implementation of the Progressive Management Pathway for aquaculture biosecurity and for antimicrobial resistance; elaboration of National or Regional Aquatic Organism Health Strategies to achieve aquatic biosecurity and address disease challenges; piloting of the transfer and adoption of innovative systems and technologies to expand aquaculture into new regions, improve feeding management, aquafeed supply and on-farm made aquafeeds with use of local ingredients or fish silage, and encourage aquaculture digitalization; and establishment of the Global Sustainable Aquaculture Advancement Partnership, a platform to enhance the scientific basis of aquaculture and promote continuous innovations.

a FAO Strategy on Climate Change https://openknowledge.fao.org/handle/20.500.14283/cc2274en; FAO Science and Innovation Strategy https://openknowledge.fao.org/handle/20.500.14283/cc2273en; FAO Strategy on Mainstreaming Biodiversity across Agricultural Sectors https://openknowledge.fao.org/handle/20.500.14283/ca7722en

Improving fisheries sustainability

FAO-led initiatives aim to achieve sustainable fisheries and equitable livelihoods by supporting the adoption and implementation of international instruments and sustainable practices. These initiatives cover actions to enhance national capacities to combat illegal, unreported and unregulated fishing; to develop and implement participatory National Plans of Action for Small-Scale Fisheries and integrate them in broader policies of agrifood systems, sustainable development and livelihoods; to strengthen the capacity of regional fishery bodies to address challenges presented by newly adopted agreements dealing with fisheries subsidies, the conservation and sustainable use of marine biological diversity and plastic pollution; to upgrade science-based approaches to assess the status of world marine fishery resources and the threats to inland fisheries, using reliable data collection protocols, privileging participatory and integrated approaches and traditional knowledge; and to disseminate cost-effective technologies and innovations on responsible fishing, processing and distribution, safety at sea, energy efficiency, and reliable data and data collection systems.

Innovations in sustainable trade and value chains

To upgrade aquatic food value chains and guarantee their social, economic and environmental sustainability, FAO supports Members to comply with trade agreements and market access requirements. Actions and initiatives include support to implement fisheries management systems and combat illegal, unreported and unregulated fishing for ensuring that countries comply with the World Trade Organization Agreement on Fisheries Subsidies, particularly its provisions prohibiting subsidies linked to overfished stocks and illegal, unreported and unregulated fishing; development of global guidance on social responsibility in fisheries and aquaculture value chains to address issues of gender equality, decent work and occupational safety; promotion of guidance on end-to-end traceability to ensure product quality, safety, legality and sustainability; endorsement of the multidimensional solutions approach to reduce food loss and waste in aquatic food systems, based on a multistakeholder platform involving a wide range of public and private stakeholders; and support to expert consultations and provision of advice on the risks and benefits of aquatic food consumption in relation to emerging chemical contaminants.

OUTLOOK AND CONTEMPORARY ISSUES

Aquatic foods are considered among the healthiest and their consumption is linked to improved public health outcomes. The importance of fisheries and aquaculture is increasingly recognized in global fora, underlying the potential of aquatic food systems to provide solutions for improving food security, healthy diets, economic development and environmental protection.

Aquatic foods: an untapped potential for healthy diets

Consumption of whole fish provides important essential nutrients – in particular omega-3 fatty acids, minerals and vitamins – and is relatively affordable for low-income populations, ensuring their access to nutritious foods. During processing, many parts considered not edible are often discarded. These parts are rich in micronutrients, and adoption of simple low-cost technologies such as drying, smoking, fermentation and milling can transform them into affordable and nutritious products. FAO supports home-grown school feeding programmes to produce aquatic foods using locally produced small fish or fish powders made from fisheries by-products. For example, acceptability of dried fish powder produced from tuna frames in Ghana and fish cake from whole tilapia in Guatemala was high, enabling the provision of more foods, improving nutrition, reducing the cost per meal, and lessening the environmental impact.

To promote consumption of aquatic foods and increase public awareness of their nutritional and health benefits, FAO has prepared a global nutrient conversion table for application to the FAO Supply Utilization Accounts, based on national or regional food composition data. The global table provides data required to generate statistics on aquatic foods for energy, macronutrients, micronutrients, and polyunsaturated and omega-3 fatty acids.

The key role of aquatic foods in climate action

Policies in recent years have focused on the nexus between climate change, aquatic ecosystems and food production within the United Nations Framework Convention on Climate Change (UNFCCC). The 2023 UNFCCC Ocean Dialogue recognized the significant potential of aquatic foods for providing critical climate solutions and the importance of integrating them into both national and multilateral climate action-related processes. The FAO field programmes implementing climate change adaptation solutions for aquatic food systems across regions support highly vulnerable coastal and riparian communities to reduce vulnerability, boost resilience, and diversify local food systems and livelihoods. They integrate traditional knowledge for adapting to climate change in specific areas, offer key insights into local species most suited to adapt to evolving conditions, and engage stakeholders including youth, women and Indigenous Peoples. Ensuring access to climate finance for the aquatic food sector is challenging – especially for small-scale producers, who lack awareness of funding possibilities and the know-how to access them. FAO has developed climate finance training materials and guidance to help governments and other stakeholders assess climate risks, build climate rationale, develop adaptation actions, and formulate adaptation finance proposals.

Impacts of El Niño on marine fisheries and aquaculture

The El Niño Southern Oscillation (ENSO) events cause natural ocean conditions to alter due to changes in sea surface temperature and upwelling, affecting food availability and suitability of habitats for fish and other marine species. El Niño events have been linked to declines in fish catch from a variety of fisheries such as those in the North Pacific and the East China Sea, as well as those of highly migratory species and of Peruvian anchoveta in the Eastern Pacific. They affect aquaculture infrastructure and cultured organisms; for example, conditions resulting from El Niño events can strongly affect the growth and survival of seaweed farmed in the Philippines, where this industry supports around 200 000 family farms.

According to FAO's retrospective analysis (1950 to 2023), strong to extraordinary Eastern Pacific El Niño events affected marine fisheries in 11 of the 19 marine FAO Major Fishing Areas. Impacts differ across geographical areas, target species, and types of fishing or aquaculture, and may be both negative and positive. For example, 2023 El Niño conditions diminished the habitat and food availability of Peruvian anchoveta, leading to a 50 percent reduction in landings compared with 2022. On the other hand, the 2023–2024 El Niño had a positive impact on skipjack fishing and catchability of yellowfin tuna in the exclusive economic zones of the Pacific Island Countries and Territories.

Climate models project more frequent extreme ENSO events due to global warming. It is therefore vital to implement adaptive fisheries management measures such as dynamic adjustment of the fishing season and limiting access to fishing grounds based on near real-time monitoring.

Fisheries and aquaculture in the context of global biodiversity agreements

The Convention on Biological Diversity (CBD) is a multilateral treaty to conserve biodiversity while ensuring sustainable and fair use of its components and equitable sharing of the benefits arising from genetic resources. Under the CBD's 2050 vision of ″Living in harmony with nature″, the fifteenth meeting of the Conference of Parties adopted the landmark Kunming-Montreal Global Biodiversity Framework (GBF) in 2022 to be used by countries to develop National Biodiversity Strategies and Action Plans. Aquatic food systems are directly related to many GBF targets such as management of aquatic spaces; reduction of species extinction risk; sustainability of use and trade of wild aquatic species; and actions to deter and mitigate the impacts of invasive alien species. FAO is working across stakeholder groups to identify the opportunities and challenges for the timely implementation of the framework in aquatic food systems.

In 2023, United Nations Member States agreed to an international legally binding instrument on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. The agreement covers 64 percent of the total ocean surface area and around half the surface area of the planet. It tackles threats such as climate change and overfishing, and promotes coordination between relevant bodies, including regional fishery bodies. The agreement represents an opportunity to build on existing policy instruments, processes and works of sectoral bodies.

To address plastic pollution, the United Nations Environment Programme-led Intergovernmental Negotiating Committee is developing an international legally binding instrument on plastic pollution, including in the marine environment. FAO is actively participating in the consultations, providing technical advice on fisheries and aquaculture.

Fisheries and aquaculture projections, 2022–2032

The FAO outlook for fisheries and aquaculture foresees an increase in world production, apparent consumption and trade for the period up to 2032, although at slower rates compared with previous decades. World production of aquatic animals is projected to reach 205 million tonnes in 2032, 111 million tonnes from aquaculture and 94 million tonnes from capture fisheries, increasing respectively by 17 percent and 3 percent. Aquaculture will account for 54 percent of the total production of aquatic animals and 60 percent of total aquatic food for human consumption, estimated at 184 million tonnes or 90 percent of total production. Apparent consumption of aquatic animal foods will increase by 12 percent to supply on average 21.3 kg per capita in 2032, driven mostly by rising incomes and urbanization, improvements in post-harvest practices and distribution, and dietary trends. Unfortunately, per capita apparent consumption in Africa will continue decreasing, alarmingly more so in sub-Saharan Africa, where many depend on aquatic foods to meet their nutritional needs, particularly for animal proteins and micronutrients. Exports of aquatic products will continue to grow but will represent only 34 percent of total production in 2032, compared with 38 percent in 2022. Prices are expected to continue declining slightly in both nominal and real terms until 2025–2027, before increasing again.

UNITED STATES OF AMERICA
Cage culture in a floating fish farm.
© Tolga Aslantürk

PART 1
WORLD REVIEW

GLOBAL FISHERIES AND AQUACULTURE AT A GLANCE

Aquatic food systems are very diverse and offer a variety of environmental, economic and social benefits and services. They are increasingly recognized – at the global level and in many countries and communities – for their nutritional value and ecosystem services that contribute to sustaining healthy diets and aquatic biodiversity. More than ever before, they represent viable solutions and offer opportunities to improve global food security and nutrition, enhance livelihoods and preserve the environment.

Consolidation of the role of aquatic food systems requires the acceleration of transformative changes to achieve sustainable and equitable global fisheries and aquaculture. In 2021, FAO adopted Blue transformation as Programme Priority Area BP2,[b] aimed at maximizing the opportunities presented by aquatic food systems to enhance food security, improve nutrition, eradicate poverty and support the achievements of the 2030 Agenda for Sustainable Development. FAO developed the FAO Blue Transformation Roadmap to clarify concepts and offer guidance on its objectives and priority actions.[c]

The State of World Fisheries and Aquaculture 2024 presents the status of global fisheries and aquaculture, showcasing how, through "Blue Transformation in action", FAO, in coordination with Members and partners, promotes collaborative efforts and implements initiatives to support sustainable aquaculture intensification and expansion, effective management of global fisheries, and upgrading of aquatic food value chains. Following improvements in data collection and advancements in analytical and assessment tools and methodologies (Box 1), the data on the state of world fisheries and aquaculture production and utilization have been revised and expanded.

In 2022, the global production of aquatic animals reached a new world high of 185 million tonnes (live weight equivalent), an increase of 4 percent from 2020. Farming of aquatic animals produced an estimated 94 million tonnes, representing 51 percent of the total, surpassing for the first time capture fisheries, which produced 91 million tonnes (49 percent). Production from marine areas was 115 million tonnes (62 percent of the total), of which 69 percent was from capture fisheries and 31 percent from aquaculture. Inland waters contributed 70 million tonnes (38 percent of the total), of which 84 percent was from aquaculture and 16 percent from capture fisheries (Table 1 and Figure 1). The world fishing fleet continued to decrease from the 2019 peak of 5.3 million vessels to an estimated 4.9 million vessels in 2022, of which two-thirds were motorized.

The first sale value of the 2022 global production of aquatic animals was estimated at USD 452 billion, comprising USD 157 billion for capture fisheries and USD 296 billion for aquaculture. Of the total 185 million tonnes of aquatic animals produced in 2022 (Figure 2), about 164.6 million tonnes (89 percent) were destined for human consumption, equivalent to an estimated 20.7 kg per capita. The remaining 20.8 million tonnes were destined for non-food uses, to produce mainly fishmeal »

b See the Strategic Framework 2022–2031 for further details: https://www.fao.org/3/cb7099en/cb7099en.pdf

c See: https://doi.org/10.4060/cc0459en

BOX 1 FISHERIES AND AQUACULTURE STATISTICS: CHALLENGES AND OPPORTUNITIES

The crucial role of data in evidence-based policymaking, monitoring and performance evaluation depends on their accessibility, reliability and relevance. Over the years, most countries have developed systems for collecting and analysing fisheries and aquaculture statistics. Unfortunately, coverage and frequency of data collection remain a challenge for many countries. Use of non-standardized processes, combined with weak capacity for data collection, storage, digitalization and analysis, results in fragmentation of collection and dispersion of data across different institutions with limited communication and coordination.

Specific challenges include the following:

- Fisher and vessel registries are absent in many countries, hampering quality of employment and fleet statistics.
- Small-scale, subsistence (FAO, 2023) and recreational fisheries, and illegal, unreported and unregulated fishing often go unaccounted for.
- Transshipment is hard to track at sea, as are landings in in foreign ports, hindering collection of catch data and trade statistics.
- National household or labour surveys often fail to cover the necessary fisheries and aquaculture information, resulting in poor quality data.

The result is insufficient evidence of the importance of fisheries and aquaculture and their vital contribution to national development. This can obscure the visibility of aquatic food systems leading to their marginalization in national, regional or global policy and decision-making processes addressing resource allocation and international development.

These issues were discussed in a series of meetings organized by FAO in 2022, involving about 500 people representing 120 national focal points for the provision of fisheries and aquaculture statistics to FAO. A key outcome was a call for the urgent development of a new global strategy for fisheries and aquaculture statistics.* In addition, the meetings highlighted the need to support the development of national statistical strategies, strengthen institutional and technical capacities, and improve statistical systems to better design, monitor and evaluate the effectiveness of policies, interventions and programmes. In this regard, FAO should enhance its work on improving and developing adapted methodologies and tools for the collection of different typologies of fisheries and aquaculture statistics, in collaboration with other international and regional organizations, also within the framework of the Coordinating Working Party on Fishery Statistics of which FAO is Secretariat. FAO works to mobilize the necessary resources for this ambitious, yet fundamental programme to enhance national, regional and global data collection schemes for fisheries and aquaculture.

FAO is mandated by its Members to regularly produce updated and reliable information by collecting and curating global statistics, studies and analyses and by disseminating this information through its channels to serve for evidence-based policymaking, monitoring and performance evaluation (Ababouch *et al.*, 2016). FAO is the only source of global fisheries and aquaculture statistics (FAO, 2022); its FishStat database covers employment, fleet, production, utilization, trade and consumption, using primarily data collected annually from national sources. In the absence of national reporting, or in the event of insufficient or inconsistent data, FAO makes estimates based on the best data available from alternative authoritative sources using approved methodologies. These estimates enable meaningful aggregates at the global, regional and national levels. Overall, in 2022, the share of estimated data was 16 percent for production, 6 percent (compared to the usual 2 percent) for trade, 48 percent for employment and 44 percent for fleet. While these percentages may vary from year to year, data collection on employment and fishing vessels presents a major challenge for many countries.

The FishStat data collected and disseminated by FAO since 1950 reflect the evolution of fisheries and aquaculture statistics collection, with significant variations in the quality of the data received. The granularity of the data – for example, the level of detail by species – is critical for monitoring the exploitation of fishery resources and their economics along value chains. On the one hand, the granularity of the FAO production statistics has improved significantly – from 660 species items in the early 1950s to about 3 600 species items in 2022 (with approximately 3 400 items for the capture fisheries

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BOX 1 (Continued)

dataset and 730 for aquaculture); on the other, a significant share of production – 20 percent in 2022 (compared with 24 percent in the 1990s) – is still not reported at species level, but in broader groups, at family or higher taxonomic levels. The table shows that data reported under broader groups accounted for 6 percent of the total production in high-income countries in 2022, compared with 52 percent in low-income countries. The revised FAO Fishery and Aquaculture Statistics Yearbook** presents in tables T.8 and T.9 a detailed analysis of the evolution of these trends. Similar trends are encountered in trade statistics: granularity has improved over time (from about 32 percent of trade data reported by major species group in the 1970s to about 15 percent in 2022), but there is still much room for improvement.

SHARE OF FISHERIES AND AQUACULTURE PRODUCTION REPORTED UNDER GENERIC ITEMS AT FAMILY OR HIGHER TAXONOMIC LEVEL

	1980s	1990s	2000s	2010s	2020	2021	2022
World	**22.9**	**24.2**	**22.9**	**21.5**	**20.9**	**19.9**	**19.9**
Africa	35.9	33.1	30.6	27.3	28.6	27.9	26.9
Americas	8.8	6.9	5.6	5.4	5.1	4.3	4.3
Asia	37.9	37.4	31.2	26.7	25.4	24.4	24.2
Europe	7.9	5.8	5.7	4.5	3.6	3.4	3.3
Oceania	33.4	23.5	15.1	13.1	11.0	9.5	9.3
High-income countries	10.5	8.6	7.2	6.3	5.7	5.9	5.6
Upper-middle-income countries	30.1	28.1	21.4	18.0	16.3	15.1	15.1
Lower-middle-income countries	53.9	45.5	41.9	35.5	34.0	37.6	36.8
Low-income countries	79.9	68.4	59.0	52.3	51.9	50.7	51.5

SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

NOTES: * The most recent was in 2003 (FAO, 2003).
** Available at: https://www.fao.org/fishery/en/statistics/yearbook

SOURCES: Ababouch, L., Taconet, M., Plummer, J., Garibaldi, L. & Vannuccini, S. 2016. *Bridging the Science–Policy Divide to Promote Fisheries Knowledge for All: The Case of the Food and Agriculture Organization of the United Nations*. In: Bertrum, H., MacDonald, B.H., Soomai, S.S., De Santo, E.M. & Wells, P.G., eds. *Science, Information, and Policy Interface for Effective Coastal and Ocean Management.* Boca Raton, USA, CRC Press. https://doi.org/10.1201/b21483
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FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation*. Rome. https://doi.org/10.4060/cc0461en

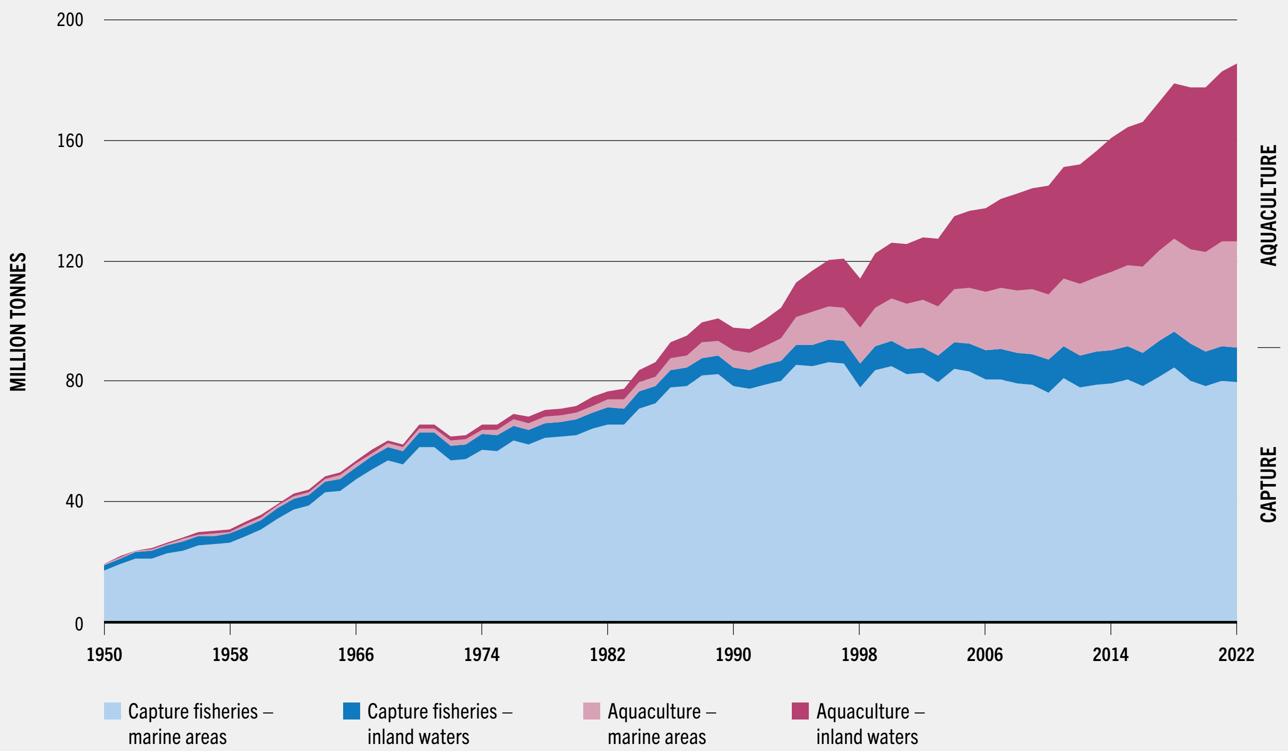
TABLE 1 WORLD FISHERIES AND AQUACULTURE TRENDS AT A GLANCE

	1990s	2000s	2010s	2020	2021	2022
	Average per year					
	(million tonnes, live weight equivalent)					
Production						
Capture fisheries:						
Inland	7.1	9.3	11.3	11.5	11.4	11.3
Marine	81.9	81.6	79.8	78.3	80.3	79.7
Total capture fisheries	**88.9**	**90.9**	**91.1**	**89.8**	**91.6**	**91.0**
Aquaculture:						
Inland	12.6	25.6	44.8	54.5	56.4	59.1
Marine	9.2	17.9	26.7	33.2	34.7	35.3
Total aquaculture	**21.8**	**43.4**	**71.5**	**87.7**	**91.1**	**94.4**
Total world fisheries and aquaculture	**110.7**	**134.3**	**162.6**	**177.5**	**182.8**	**185.4**
Utilization*						
Human consumption	81.6	109.3	143.1	157.4	162.5	164.6
Non-food uses	29.1	25.0	19.5	20.1	20.3	20.8
Apparent consumption per capita (kg)	14.4	16.9	19.5	20.2	20.6	20.7
Trade**						
Exports – in quantity	39.3	51.2	60.8	63.8	67.8	70.0
Share of exports in total production (%)	*35.4*	*38.3*	*37.5*	*35.8*	*36.9*	*37.6*
Exports – in value (USD billion)	46.6	76.4	141.8	151.0	176.6	192.2
Employment (millions of people)***						
Aquaculture	12.1	15.9	21.9	22.2	22.3	22.1
Fisheries	24.4	29.1	31.9	34.3	33.4	33.6
Unspecified	7.2	6.8	7.0	6.3	6.1	6.1
Fishing fleet (millions of vessels)****						
Motorized and non-motorized vessels	4.5	4.7	5.0	5.3	5.1	4.9

NOTES: Data on production, utilization and trade refer to aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data may not match totals due to rounding.
* Utilization data for 2020–2022 are provisional estimates. These data might differ from the apparent consumption data as they do not take into account trade.
** Exports including re-exports. Share of trade in total production calculated excluding re-exports. Trade data do not include frogs and turtles.
*** Employment refers to the number of people engaged in the primary sector only. Figures for the 1990s are based on 1995–1999 data.
**** Fishing fleet figures for the 1990s are based on 1995–1999 data.

SOURCES: For production: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.
For trade: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.
For employment: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook
Population data used to calculate apparent consumption per capita are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp

FIGURE 1 WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

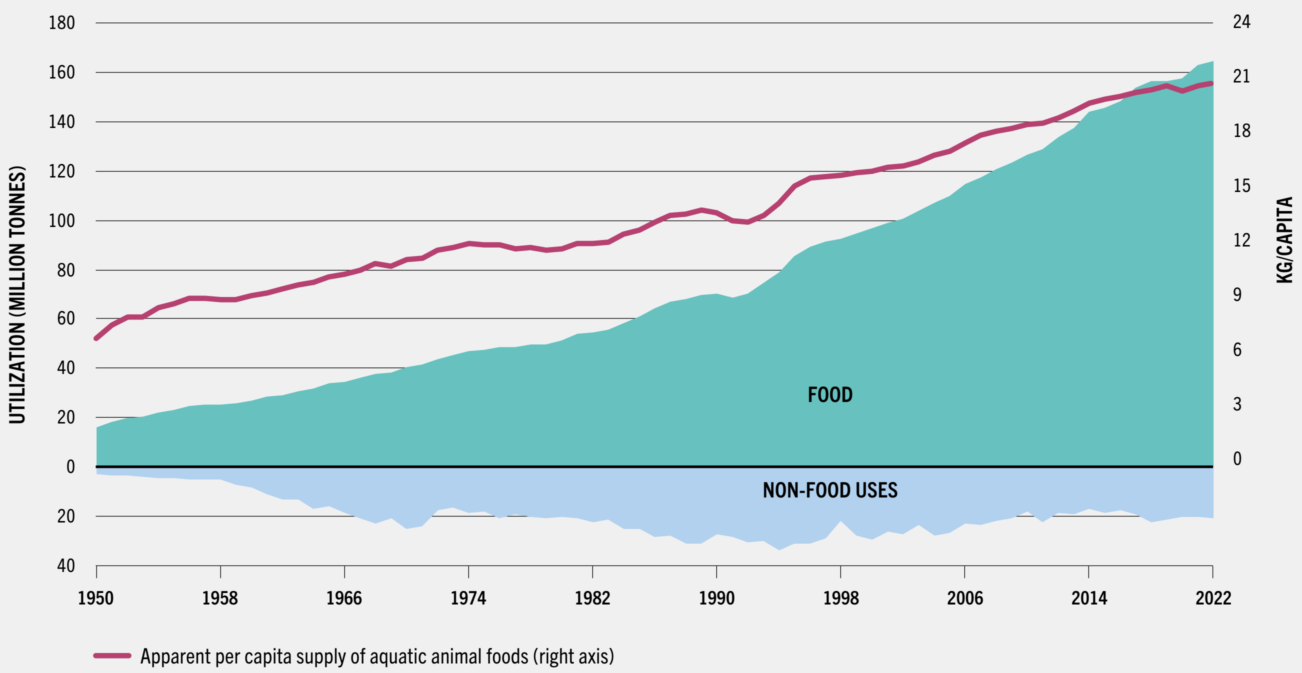
SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» and fish oil (17 million tonnes or 83 percent). Aquaculture consolidated its contribution to food for human consumption, supplying over 57 percent of aquatic animal foods (live weight equivalent) in 2022.

Over the decades, global apparent consumption of aquatic animal foods has increased significantly, at a higher annual growth rate than the world population. Between 1961 and 2021, apparent consumption of aquatic animal foods increased at an average annual rate of 3.0 percent compared with a world population annual growth rate of 1.6 percent for the same period. Per capita apparent consumption of aquatic animal foods grew on average by 1.4 percent per year, from 9.1 kg (live weight equivalent) in 1961 to 20.6 kg in 2021. The main drivers of the continuous growth in per capita consumption are increased supplies, advancements in preservation and distribution technology, changing consumer preferences, and income growth.

Following a decrease of 6.7 percent in the value of trade of aquatic animal products experienced in 2020 because of the COVID-19 pandemic, there was a rapid recovery starting in late 2020. It was driven by a robust recovery in global supply and demand and increasing commodity prices. This caused a significant rebound in 2021 and 2022, with trade of aquatic animal products in 2022 increasing by 19 percent compared with the pre-pandemic levels of 2019. Seventy million tonnes (live weight equivalent) of aquatic animal

FIGURE 2 UTILIZATION OF WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCES: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed on 13 January 2023]. https://population.un.org/wpp

products (38 percent of the total production), worth USD 192 billion (Table 1), were exported worldwide in 2022, representing more than 9.1 percent of total agricultural trade (excluding forest products) and about 1 percent of total merchandise trade in value terms in 2022. This represents a new world high, surpassing the 2018 record of USD 165 billion.

From a value of USD 7.9 billion in 1976, trade of aquatic animal products has experienced an average annual growth rate of 7.2 percent in nominal terms and 4.0 percent in real terms (adjusted for inflation). Exports of algae contributed an additional USD 1.6 billion and exports of other aquatic products such as sponges, corals, shells and inedible by-products added an extra USD 0.9 billion in 2022. The total export value of all aquatic products reached a record high of USD 195 billion in 2022.

Fisheries and aquaculture generate significant employment and support livelihoods in many coastal communities. In 2022, about 62 million people were engaged in the primary sector of fisheries and aquaculture as full-time, part-time, occasional or unspecified workers. About 54 percent of this workforce was engaged in fisheries and 36 percent in aquaculture, while the remaining 10 percent could not be broken down between fisheries and aquaculture. A significant proportion of this workforce was engaged in artisanal and small-scale operations. ■

TOTAL FISHERIES AND AQUACULTURE PRODUCTION

Total production of aquatic animals has increased over the decades, going from 19 million tonnes (live weight equivalent) in 1950 to an all-time record of over 185 million tonnes in 2022, with an average annual growth rate of 3.2 percent. The total first sale value was estimated at USD 452 billion in 2022, of which USD 296 billion came from aquaculture production.

The overall growth of production has been regular since 1950, except for a few marginal declines. The last decline was experienced in 2019 (−0.8 percent compared with 2018), followed by static production in 2020 and subsequent yearly increases of 3.0 percent in 2021 and 1.5 percent in 2022. The stagnation during 2019 and 2020 was mainly linked to a marginal decline in capture fisheries caused by fluctuating catches of pelagic species (particularly anchoveta), the reduction in China's catches and the impacts on the sector of the COVID-19 pandemic in 2020.

Global capture fisheries production has been relatively stable since the late 1980s, fluctuating between 86 million tonnes and 94 million tonnes per year with an isolated peak at 96 million tonnes in 2018. Aquaculture on the other hand has grown significantly during the same period (Figure 3), albeit at a slower rate during the last two decades. Aquaculture growth averaged 6.1 percent per year in the 2000s, 4.4 percent in the 2010s and 3.7 percent in the first three years of the 2020s. These decelerations are due to a range of factors, including the impact of recent policy changes in China focused on environmental protection, and reductions in the availability of land, water and sites suitable for aquaculture in the traditional producing regions and countries.

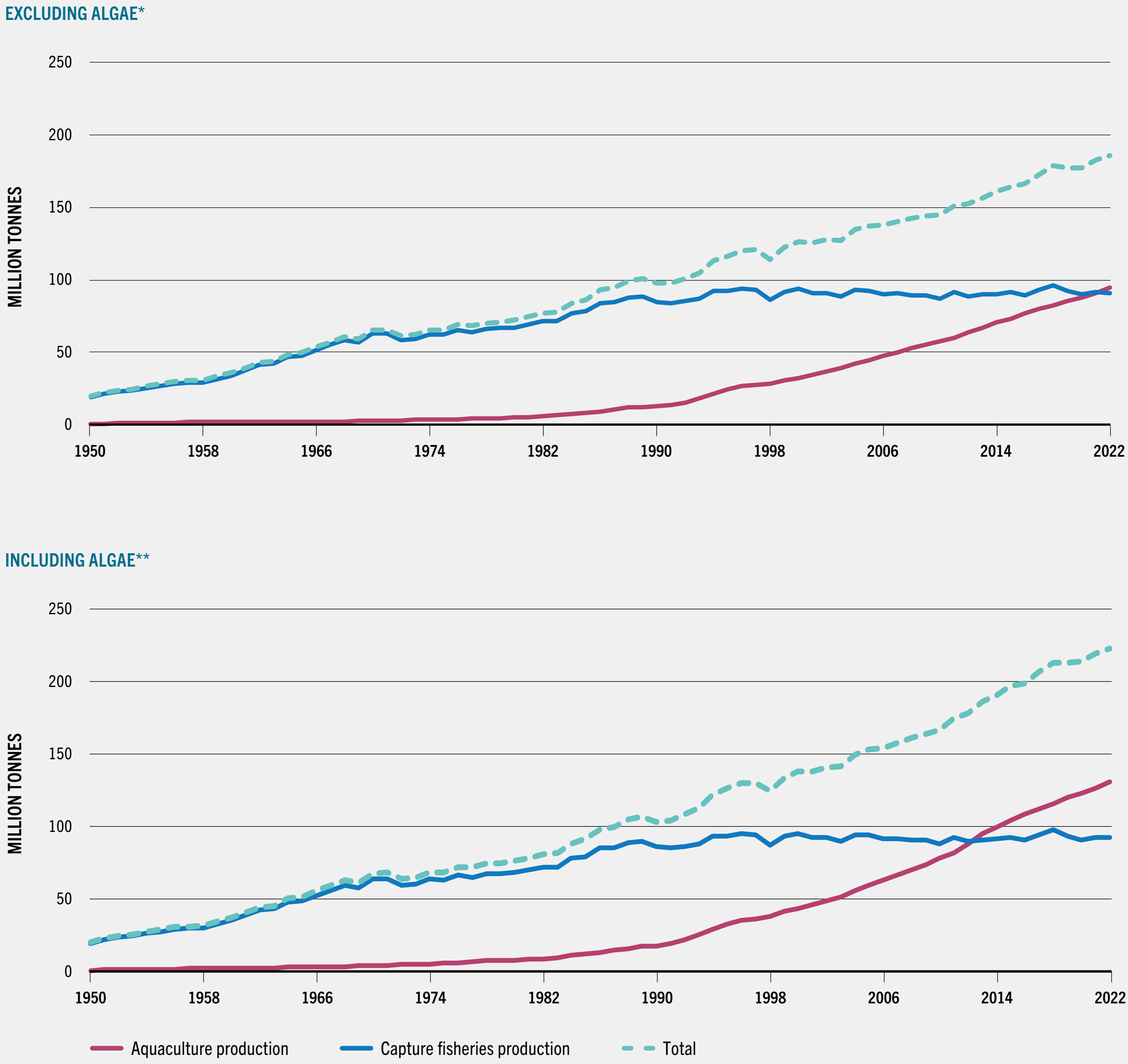
The share of aquaculture in total production was around 4 to 5 percent during the period 1950–1970, before rapidly rising to 20 percent in the 1990s and 44 percent in the 2010s. The year 2022 marked the first time in history that aquaculture production of aquatic animals surpassed capture fisheries production. Of the 185 million tonnes of aquatic animals produced in 2022, 51 percent (94 million tonnes) was from aquaculture and 49 percent (91 million tonnes) from capture fisheries. Aquaculture production in 2022 represents the second-highest yearly amount of aquatic animal production by subsector, following the over 96 million tonnes produced by capture fisheries in 2018.

Of the total production of aquatic animals in 2022, 62 percent (115 million tonnes) was harvested in marine areas (69 percent from capture fisheries, 31 percent from aquaculture) and 38 percent (70 million tonnes) in inland waters (84 percent from aquaculture, 16 percent from capture fisheries). The expansion of aquaculture in the last few decades has boosted the overall growth of production in inland waters. Between the 1950s and the late 1980s, fisheries and aquaculture production in inland waters fluctuated at around 12 percent of the total production of aquatic animals. With the growth of aquaculture production, this gradually increased to 18 percent in the 1990s, 26 percent in the 2000s and 35 percent in the 2010s. Capture fisheries in marine areas remain however the main source of production (43 percent of total aquatic animal production in 2022); still, this is well below the 87 percent share during 1950–1980. Marine capture fisheries are also the dominant method of production for several species and 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.

These general trends mask important variations between continents, regions and countries. In 2022, Asian countries produced 70 percent of the total output of aquatic animals, followed by countries in Europe and Latin America and the Caribbean (9 percent each), Africa (7 percent), Northern America (3 percent) and Oceania (1 percent).[d] Overall, total fisheries and aquaculture production has seen important increases in most of the continents in the last few decades (Figure 4). The exceptions are Europe (with a gradual decrease from the late 1980s, but recovering slightly since the late 2000s with some interannual fluctuations), Northern America and »

d The percentages do not add up to a total of 100 due to data on not identified countries (others nei) and rounding issues.

FIGURE 3 WORLD FISHERIES AND AQUACULTURE PRODUCTION



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent for aquatic animals and wet weight for algae. * Aquatic animals. ** Aquatic animals and algae.

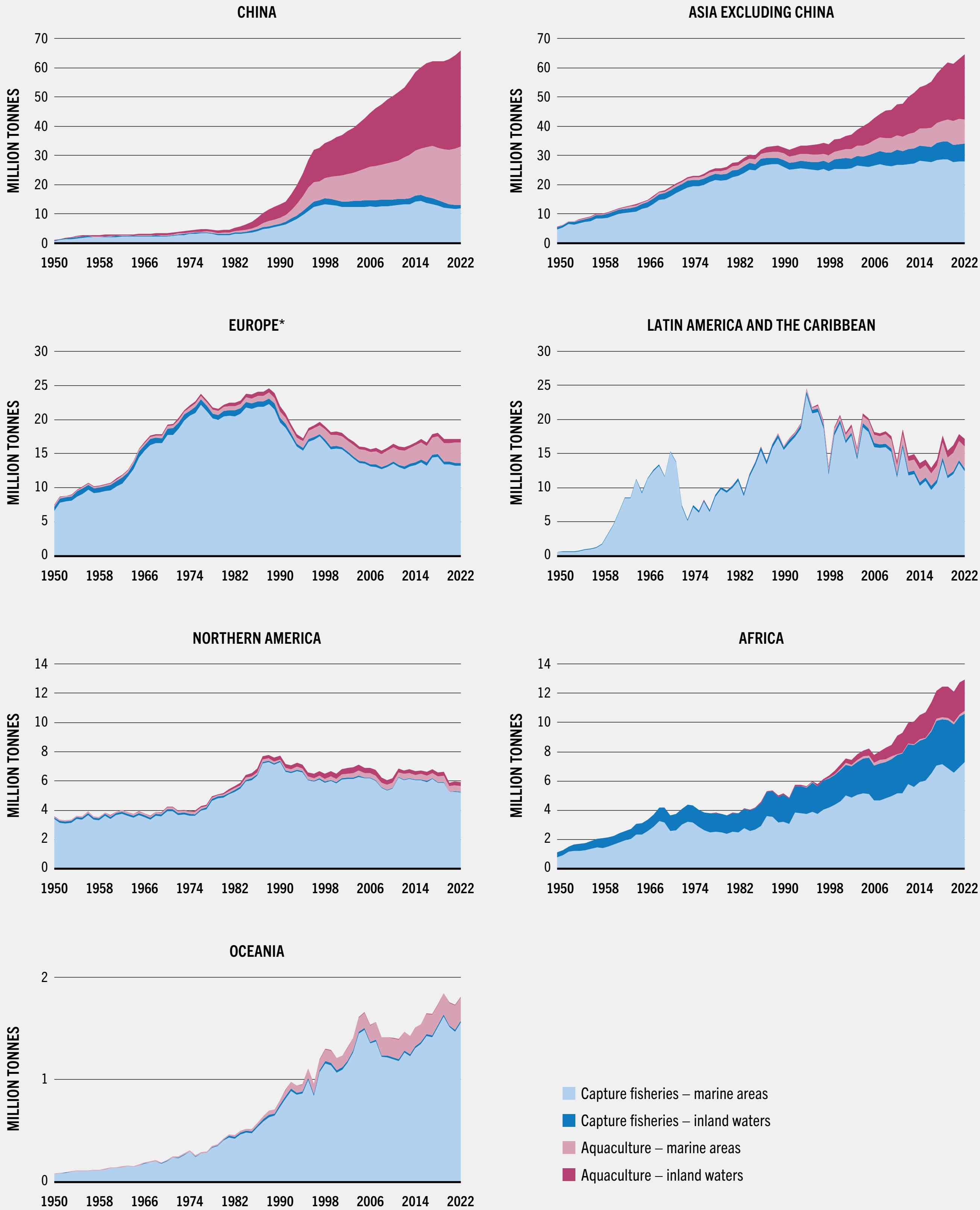
SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» Latin America and the Caribbean (with several ups and downs since the peak of the mid-1990s, mainly due to fluctuations in catches of anchoveta). Total production has almost doubled during the last 20 years in Africa and Asia.

In 2022, China remained the major producer (36 percent of the total production of aquatic animals), followed by India (8 percent), Indonesia (7 percent), Viet Nam (5 percent) and Peru (3 percent). These five countries were responsible for about 59 percent of the world production of aquatic animals in 2022. Differences exist also in terms of the sector's contribution to economic development.[e] In recent decades, the share of »

e The analysis by income groups carried out in this publication is based on the World Bank income group classification (2024 revision) that assigns the world's economies to four income groups: low, lower-middle, upper-middle and high. More information about the classification, including the country composition for each of the four groups, is available at: https://datatopics.worldbank.org/world-development-indicators/the-world-by-income-and-region.html

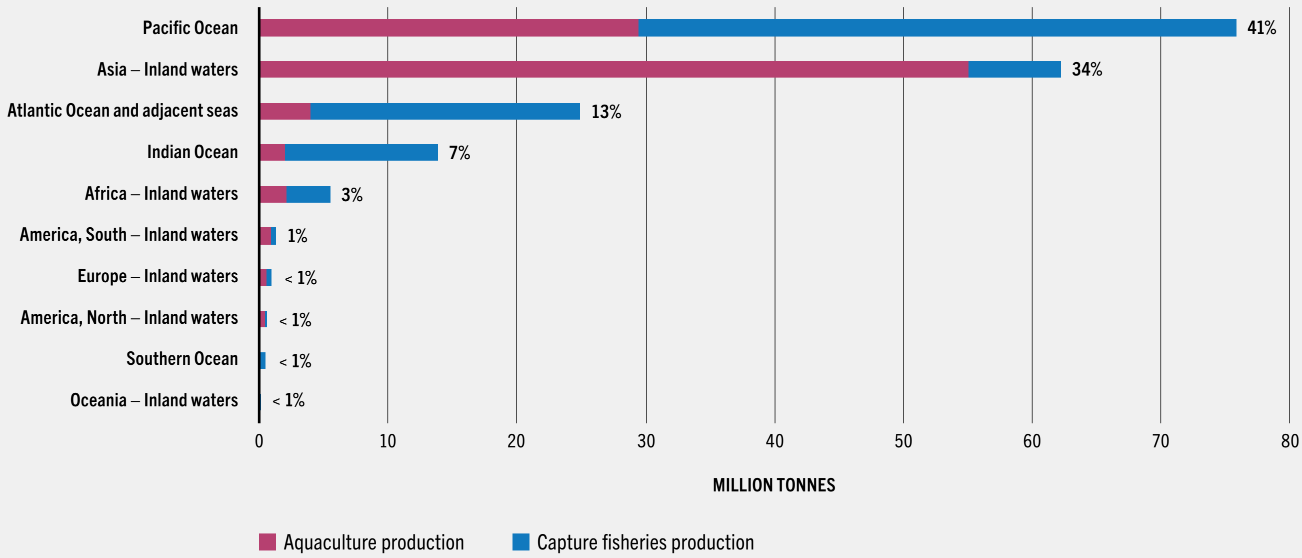
FIGURE 4 WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY REGION, 1950–2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent. Different scales used to improve the readability of the trends.
* Europe includes data for the Union of Soviet Socialist Republics for the years 1950–1991.

SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 5 WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY AREA AND RELATIVE SHARES OF WORLD PRODUCTION, 2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent. Areas based on FAO Major Fishing Areas.

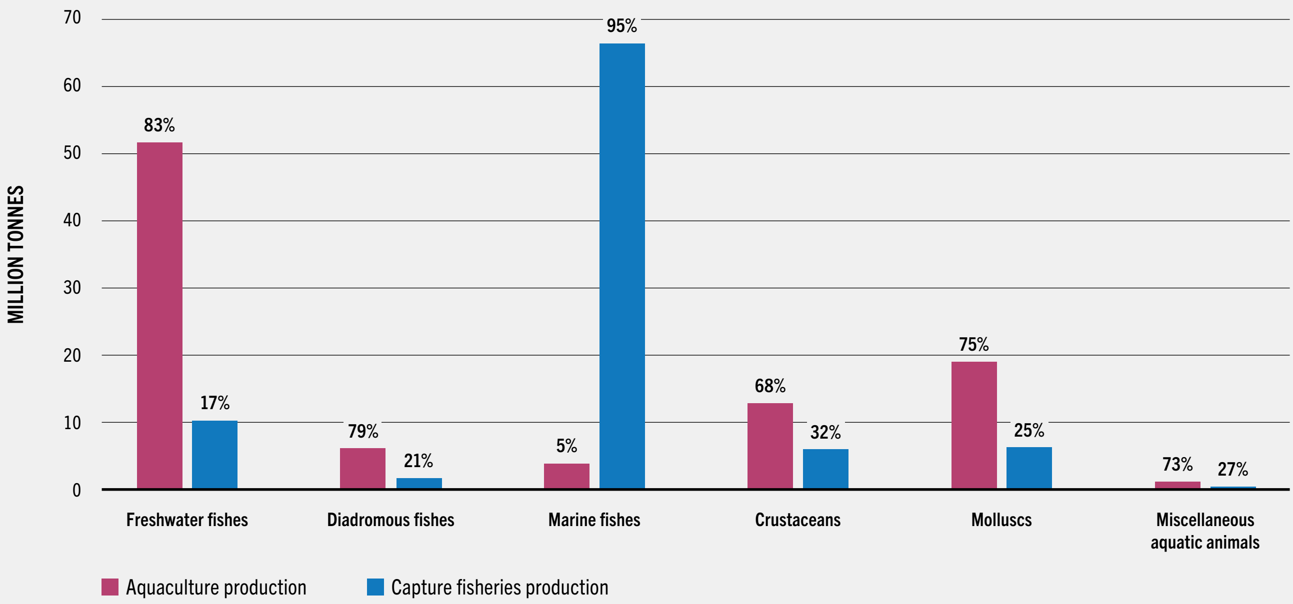
SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» total fisheries and aquaculture production of aquatic animals harvested by non-high-income countries (as per 2024 World Bank classification) has increased, rising from about 33 percent in the 1950s to 84 percent in 2022. Upper-middle-income countries, including China, were responsible for 56 percent of the total production of aquatic animals in 2022, followed by lower-middle-income countries (26 percent), high-income countries (16 percent) and low-income countries (2 percent).

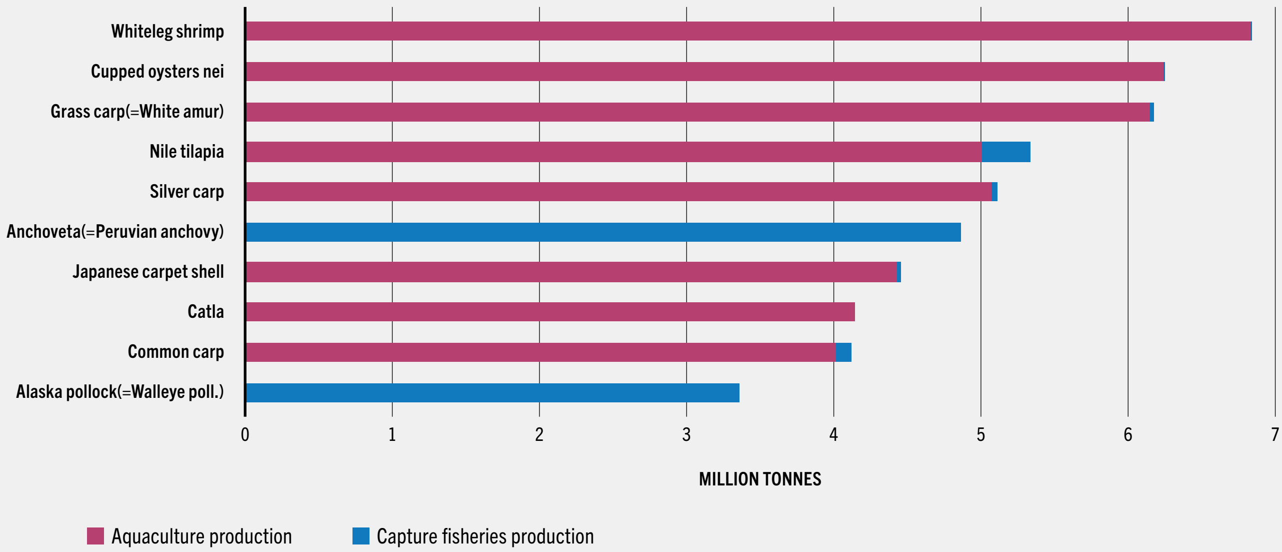
An analysis of the 2022 global fisheries and aquaculture data by FAO Major Fishing Area reveals significant differences. About 34 percent of the total production of aquatic animals came from inland waters in Asia, followed by 22 percent in the Pacific Northwest and 10 percent in the Western Central Pacific. It is worth highlighting that, while in the 1950s more than 40 percent of total production was harvested in the Atlantic Ocean and adjacent area, in contrast, the largest share of total production in 2022 originated in the Pacific Ocean (41 percent) against just 13 percent in the Atlantic Ocean (Figure 5). Production differs from area to area depending also on a range of factors, including the level of development of the coastal country to fully exploit its fishery resources, including through fishing agreements with distant water fishing nations; the fisheries and aquaculture management measures implemented; the amount of illegal, unreported and unregulated (IUU) fishing; the status of fishery stocks; the availability and productivity of inland waters; and the species harvested. As an example of the latter, in some fishing areas, capture fisheries production may vary more when catches comprise predominantly small pelagic fish, because they are more prone to significant fluctuations linked to climatic variability; this is the case for catches of anchoveta in the Pacific Southeast in South America (see **Impacts of El Niño on marine fisheries and aquaculture**, p. 202). »

FIGURE 6 WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY ISSCAAP DIVISION AND TOP TEN SPECIES ITEMS, 2022

A) ISSCAAP DIVISION



B) TOP TEN SPECIES ITEMS*



NOTES: ISSCAAP – International Standard Statistical Classification of Aquatic Animals and Plants.
Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
Data expressed in live weight equivalent.
* Excluding species items "marine fishes nei" and "freshwater fishes nei".

SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» The number of species harvested has varied greatly over the years, with major differences from region to region. Until the late 1970s, finfish represented about 90 percent of the total production of aquatic animals, compared with 75 percent in 2022; this was due to the increase in aquaculture production, which caused a rise in the shares of molluscs and crustaceans. In 2022, marine fishes represented 50 percent of the total finfish and 38 percent of the total aquatic animal production, followed by freshwater fishes, representing 44 percent of the total finfish and 33 percent of the total aquatic animal production. Carps, barbels and other cyprinids represented the main group of species produced in 2022, with a share of 18 percent of the production of aquatic animals, followed by miscellaneous freshwater species (11 percent) and Clupeiformes such as herrings, sardines and anchovies (10 percent). At the species level, whiteleg shrimp (*Penaeus vannamei*), with 6.8 million tonnes, was the top species produced in 2022, closely followed by cupped oysters nei (*Crassostrea* spp., 6.2 million tonnes), grass carp (=white amur; *Ctenopharyngodon idellus*, 6.2 million tonnes), Nile tilapia (*Oreochromis niloticus*, 5.3 million tonnes), silver carp (*Hypophthalmichthys molitrix*, 5.1 million tonnes) and anchoveta (=Peruvian anchovy; *Engraulis ringens*, 4.9 million tonnes). It is worthy of note that aquaculture was the main source of production of the top five species and of eight of the top ten species of aquatic animals in 2022 (Figure 6).

Production of algae reached 38 million tonnes (wet weight) in 2022, of which 97 percent originated from aquaculture. This is a 4 percent increase from 2020, continuing the impressive growth of the last decades, from just 12 million tonnes in 2000. Asian countries produced 97 percent of the total, with China alone accounting for 60 percent of the overall total algae produced, followed by Indonesia (25 percent), the Republic of Korea (5 percent) and the Philippines (4 percent). In addition, there were 10 420 tonnes of aquatic products such as sponges, corals, shells and pearls harvested from both aquaculture and capture fisheries operations.

Total production of algae, aquatic animals and aquatic products reached an all-time record of 223 million tonnes in 2022, with an overall growth of 1.9 percent compared with 2021 and 4.4 percent compared with 2020. Since 2013, aquaculture has overtaken capture fisheries as the primary source of total production, and this share reached 59 percent in 2022 (see Figure 3, p. 8). Of the 223 million tonnes, Asian countries produced 75 percent, followed by countries in Europe and Latin America and the Caribbean (8 percent each), Africa (6 percent), Northern America (3 percent) and Oceania (1 percent). China further confirmed its role as top producer with a share of 40 percent of the total, followed by Indonesia (10 percent) and India (7 percent). The overall value of total fisheries and aquaculture production was USD 472 billion in 2022. ■

AQUACULTURE PRODUCTION

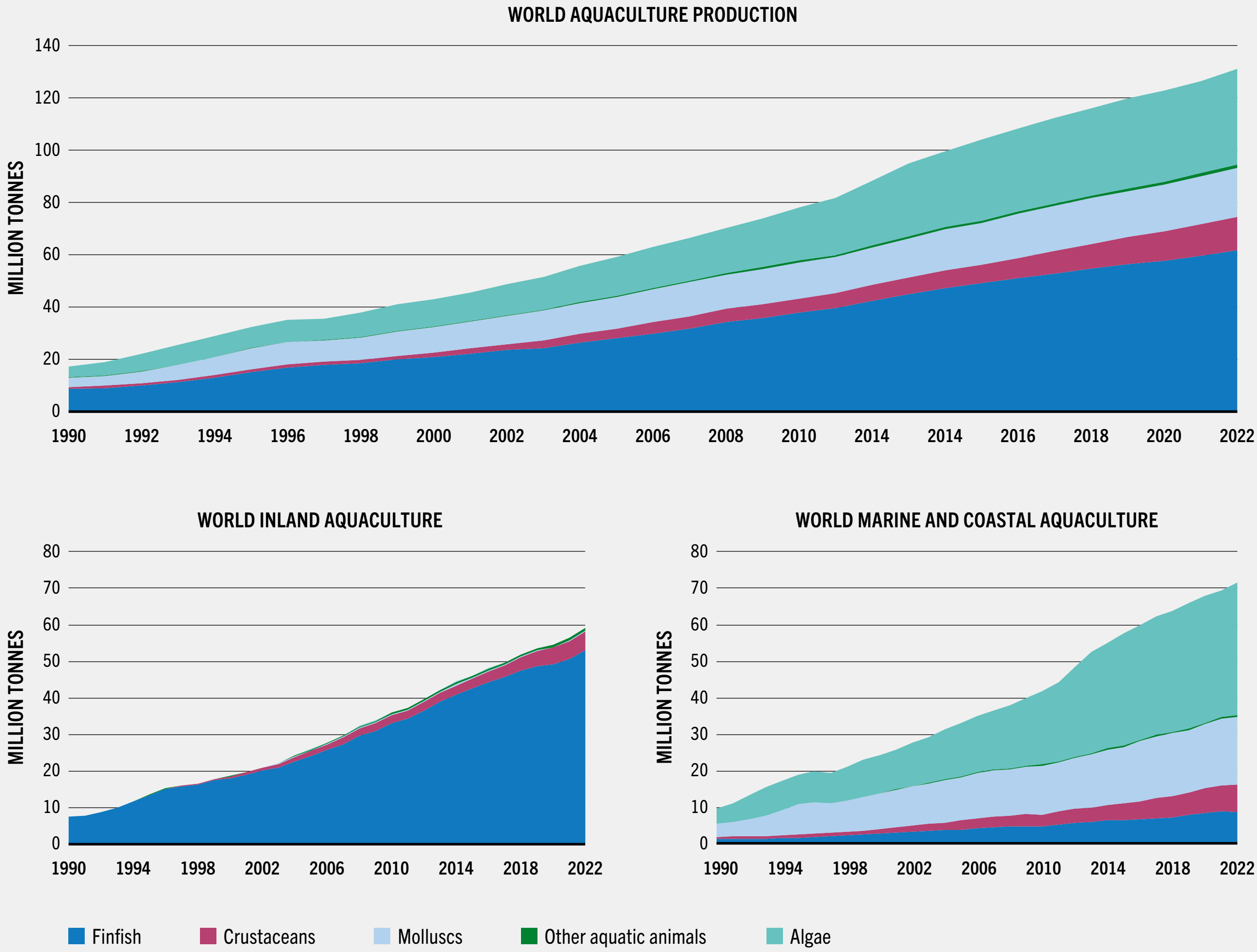
Overall production status and trends

Global aquaculture production continued its increasing trend in 2020, 2021 and 2022, undisrupted by the COVID-19 pandemic. Growth patterns differed between regions, countries and territories, with important disparities in the scale of production, distribution, farming technologies, performance and management.

World aquaculture production in 2022 achieved an all-time record of 130.9 million tonnes, up by 8.1 million tonnes from 122.8 million tonnes in 2020. Its estimated farm-gate value was USD 312.8 billion in 2022, an increase of USD 34.2 billion from USD 278.5 billion in 2020. It comprised 94.4 million tonnes (live weight equivalent; worth USD 295.7 billion) of aquatic animals and 36.5 million tonnes (wet weight; worth USD 17 billion) of algae (seaweed and micro-algae), plus a further 2 700 tonnes (worth USD 138.5 million) of shells and pearls.

The year 2022 was the first time in history that global aquaculture production of animal species surpassed capture production estimated at 91 million tonnes. In fact, the 2022 figure of 94.4 million tonnes of farmed aquatic animals was higher than the annual capture production for every year since 1950 – with the sole exception of

FIGURE 7 WORLD AQUACULTURE PRODUCTION, 1990–2022



NOTES: Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent for aquatic animals and wet weight for algae.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

2018, when 96.5 million tonnes of aquatic animals were caught from the wild.

The production of farmed animal species increased in 2022 by 6.7 million tonnes (7.6 percent) from 2020. This net increase was due mainly to Asia, whose contribution (5.9 million tonnes, 87.9 percent) was far higher than that of Latin America and the Caribbean (448 300 tonnes, 7.3 percent), Europe (232 100 tonnes, 3.5 percent), Africa (50 500 tonnes, 0.8 percent), Northern America (26 500 tonnes, 0.4 percent) and Oceania (10 100 tonnes, 0.2 percent). By species group, the net increase was mainly attributed to finfish (3.9 million tonnes, 58.1 percent), followed by crustaceans (1.6 million tonnes, 24.6 percent), molluscs (1 million tonnes, 15.6 percent) and other aquatic animal species (121 800 tonnes, 1.8 percent).

Global production of farmed algae reached 36.5 million tonnes in 2022, an increase of 1.4 million tonnes (4.1 percent) from the 2020 production of 35.1 million tonnes. This increase was the result of production expansions led by China, followed by Malaysia, the Philippines, the United Republic of Tanzania, the Russian Federation and a few others, unfortunately offset by drops (in descending order of reduction in output) in Indonesia, the Republic of Korea, Japan and a few other smaller producers.

The breakdown and trend of production by major farmed species group of aquatic animals from inland and marine and coastal aquaculture during the period 1990–2022 are illustrated in Figure 7.

Total world aquaculture production in 2022 grew by 87.9 million tonnes from 43 million tonnes in 2000, an increase of 204 percent (average yearly growth rate of 5.2 percent). In the same period, farming of aquatic animals expanded by 62 million tonnes from 32.4 million tonnes, a 191 percent increase (average yearly growth rate of 5 percent). The production of cultivated algae more than tripled in the same period. Different regions show huge differences in the scale of aquaculture production and its growth pattern (Table 2).

Within each region, the scale and annual variation pattern differ from country to country. Figure 8 illustrates the trend in annual variation during the period 2001–2022 in six regions.

Source of aquaculture data for analysis

The FAO aquaculture production statistics cover 208 producing countries and territories worldwide. They are the primary source of data used for the analytical review of status and trends in aquaculture development worldwide. They have been revised for some countries, based on newly available information and evidence, as per FAO's standard practice. For example, the revised data of global farmed aquatic animal production is 87.7 million tonnes for 2020, that is 0.2 million tonnes higher than the 87.5 million tonnes reported prior to the revision. However, even though the revisions for certain data-poor countries are significant – even drastic – they do not modify the conclusions drawn on the global and regional scales or on trends reported previously.

The issue of numerous countries not reporting aquaculture data continues to be of concern. In addition, the fact that confidential data may be excluded from national data reports exacerbates the operational difficulties faced by FAO; indeed, demonstrating the real scale of aquaculture at the required level of detail is challenging in an increasing number of countries, particularly high-income countries.

For example, in 2022, about half of the 208 aquaculture producers worldwide did not report data to FAO. The ratio of non-reporting to total producers by region was 27:52 in Africa, 25:48 in the Americas, 22:48 in Asia, 8:40 in Europe and 17:19 in Oceania. FAO estimates for non-reporting producers were 13.3 million tonnes of aquatic animals and 736 900 tonnes of algae; this compares with the data for reporting producers (including adjustments and estimates of missing or misreported data for some countries), which totalled 81.1 million tonnes of aquatic animals and 35.8 million tonnes of algae.

Production distribution and trend

Africa was reported in *The State of World Fisheries and Aquaculture 2022* as the only region that suffered a contraction in production during 2020 – the first year of the COVID-19 pandemic – caused mainly by reduced harvests in Egypt, Africa's top producer, and Nigeria, the top producer in sub-Saharan Africa. Africa produced just over 2.3 million tonnes of farmed aquatic animal species in 2022, an increase of only 50 500 tonnes (2.2 percent) from 2020 (Table 3). The net increase came mainly from inland aquaculture, mostly in Ghana, followed by Zambia, the United Republic of Tanzania and Rwanda.

In 2022, Egyptian aquaculture production was 2.2 percent (39 500 tonnes) lower than the 1.6 million tonnes produced in 2020 – the result of slight drops in two consecutive years – while Nigeria witnessed a fall to below its 2020 production level following a recovery in 2021. Double-digit percentage contractions

TABLE 2 WORLD AND REGIONAL AQUACULTURE PRODUCTION AND GROWTH

	Africa	Latin America and the Caribbean	Northern America	Asia	Europe	Oceania	World
Aquatic animal species*							
A. Production 2000 (tonnes)	399 622	838 939	584 495	28 422 489	2 052 889	121 824	32 420 258
B. Production 2022 (tonnes)	2 316 825	4 313 508	644 547	83 399 172	3 503 440	235 231	94 412 723
C. Overall growth 2000–2022 (tonnes)	1 917 203	3 474 569	60 052	54 976 683	1 450 551	113 407	61 992 465
D. Overall growth 2000–2022 (%)	479.8	414.2	10.3	193.4	70.7	93.1	191.2
E. Average annual growth rate 2000–2022 (%)	8.3	7.7	0.4	5.0	2.5	3.0	5.0
Algae**							
A. Production 2000 (tonnes)	51 642	33 582	0	10 487 877	6 040	16 424	10 595 565
B. Production 2022 (tonnes)	188 395	21 241	740	36 252 361	29 988	12 635	36 505 360
C. Overall growth 2000–2022 (tonnes)	136 753	–12 341	740	25 764 484	23 948	–3 789	25 909 795
D. Overall growth 2000–2022 (%)	264.8	–36.8	n/a	245.7	396.5	–23.1	244.5
E. Average annual growth rate 2000–2022 (%)	6.1	–2.1	n/a	5.8	7.6	–1.2	5.8
Aquatic animals and algae combined							
A. Production 2000 (tonnes)	451 264	872 521	584 495	38 910 366	2 058 929	138 248	43 015 823
B. Production 2022 (tonnes)	2 505 220	4 334 748	645 287	119 651 533	3 533 428	247 866	130 918 083
C. Overall growth 2000–2022 (tonnes)	2 053 956	3 462 227	60 792	80 741 167	1 474 499	109 618	87 902 260
D. Overall growth 2000–2022 (%)	455.2	396.8	10.4	207.5	71.6	79.3	204.3
E. Average annual growth rate 2000–2022 (%)	8.1	7.6	0.5	5.2	2.5	2.7	5.2

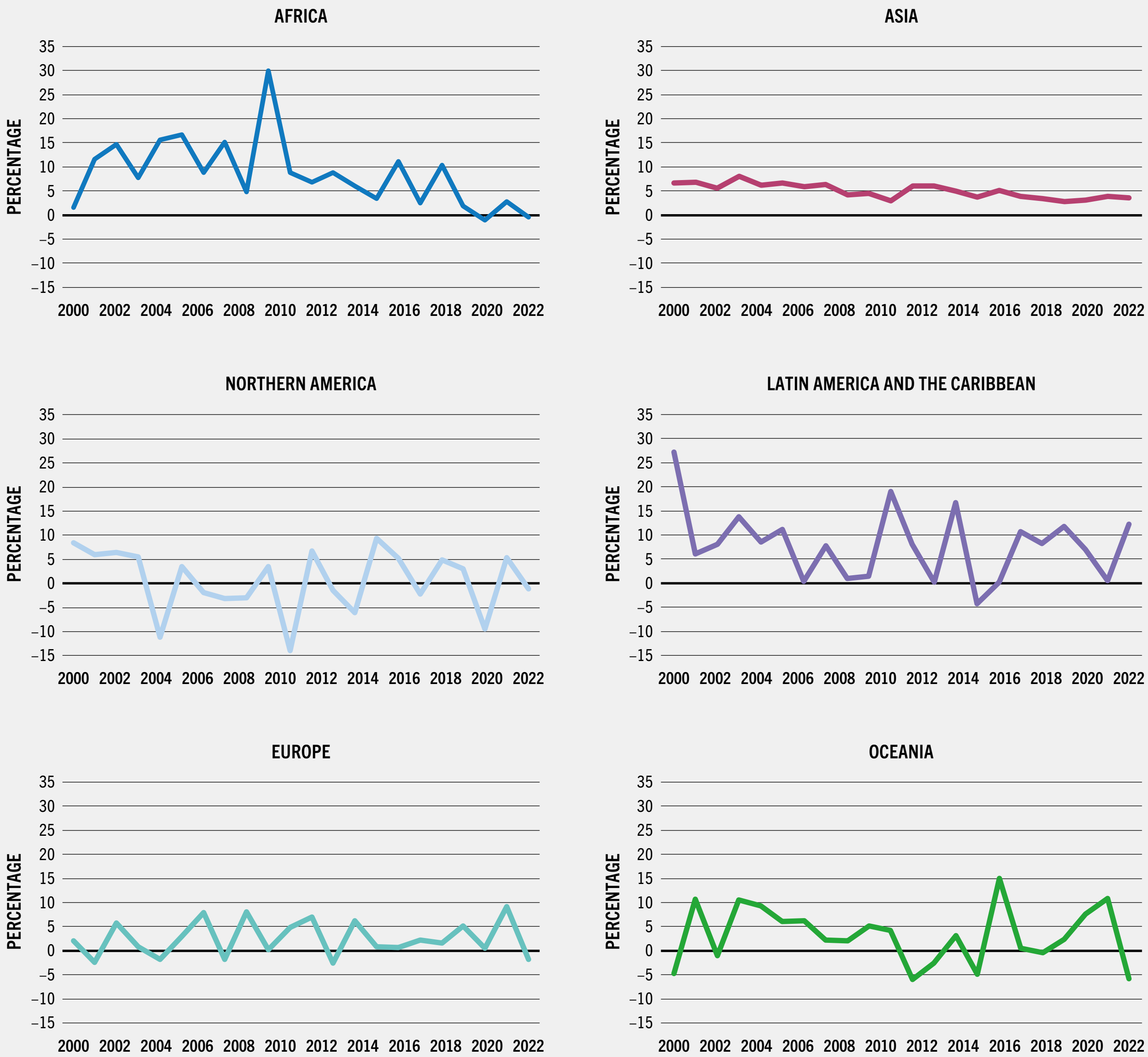
NOTES: n/a – not applicable.
* Excluding crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.
** Including marine macro-algae (seaweeds), micro-algae and cyanobacteria. Data expressed in wet weight.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

in output (compared with 2020 production levels) were observed in landlocked Malawi (–23.9 percent), Uganda (–18.2 percent) and Zimbabwe (–60.7 percent). Important African finfish producers adopting marine cage culture recorded decreases in production from 2020: by 11.6 percent in Tunisia, despite an all-time high in 2021, and by more than half (53.2 percent) in Mauritius.

Latin America and the Caribbean raised 4.3 million tonnes of aquatic animals in 2022, an increase of 448 300 tonnes (12.8 percent) from 3.8 million tonnes in 2020. This increase was largely driven by Ecuador (348 400 tonnes, 71.4 percent) and Brazil (108 000 tonnes, 22.1 percent), followed by Columbia (25 600 tonnes, 5.2 percent), Chile (22 700 tonnes, 4.6 percent) and the Bolivarian Republic of Venezuela (12 600 tonnes, 2.6 percent), and most of the smaller producers

FIGURE 8 ANNUAL GROWTH RATE OF AQUATIC ANIMAL AQUACULTURE PRODUCTION BY REGION, 2000–2022



NOTE: Aquatic animals excluding crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

in the region. Chile, the regional top producer, increased its production by just 1.5 percent. On the other hand, significant contractions in production were observed in Mexico and Cuba – by 59 000 tonnes (16.9 percent) and 10 500 tonnes (40.66 percent), respectively – compared with 2020. Peruvian aquaculture experienced growth in 2021, but then fell in 2022 by 2 percent »

TABLE 3 WORLD AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY REGION AND SELECTED MAJOR PRODUCERS

	2000	2005	2010	2015	2020	2021	2022	Share in regional total, 2022 (%)	2020/2022 variation
	(thousand tonnes, live weight equivalent)								
Africa	**400**	**646**	**1 289**	**1 788**	**2 266**	**2 328**	**2 317**	100	↗
Egypt	340	540	920	1 175	1 592	1 576	1 552	67.0	↘
Nigeria	26	56	201	317	262	276	259	11.2	↘
Ghana	5	1	10	45	64	89	133	5.7	↗
Uganda	1	11	95	118	124	139	101	4.4	↘
Others	28	38	64	134	225	249	271	11.7	↗
Americas	**1 423**	**2 177**	**2 515**	**3 280**	**4 443**	**4 494**	**4 958**	100	↗
Chile	392	724	701	1 046	1 486	1 427	1 509	30.4	↗
Ecuador	61	139	273	427	775	904	1 123	22.6	↗
Brazil	172	258	411	578	630	649	738	14.9	↗
United States of America	457	514	497	426	448	461	478	9.6	↗
Others	341	543	633	804	1 105	1 053	1 111	22.4	↗
Asia	**28 422**	**39 190**	**51 233**	**64 682**	**77 513**	**80 485**	**83 399**	100	↗
China	21 522	28 121	35 513	43 748	49 620	51 221	52 884	63.4	↗
India	1 943	2 967	3 786	5 341	8 636	9 403	10 230	12.3	↗
Indonesia	789	1 197	2 305	4 342	5 227	5 536	5 414	6.5	↗
Viet Nam	499	1 437	2 683	3 462	4 668	4 736	5 160	6.2	↗
Bangladesh	657	882	1 309	2 060	2 584	2 639	2 731	3.3	↗
Myanmar	99	485	851	997	1 145	1 167	1 197	1.4	↗
Thailand	738	1 304	1 286	921	1 012	991	1 001	1.2	↘
Others	2 177	2 796	3 500	3 810	4 623	4 792	4 783	5.7	↗
Europe	**2 053**	**2 144**	**2 533**	**2 956**	**3 271**	**3 570**	**3 503**	100	↗
Norway	491	662	1 020	1 381	1 490	1 665	1 648	47.0	↗
Russian Federation	74	115	120	152	270	295	320	9.1	↗
Spain	311	225	257	297	277	280	276	7.9	↘
United Kingdom of Great Britain and Northern Ireland	152	173	201	212	220	239	203	5.8	↘
France	267	245	203	163	191	193	200	5.7	↗
Greece	95	106	121	107	132	144	142	4.1	↗
Italy	214	182	153	149	126	146	133	3.8	↗
Others	448	436	457	496	566	608	582	16.6	↗
Oceania	**122**	**154**	**190**	**178**	**225**	**250**	**235**	100	↗
Australia	32	45	76	83	103	129	125	53.2	↗
New Zealand	86	105	111	91	119	117	106	45.1	↘
Papua New Guinea	0	0	2	2	2	2	2	0.8	↗
New Caledonia	2	3	1	1	1	1	1	0.6	↗
Others	2	0	1	0	1	1	1	0.2	↗

NOTE: Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj.

» compared with its 2020 level; the strong growth in the marine shrimp and finfish subsectors was unable to offset the plunge by 44.2 percent in the harvest of farmed scallop.

Northern America increased its overall farmed aquatic animal production, reaching 644 500 tonnes in 2022, up by 4.3 percent from 618 000 tonnes in 2020. The United States of America saw a 6.7 percent rise to 478 100 tonnes in 2022, while production in Canada dropped by 2 percent to 166 500 tonnes. These levels were lower than their record-high production levels of 607 600 tonnes (United States of America, 2004) and 200 800 tonnes (Canada, 2016).

Asia harvested 83.4 million tonnes of farmed aquatic animals in 2022, up by 5.9 million tonnes (7.6 percent) from 77.5 million tonnes in 2020. China remained the major driver, contributing 55.4 percent (3.3 million tonnes) of the growth in Asian aquaculture. India produced 10.2 million tonnes in 2022 (an increase from 8.6 million tonnes in 2020) and was second after China, contributing 27.1 percent (1.6 million tonnes) to Asia's aquaculture growth, followed in order of importance by Viet Nam, Bangladesh and Indonesia with a combined contribution of 14.1 percent (826 400 tonnes). Thailand and the Philippines were the only two of the top ten Asian producers whose 2022 production contracted compared with 2020 – by 5.8 percent (49 900 tonnes) and 1 percent (10 400 tonnes) respectively. Among other Asian producers, Türkiye was the main contributor to the increase in West Asia, while Uzbekistan and Kyrgyzstan were the main contributors to the growth in Central Asia.

Europe farmed 3.5 million tonnes of aquatic animals in 2022, up by 232 100 tonnes (7.1 percent) from 3.3 million tonnes in 2020. This increase in production came mainly from Norway (158 200 tonnes, 68.1 percent), followed by the Russian Federation (49 200 tonnes, 21.2 percent). The Faroe Islands, Iceland, Greece, France, Italy, Ireland and Croatia, in order of importance, contributed 68 200 tonnes (29.4 percent) collectively. In the same period, there was a total drop in production of 47 800 tonnes in 17 European countries, mainly in the United Kingdom of Great Britain and Northern Ireland, followed by Germany, Bulgaria, Denmark and Ukraine.

Oceania recorded an increase in farmed production of aquatic animal species of 10 100 tonnes, up by 4.5 percent from 225 100 tonnes in 2020 to 235 200 tonnes in 2022. This was mainly due to the 22 percent growth in Australia, contrasted by a 10.5 percent fall in New Zealand. Indeed, the combined production of the other 18 island countries and territories in the region was much smaller, unchanged from the 2020 estimated figure of 3 800 tonnes.

The regional disparity in aquaculture production reflects significant differences at the country level. Figure 9 presents the production distribution patterns for six selected species and subsectors of aquaculture, typically characterized by the dominance of a small number of leading producers.

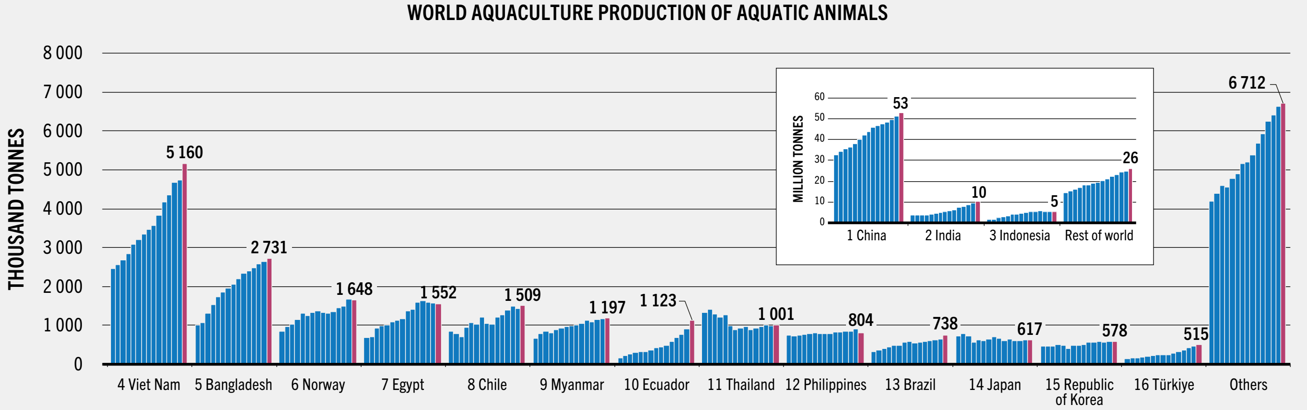
Aquaculture contribution to total fisheries and aquaculture production

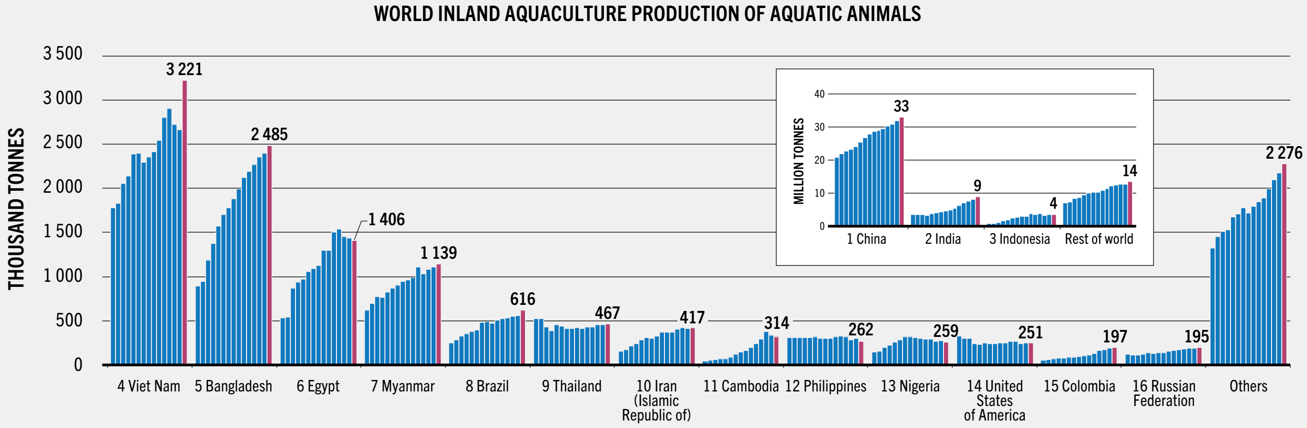
World production of farmed aquatic animals contributed 50.9 percent to the combined production of capture and aquaculture in 2022, up from 49.4 percent in 2020. Aquaculture production has surpassed capture fisheries for years in several countries, particularly major aquaculture producers, led by China, India, Viet Nam and Bangladesh, as well as some small producers with limited capture fishery resources such as Jordan or Lesotho. In 2022, there were 45 countries where farmed production of aquatic animals exceeded capture fisheries production. There were a further ten producers whose aquaculture share ranged between 40 and 50 percent of the total, including (in order of production) Indonesia, Norway, Chile, Thailand and Brazil. In many other countries, especially low-income countries, aquaculture remains insignificant (Figure 10) and it is vital that aquaculture development be urgently accelerated in countries which have an aquaculture potential.

Inland aquaculture

Global aquaculture of aquatic animals in inland waters produced 59.1 million tonnes in 2022, accounting for 62.6 percent of the total world aquaculture production. Finfish contributed 89.7 percent of global inland aquaculture production, followed by crustaceans (8.7 percent), far ahead of all other species »

FIGURE 9 AQUACULTURE PRODUCTION OF SELECTED MAIN SPECIES GROUPS BY MAJOR PRODUCER, 2008–2022





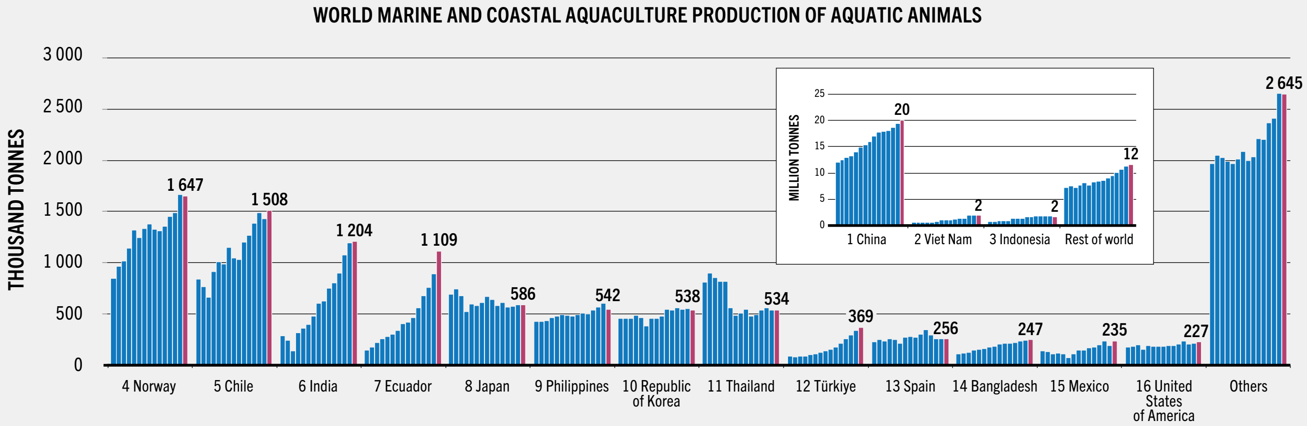
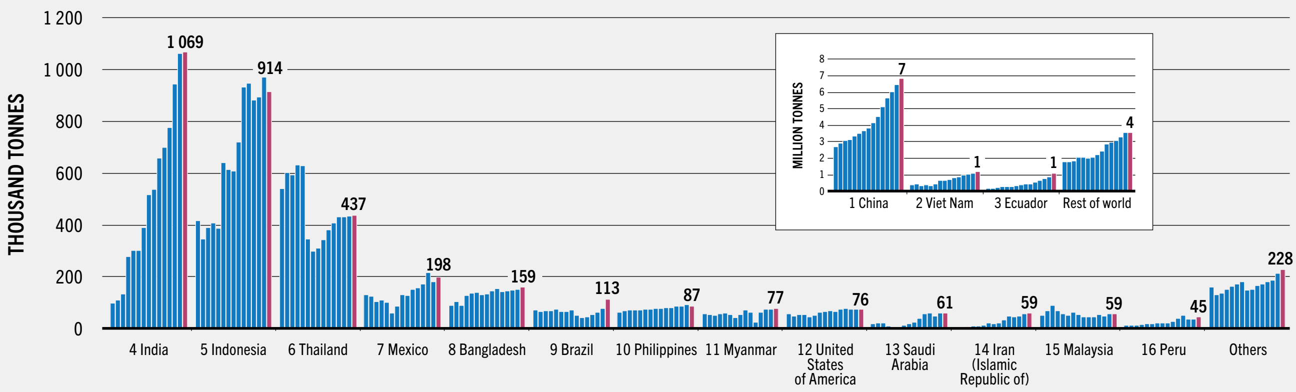
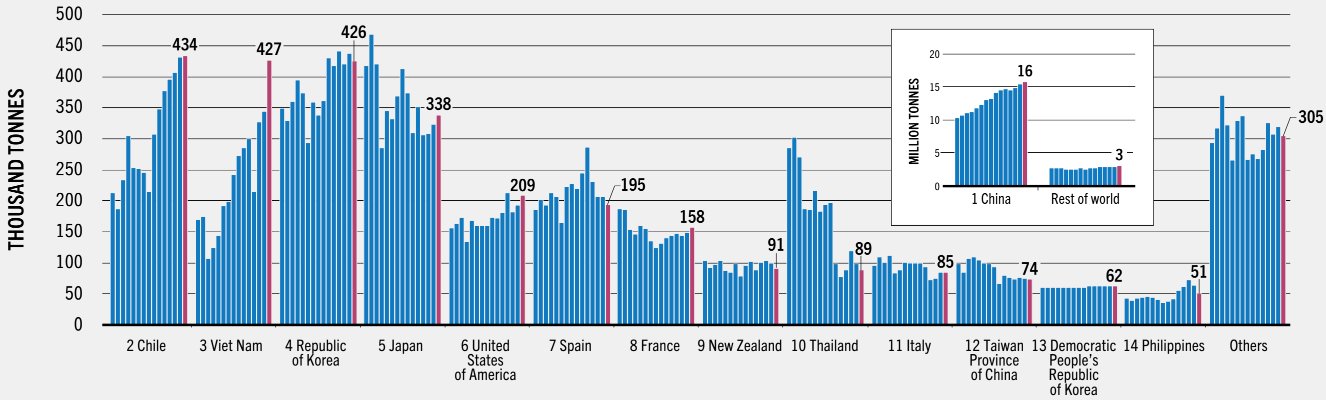


FIGURE 9 (Continued)

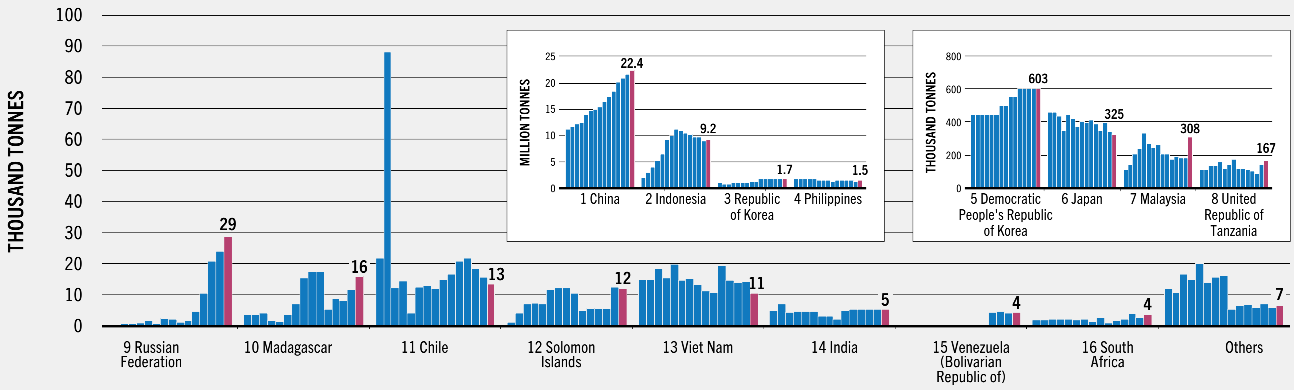
WORLD AQUACULTURE PRODUCTION OF CRUSTACEANS



WORLD AQUACULTURE PRODUCTION OF MOLLUSCS



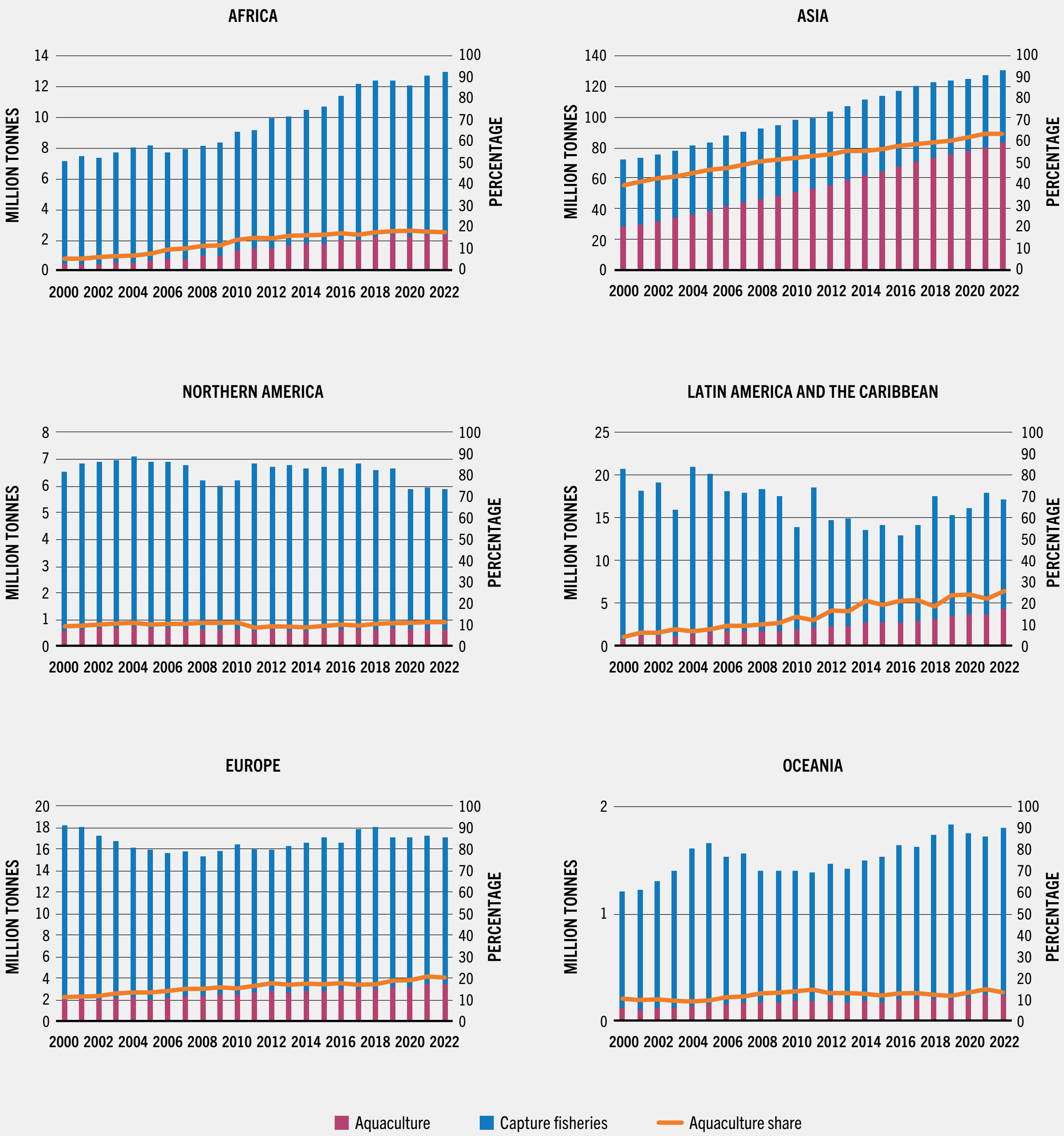
WORLD AQUACULTURE PRODUCTION OF ALGAE



NOTES: Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent for aquatic animals and wet weight for algae. Blue bars from left to right represent the years 2008–2021; red bars represent the year 2022.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 10 SHARE OF AQUACULTURE IN TOTAL FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY REGION, 2000–2022



NOTES: Aquatic animal excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data in million tonnes expressed in live weight equivalent. Different scales used to improve the readability of the trends.

SOURCE: FAO. 2024. FishStat: Global production by production source 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

TABLE 4 WORLD INLAND AQUACULTURE AND MARINE AND COASTAL AQUACULTURE PRODUCTION BY REGION AND MAIN SPECIES GROUP, 2022

	Africa	Latin America and the Caribbean	Northern America	Asia	Europe	Oceania	World	Share of species group in total (%)
	(tonnes, live weight equivalent)							
Finfish	2 129 550	1 103 656	184 236	49 045 562	524 373	5 665	52 993 044	89.7
Crustaceans	4	262	73 676	5 082 690	3 344	72	5 160 047	8.7
Molluscs	n/a	n/a	n/a	203 898	8	n/a	203 898	0.3
Other aquatic animals	n/a	393	n/a	715 144	n/a	n/a	715 545	1.2
Inland aquaculture – all aquatic animals	**2 129 554**	**1 104 311**	**257 912**	**55 047 294**	**527 725**	**5 737**	**59 072 534**	**100**
Share of region (%)	*3.6*	*1.9*	*0.4*	*93.2*	*0.9*	*0.0*	*100*	
Finfish	169 787	1 088 564	134 942	4 702 468	2 365 259	112 742	8 573 763	24.3
Crustaceans	8 959	1 621 429	2 035	5 947 142	687	11 111	7 591 363	21.5
Molluscs	8 407	499 117	249 658	17 245 928	598 672	105 640	18 707 422	52.9
Other aquatic animals	118	88	0	456 339	11 096	0	467 642	1.3
Marine and coastal aquaculture – all aquatic animals	**187 271**	**3 209 198**	**386 635**	**28 351 877**	**2 975 714**	**229 493**	**35 340 190**	**100**
Share of region (%)	*0.5*	*9.1*	*1.1*	*80.2*	*8.4*	*0.6*	*100*	
Finfish	2 299 337	2 192 220	319 178	53 748 030	2 889 632	118 407	61 566 807	65.2
Crustaceans	8 963	1 621 691	75 711	11 029 832	4 031	11 183	12 751 410	13.5
Molluscs	8 407	499 117	249 658	17 449 826	598 680	105 640	18 911 320	20.0
Other aquatic animals	118	481	0	1 171 483	11 096	0	1 183 187	1.3
Total aquaculture – all aquatic animals	**2 316 825**	**4 313 509**	**644 547**	**83 399 171**	**3 503 439**	**235 230**	**94 412 724**	**100**
Share of region (%)	*2.5*	*4.6*	*0.7*	*88.3*	*3.7*	*0.2*	*100*	
Inland aquaculture – micro-algae	172	2 156	n/a	100 130	295	n/a	102 753	0.3
Marine and coastal aquaculture – seaweeds	188 223	19 084	740	36 152 231	29 694	12 635	36 402 607	99.7
Total aquaculture – algae*	**188 395**	**21 240**	**740**	**36 252 361**	**29 989**	**12 635**	**36 505 360**	**100**
Share of region (%)	*0.5*	*0.1*	*0.0*	*99.3*	*0.1*	*0.0*	*100*	
Total aquaculture – all species	**2 533 433**	**4 333 798**	**645 287**	**119 641 632**	**3 533 428**	**247 865**	**130 935 443**	
Share in world total (%)	*1.9*	*3.3*	*0.5*	*91.4*	*2.7*	*0.2*	*100*	

NOTES: n/a – no production or production data unavailable. Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges). Data may not match totals due to rounding.
* Data on algae expressed in wet weight.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» groups (Table 4). At the regional level, farming of crustaceans, molluscs and other species such as aquatic turtles and frogs is of limited importance except in Asia. Within Asia, farming of non-fish species is mostly practised in East and Southeast Asia.

World inland aquaculture employs a diverse range of culture methods and technologies. It varies greatly in terms of input intensity, level of technological and management sophistication, and degree of integration with other economic activities. Globally, raising finfish and other species in constructed earthen ponds remains the most widely adopted culture method. In the recent past, many technical innovations in pond-based aquaculture production have been adopted by farmers to improve production efficiency and to reduce impact on the environment. For example, the in-pond raceway system, characterized by higher production rate and lower fish waste accumulation in the farming environment, is increasingly adopted in many provinces in China, followed by, to a lesser extent, other countries including Viet Nam, Colombia, Mexico, Uzbekistan, Bangladesh and Egypt. Fish farm cluster-based effluent treatment with constructed wetland and a low-cost filter for recycled use of water is another example.

Mariculture and coastal aquaculture

Mariculture – or marine aquaculture – takes place in the sea and may last the entire production cycle or only the grow-out phase. Mariculture lasting the full cycle is for species dependent on wild seeds from the sea, for example, sea mussels. On the other hand, mariculture lasting only the grow-out phase is for species produced in a land-based hatchery and sometimes even in freshwater, as is the case with Atlantic salmon. Coastal aquaculture, typically practised in constructed ponds onshore or in intertidal zones, plays an important role by providing livelihoods and employment, facilitating economic development among coastal communities in many countries, particularly in Asia and Latin America.

Global production of marine and coastal aquaculture reached 71.1 million tonnes in 2022, including 35.3 million tonnes of aquatic animals and 36.4 million tonnes of algae. Table 4 presents data on mariculture and coastal aquaculture production in 2022, disaggregated by region and by main species group.

Separating the production of mariculture from coastal brackish water is traditionally difficult, as the two are often aggregated in national production data, particularly from countries farming finfish in both environments. Figure 11 herein presents an estimation of the production of major species groups since 2016, separating mariculture and coastal aquaculture, using information and data from alternative sources. On a global scale, seaweed farming and mollusc culture are overwhelmingly dominated by production in the sea, while crustaceans are primarily raised in coastal brackish water ponds and tanks. According to the available information, cage culture in the sea contributes around 65 percent of the total world production of finfish farmed in marine and coastal aquaculture combined.

Aquaculture production with and without feeding

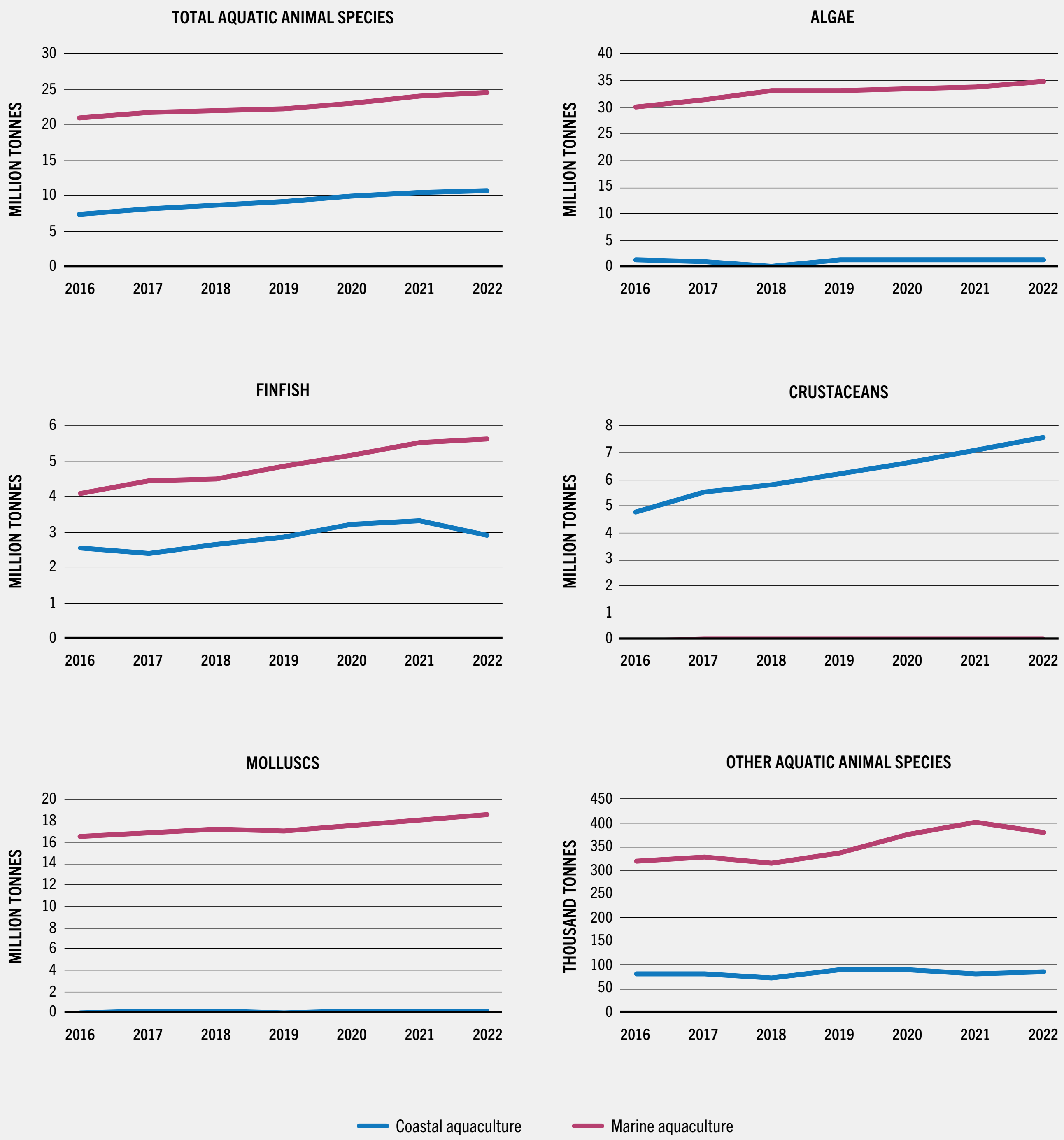
The production of fed aquaculture continued to outpace that of non-fed aquaculture in 2021–2022. Globally, the share of non-fed aquaculture in total farmed animal species production fell from 39.7 percent in 2000 to 27.6 percent in 2020 and to 26.9 percent in 2022 (Figure 12).

However, in inland or coastal multispecies polyculture systems, the separation between fed and non-fed species is not easily defined, as feeds intended for fed species benefit also filter-feeding species, especially when using powder feeds or pellet feeds with low water stability that dissolve quickly. In some areas in Asia, for example, bivalve species such as hard clams and constricted razor clams grown in coastal ponds are intentionally fed with specially prepared feed in fine particle form at the final stage of culture for "fattening" purposes.

Farmed aquatic species and diversity

FAO's global aquaculture production statistics dataset 1950–2022 released in March 2024 reports 731 statistical units technically known as "species items" – an increase from the 652 reported »

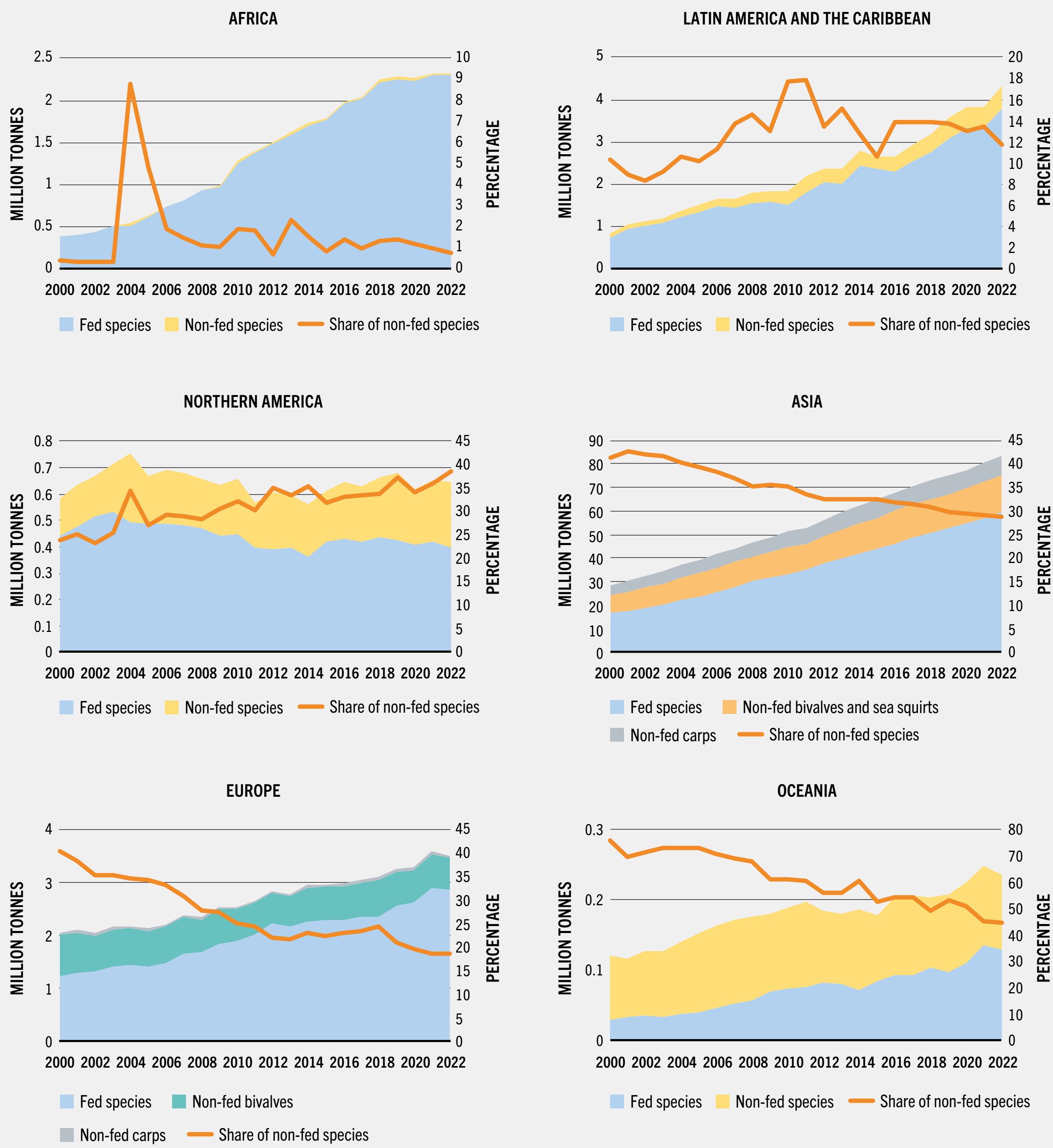
FIGURE 11 COMPOSITION OF WORLD MARINE AND COASTAL AQUACULTURE BY MAIN SPECIES GROUP, 2016–2022



NOTES: Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent for aquatic animals and wet weight for algae. Different scales used to improve the readability of the trends.

SOURCE: FAO estimates based on FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 12 FED AND NON-FED AQUACULTURE PRODUCTION OF ANIMAL SPECIES BY REGION, 2000–2022



NOTE: Data expressed in live weight equivalent.

SOURCE: FAO estimates based on FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

TABLE 5 WORLD PRODUCTION OF MAJOR AQUACULTURE SPECIES AND MAIN SPECIES GROUPS

Species or species group	2018	2019	2020	2021	2022	Share of species in species group, 2022 (%)
	(thousand tonnes, live weight equivalent)					
Finfish	**54 564**	**56 354**	**57 681**	**59 602**	**61 567**	**100**
Carps	29 015	29 426	30 208	30 901	31 788	51.6
Catfishes	5 782	6 286	6 092	6 199	6 628	10.8
Cichlids	6 043	6 407	6 066	6 293	6 549	10.6
Salmonids	3 517	3 812	3 996	4 205	4 243	6.9
Milkfish	1 327	1 297	1 284	1 278	1 196	1.9
Largemouth black bass	434	480	621	704	804	1.3
Snakeheads	554	583	649	687	690	1.1
Sea breams and porgies	391	436	485	533	564	0.9
Other finfish	7 500	7 628	8 280	8 803	9 105	14.8
Crustacean	**9 501**	**10 422**	**11 108**	**11 948**	**12 751**	**100**
Penaeid shrimps	6 056	6 504	6 881	7 405	7 934	62.2
Red swamp crayfish	1 714	2 168	2 469	2 710	2 967	23.3
Chinese mitten crab	757	779	776	808	815	6.4
River prawns	533	536	553	590	600	4.7
Swimming crabs	419	404	399	396	395	3.1
Other crustaceans	22	31	30	39	40	0.3
Molluscs	**17 524**	**17 407**	**17 869**	**18 434**	**18 911**	**100**
Oysters	5 998	6 129	6 270	6 685	7 072	37.4
Clams, cockles and arkshells	4 212	4 100	4 350	4 426	4 514	23.9
Scallops	2 141	2 055	1 970	2 077	2 022	10.7
Sea mussels	2 093	2 032	2 046	2 024	1 927	10.2
Constricted tagelus	853	869	860	860	848	4.5
Other molluscs	2 227	2 222	2 373	2 363	2 528	13.4
Other animals	**918**	**978**	**1 061**	**1 143**	**1 183**	**100**
Soft-shell turtles	321	327	334	366	375	31.7
Japanese sea cucumber	177	176	202	229	256	21.6
Frogs	111	122	151	188	229	19.3
Edible jellyfish	73	90	90	78	84	7.1
Other species	237	264	284	282	239	20.2
Algae	**33 428**	**34 582**	**35 073**	**35 097**	**36 505**	**100**
Red algae	18 334	18 015	18 118	17 383	20 379	55.8
Brown algae	14 980	16 475	16 843	17 572	15 985	43.8
Green algae	20	18	24	28	19	0.1
Algae not identified	23	17	25	28	20	0.1
Cyanobacteria (Spirulina)	70	56	64	85	102	0.3

NOTE: Data on aquatic animals exclude crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» in 2022. They comprise 564 aquatic species identified at species level and 7 interspecific hybrids of finfish, 99 species groups identified at genus level, and 61 groups of species identified at family or higher levels. The 564 farmed species taxonomically recognized in the world comprise 368 species of finfish grouped in more than 200 genera, 88 species of molluscs, 62 species of crustaceans, 32 species of algae, 2 species of cyanobacteria, 7 species of marine invertebrates, 3 species of frogs, and 2 species of aquatic turtles.

Despite this great diversity of aquatic species farmed worldwide, a relatively small number of "staple" species dominate total aquaculture production globally, regionally and nationally. Table 5 illustrates the dominant species or species groups and their relative importance in global production by subsector of aquaculture. ■

CAPTURE FISHERIES PRODUCTION

In 2022, global capture fisheries production reached 92.3 million tonnes, comprising 91.0 million tonnes (live weight equivalent) of aquatic animals and 1.3 million tonnes (wet weight) of algae, in addition to about 7 700 tonnes of other aquatic products such as corals, pearls, shells and sponges. Capture fisheries production of aquatic animals (91.0 million tonnes) decreased by 0.2 percent compared with the average of the previous three years (see Table 1, p. 4). It peaked in 2018 at 96.5 million tonnes, coinciding with the exceptionally high catches of anchoveta (*Engraulis ringens*) reported by Peru and Chile. Catches then dropped to marginally lower levels, impacted in 2020 by the COVID-19 pandemic. The relatively static trend in global capture fisheries continued in 2022, fluctuating between 86 million tonnes and 93 million tonnes per year from the late 1980s (Figure 13).

China remained the top producer with 13.0 million tonnes, accounting for 14.3 percent of global captures of aquatic animals in 2022, more than the total captures of the second- and third-ranked countries combined. The top seven capture producers (China, Indonesia, India, Peru, Russian Federation, United States of America and Viet Nam) accounted for over 48 percent of total global capture production, while the top twenty producers accounted for about 73 percent.

The latest trends in marine areas and inland waters, which represent 87.5 percent and 12.5 percent, respectively, of the global production of capture fisheries, are discussed below.

Marine capture production

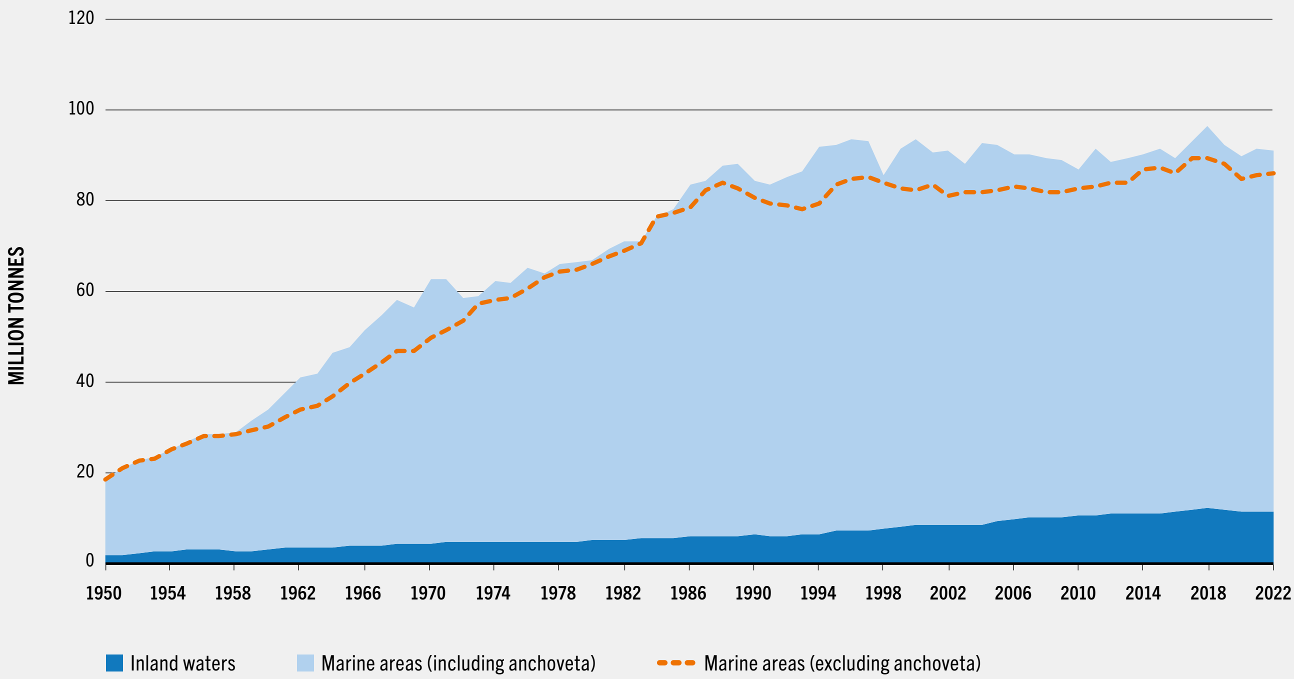
In 2022, total production of aquatic animals in marine areas was 79.7 million tonnes, a decrease of 0.7 percent compared with 2021, and 5.5 percent lower than the most recent peak of 84.4 million tonnes in 2018, when relatively high catches of anchoveta were reported by Peru and Chile (Table 6).

Global trends in marine water captures in recent years continue to be driven to a large extent by the main producers and also top species, notably the ongoing and planned reduction in catches by China, and fluctuations in the abundance of major species such as anchoveta, Pacific sardine (*Sardinops sagax*) and Pacific jack mackerel (*Trachurus symmetricus*), which are highly variable and influenced by El Niño events and other variations in oceanographic conditions (see **Impacts of El Niño on marine fisheries and aquaculture**, p. 202).

Despite the ubiquitous nature of fishing in marine areas, production is concentrated in a small number of countries (Figure 14a). As in previous years, the top seven producers in 2022 accounted for 50 percent of total marine captures (Figure 14b). China alone accounted for 14.8 percent of the world total, followed by Indonesia (8.6 percent), Peru (6.6 percent), the Russian Federation (5.9 percent), the United States of America (5.3 percent), India (4.5 percent) and Viet Nam (4.3 percent) (Table 6).

While China remains the world's top producer of marine captures, its catches have declined by 17.9 percent, from 14.4 million tonnes in 2015 to 11.8 million tonnes in 2022. 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

FIGURE 13 WORLD CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS, 1950–2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

decreases in coming years, although 2022 marine capture catches were broadly similar to those in 2021.

While China regularly reports capture production data to FAO, in recent years only partial information has been submitted by species and fishing area. In 2022, China reported a total of 2.3 million tonnes for its "distant-water fishery", but only provided details on species and fishing areas for catches landed in China (Northwest Pacific, area 61). To complement the missing catch data in other fishing areas, catch data were taken from the regional fisheries management organizations (RFMOs), and an additional 1.3 million tonnes were entered into the FAO database under "marine fishes not elsewhere included" in area 61, likely overstating total catches occurring in this area and the species group "other fish and aquatic animals" shown in Figure 15. As the largest marine capture producer, further work is needed – in close collaboration with the official agencies involved – to ensure the timely reporting and correct allocation of China's capture statistics by fishing area.

At the regional level, Asian countries[f] were responsible for 50.0 percent of global marine captures in 2022, followed by Latin America and the Caribbean (15.6 percent), Europe (16.7 percent), Africa (9.2 percent), Northern America (6.5 percent) and Oceania (2.0 percent).

»

f In the case of capture fisheries production by marine areas, data aggregated by continent or major geographical region refer to the quantities caught by all countries of that continent or region, irrespective of the fishing area where they fished, rather than the amount caught in marine waters surrounding that continent or region.

TABLE 6 CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN MARINE AREAS BY MAJOR PRODUCER

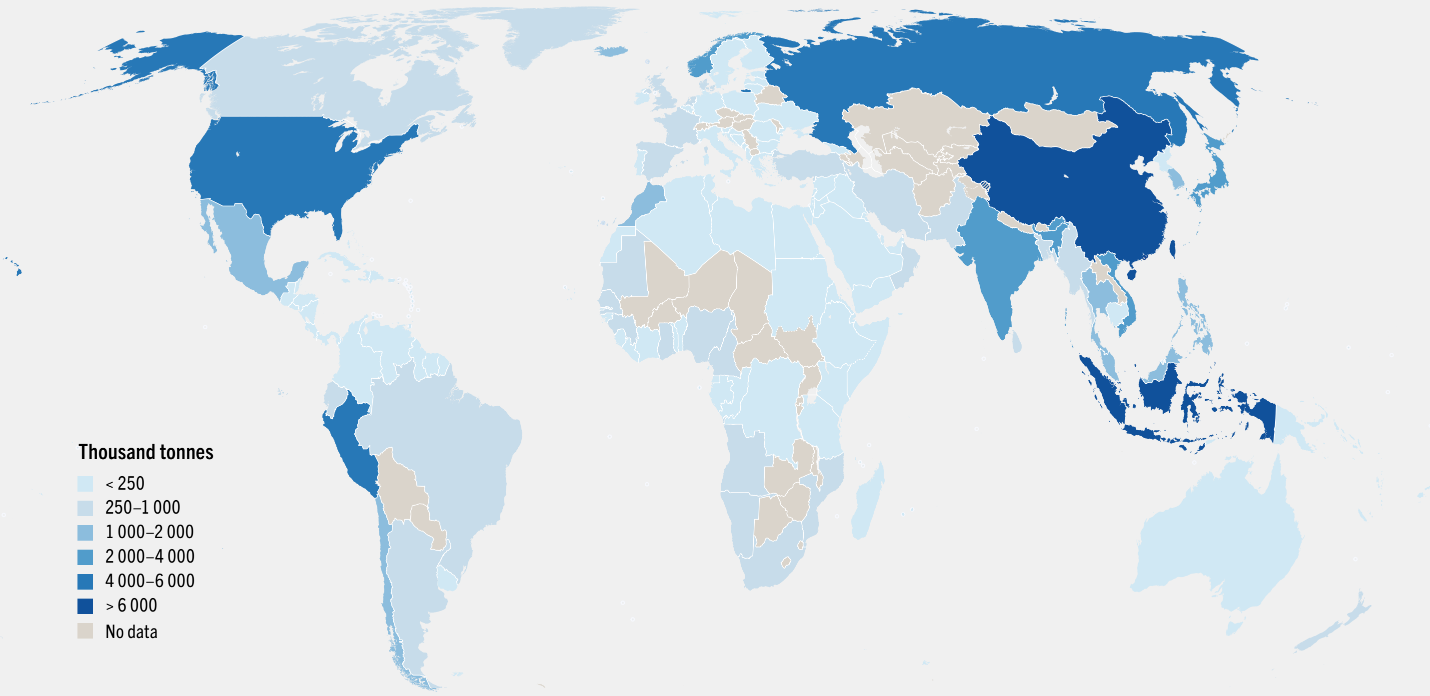
Country or territory	Production (average per year)				Production				Share in total, 2022 (%)
	1980s	1990s	2000s	2010s	2019	2020	2021	2022	
	(thousand tonnes, live weight equivalent)								
China	3 819	9 963	12 425	13 238	12 154	11 769	11 741	11 819	14.8
Indonesia	1 742	3 030	4 369	5 962	6 513	6 385	6 675	6 843	8.6
Peru (total)	4 136	8 099	8 066	5 130	4 796	5 610	6 508	5 289	6.6
Peru (excluding anchoveta)	*2 504*	*2 541*	*952*	*1 013*	*1 292*	*1 216*	*1 239*	*1 171*	*n/a*
Russian Federation	n/a	3 377	3 201	4 278	4 720	4 792	4 888	4 717	5.9
United States of America	4 531	5 147	4 746	4 882	4 810	4 249	4 286	4 243	5.3
India	1 685	2 602	2 947	3 549	3 672	2 834	3 145	3 597	4.5
Viet Nam	533	943	1 720	2 698	3 294	3 358	3 391	3 443	4.3
Japan	10 592	6 718	4 412	3 485	3 171	3 182	3 174	2 889	3.6
Norway	2 206	2 435	2 519	2 303	2 315	2 472	2 419	2 442	3.1
Chile	4 517	5 948	4 022	2 156	1 975	1 774	1 996	2 226	2.8
Chile (excluding anchoveta)	*4 002*	*4 447*	*2 745*	*1 399*	*1 231*	*1 272*	*1 389*	*1 485*	*n/a*
Mexico	1 206	1 175	1 308	1 431	1 526	1 550	1 618	1 659	2.1
Philippines	1 320	1 677	2 101	1 924	1 673	1 764	1 638	1 595	2.0
Morocco	463	680	971	1 275	1 443	1 360	1 396	1 563	2.0
Iceland	1 434	1 669	1 664	1 199	1 049	1 023	1 155	1 416	1.8
Malaysia	756	1 080	1 306	1 465	1 455	1 381	1 329	1 310	1.6
Thailand	2 076	2 698	2 385	1 460	1 411	1 472	1 300	1 280	1.6
Republic of Korea	2 175	2 253	1 776	1 556	1 412	1 362	1 347	1 247	1.6
Myanmar	496	611	1 098	1 146	1 064	1 087	880	1 010	1.3
Argentina	412	985	936	793	801	818	835	835	1.0
Spain	1 214	1 134	915	957	879	796	800	805	1.0
Mauritania	60	64	186	520	706	663	748	765	1.0
Oman	111	117	146	295	579	793	922	748	0.9
Bangladesh	178	281	456	610	660	671	681	706	0.9
Iran (Islamic Republic of)	114	232	314	550	720	684	672	701	0.9
Ecuador	696	403	460	575	608	636	863	688	0.9
Total 25 major producers	**46 473**	**63 318**	**64 450**	**63 436**	**63 406**	**62 487**	**64 407**	**63 836**	**80.1**
Total all other producers	**25 613**	**18 540**	**17 139**	**16 361**	**16 820**	**15 818**	**15 879**	**15 872**	**19.9**
World total	**72 086**	**81 858**	**81 589**	**79 797**	**80 225**	**78 305**	**80 286**	**79 709**	**100.0**

NOTES: n/a – not applicable. Aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 14 WORLD CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN MARINE AREAS

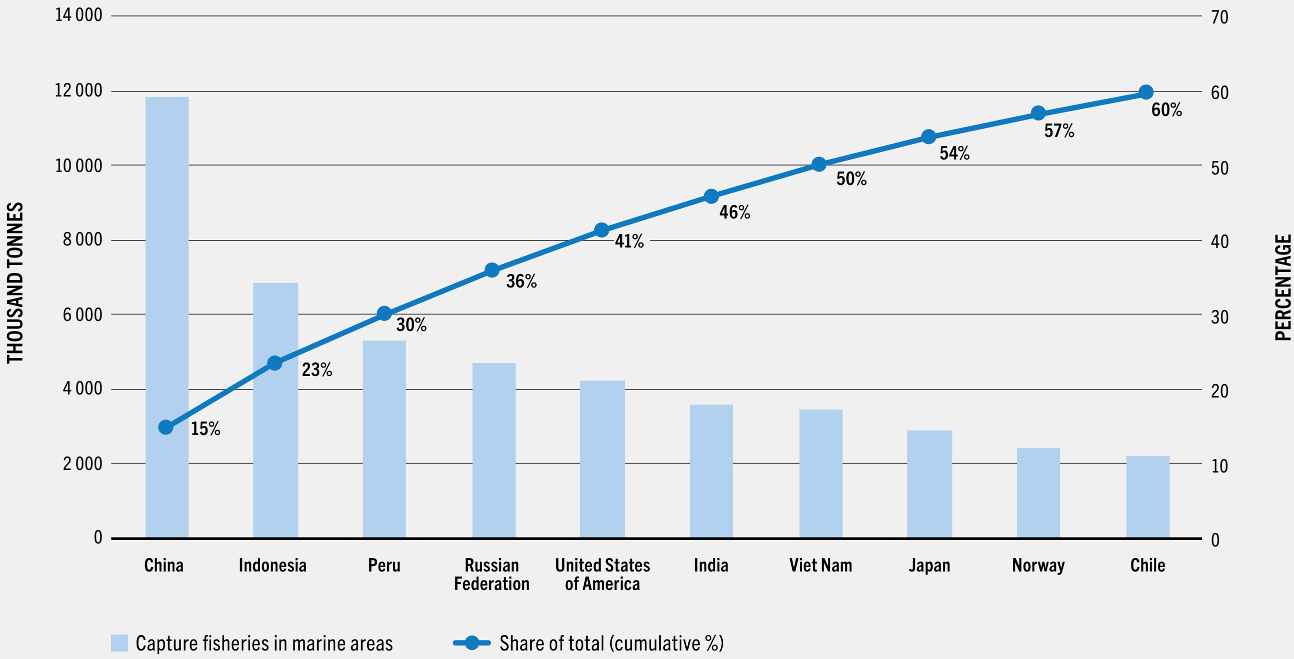
A) COUNTRIES AND TERRITORIES, AVERAGE 2020–2022



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.

SOURCE: United Nations Geospatial. 2020. Map geodata.

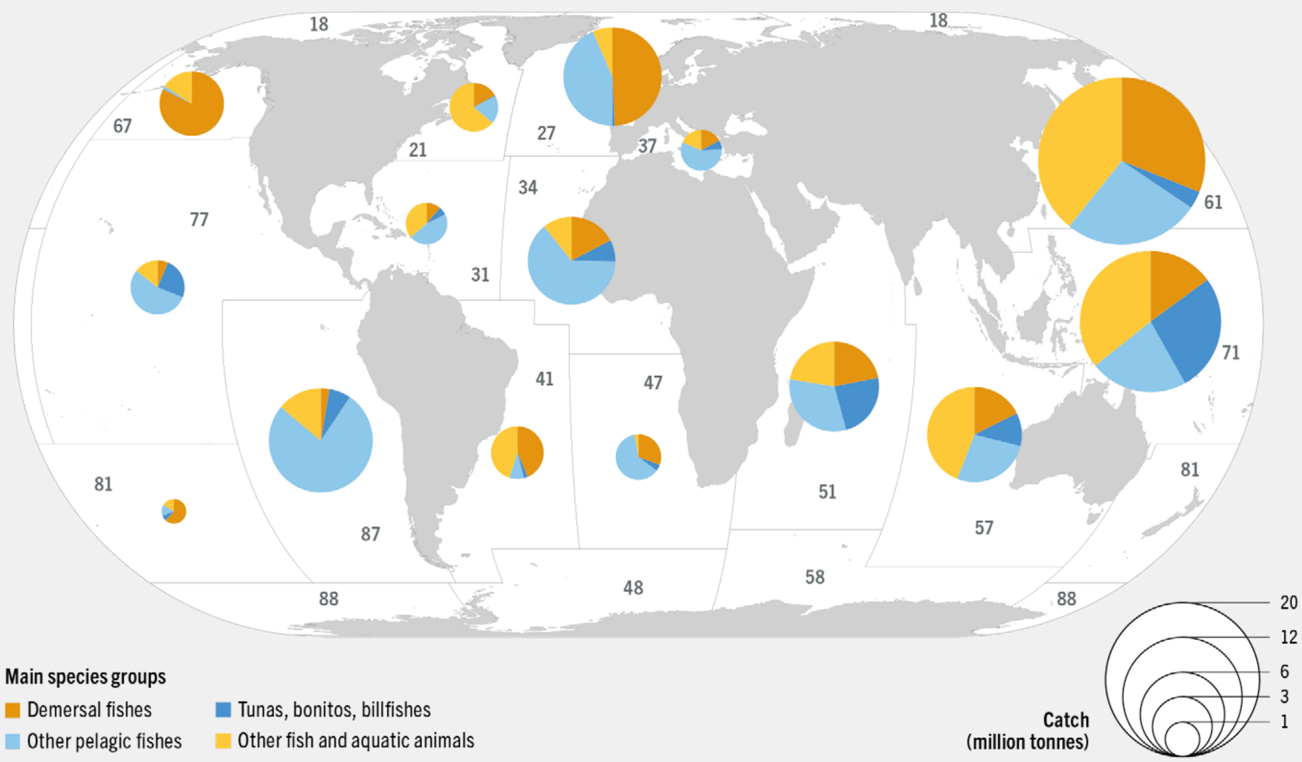
B) TOP TEN PRODUCERS, 2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 15 WORLD CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN MARINE AREAS BY FAO MAJOR FISHING AREA, AVERAGE 2020–2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCES: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.
United Nations Geospatial. 2020. Map geodata.

» The FAO global marine capture database includes catches for more than 3 000 species (including "not elsewhere included" categories); finfish account for about 85 percent of total marine capture production in 2022, 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 and by FAO Major Fishing Area is shown in Figure 15.

The top three marine species have remained unchanged since 2010. In 2022, the catches of anchoveta continued to rank first at almost 4.9 million tonnes per year, in line with recent years but lower than the 2018 peak that exceeded 7.0 million tonnes. Alaska pollock (*Gadus chalcogrammus*) was second at 3.4 million tonnes, and skipjack tuna (*Katsuwonus pelamis*) third at 3.1 million tonnes (Table 7). Of the top ten species in 2022 – all finfish – three species, European pilchards (*Sardina pilchardus*), skipjack tuna and yellowfin tuna (*Thunnus albacares*), reported catches in 2022 close to their highest levels recorded.

Catches of tunas in particular, one of the most valuable groups, continued to increase, reaching 8.3 million tonnes in 2022, the highest level recorded. Catches of other highly valuable groups »

TABLE 7 CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN MARINE AREAS BY MAJOR SPECIES AND GENUS

Species item	2009–2018	2019	2020	2021	2022	Share in total, 2022 (%)
	(thousand tonnes, live weight equivalent)					
Finfish						
Anchoveta, *Engraulis ringens*	5 141	4 249	4 896	5 876	4 859	7.2
Alaska pollock, *Gadus chalcogrammus*	3 204	3 495	3 544	3 484	3 359	5.0
Skipjack tuna, *Katsuwonus pelamis*	2 767	3 318	2 849	2 990	3 061	4.5
Atlantic herring, *Clupea harengus*	1 855	1 713	1 606	1 628	1 648	2.4
Yellowfin tuna, *Thunnus albacares*	1 356	1 559	1 595	1 570	1 564	2.3
European pilchard, *Sardina pilchardus*	1 226	1 501	1 335	1 363	1 551	2.3
Pacific chub mackerel, *Scomber japonicus*	1 405	1 465	1 409	1 708	1 399	2.1
Pacific sardine, *Sardinops sagax*	839	1 108	1 625	1 412	1 377	2.0
Scads nei*, *Decapterus spp.*	1 195	1 293	1 313	1 230	1 292	1.9
Atlantic mackerel, *Scomber scombrus*	1 053	873	1 049	1 142	1 097	1.6
Atlantic cod, *Gadus morhua*	1 189	1 141	1 093	1 145	1 074	1.6
Largehead hairtail, *Trichiurus lepturus*	1 260	1 134	1 122	1 124	1 069	1.6
Chilean jack mackerel, *Trachurus murphyi*	573	657	744	828	1 049	1.6
Blue whiting, *Micromesistius poutassou*	935	1 519	1 475	1 146	1 044	1.5
Others	42 939	42 807	40 978	41 344	42 022	62.3
Total finfish	**66 937**	**67 832**	**66 633**	**67 991**	**67 466**	**100.0**
Crustaceans						
Natantian decapods nei, *Natantia*	835	724	651	701	695	12.2
Gazami crab, *Portunus trituberculatus*	478	473	442	476	482	8.5
Antarctic krill, *Euphausia superba*	225	371	460	368	404	7.1
Akiami paste shrimp, *Acetes japonicus*	538	402	251	380	387	6.8
Marine crabs nei, *Brachyura*	308	356	319	327	352	6.2
Northern prawn, *Pandalus borealis*	288	267	255	248	259	4.6
Southern rough shrimp, *Trachysalambria curvirostris*	304	243	195	242	245	4.3
Blue swimming crab, *Portunus pelagicus*	237	283	247	245	243	4.3
Others	2 606	2 725	2 624	2 647	2 612	46.0
Total crustaceans	**5 819**	**5 844**	**5 447**	**5 635**	**5 679**	**100.0**
Molluscs						
Jumbo flying squid, *Dosidicus gigas*	873	907	905	997	1 076	17.5
Marine molluscs nei, *Mollusca*	733	694	578	582	581	9.4

»

TABLE 7 (Continued)

Species item	2009–2018	2019	2020	2021	2022	Share in total, 2022 (%)
	(thousand tonnes, live weight equivalent)					
Various squids nei,* *Loliginidae, Ommastrephidae*	603	610	536	537	543	8.8
Cephalopods nei,* *Cephalopoda*	418	426	424	425	408	6.6
Argentine shortfin squid, *Illex argentinus*	408	171	345	491	396	6.4
Yesso scallop, *Mizuhopecten yessoensis*	303	351	357	367	349	5.7
Common squids nei,* *Loligo* spp.	308	328	326	332	334	5.4
Others	2 709	2 624	2 354	2 479	2 461	40.0
Total molluscs	**6 356**	**6 110**	**5 825**	**6 209**	**6 150**	**100.0**
Other aquatic animals						
Jellyfishes nei,* *Rhopilema* spp.	314	184	208	217	193	46.6
Cannonball jellyfish, *Stomolophus meleagris*	36	67	19	78	55	13.4
Aquatic invertebrates nei,* *Invertebrata*	61	53	46	41	49	11.9
Sea cucumbers nei,* *Holothuroidea*	32	49	40	41	42	10.1
Chilean sea urchin, *Loxechinus albus*	33	37	38	27	28	6.8
Sea urchins nei,* *Strongylocentrotus* spp.	33	25	30	25	24	5.8
Others	25	25	20	22	22	5.4
Total other aquatic animals	**534**	**439**	**400**	**452**	**414**	**100.0**
Total all species	**79 646**	**80 225**	**78 305**	**80 286**	**79 709**	

NOTES: Aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
* nei: not elsewhere included.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» such as cephalopods, shrimps and lobsters also maintained their highest levels in 2022. In the case of lobsters – one of the species groups most impacted by COVID-19 restrictions and the closure of export markets – catches have recovered and in 2022 they increased to over 290 000 tonnes, albeit not to the same level as the immediate pre-pandemic years.

Catch statistics by FAO Major Fishing Area for the last four years, as well as marine catches in recent decades, are presented in Table 8.

The contribution to global marine catches varies considerably between fishing areas, with over 50 percent of the marine catches in 2022 occurring in the Northwest Pacific (area 61), Western Central Pacific (area 71) and Southeast Pacific (area 87).

The Northwest Pacific (area 61) continued to have the highest production among the FAO Major Fishing Areas, with 18.6 million tonnes (23.3 percent) of global marine area catches in 2022, driven largely by catches of its two most productive species, Alaska pollock and Pacific sardine (*Sardinox sagax*). Even after discounting the 1.3 million tonnes in 2022 re-assigned from China's distant-water fishery, this area still recorded the highest production by a significant margin compared with the Western Central Pacific (area 71), which was second with 13.8 million »

TABLE 8 CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS BY FAO MAJOR FISHING AREA

FAO Major Fishing Area code	Fishing area name	Production (average per year)				Production				Share in total, 2022 (%)
		1980s	1990s	2000s	2010s	2019	2020	2021	2022	
		(thousand tonnes, live weight equivalent)								
Capture fisheries in inland waters										
01	Africa – Inland waters	1 465	1 892	2 334	2 888	3 290	3 276	3 415	3 324	29.4
02	America, North – Inland waters	234	213	182	198	88	77	96	68	0.6
03	America, South – Inland waters	321	327	393	361	349	337	342	346	3.1
04	Asia – Inland waters	2 827	4 133	5 979	7 427	7 961	7 331	7 075	7 174	63.4
05	Europe – Inland waters	184	361	355	397	387	419	406	392	3.5
06	Oceania – Inland waters	18	20	18	17	17	17	17	17	0.1
07	Former USSR area* – Inland waters	646	106	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Total inland waters	**5 697**	**7 052**	**9 261**	**11 288**	**12 092**	**11 457**	**11 351**	**11 321**	**100.0**
Capture fisheries in marine areas										
21	Atlantic, Northwest	2 908	2 333	2 219	1 846	1 785	1 573	1 623	1 615	7.7
27	Atlantic, Northeast	10 439	10 391	9 814	8 653	8 314	8 350	8 089	8 223	39.2
31	Atlantic, Western Central	2 015	1 826	1 553	1 351	1 232	1 133	1 162	1 212	5.8
34	Atlantic, Eastern Central	3 199	3 557	3 758	4 750	5 374	4 918	5 167	5 547	26.5
37	Mediterranean and Black Sea	1 841	1 499	1 536	1 320	1 416	1 194	1 136	1 090	5.2
41	Atlantic, Southwest	1 783	2 250	2 146	1 899	1 677	1 724	2 014	1 891	9.0
47	Altantic, Southeast	2 318	1 556	1 543	1 539	1 364	1 370	1 460	1 375	6.6
	Total Atlantic Ocean and Mediterranean	**24 501**	**23 412**	**22 569**	**21 358**	**21 161**	**20 262**	**20 650**	**20 953**	**100.0**
51	Indian Ocean, Western	2 369	3 675	4 236	4 877	5 597	5 134	5 481	5 713	48.3
57	Indian Ocean, Eastern	2 672	4 131	5 481	6 394	6 605	6 253	5 887	6 124	51.7
	Total Indian Ocean	**5 042**	**7 806**	**9 717**	**11 271**	**12 202**	**11 388**	**11 369**	**11 837**	**100.0**
61	Pacific, Northwest	20 955	21 797	19 969	20 608	19 526	19 215	19 079	18 590	40.0
67	Pacific, Northeast	2 743	2 982	2 790	3 053	3 169	2 851	2 914	2 690	5.8
71	Pacific, Western Central	5 941	8 511	10 800	12 509	13 442	13 240	13 498	13 771	29.6
77	Pacific, Eastern Central	1 622	1 441	1 811	1 872	2 051	1 984	1 959	1 986	4.3
81	Pacific, Southwest	568	820	689	535	469	425	388	398	0.9
87	Pacific, Southeast	10 232	14 897	13 104	8 324	7 815	8 463	10 040	9 046	19.5
	Total Pacific Ocean	**42 062**	**50 449**	**49 162**	**46 900**	**46 473**	**46 179**	**47 877**	**46 481**	**100.0**

TABLE 8 (Continued)

FAO Major Fishing Area code	Fishing area name	Production (average per year)				Production				Share in total, 2022 (%)
		1980s	1990s	2000s	2010s	2019	2020	2021	2022	
		(thousand tonnes, live weight equivalent)								
18, 48, 58, 88	**Total Arctic and Antarctic**	**481**	**191**	**141**	**268**	**389**	**477**	**391**	**437**	
	Total marine areas	**72 086**	**81 858**	**81 589**	**79 797**	**80 225**	**78 305**	**80 286**	**79 709**	
Capture fisheries by type of marine area										
	Temperate areas	41 237	42 073	39 162	37 913	36 355	35 331	35 241	34 498	43.3
	Tropical areas	12 997	18 142	22 070	25 131	26 877	25 761	26 028	26 820	33.6
	Upwelling areas	17 371	21 451	20 216	16 486	16 604	16 736	18 625	17 954	22.5
	Arctic and Antartic areas	481	191	141	268	389	477	391	437	0.5
	Total marine areas	**72 086**	**81 858**	**81 589**	**79 797**	**80 225**	**78 305**	**80 286**	**79 709**	**100.0**

NOTES: n/a – not applicable. Aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
FAO Major Fishing Areas defined as: temperate areas (fishing 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).
* Up to 1991.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» tonnes or 17.3 percent of global marine area catches in 2022.

The Southeast Pacific (area 87) was the third-highest, producing 9.0 million tonnes in 2022, equivalent to 11.3 percent of global landings. Recent catches in this area indicate a partial reversal of the decreasing trend from the early 1990s to 2016, primarily due to the increase in landings of anchoveta. Fluctuating catches in area 87 are also characteristic of the high annual variability associated with upwelling areas, particularly in the case of anchoveta, which accounts for 50–70 percent of total catches in this area, as well as jumbo flying squid (*Dosidicus gigas*).

All-time record marine captures in 2022 were also notable for the following fishing areas:

- **Eastern Central Atlantic (area 34):** 5.5 million tonnes in 2022. This area is characterized by great biological diversity including coastal and offshore pelagic resources and deep demersal resources. The 2022 catches continued the upward trend observed since the 1970s, notable in particular for the increasing catches of European pilchards.
- **Western Central Pacific (area 71):** 13.8 million tonnes in 2022. Tuna and tuna-like species are important and account for the area's top two most productive species (skipjack tuna and yellowfin tuna). In addition, the area is characterized by small pelagic species such as sardines, anchovies and scads. However, this area is also noted for the substantial proportion of catches reported as "marine fishes not elsewhere included" (23 percent in 2022), or other generic categories.
- **Western Indian Ocean (area 51):** 5.7 million tonnes in 2022. Tunas and tuna-like species contribute the most in this fishing area, followed by small pelagics and mixed (mainly reef-associated) fishes. Catches in the Indian Ocean have generally increased steadily since the 1950s, driven in particular by catches in the Eastern Indian Ocean (area 57); however, in recent years, catches have decreased due to a reduction in fishing pressure.

In light of the 2023 Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction, there is a growing interest in the management of high seas resources – due in part to general concerns regarding overfishing, but also to better understand the status of exploitation of the species in these areas (see **Fisheries and aquaculture in the context of global biodiversity agreements**, p. 205). High seas areas are defined as those occurring outside exclusive economic zones (EEZs), that is, extending beyond 200 nautical miles into the sea and covering nearly two-thirds of the world's oceans. Unfortunately, it is not possible to assess the status of fishing on the high seas, because the FAO global capture fisheries statistics make no distinction between those taken within EEZs and those taken on the high seas. In the annual data calls, countries are requested to report to FAO their capture fisheries production by species and by fishing area. The FAO Major Fishing Areas were established in the 1950s, many years before the EEZs, and are therefore the two are not directly comparable.

Indications of prevailing trends in high seas catches can be obtained through an analysis of the catches of oceanic (epipelagic and "deep-water") species that are likely to occur in high seas areas. The total catches of these species indicate an increase since the 1950s, from 1 million tonnes to about 11 million tonnes in 2022, with more sustained growth from the late 1970s to the mid-2000s, in particular for deep-water resources, due to technological developments facilitating fishing in deeper waters as well as the need to exploit new fishing grounds following reduced opportunities owing to extended jurisdictions and declining resources in coastal areas.

Inland waters capture production

In 2022, global catches in inland waters were 11.3 million tonnes (Table 9), a decrease of 0.3 percent from 2021. While fishing in inland waters was also severely impacted by the COVID-19 pandemic during 2020, recent trends in global inland water production have been driven more by the recent decline in China's catches. Otherwise, global inland water catches appear to remain relatively static – according to the officially reported data – and marginally below the highest level of 12.1 million tonnes recorded in 2018.

Since 2020, China has no longer been the top inland water producer. It was surpassed in 2022 by India and Bangladesh with catches of 1.9 million tonnes and 1.3 million tonnes, respectively. While China continues to be in the top three inland water capture producers (1.2 million tonnes in 2022), official catches have decreased by almost 47 percent from 2.2 million tonnes in 2017 as a result of 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 aims for conservation of living aquatic resources. The decrease in China's inland water catches has also been offset by the expansion of inland aquaculture and culture-based fisheries that has resulted in an overall increase in China's total inland water production over the same period.

With the exception of China, the relatively modest growth in inland water catches in recent years has been driven by increasing production among several of the major producing countries – notably Bangladesh, India and the United Republic of Tanzania.

However, assessing the long-term trend in inland waters capture production is problematic. The catch increases of the last 20 years are partly attributed to improvements in reporting and assessment at the country level, rather than an actual increase in catches reported by some countries. These improvements may also mask static or declining trends in inland water fisheries. Many of the national data collection systems for inland waters continue to be unreliable and of low quality, or in some cases non-existent, leading to underestimation of inland water catches – including for several major producers. Catches for subsistence fisheries and recreational fisheries are generally either under-reported or missing entirely from official catches. Many countries also do not report, or report only partial inland water catches to FAO. Hence work has recently been undertaken by FAO to evaluate the potential of alternative methods to address these gaps and improve FAO's inland water fisheries statistics (Box 2).

»

TABLE 9 CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN INLAND WATERS BY MAJOR PRODUCER AND REGION

Country or territory	Production (average per year)				Production				Share in total, 2022 (%)
	1980s	1990s	2000s	2010s	2019	2020	2021	2022	
	(thousand tonnes, live weight equivalent)								
By country or territory									
India	495	584	837	1 434	1 787	1 796	1 847	1 890	16.7
Bangladesh	441	502	859	1 078	1 236	1 248	1 301	1 322	11.7
China	537	1 457	2 111	2 027	1 841	1 457	1 198	1 166	10.3
Myanmar	142	146	478	852	887	891	786	855	7.5
Indonesia	272	311	307	471	712	497	459	464	4.1
Uganda	187	223	331	435	603	579	635	445	3.9
United Republic of Tanzania	252	289	301	314	384	405	414	403	3.6
Cambodia	54	86	344	493	479	413	383	402	3.6
Nigeria	101	104	211	350	373	354	363	355	3.1
Egypt	123	228	267	255	298	317	330	343	3.0
Russian Federation	0	197	222	267	254	280	272	267	2.4
Democratic Republic of the Congo	133	170	231	228	254	241	253	266	2.3
Brazil	200	182	237	232	226	225	226	226	2.0
Malawi	68	59	58	141	155	171	171	187	1.7
Philippines	261	193	153	183	155	148	201	173	1.5
Pakistan	67	132	115	130	144	148	150	151	1.3
Viet Nam	111	137	207	160	146	148	150	147	1.3
Mozambique	3	9	24	86	117	92	117	129	1.1
Iran (Islamic Republic of)	11	92	72	90	105	107	108	111	1.0
Mali	65	88	101	96	109	118	105	110	1.0
Zambia	58	68	69	89	97	107	105	109	1.0
Kenya	95	179	141	138	103	105	114	108	1.0
Chad	54	76	78	106	107	105	103	107	0.9
Thailand	103	178	208	187	116	117	115	106	0.9
Ethiopia	3	8	13	44	59	60	73	101	0.9
Top 25 producers	3 838	5 697	7 977	9 884	10 751	10 129	9 978	9 942	87.8
Total all other producers	1 859	1 355	1 284	1 404	1 342	1 328	1 373	1 379	12.2
All producers	**5 697**	**7 052**	**9 261**	**11 288**	**12 092**	**11 457**	**11 351**	**11 321**	**100.0**

TABLE 9 (Continued)

Country or territory	Production (average per year) 1980s	1990s	2000s	2010s	Production 2019	2020	2021	2022	Share in total, 2022 (%)
	(thousand tonnes, live weight equivalent)								
By region									
Asia	2 827	4 133	5 979	7 427	7 961	7 331	7 075	7 174	63.4
Africa	1 465	1 892	2 334	2 888	3 290	3 276	3 415	3 324	29.4
Americas	555	540	575	559	437	414	438	414	3.7
Europe	184	361	355	397	387	419	406	392	3.5
Oceania	18	20	18	17	17	17	17	17	0.1
Others*	646	106	n/a	n/a	n/a	n/a	n/a	n/a	n/a
World total	**5 697**	**7 052**	**9 261**	**11 288**	**12 092**	**11 457**	**11 351**	**11 321**	**100.0**

NOTES: n/a – not available.Aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
* Includes Union of Soviet Socialist Republics up to 1991.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

» The lack of species granularity available for inland water capture fisheries is a persistent and longstanding issue. Despite improvements in the monitoring of inland waters by many countries, 50 percent of global inland water capture production is available only at the highest level of aggregation of the so-called freshwater fishes nei (*Actinopterygii*) – a figure that has remained largely unchanged in the last 20 years. This proportion of unidentified catches, however, varies significantly between countries and regions, ranging from as low as 10 percent for Europe to over 60 percent for some countries in Asia.

One of the main species groups, "carps, barbels and other cyprinids", has shown a continuous increase, rising from around 0.7 million tonnes per year in the mid-2000s to almost 1.8 million tonnes in 2022, and accounts for most of the increase in catches from inland waters in recent years. Catches of "tilapias and other cichlids" have also increased in recent years from less than 0.7 million tonnes to over 0.8 million tonnes per year. Catches of "freshwater crustaceans" remained stable at between 0.4 million tonnes and 0.45 million tonnes per year but have fallen in recent years to 0.27 million tonnes in 2022, mostly as a result of the decrease in China's inland water catches.

Captures in inland waters are more concentrated than in marine areas. They are harvested by many major producers in areas endowed with important waterbodies or river basins (Figure 16a and Figure 16b). In 2022, 14 countries produced over 75 percent of total inland captures, compared with 19 countries for marine captures. Most major inland water producers are located in less developed economies – with over 90 percent of total inland water captures occurring in Asia and Africa, where producing countries face severe challenges in monitoring inland fisheries that are by their nature highly dispersed, complex in operation and resource intensive to monitor.

Asia has consistently accounted for over 60 percent of global inland water production since the mid-1990s (7.2 million tonnes in 2022) and includes the top five producers harvesting over 50 percent of inland water catches in 2022. However, in many Asian countries, the historical contribution of inland fisheries is complemented or replaced by the contribution of aquaculture.

The situation in Africa is markedly different. With 3.3 million tonnes harvested in 2022, accounting for around 29 percent of global inland captures, for many African countries inland fisheries represent »

BOX 2 EVALUATING THE STATUS OF FAO'S INLAND FISHERY STATISTICS

While the quality and completeness of inland water fisheries statistics have improved significantly in recent years, there continue to be persistent issues with the collection and reporting of the relevant data to FAO.

The importance of inland fisheries for national and global food security and livelihoods, especially in low-income food-deficit countries and landlocked developing countries, is well recognized. Unfortunately, production statistics are not routinely collected by many countries, jeopardizing the development of national and regional fisheries policy and planning, and the management and conservation of resources and ecosystems, all of which require updated and reliable statistics. Fisheries administration and stakeholders are also often marginalized within the circle of policy- and decision-makers in charge of inland water resources management, and improved statistics can help reduce this marginalization (see **Management priorities for inland fisheries**, p. 163).

The official inland fisheries data reported to FAO are often incomplete in terms of fisheries coverage or reported species. The wide species diversity of inland fisheries contrasts with the relatively low number of species actually reported by many countries. As a result, in many cases only major target or commercial species are being routinely monitored. Consequently, around 50 percent of global inland water catches are only available at the highest level of aggregation, the so-called freshwater fishes nei (*Actinopterygii*). The contribution of low value, but locally important catches of informal or subsistence fisheries in inland waters is either under-reported or excluded entirely. Countries that have improved catch surveys or reporting commonly do not include retrospective analysis or revisions to the historical time series, creating breaks in the time series or year-on-year increases in catches as an artefact of improvements in the data collection.

These issues are largely driven by the practical challenges of monitoring inland fisheries, which are predominantly small-scale, often highly dispersed, and seasonal or occasional in terms of fishing operations. Inland water fishing also occurs in diverse environments such as large lakes, reservoirs, rivers and floodplains, streams, and rice fields. For many inland fisheries, particularly those that constitute a critical source of nutrition for local communities, these practical challenges are compounded by limited resources available for monitoring and management of inland waters. Most inland water producers are in less advanced economies, with five of the top ten inland water producers categorized as least developed countries* (Bangladesh, Cambodia, Myanmar, Uganda and United Republic of Tanzania).

Consequently, FAO estimates or adjusts a higher proportion of catches from inland fisheries than from marine fisheries – in some cases based on limited alternative information of the prevailing trends occurring within the fisheries in question. Catch estimates may also be repeated over several years, potentially leading to systematic under- or over-reporting.

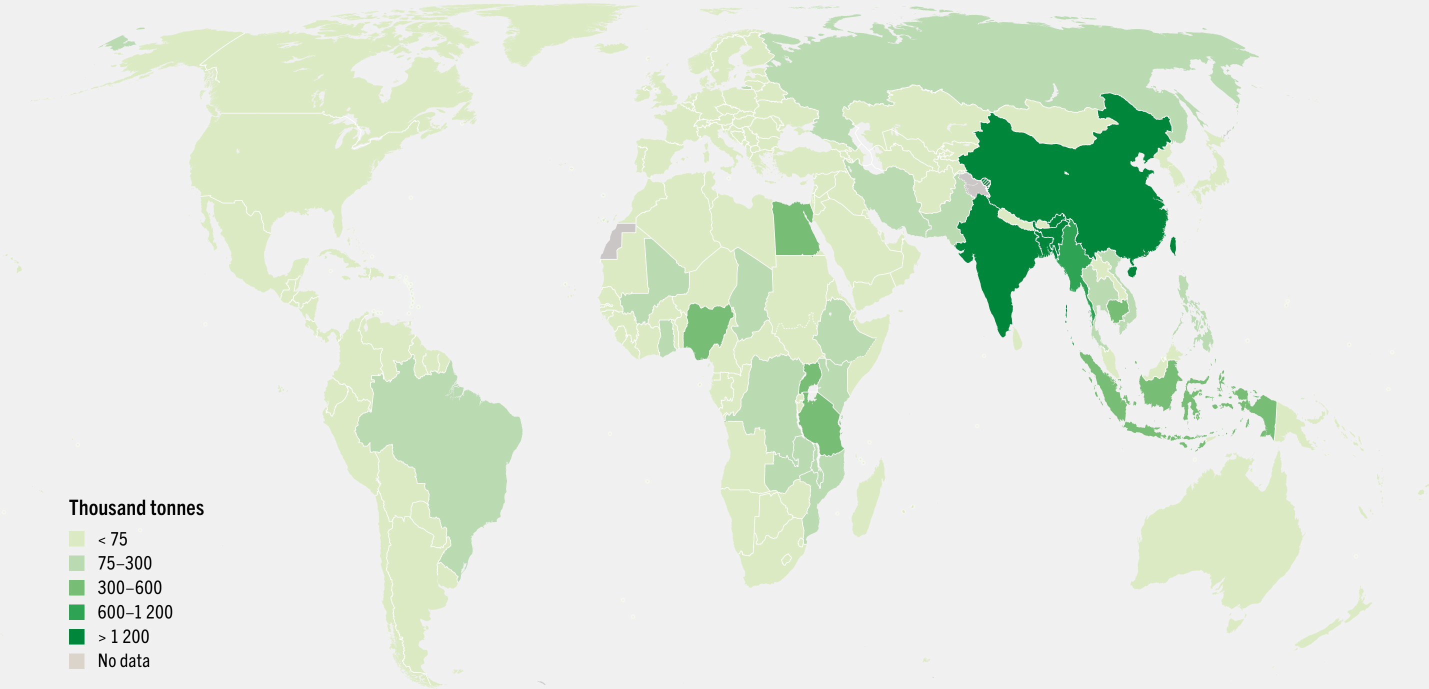
To address this situation, FAO has proactively initiated an assessment of inland fisheries statistics that are publicly disseminated. The aim is to identify countries where efforts and future support may be needed to strengthen the collection of data from inland water fisheries. FAO is developing technical guidelines to assess the potential of alternative methods to estimate inland water catch production alongside conventional catch assessment surveys. This includes an evaluation of predictive methods, for example, fish habitat models, fishing effort density models, and inference-based methods such as fish consumption models. The objective is to improve the overall quality of national and FAO inland fisheries statistics, increasing recognition in policy fora discussing the importance and critical contribution of inland fisheries for food security, livelihoods and poverty alleviation, as well as aquatic resources management.

Pelagics fishers on Lake Tanganyika, where FISH4ACP developed a value chain analysis of the sector, United Republic of Tanzania

NOTE: * See: https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/publication/ldc_list.pdf

FIGURE 16 CAPTURE FISHERIES PRODUCTION OF AQUATIC ANIMALS IN INLAND WATERS

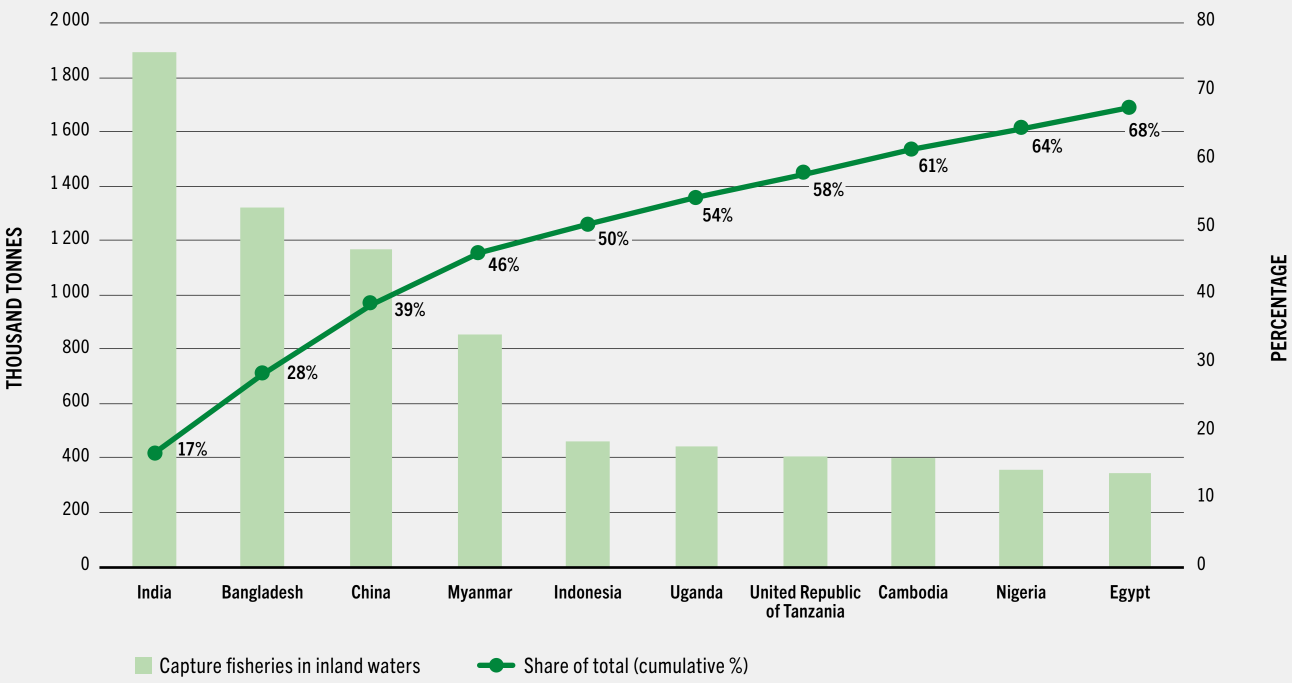
A) COUNTRIES AND TERRITORIES, AVERAGE 2020–2022



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.

SOURCE: United Nations Geospatial. 2020. Map geodata.

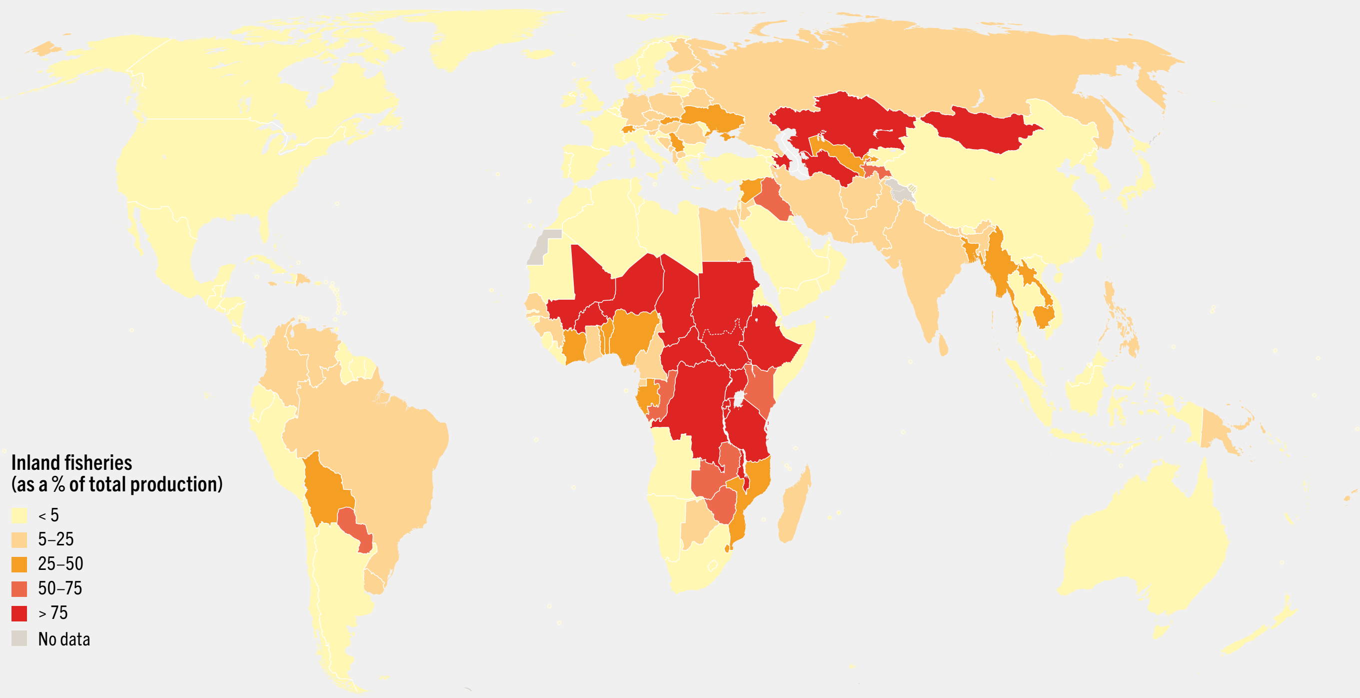
B) TOP TEN PRODUCERS, 2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCE: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

FIGURE 17 SHARE OF CAPTURE FISHERIES IN INLAND WATERS IN TOTAL FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY VOLUME, AVERAGE 2020–2022



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.

NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Based on live weight equivalent.

SOURCES: FAO. 2024. FishStat: Global capture production 1950–2022. [Accessed on 29 March 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.
United Nations Geospatial. 2020. Map geodata.

» an important source of food security compared with the relatively small contribution of aquaculture. For many landlocked countries in Africa, inland water capture fisheries represent between 80 percent and 100 percent of total production of aquatic animals (Figure 17). This production is important but also highly uncertain for many of these countries (e.g. Chad, Democratic Republic of the Congo and Nigeria), stressing the urgent need for effective monitoring and management of the sector.

Data 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 as far as possible in collaboration with Members. Unfortunately, in many cases the countries concerned do not respond to FAO calls to address the identified official data issues. In such cases and in the event of inconsistencies in the data, FAO may make estimates or adjustments based on the best data available from alternative official data sources (including data published by RFMOs, or through standard methodologies).

Issues of timeliness or the non-reporting of the data to FAO by Member Nations also persist, affecting the overall quality of FAO's estimates of total capture fisheries production. Late submissions of questionnaires make it challenging for FAO to process, validate and review the statistics – in particular for the most recent year – prior to the official annual release of the data, usually in mid-March.

While most capture fisheries production statistics are reported by the largest producers, ensuring the reliability of FAO estimates of global capture production, FAO continues to express concern regarding issues of data submission or data quality for some important countries. ■

THE STATUS OF FISHERY RESOURCES

Marine fisheries

Status of resources

Since 1971, FAO has been publishing regular analyses of the state of fish stocks (Gulland, 1971), including the summary and classification updates shown in previous versions of this report (FAO, 2020). To promote consistency and comparability across time, these analyses were based on a fixed list of stocks (445 aggregated stocks accounting for approximately 72 percent of global marine fisheries production) and a clear process and methodology that has only had minor adjustments since the start of the series (FAO, 2011a).

These analyses indicate that the fraction of fishery stocks within biologically sustainable levels decreased to 62.3 percent in 2021, that is 2.3 percent lower than in 2019 (Figure 18). This fraction was 90 percent in 1974. In contrast, the percentage of stocks fished at unsustainable levels has been increasing since the mid-1970s, from 10 percent in 1974 to 37.7 percent in 2021. This calculation treats all fishery stocks equally, regardless of abundance and catch. When weighted by their production levels, biologically sustainable stocks account for 76.9 percent of the 2021 landings of assessed stocks monitored by FAO.

Biologically sustainable stocks consist of those classified as maximally sustainably fished[g] and underfished[h] and account for, respectively, 50.5 percent and 11.8 percent of the total number of assessed stocks in 2021. Underfished stocks maintained a decreasing trend over the period 1974–2018 and bounced back slightly during 2019–2021, possibly due to the effects of the COVID-19 pandemic in the Asia and Pacific region. Maximally sustainably fished stocks on the other hand decreased between 1974 and 1989, then increased to reach 57.3 percent in 2019, and decreased again in 2021 to 50.5 percent.

In 2021, among the 15 FAO Major Fishing Areas reviewed (Figure 19), the Eastern Central Pacific (area 77), Northeast Atlantic (area 27), Northeast Pacific (area 67) and Southwest Pacific (area 81) had the highest percentage of stocks fished at sustainable levels (84–76 percent). In contrast, the following four showed the lowest scores: Eastern Central Atlantic (area 34) 48.7 percent; Northwest Pacific (area 61) 44.0 percent; Mediterranean and Black Sea (area 37) 37.5 percent; and finally the Southeast Pacific (area 87), where just 33.3 percent of stocks were fished at sustainable levels in 2021. Other areas had biologically sustainable levels that varied between 59 percent and 66 percent.

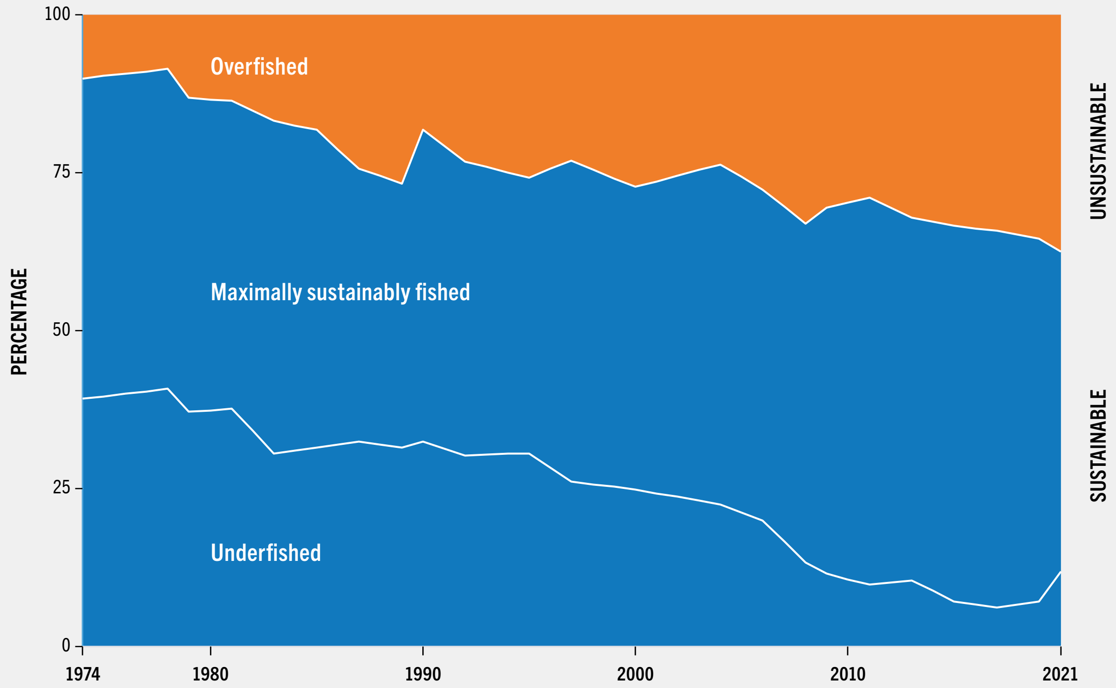
Landings of aquatic species[i] vary greatly among fishing areas (Figure 20) and, therefore, the significance of each area for global fishery sustainability depends on its proportionate contribution to global landings. The temporal pattern of an area's landings often reveals information about its ecological productivity,

g Stocks with abundance at or close to maximum sustainable yield (MSY). FAO defines a fish population as maximally sustainably fished when its biomass is above 80 percent but below 120 percent of the target level, that is 0.8B/BMSY – 1.2 B/BMSY (BMSY – biomass corresponding to maximum sustainable yield).

h Stocks with abundance above the level corresponding to MSY. FAO defines a fish population as underfished when its biomass is above 120 percent of the target level (B/BMSY > 1.2).

i The term landings in this section Marine fisheries refers to capture fisheries production of aquatic animals in marine areas.

FIGURE 18 GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISHERY STOCKS, 1974–2021

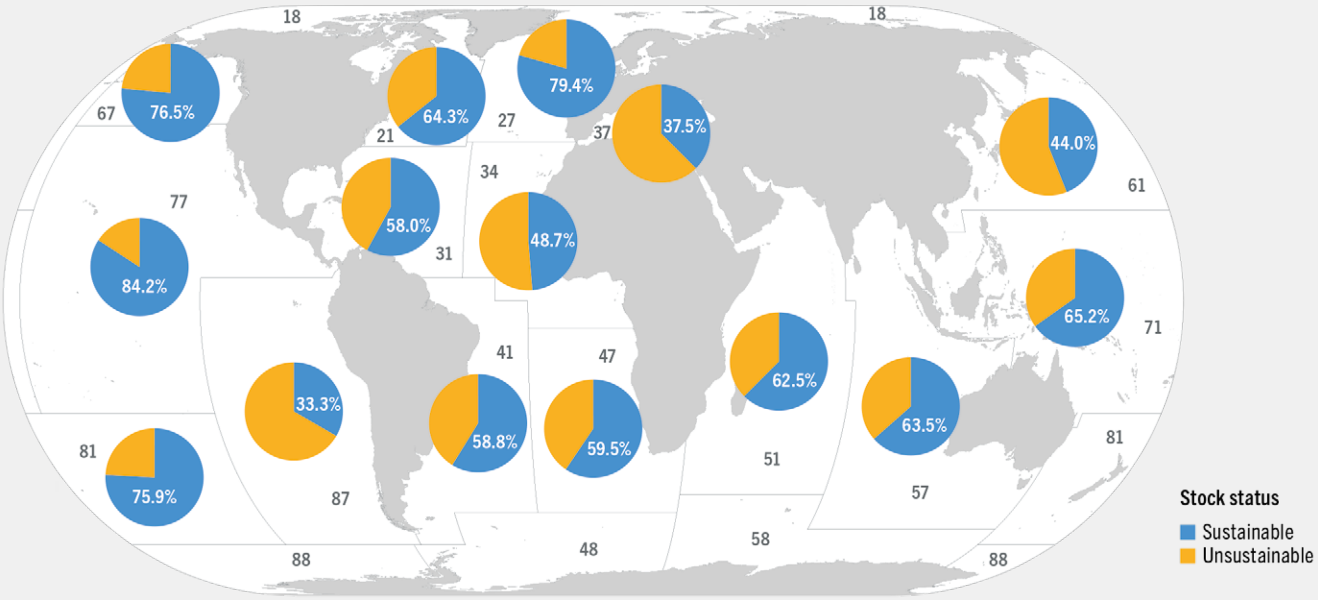


SOURCE: FAO estimates.

fishery development stage, and 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 20): (i) areas with a continuously increasing trend in landings since 1950; (ii) areas with landings oscillating around a globally stable value since 1990, associated with the dominance of pelagic, short-lived species; and (iii) areas with an overall declining landing trend following historical peaks.

In areas where management intervention is weak, a rising trend in landings (first group) signals growing fishing activity, indicating potential for overexploitation and limited control. Despite this, resource sustainability is not necessarily deteriorating. On the other hand, a declining landing trend (third group) typically indicates either a deterioration in the sustainability of fishery stocks or the enforcement of stringent measures without significant signs of recovery. According to the results of the analyses presented here, the first and third groups of areas have the lowest percentage of stocks at biologically sustainable levels (60 percent each), while the second group has the highest (68 percent). Normally, the third group of areas would fall between the other two in terms of resource sustainability, but conditions in the Western Central Pacific, that is in the third group, appear to have deteriorated more than in other places in recent years, causing the difference between the first and third groups to become marginal. The highest level of sustainability observed in the second group of areas is likely the result of full development of fisheries, adequate management and effective regulation of fishing. However, other issues, such as the type of resources,

FIGURE 19 PERCENTAGES OF BIOLOGICALLY SUSTAINABLE AND UNSUSTAINABLE FISHERY STOCKS BY FAO MAJOR FISHING AREA, 2021



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

environmental changes and social factors, can also influence landing trends.

Status and trends by major species

The species with the ten largest landings in 2021 were anchoveta (Peruvian anchovy) (*Engraulis ringens*), Alaska pollock (walleye pollock) (*Gadus chalcogrammus*), skipjack tuna (*Katsuwonus pelamis*), Pacific chub mackerel (*Scomber japonicus*), yellowfin tuna (*Thunnus albacares*), Atlantic herring (*Clupea harengus*), European pilchard (*Sardina pilchardus*), blue whiting (*Micromesistius poutassou*), Pacific sardine (*Sardinops sagax*) and Atlantic cod (*Gadus morhua*). On average, 78.9 percent of these stocks were fished within biologically sustainable levels in 2021, significantly higher than the global average of 62.3 percent. This further demonstrates that the larger stocks are better managed, and that effective fisheries management reaps positive outcomes. However, some stocks of Pacific chub mackerel, Pacific sardine and Alaska pollock were overfished.[j]

Within all seven major commercial tuna species, 23 stocks (six albacore, four bigeye, four bluefin [Atlantic, Pacific and Southern], five skipjack and four yellowfin) are assessed by tuna regional fisheries management organizations (RFMOs), with all their countries participating in the scientific review process. The main commercial tunas contributed 4.95 million tonnes of catch in 2021, a 10 percent decrease from 2019. Fifty-seven percent of the catch was skipjack tuna, followed by yellowfin (31 percent), bigeye (7 percent) and albacore (4 percent). Bluefin tunas accounted for just 1 percent of the global catch.

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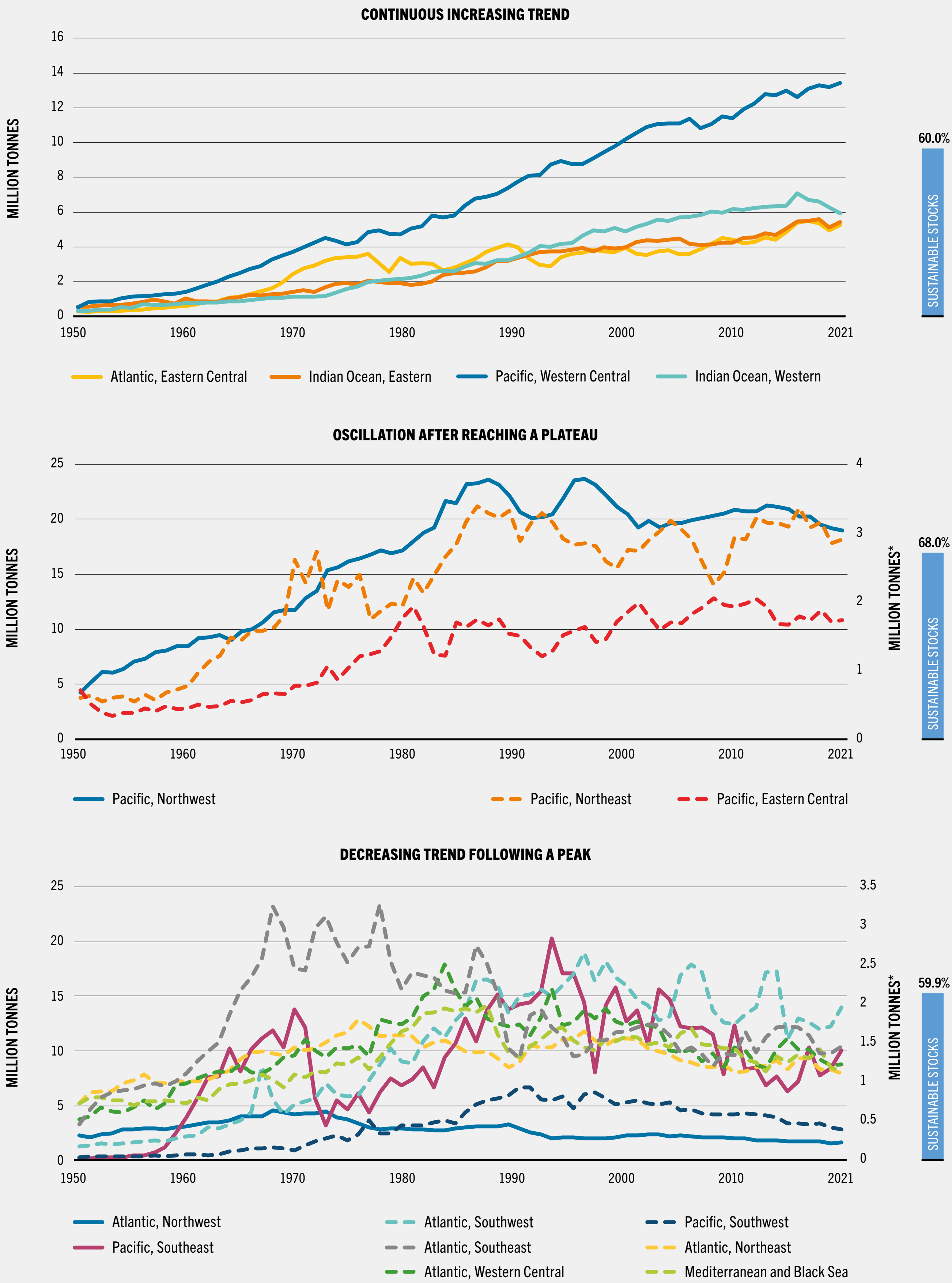
j Overfished refers to stocks having abundance lower than the level that can produce MSY. FAO defines a fish population as overfished when its biomass is below 80 percent of the target level (B/BMSY < 0.8).

FIGURE 20 THE THREE TEMPORAL PATTERNS IN FISHERIES LANDINGS, 1950–2021



* The fishing areas referring to the right axis are shown as dashed lines.

SOURCE: FAO. 2023. FishStat: Global capture production 1950–2021. [Accessed on 15 November 2023]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0

» Globally, 87 percent of tuna stocks are sustainably fished, and 13 percent are considered overfished.[k] Regarding tuna catch, 99 percent of the total catch comes from healthy tuna stocks in terms of abundance (the remainder is from overfished bluefin tuna stocks and one albacore stock). Globally, the tuna RFMOs have been making a concerted effort to use management strategy evaluations to provide advice for rebuilding and keeping stocks at biomass levels above the maximum sustainable yield, with positive results.

The major tuna stocks from the seven main commercial species are closely monitored and their status known with low to moderate uncertainty. However, stocks of 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, 2023a). Furthermore, market demand for tuna remains high, and tuna fishing fleets continue to have significant overcapacity. Effective management – including better reporting of and access to data and the implementation of harvest control rules or other effective measures to control fishing pressure across all tuna stocks – is needed to maintain stocks at a sustainable level and in particular to rebuild overfished stocks. Moreover, substantial additional efforts to manage fisheries targeting tuna and tuna-like species other than the main commercial species are required.

Status and trends by FAO Major Fishing Area

Atlantic Ocean (areas 21, 27, 31, 34, 41, 47) and the Mediterranean and Black Sea (area 37)

The Northwest Atlantic (area 21) produced an average of 1.7 million tonnes (live weight equivalent) of aquatic animals per year during 2017–2021, continuing a decreasing trend from its peak of 4.6 million tonnes in the late 1960s (Figure 20). Atlantic cod (*Gadus morhua*), silver hake (*Merluccius bilinearis*), white hake (*Urophycis tenuis*) and haddock (*Melanogrammus aeglefinus*) have not shown a good recovery, with landings remaining at about 0.1 million tonnes since the late 1990s, less than 5 percent of their historical peak value of 2.1 million tonnes in 1965 (since 2019 they have declined by 30 percent). It is likely that environment-driven changes in productivity are behind the poor recovery results for stocks such as Atlantic cod, American plaice (*Hippoglossoides platessoides*), winter flounder (*Pseudopleuronectes americanus*) and yellowtail flounder (*Limanda ferruginea*). Although landings may be very low and no overfishing seems to be occurring, some of these stocks have still not recovered. In general, invertebrate stocks are in a better state than finfish stocks. Overall, 64.3 percent of the assessed stocks in the Northwest Atlantic were within biologically sustainable levels in 2021, 4.8 percent higher than in 2019.

The Northeast Atlantic (area 27) was the fourth most productive area in 2021, with total landings of 7.9 million tonnes, a decline of approximately 0.4 million tonnes from 2019 (and 1.4 million tonnes from 2017). Landings from this area reached a peak of 13 million tonnes in 1976, then dropped to recover slightly in the 1990s. Overall, they have been decreasing since fish resources experienced extreme fishing pressure in the late 1970s and early 1980s (Figure 20). Since then, countries have better managed the pressure to rebuild overfished stocks. Recovery was reported for 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 for whiting (*Merlangius merlangus*) and common sole (*Solea solea*) in the late 2010s. Some stocks such as North Sea Atlantic cod, Irish and Celtic Sea whiting, and beaked redfish (*Sebastes mentella*) are overfished or still in recovery. In the Northeast Atlantic, 79.4 percent of the assessed stocks were fished within biologically sustainable levels in 2021, a significant improvement since the last assessment, now positioning this region as the second-best globally.

Total landings caught in the Western Central Atlantic (area 31) reached a maximum of 2.5 million tonnes in 1984, then declined gradually to reach a minimum of 1.2 million tonnes in 2014, before rebounding to 1.6 million

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k ISSF (2023), which uses a different definition for the proportion of stocks considered to be sustainably fished, reports that 61 percent of tuna stocks are sustainably fished, 17 percent overfished and 22 percent in an intermediate stage. According also to ISSF (2023), 85 percent of total tuna catch comes from healthy stocks.

tonnes in 2016. They subsequently declined gradually, reaching 1.2 million tonnes in 2021. Small pelagic fishes represent around 37 percent of total landings, of which the main species, Gulf menhaden (*Brevoortia patronus*), is underfished and round sardinella (*Sardinella aurita*) is probably maximally sustainably fished. Medium-sized pelagic fishes such as king mackerel (*Scomberomorus cavalla*) and Atlantic Spanish mackerel (*Scomberomorus maculatus*) are considered maximally sustainably fished, while the serra Spanish mackerel (*Scomberomorus brasiliensis*) is probably overfished. Snappers and groupers are among the most highly valued and intensively fished species in the region and, despite reductions in fishing effort enforced through management actions, several stocks, especially for groupers, continue to be overfished. Highly valued stocks of invertebrate species such as penaeid shrimps in the Gulf of Mexico and along the Guianas–Brazil Shelf in northeastern South America are for the most part underfished or maximally sustainably fished. Stocks of other highly appreciated coral reef invertebrate species such as the Caribbean spiny lobster (*Panulirus argus*) are considered maximally sustainably fished or overfished depending on location, whereas several stocks of queen conch (*Lobatus gigas*) in the Caribbean Sea are overfished and fishing bans have been implemented to limit fishing mortality. Overall, 58.0 percent of the stocks in this region were estimated to be within biologically sustainable levels in 2021, a 4.2 percent decrease from 2019.

The Eastern Central Atlantic (area 34) is characterized by great biological diversity. The exploited resources include different groups with different bioecological characteristics and socioeconomic importance. These are coastal and offshore pelagic resources and coastal and deep demersal resources. The amount of landings from area 34 reached 5.3 million tonnes in 2021 with an upward trend observed from the 1950s. During the last decade, the annual average of landings was around 4.8 million tonnes. Coastal pelagic resources are the most abundant and in 2021 constituted about 50 percent of landings with the dominant species being sardines, sardinellas, horse mackerel and bonga. Sardine, which accounted for 30 percent of the total landings in 2021 (and about 50 percent of the landings in the northern part of this area), is overfished. The stocks of round sardinella (*Sardinella aurita*) are overfished, as are those of flat sardinella (*Sardinella maderensis*), except for the central stock (Nigeria and Cameroon coastal areas), which are classified as maximally sustainably fished. Horse mackerel is less threatened and only overfished in the southern zone. Bonga is overfished in the northern zone and maximally sustainably fished towards the south. Demersal resources include fish, crustaceans and cephalopods. For fish, the assessments carried out show overexploitation of hake, pleuronectiforms, bobo croakers (*Pseudotolithus elongatus*) and threadfins (little captain or *Galeoides decadactylus*). Overall, 48.7 percent of the assessed stocks in the Eastern Central Atlantic were estimated to be within biologically sustainable levels in 2021. This represents a drastic worsening of the estimate in recent years (60 percent of the stocks were sustainable in 2019).

Total landings harvested in the Mediterranean and Black Sea (area 37) were approximately 2 million tonnes in the mid-1980s, but gradually declined over the decades, reaching a low of 1.1 million tonnes in 2014. Subsequently, there was a modest recovery in production, with reported landings of 1.4 million tonnes in 2019, regressing to approximately 1.2 million tonnes in 2020 and 1.1 million tonnes in 2021, partly due to the fishing and trade restrictions imposed by the COVID-19 pandemic. The primary species in terms of volume of landings include small pelagic fishes and striped Venus clam. Examination of the trends in the landings of key resources reveals significant fluctuations in small pelagic stocks and some demersal stocks, with declining trends in, for example, hake (*Merluccius merluccius*), whiting (*Merlangius merlangus*) and common octopus (*Octopus vulgaris*), and increasing trends in, for example, deep water pink shrimp (*Parapenaeus longirostris*), common cuttlefish (*Sepia officinalis*) and red mullet (*Mullus barbatus*). Several commercially important stocks are beyond biologically sustainable limits, including stocks of hake and certain stocks of red mullet and sardine (*Sardina pilchardus*). In 2021, 37.5 percent of the stocks in the Mediterranean and Black Sea were within biologically sustainable levels – a

0.8 percent improvement on 2019;[l] this may be a sign that the degrading situation recorded for decades is halting.

In the Southwest Atlantic (area 41), total capture fisheries production ranged between 1.5 and 2.6 million tonnes, following an initial period of growth that ended in the mid-1980s. In 2021, the total landings amounted to about 2.0 million tonnes, marking a 17 percent increase from 2019 (Figure 20). Historically, the species with the largest reported landings is Argentine shortfin squid (*Illex argentinus*), accounting for between 10 percent and 45 percent of the region's total landings. Landings of this species reached 447 000 tonnes in 2021, representing a 216 percent increase from 2019, making it the most significant species in the region in terms of volume. Other landed species are Argentine hake (*Merluccius hubbsi*) and Argentine red shrimp (*Pleoticus muelleri*), with reported landings in 2021 close to 415 000 tonnes and 225 000 tonnes, respectively, similar to the figures recorded in 2019. Both Argentine shortfin squid and Argentine red shrimp stocks were at biologically sustainable levels, while it was confirmed that one of the hake stocks recovered to biologically sustainable levels. Patagonian squid (*Doryteuthis gahi*) stocks were also at biologically sustainable levels and showed an increase in landings of approximately 18 percent compared with 2019; as a result, it ranked as the fourth most important fishery in the region, with landings approaching 100 000 tonnes. In total, 58.8 percent of the assessed stocks in the Southwest Atlantic were at biologically sustainable levels in 2021, marking an encouraging 19 percent improvement from 2017 – an improved trend despite a marginal decline in recent years.

The Southeast Atlantic (area 47) has shown a decreasing trend in capture fisheries production since the late 1970s, from a total of 3.3 million tonnes to 1.5 million tonnes in 2021 (Figure 20). Recent stock assessments for hake (*Merluccius capensis* and *Merluccius paradoxus*) in South Africa have shown a steady increase in spawning biomass and are estimated to be at levels above the MSY. In Namibia, hake resources are dominated by *Merluccius capensis*, which is currently overfished, while red crab (*Chaceon maritae*) stocks are at biologically sustainable levels. In South Africa, relative abundance and catch of small pelagic resources – sardine (*Sardinops sagax*) and anchovy (*Engraulis capensis*) – remain low despite rigorous management and continued monitoring. The West Coast rock lobster fishery in South Africa is experiencing overfishing and is currently at 1.3 percent of pre-1910 levels. In Namibia, red crab (*Chaceon maritae*) stocks are at biologically sustainable levels. Horse mackerel supports large fisheries in the region and its stocks have recovered to biologically sustainable levels following good recruitment and strict management measures. Stock assessments for devil anglerfish (*Lophius vomenirus*) suggest that they are sustainably fished in the waters of Namibia and South Africa. The Southern African sardine stocks are still very degraded, needing special conservation measures from Namibia (*Sardinops ocellatus*) and South Africa (*Sardinops sagax*). Sardinella (*Sardinella aurita* and *Sardinella maderensis*) stocks – very important in Angola and to some extent Namibia – remain at biologically sustainable levels. Most of the locally important South African line fishes are sustainably fished or are recovering. Snoek (*Thyrsites atun*), yellowtail (*Seriola lalandi*) and carpenter (*Argyrozona argyrozona)* are sustainably fished, but some important stocks such as silver kob (*Argyrosomus inodorus*) are still overfished. Updated data for perlemoen abalone (*Haliotis midae*) do not reveal signs of resource recovery and stocks continue to decline because of illegal harvesting. Overall, 59.5 percent of the assessed stocks in the Southeast Atlantic were fished within biologically sustainable levels in 2021, a 5.2 percent drop from 2019.

Indian Ocean (areas 51, 57)

Total landings caught in the Western Indian Ocean (area 51), continued to increase and reached 5.1 million tonnes and 5.4 million tonnes in 2020 and 2021, respectively (Figure 20). Tunas and tuna-like fishes continued to contribute the most, followed by small pelagic fishes and mixed (mainly reef-associated) reef fishes. Penaeid

l With the main aim to support fisheries management, the General Fisheries Commission for the Mediterranean (GFCM) provides a parallel regional assessment of the status of priority commercial stocks in the Mediterranean and Black Sea; the most recent edition was published in 2023 based on 2021 reference year. This assessment is based on analytical scientific assessments of management units (a combination of priority species and geographical subareas of interest) covering 50 percent of the catches.

shrimps and cephalopod molluscs contributed similarly to overall landings, at relatively low levels. Pelagic fishes contributed around 56 percent of total landings. Stocks of tunas and shrimps – important generators of foreign revenue – are either maximally sustainably fished or overfished in the region. The Indian Ocean Tuna Commission regularly updates the status of tunas and tuna-like fishes, while the Southwest Indian Ocean Fisheries Commission strives to assess the other main high seas regional stocks using data-poor methods. The 2021 assessment estimated that 62.5 percent of the assessed stocks in the Western Indian Ocean were within biologically sustainable levels, while 37.5 percent were overfished.

Landings harvested from the Eastern Indian Ocean (area 57) have displayed a consistent upward trend over the past decades, surging to over 7 million tonnes in 2017 before levelling off at around 6 million tonnes in recent years. Unfortunately, comprehensive stock status data remain notably scarce, with information available primarily for selected coastal stocks in specific regions. Hilsa shad, narrow-barred Spanish mackerel and horse mackerel show increasing trends in production. Notably, stocks of small pelagic fish, including sardinellas, anchovies and Indian oil sardines, exhibit marked fluctuations in production likely caused by changes in fishing pressure and environmental conditions. Among the stocks deemed to be within sustainable levels are hilsa shad, Indian mackerel, anchovies, giant tiger prawn, squids and cuttlefish. Stocks of toli shad, Indian oil sardine and sardinellas are considered overfished. The current assessment indicates that 63.5 percent of the assessed stocks are estimated to be within biologically sustainable thresholds, a 1.8 percent decrease from 2019.

Pacific Ocean (areas 61, 67, 71, 77, 81, 87)

The Northwest Pacific (area 61) has the highest fisheries production among the FAO Major Fishing Areas, with 19.3 million tonnes of aquatic animals and accounting for 23.8 percent of global marine fisheries production in 2021. Among the 17 species analysed, the most productive in 2021 was Alaska pollock at 2 million tonnes. Historically this species has always been the most productive in area 61, peaking in 1986 at 5.1 million tonnes. The second most productive species in 2021 was Pacific chub mackerel (*Scomber japonicus*) with 1.2 million tonnes. It was followed by Pacific sardine (*Sardinox sagax*) at 1.03 million tonnes, previously indicated as Japanese pilchard (*Sardinops melanostictus*), another historically productive species with a peak landing of 5.4 million tonnes in 1988. These species were closely followed by largehead hairtail (*Trichiurus lepturus*) with 1.0 million tonnes and Japanese anchovy (*Engraulis japonicus*) with 0.9 million tonnes. Among the analysed species, largehead hairtail and Japanese anchovy had the biggest increase in landings since 1990. Overall, in 2021, about 44 percent of assessed stocks were within biologically sustainable levels – an 11 percent reduction in sustainable status compared with 2019.

Landings caught in the Northeast Pacific (area 67) remained rather stable during 2013–2021, at around 3.0 million tonnes per year (Figure 20). Alaska pollock remained the most abundant species, representing about 51 percent of total landings. North Pacific hake (*Merluccius productus*), Pacific cod (*Gadus microcephalus*) and soles were also major contributors to the landings. Most stocks in this region are within biologically sustainable levels and well managed. This is due to the science-based advice from the North Pacific Fisheries Commission and the US North Pacific Fishery Management Council to set total allowable catches well below the maximum sustainable yield potential in pollock to achieve MSY objectives across all species caught in the mixed stock trawl fishery, as well as good governance, which has helped reduce fishing pressure. However, some stocks of Pacific salmon in southerly states (British Columbia in Canada and the states of Washington, Oregon and California in the United States of America) were overfished in 2021, and some stocks of Pacific herring, king crab and yelloweye rockfish are still recovering from overfishing. Recruitment failures of the Bering Sea snow crab as a consequence of climate change are cause for concern regarding possible long-term changes in these areas. Overall, 76.5 percent of the assessed stocks in the Northeast Pacific were within biologically sustainable levels in 2021; while this score places the area in the third-best position among all areas monitored globally, the region experienced a significant drop of 9.6 percent compared to the

2019 assessment related to recruitment decline in some stocks possibly due to climate change.

The Western Central Pacific (area 71) produced the second-largest amount of landings worldwide – 13.4 million tonnes (approximately 17 percent of the global landings in marine areas) – in 2021. Many fish species were landed, but landings were not always categorized as specific species and were recorded in a multitude of generic categories such as "marine fishes not elsewhere included" and "sharks, rays, skates, etc.". These categories constituted 57 percent of the region's total landings in 2021. Tuna and tuna-like species were important, contributing around 26 percent of total landings. Small pelagic species such as sardines, anchovies and scads were also significant (13.7 percent). Of the stocks assessed, 65.2 percent were estimated to be at biologically sustainable levels, while 35 percent were not sustainable. However, these results should be treated with caution, given the uncertainties in the region´s data.

Landings caught in the Eastern Central Pacific (area 77) have fluctuated over the past few decades between 1.5 and 2.0 million tonnes; in 2021, they stood at 1.7 million tonnes. This region's landings predominantly consist of small to medium-sized pelagic fishes, squids and shrimps, which are inherently susceptible to interannual variations in oceanographic conditions and can present oscillations in landings despite sustainable exploitation rates. Estimates suggest that approximately 84.2 percent of the stocks in the Eastern Central Pacific are being harvested at biologically sustainable levels. This is the highest sustainability score among all fishing areas, despite a slight decrease from 2019. Notably, stocks of California sardine (*Sardinops caeruleus*), anchovy (*Engraulis mordax*), Pacific anchoveta (*Cetengraulis mysticetus*), Pacific thread herring (*Opisthonema libertate*) and jumbo flying squid (*Dosidicus gigas*) are currently managed within sustainable levels. However, coastal resources of high-value species, including groupers, snappers and shrimps are still overfished. Regrettably, the status of these stocks remains highly uncertain due to limited data.

Southwest Pacific (area 81) capture fisheries production in 2021 was around 390 000 tonnes (Figure 20) of highly diversified species. Major species are blue grenadier, pelagic mackerels and squid, accounting for around 47 percent of the total landings in 2021. Southern blue whiting, snoek and pink cusk-eel are also significant in the region. A major contributor to a decline in landings since the early 1990s has been a reduction in catch limits to ensure sustainability. Few stocks are considered underfished. Overall, about 75.9 percent of assessed fishery stocks in the Southwest Pacific were at biologically sustainable levels in 2021, a stable situation since 2019.

Landings caught in the Southeast Pacific (area 87) reached 10 million tonnes in 2021, that is about 12.5 percent of global landings and the third-largest capture fisheries production in marine areas. The clear decreasing trend in landings from the early 1990s to 2016 has reversed, mostly due to increases in landings of Peruvian anchoveta (*Engraulis ringens*) (Figure 20). The two most productive species were anchoveta and jumbo flying squid (*Dosidicus gigas*), with landings of almost 5.9 million tonnes and almost 1 million tonnes, respectively. While the stock of anchoveta is considered to be within biologically sustainable levels – likely because of effective fisheries management and favourable environmental conditions – the stock of jumbo flying squid shows signs of overexploitation. The stock of araucaria herring (*Strangomera bentincki*) is also estimated to be within biologically sustainable levels. In contrast, the stocks of South American pilchard (*Sardinops sagax*), South Pacific hake (*Merluccius gayi*), Southern hake (*Merluccius australis*) and Patagonian toothfish (*Dissostichus eleginoides*) are all currently estimated to be at unsustainable levels. However, stocks of Pacific chub mackerel (*Scomber japonicus*) have recovered to sustainable levels in the region. Although the majority of this region's catch (approximately 83 percent, because of Peruvian anchoveta) comes from stocks at sustainable levels, overall, just 33.3 percent of its assessed stocks were within sustainable levels in 2021, similar to the 2019 levels.

Conclusions

While for several regions there are full formal assessment reports for the major exploited stocks, enabling an effective estimate of their status, for many other regions this is not the case.

Often knowledge on stock structure for most species caught is insufficient to enable formal stock assessments. This effect is most marked in regions dominated by multispecies and multigear small-scale fisheries, for which data (quantity and quality) are limited and stock structure knowledge is poor for most species caught. For that reason, a good part of the stocks covered in this review are assessed using catch trends and supplementary data or expert knowledge, as opposed to analytical stock assessments or fishery-independent data.

FAO's world assessment relies mostly on "traditional" full statistical stock assessments, but also on data-limited assessments or expert elicitation methods (FAO, 2011a). One reason for possible differences between the FAO approach and, for example, Worm's global outlook on the world's fisheries (Worm *et al*., 2009), is that different stocks are used to estimate the global overfishing percentages across the different studies. Another potentially major factor is that FAO's methodology tends to aggregate stocks into larger units versus the Worm *et al*. approach. However, regardless of these caveats, for FAO's assessment of marine fishery resources, the fraction of fishery stocks within biologically sustainable levels decreased to 62.3 percent in 2021, continuing an overall declining trend of ~0.5–1 percent per year over the last few decades.

FAO is working to achieve an important improvement in the methodology and processes used to report on the state of exploited fishery resources (see Box 28, p. 160), and this work will improve the quality, reliability and transparency of the global indicators reported by FAO.

Prospects of achieving the SDG target on fisheries

FAO is tasked under the Sustainable Development Goals (specifically SDG 14) with tracking global progress on sustainable use of fishery resources (Target 14.4). In 2021, 62.3 percent of the fishery stocks of the world's marine fisheries were fished within biologically sustainable levels. The continuous decreasing trend of the proportion of sustainably fished stocks (see Figure 18, p. 43) is cause for alarm in the international community and among relevant stakeholders, as urgent concrete restoration plans and management efforts are needed to achieve sustainable fisheries. However, there are also positive signals in some regions of the world (like the North Atlantic and the Northeast and Southeast Pacific), which have improved the proportion of stocks sustainably fished. This is directly related to better assessment and management, which lead in turn to improved estimates of sustainable fishing (Hilborn *et al*., 2020). In other parts of the world, change is coming, but unfortunately at a slower pace than the timeline for achieving the SDG goals.

Overfishing – fishing that causes the reduction of stock abundance to below the level that can produce MSY – not only causes negative impacts on biodiversity and ecosystem functioning, but also reduces fish 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). A more recent study estimates that poor fisheries management results in foregone revenues of more than USD 83 billion annually (World Bank, 2017). It would also increase significantly the contribution of marine fisheries to the food security, nutrition, economy and well-being of coastal communities.

Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) set Target 14.4: to end overfishing by 2020. Unfortunately, world fisheries have diverged from this target, with overfishing increasing from 35.4 percent in 2019 to 37.7 percent in 2021. However, this global picture masks regional and intra-country differences. A study (Hilborn *et al*., 2020) shows that intensively managed stocks have, on average, seen abundance increasing or at proposed target levels, while in contrast, regions with less developed fisheries management have much higher harvest rates and lower abundance with regard to target levels. 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 effective fisheries management for the sustainable use of marine resources around the world, in line with the FAO Blue Transformation objective of ensuring that 100 percent of fisheries are placed under effective management, and consistent with the Blue Transformation Roadmap (FAO, 2022a).

Inland fisheries

Inland fisheries contribute over 12 percent of world fish landings. Their contribution can be particularly important in landlocked developing countries and low-income food-deficit countries (LIFDCs). Indeed, 21 percent (2.4 million tonnes, 2021) of the world's inland fish capture harvest comes from LIFDCs, making them particularly important for the subsistence of people in these countries – for their food security and poverty alleviation. Nearly 70 percent of all subsistence fishers exploit inland fisheries, often alongside other activities or as a complementary activity during times of low labour demand.

Inland fisheries are widespread and exhibit significant diversity. In addition to large lakes, reservoirs, rivers and floodplains, fishing takes place in swamps, streams and ponds, reservoirs, canals, ditches and rice fields. Fishing in these waterbodies is predominantly small-scale in nature, with 99 percent of total inland capture production coming from small-scale fisheries. These fisheries can be further characterized by the diversity of fishers, fishing practices, management arrangements and associated value chains.

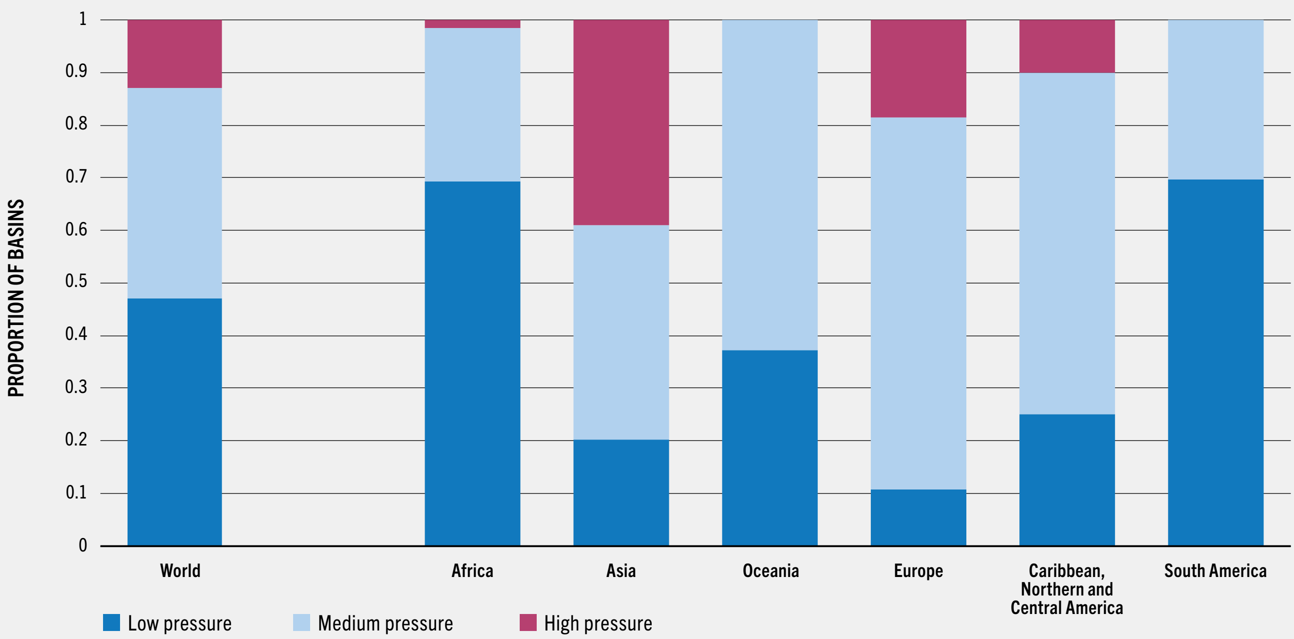
Production from inland fisheries is more concentrated in those countries with important waterbodies or river basins. Asia hosts the top four producers of inland fish – India, China, Bangladesh and Myanmar – and accounts for nearly two-thirds of global inland fisheries production. Tropical floodplains associated with lakes and river basins are home to some of the world's largest inland fisheries that make important contributions to livelihoods, food security and nutrition. In these dynamic environments, the interannual variability in flooding can have a more significant effect on survival and growth rates than do the size and productivity of the stocks. This can give rise to changes in productivity and species composition in landings.

The distribution and nature of inland fisheries are different from those of marine fisheries. Because of the nature of inland aquatic habitats, many inland fishery stocks have life cycles that enable them to experience and recover from high levels of mortality associated with dynamic and unpredictable environments. Given the large numbers of people involved, fishing pressure can be high; however, environmental factors play an even greater role in the productivity and resilience of these fisheries. The situation is different in temperate or Arctic lakes or streams, where more isolated fishery stocks may be vulnerable to overfishing; but even in these environments, other changes – for example, in connectivity, water quality and the condition of spawning grounds – play important roles in the status and health of fishery stocks.

Fishing in inland waters is also diverse. While some fishing occurs all year round, in other cases it is seasonal or occasional, carried out to complement other income-generating activities or when there is a low demand for labour. Although the activities and livelihood contributions are recognized, much of the fishing in seasonal waterbodies, small streams and other marginal wetlands remains poorly quantified and reported, including the related post-harvest activities. While the contributions of inland fisheries to poverty reduction can be significant for many countries and communities, their small-scale, dispersed and frequently remote nature make their comprehensive assessment challenging.

The status of inland capture fisheries and their contributions to food security, livelihoods and economies ultimately depend on inland aquatic environments. These environments often fluctuate, with communities adapting to these natural changes and turning the resulting seasonal and interannual variations into a strength. However, these changes are also among the most rapid in the world, presenting unique challenges. They can be the result of competing demands for water use by agriculture, industry, human consumption or recreation, occurring at different scales. The small-scale and dispersed nature of many inland fisheries – each of which may be affected

FIGURE 21 **STATE OF MAJOR INLAND FISHERIES**



NOTE: Proportional threat status of the basins most important for inland fisheries and fish catch (n=45 basins) is averaged by region and across regions.

SOURCE: Stokes, G.L., Lynch, A.J., Funge-Smith, S., Valbo-Jørgensen, J., Beard Jr, T.D., Lowe, B.S., Wong, J.P. & Smidt, S.J. 2021. A global dataset of inland fisheries expert knowledge. *Scientific Data*, 8(1): 182. https://doi.org/10.1038/s41597-021-00949-0

by a combination of localized drivers – results in specific challenges; consequently, aggregate national production statistics (when they exist) tend not to provide a reliable indicator to assess the status of inland fisheries. Many of the livelihoods and economic benefits of inland fisheries are not captured in regular monitoring. Furthermore, subsistence, recreational and occasional fishing activities and informal exchanges can all represent important contributions to households and communities that can be difficult to quantify. The global threat assessment instead highlights where there may be pressures that can affect these contributions. The threat assessment can therefore provide the basis for assessing how changes in inland aquatic environments can affect the benefits and opportunities provided by inland fisheries.

These challenges require an approach that can place the status of inland fisheries in the context of wider change. This and the connections between inland aquatic environments have led to the adoption of the river basin or catchment as the appropriate scale at which to assess threats, so that the implications of modifications in land use, water quality and infrastructure development, as well as climate change, can be determined. This has been the basis of an approach to create a global threat map for inland fisheries developed by FAO in collaboration with the United States Geological Survey.

The approach analysed 20 anthropogenic threat types to create indicators of the aggregate threat to inland fishery stocks (Stokes *et al.*, 2021). To monitor dispersed, seasonal and occasional small-scale inland fisheries, the approach combines information from multiple sources,

FIGURE 22 PROPORTION OF FISHING VESSELS BY MOTORIZATION STATUS, GEOGRAPHICAL REGION AND INCOME GROUP, 2022

SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

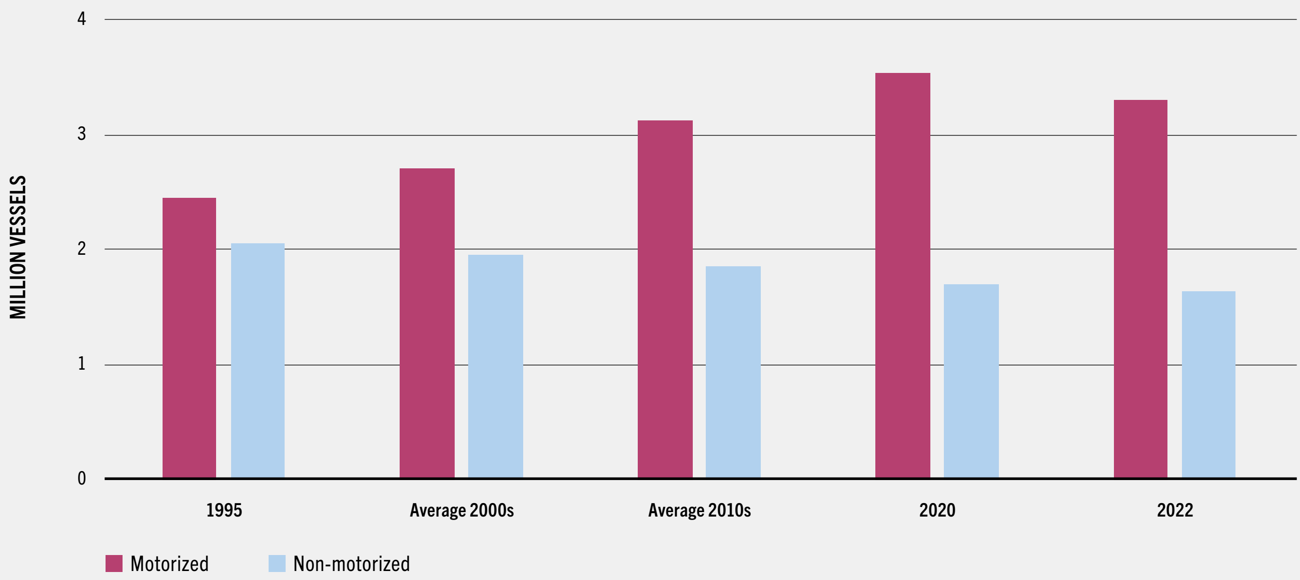
including the use of proxy indicators to provide transparent replicable assessments of the threats to inland fisheries. The most recent results suggest that across all major basins included in the assessment as important to inland fisheries, 47 percent of basins are estimated to be under "low pressure", 40 percent under "moderate pressure" and 13 percent under "high pressure" (Figure 21). Criteria for describing the pressure category are based on a numeric scale of one to ten, where low pressure refers to those with a score of 1–3, moderate pressure a score of 4–7 and high pressure a score of 8–10. The results can help inform the prioritization of interventions in the context of integrated water resources management. ■

FISHING FLEET

Estimate of the global fishing fleet and its regional distribution

In recent years, FAO has adopted improved data collection tools and analysis, resulting in a significant revision of the 1995–2022 data on fishing fleet, in particular in Asian countries. The largest increase was in Indonesia, due to improved data collection and the inclusion of inland fishing vessels, with an estimated total of 1.1 million fishing vessels reported in 2022, making it the largest fleet in the world. Updates were also reported by the Philippines and India. Thailand reported undecked vessels for the first time in 2021, increasing the reported

FIGURE 23 **GLOBAL FISHING FLEET, MOTORIZED VS NON-MOTORIZED, 1995–2022**



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

fleet size from 20 000 to 70 000 vessels. As a result, the revised figures are higher than those reported previously, with the exception of 1995. These reported increases in the time series since 1995 should not be attributed to an increase in fleet size.

In light of these revisions, the world fishing fleet was estimated at 4.9 million vessels in 2022, with data showing a decreasing trend since the peak of 5.3 million reported in 2019. Among many fishing nations such as China, Japan and European Union Member States, the downward trend of the fleet size continues, reflecting efforts to improve fisheries sustainability. However, it should be highlighted that merely reducing the number of vessels in a fleet is not sufficient to guarantee improved sustainability outcomes.

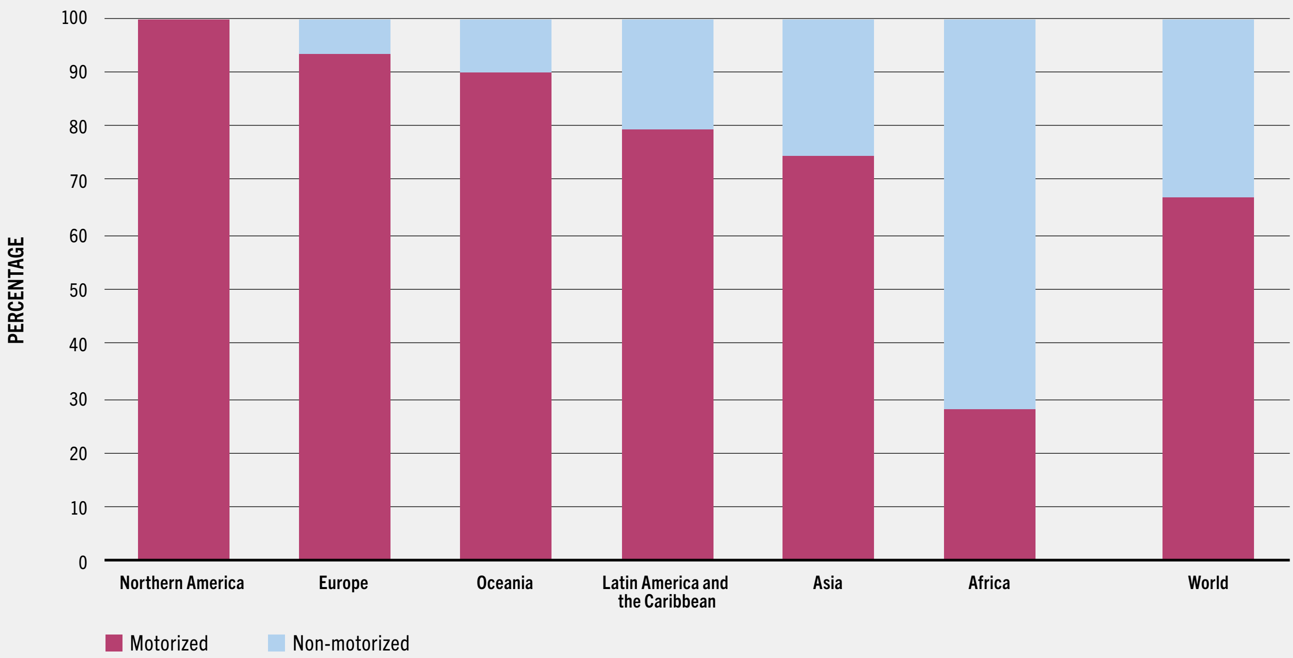
Asia hosts the world's largest fishing fleet, estimated at 3.5 million vessels or 71 percent of the global total in 2022 (Figure 22). This proportion is a drop from 73 percent in 2019. Africa's fleet has been increasing relative to the rest of the world and represented over 19 percent of the world's fishing vessels in 2022, up from 18 percent in 2019. The shares of Latin America and the Caribbean (5 percent), Northern America, Europe (both 2 percent) and Oceania (less than 1 percent) have not changed since 2019.

The largest part of the global fishing fleet is found in upper-middle-income (41 percent) and lower-middle-income (39 percent) countries, followed by high-income (11 percent) and low-income countries (8 percent).

Analysis by motorization status

There are approximately 3.3 million motorized vessels, comprising two-thirds of the global fishing fleet. Their number increased from 2.4 million units in 1995 to a peak of 3.5 million in 2020, after which it slightly decreased to 3.3 million vessels in 2022. Meanwhile, the number of non-motorized vessels decreased from 2 million in 1995 to 1.6 million in 2022 (Figure 23).

FIGURE 24 SHARE OF MOTORIZED AND NON-MOTORIZED VESSELS BY GEOGRAPHICAL REGION, 2022



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

Figure 22 shows that Asia had 80 percent (2.6 million) of the world's motorized vessels and 54 percent (0.9 million) of non-motorized vessels in 2022. Africa has the second-largest non-motorized fleet, estimated at 42 percent of the world total. Together, Asia and Africa account for 96 percent of the global non-motorized fleet. Figure 24 presents the share of motorized and non-motorized vessels in the total fleet for each continent, showing that Africa is the only continent where non-motorized vessels outnumber motorized vessels. It is also the only continent where the number of vessels has increased since 2019.

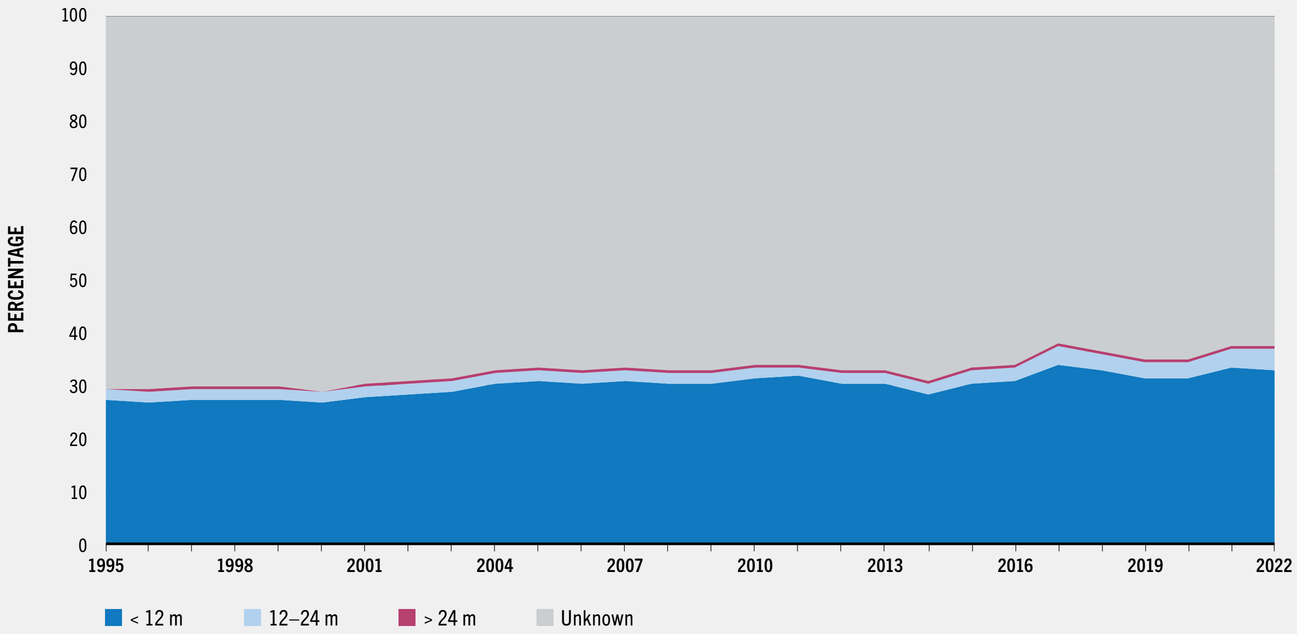
Figure 22 shows also that nearly half of the world's motorized vessels can be found in upper-middle-income countries (49 percent), followed by lower-middle-income countries (31 percent), high-income countries (16 percent) and low-income countries (3 percent). Non-motorized vessels have a very different distribution among income groups: more than half of these vessels are found in lower-middle-income countries (55 percent), followed by upper-middle-income countries (25 percent) and low-income countries (19 percent), while only 1 percent are found in high-income countries.

Size distribution of vessels and the importance of small boats

Information on the size of vessels is available for only 37 percent of the total vessels reported. This information is not available for the three countries with the world's largest fleets that accounted for nearly half of the global fishing fleet in 2022 – China, Indonesia and the Philippines. Among those vessels for which information on length overall (LOA) was available in 2022, 89 percent were in the LOA class of under 12 m, 10 percent in the LOA class of 12 to 24 m, and 2 percent in the LOA class of over 24 m. Figure 25 and Figure 26 show a gradual increase in the information on size and indicate that the share of small vessels has been decreasing since 2010.

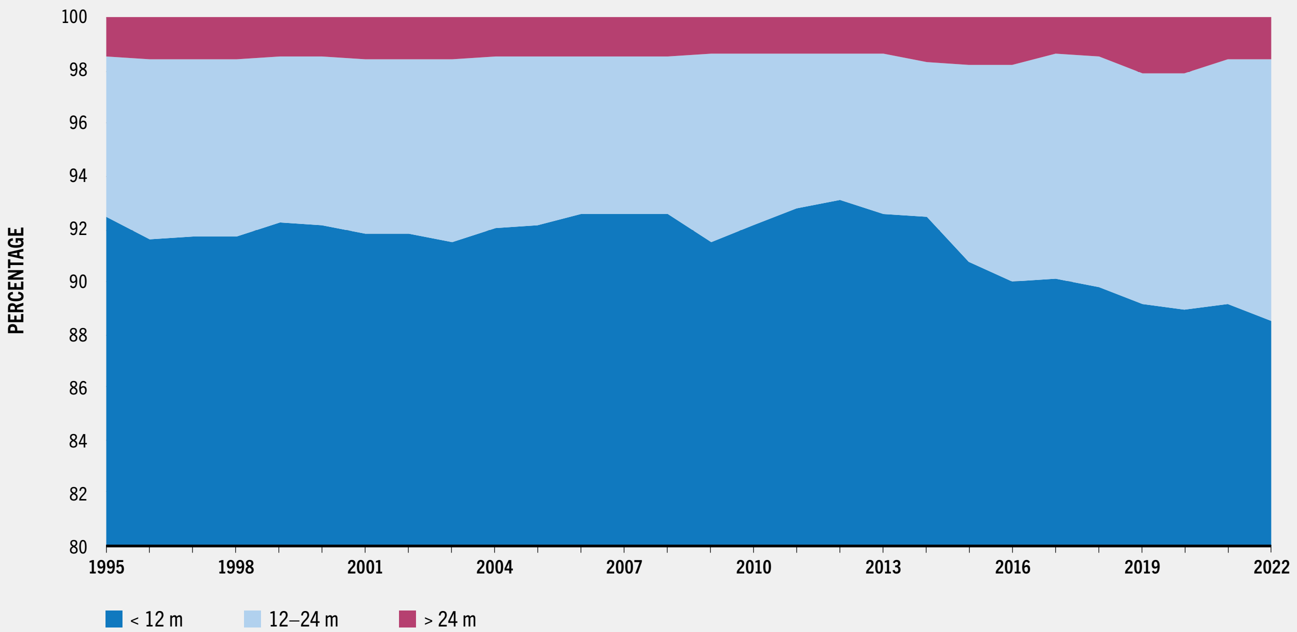
These data confirm FAO results (Van Anrooy *et al.*, 2021), which underline general increases in gross tonnage and length overall observed in fleets around the world. Large vessels, though small in number, continue to account for around one-third of the total engine power of the global »

FIGURE 25 SIZE DISTRIBUTION OF FISHING FLEET, 1995–2022



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

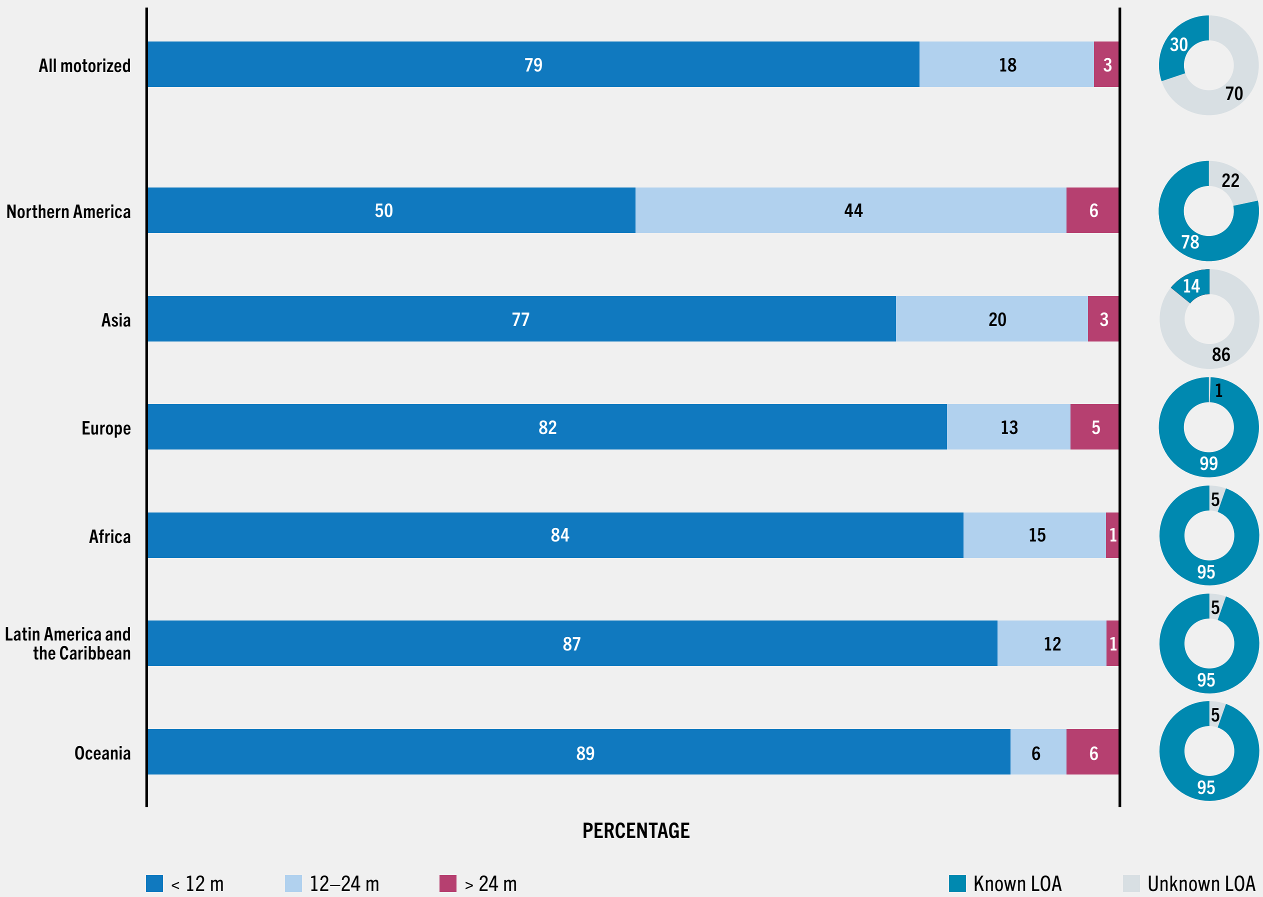
FIGURE 26 SIZE DISTRIBUTION OF FISHING FLEET WITH KNOWN LENGTH OVERALL, 1995–2022



NOTE: The Y axis starts at 80 percent to makes changes more visible.

SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

FIGURE 27 SIZE DISTRIBUTION OF MOTORIZED FISHING FLEET BY GEOGRAPHICAL REGION, 2022



NOTE: LOA – length overall.

SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

» fishing fleet (Rousseau *et al.*, 2019). It is important to consider the differences in data coverage and quality between the different size groups. While industrial vessels are usually subject to licensing and registration requirements, this is less often the case for small vessels, which may not always be reported in national statistics even when registries exist.

For motorized vessels, size data are available for only 30 percent of vessels. Of these, 80 percent belong to the LOA class of under 12 m, 18 percent to 12 to 24 m, and 3 percent to over 24 m. For non-motorized vessels, information on size accounts for 52 percent of the data. Around 99 percent of these are LOA class under 12 m, compared with just 1 percent 12 to 24 m and only a few vessels reported over 24 m.

Figure 27 shows the distribution of motorized vessels with known LOA in 2022 by geographical region. The same breakdown for non-motorized vessels is not shown because – as noted above – 99 percent belong to the small category. Small vessels represent the largest share among all motorized vessels with known LOA in all

BOX 3 NEW GUIDANCE TO ENHANCE GLOBAL REPORTING BY FISHING VESSEL TYPE

The design, size, equipment and other characteristics of the main types of semi-industrial and industrial fishing vessels have evolved significantly in recent decades. This has made it necessary for FAO to update its 1985 Fisheries and Aquaculture Technical Paper, *Classification and definition of fishing vessel types* (Thermes *et al*., 2023). This new edition includes most fishing vessel types with illustrations of selected vessels. The vessel type classification codes employed have been updated to align them to the revised version (2019) of the International Standard Statistical Classification of Fishery Vessels by vessel type of the Coordinating Working Party on Fishery Statistics. In addition, the publication also presents updates of the approximate relationship between the length overall of fishing vessels and their gross tonnage.

The technical paper assists FAO Members, regional fishery bodies and all those working on fishery statistics and management, by providing updated information on vessel types and characteristics. It includes the necessary information to identify and classify all types of semi-industrial and industrial fishing vessels for reporting purposes. This is particularly relevant for reporting data on vessels and on catches by vessel type. Likewise, the information can be useful in the implementation of the 1999 International Plan of Action for the Management of Fishing Capacity.

Longtail boats berthed off the beach, Koh Lipe, Thailand
© FAO/Sirachai Arunrugstichai

REFERENCE: Thermes, S., Van Anrooy, R., Gudmundsson, A. & Davy, D. 2023. *Classification and definition of fishing vessel types.* Second edition. FAO Fisheries and Aquaculture Technical Paper, No. 267. Rome, FAO. https://doi.org/10.4060/cc7468en

regions. In 2022, this share was highest in Oceania (89 percent) and over 80 percent also in Latin America and the Caribbean, Europe and Africa. In Asia, 77 percent of vessels belonged to this category, while in Northern America only half of the fleet consisted of small vessels. The proportion of large vessels (with an LOA of over 24 m and usually associated with over 100 gross tonnage) was highest in Northern America and Oceania (both 6 percent), followed by Europe (5 percent), Asia (3 percent), Latin America and the Caribbean and Africa (both 1 percent).

Data quality and improvements

Data collection at the country level continues to improve; furthermore, FAO's comprehensive revision of fleet data dating back to 1995 involves close communication with countries to ensure correct interpretation of the data received, uncovering new data sources, controlling for data errors, and making informed estimations where necessary. Efforts are made to clarify and harmonize data coverage comprising all active vessels operating in marine and inland waters. FAO continues to provide support to countries to improve data collection and develop updated classifications and definitions (see Box 3), and the fishing fleet analysis will eventually include data from 1950 to 1995. ■

EMPLOYMENT IN FISHERIES AND AQUACULTURE

Employment in the primary sector

Similarly to the data on fishing vessels, the data on global employment in fisheries and aquaculture have been revised resulting in figures higher than those previously reported for 1995–2021. In 2022, an estimated 61.8 million people were engaged as full-time, part-time, occasional or unspecified workers[m] in the primary sector of commercial fisheries and aquaculture – a slight decrease from 62.8 million in 2020. The aquaculture sector accounted for 36 percent of this global workforce, 54 percent were employed in capture fisheries, while it was not possible to break down the remaining 10 percent between fisheries and aquaculture.

Asia accounted for the vast majority (85 percent) of workers involved in fisheries and aquaculture, followed by Africa (10 percent) and Latin America and the Caribbean (4 percent), while Europe, Oceania and Northern America combined accounted for just 1 percent. The total fisheries and aquaculture workforce comprised 1.7 percent of the working age population (15–64 years of age) in Asia, followed by Africa (0.8 percent), Latin America and the Caribbean (0.5 percent), Oceania (0.3 percent) and Northern America and Europe (both 0.1 percent). It should be noted that the age of employment may fall outside this age range, as child labour is a notable issue in the sector (FAO, 2021a; Lozano *et al.*, 2022).

Considered separately, aquaculture provided employment for approximately 22 million people globally, mainly in Asia (95 percent), followed by Africa (3 percent) and Latin America and the Caribbean (2 percent). Comparatively, 77 percent of the global fisheries workforce was in Asia, while Africa and Latin America and the Caribbean employed about 16 percent and 5 percent of the world's fishers, respectively.

m Fisheries and aquaculture employment data can be disaggregated into full-time, part-time and occasional work. When such information is unavailable, the data is classified as "status unspecified".

Northern America, Europe and Oceania each contributed 1 percent or less in both subsectors. Table 10 presents the number of fishers and fish farmers by geographical region and subsector, breaking down further fisheries into inland and marine.

Total employment in fisheries and aquaculture gradually increased from 41.3 million in 1995 to a peak of an estimated 63.1 million in 2018, after which a slight decrease is observed (Figure 28). The trends in the number of people engaged as fishers or fish farmers vary by region. Between 1995 and 2022, this workforce increased in Africa, Asia and Latin America and the Caribbean by 91 percent, 49 percent and 44 percent, respectively, while it decreased in Europe, Northern America and Oceania by 32 percent, 26 percent and 20 percent, respectively.

Where data could be disaggregated by subsector, employment in aquaculture more than doubled between 1995 and 2016, when it peaked at 22.8 million. Since 2016, there has been a slight decrease, reaching 22.1 million in 2022. The number of people employed in fisheries increased from 23.2 million in 1995 to 34.3 million in 2020, after which it fell slightly to 33.6 million in 2022.

Figure 29 shows the share of fishers and fish farmers by geographical region in 2022, separating aquaculture, inland fisheries, marine fisheries and the unspecified sector. Aquaculture provides the largest share of employment only in Asia (40 percent), compared with 25 percent of total employment in the sector in Europe. Marine fisheries is the most important subsector in Northern America (93 percent), Oceania (85 percent), Latin America and the Caribbean (67 percent) and Europe (45 percent). Inland fisheries is the most important subsector in Africa (51 percent) and accounts for over 25 percent of employment in the sector in Asia.

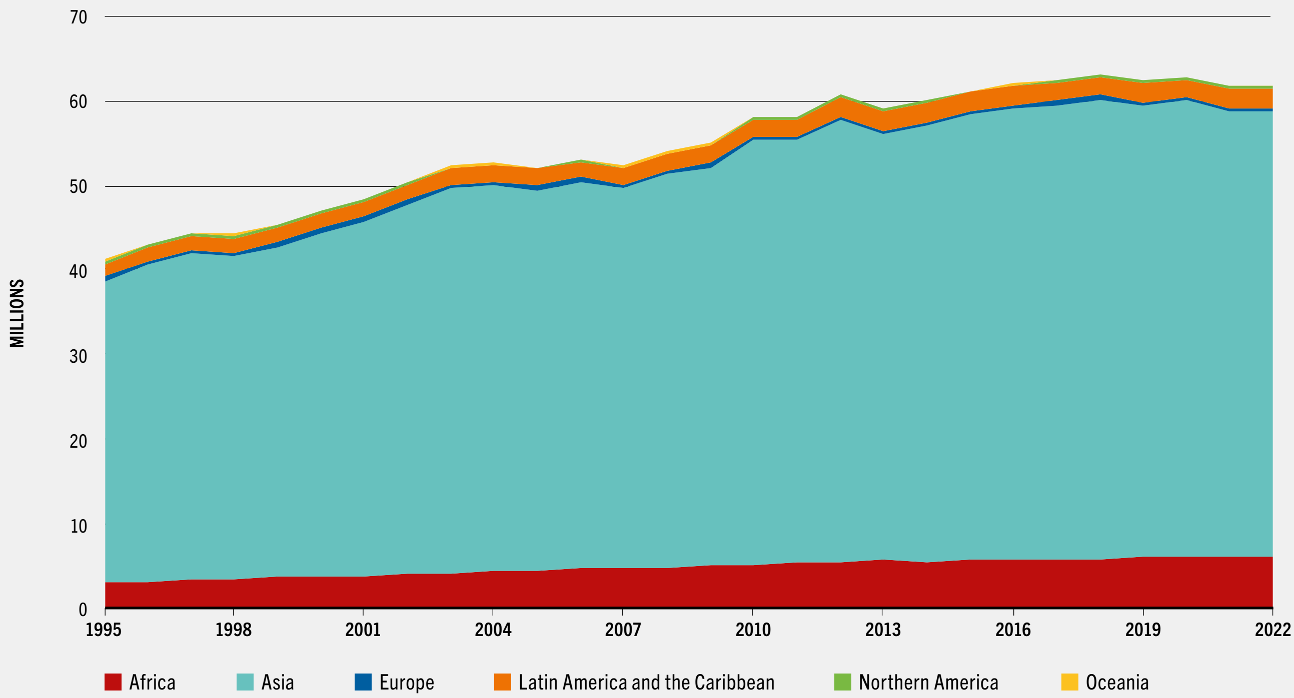
Most fishers and fish farmers are found in lower-middle-income countries (62 percent in 2022), followed by upper-middle-income countries (31 percent). In 2022, low-income countries hosted 5 percent of fishers and fish »

TABLE 10 EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY GEOGRAPHICAL REGION AND SUBSECTOR, 1995–2022

	1995	2000s	2010s	2020	2022	Share of sector in total, 2022 (%)
	(thousands of people)					
Aquaculture	**11 169**	**15 912**	**21 879**	**22 151**	**22 086**	
Africa	152	241	498	608	648	2.9
Asia	10 561	15 124	20 866	21 039	20 900	94.6
Europe	106	110	106	102	102	0.5
Latin America and the Caribbean	330	415	390	380	413	1.9
Northern America	11	11	10	11	11	0.1
Oceania	9	10	9	10	12	0.1
Inland fisheries	**11 530**	**15 601**	**16 682**	**18 640**	**17 935**	
Africa	1 547	2 418	3 067	3 144	3 133	17.5
Asia	9 667	12 762	13 210	15 153	14 451	80.6
Europe	46	40	36	37	32	0.2
Latin America and the Caribbean	262	375	365	301	313	1.7
Northern America	7	6	4	3	3	0.0
Oceania	1	1	1	1	1	0.0
Marine fisheries	**11 631**	**13 472**	**15 228**	**15 698**	**15 685**	
Africa	1 317	1 602	1 944	2 084	2 155	13.7
Asia	8 653	10 278	11 339	11 678	11 535	73.5
Europe	322	241	197	180	175	1.1
Latin America and the Caribbean	946	1 086	1 452	1 495	1 516	9.7
Northern America	313	188	216	181	226	1.4
Oceania	80	77	80	79	78	0.5
Unspecified	**6 920**	**6 750**	**6 965**	**6 341**	**6 109**	
Africa	193	201	208	205	204	3.3
Asia	6 584	6 415	6 651	6 041	5 808	95.1
Europe	82	85	62	66	69	1.1
Latin America and the Caribbean	37	46	40	26	23	0.4
Northern America			3	4	4	0.1
Oceania	24	2	0	0	0	0.0
Fisheries and aquaculture, total	**41 250**	**51 735**	**60 755**	**62 829**	**61 815**	
Africa	3 209	4 462	5 717	6 042	6 141	9.9
Asia	35 465	44 579	52 066	53 911	52 695	85.2
Europe	554	477	401	385	379	0.6
Latin America and the Caribbean	1 576	1 923	2 246	2 202	2 265	3.7
Northern America	331	205	234	199	244	0.4
Oceania	114	89	90	91	91	0.1

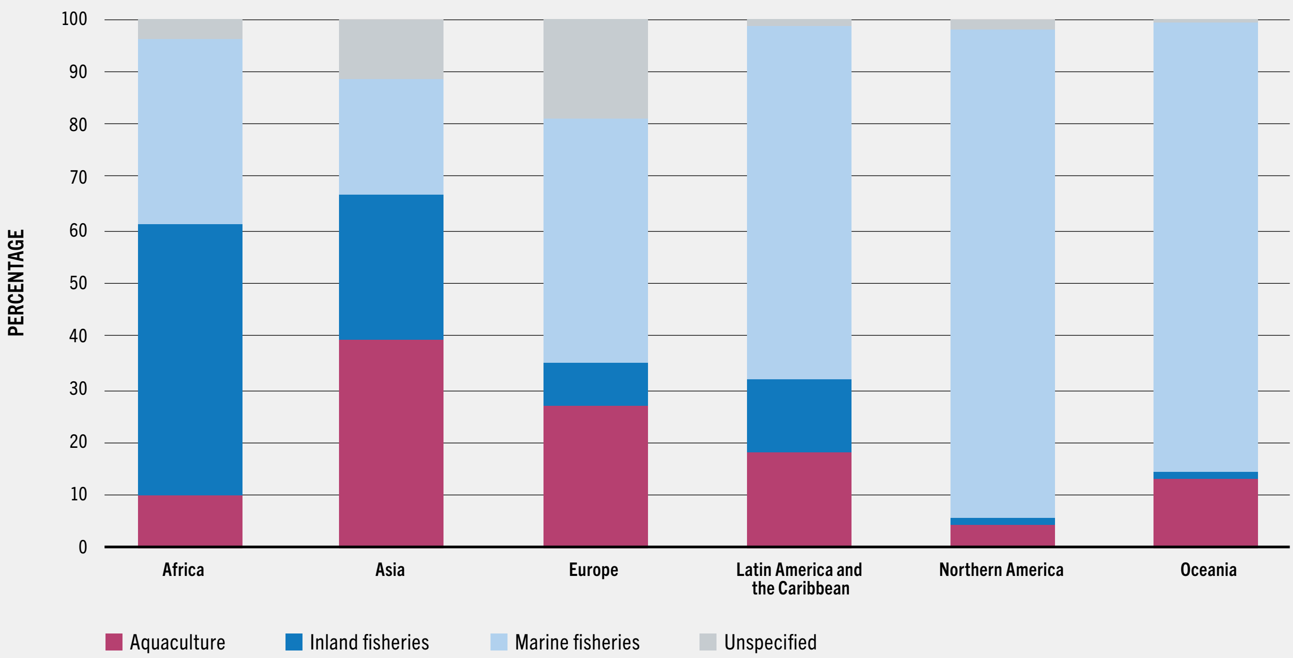
SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022.* FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

FIGURE 28 EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY GEOGRAPHICAL REGION, 1995–2022



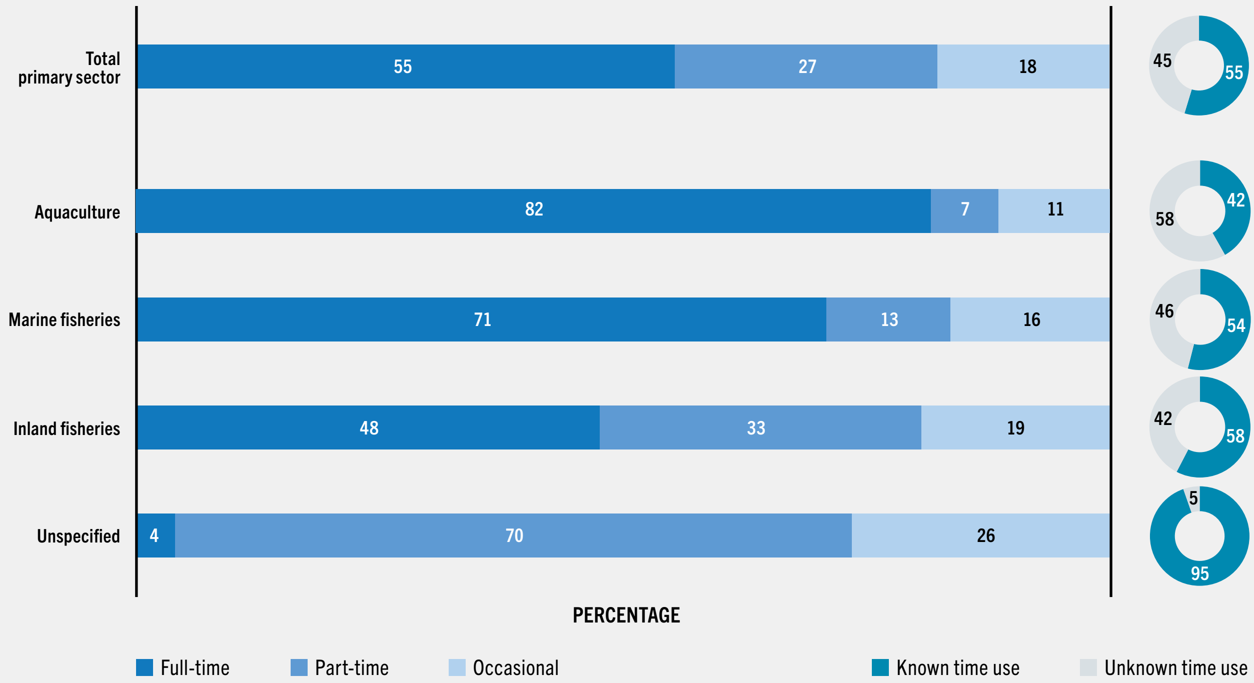
SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

FIGURE 29 SHARE OF SUBSECTOR EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY GEOGRAPHICAL REGION, 2022



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

FIGURE 30 TIME USE CATEGORIES REPORTING IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE, 2022



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

» farmers, and high-income countries only 2 percent. Where data can be separated by subsector, major differences are revealed between fisheries and aquaculture. While lower-middle-income countries host most fishers and fish farmers, the second-largest group is found in low-income countries for aquaculture (10 percent in 2022) and in upper-middle-income countries for fisheries (19 percent). There is also a difference in the share of employment in high-income countries, which are home to just 3 percent of fishers and less than 1 percent of fish farmers.

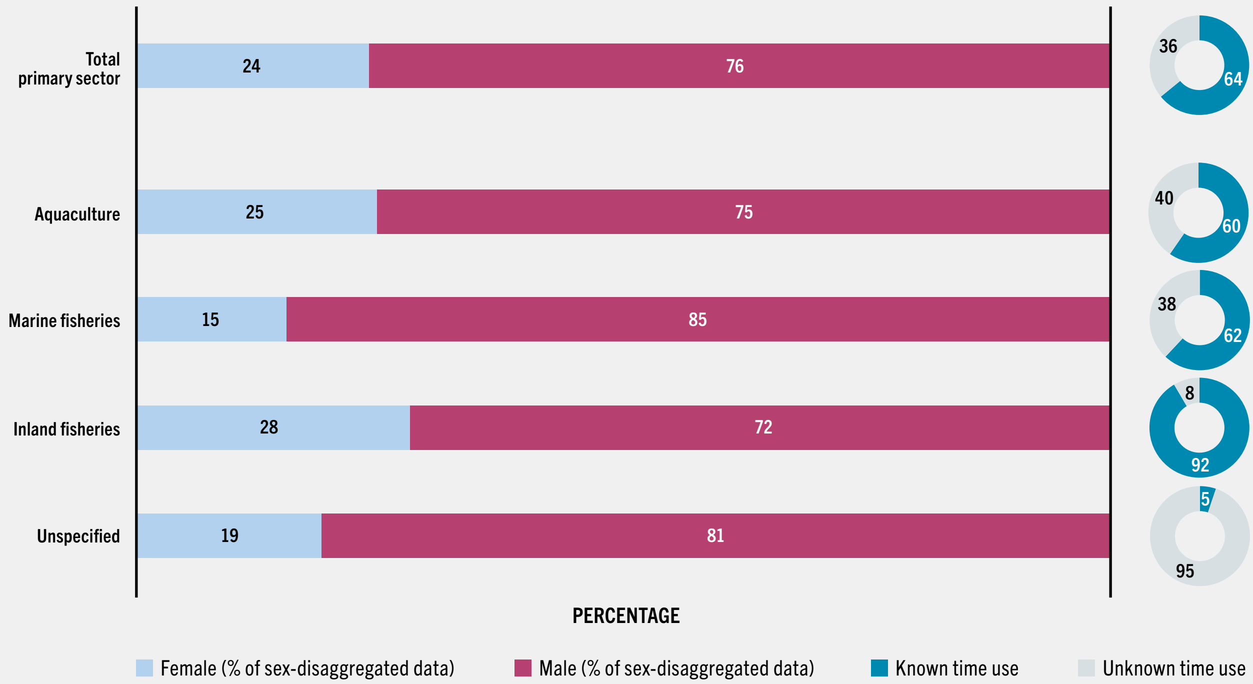
As Figure 30 shows, close to half of global employment data cannot be disaggregated into full-time, part-time, occasional or unspecified work, limiting significantly the analysis of the data from this perspective. This issue is most pronounced in the aquaculture sector (58 percent), as the relative disaggregated data are not available in some countries with large aquaculture workforces.

Considering only data where time use is available, in 2022, 82 percent of fish farmers were employed full time, 7 percent part time and 11 percent on an occasional basis. In fisheries, only 48 percent of inland fishers and 71 percent of marine fishers were engaged full time, while, respectively, 33 percent and 13 percent were engaged part time, and 19 percent and 16 percent were engaged on an occasional basis.

Similarly to information on time use, 36 percent of the employment data in the primary sector cannot be disaggregated by sex (Figure 31). There is no sex disaggregation for 40 percent of data in aquaculture, 8 percent in inland fisheries, 38 percent in marine fisheries and 95 percent in the unspecified sector. Where there is sex disaggregation, women accounted for 24 percent of fishers and fish farmers in 2022: 28 percent in inland fisheries, 25 percent in aquaculture, 15 percent in marine fisheries and 19 percent in the unspecified subsector.

Where sex-disaggregated data are available, 53 percent of women were reported to be employed on a full-time basis, compared with 57 percent of men. This represents a great improvement since 1995, when only 32 percent of women were employed full time compared with 48 percent of men. Despite this improvement, research shows that women tend to have more unstable positions within the value chains of

FIGURE 31 SEX-DISAGGREGATED DATA ON EMPLOYMENT IN THE PRIMARY SECTOR OF FISHERIES AND AQUACULTURE BY SUBSECTOR, 2022



SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

aquaculture and fisheries (EUROSTAT, 2023; UN Women, 2020). This difference is greater in the processing sector, where 63 percent of women are employed on a full-time basis compared with 74 percent of men. Furthermore, several issues related to gender inequality remain, including difference in wages (Aini, 2022), no acknowledgement of work (UN Women, 2020), and violence against women in the sector (Mangubhai *et al*., 2023; see also Box 23, p. 149).

Employment in the processing sector

In recent years, FAO has been collecting data on employment in the processing of aquatic products from the time they are harvested through to delivery of the final product to the customer. At present, data have been received from 52 out of 223 reporting countries and territories, regarding a total of 1.7 million people. Sex-disaggregated data for 27 countries are available for 238 000 processing workers, 62 percent of whom are women. These figures are complemented by the Illuminating Hidden Harvests study (FAO, Duke University and WorldFish, 2023b), which reports that 39.6 percent of workers (both formally employed and subsistence workers) throughout the entire small-scale fisheries value chain and 49.8 percent of post-harvest workers are women. The focus on small-scale actors is particularly important, because although data availability is insufficient, they seem to comprise a greater proportion of women workers.

Data quality and improvements

Collection and analysis of employment data in fisheries and aquaculture continue to improve as a result of enhanced country reporting combined with FAO's ongoing effort to improve the quality of these data. This process applies to the entire dataset from 1995 onwards, and the aim is to apply it also to earlier years, where feasible. FAO strives to improve and harmonize definitions, to ensure a common understanding between data collectors, data processors and data users, and to be able to present more disaggregated data in the future. For 53 countries, FAO has worked in collaboration with the Organisation for Economic Co-operation and Development (OECD). The two organizations have also harmonized their employment datasets and streamlined data collection through a joint questionnaire on fisheries and aquaculture employment to eliminate a double reporting burden for countries.

In addition to regular data updates and checks for inconsistencies, there is an increasing focus on improving data coverage, in particular for subsistence fishers. Currently, such data are available for only 40 countries – thus excluding this category from the analysis above – but efforts are ongoing to expand coverage and include subsistence fisheries in future analyses. Information on small-scale and artisanal fisheries can be found in the Illuminating Hidden Harvests study (FAO, Duke University and WorldFish, 2023b), where it is estimated that subsistence fishing engages around 53 million people, of whom 45.2 percent (23.8 million) are women.

Efforts are also made to improve data disaggregation; for example, "unspecified" is presented as a separate category, rather than under capture fisheries as previously. FAO supports and encourages data collectors to disaggregate the data for the two main subsectors (fisheries and aquaculture), but when such disaggregated data or reliable estimations are not available, it is deemed preferable to include these data as a separate category.

Finally, work on data collection in the processing sector will continue with regular updates in this report and in future editions of the *FAO Yearbook of Fishery and Aquaculture Statistics*. ■

UTILIZATION AND PROCESSING

Recent trends

Of the 185.4 million tonnes (live weight equivalent) of aquatic animals harvested globally in 2022, about 89 percent (164.6 million tonnes) was used for direct human consumption. The remaining 11 percent (20.8 million tonnes) was destined for non-food purposes, of which about 83 percent (17 million tonnes) was reduced to fishmeal and fish oil, while the rest (about 4 million tonnes) was largely utilized as ornamental fish, in aquaculture (e.g. as fry, fingerlings or small adults for ongrowing), as bait, in pharmaceutical applications, for pet food, or as raw material for direct feeding in aquaculture and for the raising of livestock and fur animals.

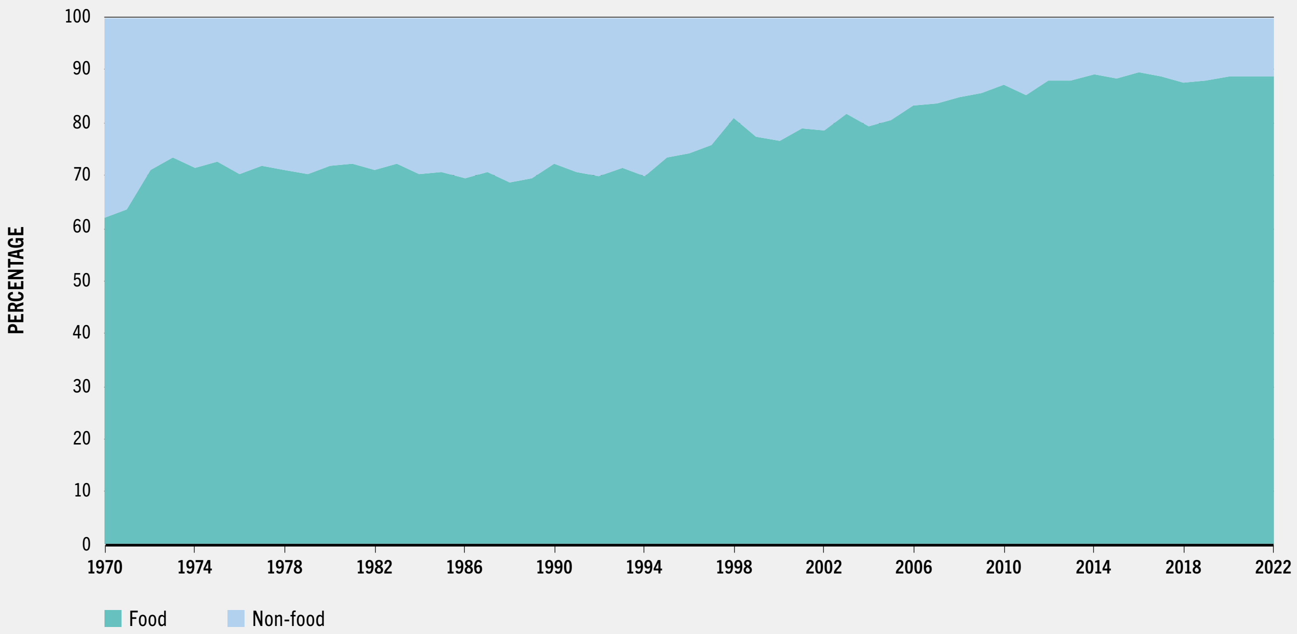
With some fluctuations, the proportion of production used for direct human consumption has increased significantly over the last decades, from 62 percent in 1970 to 89 percent in 2022 (Figure 32). The more notable growth since the mid-1990s was also due to a decrease in the catches of species targeted for reduction to fishmeal (see **Products: fishmeal and fish oil**, p. 68).

In 2022, of the 165 million tonnes destined for human consumption, live, fresh or chilled accounted for about 43 percent. This continues to represent the preferred and most high-priced form of aquatic food products, followed by frozen (35 percent), prepared and preserved (12 percent) and cured[n] (10 percent) (Figure 33). Freezing is the main method of preserving aquatic foods, accounting for 62 percent of the 93 million tonnes of processed aquatic animal production for human consumption (i.e. excluding live, fresh or chilled).

Significant differences exist in the utilization and processing methods across continents, regions and countries, and even within countries. Preservation and processing may vary due to differences between species related

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

FIGURE 32 SHARE OF UTILIZATION OF WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY FOOD AND NON-FOOD USE BY VOLUME



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, sponges, corals, pearls and algae. Based on live weight equivalent.

SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

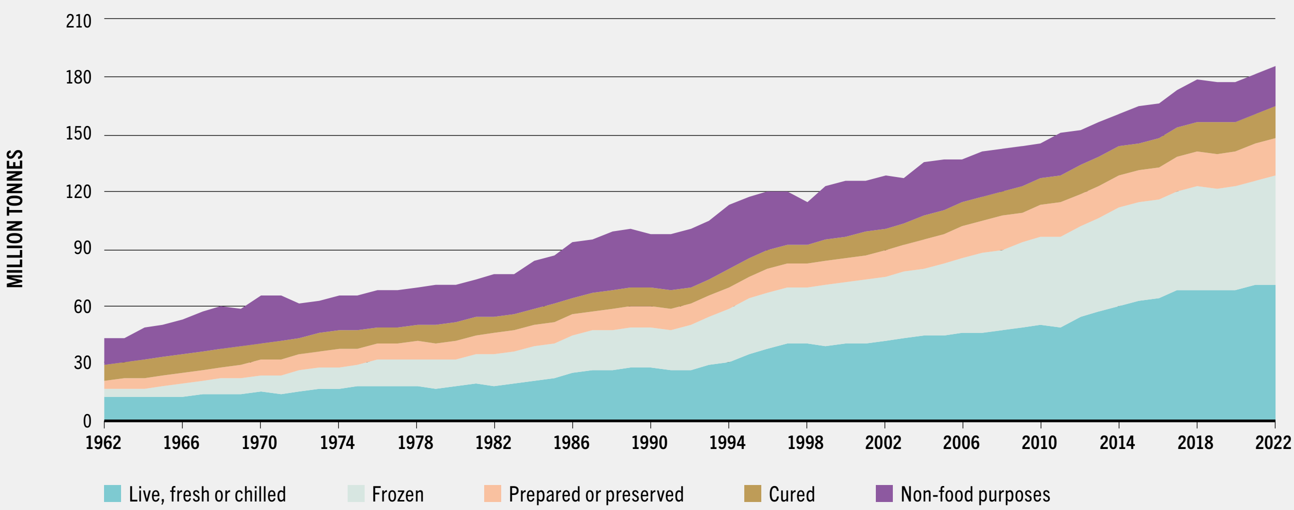
to their characteristics, composition, size and shape. Aquatic species can be prepared using a wide range of methods, from manual to fully automated. An industrialized fishery often has different processing requirements from a small-scale artisanal fishery. Products can be packaged and commercialized in a wide variety of ways depending on the location, scale of operation, country's infrastructure and market demand.

Overall, in high-income countries, aquatic foods are more processed than in other countries, with an increasing share of high-value-added products, such as ready-to-eat meals. In 2022, over 55 percent of the aquatic animal production destined for human consumption in high-income countries was in frozen form, 26 percent in prepared and preserved form, and 13 percent in cured form. In many countries, processing of aquatic products has been evolving from traditional methods to more advanced value-adding processes, depending on the commodity and market value.

In 2022, about 31 percent of the aquatic food production of upper- and lower-middle-income countries was utilized in frozen form, 9 percent each in canned and cured forms, and over 50 percent in live, fresh or chilled form. In contrast, for low-income countries, only 7 percent was frozen, about 20 percent cured and about 70 percent live, fresh or chilled.

Approximately two-thirds of the fisheries and aquaculture production used for human consumption is in frozen, prepared and preserved forms in Europe and Northern America. In Asia and Africa, the share of aquatic food production preserved by salting, smoking, fermentation or

FIGURE 33 UTILIZATION OF WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS, 1962–2022



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, sponges, corals, pearls and algae. Data expressed in live weight equivalent.

SOURCE: Preliminary data. Final data available here: FAO. (forthcoming). *Fishery and Aquaculture Statistics – Yearbook 2022*. FAO Yearbook of Fishery and Aquaculture Statistics. Rome. https://www.fao.org/fishery/en/statistics/yearbook

drying is higher than the world average. 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.

A proportion of the production of aquatic animals for human consumption is commercialized in live form; this form is principally appreciated in East and Southeast Asia and has niche markets in other countries – mainly to supply Asian communities. Commercialization of live aquatic animals has continued to grow in recent years, thanks also to improved logistics and technological developments. Yet, marketing and transportation can be challenging, as they are often subject to stringent sanitary regulations, quality standards and animal welfare requirements (notably in Europe and Northern America).

Interest in the production and utilization of algae (seaweed and micro-algae) has increased greatly in recent years beyond the traditional Asian producing countries. Algae contribute significantly to food and nutrition security, provide ecosystem services, and their production and processing offer significant employment opportunities for coastal communities, in particular for women and youth. They can be processed into food products, as well as food additives and supplements. They are also used by the non-food industry to extract thickening agents such as alginate, agar and carrageenan, as hydrocolloid products in nutraceuticals, pharmaceuticals and cosmetics, and as fertilizers, feed ingredients, biofuels and bioplastics.

In general, aquatic species are highly perishable and several chemical and biological changes take place immediately after harvest; this can result in spoilage and food safety risks if good handling and preservation practices are not applied at harvesting and all along the supply chain. These practices 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). Aquatic food products also require special facilities such as cold storage and refrigerated transport, and rapid delivery to consumers.

During the last few decades, major improvements in processing, refrigeration, ice production and use, freezing, storage and transportation have enabled extended shelf-life – while ensuring food safety, maintaining quality and nutritional attributes, and avoiding loss and waste – thus enabling distribution domestically and internationally over long distances. These improvements have also led to an increasing variety of products, with more 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 including through the utilization of by-products (see **Products: fishmeal and fish oil**, p. 68 and **By-product utilization**, p. 71).

Overall, the expansion in commercialization and human consumption of aquatic food products (see **Apparent consumption of aquatic foods**, p. 214, and **Trade of aquatic products**, p. 82) has been accompanied by a significant improvement in food 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. As supermarket chains and large retailers have expanded worldwide, their role as key players has increased, as they influence market access requirements and standards. To meet 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. Nutritional attributes of aquatic foods can vary according to how they are processed and prepared. Heating the product (for sterilization, pasteurization, hot smoking or cooking) reduces the quantities of thermolabile nutrients, including many vitamins; on the other hand, the concentration of some nutrients can increase with heating, as water is removed.

Products: 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 are considered among the most nutritious and most digestible ingredients for farmed fish, as well as the principal source of omega-3 long-chain polyunsaturated fatty acids (eicosapentaenoic acid [EPA] and docosahexaenoic acid [DHA]) in animal diets. Regarding human consumption, fish oil is the major natural source of EPA and DHA, which perform a wide range of critical functions for human health.

Fishmeal and fish oil can be produced from whole fish, fish trimmings or other fish by-products. The species used whole are mainly small pelagic fish, such as Peruvian anchoveta (accounting for the greatest proportion), menhaden, blue whiting, capelin, sardine, mackerel and herring. The amount of fishmeal and fish oil production fluctuates yearly according to changes in the catches of those species, in particular anchoveta, whose catchability can be affected by the El Niño Southern Oscillation and by the adopted management practices (see **Impacts of El Niño on marine fisheries and aquaculture**, p. 202). Over time, the adoption of good management practices and certification schemes has increased the volume of species fished and recognized as sourced responsibly for reduction to fishmeal, thus decreasing the volumes of unsustainable catches for those species.

The volume of world capture fisheries production processed into fishmeal and fish oil has declined during the last few decades. From a peak of over 30 million tonnes in 1994, representing about 35 percent of marine capture fisheries, it declined over the years to less than 14 million tonnes in 2014, then rose to about 18 million tonnes in 2018 due to increased catches of Peruvian anchoveta, before going back to previous trends, with more than 17 million tonnes utilized in 2022. This corresponds to about 22 percent of capture fisheries in marine waters in 2022. At the same time, a growing share of fishmeal and fish oil is produced from fish by-products of the processing industry, thus reducing waste and improving resource valorization. According to the estimates of the Marine Ingredients Organisation (IFFO), in 2022, 34 percent of the global production of fishmeal and 53 percent of the total production of fish oil were obtained from by-products; Figure 34). This utilization of by-products has helped to keep the overall amount of fishmeal and fish oil reasonably stable since the mid-2000s at, respectively, around 5 million tonnes and 1 million tonnes in product weight, despite the decline in the share obtained from whole fish. It is worth noting that fishmeal from by-products has a different nutritional value, being lower in protein but richer in minerals compared with fishmeal obtained from whole fish.

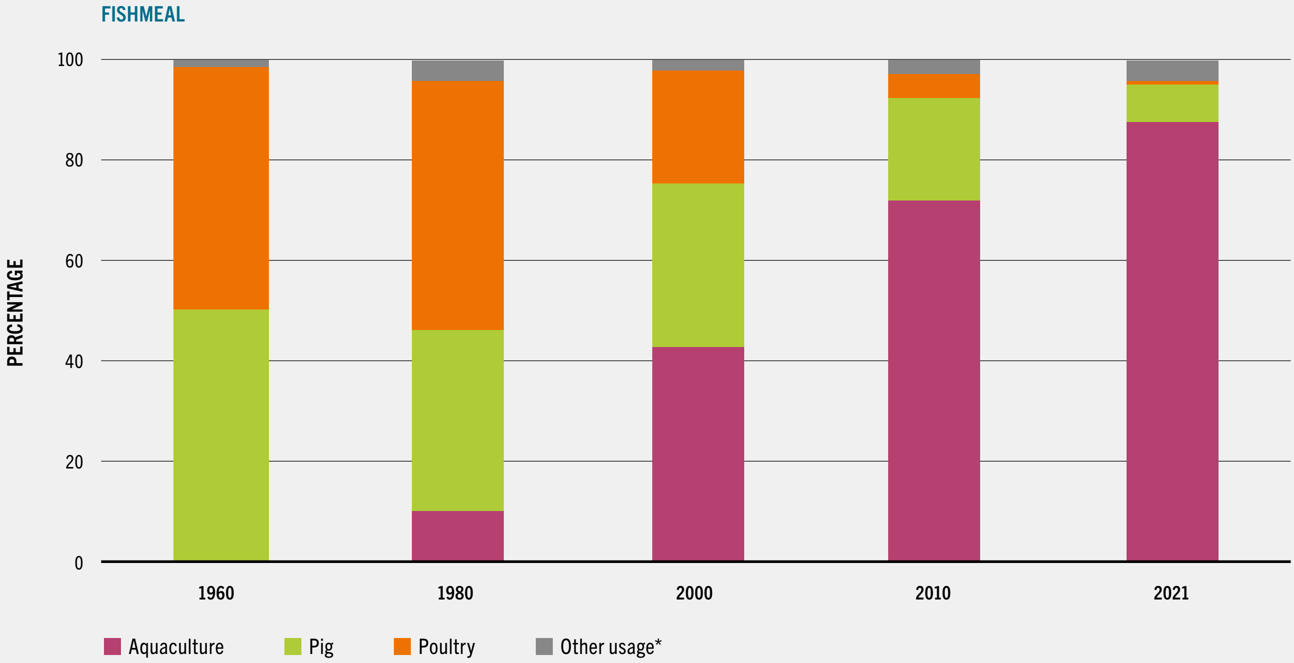
The overall stable production has been coupled with a surging demand driven by a fast-growing aquaculture industry, as well as by pig and poultry farming, and the pet food and pharmaceutical industries. According to the estimates of IFFO, in 2021, over 87 percent of fishmeal was used in aquaculture, over 7 percent in pig farming, 4 percent for other uses (mainly pet food) and 1 percent for poultry. In the same year, about 74 percent of fish oil was destined for aquaculture, 16 percent for human consumption and 10 percent for other uses (including pet food and biofuel) (Figure 35).

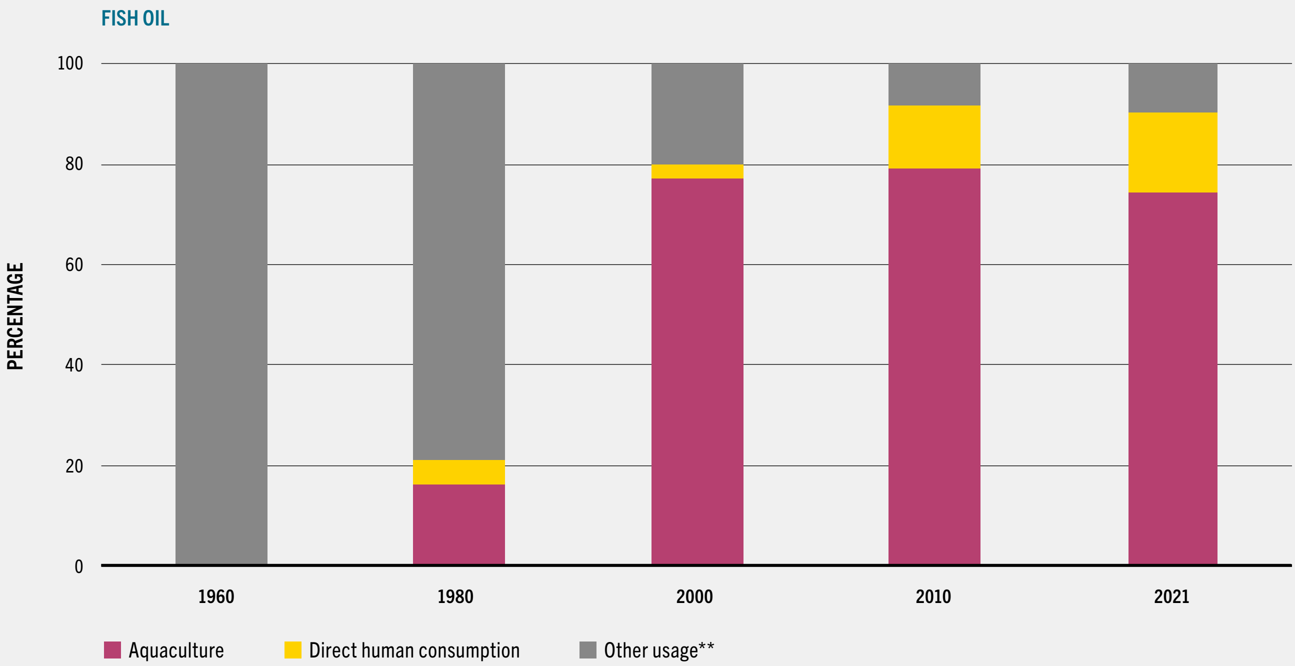
The increasing demand for fishmeal and fish oil has led to an increase in their prices, with an impact on their utilization. Their inclusion rates in compound feeds for aquaculture have shown a clear downward trend, largely as a result of diversified protein sources and improved feeding efficiency to respond to supply and price variations and 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. Moreover, most of the main aquaculture species produced do not use only fishmeal or fish oil as a source of protein, but also ingredients such as other animal by-products and plant-based proteins.

Increasing demand and the profitability of the sector have led to pressure to find additional or alternative sources of aquafeeds. Although most fishmeal and fish oil produced from whole fish originate from well-managed fisheries, there is concern regarding the sustainability of certain fisheries in some countries where fishmeal production is increasing significantly. This is the case of some West African countries where increasing amounts of catch are reduced into fishmeal for export purposes, competing with their traditional use for domestic human consumption. This not only increases the pressure on fishery resources in the absence of proper resource management, but it negatively impacts food security and livelihoods. In these areas, it is essential to improve governance and fisheries management, while prioritizing the utilization of aquatic species for human consumption and food security (Thiao and Bunting, 2022).

Overall, with no major increases in raw material expected to come from wild fisheries, any increase in fishmeal and fish oil production will need to come from fish by-products and other sources. Research has recently focused on finding alternative sources of polyunsaturated fatty acids. These include stocks of 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, krill processing presents practical challenges regarding reduction of its fluoride content and the high cost of zooplankton products means they are not included as a bulk oil or protein ingredient in fish feed. Other sources such as insect and bacterial meals offer good potential as protein feed inputs to aquafeeds (Glencross *et al.*, 2024). Fish silage, a rich protein hydrolysate that contains high amounts of essential amino acids, is also increasingly used as a feed additive, »

FIGURE 34 UTILIZATION OF FISHMEAL AND FISH OIL IN SELECTED YEARS





NOTES: * Mainly pet food. ** Pet food, biofuel, cooking oil.
SOURCE: IFFO estimates.

FIGURE 35 SHARE OF RAW MATERIAL UTILIZED FOR REDUCTION INTO FISHMEAL AND FISH OIL, 2022

SOURCE: IFFO estimates.

» for example, in aquaculture and the pet food industry (see **Innovative aquaculture systems and aquafeed solutions**, p. 131).

By-product utilization

The increase in global fisheries and aquaculture production poses a challenge for the aquatic food processing industry. Fish processing generates large quantities of by-products such as heads, skins, bones, scales and viscera, constituting 30 to 70 percent of the whole fish, depending on the species and type of processing (Peñarubia *et al.*, 2023). A tilapia fillet typically represents 30 percent of the fish, leaving the rest unused for human consumption (see **Aquatic foods: an untapped potential for healthy diets**, p. 191). It is estimated that 50 to 70 percent of whole tuna is discarded in tuna canning (Honrado *et al.*, 2023), while the by-products from shrimp processing make up 40 to 60 percent of the whole shrimp (Abuzar *et al.*, 2023).

The by-products of aquatic food processing were traditionally considered of low value and discarded as waste. Inappropriate waste management causes environmental pollution leading to breeding grounds for insects and vermin, posing significant public health risks. Accordingly, waste management is increasingly subject to strict regulations for environmental reasons, and it represents a growing cost burden for the aquatic food industry. At the same time, by-products can represent an opportunity for industry. Improving their utilization is important for ecological, social and economic reasons and to safeguard consumer health and food security (see Box 17, p. 140).

Aquatic by-products can be converted into food products for human consumption. Those particularly rich in micronutrients and bioactive ingredients can be used as valuable raw materials for low-cost nutritious foods or high-value products used by the food, pharmaceutical, cosmetic and material industries. The conversion of these by-products into value-added products can enhance human nutrition and health, mitigate environmental pollution, and provide livelihoods and economic returns. This way, it can help reduce the pressure on living aquatic resources and foster their sustainability.

By-products containing heads, frames and belly flaps, and parts of the viscera like liver and roe are good sources of high-quality proteins, lipids with long-chain omega-3 fatty acids, micronutrients like vitamins A, D and B12, and minerals such as iron, zinc, selenium and iodine. Their minced meat and mechanically separated meat can be used as raw materials to produce surimi, patties, nuggets and sausages. Heads and frames can be minced and processed into powder (Abbey *et al.*, 2017) to be used as either condiments or flour, producing a healthy alternative (Monteiro *et al.*, 2014). Gelatin can also be extracted and used as a food ingredient for edible films or coatings; it can also replace mammal-based gelatin – which is usually pork-based – providing a valid alternative for some religious groups.

Aquatic by-products are a source of high-value biocompounds containing collagen, peptides, chitin, polyunsaturated fatty acids, enzymes and minerals, suitable for biotechnological or pharmaceutical applications. Collagen and gelatin can be extracted from skin, scales and bones. Collagen can be used to treat burns for wound healing and skin regeneration (Lima Verde *et al.*, 2021). By-products can be converted into protein hydrolysate with beneficial functional properties and potential for applications in health care and pharmaceutical products (Ryu, Shin and Kim, 2021) and used as a valuable low-cost natural antioxidant for several food and pharmaceutical applications (Sierra *et al.*, 2021). Chitin, which is present in almost all crustaceans, has been used to produce bioactive products for pharmaceutical and food applications.

Fish by-products deteriorate very fast, especially when they contain viscera. They should be preserved or processed as soon as possible. In the absence of cold rooms, they can be converted into feed, fertilizer or fish silage rich in hydrolysed protein and essential amino acids. Biodiesel made from fish oil can meet the specifications for biodiesel, for example, low ash content, flash point and density (Patchimpet *et al.*, 2020). Because of its excellent biocompatibility and biodegradability, fish skin has been used in food and pharmaceutical applications, and in the production of clothing and leather products (Yoshida *et al.*, 2016).

These technologies using fish by-products are also used to process low-value and bycatch aquatic resources into value-added products, reducing environmental pollution and improving human nutrition, income and livelihoods.

Aquatic food loss and waste

Food loss and waste (FLW) in aquatic value chains remains an important focus for FAO. In terms of quantity and quality, FLW is 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. The inability to access electricity, potable water, roads, ice, cold storage and refrigerated transport are contributing factors. Food loss and waste equates to a waste of time, energy and money, producing a detrimental effect on the well-being of fishers, processors, traders and consumers.

The Code of Conduct for Responsible Fisheries, the Voluntary Guidelines for Securing Small-Scale Fisheries in the Context of Food Security and Poverty Eradication and the FAO Fisheries Blue Transformation Roadmap all flag food loss and waste as a key issue. Reducing FLW ultimately helps achieve FAO's high-level policy objectives of better production, better nutrition, a better environment and a better life,[o] and SDG Target 12.3, which focuses on responsible consumption and production and halving food wastage by 2030. The FAO Blue Transformation Roadmap (FAO, 2022a) promotes access to safe and nutritious aquatic food for all, in particular for vulnerable populations, and the reduction of FLW using diverse practices and processes.

In 2011, FAO estimated that up to 35 percent of global fisheries and aquaculture production is either lost or wasted every year (FAO, 2011b). Decision-making is hampered, particularly at the national level, by the lack of current data and information that could be used to target and design FLW interventions.

Bearing in mind that data are key to informed decision-making, FAO has adopted methodologies to assess, measure and understand fish loss and waste and is developing a Food Loss Index methodology,[p] which will be used to standardize the way in which quantitative data on fish loss will be collected globally. Knowledge tools such

o For details, please see: https://www.fao.org/strategic-framework/en

p See: https://www.fao.org/platform-food-loss-waste/food-loss/food-loss-measurement/en as e-learning courses[q] in fish loss and waste are available alongside a comprehensive website[r] which provides information on all aspects of FLW in aquatic value chains. Initiatives are informed by renewable energy work (Puri *et al*., 2023) around cold chains, improved onboard handling (Ward, 2022), best practices and guidance on gender in relation to food losses (FAO, 2018a).

The Voluntary Code of Conduct for Food Loss and Waste Reduction[s] provides internationally recognized guiding principles and standards for responsible practices for food loss and waste reduction. It acts as a framework for strategies, policies, institutions, legislation and programmes on FLW reduction and provides guidance to gauge the effectiveness of solutions, promoting joint action, the harmonization of approaches and the assessment of progress. This code of conduct is applied in the fisheries context as part of the adoption of a multidimensional and multistakeholder approach to FLW reduction with a focus on seven key entry points: policy; social and gender equity; services and infrastructure; markets; technology; skills and knowledge; and the regulatory environment. To date, strategies for FLW reduction in fisheries value chains have been developed with partners in Colombia, Sri Lanka, Togo and the United Republic of Tanzania[t] (see Box 33, p. 172 and **Multidimensional solutions to food loss and waste**, p. 183). ■

APPARENT CONSUMPTION OF AQUATIC FOODS

Data presented in this section are sourced from FAO Food Balance Sheets (FBS) spanning from 1961. The balance sheets allow an estimation of the amount of food available for human consumption (apparent consumption) expressed in live weight equivalent, rather than the actual quantity of food consumed (effective consumption).

Trends in total apparent consumption of aquatic animal foods

In 2021,[u] global apparent consumption of aquatic animal foods (i.e. excluding algae) surged to an estimated 162 million tonnes (live weight equivalent) (Table 11), marking a substantial increase from 28 million tonnes in 1961. Historically, Europe, Japan and the United States of America have accounted for a significant portion of the global amount of aquatic animal foods available for human consumption. In 1961, their collective share was 47 percent of the world supply. However, by 2021, their combined share had dropped to 18 percent. Meanwhile, China, Indonesia and India experienced significant increases in their shares of global consumption of aquatic animal foods. While collectively representing only 17 percent in 1961, their combined share had surged to 51 percent by 2021, with China alone representing 36 percent. The notable decline in the prominence of historical countries for consumption of aquatic animal foods can be attributed to structural shifts in the sector. These shifts encompass the influence of Asian countries in fisheries and aquaculture production, in addition to the increasing urbanization and rising proportion of middle-class citizens in Asia. In 2021, Asia accounted for 71 percent of global consumption of aquatic animal foods, followed by Europe (10 percent), Africa (8 percent), Northern America (5 percent), Latin America and the Caribbean (4 percent) and Oceania (1 percent). Although Europe and Africa account for similar shares of global consumption, their population sizes are significantly different, resulting in notable differences in per capita consumption.

For sixty years, the global amount of aquatic animal foods available for human consumption has increased at a significantly higher rate than world population growth, resulting in a rise in consumption per capita (Figure 36). Between 1961 and 2021, the average annual growth rate of global consumption of aquatic animal foods was 3.0 percent, outpacing the annual population growth rate of 1.6 percent. Africa

q See: https://elearning.fao.org/course/view.php?id=567 and https://elearning.fao.org/course/view.php?id=1031

r See: https://www.fao.org/flw-in-fish-value-chains/en/

s See: https://www.fao.org/3/nf393en/nf393en.pdf

t See: https://www.fao.org/flw-in-fish-value-chains/projects/en/

u Consumption data for 2021 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 2022*, and in the FishStatJ workspace to be disseminated in 2024. The updated data will be available through the FAO website, available at: https://www.fao.org/fishery/en/fishstat

TABLE 11 TOTAL AND PER CAPITA APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS BY REGION AND ECONOMIC CLASS, 2021

Region/economic class	Apparent consumption of aquatic animal foods		Per capita apparent consumption of aquatic animal foods
	(million tonnes, live weight equivalent)	*(Percentage of world total)*	*(kg/year)*
World	**162.5**	**100**	**20.6**
World, excluding China	103.2	64	15.9
Africa	**13.1**	**8**	**9.4**
Americas	**15.8**	**10**	**15.3**
Northern America	8.8	5	23.4
Latin America and the Caribbean	7.0	4	10.7
Asia	**116.1**	**71**	**24.7**
Europe	**16.5**	**10**	**22.2**
Oceania	**1.0**	**1**	**21.8**
High-income countries	**33.2**	**20**	**26.7**
Upper-middle-income countries	**86.2**	**53**	**30.6**
Lower-middle-income countries	**39.5**	**24**	**12.5**
Low-income countries	**3.6**	**2**	**5.3**

NOTE: Data are preliminary.

SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp.

and Asia experienced the strongest consumption growth rates: 3.8 percent and 3.7 percent per year, respectively.

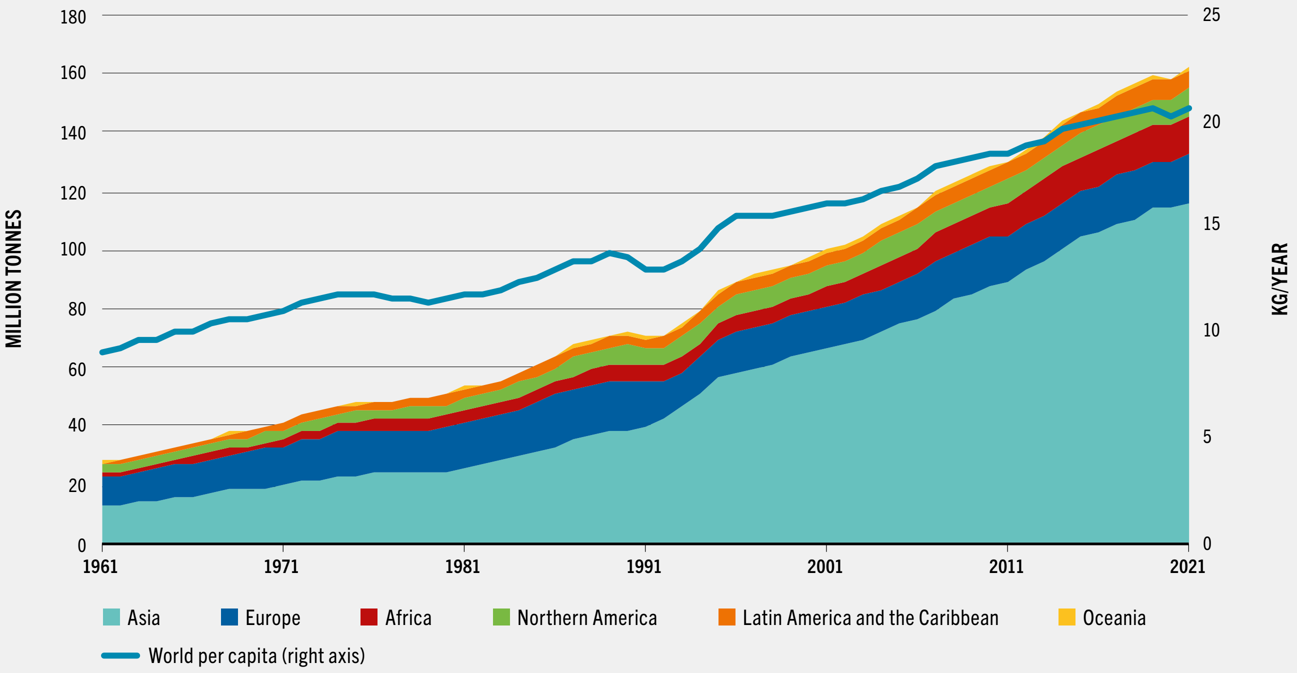
Furthermore, in the same period, the consumption of aquatic animal foods exhibited more robust growth than all terrestrial meats combined, which had an estimated average growth rate of 2.7 percent per year. Likewise, it outpaced that of individual meat categories such as bovine, sheep and goat, and pig; the exception was poultry meat, which experienced a higher growth rate of 4.7 percent per year.

Trends in apparent consumption per capita of aquatic animal foods

Globally, annual per capita apparent consumption of aquatic animal foods was estimated at 20.6 kg (live weight equivalent) in 2021, with preliminary estimates for 2022 currently standing at 20.7 kg. High food price inflation in many of the main consuming countries and limited growth in fisheries and aquaculture production are the main drivers for this limited growth.

However, the world average masks differences across countries (Figure 37). Of the 227 countries and territories for which FAO estimated the per capita consumption of aquatic animal foods, 135 were below the world average and 92 above it in 2021. Differences between countries can be attributed to diverse factors, in particular the availability of and access to aquatic and other foods. This availability is influenced by various factors such as proximity and access to aquaculture facilities, landing sites and markets. Moreover, differences in prices, income levels,

FIGURE 36 APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS BY REGION, 1961–2021



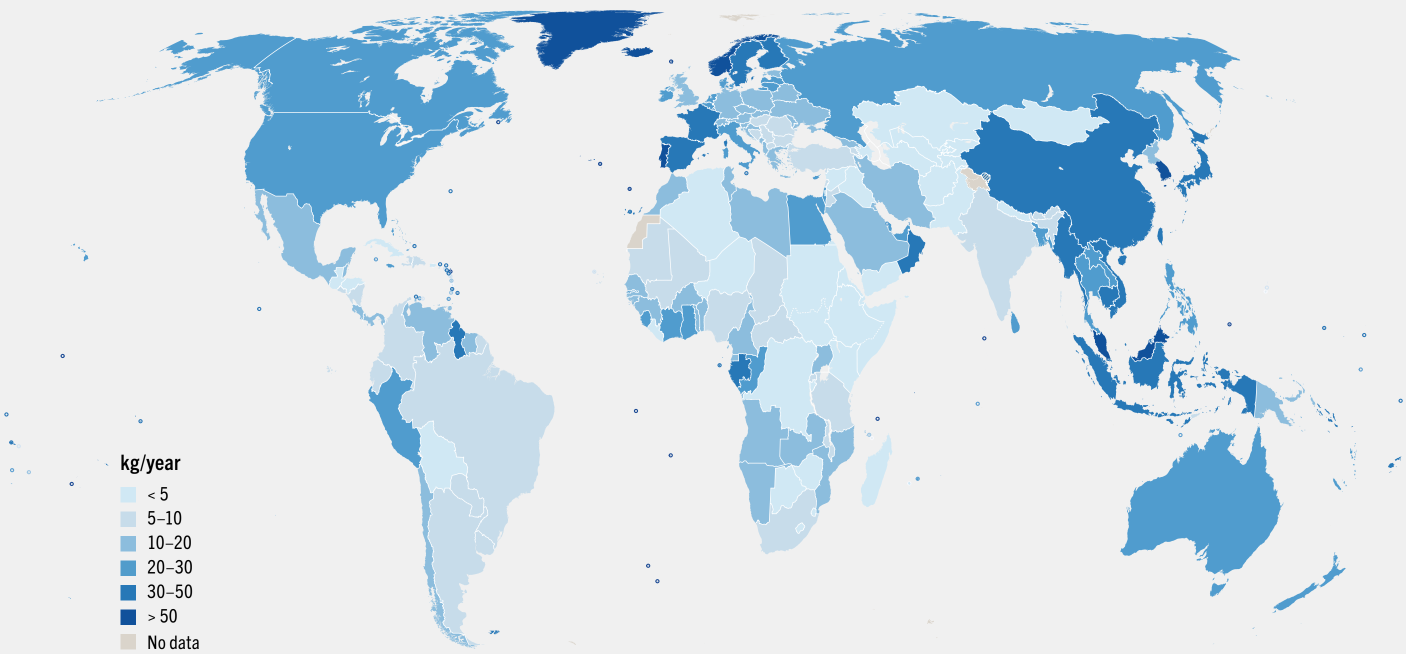
NOTES: Food for human consumption originating from animals grown in, or harvested from, water. It includes food from all types of aquatic animals, with the exception of aquatic mammals and reptiles. Data expressed in live weight equivalent.

SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp

nutritional awareness, culinary traditions, food habits and consumer preferences further contribute to this variation. For instance, in low-income countries, the per capita apparent consumption of aquatic animal foods averaged 5.3 kg in 2021, compared with 12.5 kg in lower-middle-income countries, 30.6 kg in upper-middle-income countries and 26.7 kg in high-income countries.

During 1961–2021, apparent consumption per capita of aquatic animal foods increased at an average rate of about 1.4 percent per year, from 9.1 kg in 1961 to 20.6 kg in 2021. Japan was the most notable exception, with a decrease from 50.2 kg in 1961 to 43.1 kg in 2021. However, the rate of growth varied greatly across regions (Figure 38) and countries. Asia experienced the strongest annual growth rate (1.9 percent), followed by Latin America and the Caribbean (1.3 percent) and Africa (1.1 percent). China was the major driver for this growth, reflecting the expansion of its capture fisheries and aquaculture production. Its apparent consumption per capita grew from 4.3 kg in 1961 to 41.6 kg in 2021, an increase of 3.8 percent per year on average. Despite a relatively strong growth rate, Africa's per capita consumption of aquatic animal foods has remained lower than in other regions. Conversely, Europe, Northern America and Oceania experienced the slowest growth rates in per capita consumption of aquatic animal foods, rising at an average annual rate of 0.7 to 0.9 percent. These regions have already high levels of per capita consumption of aquatic animal foods.

FIGURE 37 APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS PER CAPITA, AVERAGE 2019–2021



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.

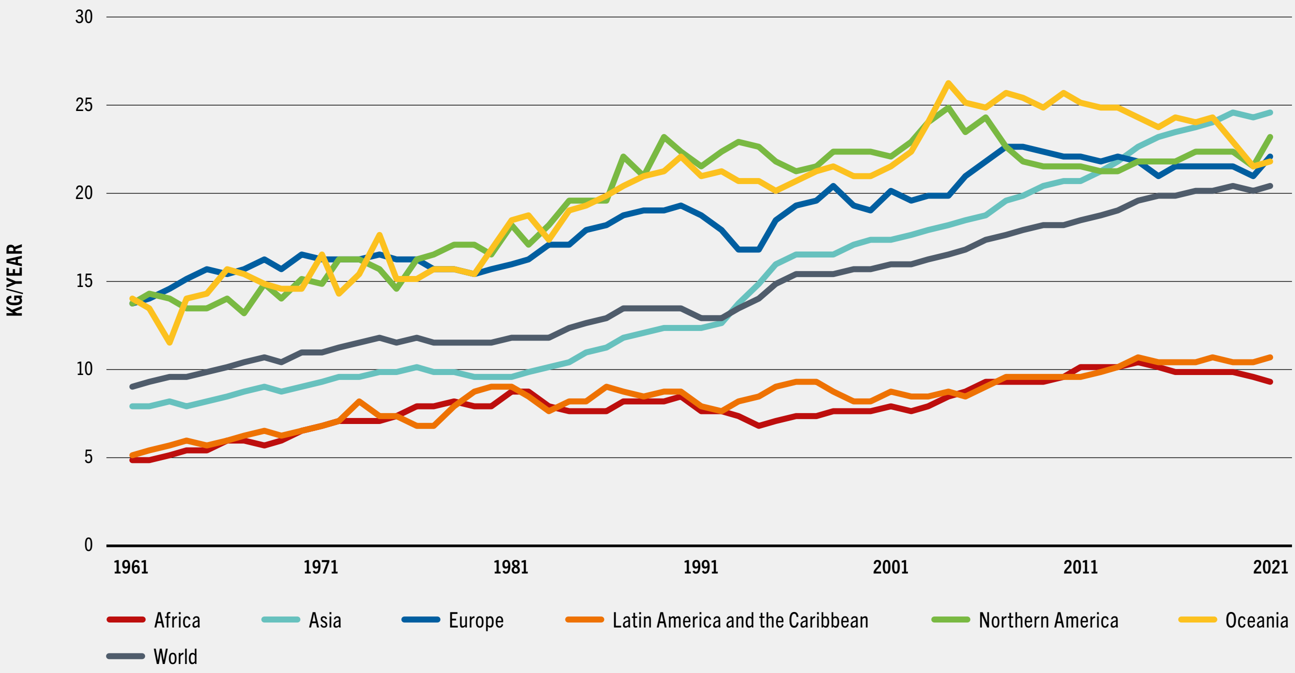
NOTES: Food for human consumption originating from animals grown in, or harvested from, water. It includes food from all types of aquatic animals, with the exception of aquatic mammals and reptiles. Data expressed in live weight equivalent.

SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp
United Nations Geospatial. 2020. Map geodata.

The main factors driving the long-term upward trend in per capita consumption of aquatic animal foods, in addition to increased production, include urbanization, rising income levels, and demographic changes (e.g. smaller family size), all of which influence changes in dietary habits. Over time, the world has been increasingly urbanized, with the urban population increasing from 34 percent to 57 percent of the world population between 1961 and 2021 (FAO *et al.*, 2023). Urbanization represents a multifaceted phenomenon, not only indicating an increase in urban residents and the expansion of urban infrastructure, but also triggering profound shifts in societal norms, cultural practices, and lifestyles, including dietary patterns.

Traditionally, rural populations have tended to adhere to plant-based diets rich in grains, fruits and vegetables, and with low fat content. However, rural people migrating to urban areas often experience a shift towards diets that rely more on processed foods characterized by a higher content of energy, sugars, refined grains, and fats; furthermore, urban residents tend to consume diets with a greater proportion of animal proteins. Indeed, urban residents typically have reduced time available for at-home food preparation combined with increased disposable income, facilitating access to convenience foods and ready-to-eat meals. From 1961 to 2021, average world gross domestic product per capita experienced steady growth, with low-

FIGURE 38 APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS PER CAPITA BY REGION, 1961–2021



NOTES: Food for human consumption originating from animals grown in, or harvested from, water. It includes food from all types of aquatic animals, with the exception of aquatic mammals and reptiles. Data expressed in live weight equivalent.

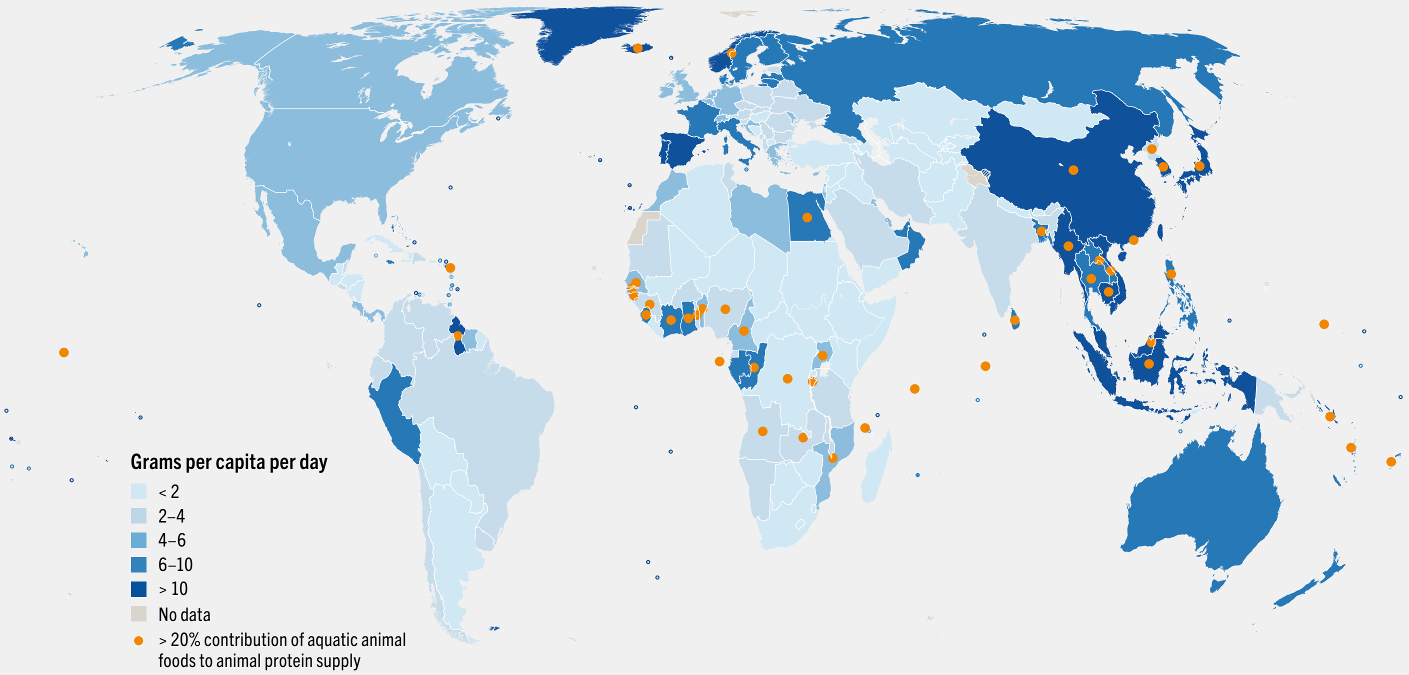
SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp

and middle-income countries exhibiting more pronounced increases than high-income countries.

Despite this overall upward trend, there have been a few instances of decline in per capita consumption of aquatic animal foods since 1961. Notably, such a decline occurred in 2020 when per capita consumption of aquatic animal foods decreased by 1.3 percent, falling from 20.5 kg in 2019 to 20.2 kg. This reduction was largely attributed to the effects of the COVID-19 pandemic, which resulted in stable global fisheries and aquaculture production and a decrease in traded volumes. The resulting drop in per capita consumption was strongest in Oceania (–5.3 percent), followed by Africa (–4.0 percent), Europe (–3.3 percent), Northern America (–2.9 percent), Asia (–0.4 percent) and Latin America and the Caribbean (–0.3 percent). In 2021, per capita consumption of aquatic animal foods increased at the global level, yet about half of the countries remained below pre-pandemic levels.

The COVID-19 pandemic resulted in reduced per capita consumption not only of aquatic animal foods but of all animal foods. The pandemic resulted in an estimated increase of nearly 90 million people experiencing hunger from 2019 to 2020. The impact was especially acute in low- and lower-middle-income countries and among disadvantaged populations worldwide, not due to actual food shortages, but because of income losses incurred at the peak of the pandemic (FAO *et al.*, 2023).

FIGURE 39 CONTRIBUTION OF AQUATIC ANIMAL FOODS TO ANIMAL PROTEIN SUPPLY PER CAPITA, AVERAGE 2019–2021



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.

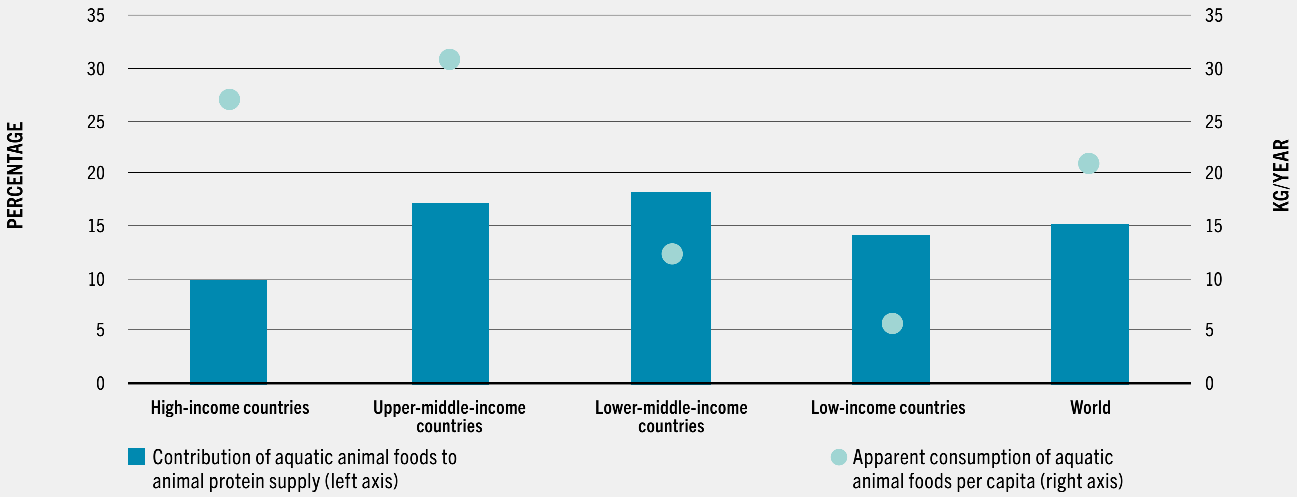
SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp
United Nations Geospatial. 2020. Map geodata.

Nutritional benefits of aquatic animal foods

Aquatic animal foods, with their diverse and valuable nutritional attributes, can contribute to reducing food and nutrition insecurity and tackling many forms of malnutrition, providing high-quality nutrients with a moderate energy contribution. Even small quantities of aquatic animal foods can provide essential nutrients for a healthy diet. They provide high-quality proteins and essential amino acids, vitamins (particularly B and D), and minerals such as calcium, zinc, iron, iodine, magnesium, potassium, phosphorus and selenium. Species such as sardines, mackerels, salmon and tuna are good sources of omega-3 fatty acids. Moreover, consuming the entire fish including the head, bones and skin can maximize nutritional benefits and reduce waste, contributing to global food security (see Box 44, p. 192 and **Aquatic foods: an untapped potential for healthy diets**, p. 191).

Aquatic animal foods contributed at least 20 percent of the per capita protein supply from all animal sources to 3.2 billion people – that is over 40 percent of the world's population. Globally, aquatic animal foods supplied 15 percent of animal proteins and 6 percent of all proteins in 2021. However, the extent of their contribution varies from country to country (Figure 39), with non-high-income countries generally relying more heavily on proteins from aquatic animal

FIGURE 40 APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS PER CAPITA AND CONTRIBUTION TO SUPPLY OF ANIMAL PROTEINS BY ECONOMIC CLASS, 2021



SOURCES: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.
Animal (excluding aquatic) protein data are based on FAOSTAT: Food Balance Sheets. [Accessed 29 February 2024]. www.fao.org/faostat/en/#data/FBS. Licence: CC-BY-4.0.
Population data are based on United Nations Population Division. 2022. World Population Prospects 2022. [Accessed 13 January 2023]. https://population.un.org/wpp

foods, compared with high-income countries. This reflects their affordability, availability and accessibility, making them a staple in many culinary traditions. In 2021, aquatic animal foods accounted for 14 percent of animal proteins in low-income countries, 18 percent in lower-middle-income countries, 17 percent in upper-middle-income countries, and 10 percent in high-income countries.

Despite the fact that apparent consumption of aquatic animal foods per capita was significantly lower in low-income than in high-income countries in 2021, aquatic animal foods contributed to a greater share of animal protein supply in low-income than in high-income countries (Figure 40). Similarly, apparent consumption of aquatic animal foods per capita averaged 9.4 kg in Africa in 2021, representing the lowest figure across regions, while aquatic animal foods supplied 18 percent of animal proteins, a figure well above the world average.

Enhancement of the FAO Food Balance Sheets on aquatic foods (Box 4) has made it possible to provide data on 22 additional macro- and micronutrients for aquatic foods, of which 13 are also available for all other food products, enabling comparisons between different food groups.

Globally, 6 percent of riboflavin, 6 percent of thiamin, 8 percent of calcium, 8 percent of vitamin C, 9 percent of vitamin A, 11 percent of zinc, 12 percent of iron, 13 percent of phosphorus, 13 percent of potassium and 17 percent of magnesium supplied by animal products were from aquatic animal products. However, notable variations exist among countries. For example, in Botswana, the contribution of aquatic animal foods to the nutrient supply sourced from animal products was very low, ranging from 0 percent for vitamin C to a mere 1 percent for magnesium. On the other hand, in Cambodia, the contribution of aquatic animal foods to the nutrient supply »

BOX 4 ENHANCEMENT OF FAO'S FOOD BALANCE SHEETS ON AQUATIC PRODUCTS

Since the 1960s, FAO has annually compiled Food Balance Sheet (FBS) statistics for aquatic products across 227 countries and territories, providing a comprehensive overview of each country's supply and utilization of aquatic foods. The latest FBS dataset released in 2023 includes revised time series due to updated population estimates and data on nutritional composition. These revisions were also implemented in FBS calculated by FAO for other foods. The population data were updated using the World Population Prospects published by the United Nations Population Division in 2022. These updates led to revisions of the per capita series, for the historical trends and absolute numbers.

The nutritional composition values used to convert food supply into calories, protein and fats were revised and their scope was expanded to include vitamins and minerals. FAO developed the global nutrient conversion table for FAO supply utilization accounts (Grande *et al.*, 2024), which presents average nutrient profiles drawing data from 13 high-quality national and regional food composition tables. This global resource covers a total of 530 food items – 435 food items for crops and livestock and 95 food items for aquatic products. Moreover, to improve our understanding of the nutritional value of aquatic foods beyond calories, protein and total fats, nutritional conversion factors for aquatic foods were calculated for 22 additional macro- and micronutrients. As a result, the supply of aquatic foods can now also be expressed in terms of available carbohydrates, dietary fibre, calcium, iron, magnesium, potassium, phosphorus, zinc, copper, selenium, riboflavin, vitamin C, vitamin A (in RE and RAE),* thiamin, vitamin B6, vitamin B12, total saturated fatty acids, total monounsaturated fatty acids, total polyunsaturated fatty acids, docosahexaenoic acid and eicosapentaenoic acid. For all other food products, nutritional composition values are available for 13 out of the 22 new macro- and micronutrients, with plans underway to include the remaining nine nutrients.

Fresh fish for sale on a market in Tuxtla Gutierez, Chiapas, Mexico
© Alex Webb/Magnum Photos for FAO

The revision of the calorie and protein composition values had a minimal effect on the overall calories and protein provided by aquatic animal foods. On the other hand, the quantity of fats supplied by aquatic animal foods was seen to increase. This could be indicative of advancements in analytical techniques for measuring fat content in foods, increased data availability for aquatic animal foods across various food composition tables, and shifts in the production methods of aquatic animal foods. Among the different species groups, freshwater and diadromous fish experienced the most notable change in fat supply following the update; this is the species group that has the highest proportion of production originating from aquaculture.

These newly updated data are accessible under the Food and Diet domain of FAOSTAT.** Data on aquatic animal foods are aggregated under the food group "Fish, shellfish and their products" and can be compared with other food groups, except for nutrients currently exclusively available for aquatic foods.***

NOTES: * RE – retinol equivalent; RAE – retinol activity equivalent.
** The FAOSTAT Food and Diet domain can be accessed at: https://www.fao.org/faostat/en/#data/SUA
*** For further information on the FAOSTAT Food and Diet domain, see: https://www.fao.org/documents/card/en/c/cc9454en

SOURCE: Grande, F., Ueda, Y., Masangwi, S. & Holmes, B. 2024. *Global nutrient conversion table for FAO supply utilization accounts*. Rome, FAO. https://doi.org/10.4060/cc9678en

» sourced from animal products ranged from 37 percent for thiamin to 74 percent for calcium.

Aquatic animal products are also valuable sources of fats, specifically unsaturated fatty acids, which are an essential component of a healthy diet. Aquatic animal products are rich in both monounsaturated and polyunsaturated (such as omega-3 fatty acids) fats. Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are vital for human health, in particular the structural composition of cell membranes, the optimal development of a baby's brain and nervous system, and the healthy functioning of the cardiovascular system. Since the human body cannot produce these fatty acids on its own, they must be obtained through diet.

Available data on the per capita supply of monounsaturated and polyunsaturated fats derived from aquatic animal foods reveal significant variations across countries and regions. For example, Iceland, Palau and Kiribati ranked highest in per capita supply of these fats, while Afghanistan, Ethiopia and Eritrea registered levels close to zero. At regional level, Africa, Latin America and the Caribbean and Northern America ranked lowest in per capita supply of these fats, while Asia, Europe and Oceania ranked highest. While differences in the quantities of aquatic animal foods consumed partly explain these variations, the types of aquatic animal foods also play a role. For instance, the apparent consumption of aquatic animal foods was estimated at 23.4 kg per capita in Northern America, higher than in Europe (estimated at 22.2 kg). Despite this, the supply of monounsaturated and polyunsaturated fats from aquatic animal foods in Northern America was 0.7 grams per capita per day – less than in Europe (estimated at 1.0 gram per capita per day).

Evolution of species composition of aquatic animal foods

Since the late 1990s, capture fisheries production has remained relatively stagnant, while there has been a significant increase in aquaculture production, driving the surge in apparent consumption of aquatic animal foods. As a result, the proportion of aquatic animal foods originating from aquaculture production has risen significantly, jumping from 6 percent in the 1960s to 56 percent in 2021, causing a shift in the species composition. Preliminary data point to a further growth to 57 percent in 2022. These figures represent available food in live weight equivalent and do not take into account that bivalves and crustaceans, which contain substantial amounts of inedible parts, represent a higher share of aquaculture than of capture fisheries production of aquatic animals (32 percent vs 8 percent in 2022). Therefore, it is likely that capture fisheries are still the main source of edible aquatic animal foods.[v]

Consumption has shifted away from finfish in favour of shellfish (Figure 41). The share of finfish in aquatic animal food consumption decreased from 86 percent in 1961 to 74 percent in 2021. Within finfish, the share of freshwater and diadromous species grew from 20 percent of the per capita consumption of finfish in 1961 to 55 percent in 2021. This reflects the increase in the production of farmed salmonoids, tilapia, carp and catfish over time. In parallel, the share of marine finfish species declined from 80 percent of the per capita consumption of finfish in 1961 to 45 percent in 2021, with the most significant declines registered for demersal and pelagic fish.

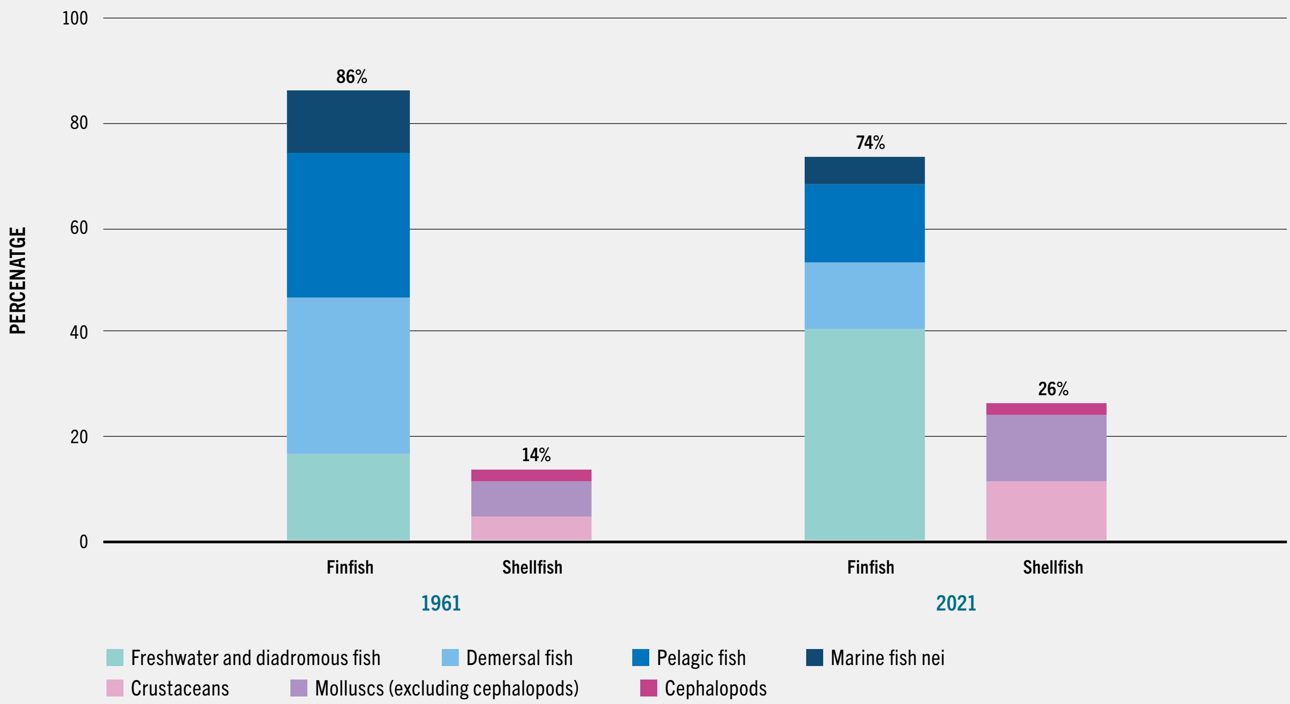
The share of shellfish has risen over time and nowadays most shellfish, particularly molluscs and to a lesser extent crustaceans, are farmed. Shellfish accounted for 14 percent of aquatic animal food consumption in 1961, compared with 26 percent in 2021; within shellfish, the share of crustaceans rose at the expense of cephalopods, while molluscs maintained a stable share, accounting for nearly half of shellfish consumption.

Algae

Seaweeds and other algae are currently not included in the FAO Food Balance Sheets for aquatic foods due to insufficient data on their utilization across most countries. Nevertheless, seaweeds have been important for the daily diets of various countries, particularly in East Asia, for centuries. Seaweeds can represent a nutritious,

v For more information, please refer to the 2022 edition of this report (FAO, 2022b, p. 88).

FIGURE 41 APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS BY MAIN SPECIES GROUP, 1961 AND 2021



SOURCE: Preliminary data. Final data available here: FAO. 2024. Consumption of aquatic products. https://www.fao.org/fishery/en/collection/global_fish_consump. Licence: CC-BY-4.0.

healthy, high-fibre and low-calorie food option. In light of the growing global population and mounting environmental challenges, seaweed emerges as a sustainable solution for bolstering food security and restoring aquatic ecosystems. Unlike land-based crops, seaweed cultivation makes use of seawater, thereby avoiding competition for arable land and freshwater resources. Throughout Asia and other regions, seaweeds like nori, Japanese kelp and Eucheuma seaweeds nei have significant cultural and nutritional importance. These seaweeds are not only fundamental elements of local cuisines but are also highly valued for their rich micronutrient content. As such, they play a crucial role in shaping national culinary traditions and show potential as valuable contributors to global efforts to improve food security. ■

TRADE OF AQUATIC PRODUCTS

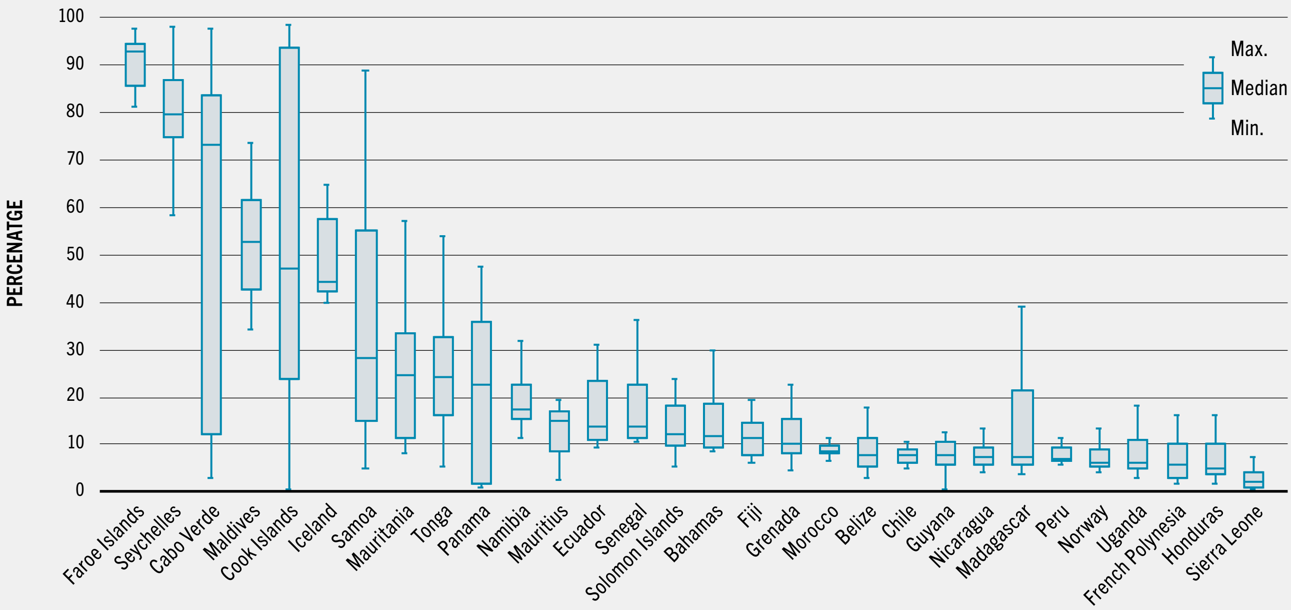
Significance of trade and latest trends

A significant share of aquatic products enters international trade, contributing to employment, value addition, food supply and diversification, revenue generation, and overall economic growth and development. Moreover, trade plays a pivotal role in enhancing food and nutrition security by expanding access to a variety of nutritious aquatic foods.

Significance of trade

Aquatic animal products represent some of the most extensively traded food commodities on a global scale. The proportion of total aquatic

FIGURE 42 TOP 30 COUNTRIES AND TERRITORIES WITH HIGHEST SHARE OF AQUATIC ANIMAL PRODUCT EXPORTS IN TOTAL MERCHANDISE EXPORTS, 2000–2022



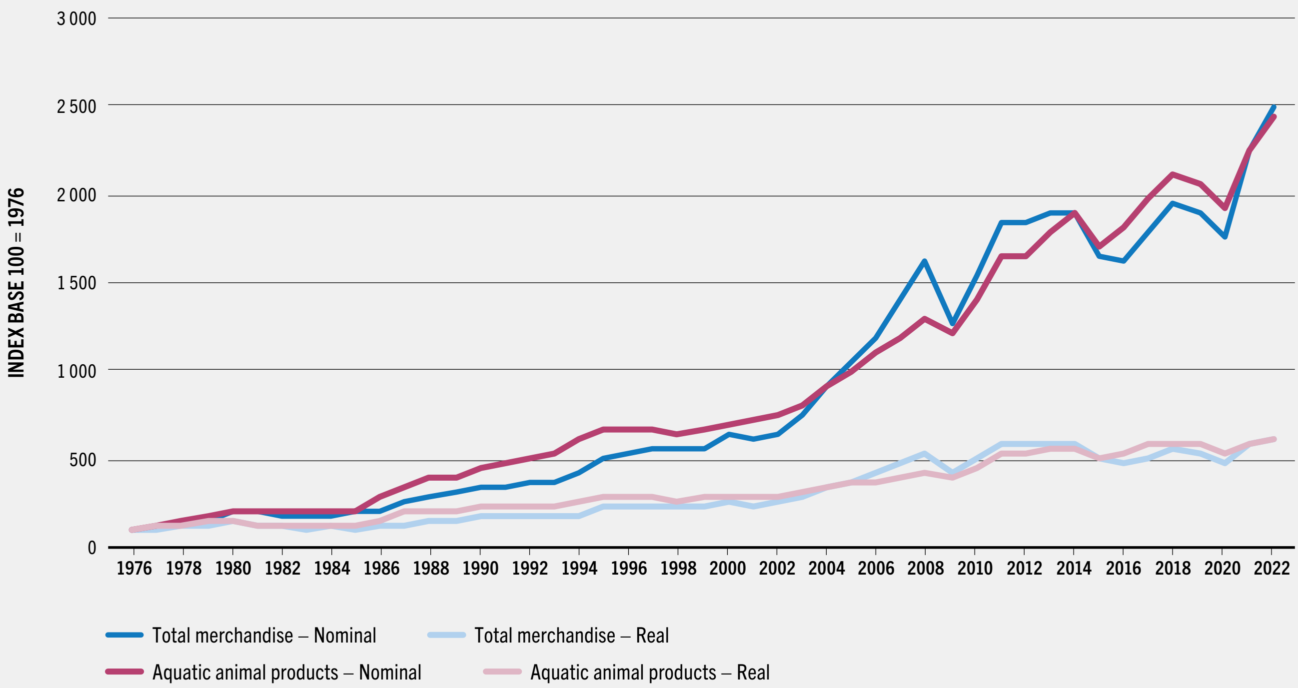
SOURCES: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.
Merchandise export data are based on FAO. 2023. FAOSTAT: Crops and livestock products. [Accessed 29 February 2024]. https://www.fao.org/faostat/en/#data/TCL. Licence: CC-BY-4.0.

animal production entering international trade has increased significantly. It rose from 25 percent in the mid-1970s to approximately 38 percent in 2022 – attesting to the sector's increasing integration in the global economy. The trade of aquatic products is crucially important in numerous countries and regions. It is particularly important for communities in coastal, riverine, insular and inland areas, where exports of aquatic products constitute a substantial portion of overall merchandise trade, generating export earnings, jobs, income and socioeconomic growth. For example, exports of aquatic animal products contribute to over 30 percent of the total value of merchandise trade in countries and territories such as the Faroe Islands, Maldives and Seychelles (Figure 42). Globally, trade of aquatic animal products represented more than 9.1 percent of total agricultural trade (excluding forest products) and about 1 percent of total merchandise trade in value terms in 2022.

Long-term trends

Trade in aquatic products has expanded considerably in recent decades. Increased aquatic production provides the incentive to expand trade, but this expansion is enabled by improved storage, preservation, transportation and logistics together with competitive prices and liberalization policies. Indeed, reduced transportation costs, and improved technology, logistics and storage have facilitated the processing of aquatic products in locations far from their production site. Similarly, the trade of fresh aquatic products has resulted in competition from producers located thousands of miles away from the high-end fresh markets traditionally served only by local fishers and farmers. Such trends have resulted in the

FIGURE 43 **WORLD MERCHANDISE AND AQUATIC ANIMAL EXPORT VALUE, FIXED-BASE INDICES (1976=100), 1976–2022**



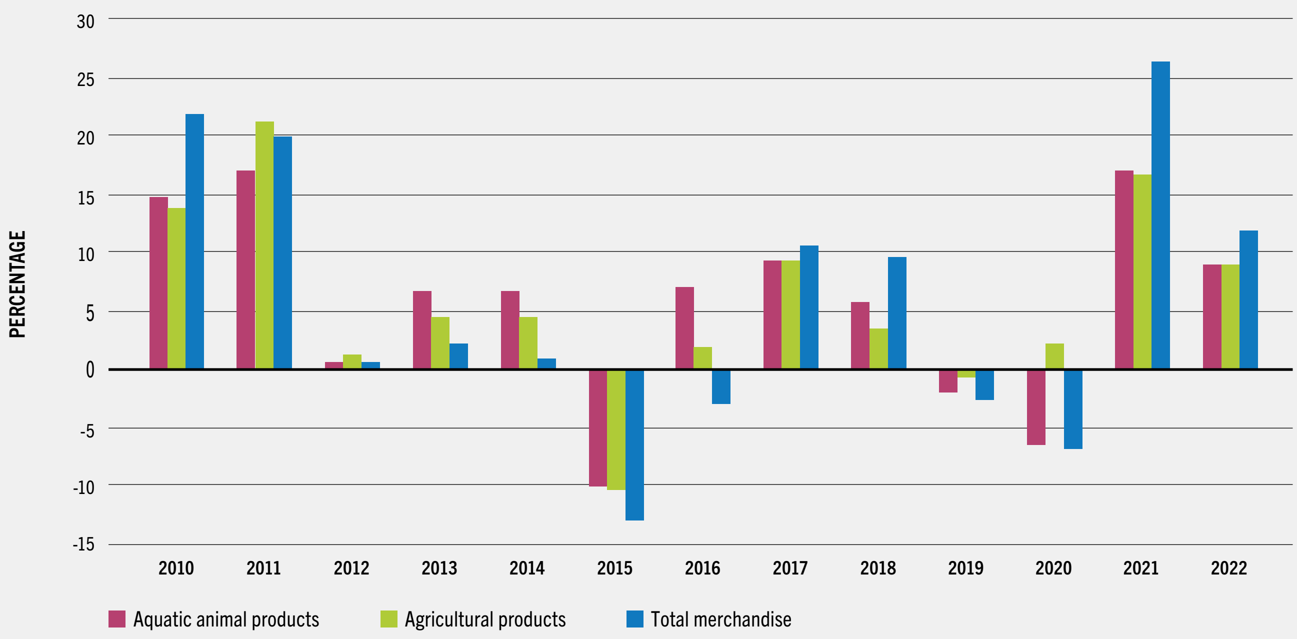
SOURCES: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.
Merchandise export data are based on FAO. 2023. FAOSTAT: Crops and livestock products. [Accessed 29 February 2024]. https://www.fao.org/faostat/en/#data/TCL. Licence: CC-BY-4.0.
Deflator data are based on World Bank. 2024. World Bank national accounts data, and OECD National Accounts data files. [Accessed 29 February 2024]. https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS. Licence: CC-BY-4.0.

emergence of complex supply chains in which aquatic products often cross several national boundaries before final consumption. In parallel, control of the aquaculture production process has enabled producers to cater for consumer needs and innovate more effectively within supply chains. An increasing number of markets have gone from regional to global, and ever more producers are seizing new market opportunities. These transformations are most apparent in the expanded geographical participation in trade. In 2022, more than 200 countries and territories engaged in aquatic trade during the year compared with 150 in the mid-1970s.

World trade in aquatic animal products has grown significantly in value terms, with exports rising from USD 7.9 billion in 1976 to a record high of USD 192 billion in 2022,[w] at an average annual growth rate of 7.2 percent in nominal terms and 4.0 percent in real terms (Figure 43). Exports of algae contributed an additional USD 1.6 billion and exports of other aquatic products such as sponges, corals, shells and inedible by-products added an

w Trade data for 2022 should be considered preliminary as they refer to the information available as at February 2024. These values could differ slightly from those to be released in the Trade section of the *FAO Yearbook of Fishery and Aquaculture Statistics 2022*, and in the FishStatJ workspace to be disseminated in mid-2024. The updated data will be available through the FAO website, available at: https://www.fao.org/fishery/en/fishstat

FIGURE 44 ANNUAL GROWTH RATE OF WORLD MERCHANDISE, AGRICULTURAL AND AQUATIC ANIMAL EXPORTS BY VALUE, 2010–2022



NOTE: Agricultural products include aquatic animal products but exclude forestry products.

SOURCES: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0
Merchandise and agricultural product exports data are based on FAO. 2023. FAOSTAT: Crops and livestock products. [Accessed 29 February 2024]. https://www.fao.org/faostat/en/#data/TCL. Licence: CC-BY-4.0.

extra USD 0.9 billion in 2022. The total export value of all aquatic products reached a record high of USD 195 billion in 2022.

Similarly to the trade of other merchandise, trade of aquatic animal products is closely tied to the broader economic context. World merchandise exports have experienced strong growth since 1976, reaching USD 25 trillion in 2022, almost 25 times the value recorded in 1976. This is equivalent to an annual growth rate of 7.3 percent in nominal terms and 4.0 percent in real terms.

Despite its upward trend, aquatic animal trade has contracted on six occasions since 1976: in 1982, 1998, 2009, 2015, 2019 and 2020. Preliminary estimates for 2023 point to another decline of about 4 percent in the value of exports of aquatic animal products compared with 2022.

Short-term trends

Between 2020 and 2022, the international trade landscape was significantly influenced by the COVID-19 pandemic, and aquatic products were no exception. Compared with 2019, global aquatic animal exports and merchandise exports witnessed declines estimated at −6.7 percent and −6.9 percent, respectively (Figure 44). This severe downturn in 2020 was a consequence of widespread lockdowns, disruptions in supply chains, and reduced consumer demand. Nevertheless, there was a rapid rebound, as recovery commenced before the end of 2020.

In 2021 and 2022, the value of global trade, including aquatic trade, experienced a rapid rebound, driven by a robust recovery in global demand and increasing commodity prices. Trade of aquatic animal products in 2022 increased by

BOX 5 FAO FISH PRICE INDEX

Food prices are an important factor in the global food system, as they can impact all value chain actors – from producers, processors and distributors to consumers. They are carefully studied and monitored by policymakers, marketing strategists and traders. Fluctuations in food prices can have significant economic and social repercussions, affecting the availability, accessibility and affordability of foods around the world. Information on food prices and their structures provides an essential economic indicator and is indispensable for a proper understanding of food value chain economics.

The FAO Fish Price Index (FPI), disseminated for the first time in June 2010, is a key barometer of the world market of aquatic products. It was developed in collaboration with the University of Florida, United States of America and the University of Stavanger, Norway. The index measures monthly changes in international prices of a basket of fisheries and aquaculture commodities, with data stretching back to January 1990. The FPI is calculated as a weighted average of five subindices associated to the main traded species groups: pelagic fishes, salmons, shrimps, tunas and whitefishes. Subindices are calculated as an average of the normalized prices of each species group.

Over time, the methodology of the index has evolved, and efforts have been made to ensure comparability of the index across time. The index currently consists of 15 individual price series representing the five main species group categories. Prices originating from different countries around the world are used to best capture the global characteristics of sourcing and trade of aquatic products. Due to the relatively low number of auctions and exchanges for aquatic products in comparison with crops and meats, different price types are used (auction, wholesale and trade prices).

For the largest traded species groups, the fish market is global, meaning that all price types provide a fairly accurate representation of the price fluctuations over time for the species in question. The prices collected can be daily, weekly or monthly and they are averaged accordingly when computing the index. The export value shares observed for each species group over the period 2014–2016 are used to weigh its contribution to the FPI. The species group accounting for the largest weight in the FPI is salmons, followed by shrimps and whitefishes. The index is set to 100 for the average of the years 2014, 2015 and 2016, making the average price for the basket of fisheries and aquaculture commodities in those three years the baseline.

The prices are sourced from the European Market Observatory for Fisheries and Aquaculture Products, Statistics Norway, the Danish Fisheries Agency and the FISHINFONetwork (FIN). The FIN, consisting of seven independent intergovernmental and governmental organizations plus the FAO-based GLOBEFISH unit (see **GLOBEFISH: 40 years of market monitoring and marketing intelligence**, p. 174), plays an important role in collecting and disseminating worldwide market and price information.

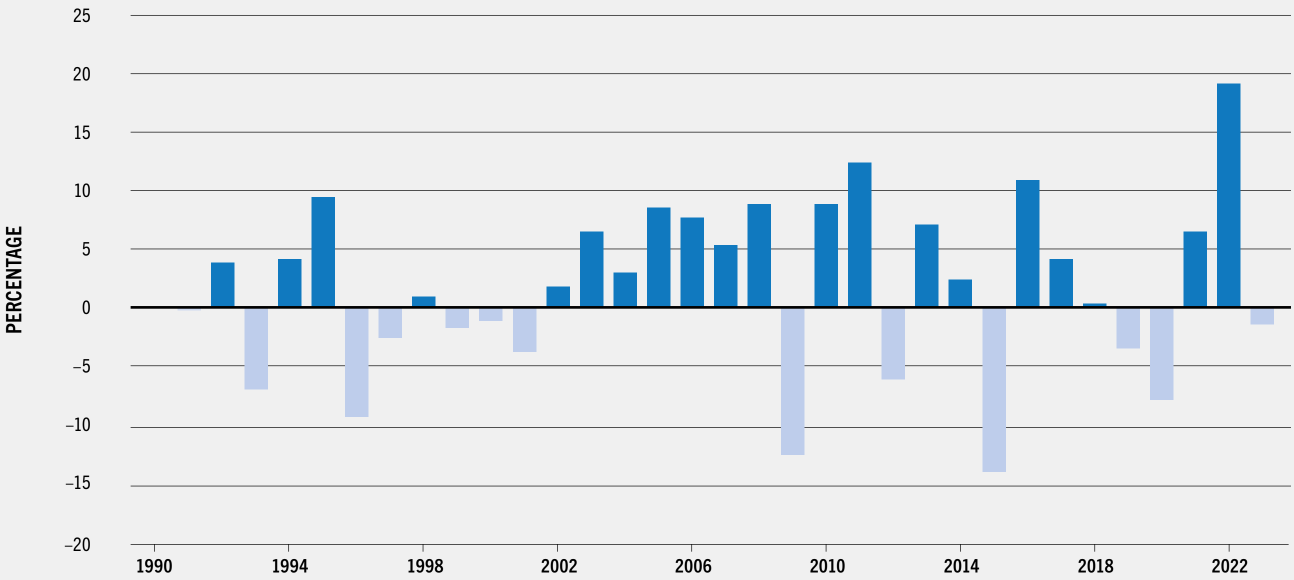
A webpage dedicated to the FAO Fish Price Index is on the FAO website and is updated on a monthly basis to report the latest trends. It is available at: https://www.fao.org/fishery/en/fishstat/fishpriceindex and will be updated on a monthly basis to report the latest trends.

19 percent relative to the pre-pandemic levels of 2019. The value of world merchandise exports recovered even more rapidly than that of aquatic animal exports, particularly in 2021, with a rise of 32 percent over the period 2019–2022.

Slower growth in traded volumes

From 2020, the dynamics of aquatic trade have been influenced not just by changes in worldwide demand since the COVID-19 pandemic but also by variations in prices. A significant proportion of the increase in the global trade of aquatic products has been in value, with trade in volumes experiencing a more moderate expansion. Between 2019 and 2022, world exports of aquatic animal products increased by 5.7 percent in volume, compared with 19 percent in value over the same period reflecting a steady increase in unit value. In 2022, the unit value of exported aquatic animal products averaged USD 2.7 per kg

FIGURE 45 ANNUAL CHANGES IN FAO FISH PRICE INDEX, 1990–2023



NOTE: Raw data for the FAO Fish Price Index sourced from: EUMOFA, INFOFISH, INFOPESCA, Statistics Norway, Danish Fisheries Agency.
SOURCE: FAO. (forthcoming). FAO Fish Price Index. https://www.fao.org/fishery/en/fishstat/fishpriceindex. Licence: CC-BY-4.0.

(live weight equivalent), up from USD 2.4 in 2019 and an increase of 12 percent.

According to the FAO Fish Price Index (Box 5), average international fish prices in 2022 were 19 percent higher than 2021 prices, which in turn were 6.4 percent higher than 2020 prices. They then stabilized over 2023, marginally down compared with their level in 2022 (Figure 45). Such inflation was not specific to aquatic products but extended to food prices in general. The FAO Food Price Index (which excludes fish prices) increased by 28 percent in 2021 and by another 15 percent in 2022. However, a notable reversal occurred in 2023, with food prices (excluding fish) experiencing a decline of 14 percent.

Key players

Top exporters

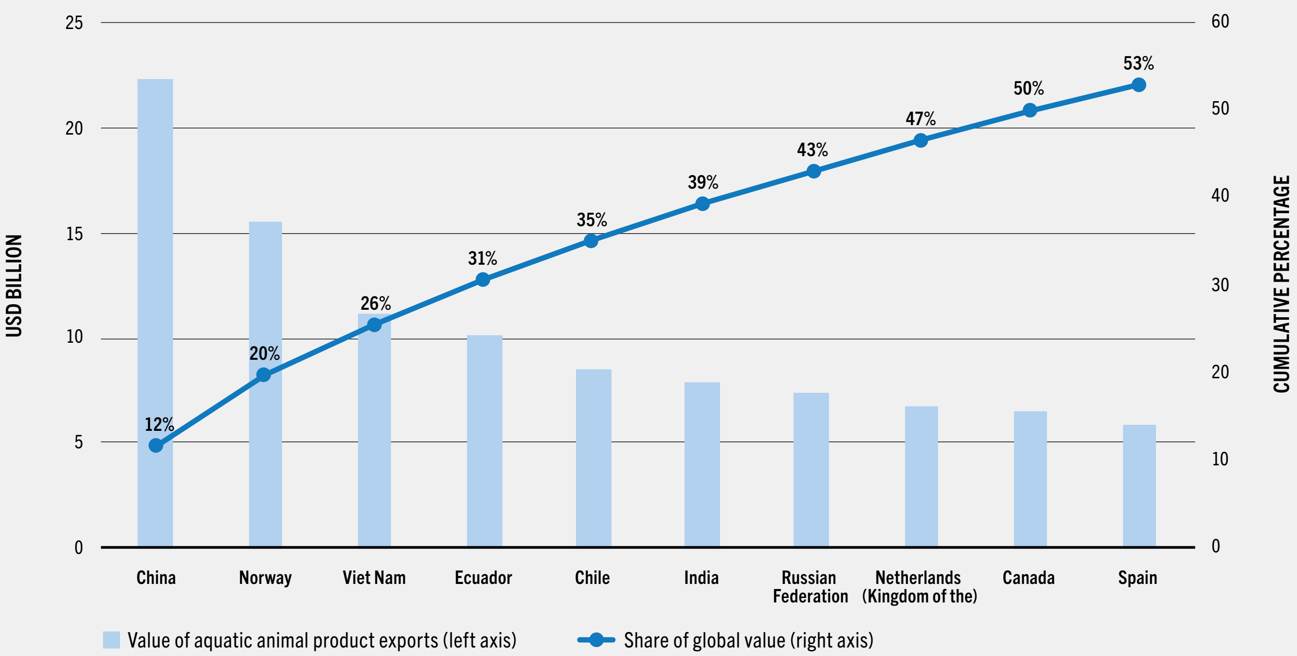
Since 1976, Asia has experienced the highest average annual growth rate in the export value of aquatic animal products, followed by Africa, Europe, the Americas and Oceania. In 2022, Europe and Asia maintained their positions as the leading exporting continents for aquatic animal products, accounting for 37 percent and 35 percent of the total export value, respectively. They were followed by Latin America and the Caribbean (15 percent), Northern America (7 percent), Africa (4 percent) and Oceania (2 percent).

High-income countries and middle-income countries each contributed to approximately half of the total value of aquatic animal exports in 2022. Conversely, the share of low-income countries was negligible. Regarding the destination of exports in 2022, high-income countries were the destination for 81 percent of the value of exports from high-income countries compared with 63 percent of the value from non-high-income countries. Figure 46 shows the top exporting countries of aquatic animal products.

China

In addition to being by far the major producer of aquatic products, China has also been the

FIGURE 46 TOP TEN EXPORTING COUNTRIES OF AQUATIC ANIMAL PRODUCTS BY VALUE, 2022



SOURCE: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.

main exporter of aquatic products since 2002. In 2022, China's contribution to world exports of aquatic animal products stood at 12 percent, which is comparable to – although slightly less than – the country's 14 percent share in total merchandise trade.

Chinese aquatic animal product exports have experienced a dynamic evolution over the past decades, registering a robust average annual growth rate of 14.2 percent between 1976 and 2009. However, during the 2010s, the pace of expansion decelerated to an average of 4.7 percent per year. Overall, Chinese exports of aquatic animal products increased from approximately USD 0.1 billion in 1976 to an estimated USD 22.4 billion in 2022, despite noticeable fluctuations. Notably, there were declines in 2019 and 2020 – of 7.3 percent and 7.9 percent, respectively – driven by the trade tensions between the United States of America and China and the impact of the COVID-19 pandemic. Nevertheless, positive rebounds were observed in 2021 and 2022, with annual increases of 15 percent and 5.1 percent, respectively.

China's aquatic animal product exports showcase a rich diversity of species and product forms. Notably, China is a major exporter of cephalopods, tilapias, Alaska pollock, mackerels, tunas and shrimps. A distinctive feature of Chinese exports is the prevalence of processed aquatic products originating from both domestic and imported raw material. Chinese exports include a wide array of products, ranging from frozen whole fish to frozen fillets and canned cuttlefish. This illustrates the versatility of the Chinese processing industry and its capacity to adapt to international demand for a variety of processed and value-added aquatic products.

China maintains exports to over 170 countries and territories. In 2022, Japan remained by far the largest export destination in value terms, followed by the United States of America and the Republic of Korea. These top three export destinations accounted for, respectively, 16 percent, 12 percent and 8 percent of China's aquatic animal product export value. In 2022, the value of aquatic animal product exports to the United States of America and the Republic of Korea grew by 6.6 percent and 6.4 percent, respectively, against only 1.8 percent for exports to Japan.

Norway

Following China, Norway is the second-largest exporter of aquatic animal products. Norway exports mostly farmed salmonids and some wild fish such as cod, herring, mackerel, other whitefish and small pelagic species. In 2022, Norway experienced a surge in the value of its exports of aquatic animal products, which increased by 12 percent from 2021. This outpaced the overall global annual growth rate of aquatic animal export value, which stood at 8.8 percent, elevating Norway's share in the global value of aquatic animal product exports to 8 percent. Norwegian exports of aquatic animal products reached USD 15.5 billion in 2022, a new record high, while quantities in live weight equivalent were down by 6.7 percent compared with 2021. This was primarily attributed to elevated prices, particularly for salmonoids, the predominant species group in Norwegian exports.

Norway distinguishes itself from China by its specialization in salmonoids. Salmon products constitute over 73 percent of Norway's aquatic animal export revenue, destined to a wide range of markets, reaching more than 140 countries and territories. In 2022, the top three destinations for Norwegian aquatic animal product exports were Poland and Denmark – where it is processed before re-export – and the United States of America.

Viet Nam

Viet Nam, the third-largest exporter of aquatic animal products, recorded export values totalling USD 11.2 billion in 2022. The primary exports from Viet Nam are farmed shrimps, farmed catfish (*Pangasius* spp.) and tuna products. The United States of America, China and Japan were the top destinations for Vietnamese exports of aquatic animal products, accounting together for 51 percent of Viet Nam's aquatic animal export revenue. While exports to each of these destinations increased in 2022, the strongest export growth was to China and Japan.

Ecuador

Ecuador has witnessed a substantial upswing in its exports of aquatic animal products over the past decade (+13.3 percent on average per year), primarily driven by a notable increase in farmed shrimp production. In 2022, Ecuador became the largest exporter of shrimps and prawns globally, ahead of India and Viet Nam, and was ranked the fourth-largest exporter of aquatic animal products. In 2022, Ecuador's total exports reached USD 10.1 billion, increasing by nearly USD 3 billion, equivalent to a 42 percent growth from 2021. The key drivers behind Ecuador's success include a slowdown in shrimp production in several Asian countries, modernization efforts in the shrimp farming programme enhancing Ecuador's competitiveness, and the implementation of local breeding programmes. Ecuador's export trade initially revolved around exporting shrimp to the United States of America and European markets. Nevertheless, in recent years, China has emerged as the primary destination for Ecuadorian exports, contributing 43 percent to the country's total export revenue of aquatic animal products.

Chile

In Chile, aquaculture production of Atlantic salmon, coho salmon and rainbow trout has developed into a highly competitive and modern export-oriented industry. Chile has witnessed consistent growth in export revenue driven by strong global demand for salmonids and high prices. In 2022, Chilean exports of aquatic animal products totalled USD 8.5 billion, up 25 percent from 2021.

India

India slipped to sixth position in 2022, having previously been the fourth-largest exporter of aquatic animal products in 2019. This drop was mainly due to a decrease in shrimp prices in addition to exported volumes not increasing as much as from other shrimp-exporting countries such as Ecuador. Nevertheless, shrimp exports accounted for 70 percent of the USD 7.9 billion generated by Indian aquatic animal product exports in 2022.

Other exporters

Other major exporters include the European Union, the Russian Federation, Canada and the United States of America. The European Union is the largest exporter with USD 39.8 billion in 2022, although the vast majority (80 percent in value) is attributed to intra-European Union trade. Moreover, a large proportion of these trade flows consist of re-exported products, either after processing within the European Union or after import into the EU market from non-EU countries.

In 2022, the Russian trade data were estimated through mirroring due to the absence of reported data at the time of writing. Consequently, observed changes may be the result of disparities in data sources compared with previous years. The estimates indicate substantial growth in both volume and value of aquatic product exports in 2022. The total value of Russian exports of aquatic animal products was estimated at USD 7.4 billion in 2022, marking an increase of 14 percent compared with 2021 and positioning the Russian Federation as the seventh-largest exporter of aquatic animal products. The Russian Federation exports a range of aquatic products, including Alaska pollock, cods, crabs and salmons.

The collective contribution of Canada and the United States of America to the global export value of aquatic animal products was 6.4 percent in 2022, with a substantial portion of this trade occuring bilaterally between the two nations.

Top importers

Europe has traditionally held the position of leading importing region for aquatic animal products. However, its dominance has been gradually declining since the late 2000s, while other regions such as Asia and Latin America and the Caribbean have witnessed an upward trend in their import shares. In 2022, Europe accounted for 39 percent of the total import value of aquatic animal products, followed by Asia (35 percent), Northern America (19 percent), Latin America and the Caribbean (3 percent), Africa (3 percent) and Oceania (1 percent).

High-income countries overwhelmingly dominate global imports of aquatic animal products. In 2022, they accounted for 74 percent of the total import value. With regard to the origin of imports in 2022, high-income countries were the origin of 56 percent of the value of imports in high-income countries compared with 36 percent of the value in non-high-income countries.

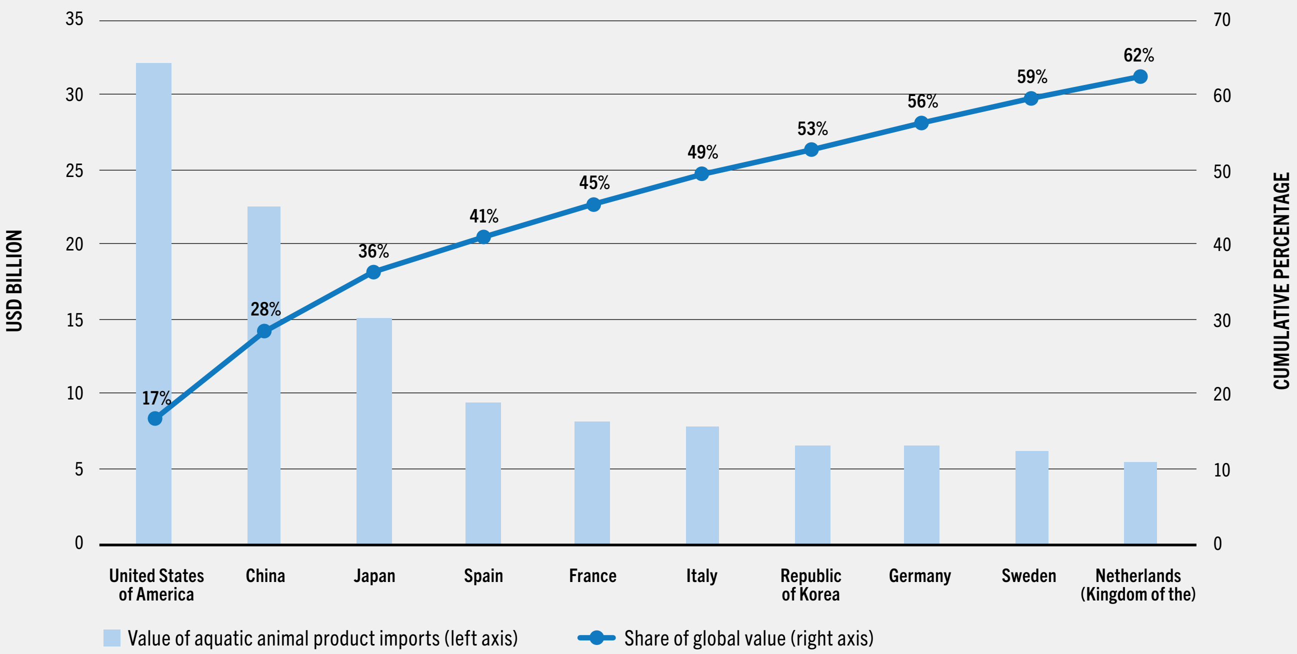
European Union

The European Union was the largest single market for aquatic animal products in 2022, with imports valued at USD 62.7 billion. While intra-European Union trade flows are significant, it is noteworthy that even when exclusively considering EU imports originating from non-EU countries, the European Union remained the top importer of aquatic animal products, with an import value of USD 33.2 billion in 2022. About 27 percent of aquatic animal products imported into the European Union from non-member countries were sourced from Norway, with China (6 percent), Ecuador (6 percent), Morocco (5 percent) and the United Kingdom of Great Britain and Northern Ireland (5 percent) following. While the European Union imports a wide variety of aquatic animal products, nearly 80 percent of its imports comprise salmonids, cods, shrimps, tunas and squids. In 2022, the European Union experienced a 9.7 percent growth in the value of imports of aquatic animal products from non-member countries and a 0.8 percent increase in volumes measured in live weight equivalent. This dynamic resulted in an 8.9 percent increase in the unit value of imports into the European Union in 2022 and is consistent with the observed inflation, particularly in the food sector, experienced across Europe over 2022.

United States of America

The largest individual importing country in 2022 was the United States of America (Figure 47). The value of its imports reached USD 32.1 billion, representing 17 percent of the world import value of aquatic animal products and reflecting a growth of 7.3 percent in 2022 compared with 2021, along with a 4.9 percent increase in volume (live weight equivalent). It resulted in a rise in unit value (+2.3 percent), although significantly lower than that observed in the European Union (+8.9 percent). The primary suppliers of aquatic animal products to the United States of America were Canada (13 percent), Chile (12 percent), India (10 percent), Indonesia (9 percent) and Viet Nam (7 percent), which collectively represented 51 percent of the total import value

FIGURE 47 TOP TEN IMPORTING COUNTRIES OF AQUATIC ANIMAL PRODUCTS BY VALUE, 2022



SOURCE: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.

in 2022. Notably, in 2022, Chile surpassed India to become the second-largest supplier of aquatic animal products to the United States of America. Shrimps, salmonids and tunas were the most imported aquatic animal products, contributing 26 percent, 22 percent and 8 percent, respectively, to the total value of imports to the United States of America in 2022.

China

The second-largest individual importing country was China in 2022, accounting for 12 percent of the world's import value of aquatic animal products. With a significant surge of 30 percent from 2021, China's imports reached USD 22.5 billion in 2022. Import volume (live weight equivalent) experienced a growth of 6.5 percent in 2022 compared with 2021, leading to a unit value rise of 23 percent. The surge in China's imports can be attributed in part to the outsourcing of processing from other nations. Moreover, it reflects the increasing domestic consumption of species not locally produced within the country. The rapid growth rate of Chinese imports compared with exports resulted in China becoming a net importer of aquatic animal products in value terms for the first time in 2022 (Box 6). While China increased imports from the majority of its suppliers, key contributors were Ecuador (the main origin of Chinese imports), the Russian Federation and Viet Nam. Shrimps, cods, lobsters and crabs are the most imported aquatic products, and in 2022 they accounted for 51 percent of the total value of Chinese imports of aquatic animal products.

Japan

Japan was the third-largest individual importing country in 2022. The value of aquatic animal products imported by Japan in 2022 reached USD 15.1 billion, constituting 8 percent of the total global value of aquatic animal products. While there was an upswing in the Japanese import value in 2022, denoting a recovery phase from the disruptions

BOX 6 CHINA: THE SHIFT FROM NET EXPORTER TO NET IMPORTER

The development of China's fisheries and aquaculture production and processing industry has resulted in substantial growth in its exports of aquatic animal products over time. To the point that China became and remains the world's largest exporter of aquatic animal products in value terms since 2002. Simultaneously, Chinese imports of aquatic animal products have also seen substantial growth since the 1980s. These imports supply raw materials to the processing industry, feed for the aquaculture and livestock sectors, and aquatic foods to meet the domestic demand.

Throughout the 2000s, the value of both Chinese exports and imports of aquatic animal products experienced an average annual growth rate of 12 percent. However, in the following decade, while exports maintained a more modest average growth rate of 5 percent per year, imports surged at an average annual rate of 13 percent. This difference in growth rate between exports and imports persisted into 2021 and 2022. To illustrate the magnitude of this growth, Chinese imports of aquatic animal products more than doubled between 2017 and 2022, soaring from USD 10.7 billion to USD 22.5 billion. Meanwhile, over the same period, Chinese exports of aquatic animal products increased from USD 20.5 billion to USD 22.4 billion. This substantial difference between the growth rates of imports and exports resulted in China transitioning from being a historically net exporter of aquatic animal products to becoming a net importer in value terms for the first time in 2022. Preliminary data for 2023 indicate a further increase in the Chinese trade deficit, from USD 0.1 billion in 2022 to USD 2.7 billion in 2023.

Both short- and long-term drivers reflect such change in the net trade situation of China. On the short-term side, the surge in Chinese imports of aquatic animal products is attributed to the reopening of the country's food service and processing sectors, which had been severely impacted by the COVID-19-related restrictions. This surge includes increased imports of various items such as frozen shrimps, fresh rock lobster, frozen Alaska pollack and fresh salmon. With restrictions easing in 2022 and anticipation building around the first significant Chinese New Year celebration post-pandemic, importers increased their inventories in anticipation of greater demand. Long-term trends include the expansion of the middle class, which seeks higher-value aquatic animal products, including from distant regions. Additionally, rising labour costs undermine the competitiveness of Chinese exports, with implications for its processing export industry.

This transition in China's aquatic animal trade dynamics has implications not only for the domestic industry but also for the global market. As China shifts from being a net exporter to a net importer of aquatic animal products in value terms, new opportunities arise for other exporting countries to meet the rising demand in the Chinese market.

While China became a net importer of aquatic animal products in value terms in 2022, it is important to note that – from a volume perspective – China has been a net importer since the mid-1980s. However, the trade deficit in volume terms has been widening significantly in recent years.

»

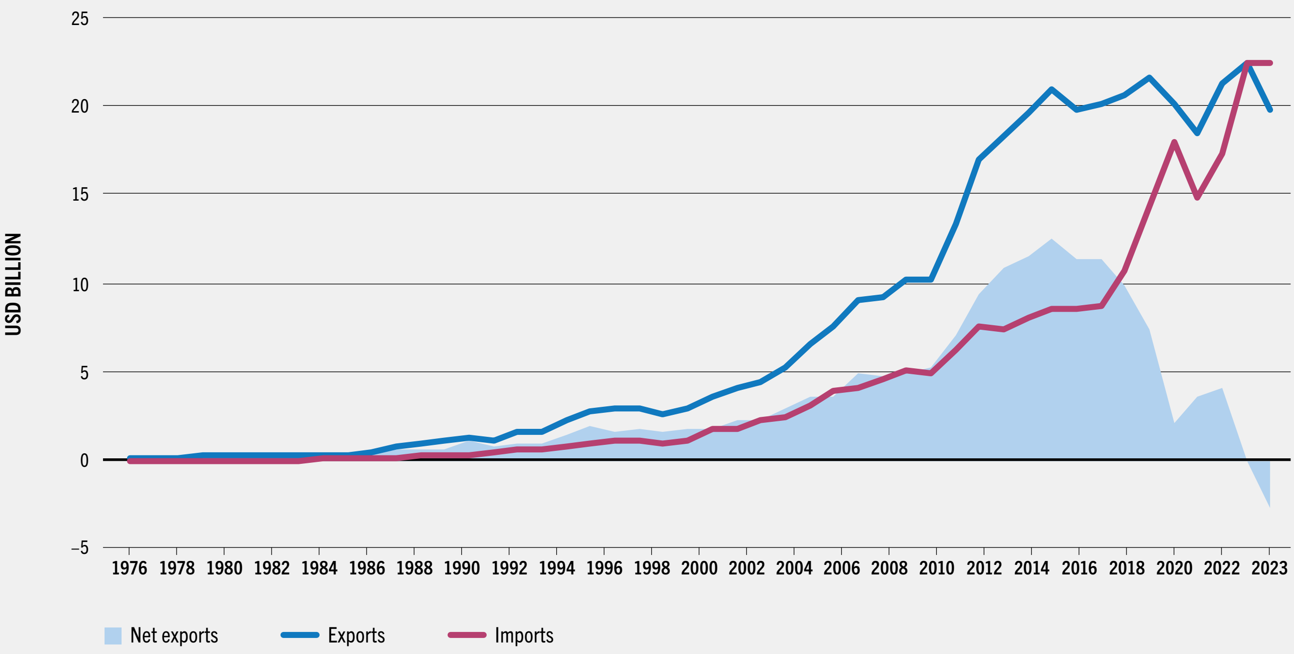
caused by the COVID-19 pandemic, it is noteworthy that import levels did not fully rebound to their pre-pandemic heights. This suggests that, despite the post-pandemic resurgence, Japan might be resuming the downward trend observed in its imports of aquatic animal products during the 2010s.

Particular situation of Africa

In addition to the countries mentioned above, numerous other countries actively engage in the trade of aquatic products, whether at the inter- or intraregional level (Figure 48). However, it is worth noting that African countries tend to have a relatively modest participation in aquatic trade. Overall, Africa accounted for 4 percent of the total value of aquatic animal exports and for 3 percent of the total value of aquatic animal imports in 2022. This relatively modest engagement in trade can also be partially attributed to the challenge of accurately capturing data on regional trade flows,

BOX 6 (Continued)

CHINA'S NET AQUATIC ANIMAL PRODUCTS TRADE BALANCE BY VALUE, 1976–2023



NOTE: Data for 2023 are preliminary. Values are nominal terms.

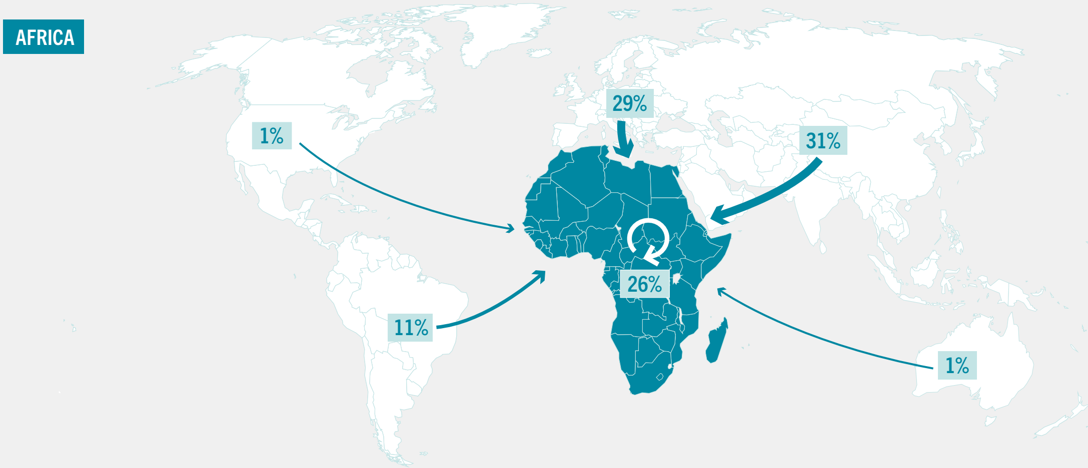
SOURCE: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0

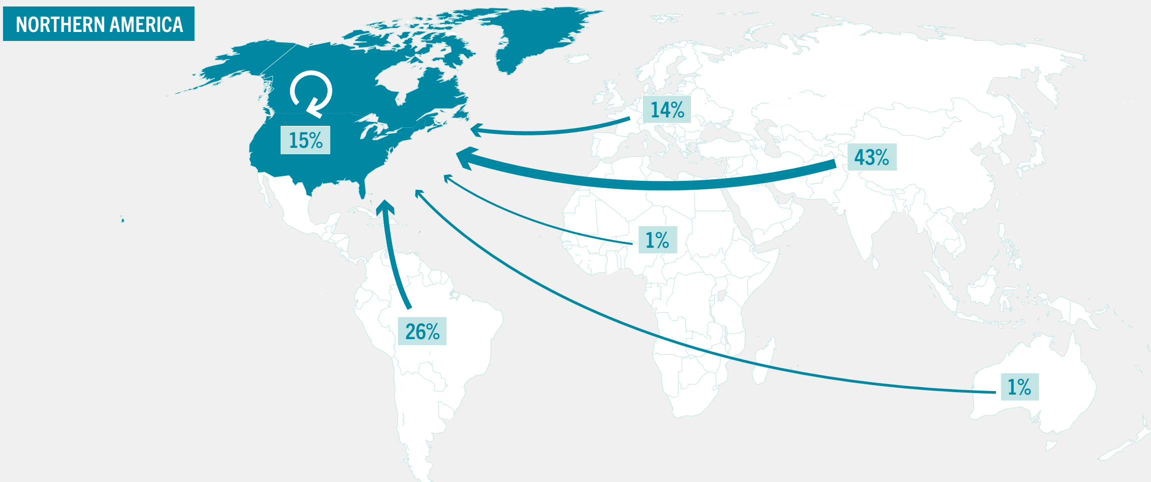
which are not consistently reflected in official statistics. In terms of both value and volume (live weight equivalent), Africa is a net exporter. The bulk of African imports comprises cheap small pelagic species, such as mackerels or sardines, which play a crucial role in diversifying diets for populations heavily reliant on a limited range of staple foods. Beyond the analysis by volume and value, trade can also be analysed from a nutritional point of view. To do this, aquatic animal trade data were categorized into groups of products, according to species, product form characteristics, and related average nutritional values. Based on this analysis, the protein content of African imports of aquatic animal products surpasses that of exports by nearly 50 percent. This implies that although Africa is a net exporter of aquatic animal products in terms of value and volume, it is a net importer from a protein perspective, meaning that Africa enhances its protein supply from aquatic animal products through trade.

Main traded products

In 2022, around 76 percent of the exported quantity of aquatic animal products in live weight equivalent was intended for food consumption. Among non-food traded items, fishmeal and fish oil took the largest share, accounting for nearly one-quarter of the globally traded quantities of aquatic animal products (Figure 49). The proportion of non-food items within the overall traded quantities of aquatic animal products has »

FIGURE 48 TRADE FLOWS OF AQUATIC ANIMAL PRODUCTS BY REGION (SHARE OF TOTAL IMPORTS, IN VALUE), 2022

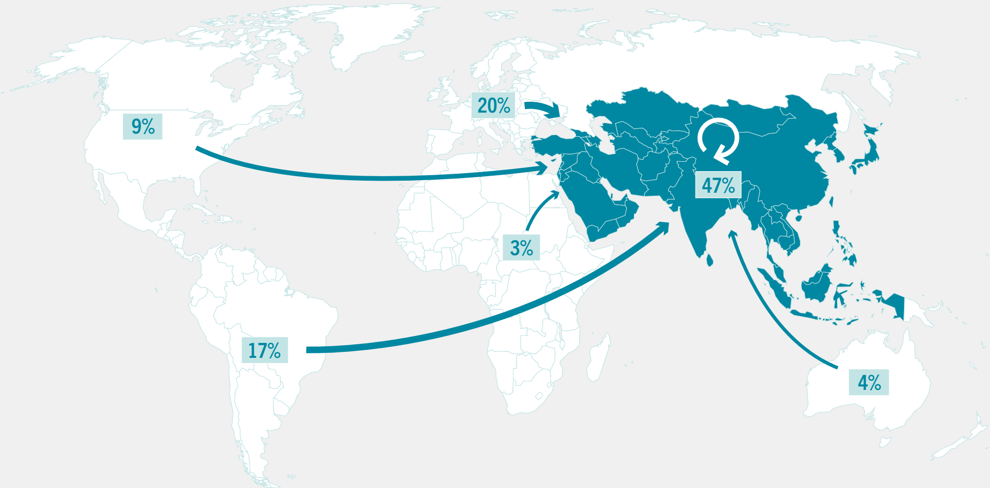




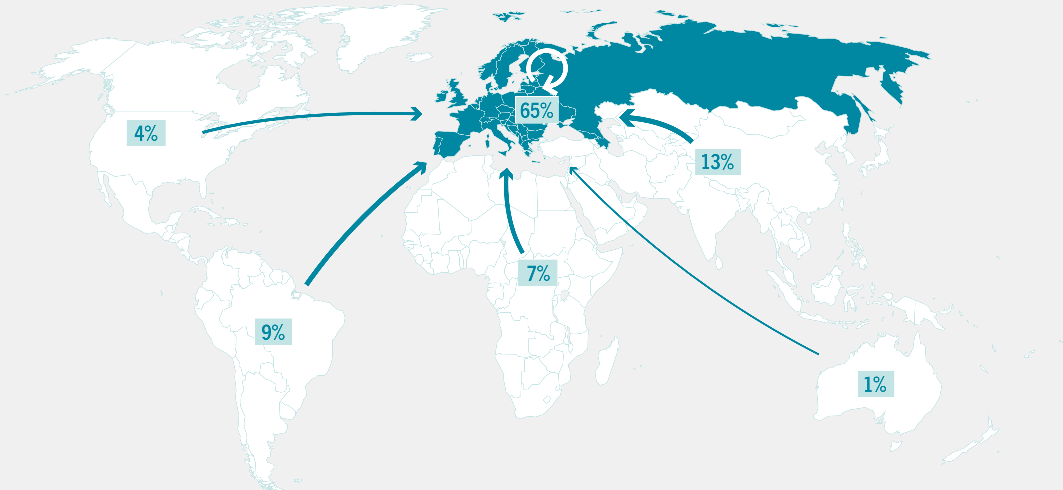
Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Final boundary between the Republic of Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area is not yet determined.

FIGURE 48 (Continued)

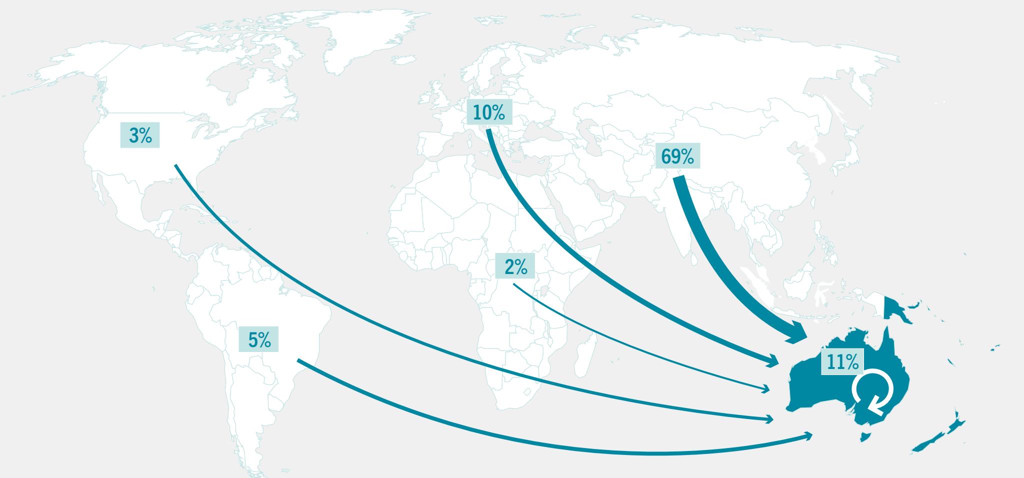
ASIA



EUROPE



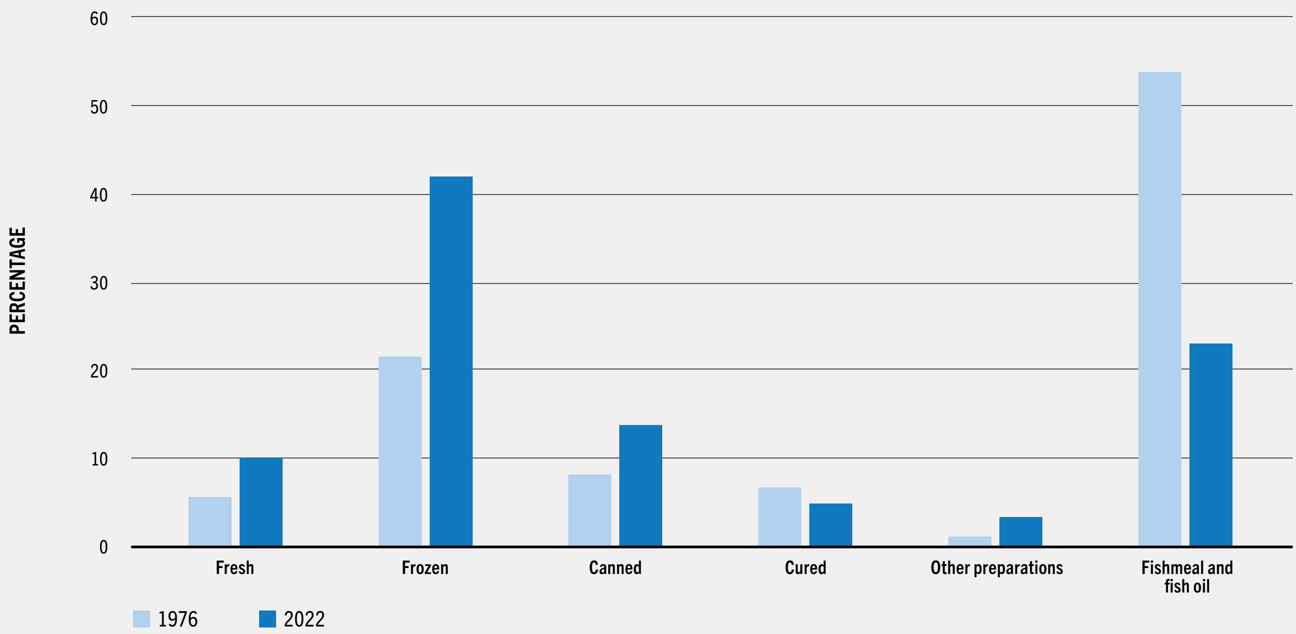
OCEANIA



NOTE: Shares may not add up to 100 percent due to unspecified trading partners.

SOURCES: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod. Licence: CC-BY-4.0.
United Nations Geospatial. 2020. Map geodata.

FIGURE 49 SHARE OF MAIN PRODUCT FORMS IN EXPORTS OF AQUATIC ANIMAL PRODUCTS BY VOLUME, 1976 VS 2022



NOTE: Based on live weight equivalent.
SOURCE: FAO estimates.

» declined significantly over the years: from over 50 percent in 1976 to under 25 percent in 2022.

Another distinctive feature of aquatic animal product trade is the increasing prevalence of processed products, other than live and fresh whole aquatic animals. In 2022, 92 percent of aquatic animal products, measured in live weight equivalent, were processed items. Processing methods have evolved with increasing adoption of freezing. As a result, frozen products in 2022 constituted 44 percent of the total traded quantity, a significant increase from the 22 percent recorded in 1976. This expansion was made possible through the adoption of innovative technologies in chilling, packaging and distribution. These new technologies also facilitated growth of trade in fresh processed products such as fresh fillets.

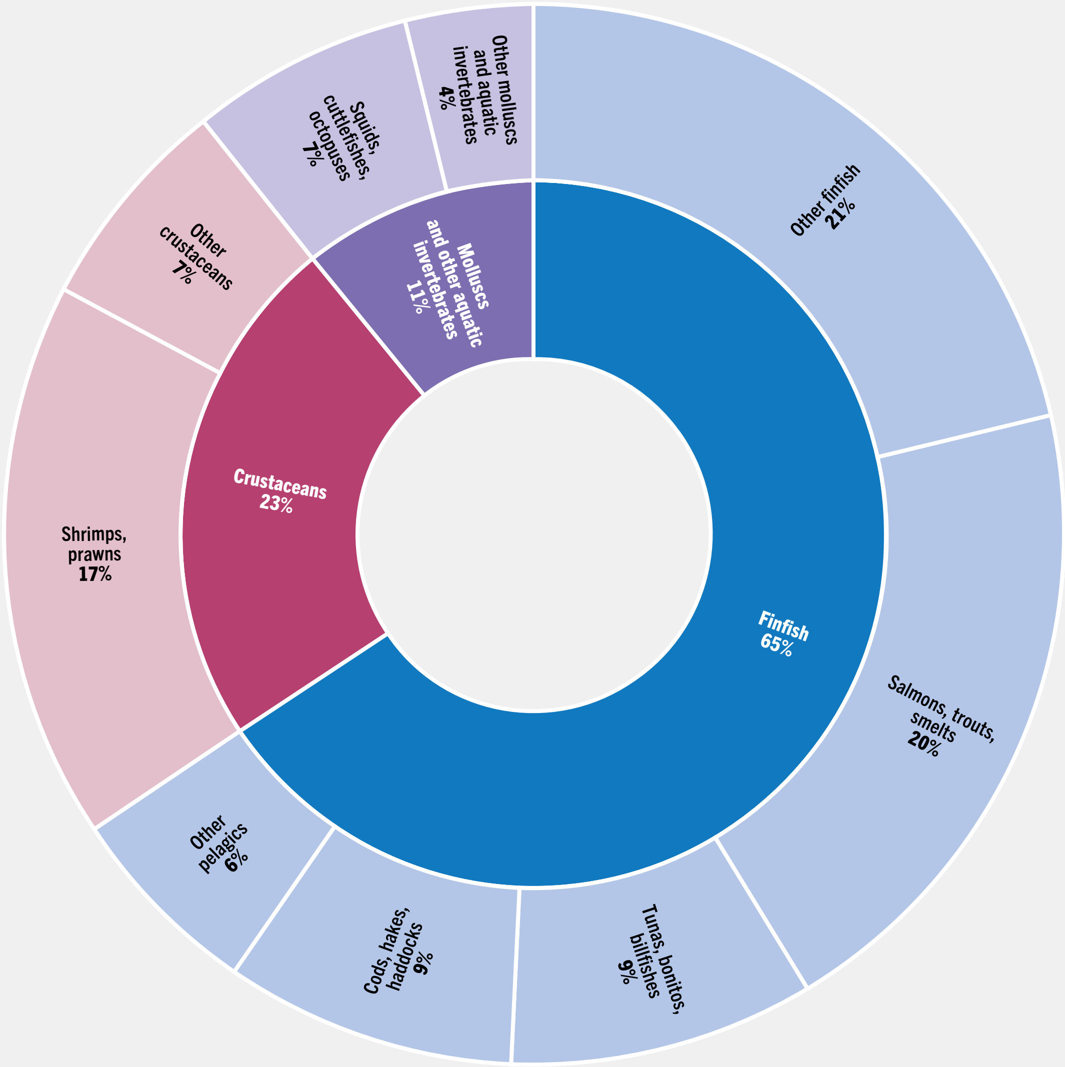
Aquatic animal product trade involves a wide variety of species. Figure 50 shows the breakdown of the total value of globally traded aquatic animal products by major species group in 2022.

Finfish dominated the global trade in aquatic animal products in 2022, making up 65 percent of the total value. Crustaceans followed with 23 percent, and molluscs and other aquatic invertebrates contributed 11 percent. Since 2013, salmonids have been the most valuable traded aquatic species group, and in 2022 they accounted for 20 percent of the total value. Other important species groups in terms of export value included shrimps and prawns (17 percent), cods, hakes and haddocks (9 percent), tunas, bonitos and billfishes (9 percent), and squids, cuttlefishes and octopuses (7 percent). There follows a succinct analysis of recent trends in key species groups and products.

Salmon and trout

The trade in salmon and trout has shown a consistent increase, averaging 10.4 percent per

FIGURE 50 SHARE OF MAIN GROUPS OF SPECIES IN EXPORTS OF AQUATIC ANIMAL PRODUCTS BY VALUE, 2022



NOTE: Shares may not add up to 100 percent due to rounding.

SOURCE: Preliminary data. Final data available here: FAO. 2024. Global aquatic trade statistics. https://www.fao.org/fishery/en/collection/global_commodity_prod.

year in value since 1976. This surpasses the overall average growth rate observed for aquatic animal product trade, which stood at 7.2 percent during 1976–2022. Consequently, salmon – and particularly farmed Atlantic salmon – has emerged as a significant contributor to the expansion of global trade in aquatic products in recent decades. Global marketing strategies, product innovation, and advancements in logistical and production technology have played pivotal roles in positioning salmon as a popular item in markets worldwide, leading to a rapid growth in demand. In 2022, world salmon and trout exports reached USD 38 billion, up 15 percent from the previous year. The main exporters of salmon, namely Norway and Chile, registered record-high export revenues in 2022, driven by rising prices and higher added value of products. In 2023, the Norwegian parliament endorsed the government's proposition to levy taxes on fish farming conducted in coastal waters, potentially influencing future investment decisions.

Shrimps and prawns

Formerly the leading traded species group (until surpassed by salmon in 2013), shrimp and prawn exports have experienced renewed growth in recent years. This resurgence is primarily attributed to the exceptional production expansion in Ecuador. The Ecuadorian industry has benefited significantly from advancements in farming technology such as automatic feeding and mechanical aeration, major investments in genetic enhancement, a strong industry vertical consolidation, and increasing exports to China. The Ecuador–China Free Trade Agreement, set to enter into force in 2024, is expected to remove the 5–7 percent tariffs currently imposed on Ecuadorian aquatic exports to China.

Demand for shrimps and prawns was high in China and the European Union in 2022, contrasting with a marginal decline in the United States of America. In 2022, global exports of shrimps and prawns reached USD 32.3 billion, an increase of 8.7 percent from 2021 – which had already seen a 22 percent growth from 2020 following three consecutive years of decline between 2018 and 2020. This downward trend reflected the diminished prices driven by large production volumes, particularly from aquaculture. Although prices saw a slight increase in 2022, they remained lower than historical levels. However, in 2023, international shrimp prices dropped by 16 percent compared with 2022, as reported by the FAO Fish Price Index. This, combined with rising production costs, had a negative impact on the profitability of the sector.

Cods, hakes and haddocks

Cods, hakes and haddocks primarily originate from capture fisheries, and the Russian Federation, China and Norway are the main exporting countries. In 1976, this species group accounted for 12 percent of the overall export value of aquatic animal products. Over time, the share of cods, hakes and haddocks has experienced a decline within the total value of aquatic exports reflecting a corresponding decrease in production volumes. In 2022, global exports of cods, hakes and haddocks reached USD 17.8 billion, representing 9 percent of the total value of aquatic animal product exports. The main importers remain the European Union, China and the United States of America. Reduced supplies of these wild-caught species have led to an upward trend in prices in recent years, a trajectory which is expected to persist, particularly for cods. This may prompt consumers to shift towards more affordable alternatives. Farmed whitefish species such as tilapia and *Pangasius* spp. represent strong competition in terms of pricing for wild-caught species.

Tunas, bonitos and billfishes

In 2022, global exports of tunas, bonitos and billfishes reached a value of USD 17 billion, representing 9 percent of the total value of aquatic animal product exports. Canned tuna constituted slightly over half of tuna exports, with Thailand being the leading exporter, followed by Ecuador, China and several European countries. While traditional importers of canned tuna include the United States of America and the European Union, in recent years there has been a rising trend in imports by Near East countries. Canned tuna exports, unlike many other aquatic products during the pandemic, witnessed both volume and value growth in 2020, reflecting heightened consumer demand for affordable proteins that are convenient for preparation and storage. However, exports declined in 2021 due to elevated retailer inventories resulting from substantial orders placed throughout 2020 in response to the initial surge in consumer purchases at the beginning of the pandemic. In 2022, canned tuna exports experienced a robust rebound in both value and volume, primarily driven by increased demand in the United States of America and numerous European countries. Although fresh tuna exports are lower in volume, their unit price is three times higher than that of canned tuna. The fresh market faced substantial challenges during the pandemic, experiencing a sharp decline in exports in 2020. However, it demonstrated a robust recovery in

2021 and continued to exhibit growth in 2022. The primary importers of fresh tuna products include the European Union, the United States of America and Japan.

Cephalopods

Cephalopods, which comprise octopus, squid and cuttlefish, have witnessed a growing share in global trade, despite facing potential risks due to inadequate management practices. In 2022, global cephalopod exports reached USD 14.3 billion, constituting 7 percent of the world's total exports of aquatic animal products. Spain, Italy and Japan maintain their positions as the largest importers of cephalopods. China, Spain, India and Indonesia emerge as primary exporters of squid and cuttlefish, while China, Morocco, Spain and Mauritania lead in octopus exports. Cephalopods are predominantly exported as frozen products, representing 72 percent of the total value in 2022, followed by canned (22 percent) and fresh (4 percent). Limited octopus supplies, combined with the reopening of the food service sector, resulted in price increases after the COVID-19 pandemic. However, these high prices triggered consumer resistance in certain markets in 2023. A comparable trend is noticed for squids, where escalating prices are attributed to limited supplies.

Bivalves

The most heavily traded bivalve mollusc species are scallops, clams and mussels, the vast majority of which are farmed. In 2022, global exports of bivalve molluscs totalled USD 6.0 billion, representing around 3 percent of the value of global exports of aquatic animal products. China was by far the largest exporter of bivalves, accounting for about one-quarter of all bivalve mollusc exports in value terms. The European Union, the United States of America, China and Japan account for the bulk of import demand. The export of bivalve molluscs experienced a do wnturn in 2020, primarily as a consequence of restaurant closures due to pandemic-related lockdown restrictions. However, the industry demonstrated a robust recovery in 2021 and 2022. Bivalve prices are increasing in all major markets due to inflation and high demand. However, as observed for other products, consumer resistance to high prices may emerge in response to challenging economic conditions.

Fishmeal and fish oil

In 2022, fishmeal exports totalled USD 6.1 billion, representing 3 percent of the value of global exports of aquatic animal products. Peru experienced a decrease in exports in 2022, but remained the top exporter of fishmeal, accounting for nearly one-third of the total value of fishmeal exports. Meanwhile, exports from India, Iceland, Viet Nam and Morocco have been rapidly increasing. In countries where small pelagic fish, utilized for fishmeal, are also consumed locally, signs of increasing competition between fishmeal production and human consumption arise. Major aquaculture producers like China drive most of the import demand for fishmeal. In 2023, the Peruvian catches of anchoveta were hugely reduced for stock management reasons associated with the El Niño phenomenon (see **Impacts of El Niño on marine fisheries and aquaculture**, p. 202), with exported volumes more than halving, causing fishmeal prices to rise.

In 2022, compared with 2021, fish oil exports grew by 27 percent in value terms and declined by 1.6 percent in product weight, representing a surge of 30 percent in the unit value. The increase reflected both the limited supplies of fish oils and, more importantly, the soaring prices of vegetable oils, leading to greater demand for fish oil. In 2023, the drop in exports of Peruvian fish oil was even more pronounced than the drop in exports of fishmeal, contributing to prices reaching unprecedented high levels.

Algae

In 2022, exports of algae surged by 26 percent compared with the previous year, reaching USD 1.6 billion, mainly reflecting a substantial rise in Indonesian and Chilean exports to China. As a result, Indonesia became the largest exporter of algae in 2022 in value terms, followed by the Republic of Korea and Chile. Together, these three countries accounted for 58 percent of the total export value of algae in 2022. On the import side, China, Japan and the United States of America remained the top importers of algae, representing together 56 percent of the total import value in 2022. In 2022, 53 percent of the export value of algae was specifically recorded as being edible, while the remaining 47 percent was either not edible or not specified.

This distinction underscores the diverse uses of algae in various industries such as those manufacturing cosmetics, pharmaceuticals or food additives extending beyond traditional food consumption.

Other aquatic products

Exports of other aquatic products such as sponges, corals, shells and inedible by-products reached USD 0.9 billion in 2022, up 3.7 percent on 2021. Inedible by-products accounted for 81 percent of the total, while sponges, corals and shells accounted for the remaining 19 percent. The United States of America, Viet Nam and China were the top exporters in 2022, while the United States of America, Canada and Denmark were the top importers. ■

STATUS AND TRENDS OF SUSTAINABLE DEVELOPMENT GOAL 14 INDICATORS UNDER FAO CUSTODIANSHIP

Introduction

The 2030 Agenda for Sustainable Development (UN, 2015) acknowledges the key role of agrifood systems in combating hunger and food insecurity and alleviating poverty (FAO, 2024a). The year 2022 marked the mid-term pathway of the 2030 Agenda with an alarming declaration by the United Nations General Assembly: "at the midpoint of the 2030 Agenda, the progress on most of the SDGs is either moving much too slowly or has regressed below the 2015 baseline".[x] The progress made with agrifood systems remains insufficient, and there is an urgent call to accelerate the transformational change required to address the many challenges of the 2030 Agenda (UN, 2020).

The Sustainable Development Goals (SDGs) have become central to the FAO Strategic Framework 2022–2031 (FAO, 2024b) and to the Blue Transformation Roadmap, which identifies key objectives, outcomes, priority actions and targets to transform aquatic food systems (see **Blue Transformation: a roadmap**, p. 119). Blue Transformation fully engages FAO in supporting Members and other actors to achieve several SDG targets, in particular the targets of SDG 14 (Life below Water) relevant to fisheries and aquaculture, measuring and reporting progress through the SDG indicator framework (FAO, 2022b). FAO is custodian of four SDG 14 indicators (14.4.1, 14.6.1, 14.7.1, 14.b.1). Table 12 summarizes countries' participation in FAO calls for reporting during 2018–2024.

Quantifying fishery stocks within biologically sustainable levels: Indicator 14.4.1

Target SDG 14.4 aims to achieve 100 percent of fishery stocks within biologically sustainable levels by 2020. The latest assessment of the global and regional status of fishery resources (FAO, 2024c) (see **The status of fishery resources**, p. 42) confirms that this target has not been achieved (UN, 2020). This is supported by the results of the country reports on Indicator 14.4.1.[y]

FAO piloted two questionnaire calls – in 2019/20 and 2022/23 – to facilitate harmonized and consistent reporting by countries on Indicator 14.4.1 (UNSD, 2024a). Of the 157 FAO Members with maritime coastlines and 23 of their territories, 48 reported once, 69 reported twice, and 63 did not report. Their participation increased from 87 in 2019/20 to 99 in 2022/23 (Table 12). These 99 submitted reports were reviewed by FAO for quality assurance and validation (FAO, 2022b). Reports of 46 countries passed both first and second levels of quality assurance, an increase of 48.4 percent from 2019 when there were 31 high-quality reports. Thirty-three countries passed only the first level

x The full declaration of the High-Level Political Forum on Sustainable Development convened in 2023 under the auspices of the General Assembly is available at: https://hlpf.un.org/sites/default/files/2023-09/A%20HLPF%202023%20L1.pdf?_gl=1*krm5r*_ga*Mjc5NDQ5NDA4LjE2MDMxNDUzNDU.*_ga_TK9BQL5X7Z*MTY5NjM0NTIzNi4xMjEuMS4xNjk2MzQ3Nzk1LjAuMC4w

y In 2022 (and 2019 respectively), an average of 61.6 (53.4) percent of stocks within biological sustainable levels was estimated from reports of 46 (31) countries which passed the second level of the quality assurance process; these estimates are preliminary awaiting the expansion of the number of countries and further adjustments to the quality assurance methodology.

TABLE 12 NUMBER OF COUNTRIES AND TERRITORIES CALLED FOR REPORTING, AND NUMBER OF REPORTING COUNTRIES AND TERRITORIES FOR SDG INDICATORS 14.4.1, 14.6.1 AND 14.B.1

	Questionnaire 14.4.1			CCRF questionnaire for 14.6.1 and 14.b.1								
	Number called for reporting	Number reporting		Number called for reporting	Number* reporting on 14.6.1				Number* reporting on 14.b.1			
Reporting year		2019	2022		2018	2020	2022	2024	2018	2020	2022	2024
Latin America and the Caribbean	42	20	20	33	21	17	22	20	21	23	24	22
Europe and Northern America	37	22	29	45	33	28	36	33	32	29	33	33
Central and Southern Asia	7	5	5	14	7	3	2	2	9	6	5	8
Eastern and South-Eastern Asia	15	7	7	16	8	6	7	9	8	9	6	9
Northern Africa and Western Asia	23	11	14	23	8	6	6	10	10	6	7	13
Sub-Saharan Africa	34	18	16	48	18	11	9	20	26	12	13	24
Oceania	22	4	8	17	9	9	8	7	7	7	6	3
World	**180**	**87**	**99**	**196**	**104**	**80**	**90**	**101**	**113**	**92**	**94**	**112**

NOTES: Number called for reporting are: countries and territories with coastline for 14.4.1; FAO Member States to which CCRF questionnaire is sent for 14.6.1 and 14.b.1.
* Countries which did not validate the indicator score or which were found to be not applicable were not included in the reported numbers.

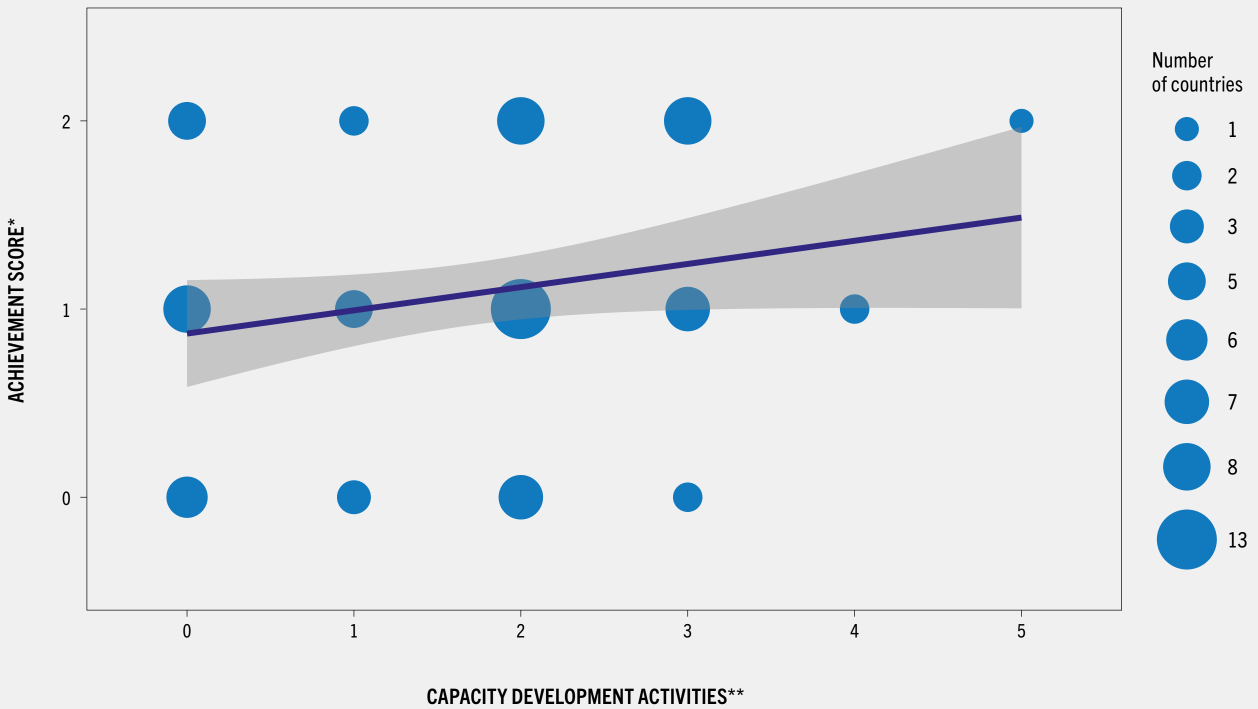
of quality assurance, down by 10.8 percent from 2019, and 20 countries failed to pass the first level of quality assurance, compared with 19 in 2019. Finally, nine countries acknowledged interest but could not submit reports because of lack of data.

Though these improvements in the quantity and quality of country reporting indicate a positive trend in monitoring practices (see Box 7, p. 104), many of the challenges faced in the 2019/20 call remain, as countries are hindered by limited capacity to effectively address deficiencies in fisheries data collection and management, with poor coordination among agencies involved in the reporting process. FAO's efforts and support to build countries' capacities (FAO, 2022b) contributed to increased reporting and improved quality of the responses by countries (Figure 51a). Though these positive trends are encouraging, indicator scores require more frequent reporting by countries in order to stabilize. FAO will build on this experience to enhance its support to countries, particularly developing countries, ensuring a progressive convergence between national SDG reporting and the FAO State of Stocks Index (SoSI) (see **Evolving the way we assess the status of marine fishery stocks**, p. 159).

Assessing the degree of implementation of international instruments to combat illegal, unreported and unregulated fishing: Indicator 14.6.1

Indicator 14.6.1 measures the degree of implementation by states of six international instruments to combat illegal, unreported and unregulated (IUU) fishing (UNSD, 2024b) by scoring their responses to the questionnaire for monitoring the implementation of the Code of Conduct for Responsible Fisheries and related instruments using a scale of 1 (lowest) to 5 (highest) (FAO, 2020). The average score for implementation of the six instruments by states increased from 3 in 2018 to 4 in 2022, kept throughout the 2024 reporting (see Figure 52, p. 106) with the percentage of states achieving a score

FIGURE 51A FAO CAPACITY DEVELOPMENT ACTIVITIES AND MOST RECENT QUALITY ASSURANCE SCORES (SDG INDICATOR 14.4.1)

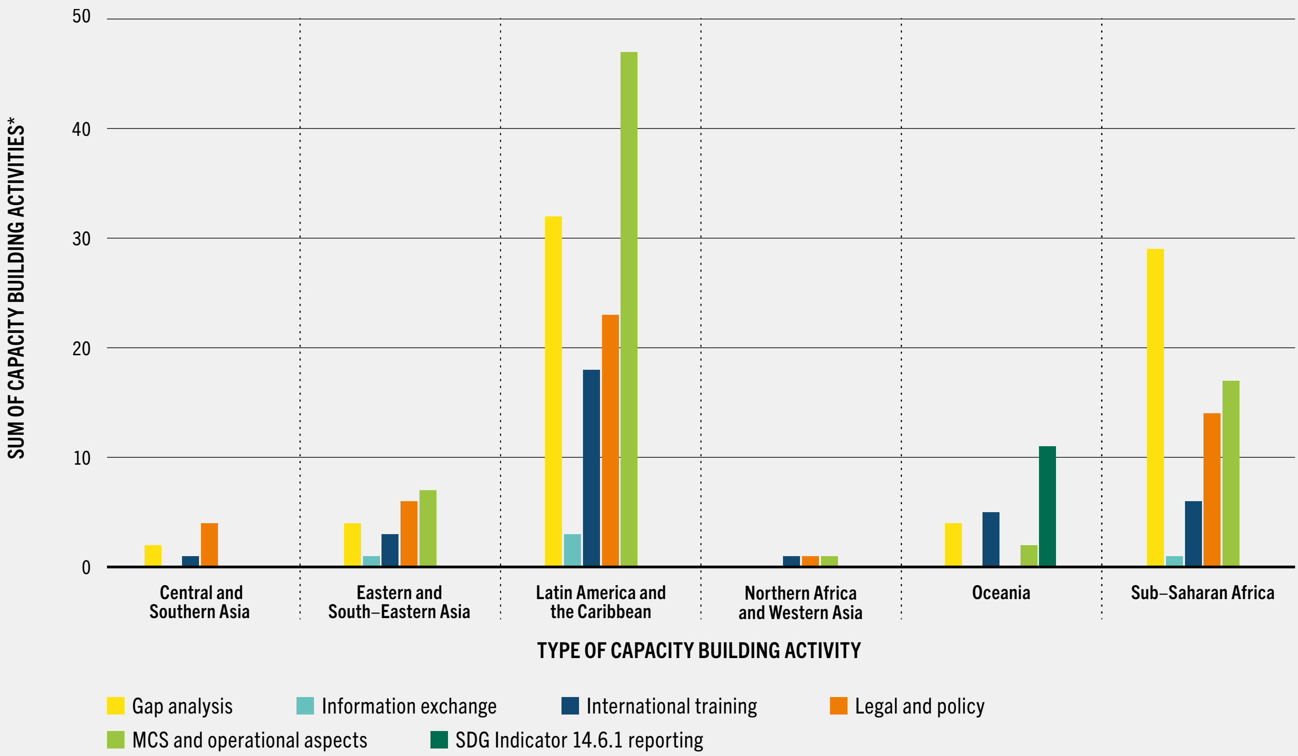


NOTES: QA – quality assessment. Only developing countries were retained in this analysis. The size of the dot on the grid is proportional to the number of countries counted for the (X, Y) pair value.
* The most recent QA level for the submitted 14.4.1 questionnaire during 2019–2022.
** Number of FAO capacity development activities on Indicator 14.4 1 received by a single country during 2019–2022.
SOURCES: For achievement scores: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/
For number of capacity development activities: FAO calculations.

of 5 increasing from 48 percent in 2018 to 56 percent in 2022 and 2024. Reporting rates for this indicator increased from 90 in 2022 to 101 states in 2024, enabling more representative figures globally and for certain regions (Table 12) (FAO, 2024d).

Key developments relevant to Indicator 14.6.1 have occurred with the adoption in 2022 of the FAO Voluntary Guidelines on Transshipment (see Box 22, p. 148) and the World Trade Organization (WTO) Agreement on Fisheries Subsidies (see **The WTO Agreement on Fisheries Subsidies, the sustainability of fishery stocks and the role of FAO**, p. 168), and the launch in 2023 of the Global Information Exchange System (GIES), allowing states to exchange compliance information on fishing vessels (see **Progress in implementing the FAO Port State Measures Agreement**, p. 146). These instruments have enhanced further the international efforts to combat IUU fishing. The FAO Global Capacity Building Programme (Figure 51b) has expanded its technical assistance to support states, including Small Island Developing States (SIDS), improve reporting on Indicator 14.6.1, and develop legal and policy, monitoring, control and surveillance operations, training, and electronic information exchange.

FIGURE 51B ACTIVITIES CARRIED OUT WITHIN THE FAO GLOBAL CAPACITY BUILDING PROGRAMME IN SUPPORT OF THE PSMA AND COMPLEMENTARY INSTRUMENTS DURING 2018–2024



NOTES: PSMA – Agreement on Port State Measures. MCS – monitoring, control and surveillance. Only developing countries were retained in this analysis.
* Total of capacity building activities carried out in countries within each SDG region, by type.

SOURCE: FAO calculations.

Monitoring sustainable fisheries as a driver of economic change: Indicator 14.7.1

Fisheries and aquaculture can be driving forces for economic development, food security and livelihoods. The sector has seen continuous growth over the past decade, with a 38 percent increase in value added between 2011 and 2021 (UNSD, 2024c).

During this period, Indicator 14.7.1, which measures the value of sustainable fisheries as a percentage of national GDP (UNSD, 2024d), has experienced a gradual decline. Figures for 2021 indicate that sustainable fisheries value accounted for 0.092 percent of global GDP, down from 0.097 percent in 2019 and 0.11 percent in 2011 (FAO, 2024e). Certain drivers of this change are exogenous to the indicator itself – for example, growth in other sectors of the economy causing a reduction in the relative importance of primary sectors in national economies, including fisheries. Other factors are endogenous, with a decline in stock sustainability in certain FAO Major Fishing Areas contributing to lower sustainability multipliers for a number of fisheries.

Global fisheries are distinctive in their specific context and intricately interconnected as trade, »

BOX 7 REGIONAL ANALYSIS OF REPORTING ON SDG INDICATOR 14.4.1

Sustainable Development Goal Indicator 14.4.1 measures the percentage of fishery stocks within biologically sustainable levels. Between the 2019 and 2022 calls for reporting on Indicator 14.4.1, data show equal or increased reporting rate by region, with Oceania (which lags behind) showing a notable increase thanks to four newly reporting Pacific Small Island Developing States (SIDS) in 2022. The exception is sub-Saharan Africa, which had a lower reporting rate in 2022 and very low recurrence of reporting countries across the two calls (Figure A). The number of high-quality questionnaires (i.e. questionnaires that passed Quality Assurance level 2) rose in most regions, with the greatest improvements in Europe and Northern America, Latin America and the Caribbean, Eastern and South-Eastern Asia, followed by Northern Africa and Western Asia, finally Central and Southern Asia. The number of high-quality questionnaires remained unchanged in Oceania and slightly decreased in sub-Saharan Africa (Figure B). The general quality of the reported questionnaires (i.e. questionnaires that passed both Quality Assurance level 1 and 2) increased between 2019 and 2022 in most regions; the greatest improvements were in Oceania, Northern Africa and Western Asia, and Europe and Northern America, followed by Eastern and South-Eastern Asia, and Latin America and the Caribbean.

The review also shows a slight improvement in the average national indicators in most regions between 2019 and 2022; the exceptions are Northern Africa and Western Asia, as well as Oceania.

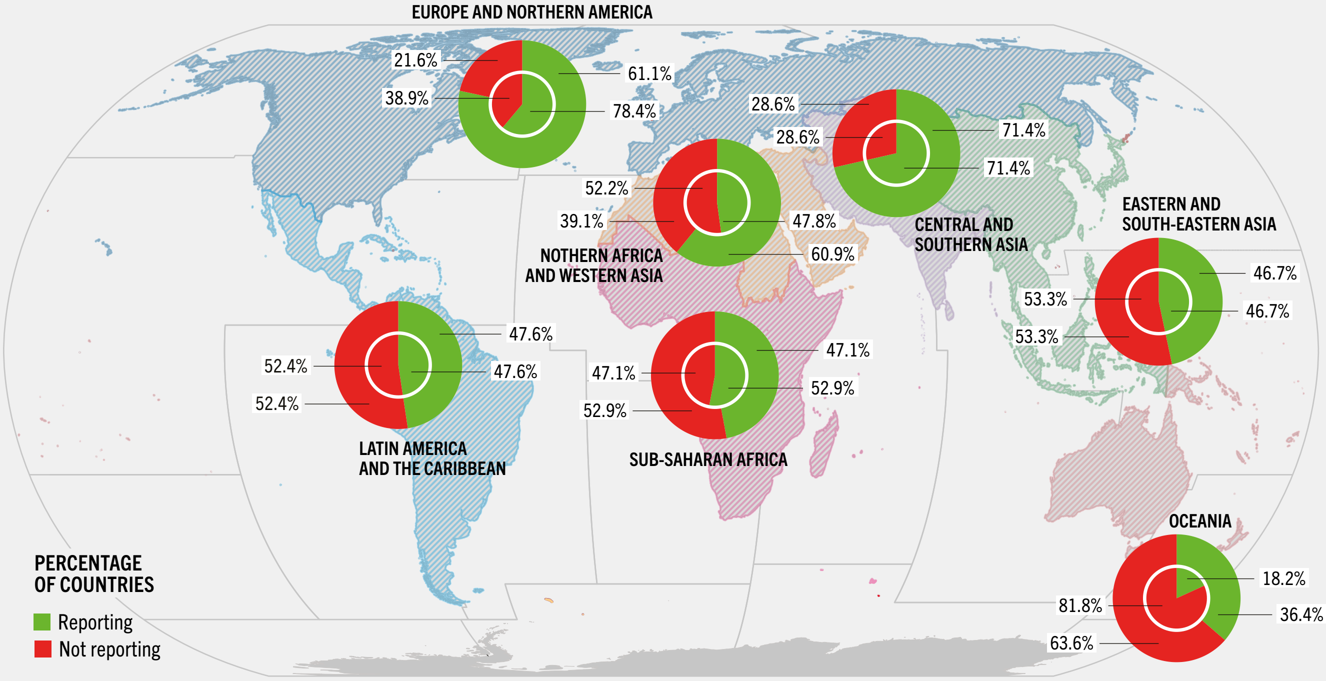
These results clearly show the challenges faced by developing regions in reporting on Indicator 14.4.1. Despite these difficulties, countries' improved responses testify to their interest in the indicator. The progress since 2019 also reflects the impact of FAO's capacity building efforts (FAO, 2023; see Figure 51A). Between the end of 2019 and early 2022, eight regional workshops benefiting over 600 participants from 96 countries provided guidance on the process and tools for analysis and reporting on Indicator 14.4.1. These were complemented by support services and resources including the Virtual Research Environment tool for online community support, a specific e-learning course on Indicator 14.4.1,* data collection and stock monitoring training toolkits, and direct assistance to countries during the reporting exercises.

»

NOTE: * See: https://elearning.fao.org/course/view.php?id=502

SOURCE: FAO. 2023. *Evaluation of FAO's Support to Life below Water (SDG 14). Hundred and Thirty-seventh Session of the Programme Committee, Rome, 6–10 November 2023*. Rome. https://www.fao.org/3/nn072en/nn072en.pdf

FIGURE A SDG INDICATOR 14.4.1 – NATIONAL REPORTING RATE BY SDG REGION IN 2019 AND 2022 CALLS

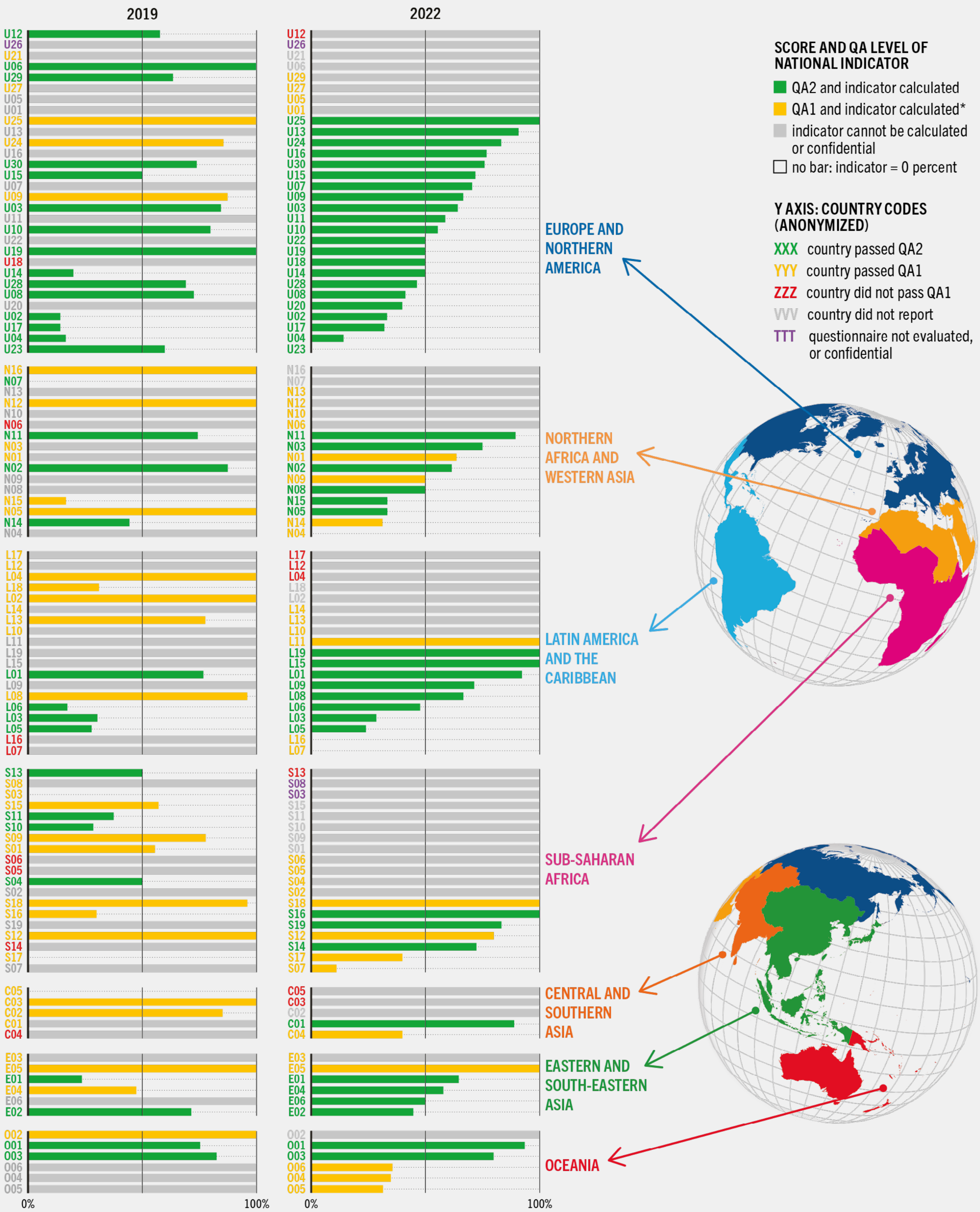


NOTE: Inner circle = 2019 call; outer circle = 2022 call.

SOURCES: For the donut chart: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/

For the map of the SDG regions: UNSD. 2024. SDG Indicators. Regional groupings used in Report and Statistical Annex. In: *United Nations*. New York. [Cited 19 April 2024]. https://unstats.un.org/sdgs/indicators/regional-groups/

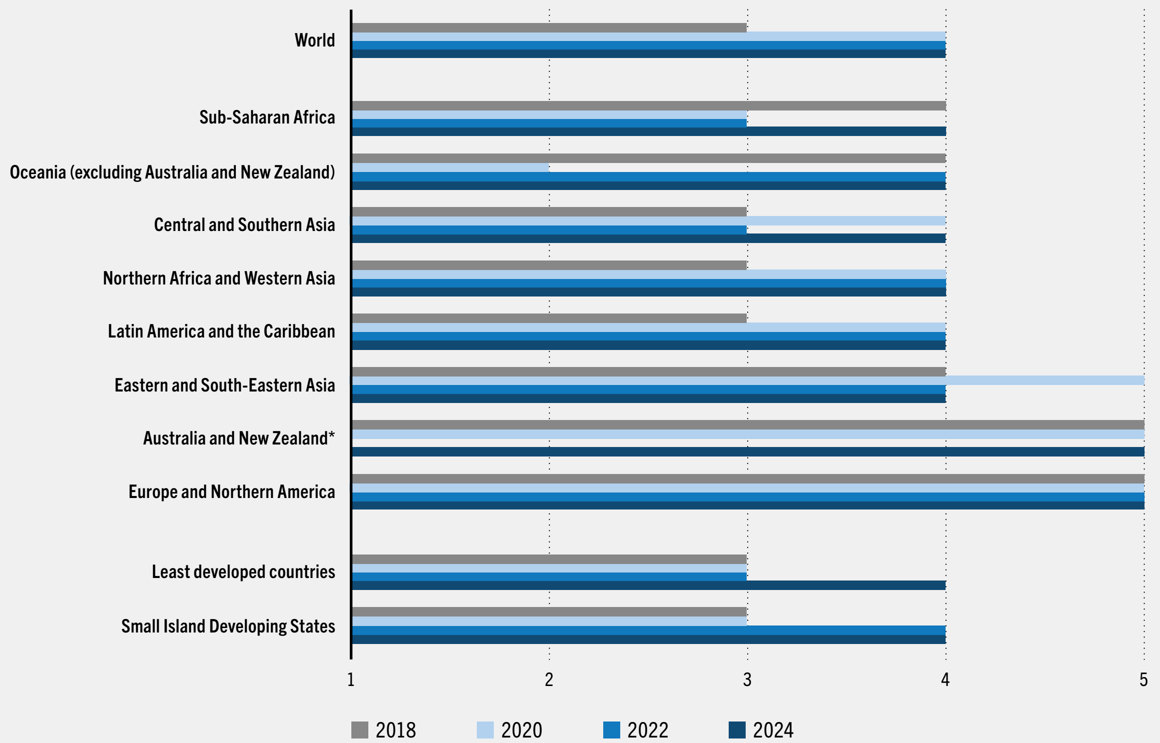
FIGURE B SDG INDICATOR 14.4.1 – NATIONAL REPORTING SCORE AND QUALITY LEVEL IN 2019 AND 2022 CALLS



Notes: QA – quality assessment. The bar chart shows country scores (anonymized, e.g. N16) where sufficient quality levels (either QA1 or QA2 in 2019 or 2022) could be achieved. Countries which reported but did not pass QA1 in either 2019 or 2022 are not represented. In the legend, the amplitude of the bars shows the Indicator 14.4.1 score (between 0 and 100 percent) and the colours indicate the QA level passed.
* For countries passing only QA1, an indicator can be calculated when a stock status is provided for at least one stock of the country reference list; indicators calculated for these countries are reported with low reliability. If less than five stocks are presented with status not covering the required portion of the landings, a low reliability index will however not be reported.

SOURCES: For the bar chart: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/
For the map of the SDG regions: UNSD. 2024. SDG Indicators. Regional groupings used in Report and Statistical Annex. In: *United Nations*. New York. [Cited 19 April 2024]. https://unstats.un.org/sdgs/indicators/regional-groups/

FIGURE 52 PROGRESS IN THE DEGREE OF IMPLEMENTATION OF INTERNATIONAL INSTRUMENTS AIMED AT COMBATING IUU FISHING BY REGION, 2018–2024 (SDG INDICATOR 14.6.1)



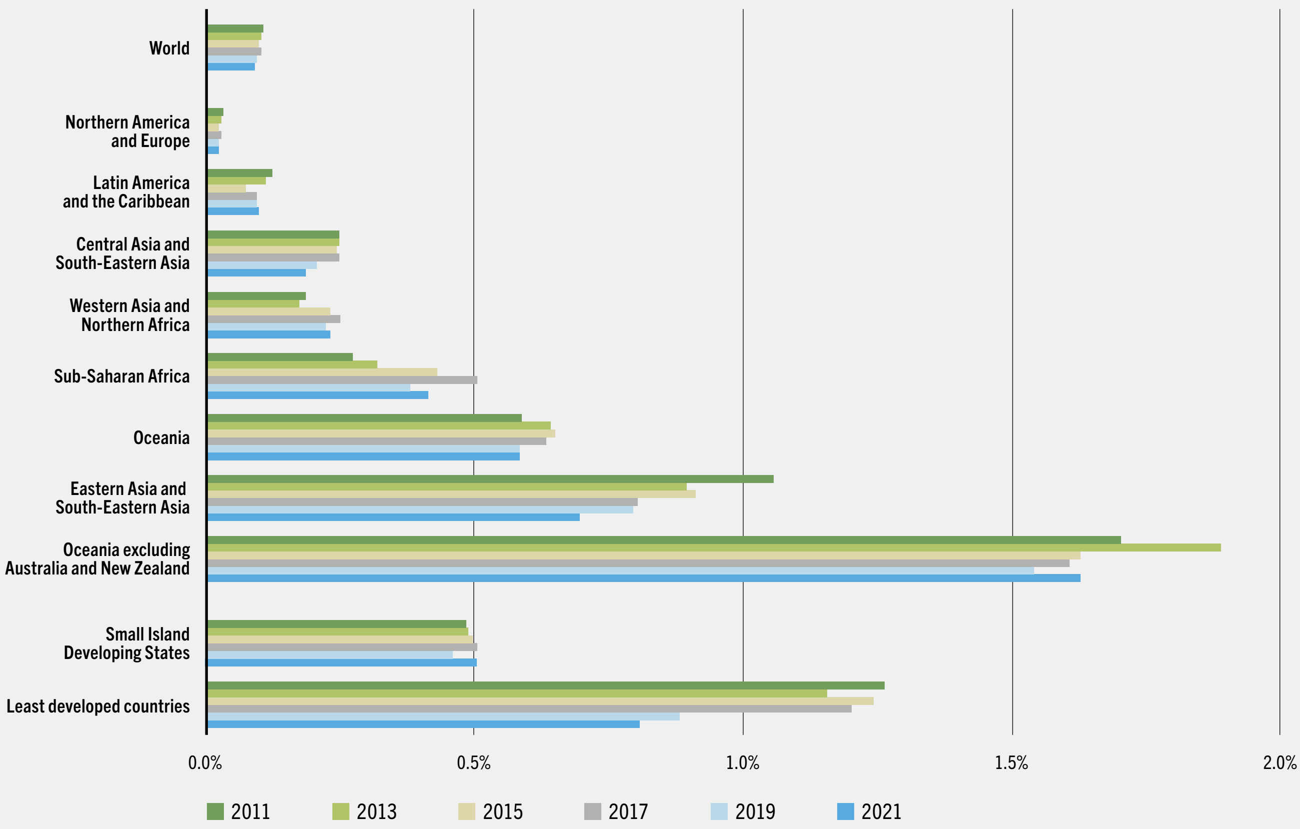
NOTES: IUU – illegal, unreported and unregulated. The chart shows the average level of implementation of the indicator by countries within each grouping, from the lowest (1) to the highest (5).
* Insufficient number of reporting states to create an aggregated score for this regional grouping in 2022.

SOURCE: For the bar chart data: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/

» shared ecosystems and the transboundary nature of many stocks form a complex web. As such, it is important to consider not only the global trend of the indicator but also the national and regional contexts of these figures. Despite a marginal decline globally, fisheries and aquaculture remain essential to many economies throughout the world, especially in least developed countries (LDCs), where contributions to GDP are far above the global average (Figure 53). Sub-Saharan Africa has seen a growing contribution of sustainable fisheries to GDP, from 0.27 percent in 2011 to 0.42 percent in 2021. Similarly, in SIDS, the contribution rose from 0.46 percent in 2019 to 0.51 percent by 2021. Pacific SIDS – among the most reliant on fisheries worldwide – saw the percentage of GDP linked to sustainable fisheries climb from 1.54 percent in 2019 to 1.63 percent in 2021. This growth highlights the sector's potential as a catalyst for economic development despite facing challenges of diminishing returns in other regions of the world, notably in LDCs.

The existing framework for evaluating Indicator 14.7.1 (FAO, 2020) establishes a global benchmark for analysing the sector while also aiming for progressive methodological improvement and developing parallel indicators, as appropriate. Box 8 explores one example of enhancing sustainability reporting and interlinkages between Indicator 14.4.1 and Indicator 14.7.1.

FIGURE 53 VALUE OF SUSTAINABLE FISHERIES AS A PERCENTAGE OF COUNTRIES' GDP BY SDG REGION OR GROUPING (SDG INDICATOR 14.7.1)



NOTE: GDP – gross domestic product.

SOURCE: For the bar chart data: UNSD. 2024. SDG Indicators Database. [Accessed on 1 June 2024]. https://unstats.un.org/sdgs/

Assessing the degree of recognition and protection of access rights for small-scale fishers: Indicator 14.b.1

Indicator 14.b.1 measures the progress by countries in the degree of application of a legal/regulatory/policy/institutional framework that recognizes and protects access rights for small-scale fisheries (UNSD, 2024e). The indicator scores are provided by FAO Members when responding to three questions in the CCRF online questionnaire (FAO, 2020). The first feature of the indicator score explores legislation or policies in place that specifically target or address small-scale fisheries. The second feature assesses concrete action in support of small-scale fisheries, in line with the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines). The third feature measures participation of small-scale fisheries actors in decision-making.

The global average of the indicator score generated from countries reporting in 2024 showed a decline in the level of implementation from 5 in 2022 to 4 in 2024, with 54 percent of reporting states scoring 5 in 2024 (FAO, 2024f). This decline may represent more the global average score given a slight increase in total reporting countries in 2024 from 2022 (Table 12).

BOX 8 ENHANCING SUSTAINABILITY REPORTING AND INTERLINKAGES BETWEEN SDGS: INTEGRATION OF INDICATOR 14.4.1 WITH INDICATOR 14.7.1

The interconnected nature of the Sustainable Development Goals (SDGs) makes them indivisible by nature, with progress in one area impacting advancements in others. It also strongly emphasizes integrated approaches, with results from related indicators being jointly evaluated whenever possible to allow a comprehensive analysis of the impacts and trade-offs between different development pathways.

In the context of SDG 14 (Life below Water), the mutual dependence of fisheries on the biological sustainability of stocks and the economic viability of the sector has long been acknowledged when formulating development frameworks. Progress in developing reporting capacity for sustainability indicators such as Indicator 14.4.1 gives rise to the opportunity for the further examination of their integration into other international measures, particularly indicators such as 14.7.1 which already seek to take an integrated approach considering economic and biological sustainability.

The current methodology for estimating Indicator 14.7.1 provides an international baseline for assessing the economic value of sustainable fisheries, adjusting dividends from the sector by the biological sustainability of fishery stocks using a sustainability multiplier. This adjustment is currently based on the regional stock status by FAO Major Fishing Area, which provides a representative assessment of fishery stocks. Current work under Indicator 14.4.1 provides a pathway for improving the periodic assessment of fishery stocks, not only by improving data quality but also by enabling harmonized international monitoring at the national level. This development, providing greater granularity of data on stock status, could potentially have positive implications for estimating the sustainability of marine capture fisheries and the multiplier for stock sustainability used in Indicator 14.7.1.

The integration of a high-quality national stock status indicator for the rationalization of the interplay between stock sustainability and economic dividends from fisheries should be pursued in order to enhance reporting of national contexts that differ within the same FAO area. To this end, pilot projects will be undertaken to integrate available figures for Indicator 14.4.1 into the sustainability multiplier for Indicator 14.7.1, allowing for a comparison of the two approaches and analysis of the resulting trends.

Regionally, reporting rates of sub-Saharan Africa, and of Northern Africa and Western Asia nearly doubled in 2024 from 2022. The lower indicator score of the Northern Africa and Western Asia region may have influenced the global score. Only Europe and Northern America reported full achievement in 2024 (Figure 54).

As Indicator 14.b.1 moves close to its target, requests from countries for further support continue. A dedicated legislation and policy online database, SSF-LEX, provides country profiles with information on small-scale fisheries. Thirteen profiles are available,[z] and more are expected to be published throughout 2024.

Support to concretely implement at national level the SSF Guidelines is progressing as five countries[aa] have already developed National Plans of Action for Small-Scale Fisheries (NPOAs-SSF) since 2021 and two countries[ab] are developing or finalizing their plans in 2024.

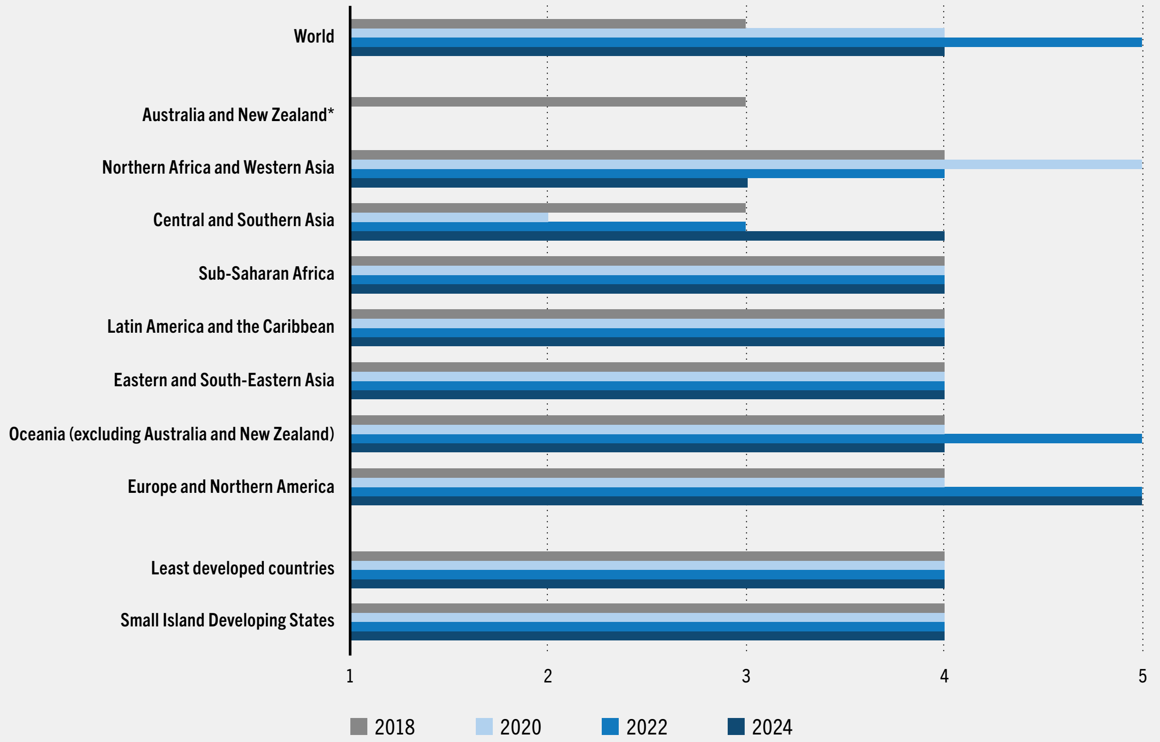
With the third feature of the indicator score determined by the measurement of the participation of small-scale fisheries actors in decision-making, co-management is one expression of such participation and some related evidence for this has been compiled and analysed for the Illuminating Hidden Harvests

z As at April 2024, profiles are available for Albania, Cabo Verde, Gambia, Ghana, Morocco, Namibia, Oman, Senegal, Solomon Islands, South Africa, Togo, Tunisia and Turkiye at: https://ssflex.fao.org/

aa United Republic of Tanzania (2021), Namibia (2022), Madagascar, Malawi and Uganda (2023).

ab Indonesia and the Philippines.

FIGURE 54 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, 2018–2024 (SDG INDICATOR 14.B.1)



NOTES: The chart shows the average level of implementation of the indicator by countries within each grouping, from the lowest (1) to the highest (5).
* Insufficient number of reporting states to create an aggregated score for this regional grouping in 2022.

SOURCE: For the bar chart data: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/

global study.[ac] It found that for every 10 tonnes of small-scale fisheries catch, 4 tonnes are formally governed through co-management, but co-management is actually implemented for only 2 of these tonnes. Countries with NPOAs-SSF have prioritized fishers' empowerment and improving governance, including putting in place effective and applicable co-management frameworks. New national small-scale fisheries organizations such as national chapters of the regional African Women Network of Fish Processors and Traders and of the Ibero-American Small-Scale Artisanal Fishing Network illustrate the readiness of small-scale fisheries actors to engage.

To strengthen capacities to achieve Target 14.b more broadly, countries have been supported in relation to enhanced post-harvest practices for improved food safety, quality standards and marketability of products, as well as organizational development of small-scale fishers on governance,[ad] leadership skills, gender transformative approaches and business management. Mappings of women's small-scale »

ac See: https://www.fao.org/voluntary-guidelines-small-scale-fisheries/ihh/en/

ad See, for example, the FAO elearning Academy course on Governance in small-scale fisheries available at: https://elearning.fao.org/course/view.php?id=907

FIGURE 55 REPORTING RATES RECORDED FOR SDG INDICATORS 14.4.1, 14.6.1 AND 14.B.1 BETWEEN 2018 AND 2024 ACCORDING TO UNSD GROUPINGS

NOTE: United Nations Statistics Division (UNSD) groupings: developed, developing, least developed countries (LDCs), Small Island Developing States (SIDS).

SOURCES: For the donut chart data: UNSD. (forthcoming). SDG Indicators Database. https://unstats.un.org/sdgs/
For UNSD groupings: UNSD. 2024. SDG Indicators. Regional groupings used in Report and Statistical Annex. In: *United Nations*. New York. [Cited 19 April 2024]. https://unstats.un.org/sdgs/indicators/regional-groups/

» fisheries organizations on their capacities, including challenges and opportunities, are available for seven countries,[ae] and can inform future capacity development and action towards achieving Target 14.b and Indicator 14.b.1.

Conclusion

Overall, there has been good progress in the adoption of the SDG 14 monitoring and reporting framework by countries across the biological, social and economic sustainability dimensions covered by the four fisheries indicators under FAO custodianship. FAO has successfully supported the development of the indicators, their monitoring and reporting methodologies and related capacity development. The FAO Programme Committee's evaluation of the Organization's role in supporting SDG 14 is positive (FAO, 2023a).

Full implementation and reporting by Members are works in progress and challenges remain, especially for developing countries. Indicators 14.6.1 and 14.b.1, which are close to reaching their target, testify to a general uptake of international policies and guidelines by countries, however, there remains much to do in terms of implementation on the ground. Moreover, good reporting by certain countries should not distract attention from those countries still unable to report, many being LDCs and SIDS. The improved 2024 reporting rate for these two groups may nonetheless send a positive signal (Figure 55). Regarding Indicator 14.4.1, while noticeable progress is generally observed on the rate and quality of reporting, several countries – particularly SIDS – struggle to meet the requirements for data collection and analysis due to insufficient technical capacity.

Indicator 14.7.1 data show that SIDS are most reliant on sustainable fisheries, highlighting the sector's role to catalyse economic development. Their lower reporting rate should be a major concern to the global community to ensure that no one is left behind.

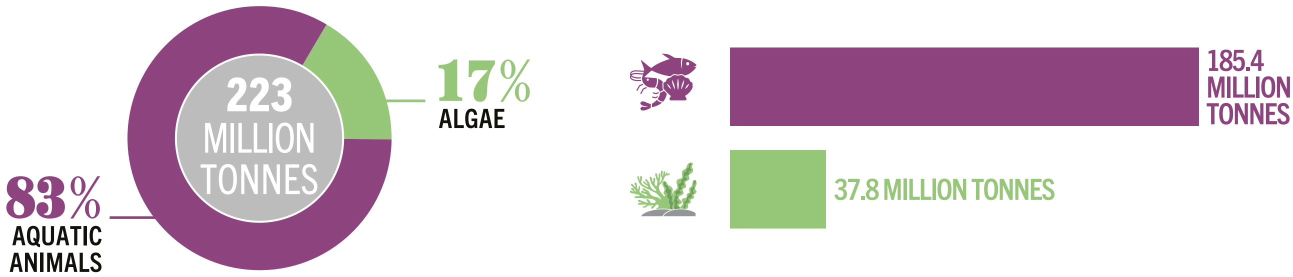
This situation calls for urgent mobilization and support to upscale FAO's programme on SDG Target 14.4 to build the capacity of countries most in need and adapt reliable methodologies for their specific contexts. ■

ae Ghana, Indonesia, Madagascar, Malawi, Philippines, Sierra Leone and Uganda.

FISHERIES AND AQUACULTURE IN NUMBERS

PRODUCTION 2022

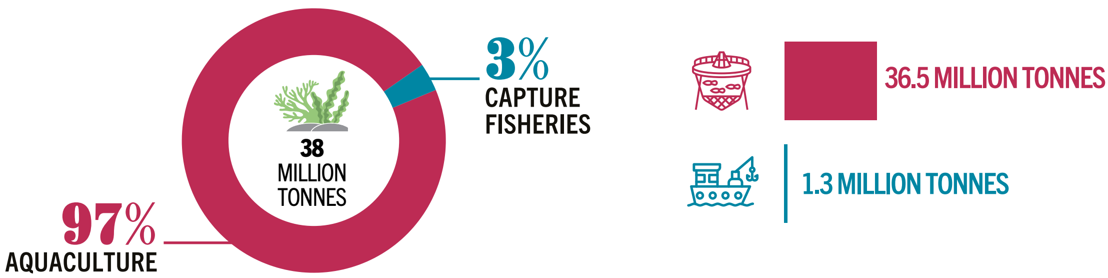
WORLD FISHERIES AND AQUACULTURE PRODUCTION



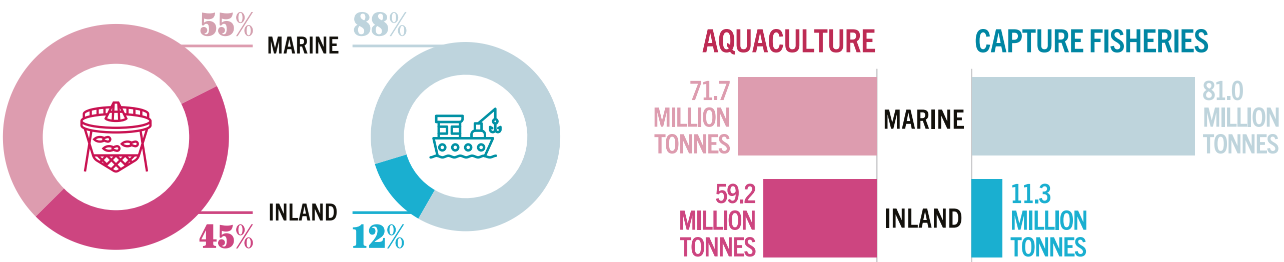
WORLD AQUATIC ANIMAL PRODUCTION

* Farmed aquatic animals for the first time ever exceeded captured aquatic animals by volume.

WORLD ALGAE PRODUCTION

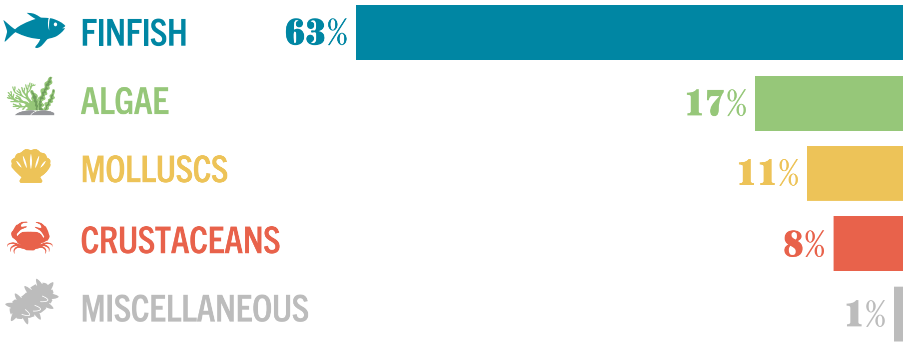


WORLD FISHERIES AND AQUACULTURE PRODUCTION BY MARINE AREAS AND INLAND WATERS

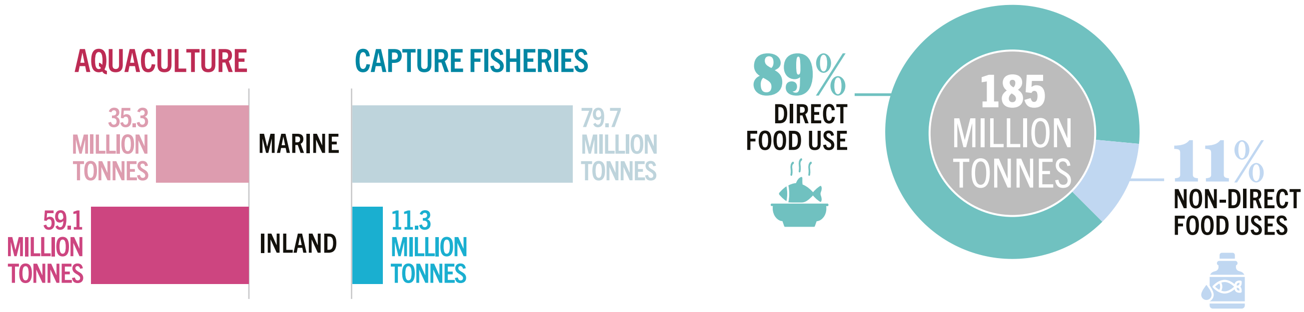


PRODUCTION 2022

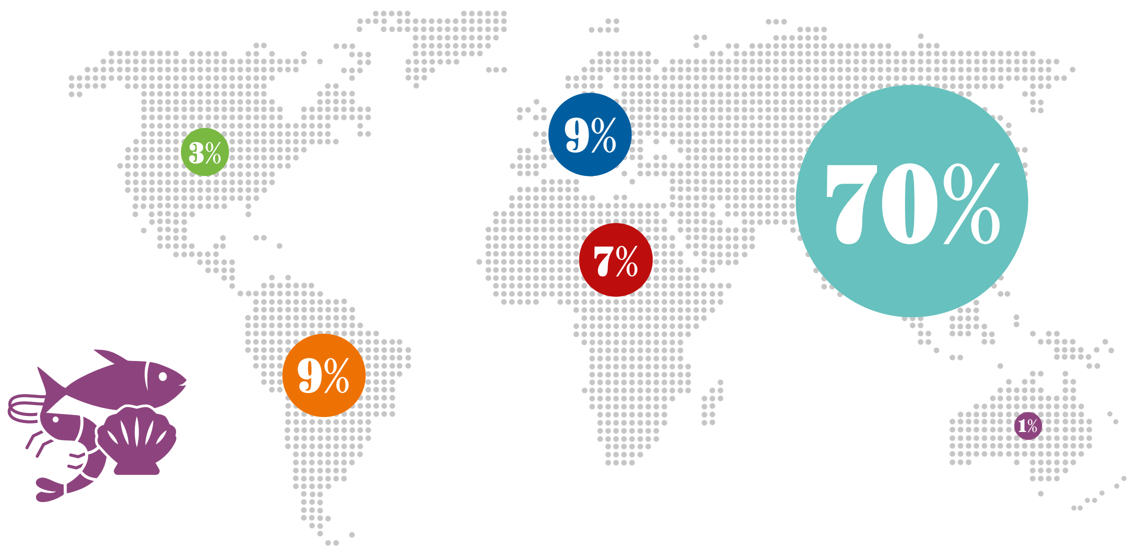
WORLD FISHERIES AND AQUACULTURE PRODUCTION BY SPECIES GROUP



WORLD AQUATIC ANIMAL PRODUCTION AND USE FOR HUMAN CONSUMPTION



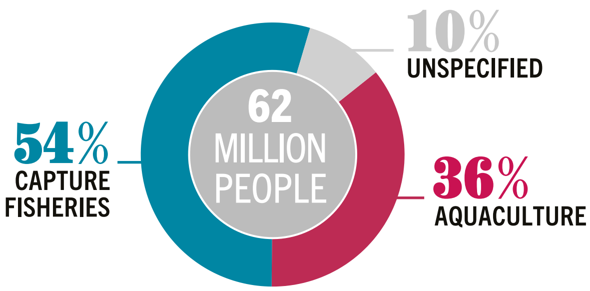
WORLD AQUATIC ANIMAL PRODUCTION BY REGION*

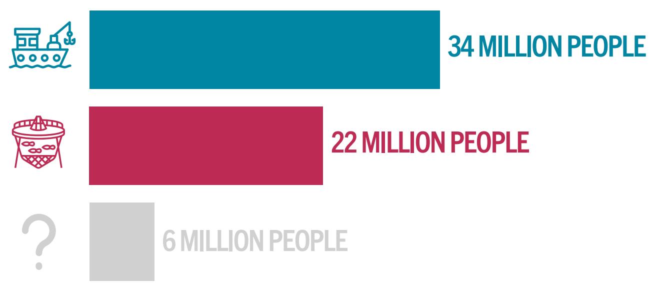


* Rounded percentages.

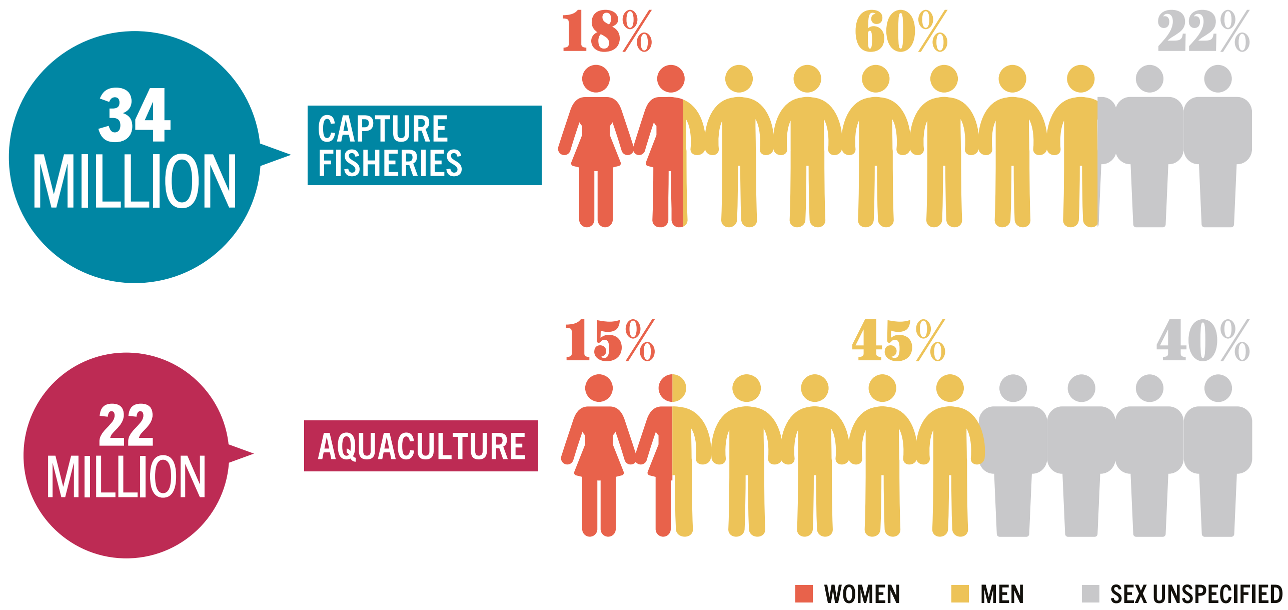
EMPLOYMENT 2022

EMPLOYMENT IN THE PRIMARY SECTOR



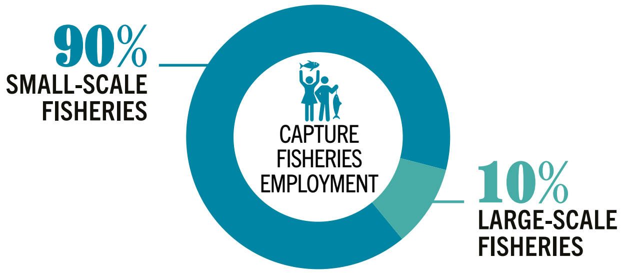


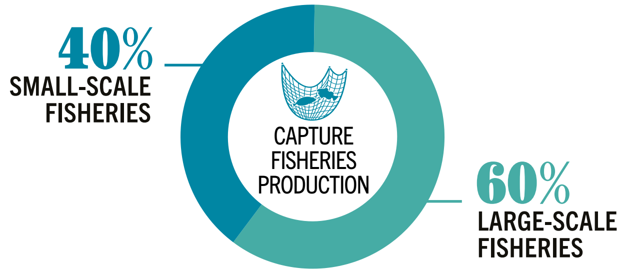
FISHERS AND FISH FARMERS IN THE PRIMARY SECTOR*



* Excluding 6 million unspecified workers.

SCALE OF FISHERIES OPERATIONS*

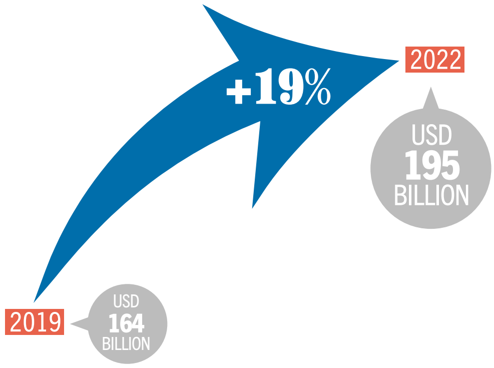




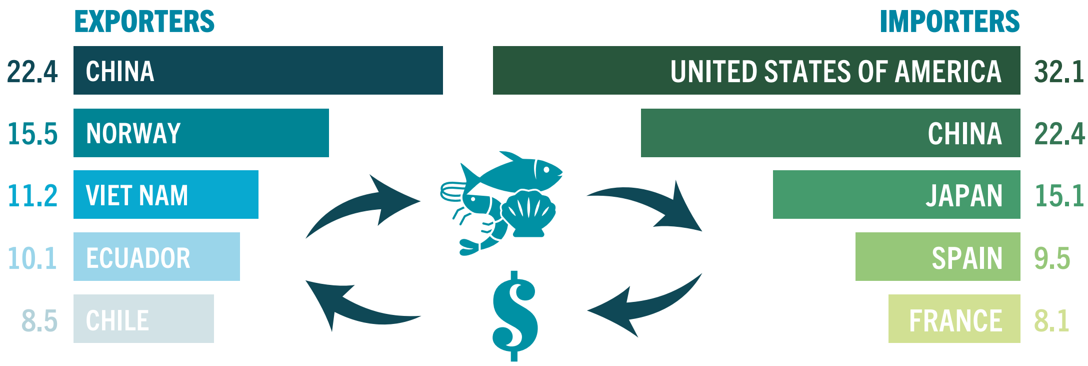
* Estimates from FAO, Duke University & WorldFish. 2023. *Illuminating Hidden Harvests – The contributions of small-scale fisheries to sustainable development.* Rome. https://doi.org/10.4060/cc4576en

TRADE 2022

INTERNATIONAL TRADE OF AQUATIC PRODUCTS



TOP EXPORTERS AND IMPORTERS OF AQUATIC ANIMAL PRODUCTS (USD BILLION)



FISHING FLEET 2022

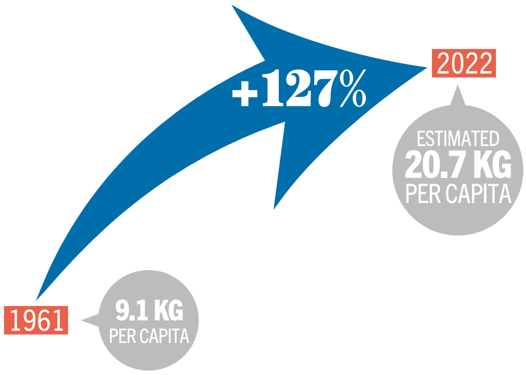
FISHING FLEET CAPACITY

BY MOTORIZATION

BY REGION

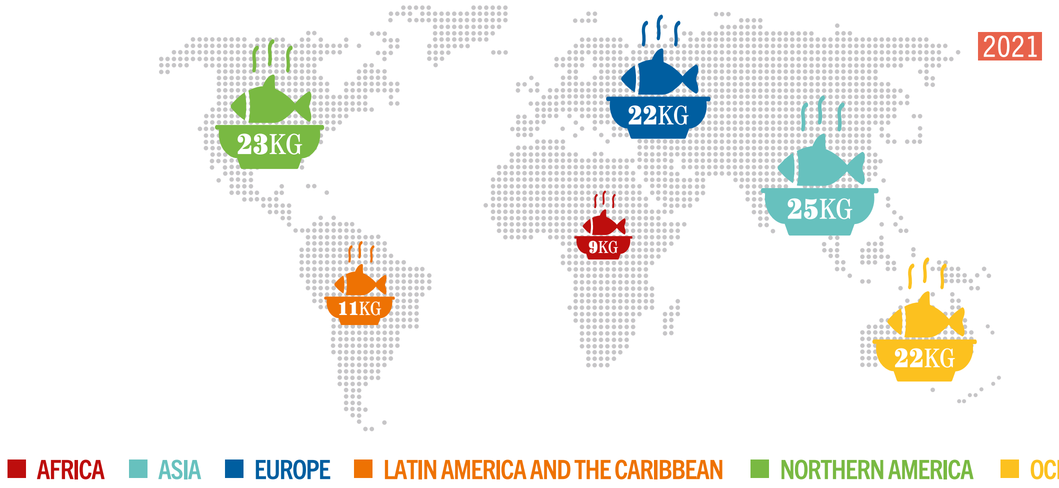
CONSUMPTION

WORLD APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS PER CAPITA PER YEAR

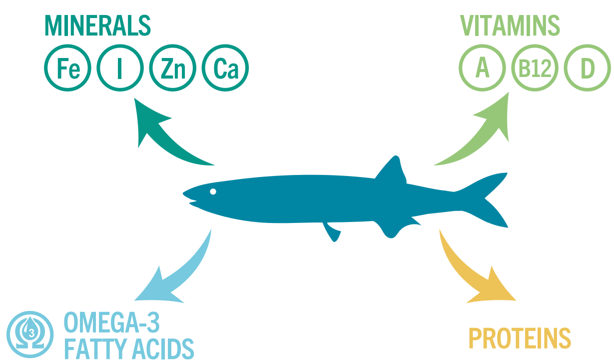


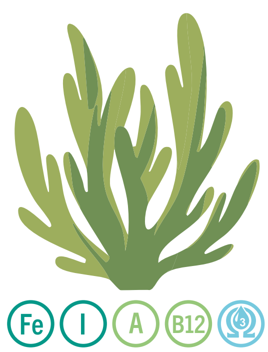
WORLD APPARENT SUPPLY OF AQUATIC ANIMAL FOODS

APPARENT CONSUMPTION OF AQUATIC ANIMAL FOODS PER CAPITA BY REGION



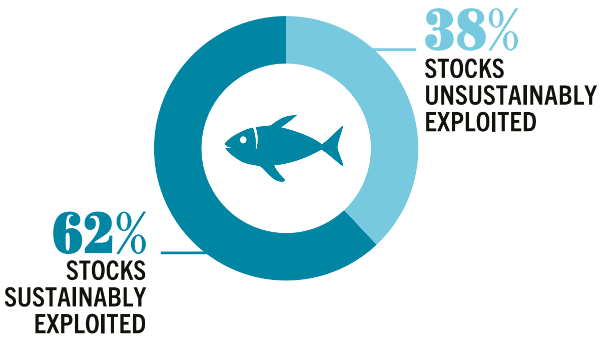
AQUATIC FOODS AND NUTRITION



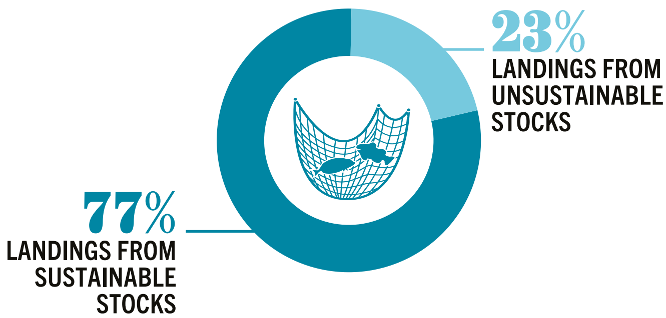


STATE OF WORLD MARINE FISHERY RESOURCES 2021*

BY NUMBER**



BY VOLUME***

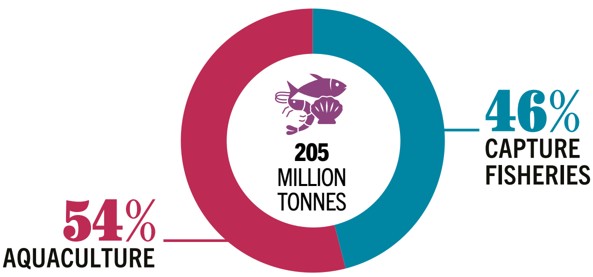


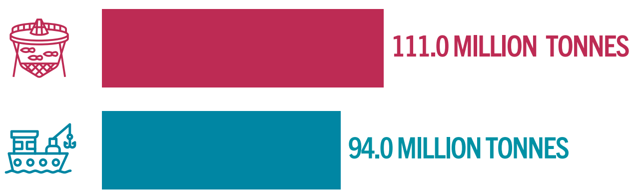
2021

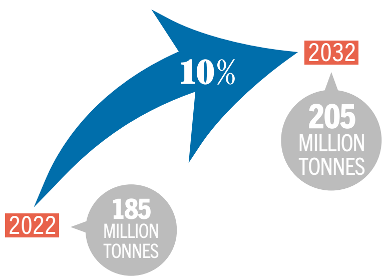
* Based on assessed stocks monitored by FAO. ** Each fishery stock is weighted equally. *** Each fishery stock is weighted by volume of landings.

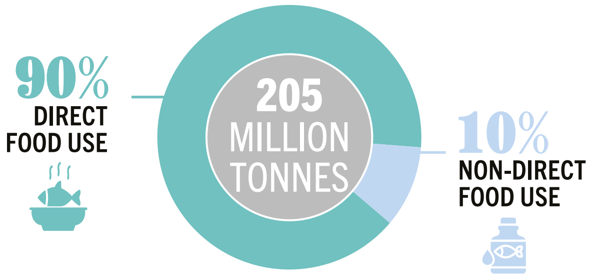
OUTLOOK

AQUATIC ANIMAL PRODUCTION AND USE FOR HUMAN CONSUMPTION BY 2032

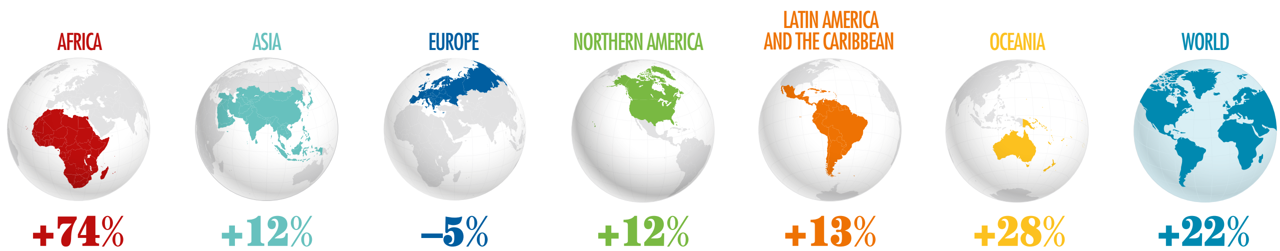








NEED FOR GROWTH IN SUPPLY OF AQUATIC ANIMAL FOODS BY 2050*



* Supply needed to sustain current per capita consumption scenario.

SOUTH AFRICA
Small-scale net fishers.
© FAO/Tommy Trenchard

PART 2
BLUE TRANSFORMATION IN ACTION

BLUE TRANSFORMATION: A ROADMAP

An alarming 735 million people around the world are facing hunger, 122 million more than before the COVID-19 pandemic. In addition, over 3.1 billion people cannot afford a healthy diet today and projections indicate that 600 million people will remain chronically undernourished in 2030. During both the 2021 United Nations Food Systems Summit (UNFSS) and again at the 2023 UNFSS Stocktaking Moment, UN Member States recognized the multifaceted nature of food insecurity, and the need to address both supply chains and communities involved in all food production sectors through agrifood systems transformation.

Aquatic foods – with their low environmental footprint, great diversity and capacity to supply critical nutrients to sustain healthy diets – are one of the seven priorities for ending hunger (Von Braun *et al*., 2021). In 2021, FAO launched its Blue Transformation vision (FAO, 2022a), aimed at maximizing the opportunities presented by aquatic food systems to enhance food security, improve nutrition, eradicate poverty, and support the achievement of the 2030 Agenda for Sustainable Development.

Blue Transformation is a targeted effort by which all stakeholders use existing and emerging knowledge, tools and practices to secure and sustainably maximize the contribution of aquatic food systems to food security, nutrition and affordable healthy diets for all. Blue Transformation proposes concrete actions and quantifiable targets to measure over time how aquatic food systems enhance their catalytic role to combat hunger and malnutrition, within the framework of the 2030 Agenda.

Increasing sustainable production alone does not necessarily lead to lower hunger rates, which is why Blue Transformation takes a systemic approach that builds sustainable, resilient, gender-responsive and inclusive fisheries and aquaculture at the local, regional and global levels, while ensuring that aquatic food systems are resilient to climate change and other natural and human-made disasters.

To clarify the concept and to offer guidance to its Members and partners, FAO developed the Blue Transformation Roadmap[af] around three global objectives that reflect FAO's vision for what aquatic food systems transformation must achieve by 2030 and beyond, aligning its policies and priority actions accordingly (Figure 56). These three objectives are:

1. sustainable aquaculture expansion and intensification that meet the global demand for aquatic foods while ensuring equitable distribution of benefits;
2. effective management of all fisheries, ensuring healthy stocks and equitable livelihoods; and
3. upgraded aquatic value chains that guarantee the social, economic and environmental sustainability of aquatic food systems.

For each global objective, the roadmap outlines a set of targets that reflect the social, economic and environmental aspects to address to transform aquatic food systems. To reach these global objectives and targets, FAO promotes collaborative efforts and initiatives involving its Members, international and regional organizations, the private sector, civil society, academia, non-governmental organizations (NGOs), and other actors of aquatic food systems. The roadmap

af The Blue Transformation Roadmap can be found here: https://www.fao.org/3/cc6646en/cc6646en.pdf

FIGURE 56 OBJECTIVES AND TARGETS OF BLUE TRANSFORMATION

BLUE TRANSFORMATION ROADMAP

AQUACULTURE

OBJECTIVE: Sustainable aquaculture intensification and expansion satisfies global demand for aquatic foods and distributes benefits equitably

TARGETS:

- Effective global and regional cooperation, planning and governance enhance aquaculture development and management
- Innovative technology and management support the expansion of sustainable and resilient aquaculture systems
- Equitable access to resources and services delivers new and secures existing aquaculture-based livelihoods
- Aquaculture operations minimize environmental impact and use resources efficiently
- Regular monitoring and reporting measure the growth and the ecological, social and economic impacts of aquaculture development

FISHERIES

OBJECTIVE: Effective management of all fisheries delivers healthy stocks and secures equitable livelihoods

TARGETS:

- Effective policies, governance structures and institutions support fisheries
- Equitable access to resources and services enhances the livelihoods of fishers and fishworkers
- Effective fisheries management systems address ecological, social and economic objectives, while considering trade-offs
- Fishing fleets are efficient, safe, innovative and profitable

VALUE CHAINS

OBJECTIVE: Updated value chains ensure the social, economic and environmental viability of aquatic food systems

TARGETS:

- Efficient value chains increase profitability and reduce food loss
- Transparent, inclusive and gender-equitable value chains support sustainable livelihoods
- Fisheries and aquaculture products access international markets more effectively
- Consumption of sustainable aquatic foods increases, particularly in areas with low food and nutrition security
- Access to healthy, safe and high-quality aquatic foods increases

SOURCE: Adapted from FAO. 2022. *Blue Transformation - Roadmap 2022–2030: A vision for FAO's work on aquatic food systems*. Rome. https://doi.org/10.4060/cc0459en

identifies priority action areas aligned with the FAO mandate, Strategic Framework 2022–2031 and corporate strategies that highlight where FAO can effectively contribute its expertise and comparative advantages.

To accelerate transformation, FAO is focused on global and regional policy processes and their local implementation, including the establishment of normative frameworks that reflect best practices for data collection, analysis and monitoring. This entails a focus on policies and programmes that support science-based integrated management of aquatic food systems, promote technological innovations, and advocate for stakeholder-focused outcomes, all critical in the transformation of aquatic food systems. Capacity building is an essential component of Blue Transformation, ensuring that institutions and stakeholders can develop, utilize and apply the latest data, science, technology and processes to implement best practices, particularly through knowledge-sharing networks, South–South Cooperation, and direct support to Members.

Highlighting priority action areas, innovations and results

Blue Transformation in action highlights how FAO is catalysing change to support each objective of the Blue Transformation Roadmap.

Sustainable aquaculture in action focuses on global normative frameworks, innovation and technology to support **sustainable aquaculture intensification and expansion** to meet the growing demand for aquatic foods. These actions include the development of the global Guidelines for Sustainable Aquaculture (GSA), a negotiated document that will guide the sector into the future. The section also highlights innovations to improve aquaculture systems, aquafeeds, aquatic genetic resources and biosecurity for healthier, more efficient and safer production. These actions are led by FAO in collaboration with a global network of practitioners, experts, researchers and private enterprises aiming to achieve 35 percent growth in global sustainable aquaculture production by 2030.

Improving fisheries sustainability presents recent successes in **effective management of global fisheries** to achieve healthier fishery stocks and equitable livelihoods. The section covers progress in global governance frameworks such as the Port State Measures Agreement (PSMA) and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). It also focuses on the growing role of regional fishery bodies (RFBs) that must adjust their mandates and activities to embrace new agreements such as the World Trade Organization (WTO) Agreement on Fisheries Subsidies and the United Nations Convention on the Law of the Sea (UNCLOS) Agreement on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ Agreement). The section also describes a key FAO-led initiative that implements a science-based approach to assess the status of fishery resources and better support fisheries management, and promotes the latest technological innovations to support responsible fishing practices.

Innovations in sustainable trade and value chains covers priority actions undertaken to **upgrade aquatic food value chains** and guarantee their social, economic and environmental sustainability. This includes FAO's actions to support Members so they can comply with trade agreements and market access requirements. The section also focuses on innovative and technologically inclusive approaches to traceability and certification, and the reduction of fish loss and waste. It highlights FAO's efforts to develop guidance on social sustainability in fish value chains – an urgently needed instrument to address issues of gender equality, decent work and occupational safety in aquatic food systems. Finally, the section deals with consumer awareness, and the overall goal of fully integrating aquatic foods in national and global food security and nutrition strategies.

FAO's Blue Transformation vision represents a shift in the Organization's approach to integrating aquatic foodsinto global food security and sustainability. By establishing clear objectives and enhancing policy advocacy, scientific research, capacity building, promotion of sustainable practices, innovation, and community involvement, FAO aims to charter a sustainable future for the world's aquatic food systems. **Blue Transformation in action** provides examples of how FAO and its partners address and deliver on these needs. ■

SUSTAINABLE AQUACULTURE IN ACTION

This section focuses on global normative frameworks, aquatic genetic resource management, biosecurity and disease control, innovation and technology to support sustainable aquaculture intensification and expansion to meet the growing demand for aquatic foods.

Progress in the development of the FAO Guidelines for Sustainable Aquaculture

Introduction

From 2017, FAO worked with Members to develop the first ever Guidelines for Sustainable Aquaculture (GSA). This process included seven regional consultations involving 120 Members, and two expert consultations. The guidelines were technically endorsed at the Twelfth Session of the Committee on Fisheries Sub-Committee on Aquaculture (COFI:AQ) in May 2023, and submitted to the Thirty-sixth Session of the Committee on Fisheries (COFI) for adoption in July 2024.

The guidelines aim to provide guidance to Members on the sustainable development of aquaculture – the fastest-growing food production sector – consistent with the FAO 1995 Code of Conduct for Responsible Fisheries (CCRF) and the FAO Blue Transformation Roadmap, and in line with the FAO Strategic Framework 2022–2031.

BOX 9 ALART: AN FAO TOOL TO REFORM NATIONAL AQUACULTURE LEGISLATION

Following a multidisciplinary and participatory process, FAO has developed the Aquaculture Legal Assessment and Revision Tool (ALART)* – a two-step methodology to assess the national legal framework underpinning the aquaculture sector. As the aquaculture sector is diverse and complex, with different species, water environments, aquaculture systems and technologies, the first step of the ALART methodology entails scoping the aquaculture sector of a given country, identifying the type of species cultured, the areas where aquaculture is undertaken, and at what socioeconomic scale the sector operates.

The second step allows users the opportunity to comment on existing aquaculture legislation or policies. The set of 142 questions is organized into nine sections: policy issues, institutional arrangements, tenure arrangements, planning and approval, production (inputs), production (facility management), post-production, disease prevention and control, and inspection and enforcement. ALART is useful for identifying information and normative gaps in a country's aquaculture sector, thus shedding light on the need for legislative reform or identifying areas for future research and development.

Complementing ALART is the FAO legislative study, "Legal frameworks for sustainable aquaculture",** which not only provides information, but analyses the normative framework for aquaculture at the international and national levels, identifying the key elements of an appropriate legal framework for sustainable aquaculture development. The study clarifies the issues to be addressed both in aquaculture-specific laws and in other legislation (e.g. agriculture, the environment). ALART should be used in conjunction with the related legislative study to optimize the assessment of a country's aquaculture legal framework. The ALART online portal*** provides the option of using ALART and the study online and in an interactive manner.

NOTES: * See: https://www.fao.org/policy-support/tools-and-publications/resources-details/en/c/1639260/
** See: https://www.fao.org/family-farming/detail/es/c/1640760/
*** Available at a beta version of ALART currently under review (to be updated when the site goes live): https://alart.review.fao.org/en

Overview of the guidelines

The GSA comprise three sections.

Section A describes the objectives and guiding principles of the guidelines:

- **Objectives** providing normative guidance for sustainable aquaculture policies: enhancing food security and nutrition; improving socioeconomic conditions for aquaculture-dependent communities; and promoting the sustainable use of aquatic resources.
- **Principles** forming the basis of the guidelines: sustainability, environmental stewardship, the rule of law, non-discrimination, equity and equality, consultation and participation, transparency and accountability, and holistic and integrated approaches.

Section B provides guidance for promoting sustainable aquaculture focusing on who, what and how to:

- develop and implement effective policy and planning, and legal and institutional frameworks, and integrate aquaculture into public policies for food systems and economic development, considering an ecosystem approach to aquaculture (Box 9);[ag]
- manage natural resources and aquaculture operations sustainably, considering the ecosystem and the impact of climate change and natural disasters, conserving aquatic biodiversity, managing genetic resources for sustainable seed supply, supplying sustainable feed, and strengthening biosecurity and animal welfare;
- enhance social responsibility, decent work, youth employment and gender equality,

ag See: https://www.fao.org/3/ca7972en/ca7972en.pdf

including women's empowerment in aquaculture; and
- establish sustainable aquaculture value chains, transparent and predictable market access, and trade, including reduction of aquatic food loss and waste.

Section C provides guidance for supporting and monitoring the adoption and implementation of the guidelines, focusing on who, what and how to:

- establish mechanisms and services required to support sustainable aquaculture development, including funding and financing, research and innovation, communication, and capacity development;
- develop implementation arrangements and technical support; and
- monitor and report on the implementation of these guidelines as well as collect and analyse data on aquaculture development and performance.

Actions to implement the guidelines

Once adopted, the GSA are expected to play a key role in addressing the challenges and opportunities to accelerate sustainable aquaculture production and its contribution to food security and poverty alleviation, while protecting aquatic ecosystem function and biodiversity. It is also expected that FAO and country-level monitoring and reporting mechanisms will help identify challenges and the sharing of best practices. In this context, FAO will specifically:

- support Members to develop platforms to oversee the implementation of the guidelines, including enhanced data collection systems, aquaculture policy frameworks and the development of national action plans;
- support Members to update their data collection methodologies, develop performance measurement indicators, and monitor, evaluate and report on the development of sustainable aquaculture;
- provide specific technical support for Members to enhance the capacity of small- and medium-scale aquafarmers to maximize economic and social benefits and minimize environmental impacts (Box 10);
- work with Members and partners to mobilize resources to assist Members in implementing the GSA and in support of the Blue Transformation Roadmap, review progress regularly, and disseminate findings and best practices;
- support the Global Sustainable Aquaculture Advancement Partnership (GSAAP, see Box 19, p. 143) as a mechanism and process to assist Members in implementing the guidelines, including by exchanging experiences and disseminating innovative technologies;
- promote South–South and triangular cooperation and other collaboration mechanisms and partnerships to promote the implementation of the guidelines;
- prepare progress reports on GSA implementation for discussion at the COFI Sub-Committee on Aquaculture; and
- support Members to develop strategic planning for women and youth to increase their employment in aquaculture.

The guidelines will be mainstreamed in FAO's programmatic work, advancing implementation of the Blue Transformation Roadmap to accelerate the sustainable production of aquatic foods.

Conclusion

The guidelines fully recognize that countries face diverse challenges and have different needs and capacities regarding aquaculture development, while also sharing significant challenges and opportunities in relation to investment and financing, technical capacity, access to aquatic resources, services, markets, and animal health. Through its Blue Transformation, FAO, together with its Members and partners, will leverage resources and means to address those challenges and support national strategies for sustainable aquaculture development, in line with the objectives, principles and recommendations of the Guidelines for Sustainable Aquaculture.

Supplying quality seed for aquaculture

The supply of adequate quantities of quality seed is critical to successful and sustainable aquaculture systems. The key elements of seed supply systems include: (i) species selection and diversification; (ii) effective and sustainable management and development of aquatic genetic »

BOX 10 AQUACULTURE PARKS: A MODEL FOR SUSTAINABLE AQUACULTURE PRODUCTION

In aquaculture, aquapark, also known as "aquaculture park", "aquaculture cluster" or "aquaculture village", refers to an aquaculture organizational model developed to support small-scale aquafarmers throughout the value chain. An aquapark requires a specialized, well-organized and business-oriented infrastructure, and efficient and approved operational procedures. In general, an aquapark includes all the input supply chain facilities and logistics needed to provide seed, aquafeed and technical services, production components (i.e. workers and production assets), and processing, distribution and marketing components (i.e. traders, processors, cold storage, transport and marketing facilities, and logistics). Some aquaparks integrate other activities such as ecotourism or cultural demonstrations to enhance their business model.

Aquaparks have been introduced and established worldwide, but their model varies depending on local circumstances and business objectives. An aquapark may include "enterprises + farmers" (basic stage); "enterprises + cooperatives + farmers" (intermediate stage); or "leading enterprises + demonstration sites + cooperatives + farmers" (advanced stage).

Aquaparks are managed using a community-based approach to coordinate activities and professional support. Typically, a management team is responsible for coordinating and supervising production operations and supporting services. This approach reduces costs, creates synergies and fosters development. Government authorities at local or national level often guide the planning, providing technical, financial and policy support and incentives – both to attract public and private investment for infrastructures and access to inputs and resources, and to facilitate a business-oriented development of sustainable aquaculture.

MAONAN TILAPIA AQUACULTURE PARK

The Maonan Tilapia Aquaculture Park is located in Maonan District, Maoming City, Guangdong Province, China, and covers 30 100 hectares (see figure). As of December 2022, this aquapark benefited 3 983 fish farming households and employed 12 617 workers, accounting for 73.45 percent of the total Maonan District aquaculture workforc (Zhang *et al.*, 2024). The aquapark focuses on farming tilapia and has become an aquaculture industrial base in Guangdong Province, producing 800 million high-quality tilapia fingerlings annually. The annual aquafeed supply is 286 000 tonnes for an annual production of tilapia of almost 220 000 tonnes, generating an average yearly income of over USD 4 615 per capita along the entire value chain. In addition, 1 800 farmers have received technical training on tilapia farming and gone on to become key players in the demonstration sites. Meanwhile, almost 10 percent of the total aquaculture area is allocated for water treatment and purification, and various aquatic plants and filter feeders have been stocked and grown in surrounding water bodies, securing additional environmental benefits. In addition, good pond management practices (i.e. increasing dissolved oxygen in the water and conducting water exchange regularly) promote the healthy aquatic environment required for efficient production.

The establishment of the aquapark and its operation benefited from a public–private partnership, with private operators contributing up to 60 percent of the financing, and the rest provided through provincial government (25 percent) and local government (15 percent) funding. The aquapark has adopted the development mode of "leading enterprises + demonstration sites + cooperatives + farmers". The public sector has also supported several leading enterprises that each manage the development and operations of 10–20 demonstration sites. These enterprises provide fingerlings and feeds, technical training and services for aquafarmers to carry out grow-out production of tilapia, while cooperatives are responsible for attracting pre-production investments, selecting production technologies and boosting sales.

SOURCE: Zhang, L., Hou, Y., Ye, W., Yuan, Y., Li, Q., Jiang, S., Li, H. *et al.* 2024. The establishment and operation of aquaparks – Experiences from China. FAO Fisheries and Aquaculture Technical Papers, No. 712. Rome, FAO. https://doi.org/10.4060/cd0449en

BOX 10 (Continued)

THE AQUACULTURE PARK CONCEPT

CREDITS: Nursery, Grow-out pond, Processed tilapia, Processing workshop and Hatchery workshop pictures © FFRC/Jun Qiang; Broodstock pond picture © FAO/Anton Ellenbroek.

SOURCE: Author's own elaboration.

» resources (AqGR); (iii) improved breeding technology; and (iv) efficiency of supply chains.

It is important to find a balance between the establishment of new species for aquaculture (diversification) and the expansion and development of farmed types of existing cultured species (concentration). In this latter regard, there is a clear need to apply the basic principles of genetic management and accelerate appropriate genetic improvement in aquaculture. However, optimal species selection and genetic management alone do not guarantee success; efficient seed supply chains are also fundamental to meet demand for quality seed.

FAO data indicate that countries are currently farming around 730 aquatic species, and this number is constantly growing (see **Farmed aquatic species and diversity**, p. 23). However, it is also apparent that production is increasingly concentrated within a limited group of species. For example, the top 17 cultured species by volume represent about 60 percent of global aquaculture production, and 46 species contribute about 90 percent of production. Recently, Cai *et al.* (2023) explored patterns of species diversity in global aquaculture, identifying the drivers of species diversification (e.g. market demand/price and entrepreneurial endeavours) and revealing relatively low levels of diversity within countries, with an overall trend of decelerating diversification.

The multiplicity of drivers of both diversification and concentration of farmed species, however, makes it difficult to predict the future of species diversity in aquaculture, particularly in the context of climate change. National aquaculture policies and strategies should take a holistic and balanced approach to species diversification recognizing these multiple drivers, which include resource availability and allocation, climate change, impacts on aquatic biodiversity, aquaculture system development, market demand, and institutional factors. Box 11 presents the FAO global information system on aquatic genetic resources (AquaGRIS), while Box 12 introduces an emerging area for genetic resource management and improvement.

In terms of species development, with the exception of a small number of well-advanced sectors such as Atlantic salmon or whiteleg shrimp, genetic management and improvement in aquaculture are still in their infancy. Ineffective or absent genetic management is commonplace and can result in loss of genetic variation, reduced performance due to inbreeding depression or hybrid introgression, and decreased potential for development of future farmed types. The adoption of good genetic management practices in breeding systems is critical in order to retain, over time, the genetic variation that forms the basis of a species' potential to adapt to change and on which to build selective breeding programmes. Effective genetic management, even in the absence of genetic improvement, will ensure such genetic gains can be realized in the future, in notable contrast to genetic resources in terrestrial agriculture, where much genetic diversity was lost during domestication. Potential gains from selective breeding in aquatic species are thus highly significant and, consequently, breeding programmes can greatly enhance production efficiency in coming years, making significant contributions to the sustainable intensification of aquaculture production.

The development of aquaculture must be underpinned by a robust supply chain to ensure the constant supply of quality seed well adapted to prevailing farming systems but with the capacity to adapt to climate change. In aquaculture, only a few species have been "fully domesticated" (i.e. the full life cycle completed in captivity). Much of aquaculture is still largely based on wild-sourced seed, with relatively few cases of completely closed production cycles and even fewer of selection programmes focused on specific breeding goals. Using wild-caught seed should ensure high levels of genetic diversity in cultured stocks and low risks for the wild population (in case of escapes from farms), in addition to reduced operational costs for seed producers. However, this can also result in additional pressure to overexploit poorly managed wild stocks, as well as in uncertain seed supply. Moreover, wild-caught seed is minimally adapted to captive aquaculture environments and this could have negative impacts on productivity. There are a range of measures that can be adopted to ensure the production of quality seed[ah] and its availability.

ah There are at least three important dimensions of seed quality: genetic dimension (in terms of integrity of farmed types and level of genetic improvement); absence of diseases; and survival rate (Shikuku, Ochenje and Muthini, 2021).

BOX 11 AQUAGRIS: TRANSFORMING THE KNOWLEDGE BASE ON GENETIC RESOURCES IN AQUACULTURE

The global information system on aquatic genetic resources (AquaGRIS), developed by FAO, is the first ever global database to collect and store detailed information on existing farmed types and wild stocks of aquaculture species. A farmed type is a descriptor applied to farmed aquatic organisms at a level below species, including strain, variety, hybrid, triploid, monosex group, other genetically altered form, and wild type. The primary scope of AquaGRIS is to function as a tool for countries to build their own registries of aquatic genetic resources (AqGR) used for aquaculture and to monitor their conservation, sustainable use and development status. A national registry created using AquaGRIS provides a given country with a detailed overview of available AqGR, their characteristics and their management status, which can be used in the development or revision of national aquaculture strategies.

The figure shows examples of the information collected at different levels: species, farmed type, fishery management/assessment unit, and genetic stock. Once these data are validated by national focal points (NFPs), they can be accessed through a publicly accessible dissemination interface in a range of reporting formats.

The set of indicators integrated into AquaGRIS, known as resource indicators, were developed by FAO in consultation with countries. They are linked to the priority areas and strategic priorities of the Global Plan of Action for the Conservation, Sustainable Use and Development of Aquatic Genetic Resources for Food and Agriculture.* AquaGRIS is, therefore, also an indispensable tool to monitor the future progress of the implementation of the Global Plan of Action at national and global scale. The availability of indicators for AqGR is a significant achievement and can have relevance beyond monitoring implementation of the Global Plan of Action. For example, Sustainable Development Goal (SDG) Target 2.5 uses indicators for the status of crop and livestock genetic resources that do not currently include farmed aquatic biodiversity. In the future, any review of the current SDG indicators or ongoing work to implement the Convention on Biological Diversity Kunming-Montreal Global Biodiversity Framework (particularly Target 4) may make use of the AquaGRIS resource indicators.

Countries are encouraged, especially prior to the next global assessment due in 2029, to create their national registries using AquaGRIS, with the support of FAO. Once the initial registries are created, the AqGR information will be updated biennially. Some countries have already started to use AquaGRIS to create their national registries. The collection of information for creating a national registry is the responsibility of AqGR NFPs and will involve a range of national stakeholders as sources of updated information. The whole process has the benefit of improving communication and the flow of information among aquaculture stakeholders, paving the way for more harmonized reporting mechanisms nationally and globally.

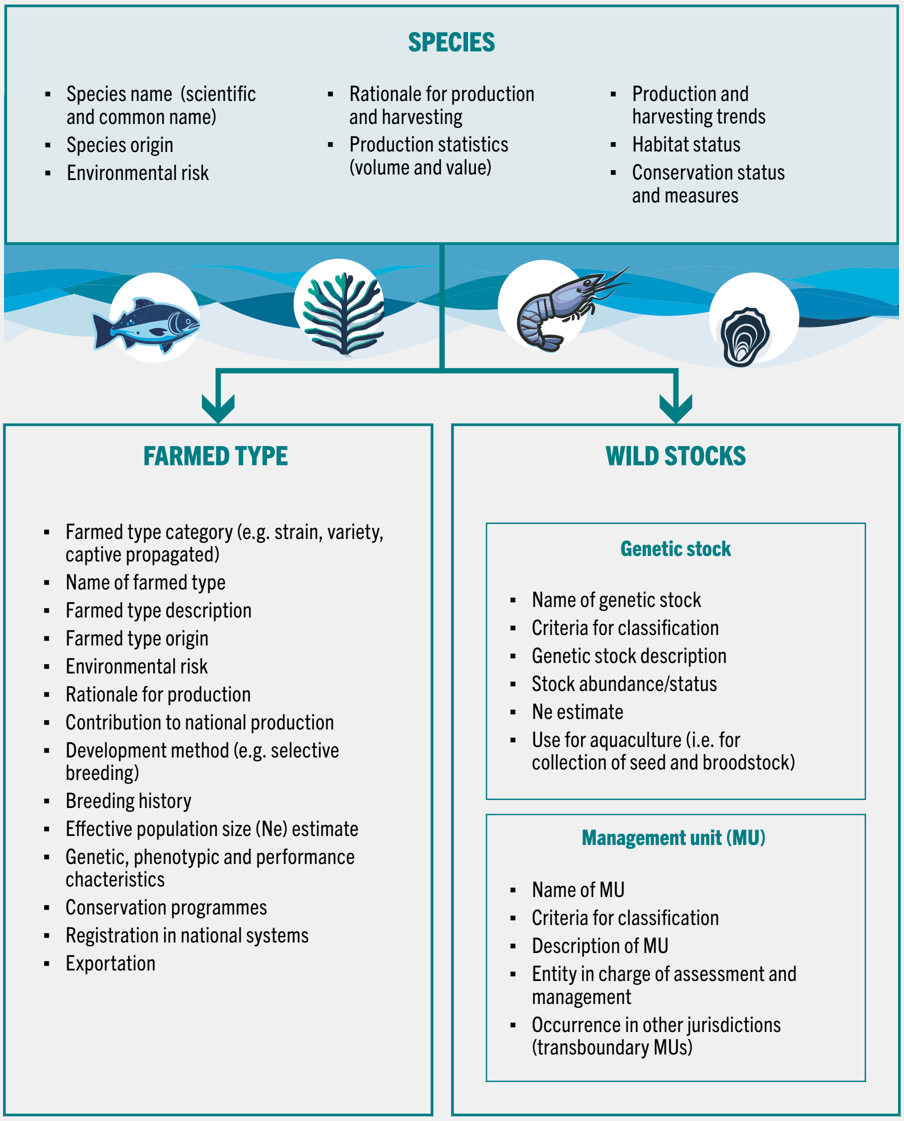
NOTE: *See: https://www.fao.org/documents/card/en?details=CB9905EN/

When seed production is hatchery-based, a wider adoption of genetic management and selective breeding programmes can help enhance seed quality and address production challenges such as infectious diseases and climate change. This requires adopting legal and institutional frameworks and effective certification schemes ensuring the quality of the broodstock used for producing seed (Varadi *et al.*, 2002). Seed quality also depends on the dissemination system; this should be adapted to the species and the production technology, be appropriate to the geographic scale (e.g. local, national, transnational), and consider the inclusion of the private sector to facilitate the long-term economic sustainability of the supply chain (Shikuku, Ochenje and Muthini, 2021).

FAO is supporting countries to improve the genetic management of aquaculture species through the implementation of the Global Plan of Action for the Conservation, Sustainable Use and Development

BOX 11 (Continued)

EXAMPLES OF INFORMATION CONTAINED IN AQUAGRIS AT SPECIES, FARMED TYPE, MANAGEMENT UNIT AND GENETIC STOCK LEVELS



SOURCE: Authors' own elaboration.

of Aquatic Genetic Resources (FAO, 2022c), a policy framework for rational and effective management of AqGR. To develop appropriate strategies for species diversification and concentration, countries should implement key elements of the Global Plan of Action and promote efficient seed supply chains. This will enhance the efficiency of their aquaculture sectors, helping to achieve the objectives and productivity targets of the Blue Transformation Roadmap for 2030, and to meet the »

BOX 12 CHALLENGES IN GENETIC MANAGEMENT AND IMPROVEMENT IN SEAWEED AQUACULTURE

Seaweeds are produced in over 56 countries worldwide (Cottier-Cook *et al.*, 2023), contributing to the economies of rural coastal communities in low- and middle-income countries (see Box 21, p. 145). The vast majority (97 percent) of this production comes from aquaculture, but its sustainability is hindered by poor knowledge of the genetic and phenotypic diversity of cultured species; poor investments in breeding programmes; and the limited effectiveness of many regulatory frameworks (Brakel *et al.*, 2021). Addressing these gaps is urgent, especially considering that overexploitation for farming purposes, combined with other factors such as pests, diseases and climate change, is contributing to declines in wild seaweed stocks around the world.

Seaweeds have complex, diverse and poorly understood life cycles, challenging the opportunity to close their life cycle for farming purposes and to develop genetic improvement programmes. Furthermore, farming of some species (e.g. *Eucheuma* spp. or *Kappaphycus* spp.) is based on asexual or vegetative reproduction with only rare cases of sexually reproductive individuals. Therefore, existing seaweed cultivars are often the result of natural selection or domestication without purposeful genetic improvement, with farmers playing a pivotal role in maintaining cultivar diversity. While some of these cultivars can be easily recognized by farmers based on specific agronomic traits, the lack of genetic information or informative genetic markers makes it difficult to reliably classify species and cultivars and to understand their distribution. Seaweeds also can have morphological plasticity, complicating their classification or description in the absence of any genetic characterization. Integrating farmers' traditional knowledge with genetic information can help identify ideal candidate seaweed stocks and cultivars for genetic improvement programmes and for adaptation to specific conditions (Dumilag *et al.*, 2023).

Some breeding programmes, mainly based on selective breeding and hybridization, and sometimes involving induction of mutation, have been established over past decades (e.g. for *Pyropia* spp., *Saccharina japonica*, *Undaria* spp.) and have generated seaweed farmed types produced on a large scale (Hwang *et al.*, 2019). However, the development of farmed types that are stable under different environmental conditions remains a significant challenge.

Despite the recognized importance of seaweeds, their production and management are still not supported by effective national and international regulatory frameworks. In terms of conservation of seaweed stocks, for example, there is a lack of seaweed-specific legislation and almost no protected areas are purposely created for protecting seaweeds and their habitats (Cottier-Cook *et al.*, 2023). Access and benefit-sharing is also less regulated compared to terrestrial plants. Although seaweeds are regulated under the Nagoya Protocol, they are not included in the scope of the International Treaty on Plant Genetic Resources for Food and Agriculture, which would simplify and standardize mechanisms for material transfer (for research, education and commercial purposes), and reduce the cost (Brakel *et al.*, 2021). Given the growing volume of seaweed production, there is a need to develop or improve seaweed regulatory frameworks, and to increase awareness of the specific challenges of seaweed cultivation, which may require specific and targeted genetic management approaches.

SOURCES: Brakel, J., Sibonga, R.C., Dumilag, R.V., Montalescot, V., Campbell, I., Cottier-Cook, E.J., Ward, G. *et al.* 2021. Exploring, harnessing and conserving marine genetic resources towards a sustainable seaweed aquaculture. *Plants People Planet,* 3: 337–349. https://doi.org/10.1002/ppp3.10190
Cottier-Cook, E.J., Lim, P., Mallinson., S., Yahya, N., Poong, S., Wilbraham, J. Nagabhatla, N., Brodie, J. 2023. *Striking a Balance: Wild Stock Protection and the Future of Our Seaweed Industries*. Policy Brief, No. 06. UNU Institute on Comparative Regional Integration Studies. https://cris.unu.edu/sites/cris.unu.edu/files/UNU-CRIS_Policy-Brief_CottierCook_Et.al_23.06.pdf
Dumilag, R.V., Crisostomo, B.A., Aguinaldo, Z-Z.A., Hinaloc, L.A.R., Liao, L.M., Roa-Quiaoit, H.A., Dangan-Galon, F. *et al.* 2023. The Diversity of Eucheumatoid Seaweed Cultivars in the Philippines. *Reviews in Fisheries Science* & *Aquaculture*, 31(1): 47–65. https://www.tandfonline.com/doi/full/10.1080/23308249.2022.2060038
Hwang, E.K., Yotsukura, N., Pang, S.J., Su, L. & Shan, T.F. 2019. Seaweed breeding programs and progress in Eastern Asian countries. *Phycologia*, 58: 484–495. https://doi.org/10.1080/00318884.2019.1639436

United Nations Sustainable Development Goals (SDGs) and the targets of the Kunming-Montreal Global Biodiversity Framework.

Pathways to effective aquaculture biosecurity and disease control

Pathogens and the diseases they cause continue to be a major challenge for a sustainable aquaculture sector capable of reaching its full potential. A recent review (Subasinghe *et al*., 2023) described the challenges of managing biosecurity practices in aquaculture as wide-ranging and multifactorial. Twelve issues were specifically identified as requiring attention to design and implement efficient and effective biosecurity strategies and protocols. These are: (i) healthy seed; (ii) emergency preparedness and response; (iii) diagnostics; (iv) microbial management at the production level; (v) disease and pathogen surveillance; (vi) trade; (vii) policies and regulatory framework; (viii) welfare; (ix) research and technology development; (x) antimicrobial resistance; (xi) non-conventional ways of pathogen transfer; and (xii) the Progressive Management Pathway for Aquaculture Biosecurity (PMP/AB).

To achieve the full potential of aquaculture as an important aquatic food system, new approaches that build on existing knowledge and capacity at the enterprise, local, national and regional levels are required. The FAO PMP/AB is such an initiative, founded on a risk-based value chain approach to address disease challenges. The PMP/AB offers participating countries, no matter what their state of aquaculture development or biosecurity situation, an effective avenue to achieve aquatic biosecurity. It also offers the possibility of tracing an aquaculture product along its value chain, from wild population to hatchery, through grow-out to processing to market, and finally to the consumer.

Since its inception in 2018, a comprehensive set of guidance for the application of the PMP/AB has been published (FAO, 2023b). It advises how a country can progress towards its desired level of biosecurity. A key component for a country to begin its implementation is the development of a National Aquatic Organism Health Strategy (NAOHS) or Regional Aquatic Organism Health Strategy (RAOHS), which helps to identify and address areas of biosecurity that need to be developed or strengthened. Through the participation of 15 countries, FAO has recently assisted the Network of Aquaculture Centres in Asia-Pacific (NACA) in developing the NACA RAOHS that was formally adopted during NACA's 32nd Governing Council Meeting in August 2023 as a policy document to guide the harmonized development of aquatic biosecurity in the region. This initiative will strengthen cooperation and the sharing of knowledge and expertise among the 19 NACA members and the harmonization of aquatic biosecurity policy related to international trade in live aquatic organisms and their products, facilitating trade among NACA members while reducing the spread of serious aquatic diseases. As NACA members constitute the top global aquaculture producers, the RAOHS is an important milestone regionally and globally.

A country, its aquaculture industry, farms and enterprises will benefit from the PMP/AB through:

- **better biosecurity governance** – to harness aquaculture production that is responsive to environmental and human-induced disease challenges;
- **partnership, shared ownership and responsibilities** – to provide a solid platform for public–private partnership through jointly developed, multistakeholder biosecurity strategies and implementation plans, thus ensuring buy-in and best fitness-for-purpose;
- **tangible benefits to stakeholders at every stage** – with co-management principles ensuring that problems are well-defined and management solutions identified;
- **commitment to risk management** – to establish risk ownership and promote active engagement and long-term commitment to risk management; and
- **aquatic animal health sustainability** – as a result of the above actions – reflecting collaboration among major stakeholders marked by coordinated efforts of various institutions and experts, pooled resources, shared knowledge, expertise and experiences to support biosecurity in aquaculture.

The PMP approach is now also being used to tackle antimicrobial resistance (PMP/AMR)[ai] and terrestrial animal biosecurity (PMP/TAB).[aj] It requires a good understanding of the relationship between host, pathogen and environment affected by human actions. Thus, host species, pathogen, environment and human management – supported by research, innovation and conducive policies – are the necessary ingredients for improving aquaculture biosecurity.

Equally important in reducing disease-related losses in aquaculture is the timely recognition that a disease problem exists, correctly diagnosing its cause and applying an appropriate management practice, control or treatment. The PMP/AB addresses this by improving disease identification among aquaculturists and increasing capacity and infrastructure for diagnostics. Good diagnostic capability is essential for protecting national borders against the entry of pathogens through imports of live aquatic organisms and their products, and for supporting disease surveillance, monitoring and reporting systems and programmes to determine the status of a pathogen and disease, detect outbreaks of new diseases, and ascertain their geographic distribution in the affected country.

Adoption of good aquaculture practices improves the welfare of cultured aquatic organisms by ensuring that they are reared under optimal environmental conditions, fed with a correct diet, and handled in ways that minimize the possibility of stress or suffering. Good welfare is directly related to reducing losses caused by diseases and increasing the profitability of aquaculture enterprises; it is also increasingly demanded by consumers.

The FAO–NACA aquaculture transformation guidance (FAO and NACA, 2023) includes an action area focused on implementing the PMP/AB and its toolkits, and on developing and implementing NAOHS and RAOHS. It also stresses the importance of the FAO Action Plan on Antimicrobial Resistance (2021–2025) (FAO, 2021b) for achieving the One Health goals, in particular the development of national action plans on AMR. Under the One Health approach, it is essential to further the prevention and control of diseases that spread between animals and humans, tackle AMR, and ensure food safety, aquatic animal health and implementation of international standards on sanitary and phytosanitary measures in aquaculture.

It is said that prevention is better than cure. Focusing on prevention – including of AMR (Box 13 and Box 14) – is a sign of a mature industry. Use of clean seed combined with good husbandry practices and biosecurity strategies in a less stressful and healthier aquatic environment are basic actions. Biosecurity should be considered alongside any aquaculture development, with special attention given to small-scale holders, who are potentially the weakest link and present the greatest risk if not provided with effective biosecurity support. Effective biosecurity, good husbandry practices, improved genetics and high-quality nutrition are important for producing healthy, nutritious and resilient farmed aquatic organisms (FAO, 2020, 2022b).

The Blue Transformation Roadmap (2022–2030) (FAO, 2022a) prioritizes increased capacity on biosecurity, disease control and aquatic health management at local, national and global levels. This stresses the importance of priority actions pertaining to aquatic organism health management and disease control, aquaculture biosecurity, disease burden assessment, prevention of antimicrobial resistance, and early warning, risk assessment and emergency preparedness related to food safety and animal health.

Innovative aquaculture systems and aquafeed solutions

Innovative aquaculture systems

Innovation in aquaculture systems is essential for any intensification or expansion of sustainable and resilient aquaculture. Innovation has already boosted aquaculture's growth in recent decades, contributing to global food security and socioeconomic development. Key benefits of innovative practices include production optimization (e.g. better seed and feed selection), alleviation of resource

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ai For further details, see: https://www.fao.org/antimicrobial-resistance/resources/tools/fao-pmp-amr/en/

aj For further details, see: https://www.fao.org/3/cc5771en/cc5771en.pdf

BOX 13 FAO REFERENCE CENTRES FOR ANTIMICROBIAL RESISTANCE AND AQUACULTURE BIOSECURITY

Antimicrobial resistance (AMR) is a global threat caused by overuse and misuse of antibiotics in human and veterinary medicine, potentially impacting the effectiveness of antibiotics in the treatment of diseases. Among the many issues addressed by the Progressive Management Pathway for Aquaculture Biosecurity (PMP/AB) and the National Aquatic Organism Health Strategy/Regional Aquatic Organism Health Strategy (NAOHS/RAOHS) are mechanisms to curtail the misuse of antibiotics in the treatment of disease outbreaks in populations of cultured aquatic organisms, and their replacement with prevention and treatment methods that do not rely on these drugs.

The FAO Reference Centres for AMR and AB are institutions designated by the FAO Director-General to provide specific and independent technical and scientific advice on issues related to FAO's mandate. To combat AMR, the Reference Centres assist in the implementation of FAO Resolution 4/2015, through the FAO Action Plan on Antimicrobial Resistance 2021–2025, which serves as a roadmap supporting global efforts of the food and agriculture sectors in addressing AMR. The following are examples of FAO Reference Centres (see figure) and their activities in aquaculture and prevention of AMR:

- The Pearl River Fisheries Research Institute, Chinese Academy of Fishery Sciences, China, performs basic and applied research and pursues advances in the development of fisheries in the Pearl River and tropical and subtropical zones.
- The Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, China, focuses on research on the development and sustainable use of marine biological resources and has made pioneering contributions to the mariculture of fish, shrimp, crab, shellfish, seaweed and sea cucumber in China.
- Nitte University, India, is a multidisciplinary university with a vision to achieve excellence in education and health care; it is equipped with a state-of-the-art hospital, rural health centres and research centres carrying out both fundamental and translational research.
- The Centre for Environment, Fisheries and Aquaculture Science, United Kingdom of Great Britain and Northern Ireland, is the UK Government's Department for Environment, Food and Rural Affairs marine and freshwater science agency.
- Mississippi State University, United States of America, is a public, land grant institution with a nationally and internationally diverse student and faculty body. It is dedicated to three broad purposes: learning, research and service.

Although the use of antibiotics will continue, as they play a critical role in food security, people's well-being, and animal and plant welfare, it should be in a responsible manner. Indeed, their misuse increases the risk of AMR, leading to the emergence of organisms resistant to antimicrobials and becoming a growing threat to human, animal or plant life. To prevent this threat, the Quadripartite organizations (World Health Organization, World Organisation for Animal Health, United Nations Environment Programme and FAO) are working together to accelerate a coordinated strategy on human, animal, plant and ecosystem health to achieve the One Health goals. The designation of FAO Reference Centres in 2022 is one step towards a better understanding of and improved collaboration in preventing the increase in AMR.

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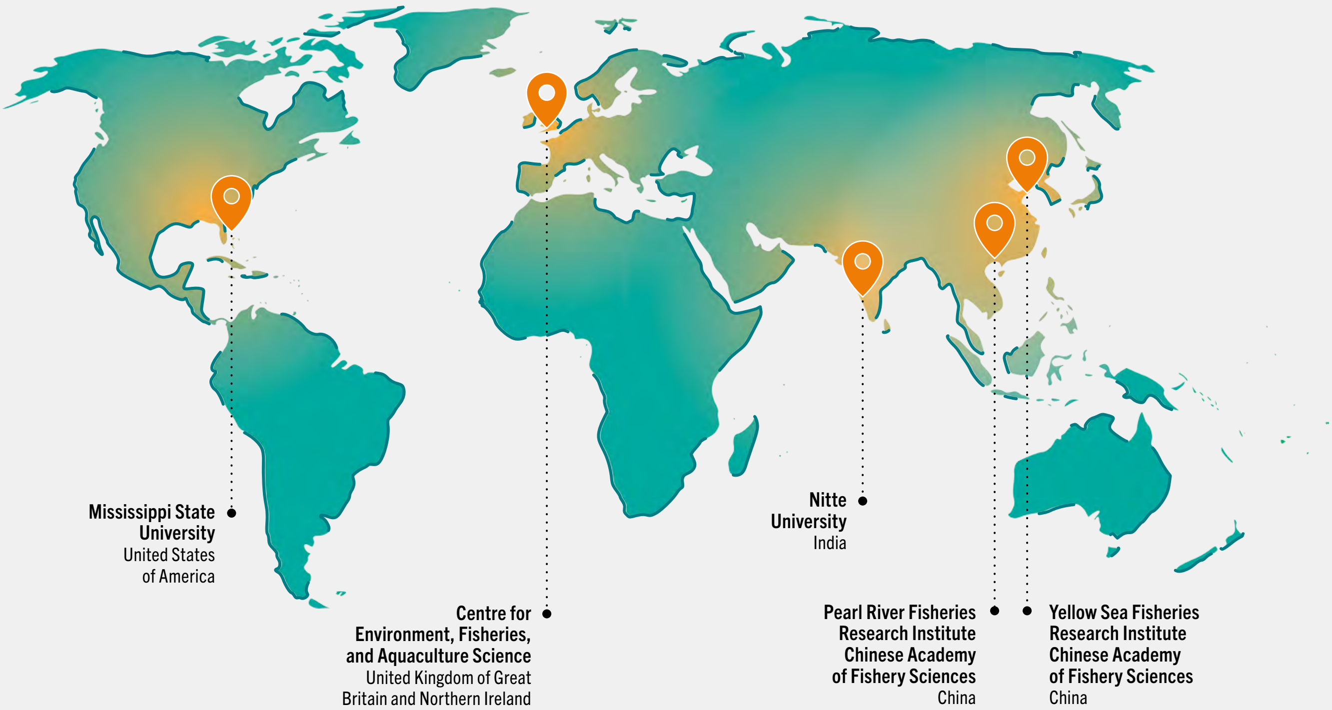
SOURCES: FAO. 2023. *FAO Reference Centres for Antimicrobial Resistance and Aquaculture Biosecurity – Combatting AMR together: ensuring healthy and safe aquatic foods.* Rome. https://www.fao.org/3/cc6625en/cc6625en.pdf

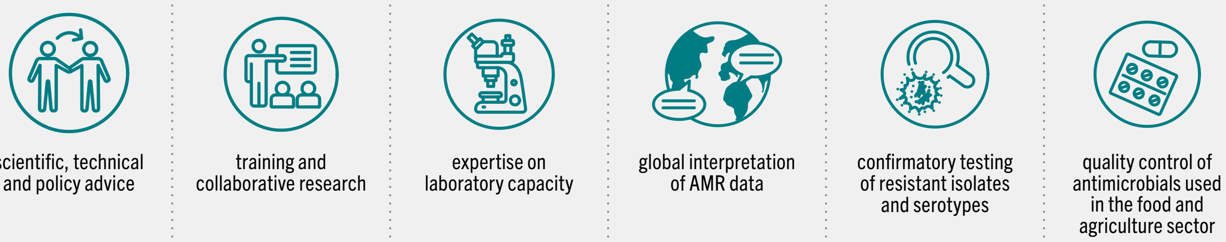
FAO. 2021. *The FAO Action Plan on Antimicrobial Resistance 2021–2025.* Rome. https://doi.org/10.4060/cb5545en

BOX 13 (Continued)

EXAMPLES OF FAO REFERENCE CENTRES FOR ANTIMICROBIAL RESISTANCE AND AQUACULTURE BIOSECURITY



FAO Reference Centres help guide and support FAO Members in:



NOTE: AMR – antimicrobial resistance.

SOURCE: Adapted from FAO. 2023. *FAO Reference Centres for Antimicrobial Resistance and Aquaculture Biosecurity – Combatting AMR together: ensuring healthy and safe aquatic foods*. Rome. https://www.fao.org/3/cc6625en/cc6625en.pdf

BOX 14 ALTERNATIVES TO REDUCE THE NEED FOR ANTIMICROBIALS AND PREVENT ANTIMICROBIAL RESISTANCE

The Global Plan of Action on Antimicrobial Resistance (AMR), with contributions from FAO and the World Organisation for Animal Health (WOAH), was adopted during the 68th World Health Assembly in May 2015. During a high-level meeting on AMR at the Seventy-first Session of the United Nations General Assembly in September 2016, a political declaration was agreed to support the development and implementation of national action plans on AMR and related activities under the One Health platform.

The World Health Organization (WHO), FAO and WOAH have since agreed to step up joint actions to combat health threats associated with interactions between humans, animals and the environment.

In May 2017, the United Nations Secretary-General convened the UN Interagency Coordination Group on Antimicrobial Resistance (IACG on AMR), in consultation with FAO, WOAH and WHO (the Tripartite Members) to provide guidance on approaches for ensuring sustained global action on AMR. The IACG recommended that Member States support the accessibility of cost-effective alternatives to antimicrobials (see figure), particularly in low- and middle-income countries (IACG, 2019). Indeed, many alternatives to antibiotics have great potential for disease control; some have proven benefits, while others are still in the experimental stage. FAO (2019) emphasized the need for more knowledge and research in order to better understand the reasons for the successes and failures, cost implications, efficacy, practicality (especially for smallholders), adverse effects on the farm environment, and how such alternatives improve health and enhance host immunity.

In 2022, the Tripartite welcomed the United Nations Environment Programme and formally became the Quadripartite, an alliance to accelerate a coordinated strategy on human, animal and ecosystem health.*

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NOTE: * For examples of the Quadripartite's achievements to date, please see: Tripartite AMR Country Self-Assessment Survey (TrACSS) 2020-2021 and Quadripartite launches a new platform to tackle antimicrobial resistance threat to human and animal health and ecosystems.

SOURCES: FAO. 2019. *Aquaculture development. 8. Recommendations for prudent and responsible use of veterinary medicines in aquaculture.* FAO Technical Guidelines for Responsible Fisheries, No. 5. Suppl. 8. Rome. [Cited 24 November 2023]. https://www.fao.org/documents/card/en/c/ca7029en
IACG. 2019. *No time to wait: securing the future from drug-resistant infections.* Report to the Secretary-General of the United Nations. [Cited 24 November 2023]. https://cdn.who.int/media/docs/default-source/documents/no-time-to-wait-securing-the-future-from-drug-resistant-infections-en.pdf?sfvrsn=5b424d7_6&download=true

» limitations, improved management, and enhanced connections between stakeholders along the aquaculture value chain.

Old becoming new

In recent decades, technological improvements in aquaculture systems, such as raceways and integrated food production, have resulted in increased efficiency and adoption of best practices. Integrated food production systems such as aquaculture–agriculture and integrated multitrophic aquaculture are experiencing a renewal because of their ability to optimize resource uses, improve income and contribute to food security.

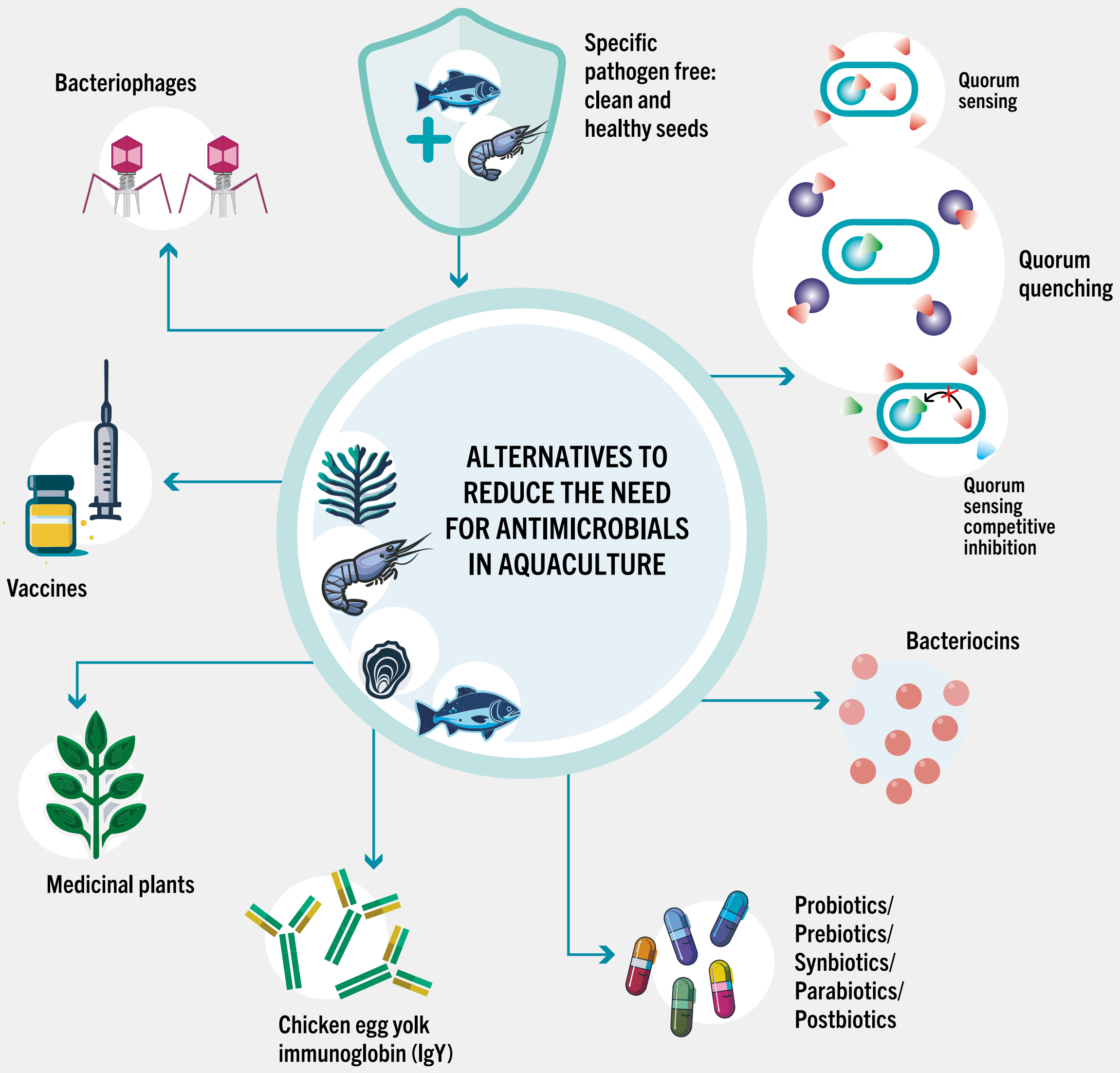
In Nigeria, farmers are integrating aquaculture into rice farms. The University of Ibadan, Nigeria, and the University of Georgia, United States of America, in collaboration with FAO, are assisting farmers by selecting compatible fish species, refining resource management techniques, and incorporating local fish feed ingredients. Such innovation reduces the cost of production and provides nutritious fish protein for rice farmers and their communities.

Context-specific solutions

By supporting the transfer and adoption of innovative systems and technologies, FAO provides solutions to introduce aquaculture

BOX 14 (Continued)

ALTERNATIVES TO REDUCE THE NEED FOR ANTIMICROBIALS



SOURCE: Adapted from Bondad-Reantaso, M.G., MacKinnon, B., Karunasagar, I., Fridman, S., Alday-Sanz, V., Brun, E., Le Groumellec, M. *et al*. 2023. Review of alternatives to antibiotic use in aquaculture. *Reviews in Aquaculture*, 15(4): 1421–1451. https://doi.org/10.1111/raq.12786

in regions where it did not exist before. For instance, producers are adopting innovative aquaculture systems in arid or desert ecosystems to overcome water scarcity (Box 15). Innovations such as the recirculating aquaculture system and biofloc technology are adopted in various regions to improve water efficiency and biosecurity (Label *et al*., 2021). However, innovations must be adapted to the specificities and needs of each region. Context-specific »

BOX 15 INVESTING IN DESERT AND ARID ZONE AQUACULTURE: A DREAM OR AN OPPORTUNITY?

The growing competition for land and water resources has led to the exploration of unconventional regions for the development of agriculture and aquaculture practices. Arid lands are one such frontier for adopting modern aquaculture practices to create new opportunities for fish farming. Sustainable and resilient integrated agriculture–aquaculture food systems able to adapt to arid conditions can help cope with resources scarcity and adjust to climate change. Available freshwater or brackish water resources can provide livelihood opportunities producing edible plants and aquatic foods, including fish.

Over the past decade, FAO has provided technical assistance to Algeria, Egypt, Ethiopia and Oman to implement integrated agriculture–aquaculture projects in arid lands. These projects, together with innovative technologies like aquaponics, have demonstrated that integrated systems can be cost-effective and suitable for both food self-sufficiency and small-scale commercial operations.

Since the 2010s, desert aquaculture has expanded, thanks to technological innovations and private sector investments supported by public incentives. For example, in Egypt, fish production from integrated agriculture–aquaculture systems increased from 700 to 2 200 tonnes between 2010 and 2017 through the establishment of some 100 farms in arid areas. Likewise, in Ouargla District, Algeria, there are now several small- to large-scale fish farms in the desert, boasting an annual production capacity of 2 000 tonnes (see photo).

Integrating aquaculture with agriculture in arid environments produces more benefits than conventional agriculture. This includes significantly reducing, and in some cases eliminating, the need for fertilizers. Crops benefit from the nutrients in fish farm water, and the same volume of farm water results in increased yields. In Egypt, Nile tilapia (*Oreochromis niloticus*) accounts for 90 percent of desert-based aquaculture production. Farms use underground saline water reserves, desalination plants and/or agricultural drainage. Water varies in salinity between 0.5 g and 26 g per litre and in temperature between 22 °C and 26 °C. European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) are other fish species suitable for farming in high salinity areas. Most commercial fish farms have adopted flow-through systems to irrigate agricultural land, enabling production of vegetables, fruits and arable crops, as well as clovers for feeding livestock. Aquaponics – linking fish production with soil-less plant production in recirculating systems – provides an additional option.

These systems may use desalinized brackish or seawater, rainwater, or treated or untreated municipal and industrial wastewater, selecting salinity-tolerant species. Efficient use of these alternative sources of water would certainly contribute to making integrated farming systems more productive and sustainable.

In 2013, FAO launched the Regional Initiative on Water Scarcity for the Near East and North Africa to address challenges of water resources management in the region and promote sustainable integrated agriculture–aquaculture production systems. Such a coordinated regional approach is crucial to raise fish and agricultural production, increase rural employment, and ensure sustainable integrated water resources management.

These efforts, together with private sector investments, research, and development initiatives, are paving the way for the transformation of these seemingly inhospitable regions into centres of agriculture–aquaculture innovation. With an integrated water resources management approach and efficient water use – an FAO priority area of work – desert and arid lands can indeed become areas for food production and economic growth in the coming years.

To learn more about agriculture–aquaculture, please visit the following resources:

- https://www.fao.org/3/ca8610en/CA8610EN.pdf
- https://www.fao.org/fileadmin/user_upload/rne/docs/WSI-Pamphlet-en.pdf
- https://hdl.handle.net/10568/134559

Earthen pond for fish farming and irrigation in the District of Ouargla, Algeria

» innovations have cascading positive impacts on local communities, making aquaculture an effective solution to improve food security and the livelihoods of many coastal communities.

Improved performance through technological advances

The adoption of technologies that promote precision farming and support decision-making and management significantly improves the performance of diverse aquaculture systems. Recent advances include the use of geographic information systems (GIS) for aquaculture planning and monitoring, sensors, robotics, bioinformatics, remote-operated equipment, and automated feeding structures. Digitalization is also driving the revolution of aquaculture by facilitating connections between stakeholders, providing access to knowledge and services, and supporting data collection and analysis (Box 16).

Pioneering technologies, such as floating, submersible or platform-based cage systems, remote sensing, and remote-operated machines, are helping to overcome the challenges of offshore marine aquaculture. A study by FAO and the United Arab Emirates uses GIS to conduct suitability analysis in offshore and nearshore sites for aquaculture, while deploying a series of floating cages of assorted designs to optimize aquaculture for each specific location.

Technological innovations are improving farm management and driving the development and upgrading of regulatory and institutional processes promoting the engagement along the value chain of a wide range of stakeholders to foster innovative aquaculture systems as sustainability solutions. For example, in Chile, a collaboration between national organizations and FAO utilizes GIS to address marine spatial planning and coastal governance.

Aquafeed solutions

Innovations in aquafeed have been crucial for the sustainable intensification and expansion of aquaculture in recent times. Fed aquaculture still represents approximately two-thirds of global aquaculture. Typically, feed represents the highest expenditure and can represent up to 70 percent of the production cost. Optimal farm productivity requires feed that meets the nutritional requirements of the farmed species and the correct adoption of on-farm feeding management.

Noticeable growth in aquaculture has been supported by a better understanding of the nutritional requirements of farmed species, resulting in significant improvements in average feed conversion ratio from 1.8–3 to 1.2–1.8 over the past two decades (Glencross *et al.*, 2023).

Commercial feeds have undergone significant technological advancements, with precision formulation ensuring the correct levels of amino acids and micronutrients, including probiotics and prebiotics, leading to improved health, survival and growth of farmed aquatic species (Romano, 2020). However, many small-scale producers with limited resources still depend on semi-commercial or farm-made aquafeeds, produced with insufficient guidance for manufacturing sustainable and nutritionally balanced feeds. FAO is preparing a training manual on production and management of aquafeed for small-scale farmers to disseminate widely the application of good feed production practices and on-farm feeding management.

Regional initiatives on aquafeed

In some regions, feed formulation and on-farm feeding management represent crucial limitations for expanding aquaculture. FAO has launched regional initiatives to assess country-specific demands for fed aquaculture and improved feeding management. This includes developing knowledge in rural areas on the best use of local ingredients (Box 17). In December 2023, WorldFish and FAO organized an expert workshop on local alternative ingredients, aquafeed supply, and on-farm feeding management in Africa. The workshop identified country-specific challenges and the requirements for technical assistance and capacity building. Furthermore, it promoted knowledge exchange and showcased technological innovations in aquafeed. In Turkmenistan, a joint project between the Ministry of Agriculture and Environmental Protection, the Ministry of Finance and Economy »

BOX 16 FAO AND AQUACULTURE DIGITALIZATION

Digitalization of aquaculture is a transformative process based on the use of digital technologies along the production cycle to improve operations and create value. Aquaculture digitalization increases the amount and quality of data collected; furthermore, the systematic availability of data throughout the cycle facilitates analysis to inform management and control decision-making.

Digitalization links farmers, input suppliers, service providers and traders, strengthening and accelerating the connections across value chains and lessening many of the challenges faced in the sector. Off-farm, technologies – such as mobile phone applications, online information and communications technologies, e-commerce platforms, smart monitoring networks, internet of things sensors, big data analytics, machine learning, artificial intelligence, and digital payment systems – can improve marketing and reduce transaction costs.

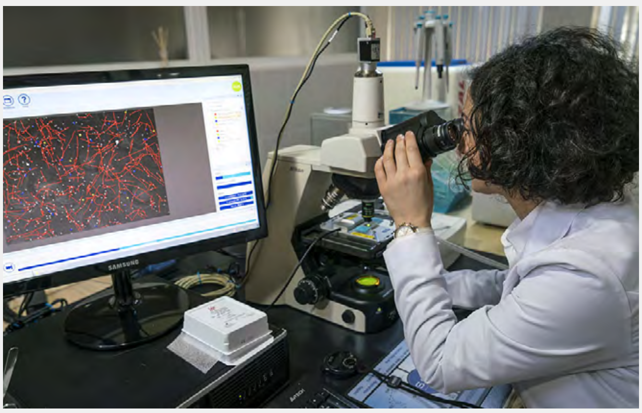
Digitalization can also accelerate aquaculture transformation in developing countries by removing barriers to the collection, dissemination and use of data and technologies. Aquaculture digitalization requires inclusive capacity building to improve digital literacy and skills, in particular for young practitioners. FAO's Blue Transformation Roadmap targets innovative technology and management to support the expansion and intensification of aquaculture by prioritizing actions that facilitate investment in digital, technological and management innovations.

However, the use of digital technologies should be properly regulated to mitigate possible infringements on personal and collective rights. FAO is paving the way for the digital transformation of aquaculture through a wide range of initiatives. These include the global Smart Aquaculture Biosecurity project,* which aims to assist countries to effectively implement biosecurity governance and best practices through smart and digital tools, and the global information system on aquatic genetic resources (AquaGRIS), which collects, validates, monitors and reports below the species level (see **Supplying quality seed for aquaculture**, p. 123, and **Pathways to effective aquaculture biosecurity and disease control**, p. 130).

IMPROVING AQUACULTURE MANAGEMENT IN AFRICA THROUGH DIGITALIZATION

During the last two decades, aquaculture in Africa has moved away from subsistence fish farming to commercial production and profit-oriented aquaculture. The transition requires technical support, and the provision of information, inputs and services in real time. To meet the needs of African fish farmers, Rhodes University (South Africa) has developed Buna Africa, an online platform designed to support the development and management of the aquaculture sector in Africa. Through the platform, farmers can submit to the government their production data, which are required to inform policy and formulate management and development plans. FAO is also supporting the implementation of Buna Africa in Rwanda and Uganda, providing farmers with technical support and services to increase production and efficiency. Buna Africa is also an entry point for service providers in the aquaculture sector to connect with fish farmers and government services, tracking production data in their area to inform policy and management decisions.

The operation and development of digital platforms and applications are accelerating aquaculture transformation in these countries, removing barriers that hinder access to technologies by all stakeholders, reducing transactional costs, and improving the quality and availability of data.

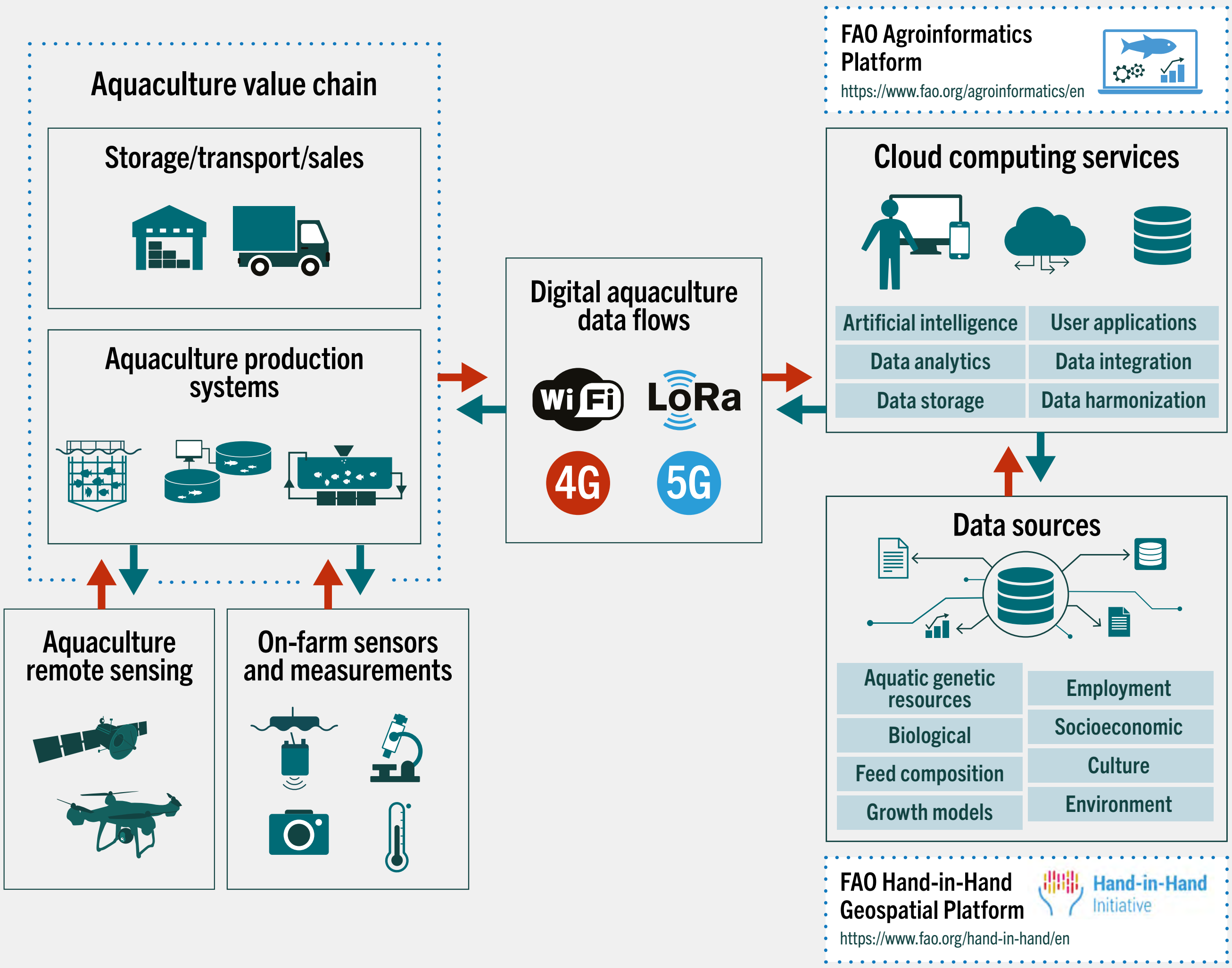


Fisheries Research Institute Trabzon, Türkiye

NOTE: * See: https://www.fao.org/in-action/smart-aquaculture-biosecurity/en/

BOX 16 (Continued)

DIGITAL AQUACULTURE – DATA SOURCES AND DATA FLOW



NOTE: LoRa (Long Range) is the technique adopted by the Long Range Wide Area Network (LoRaWAN) – a radio communication protocol that defines how terminal equipment with low-power supply sources (e.g. battery, solar panel) communicates wirelessly through gateways.

SOURCE: Adapted from Lan, H.-Y., Ubina, N.A., Cheng, S.-C., Lin, S.-S. & Huang, C.-T. 2023. *Digital Twin Architecture Evaluation for Intelligent Fish Farm Management Using Modified Analytic Hierarchy Process*. Applied Sciences, 13: 141. https://doi.org/10.3390/app13010141

» and FAO is addressing the aquafeed value chain and aquatic animal health management. The project aims to improve the quality of aquafeeds available to farmers focusing on farm-made aquafeeds.

Advances in using alternative ingredients

Current research focuses on identifying alternative protein and energy ingredients to boost sustainable aquaculture growth, including from local alternative aquafeed ingredients. Recent advancements include the

BOX 17 FISH SILAGE: A HIGH-QUALITY FEED INGREDIENT PROMOTING A CIRCULAR ECONOMY IN BARBADOS

Fish filleting yields by-products such as head, guts, bones and skin that can represent up to 70 percent of the whole fish by weight. These are of high nutritional value and can be processed into fish silage – a feed ingredient of high economic and nutritional value, easily digested by terrestrial and aquatic animals – or used as fertilizer for crop production. During the silage process, digestive enzymes from the fish break down proteins into amino acids and peptides. Usually, an organic acid is directly or indirectly added to preserve the product; this enables it to be stored for longer periods and has a positive impact on the gut health and immune system of farmed animals, particularly under unfavourable microbiological conditions (Olsen and Toppe, 2017). Fish silage could thus reduce the need to use antibiotics while improving growth performance. In diets with a high plant protein content, free amino acids and other compounds from fish silage have shown feed-attractant properties providing an excellent source of essential amino acids that are limited in most plant-based feed ingredients.

In addition to the demonstrated nutritional benefits, contributing to better animal growth performance, fish silage promotes a circular economy within the fish industry, reducing costs and improving the industry's environmental footprint. For example, in Barbados, 3 000 tonnes of fish waste are produced annually, with approximately 8 tonnes discarded daily (King, Ouadi and Cox, forthcoming).

Following confirmation by the Caribbean Agricultural Research and Development Institute of the safety of using fish silage-based feed, a livestock growth performance study was carried out; young rabbits exhibited better weight gain and the feed was demonstrated to be more effective than current commercial rations.

In 2019, the fish silage initiative was started to foster a circular economy in Small Island Developing States (SIDS) such as Barbados, characterized by a relative shortage of land for which there are many competing usages. The less state land apportioned to landfills for waste, the greater the availability for other uses and the smaller the sector's environmental footprint. Awareness-raising and capacity-building activities have led to the establishment of a national fish silage community, the mainstreaming of fish waste utilization in the 2022–2030 Fisheries Policy, private investment by a fish processor in the fertilizer business, and a high level of interest from fisherwomen and young farmers. The production of a wide range of fish silage-based feeds has proved feasible within an ecosystem of support, with institutional resource strengthening. This is the rationale behind the envisioned retrofitted public facility, designed to serve the needs of all livestock and eventually aqua farmers through fish silage-based feed production, and to fulfil the role of a farmer training centre with a national and regional outlook.

SOURCES: King, J. Ouadi, Y.D. & Cox, S. (forthcoming). An Update of Fish Waste Generation and the Potential Contribution to the Circular Economy in Barbados.
Olsen, R.L. & Toppe, J. 2017. Fish silage hydrolysates: Not only a feed nutrient, but also a useful feed additive. *Trends in Food Science and Technology*, 66: 93–97. https://doi.org/10.1016/j.tifs.2017.06.003

increased use of plant-based ingredients as protein sources (Naylor *et al.*, 2021) to reduce the reliance on wild-caught fish for aquafeed alongside supplemental amino acids, fatty acids and trace minerals.

FAO and its partners are promoting alternative and sustainable feed ingredients such as algae, insect meals, *Artemia* spp. and fish silage. These alternatives have enabled improved and cost-effective aquaculture and animal husbandry performance in Barbados (Box 18) and various countries in Africa (see Box 39, p. 183).

BOX 18 DIGITALIZATION IN SUPPORT OF AQUACULTURE DEVELOPMENT IN THE CARIBBEAN COMMUNITY

In 2021, FAO launched a digitized aquaculture library project to support information exchange and the identification of opportunities and means for the development of sustainable aquaculture in Caribbean Community (CARICOM) countries. The project contributes to national efforts, pooling available aquaculture information from the financial, technological, research and academic domains into one regional digital hub. As of 2022, the aquaculture sector remained poorly developed in the region, with four member countries – Belize, Guyana, Haiti and Jamaica – accounting for most of the regional aquaculture production of 5 047 tonnes, valued at USD 21.1 million (see figure).

The digitized aquaculture library project aims to enhance networking and sharing of knowledge and best practices among Caribbean countries – a need identified by the Caribbean Regional Fisheries Mechanism (CRFM) during the FAO 2020 regional review of aquaculture in Latin America and the Caribbean. Regional cooperation and exchange of information were indeed considered key to the development of aquaculture in the region to address the recognized limitations in expertise (Wurmann, Soto and Norambuena, 2021). Other constraints include lack of infrastructure, inadequate technology, inappropriate skills, and insufficient investment, all of which restrict production of a reliable and affordable seed and feed supply.

Completed in February 2022, the digitized aquaculture library connects CARICOM member countries and facilitates technical exchange and training on aquaculture systems and species with proven regional success. It also provides a toolbox to entrepreneurs and governments for diversifying and scaling up commercial operations. The library was built with information collected from fisheries and aquaculture officials, practitioners, researchers, and financers of all 15 CARICOM countries. All information was validated by the respective member countries, and consent for the publication of individual details was granted.

The library has two components: first, a downloadable registry of individuals and hubs in the public and private sector (including decision-makers, regulators, managers, businesspeople, financers and practitioners) posted on FAO, CRFM and country websites;* second, a publication list (including national plans, technical guides, factsheets and peer-reviewed publications) with online access to the CARICOM aquaculture library containing digital copies of Aquatic Sciences and Fisheries Abstracts** publications.

The digitized aquaculture library continues to grow, strengthening the Caribbean aquaculture network, improving access to reliable updated information and increasing the opportunities to support sustainable aquaculture expansion. FAO and CRFM member countries have agreed on a process to update and maintain the library annually to keep it relevant and informative.

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NOTES: * Available at: https://www.fao.org/fishery/services/storage/fs/fishery/documents/WECAFC/CARICOMDigitalLibrary.htm
** Available at: https://www.fao.org/fishery/en/openasfa?page=1&f=collections%3D%22CARICOM%22#search

SOURCES: FAO. 2022. Digital Aquaculture Library for the CARICOM Report. Appendices 4 and 8. FAO Subregional Office for the Caribbean (Bridgetown).
Wurmann, C., Soto, D. & Norambuena, R. 2021. *Regional Review on Status and Trends in Aquaculture Development in Latin America and the Caribbean – 2020*. FAO Fisheries and Aquaculture Circular, No. 1232/3. Rome, FAO. https://doi.org/10.4060/cb7811en

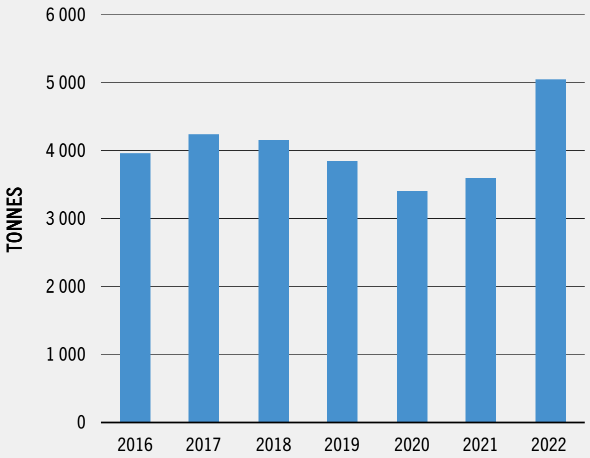
The importance of partnerships for sustainable aquaculture development

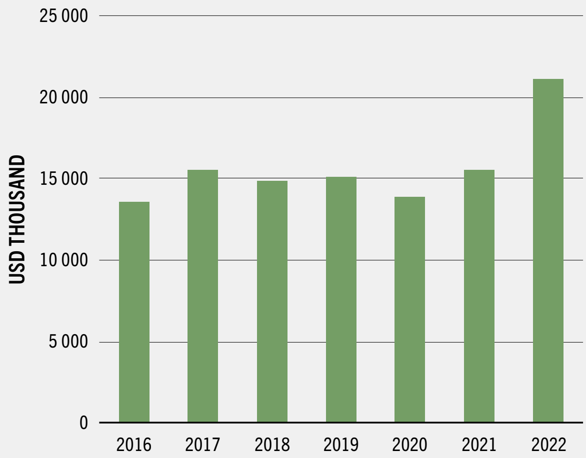
The development of sustainable aquaculture does not exist in a vacuum: to optimize the contribution of the aquaculture sector towards achieving the 2030 Agenda for Sustainable Development, coordinated and accelerated actions are required among policymakers, farmers and farmers' associations, food processors, traders, researchers, international technical and development institutions, and technical experts.

FAO recognizes the great value of partnerships, and invites organizations interested in working together to end hunger and all forms of malnutrition to combine efforts and resources.

BOX 18 (Continued)

AQUACULTURE PRODUCTION AND VALUE FOR CARIBBEAN COMMUNITY COUNTRIES, 2016–2022





NOTE: Data expressed in live weight equivalent.

SOURCE: FAO. 2024. FishStat: Global aquaculture production 1950-2022. [Accessed on 02 April 2024]. In: FishStatJ. Available at: www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.

Within sustainable aquaculture development, many actors are already cooperating, both directly and indirectly. There is a broad consensus that partnerships and cooperation arrangements should be strengthened, networks revitalized, and joint actions streamlined if we are to turn the tide of food insecurity and malnutrition. Using the SDGs as a framework and shared vision for collaboration, FAO is working with governments, academia, civil society, the private sector, research centres, aquafarm cooperatives and other partners to accelerate innovation, exchange technologies and experiences, and build capacity throughout the sector.

FAO aims to match the needs and capacity of partner institutions and benefiting Members through various mechanisms such as South–South Cooperation and engagement with the private sector and civil society. The most obvious partnership is with the FAO Members themselves, with whom FAO engages in many ways, in particular through the Committee on Fisheries and its Sub-Committees on Aquaculture (COFI:AQ) and Fish Trade (COFI:FT). The function of COFI:AQ is to provide a forum for consultation and guidance; it recommends, *inter alia*, international action to address aquaculture development needs and advise on the strengthening of international collaboration to assist developing countries in the implementation of the Code of Conduct for Responsible Fisheries (CCRF). At its last session in 2023, COFI:AQ specifically stressed the importance of FAO exploring all platforms and partnerships to support the implementation of the Guidelines for Sustainable Aquaculture (FAO, 2023c).

Working with regional fisheries advisory bodies (RFABs) and regional fisheries management organizations (RFMOs) is another important pillar of partnerships (Box 19). FAO has actively supported the establishment of regional aquaculture networks such as the Network

BOX 19 AQUACULTURE DEMONSTRATIVE CENTRES TO ACCELERATE BLUE TRANSFORMATION IN THE MEDITERRANEAN AND BLACK SEA REGION

Aquaculture is an active and growing sector in the Mediterranean and Black Sea region. With over 35 000 farms producing around 3.3 million tonnes* of aquatic foods in 2021 and directly employing almost 350 000 people in the region, this sector is an important driver for food security, employment and economic development towards the achievement of the United Nations Sustainable Development Goals, and it offers important opportunities to enhance aquatic food production and reduce the pressure on wild fishery stocks.

Boosting the sector and enhancing its benefits are one of the priorities of the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO), a regional fisheries management organization established under the provisions of Article XIV of the FAO Constitution with a mandate for sustainable development of fisheries and aquaculture. Within the framework of its 2030 Strategy for sustainable fisheries and aquaculture in the Mediterranean and the Black Sea,** the GFCM is working towards implementing Blue Transformation in the region by developing sustainable aquaculture that is productive, profitable, environmentally friendly and globally competitive.

Aquaculture demonstrative centres (ADCs) act as specialized Blue Transformation accelerator hubs to promote innovation, knowledge sharing, best practices, technical cooperation and stakeholder capacity. More specifically, they aim to:

- promote scientific research and innovation;
- provide hands-on technical and technological support;
- showcase best practices in aquatic food farming;
- advance education and increase stakeholders' skills, focusing in particular on women, youth and small-scale farmers; and
- foster further collaboration and partnerships.

The ADCs are open to all aquaculture stakeholders and are located in different areas of the Mediterranean and the Black Sea, operating as technical units tailored to the features of each subregion. There are currently three active ADCs in, respectively, Egypt, Romania and Türkiye, and a fourth is planned to be soon launched in Tunisia.

Two ADCs were established in the Black Sea: the Grigore Antipa National Institute for Marine Research and Development in Constanta, Romania, for shellfish; and the Central Fisheries Research Institute in Trabzon, Türkiye, for finfish. Following their success in training over 4 000 persons and developing innovative projects, and in light of requests made by its member countries, the GFCM established in 2023 the first Mediterranean ADC in Alexandria, Egypt, focusing on brackish water aquaculture, with the support of the Marine Aquaculture Development in Egypt (MADE II) project of the Ministry of Agriculture and Land Reclamation. The fourth ADC currently in development in Tunisia will focus on offshore cage farming and environmental monitoring.

NOTES: * The figure refers to total production, including freshwater, brackish water and marine water, from all seas of the Mediterranean and Black Sea countries.
** See: https://www.fao.org/3/cb7562en/cb7562en.pdf

of Aquaculture Centres in Asia-Pacific, the Network of Aquaculture Centres in Central-Eastern Europe and the Aquaculture Network for Africa. Regional aquaculture networks may involve academic institutions and producers' organizations. To strengthen further its engagement with the former, FAO has signed memoranda of understanding with many institutions around the world including the Shanghai Ocean University Center for Ecological Aquaculture, the Polytechnic University of Valencia, Mexico's National Commission on Aquaculture and Fisheries, the Chinese Academy of Fisheries Sciences, and Mississippi State University. These engagements bring together actors conducting research in aquaculture with

BOX 20 GLOBAL SUSTAINABLE AQUACULTURE ADVANCEMENT PARTNERSHIP

The Global Sustainable Aquaculture Advancement Partnership (GSAAP) is a voluntary platform bringing together a wide range of aquaculture stakeholders. It was established to enhance the scientific basis of aquaculture, promote continuous innovation, and fully harness the potential of aquaculture to contribute to achieving the Sustainable Development Goals. The partnership functions include: (1) serve as a global platform to discuss key issues and challenges, innovations and findings in the development of the aquaculture sector, formulating solutions to address the issues and challenges for long-term sustainability; (2) facilitate aquaculture innovation and advancement in science, technology, farming systems and practices through extensive collaboration and exchange; (3) provide strategy advice, technical assistance, and think tank services on the request of beneficiaries including, but not limited to, country governments, enterprises and other entities towards achieving sustainable aquaculture; (4) advocate and disseminate sustainable practices and successful development approaches of diversified aquaculture systems and technology across nations and continents; (5) serve as a multistakeholder platform for the advocacy of global aquaculture and enhance dialogue with the public; and (6) foster an inclusive partnership and cooperation mechanisms with the international community.

The GSAAP was founded in 2022, and its partners have already initiated substantive work. For example, a collaborative study has been carried out between farmers and the University of Ibadan on the feasibility of black soldier fly larvae as an alternative feed for catfish in Nigeria to address farmers' need to decrease feed costs; brine shrimp (*Artemia* spp.) biomass production for direct human consumption has been introduced to improve nutrition for rural families in the Lao People's Democratic Republic; and in South Africa, an interregional academic collaboration has provided local institutions with the capacity to collect data and assess the suitability of aquaponics in a data-driven and transparent way. Finally, policy dialogues on seaweed farming have been convened with the participation of 44 countries from Africa, Asia and Latin America, bringing together major stakeholders in seaweed aquaculture to support international cooperation and capacity-building initiatives to address policy gaps and develop or strengthen national strategies.

producers and extension workers. Importantly, it provides a conduit for FAO to share its own experience from the field with the academic community. For selected information on FAO's work with academia via the Global Sustainable Aquaculture Advancement Partnership, see Box 13, p. 132 and Box 20.

Likewise, FAO has adopted specific strategies for strengthening engagement with the private sector and civil society organizations towards sustainable aquaculture development in support of achieving the SDGs. These partnerships came together in 2021 during the FAO/NACA Global Conference on Aquaculture Millennium+20 (GCA+20), which convened many stakeholders from across the world. The GCA+20 captured and synthesized a wealth of information from all stakeholders, producing both regional and thematic reviews of aquaculture. The Conference and its outputs provided the most updated and relevant scientific and technical information, which contributed to the debates among FAO Members, including on the GSA, technically endorsed at the Twelfth Session of COFI:AQ (FAO, 2023c) (see **Progress in the development of the FAO Guidelines for Sustainable Aquaculture**, p. 121). This example demonstrates how its work with partners enables FAO to promote worldwide consultation and strengthen international collaboration to support sustainable aquaculture development, in particular in developing countries (Box 21).

Partnerships are essential to achieve the SDGs and develop sustainable aquaculture through effective global and regional cooperation, a key target of FAO's Blue Transformation Roadmap (FAO, 2022a). FAO takes on the role of convener – bringing together disparate stakeholders from »

BOX 21 TAWI-TAWI'S JOURNEY TOWARDS SUSTAINABLE SEAWEED FARMING

In the Sulu Sea off the southwestern coast of the Philippines, home to the Sama Dilaut sea nomads, Imilita Mawaldani Hikanti belongs to this Indigenous community historically known for its exceptional skills in seafaring, fishing and pearl diving. They once played a crucial role in supporting coastal economies and regional trade. However, the community now faces significant challenges, including displacement, environmental degradation, and threats to its cultural heritage, exacerbating poverty and marginalization for many.

Imilita, a mother of twelve (two of whom died at an early age), lives in Barangay Balimbing, Panglima Sugala, Tawi-Tawi. She and her husband have been seaweed farmers their whole lives, living in a stilt house in the Pondohan community. Their education was limited due to financial constraints and the long distance to schools.

Tawi-Tawi Island is a cornerstone of the national and global seaweed farming industry. The municipality of Sitangkai has been instrumental in promoting *Eucheuma* seaweed farming since the 1970s, when a family farming system was first developed through a partnership between the Philippines and the University of Hawaii.

Eucheuma cultivation in Sitangkai thrived, bolstering the local economy, and by 1987, the municipality was the premier *Eucheuma* farming hub in the Philippines, playing a pivotal role in increasing seaweed exports and becoming the country's most important aquaculture source of foreign exchange revenue.

In Tawi-Tawi, seaweed farming is more than an industry – it is a way of life, engaging approximately 80 percent of the population. Every year, seaweed farming is celebrated at the Agal-Agal Festival, a testament to the cultural and economic importance of seaweed in the society.

Like many, Imilita and her husband became skilled at seaweed farming with no formal training, using methods that have now become traditional on the island. It is their primary source of income, satisfying their basic living requirements, but insufficient for funding their children's education. Moreover, the activity also presents numerous challenges such as "ice-ice" disease, inadequate aquaculture practices, lack of financial support, absence of marketing opportunities, decreasing carrageenan quality in seaweeds, and even threats from marine animals.

Recognizing these challenges, the Food and Agriculture Organization of the United Nations, the International Organization for Migration, and the International Trade Centre started a collaborative project funded by the European Union in Tawi-Tawi – the Bangsamoro Agri-Enterprise Project – with the aim of improving seaweed production, value chains and marketability. It provides capacity building and technical assistance, establishes social enterprises to elevate socioeconomic conditions and increase resilience to climate change and conflict, and contributes to sustainable development of the Bangsamoro Autonomous Region in Muslim Mindanao. Furthermore, the project supports training in sustainable seaweed farming and post-harvest processing through farmer field schools, establishing seaweed nurseries and processing facilities, facilitating market linkages, promoting sustainable methods, and engaging the community to enhance its social and economic benefits.

This project provides Imilita and her community with new opportunities to improve their livelihoods and navigate the challenges of modern seaweed farming, contributing to a more sustainable and economically viable future for people in Tawi-Tawi.

Harvesting seaweeds in Tawi-Tawi, Philippines
© FAO/Rhadem Musawah Morados

Podonhan community dryer of seaweeds, Philippines
© FAO/Rhadem Musawah Morados

» across the sector and related areas – because only together and with a shared vision on aquaculture development will the sector make its full contribution to the 2030 Agenda for Sustainable Development and put Blue Transformation into action at the pace and scale needed. ■

IMPROVING FISHERIES SUSTAINABILITY

This section presents recent achievements in effective management of global fisheries, governance frameworks to combat illegal, unreported and unregulated (IUU) fishing and to promote sustainable small-scale fisheries (SSF), the emerging technological innovation in responsible fishing and the increasing role of regional fishery bodies (RFBs). It also describes a key FAO-led initiative that implements a science-based approach to improve assessment of the status of global fishery resources.

Progress in implementing the FAO Port State Measures Agreement

Responsible fisheries management is undermined by IUU fishing. Target 14.4 (effectively regulate harvesting and end overfishing, IUU fishing and destructive fishing practices) and Target 14.6 (prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing and eliminate subsidies that contribute to IUU fishing) of SDG 14 recognize the importance of eliminating IUU fishing to safeguard the sustainable use of fishery resources.

The FAO Port State Measures Agreement (PSMA) is the first binding international instrument to target IUU fishing and is widely recognized as a potent and cost-effective instrument to eliminate it. The number of parties has trebled since it came into force in 2016, making it the agreement with the highest rate of adherence of all fisheries and ocean-related treaties. As of May 2024, the PSMA has 78 parties, including the European Union representing 27 states. The agreement is in force in 54 percent of total states and 63 percent of coastal states. From a regional perspective, the percentage of coastal states where it is in force is lowest in the Near East (29 percent) and Southwest Pacific (44 percent); average in Latin America and the Caribbean (55 percent) and Asia (63 percent); and highest in Africa (76 percent), Europe (73 percent) and North America (100 percent).

International fisheries governance is complex, as the ocean is geographically divided into different maritime zones subject to different legal regimes. The PSMA complements the United Nations Convention on the Law of the Sea, continuously adapting to address current and emerging issues in relation to fisheries – in particular, the persisting issue of some flag states' failure to responsibly control their vessels, known as flags of non-compliance.

By establishing the framework for port states to request specific information from foreign-flagged vessels seeking entry into ports under their jurisdiction, the PSMA empowers port states to check compliance of these vessels with applicable conservation and management measures (CMMs) and deny entry or use of port services if there is clear evidence of IUU fishing or related activities. In such a way, it promotes adherence and efforts to implement the United Nations Fish Stocks Agreement (UNFSA), the FAO Compliance Agreement, regional CMMs, voluntary fisheries instruments including the CCRF and related instruments. Moreover, through its requirements on information exchange between port state, flag state, coastal state and regional fisheries management organizations, the PSMA facilitates transparency of the fisheries sector and strengthens cooperation, coordination and consultation of relevant international instruments, frameworks and bodies.

With the support of FAO, parties to the PSMA have acted fast in moving to implement the agreement, including through established working groups, and a critical milestone has been reached with the effectiveness of the agreement at its highest level ever. FAO has facilitated discussions among states at regional level to identify operational challenges in the implementation of port state measures and to find ways to overcome them. The outcomes of these regional dialogues at the PSMA Strategy Ad Hoc Working Group enabled the Fourth Meeting of the Parties to the PSMA to adopt the "Strategy to Improve the Effectiveness of the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing" (Bali Strategy).[ak]

Sharing information on port entry/use denials and inspection reports is key for the effective implementation of the agreement to tackle IUU fishing. The Global Information Exchange System (GIES), which was developed by FAO at the request of the parties to the PSMA, enables the sharing of this information regionally and globally. It became operational towards the end of 2023 and includes functionalities to allow connections with similar systems used at regional level. Through such systems, notifications are automatically sent to the flag state, the home state of the vessel's master, any relevant coastal state, RFMO or international organization, and FAO.

The GIES is therefore the first such system handling compliance information at a global level; as such, this information refers to compliance or non-compliance with national legislation, regional CMMs, and requirements defined in other international instruments such as the UNFSA, the FAO Compliance Agreement and the Voluntary Guidelines for Transshipment (Box 22).

Other international instruments support the implementation of the PSMA in several ways. The Voluntary Guidelines for Transshipment[al] categorize the movement of fish as either transshipment or landing, through a transshipment or landing declaration, thereby eliminating loopholes that would result in uncontrolled and undeclared movement of fish. This is important when taking decisions for approving the advance request to allow entry or use of port as per Annex A of the PSMA.

A global capacity-development programme was launched by FAO in 2017 to support the implementation of the PSMA and complementary instruments to combat IUU fishing and it continues to expand. The programme is aligned with SDG Target 14.4 and also addresses Part 6 of the PSMA.[am] Through the programme, FAO has to date assisted over 50 countries in strengthening capacity to combat IUU fishing in line with international requirements; facilitated and supported global and regional consultative processes on the development and implementation of related international instruments;[an] and developed operational tools and resources to assist in their implementation.[ao]

Progress in implementing the FAO Voluntary Guidelines for Securing Small-Scale Fisheries in the Context of Food Security and Poverty Eradication

The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines [FAO, 2015]) are integral to the implementation of FAO's Blue Transformation. The SSF Guidelines capture the complexity of a highly diverse subsector. Small-scale fisheries not only supply aquatic products to a variety of markets, but also provide livelihoods, cultural values, and food security and nutrition to millions of people (FAO, Duke University and WorldFish, 2023b). Therefore, SSF governance must include livelihoods, with approaches that combine responsible fishing with equitable socioeconomic development, including gender equity (Box 23).

A decade after the FAO Committee on Fisheries endorsed the SSF Guidelines, their implementation continues to build on the inclusiveness that characterized their development. This requires support to and collaboration with SSF organizations, governments, development partners, regional organizations, NGOs and academia.

Pathways for transformational impact

Participatory governance through National Plans of Action for Small-Scale Fisheries

Global and regional policy processes and organizations have embraced the SSF Guidelines.

ak For full details, see: https://www.fao.org/iuu-fishing/resources/detail/en/c/1643116/

al See: https://www.fao.org/iuu-fishing/resources/detail/en/c/1638082/

am Part 6 of the PSMA addresses the requirements of developing states in relation to the implementation of port state measures consistent with the PSMA.

an For example, through the Voluntary Guidelines for Transshipment, the PSMA (with statutory and related meetings of the parties), and the Joint FAO/ILO/IMO Ad Hoc Working Group on IUU Fishing and Related Matters.

ao For further details, see: https://www.fao.org/iuu-fishing/en/

BOX 22 FAO VOLUNTARY GUIDELINES FOR TRANSSHIPMENT

Transshipment is one of the critical activities that legitimately support fishing globally today. However, as an in-depth FAO study concluded in 2020, the lack of regulation in the monitoring and control of transshipments increases the risk of fish derived from illegal, unreported and unregulated fishing entering the seafood supply chain, undermining sustainable and socially responsible fisheries. In 2021 and 2022, FAO conducted an expert and a technical consultation to elaborate Voluntary Guidelines for Transshipment, endorsed by the FAO Committee on Fisheries in 2022.

The Voluntary Guidelines for Transshipment* address the regulation, monitoring and control of the transshipment of fish that have not been previously landed, whether processed or not. They also regulate fish landing at port, setting out the requirements for a declaration. The guidelines aim to assist states, regional fisheries management organizations/arrangements (RFMOs/RFMAs), regional economic integration organizations and other intergovernmental organizations when developing new transshipment regulations, revising existing ones and aligning these with the broader international regulatory framework.

Implementation of these guidelines is critical as they are intended to fill a gap concerning a significant activity supporting fishing fleets in many places lacking global or common international standards. The guidelines enjoy high legitimacy and are therefore well placed to play this role.

It is the primary responsibility of the flag states to implement transshipment regulations; the Voluntary Guidelines for Transshipment recognize the role and duties of coastal states, port states and RFMOs, and build on this as follows:

- improving flag state performance (central to the application and implementation of international instruments) – flag states must establish conditions to authorize their vessels to tranship, have control and inspection capacity, engage with RFMOs, and develop reporting procedures to collect and cross-reference all reported transshipment data;
- strengthening the Port State Measures Agreement – port states have a critical role in overseeing landing and transshipment declarations;
- reinforcing the role of RFMOs – transshipment in the high seas must be subject to the competent RFMO's regulations, including membership or participation, which should be consistent with the guidelines' minimum standards; and
- underpinning coastal states' right to know and authorize transshipments in their jurisdictional waters, including their exclusive economic zones, and to exercise control through monitoring, control and surveillance measures.

Overall, the guidelines eliminate ambiguity, by stating that moving fish from one vessel to another or to a port needs to be defined either as a transshipment or as a landing. They regulate landing activities by establishing a landing declaration as a global standard to follow. Therefore, implementation of the Voluntary Guidelines for Transshipment will support and improve traceability and transparency in international fisheries, since all fish movements must be documented.

NOTE: * See: https://www.fao.org/iuu-fishing/resources/detail/en/c/1638082/

Implementation efforts are now focusing on national and local levels, where National Plans of Action for Small-Scale Fisheries (NPOAs-SSF) provide a systematic and holistic framework for accelerated transformation.

The number of countries developing or implementing a participatory NPOA-SSF is growing, with Madagascar, Malawi, Namibia, Uganda and the United Republic of Tanzania having such plans approved already, and the Philippines having started the process. For example, the United Republic of Tanzania, guided by its NPOA-SSF, has established a gender desk in the Ministry of Fisheries and Livestock and supports capacity development of beach management units to improve sustainable participatory fisheries management. In Namibia, »

BOX 23 BUILDING GENDER-TRANSFORMATIVE CHANGE IN FISHERIES AND AQUACULTURE

Gender equality is a fundamental principle underpinning every aspect of society. This is also the case in the fisheries and aquaculture sector, which directly contributes to global food security and the livelihoods of over 600 million people worldwide. Throughout aquatic food value chains, numerous gender-based constraints (GBCs) persist, impeding women's equal rights and opportunities. The most prevalent GBCs are linked to inadequate gender norms, which shape roles and responsibilities within communities and include unequal access to resources and services critical for pursuing income-generating activities; barriers preventing women from accessing decision-making spaces and power; and gender-based violence (GBV). These constraints hamper women's empowerment and significantly reduce their contribution to healthy aquatic food systems. The gendered division of labour, for example, can result in unequal work burdens, resulting in lower profitability and inadequate levels of decision-making power for women. Furthermore, women's economic independence and empowerment are often jeopardized by a disproportionate access to lucrative markets, or unfair assumptions of ownership of fishing or processing equipment, thus preventing women from investing in their businesses and consequently reducing their revenues and opportunities for entrepreneurship.

Gender-based violence is a pervasive issue that many women face in fisheries and aquaculture, albeit with different modalities and impacts: abusive behaviours frequent in ports, markets and landing sites can affect women physically, emotionally and sexually, exposing them to exploitative and hostile working environments. In some fisheries, women have reported verbal abuse as a common occurrence, with many cases of women facing difficulties in accessing markets (Rice *et al.*, 2023) due to discrimination and lack of security and infrastructures in landing sites (FAO, 2023a)

The cycle of economic dependency on male counterparts in exchange for fishing resources can expose women to transactional sex, including the practice of "fish-for-sex" and associated risks including GBV and HIV/AIDS. This phenomenon has been observed in various countries, where it has shown that women's limited financial independence inhibits their ability to negotiate boundaries, resulting in increases in HIV transmission and early pregnancy within the community (FAO, 2023a). An example of poor social norms that blame women for the spread of HIV among fishing communities was reported by women in communities on the shore of Lake Tanganyika, particularly during low catch periods, thus highlighting the linkage between inadequate norms and behaviours and the significant level of economic and health insecurity that women traders and processors face during their work (FAO, 2023b).

To address these multifaceted challenges, a comprehensive approach is essential. It requires the adoption of gender-transformative approaches (GTAs), supported by training such as that delivered through FAO projects in support of small-scale fisheries. The GTA seeks deeper solutions to redress power imbalances at individual and societal levels and foster women as agents of change. It involves challenging inadequate gender norms, promoting equitable decision-making, and fostering supportive environments where women can thrive in the sector. As part of the work to address GBCs, the FISH4ACP project (see **FISH4ACP: transforming aquatic food systems through a value chain approach**, p. 177) has developed a specific survey to uncover evidence and data on the phenomenon of fish-for-sex, establishing a foundation for discussing and understanding these dynamics.

In addition to this, the GTA has been applied by FAO to build more resilient and equitable aquatic food systems through capacity development of stakeholders at national and local levels, such as the work conducted through the project "Implementing the Small-Scale Fisheries Guidelines for gender-equitable and climate-resilient food systems and livelihoods" across different regions.

Implementing GTAs alongside gender-responsive interventions can pave the way towards a future where women and men enjoy equal rights, opportunities and empowerment within the fisheries and aquaculture sector, ultimately fostering sustainable and inclusive communities.

SOURCES: FAO. 2023a. *The contribution of women in small-scale fisheries to healthy food systems and sustainable livelihoods in Malawi.* Rome. https://doi.org/10.4060/cc7629en
FAO. 2023b. *The contribution of women in small-scale fisheries to healthy food systems and sustainable livelihoods in the United Republic of Tanzania*. Rome. https://doi.org/10.4060/cc5368en
Rice, E.D., Bennett, A.E., Muhonda, P., Katengeza, S.P., Kawaye, P., Liverpool-Tasie, L.S.O., Infante, D.M. & Tschirely. 2023. Connecting gender norms and economic performance reveals gendered inequities in Malawian small-scale fish trade. *Maritime Studies,* 22: 46. https://doi.org/10.1007/s40152-023-00337-x

» SSF communities have been involved in consultations on developing the access rules for a new dam, while in Madagascar over 70 stakeholders validated the NPOA-SSF, and specific actions such as capacity building for women's groups (including provision of small equipment) are underway. Meanwhile, Malawi and Uganda approved NPOAs-SSF in late 2023, and the Philippines have started the process.

The extent to which national laws, policies and judicial cases refer to the SSF Guidelines is critical for their implementation (Nakamura, Chuenpagdee and El Halimi, 2021), and is the focus of a new publication of the Too Big To Ignore research partnership (Nakamura, Chuenpagdee and Jentoft, eds, 2024). The FAO policy and legal database (SSF-LEX) reports that 18 countries already refer to the SSF Guidelines in their fisheries legislative or policy frameworks (FAO, 2023d). The range of materials available to support implementation of the SSF Guidelines continues to expand and includes publications and e-learning courses (e.g. on SSF governance and legal assessments), as well as training programmes conducted by partners such as the International Ocean Institute and International Labour Organization (ILO) on decent work and social protection.[ap] A monitoring, evaluation and learning framework developed through a participatory approach is available to help assess progress (FAO, 2023e).

Going beyond fisheries: bridging access to social protection and ensuring decent work

Broad approaches to improve coherence between social protection and fisheries management policies are critical for implementing the SSF Guidelines. Examples where coherence has been achieved exist in Colombia, Paraguay and Tunisia, as well as subregional Latin America. Here policy dialogues have brought together parliamentarians, national fisheries authorities and fisherfolk organizations. In Brazil, an impact evaluation of the fishers' unemployment benefits during closed fishing seasons showed that these benefits enabled fishers to better comply with fisheries management rules. The COVID-19 pandemic provided the opportunity to better understand the importance of community organizations for provision of social security support, particularly during idiosyncratic shocks. For example, revolving funds in Colombia provided loans for family contingencies, and associations in Mexico and Tunisia partnered with state-led social protection programmes to collect contributions and provide special contributory rates for fishers.

The Bay of Bengal Regional Fisheries Advisory Body recently adopted a plan of action for enhanced safety, decent work and social protection in fisheries (FAO, 2023f). The plan commits to intersectoral action that delineates policies and actions to enhance fisheries livelihoods, including through safety standards, decent working conditions and social protection.

Better data and evidence

It is said that "not everything that can be counted counts and not everything that counts can be counted". Small-scale fisheries often fall into the latter category. The global study on Illuminating Hidden Harvests (IHH) (FAO, Duke University and WorldFish, 2023b) attempts to defy this, providing policymakers with baseline information – not only on small-scale fisheries, but also on aquatic food systems, sustainable development and livelihoods more broadly. It shows that small-scale fisheries provide at least 40 percent of the global inland and marine catch and account for 90 percent of all people working in capture fisheries value chains. Taking into account subsistence activities and household dependents, IHH estimates that almost 500 million people's livelihoods depend at least partially on small-scale fisheries. The study offers new knowledge and identifies gaps and weaknesses in information systems to ensure SSF do not remain unrecognized. Countries such as Madagascar and the United Republic of Tanzania have embraced the IHH approach to review their SSF subsector contributions and identify related gaps and opportunities to improve the multidimensional evidence base for management, policy and governance. Moreover, the fragmented knowledge base for inland fisheries is being strengthened with reviews from China (FAO, 2023g), Guinea (Dia, 2023), India (FAO, forthcoming) and Latin America and the Caribbean (Baigun and Valbo-Jørgensen, eds, 2023).

ap For further details, see: https://www.fao.org/voluntary-guidelines-small-scale-fisheries/en

Strengthening small-scale fisheries organizations

Small-scale fisheries organizations are key to advocating for and driving the implementation of the SSF Guidelines. To support the role of women – who represent four out of ten people in SSF – FAO has developed a methodology to map women's fisheries organizations and used it in seven countries (Smith, 2022). The environmental stewardship role of SSF is another dimension that is receiving further recognition (Charles, Macnaughton and Hicks, 2024).

The working group on fisheries of the International Planning Committee for Food Sovereignty used its people-centred methodology to assess the implementation of the SSF Guidelines in Africa, Asia and Latin America.

In 2022, during the International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022, Box 24) and the UN Ocean Conference, a call to action from small-scale fishers around the globe was launched to support the implementation of the SSF Guidelines.[aq]

IYAFA 2022 was an opportunity for the establishment of a new SSF network (Ibero-American Small-Scale Artisanal Fishing Network), bringing together communities across Latin American and the Iberian Peninsula, and a pan-African coordination network (AFRIFISH-Net), uniting the five African subregional non-state actor platforms on fisheries and aquaculture. The platform for Eastern Africa prepared a policy gap analysis on the SSF Guidelines implementation that was presented to the Southern African Development Community.

In Asia, the Regional Advisory Group of the Global Strategic Framework in support of the implementation of the SSF Guidelines organized webinars and conducted a regional assessment of their implementation.

In the Mediterranean and Black Sea region, SSF development and governance are guided by a Regional Plan of Action for Small-Scale Fisheries (FAO, 2023h). In this context, the Small-Scale Fishers' Forum develops the capacity of SSF actors through interactive webinars and workshops on topics identified by SSF representatives.

The way forward: a new era of support for small-scale fisheries

The SSF Guidelines have re-asserted their role as accelerator in drawing attention to and generating action in support of the SSF subsector. This is also reflected in a significant increase in research on small-scale fisheries and new development partner engagement, such as the Oak Foundation's SSF programme[ar] and the SSF Hub[as] supporting implementation of the SSF Guidelines. The first decade of implementation has confirmed the importance of participatory processes, such as those applied in the development of NPOAs-SSF or through the regional SSF networks, and their ability to drive lasting change, highlighting the benefits of having different partners work under one agreed vision.

Implementation continues to be a non-linear process. Collective learning, dissemination of successful experiences, and sharing of good practices create and strengthen trust among stakeholders. Consequently, partners with complementary roles and strengths can collaborate, leveraging more action by all.

Managing shared fishery resources: the growing role of regional fishery bodies

Shared natural resources are particularly vulnerable to overexploitation (Liu and Molina, 2021), and international cooperation among countries sharing fishery resources is recognized as fundamental for the effective management of these resources.

The development of exclusive economic zones (EEZs) under Part V of the 1982 United Nations Convention on the Law of the Sea extended boundaries to 200 nautical miles offshore, to give coastal nations sovereign rights to sustainably exploit marine resources. However,

aq For further details and information on the national, regional and interregional civil society and NGOs supporting the call, please see: https://static1.squarespace.com/static/5d402069d36563000151fa5b/t/630f4ab9289a9e1070774c67/1661946566757/UNOC+Call+to+action+online+pdf.pdf

ar See: https://oakfnd.org/small-scale-fishers-supporting-people-and-nature-worldwide/

as See: https://ssfhub.org/

BOX 24 LEGACY OF THE INTERNATIONAL YEAR OF ARTISANAL FISHERIES AND AQUACULTURE 2022

Despite the continuing impacts of the COVID-19 pandemic, 61 partners signed up as official supporters of the 2022 International Year of Artisanal Fisheries and Aquaculture (IYAFA 2022),* and many others embraced the opportunity to focus the world's attention on the role that artisanal fisheries and aquaculture play in sustainable development and to stimulate related dialogue, initiatives and actions. This resulted in over 266 events conducted in 68 countries, at least 312 publications in 22 languages, and many other creative initiatives and promotional products, including official stamps, podcasts and videos. The final report published by FAO (FAO, 2023a) provides an overview of the objectives, activities and recommendations of the International Year.

The IYAFA 2022 recommendations echo the key messages of its Global Action Plan, which were validated, elevated and expanded throughout the celebrations. One additional recommendation that emerged strongly during the Year relates to the role of youth in achieving Blue Transformation targets and priority actions, and calls for intergenerational dialogues, knowledge sharing and mentoring, as well as for support for the integration of generational change into planning processes to preserve the continuity of traditional fisheries, while encouraging innovation. Additional region-specific recommendations for South America – developed with support from the regional IYAFA 2022 committee – were compiled as public policy recommendations (FAO, 2023b).

The Year ended with a strong call to maintain the momentum, as the end of IYAFA 2022 marked the beginning of a new era of support for and development of small-scale fisheries and aquaculture.

A major legacy of IYAFA 2022 is the call by the FAO Committee on Fisheries (COFI) to establish a Small-Scale Fisheries Summit** every two years prior to the biennial COFI sessions, creating a participatory platform for SSF actors to convene and collectively support the advancement of the implementation of the 2014 FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines). The first SSF Summit took place on 2–4 September 2022 in Rome and was organized by the International Planning Committee for Food Sovereignty Working Group on Fisheries, the General Fisheries Commission for the Mediterranean and the Small-Scale Fisheries Resource and Collaboration Hub with support from FAO. The Summit brought together more than 140 participants from over 40 countries, with a focus on fostering engagement and dialogue among small-scale artisanal fishers and fishworkers, key supporters, partners and decision-makers. Attendees shared their challenges while collaborating to build a common vision around crucial topics relevant to small-scale artisanal fisheries. They also proposed actionable solutions for a new era of support for small-scale fisheries and the communities that depend on them.

NOTES: * See the IYAFA 2022 website: https://www.fao.org/artisanal-fisheries-aquaculture-2022/home/en/
** See the Small-Scale Fisheries Summit website: https://www.fao.org/artisanal-fisheries-aquaculture-2022/events/events-detail/en/c/1601136/

SOURCES: FAO. 2023a. *International Year of Artisanal Fisheries and Aquaculture 2022 – Final report*. Rome. https://doi.org/10.4060/cc5034en
FAO. 2023b. *Recomendaciones de políticas públicas para el desarrollo sostenible de la pesca y la acuicultura artesanales en pequeña escala en América del Sur - Lineamientos de políticas para las autoridades* [*Public policy recommendations for the development of sustainable small-scale artisanal fisheries and aquaculture in South America – Policy guidelines for authorities*]. Santiago. https://doi.org/10.4060/cc4105es

EEZ boundaries cut across the distribution of many species, turning stocks not constrained by human boundaries into shared resources. Similarly, management of shared inland fishery stocks spanning multiple countries requires international cooperation and effective approaches for collaboration among users.

Transboundary issues in fisheries are likely to become more significant in coming years. The number of fishing countries, and the overall number of shared fisheries, have steadily increased since the 1950s, creating additional competition (Teh and Sumaila, 2015). In addition, climate change is causing species to shift their natural distributions (Pinsky *et al*., 2013), further increasing the need for effective international management agreements (Cheung *et al*., 2012; Pinsky *et al*., 2018).

Living aquatic resources are a global common pool resource managed under national jurisdictions (e.g. territorial waters) and by different international organizations and RFBs.[at] UNCLOS encourages states to cooperate with each other in the conservation and management of living marine resources through the establishment of RFMOs.

Blue Transformation promotes effective policies, governance and institutions to support fisheries through actions leading to the adoption and implementation of new and existing international instruments, regional coordination mechanisms, plans of action, and guidelines.

For effective implementation, global instruments and normative processes should be streamlined into legal and policy instruments and actions at the country and regional level. In this regard, regionalization of fisheries governance provides opportunities to address common concerns while fostering synergies to achieve the global objectives of relevant UN bodies (Løbach *et al*., 2020).

Since its creation, FAO has promoted and supported RFMOs and RFABs, including their cooperation through the RFB Secretariats' Network.[au] The present and future role of RFBs is particularly relevant today, as countries face old and new challenges requiring transformational action to implement effectively international fisheries management and ocean governance instruments.

Highest on the agenda is the Port State Measures Agreement, adopted by FAO in 2009 to combat IUU fishing. The role of RFMOs has prominence throughout the PSMA provisions requiring parties to cooperate fully in the effective implementation of the agreement, including through RFMOs.

Similarly, the role of RFMOs is crucial for the 2022 World Trade Organization (WTO) Agreement on Fisheries Subsidies, as 80 percent of the 164 WTO members are party to at least one RFMO, with 74 members party to more than one. As a major step towards ocean sustainability, the agreement aims to prohibit harmful fisheries subsidies to parties involved in, for example, IUU fishing, fishing of overfished stocks, and operations in high seas areas not under the management of RFMOs. It also prohibits all subsidies for fishing and related activities that take place in areas outside the jurisdiction of coastal states and the competence of an RFMO (see **The WTO Agreement on Fisheries Subsidies, the sustainability of fishery stocks and the role of FAO**, p. 168).

Sustainable management of inland fisheries is challenged by competing water uses for irrigation, livestock or hydropower, further exacerbated by increasing water scarcity and pollution. To address these challenges, FAO is promoting collaboration and synergies between inland RFBs and basin management organizations responsible for activities such as hydropower, agriculture and mining (Box 25).

In 2023, a milestone was reached with the adoption of a new international legally binding instrument for the conservation and sustainable use of marine biological diversity within areas beyond national jurisdiction (ABNJ): the BBNJ Agreement. Several provisions in the agreement stress the need for coherence and coordination with relevant international instruments and sectoral bodies, and the strengthening of existing organizations. However, not enough focus has been placed on the important link between the BBNJ Agreement and the ecosystem services provided in waters under national jurisdiction. The management of the marine environment in ABNJ and the fisheries productivity and biodiversity within territorial waters are indeed connected (Popova *et al*., 2019; Ramesh *et al*., 2019). Such connectivity requires developing cooperative frameworks among RFBs, as appropriate. Box 26 presents an example of FAO's work to strengthen partnerships for managing resources in the high seas

With over 50 RFBs addressing fisheries in marine and inland waters worldwide,

at Regional fisheries management organizations (RFMOs) and regional fisheries advisory bodies (RFABs) are collectively referred to as regional fishery bodies (RFBs).

au See: https://www.fao.org/fishery/en/rsn

BOX 25 INTEGRATED WATER RESOURCES MANAGEMENT: THE CASE OF THE KOMADUGU YOBE BASIN OF LAKE CHAD

Integrated water resources management (IWRM), as defined by the United Nations Environment Programme in 2002, is a comprehensive approach that coordinates the management of water, land and related resources. It aims to optimize economic and social welfare equitably while preserving vital ecosystems. Inland fisheries, which are critical for the nutrition, food security, and livelihoods of many communities, are often overlooked in IWRM plans.

In the case of the Komadugu Yobe Basin, located upstream of Lake Chad in northern Nigeria, the implementation of IWRM has shown how integrated approaches can ensure equitable economic and social welfare outcomes while sustaining essential ecosystems. The construction of two large dams in the 1970s, combined with extensive water extraction for irrigation and the impacts of regional climate change, significantly altered the seasonal river flows, leading to severe environmental degradation. These changes, exacerbated by fragmented regulations and overlapping institutional responsibilities, adversely affected fishing, farming and pastoralist livelihoods, causing conflicts over resource use.

The adoption of an IWRM strategy through catchment management planning addressed these challenges. This strategy emphasized collaboration and active participation from all stakeholders, including under-represented groups such as women. Community leaders, exemplified by Alhaji M. Ibrahim Chedi, a village leader and fisher, showcased the readiness to take any measures necessary to ensure the river's health, directly linked to their livelihoods (Barchiesi *et al.*, 2012).

The Catchment Management Plan and the introduction of a Water Charter led to the formation of new institutions, empowering stakeholders in the planning process. This initiative gave stakeholders a voice in water resource planning and equipped them with tools to manage potential challenges. These governance structures are now being replicated across Nigeria and scaled up through the Lake Chad Basin Commission.

The emergence of a revamped water governance structure has facilitated more transparent coordination of water resources, aiming to address degraded ecosystems and restore traditional river flow patterns. Open dialogues have been crucial in reducing conflicts, reflecting the community's renewed optimism and faith in the basin's potential. In response, state governments and the Federal Government of Nigeria have committed significant funds for the basin's rejuvenation.

The Komadugu Yobe Basin initiative exemplifies the environmental and social benefits of an integrated, multisectoral approach in managing shared water resources. It underscores the importance of including all stakeholders in the solution, supporting sustainable practices in fisheries, agriculture, aquaculture and forestry, resulting in resilient communities. This case study demonstrates that comprehensive, inclusive resource management is pivotal for achieving sustainable development and it highlights the role of IWRM in facilitating such outcomes.

SOURCE: Barchiesi, S., Cartin, M., Welling, R. & Yawson, D. 2011. *Komadugu Yobe Basin, upstream of Lake Chad, Nigeria: Multi-stakeholder participation to create new institutions and legal frameworks to manage water resources.* Water and Nature Initiative (WANI) Demonstration Case study No. 1, IUCN, Gland. [Cited 11 January 2024]. https://www.fao.org/fishery/en/openasfa/a476e1b5-890d-4245-9f08-ea0cf8f7f514

issues of overlapping and fragmentation of mandates emerge. Enhancing cooperation and coordination among RFBs has for many years been on the agenda of the United Nations General Assembly and its resolutions on sustainable fisheries. Nearly 50 percent of RFBs cooperate effectively for developing fishery statistical standards (see **Technology and innovation for sustainable fisheries**, p. 164). In 2021, FAO requested RFBs to adopt common approaches on various cross-cutting issues. In 2023, FAO convened two regional consultations to support and develop a framework for identifying the coordination and cooperation »

BOX 26 PARTNERSHIPS FOR MANAGING HIGH SEAS RESOURCES

FAO's Blue Transformation calls for the effective management of 100 percent of fisheries to achieve ecological, social and economic objectives. It prioritizes actions that would facilitate the development of innovative data and information systems to support fisheries policy formulation, assessment and management, through strong and recognized partnerships, especially in relation to resources in the high seas.

Common Oceans Program. The Common Oceans Program (2022–2027) is a Global Environment Facility-funded partnership of regional fisheries management organizations (RFMOs), intergovernmental organizations, civil society and the private sector that aims to bolster the sustainable use of marine resources and biodiversity conservation in areas beyond national jurisdiction (ABNJ). It is implemented jointly by FAO, the United Nations Environment Programme and the United Nations Development Programme. It aims to bring about transformational changes by making use of the best scientific knowledge and expertise of over 65 partners, and to encourage coordinated global action, innovation and improved performance in the ABNJ. Key activities of the partnership are described below:

- The **Common Oceans Tuna project** follows ongoing processes in five tuna RFMOs. This includes support for the implementation of the ecosystem approach to fisheries (EAF) and the adoption of harvest strategies for all 23 major tuna stocks. Sustainable fisheries are promoted through market incentives in four Pacific Island countries. Joint tuna RFMO working groups on topics of common interest reinforce collaboration and the sharing of experiences and lessons learned and identify possible harmonized actions. Partners work on strengthening monitoring, control and surveillance, and compliance through capacity building, training courses and compliance support missions. Regarding the reduction of the environmental impacts of tuna fisheries, the project promotes six innovative tools for improving monitoring, bycatch mitigation, and traceability, as well as reducing marine pollution.
- The **Deep-sea fisheries (DSF) project** applies participatory approaches to tackle technical, scientific and procedural challenges in the management of resources in ABNJ. The project aims to strengthen the management of DSF through training and capacity building on, for example, stock assessment, developing tools, guidelines and frameworks for the implementation of the EAF in eight RFMOs, and fostering dialogue between different sectors. It targets reducing the impacts of DSF on vulnerable marine ecosystems (VMEs) by mapping identified VME sites and developing guidance on their protection, and on deepwater sharks by developing identification guides and data collection protocols.
- FAO has been developing a **global database on VMEs in ABNJ** at the request of the United Nations General Assembly (61/105) to assist RFMOs and regional fisheries management arrangements (RFMAs) and states in sharing information and raising awareness of fishery policymakers, managers, scientists and the public at large on DSF and their interactions with VMEs. The database – a joint effort from eight RFMOs and FAO – represents a good example of partnership in support of management of high seas resources.*

The FIRMS Partnership. The FAO Fisheries and Resources Monitoring System (FIRMS) Partnership** aims at facilitating access to high-quality web-based information on global marine fishery resources and their management. It intends to provide decision-makers with information to develop effective fisheries policies in accordance with the Code of Conduct for Responsible Fisheries. The partnership – established in 2004 – brings together 22 institutions including 18 intergovernmental organizations representing 23 regional fishery bodies contributing over 1 000 out of the 2 400 records of the FIRMS inventory of stock assessment units and about 300 fisheries monitored, guided or managed by these organizations.

Among the information shared in FIRMS on high seas resources, the five tuna RFMOs report area-specific catches of tuna and tuna-like species within the FIRMS Global Tuna Atlas launched in May 2022; and the deep-sea high seas RFMO partners regularly report on the status of fisheries management under their mandate.

FIRMS strategic decisions for the next decade include disseminating timely data on the state of stocks in support to SDG Indicator 14.4.1 (Proportion of fish stocks within biologically sustainable levels) for reporting on fisheries management in the context of the new COFI Sub-Committee on Fisheries Management, contributing to small-scale fisheries data collection and fostering interoperability among data systems.

NOTES: * Please see: FAO. n.d. Vulnerable marine ecosystems. In: *FAO*. [Cited 28 September 2023]. https://www.fao.org/in-action/vulnerable-marine-ecosystems/en/
** Please see: FAO. 2023. Fisheries and Resources Monitoring System (FIRMS). In: *FAO*. [Cited 28 November 2023]. https://firms.fao.org/

» priorities among RFBs to achieve effective fisheries governance. As a result, organizations from the same region came together to share views and gain valuable insights on matters and topics of common interest and concern, to find solutions and identify supporting tools and services (FAO, 2023i). FAO and partners will continue to develop mechanisms of cooperation in the management of shared resources, with the objective of ensuring that all fishery resources are placed under effective management.

Managing marine fisheries for sustainability: a focus on the Code of Conduct for Responsible Fisheries

Fisheries management is defined as:

> the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives (FAO, 1997).

Article 7 of the FAO Code of Conduct for Responsible Fisheries (CCRF) addresses the necessary requirements, ways and means to achieve effective fisheries management. An integral first step in designing and implementing effective fisheries management is to agree on the objectives, preferably formalized into management plans. Article 7.2 emphasizes the need to set long-term management objectives, which should not be compromised by short-term considerations. This is particularly important – but very challenging – in the context of weak or unstable institutional arrangements. In this respect, it is critical to empower stakeholders and institutions to design, implement and monitor fisheries management decisions and ensure compliance with regulations, leading to resilient fisheries, improved livelihoods and long-term resource sustainability. Institutional and regulatory frameworks, together with social, cultural and human capital, are key for achieving this.

FAO's Blue Transformation (FAO, 2022a) emphasizes the need to accelerate the development of effective policies, governance structures and institutions in support of fisheries management. This encompasses adoption of existing national and international instruments, strengthening regional coordination mechanisms, and implementing national plans of action. It aims to achieve 100 percent of fisheries under effective management, with full, productive and decent work for all women and men in the sector by 2030.

In many developing countries, the capacity to manage fisheries is limited. Participatory governance regimes have tended to develop deliberate and collective responses that strengthen fisheries management. Lessons learned from the various forms of traditional and community-based management can be useful to guide their further implementation (Galappaththi *et al*., 2021). Proper training and capacity development of industry and government staff that support effective and participatory fisheries management and governance are critical, particularly in the context of small-scale fisheries. Part 2, section 5 of the SSF Guidelines provides a comprehensive course of action to promote the development of adaptive co-management systems with an active role of empowered local communities in the governance of tenure in SSF and resource management (FAO, 2015).

The CCRF acknowledges the need to aim beyond the long-term sustainability of fishery resources and promotion of their optimum utilization, to support achieving social and economic objectives (Article 7.4.5). Throughout most of the 20th century, fisheries management objectives were largely centred around maximizing yield from capture fisheries. Most stock assessment methods applied in developed countries with high technical capacity and resources focused on how to estimate optimal yield from individual species within specific fisheries. In the 21st century, fisheries management objectives have gradually broadened to address the risk of overfishing target stocks and the protection of the biodiversity of target stocks and wider marine ecosystems (Caddy, 1999; Cochrane, 2000; FAO, 1995a; Mace, 2001). These changes have involved an increased recognition, development and implementation of precautionary approaches to fisheries management (Article 7.5).

Management objectives have gradually expanded to consider the wider social and ecological systems in which fisheries operate. This has resulted in widespread adoption of the ecosystem approach to fisheries (EAF), which encompasses the wider range of ecological, economic and social objectives.[av]

For any individual fishery, several but not necessarily all of these objectives may be targeted: some objectives may be specific to the unique context of an individual fishery, while some may carry more weight than others. For some fisheries, objectives are explicitly stated, for example in a fisheries management plan; in other contexts, an objective may be simply implied as part of wider management goals.

As fisheries management objectives broaden, managers have recognized the need to consider the related trade-offs. Common trade-offs between objectives include catch (a food production objective) versus the extent of acceptable stock depletion. The social objectives of job creation may contrast with greater efficiency or economic profitability. Similarly, minimizing aquatic environmental impacts – by significantly reducing fishing or by not fishing – can exacerbate food insecurity, unemployment or economic benefits. Trade-offs between exporting the catch to lucrative international markets and selling in the domestic market often require an assessment of the economic returns compared to the social impact on food security and nutrition. Striking an appropriate balance between competing objectives depends greatly on national policies and fishery-specific goals, with different countries (or fisheries managers within the same country) weighing differently alternative objectives. Article 10 of the CCRF recommends to base decision-making (when weighing between management objectives) on multidisciplinary research to assess the economic, social and cultural benefits of fishery resources. To this end, FAO, Duke University and WorldFish have recently developed and published a study to illustrate and inform on the environmental, social, economic and nutritional contributions of SSF (FAO, Duke University and WorldFish, 2023). In 2020, FAO Members reported that on average, approximately 92 percent of fisheries were under management plans in developed countries, compared with just 60 percent in developing countries. The gap widens when considering the proportion of fisheries management plans actually implemented: 92 percent and 56 percent, respectively.[aw] A major issue reported is the lack of capacity to design and implement management plans in developing countries, particularly for SSF.

FAO's Blue Transformation Roadmap reiterates the Organization's commitment to support capacity development to adopt and implement fisheries management plans and strategies that consider trade-offs and address ecological, social and economic objectives. It requires the design, implementation and monitoring of management plans and strategies to be based on the best available science and data, including traditional knowledge to inform management decisions.

Poor quality data often relate to insufficient financial and human resources to implement rigorous data collection systems, or inadequate technical capacities to analyse and interpret the available data. Several approaches have been implemented to address data and information deficiencies, including partnering with industry to share information collected during fishing (Mackinson *et al*., 2023), institutionalizing community-based data collection programmes in consultation with fishers and scientists (Schroeter *et al*., 2009; Haridhi *et al.*, 2021), maximizing the use of traditional knowledge (Al Mamun *et al*., 2023), and upgrading technical capacity both to design cost-effective data collection systems, and for the management, curation, interpretation and analysis of data and information (Gutierrez *et al*., 2023). While the implementation of these solutions is expanding, many fisheries remain within the data-limited realm, for which a precautionary approach should be considered. As stated in the CCRF: "the absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures".

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av For further details, see: https://www.fao.org/fishery/en/eaf-net/about/what-is-eaf

aw For more details, see: https://www.fao.org/3/nj568en/nj568en.pdf

BOX 27 EAF-NANSEN PROGRAMME: ACHIEVEMENTS IN FISHERIES MANAGEMENT AND ASSESSMENT

The Nansen Programme is a longstanding partnership between the Food and Agriculture Organization of the United Nations (FAO) and Norway, aimed at enhancing the contribution of aquatic food systems to food and nutrition security in partner countries.

In 2017, a new phase of the EAF-Nansen Programme Agreement was signed by the Norwegian Agency for Development Cooperation, FAO and the Institute of Marine Research, Norway. This expanded the programme's support to implement an ecosystem approach to fisheries (EAF) management and increased its efforts to target emerging threats to ocean sustainability, including climate change, aligned with FAO's vision for Blue Transformation.

By generating knowledge on marine resources and ecosystems, promoting the implementation of the EAF framework, and developing partners' capacities for fisheries research and management, the programme has yielded many important achievements.

From 2017 to 2023, the research vessel *Dr Fridtjof Nansen* hosted 672 researchers (32 percent female) from 42 countries to acquire and analyse knowledge, data and information for use in advising fisheries management. More than 100 scientific publications resulted from the programme, covering a wide range of scientific topics spanning ecology, biology, nutritional value, habitats and climate change. Twenty-four new marine species were discovered, bringing the total to 88 new species since the inception of the programme.

The programme contributed to the scientific advice processes of regional organizations such as the Fishery Committee for the Eastern Central Atlantic (CECAF), the Southwest Indian Ocean Fisheries Commission (SWIOFC), the Benguela Current Convention (BCC) and the South East Atlantic Fisheries Organization (SEAFO), conducting marine surveys, supporting analysis and assessments by regional scientific working groups, and disseminating advice, knowledge and information at statutory meetings of these organizations.

The programme developed a diagnostic tool for implementing the EAF through policy and legal frameworks to support partners in assessing alignment with the EAF (FAO, 2021a). A total of 144 people (31 percent female) were trained to use this tool, 31 national EAF assessment reports were produced, and six countries received support to review their fisheries legislation and policies for better alignment with the EAF. Nine countries and two regions were assisted with EAF-compliant national and shared stocks fisheries management plans. A different tool for monitoring the implementation of the EAF was developed, and over 250 fisheries stakeholders were trained on its application for 40 fisheries in seven African countries to set baselines and monitor progress. Through targeted training, the capacity of 794 people (38 percent female) from partner institutions was strengthened on the EAF, shared stocks management, gender mainstreaming, survey data analysis, stock assessment methods and tools, and data collection practices.

In 2024, the EAF-Nansen Programme embarks on a new five-year phase, building on lessons learned and achievements from previous years. The programme will have an even stronger focus on the nexus between fisheries management and science, while strengthening linkages to the broader ocean governance framework, contributing to the Sustainable Development Goals and the United Nations Decade of Ocean Science for Sustainable Development (2021–2030).

***Dr Fridtjof Nansen* research vessel**
© FAO/Mariano Silva

Researcher aboard the *Dr Fridtjof Nansen* research vessel
© FAO/Mariano Silva

SOURCES: FAO. 2021a. *A diagnostic tool for implementing an ecosystem approach to fisheries through policy and legal frameworks*. Rome. https://doi.org/10.4060/cb2945en
FAO. 2021b. *Ecosystem approach to fisheries implementation monitoring tool – A tool to monitor implementation of the ecosystem approach to fisheries (EAF) management. User manual.* Rome. https://doi.org/10.4060/cb3669en

» Together, the CCRF, the SSF Guidelines, the EAF and Blue Transformation promote environmentally and socially responsible fisheries management necessary to ensure the vitality of aquatic ecosystems together with equitable sharing of the benefits. Moreover, they provide the basis to formulate appropriate governance frameworks for fisheries management, which respect and incorporate traditional knowledge and practices, within wider environmental, economic and social management approaches (Box 27).

Evolving the way we assess the status of marine fishery stocks

Since its first publication of the global review of marine fishery stocks in 1971 (Gulland, 1971), FAO has been regularly assessing the state of world marine fishery resources, and since 1997 these results have been reported in *The State of World Fisheries and Aquaculture* reports. The objective of the FAO assessments is to provide an overview of the global and regional state of marine fishery resources to support policy and management action to secure the long-term sustainability of fishery resources. The current methodology was adopted in 2011 (FAO, 2011a) and implemented on a list of regional and global fishery stocks that has since remained the same to maintain the integrity of the time series. FAO considers that the time is right to update the assessment methodology as well as the list of fishery stocks to be included, to better respond to the changes in fisheries assessment and management as well as in fishery target species, while ensuring the integrity of the time series.

The updated methodology will be applied in a transparent manner, with new reporting formats, and with direct engagement with the growing global, regional and national community of assessment and management experts. The process begins with an update of the list of fishery stocks considered in the analysis in each FAO region, to better reflect current fishery activity in that region. This process is done collaboratively with local institutions and experts, primarily through regional workshops, but including other consultations such as the Sub-Committee on Fisheries Management of the FAO Committee on Fisheries or the process of national reporting of SDG Indicator 14.4.1 (Proportion of fish stocks within biologically sustainable levels) (see **Status and trends of Sustainable Development Goal 14 indicators under FAO custodianship**, p. 100).

Depending on the quality of the data and supplementary information available for each region, a tiered assessment approach will then be implemented:

1. Tier 1 – Stocks for which traditional stock assessments are available and deemed reliable. Formal results are used by FAO as reported by regional fishery bodies and/or national authorities.
2. Tier 2 – Stocks for which no formal assessments are available, but for which alternative approaches (such as stock reduction analysis plus [SRA+][ax]) can be adopted. This is the case if supplementary information, such as external data on landings with abundance indices (or the fishery-dependent standardized catch per unit effort [CPUE]), exists or when expert-driven priors for depletion (in the absence of CPUEs/abundance data) are available to derive a state of the particular stock.
3. Tier 3 – Where data are insufficient for either Tier 1 or Tier 2 approaches, a weight-of-evidence[ay] approach to categorize the status of the stock based on qualitative/semi-quantitative information will be used (Souza *et al.*, forthcoming).

Box 28 presents the 2021 FAO State of Stocks Indexes obtained with the current and updated methodology resulting from the first set of regional consultations conducted in six FAO statistical areas. Findings from these consultations were presented to the First Session of the COFI Sub-Committee on Fisheries Management in January 2024, also comparing the metrics derived using the current and updated methodology for 2019. A forthcoming edition »

ax SRA+ includes options to estimate depletion based on external covariates (Ovando *et al.*, 2021).

ay The weight-of-evidence approach was initially developed by Australia (Stobutzki *et al.*, 2015) to hypothesize alternative states on nature of the population 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.

BOX 28 REGIONAL CONSULTATIONS ON MARINE FISHERY STOCK ASSESSMENT

Regional consultations on the updated methodology for assessing stocks were conducted virtually and in person between 2022 and 2023 for: (i) area 31 (Western Central Atlantic); (ii) area 34 (Eastern Central Atlantic); (iii) area 37 (Mediterranean and Black Sea); (iv) area 41 (Southwest Atlantic); (v) area 51 (Western Indian Ocean); and (vi) area 57 (Eastern Indian Ocean). Engagement of local and regional experts and analysis were upscaled: 200 individuals were trained in person and another 65 virtually; 63 countries were consulted regarding the updated FAO State of Stocks Index (SoSI); and the stocks examined increased from 189 aggregated to 1 093 disaggregated stocks (see table).

RESULTS OF THE PILOT PHASE

While the results for areas 51 and 37 are still preliminary, for areas 41 and 34, the percentage of overfished stocks is relatively similar (41.2 percent vs 39.3 percent overfished for area 41, and 51.3 percent vs 48.8 percent overfished for area 34), compared with a substantial decrease from 42.0 percent to 31.8 percent in area 31, and from 36.5 percent to 28.9 percent in area 57 (see figure). The probable reason for the decrease in these two areas is the addition of many smaller units that are important regionally, increasing the stocks of importance being sustainably fished and decreasing the proportion of overfished stocks.

Some consultations also produced useful infographics synthesizing the information as illustrated for area 57. The infographic illustrates the key fisheries data from the region, including the state of stocks and the importance of fisheries in terms of fishing vessels and fishers.

The consultations at the regional level supported the use of FAO-validated data to convey region-wide information and messaging. This can be useful for preparing policy briefs at a regional or country level.

COMPARISON OF FAO STATE OF STOCKS INDEXES: CURRENT VS UPDATED METHODOLOGIES FOR SIX FAO MAJOR FISHING AREAS (REFERENCE YEAR 2021)

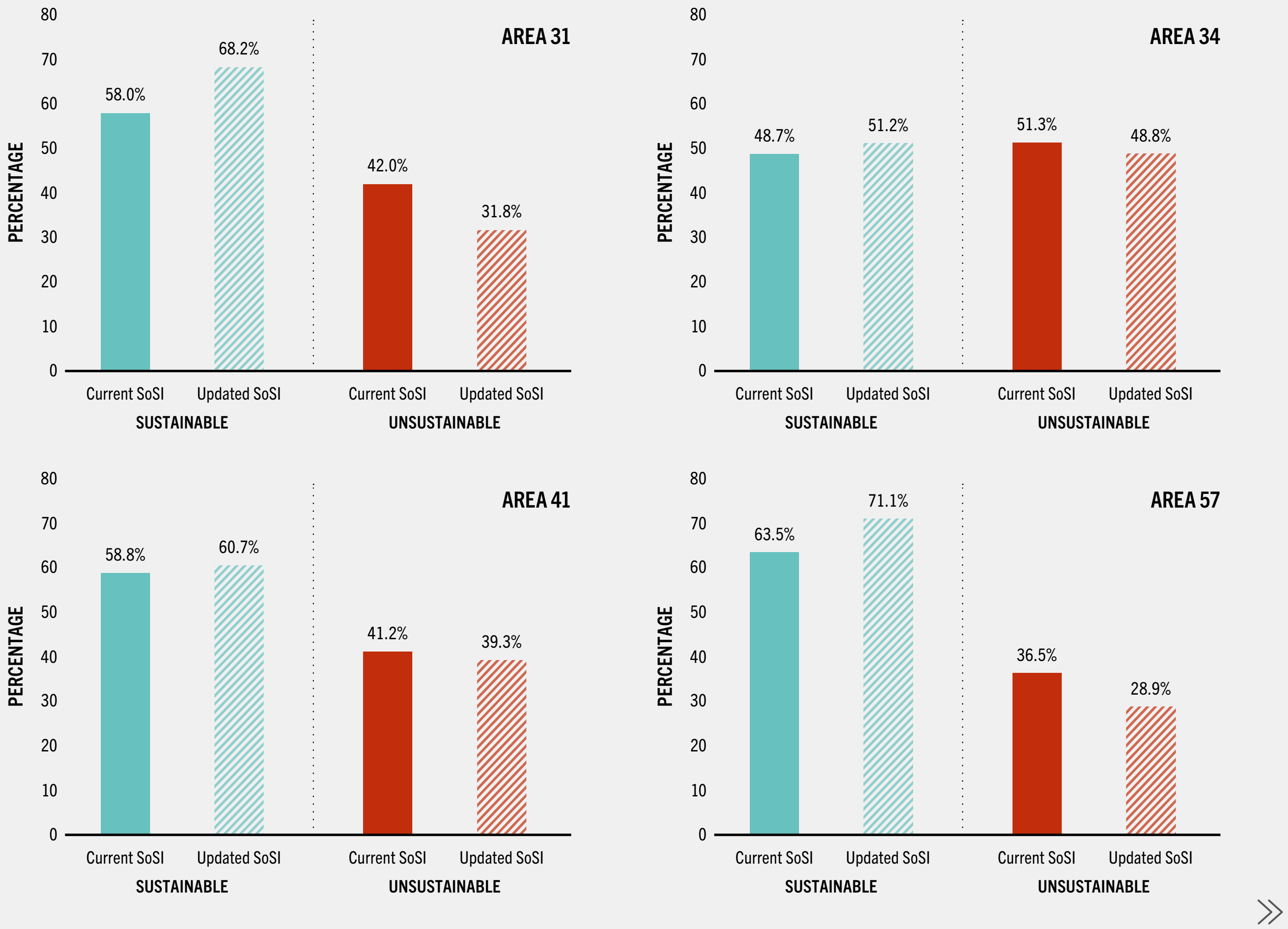
Area	No. of stocks examined		Current SoSI categories					Updated SoSI categories				
	Current SoSI	Updated SoSI	Underfished	Maximally sustainably fished	Overfished	Sustainable	Unsustainable	Underfished	Maximally sustainably fished	Overfished	Sustainable	Unsustainable
31	39	99	10.0%	48.0%	42.0%	58.0%	42.0%	13.9%	54.3%	31.8%	68.2%	31.8%
34	36	135	10.3%	38.5%	51.3%	48.7%	51.3%	15.5%	35.7%	48.8%	51.2%	48.8%
37*	30	158	2.5%	35.0%	62.5%	37.5%	62.5%	0.2%	32.6%	67.2%	32.8%	67.2%
41	15	68	5.9%	52.9%	41.2%	58.8%	41.2%	10.0%	50.7%	39.3%	60.7%	39.3%
51*	30	298	3.1%	59.4%	37.5%	62.5%	37.5%	22.5%	47.3%	30.2%	69.8%	30.2%
57	39	335	11.6%	51.9%	36.5%	63.5%	36.5%	33.5%	37.6%	28.9%	71.1%	28.9%
TOTAL	**189**	**1093**										

NOTES: FAO Major Fishing Areas: area 31 (Western Central Atlantic); area 34 (Eastern Central Atlantic); area 37 (Mediterranean and Black Sea); area 41 (Southwest Atlantic); area 51 (Western Indian Ocean); area 57 (Eastern Indian Ocean). * Data for areas 37 and 51 are preliminary. SoSI – FAO State of Stocks Index.

SOURCE: Author's own elaboration.

BOX 28 (Continued)

COMPARISON OF FAO STATE OF STOCKS INDEXES: UPDATED VS CURRENT METHODOLOGIES FOR FOUR FAO MAJOR FISHING AREAS (REFERENCE YEAR 2021)



NOTES: FAO Major Fishing Areas: area 31 (Western and Central Atlantic); area 34 (Eastern Central Atlantic); area 41 (Southwest Atlantic); area 57 (Eastern Indian Ocean). SoSI – FAO State of Stocks Index.

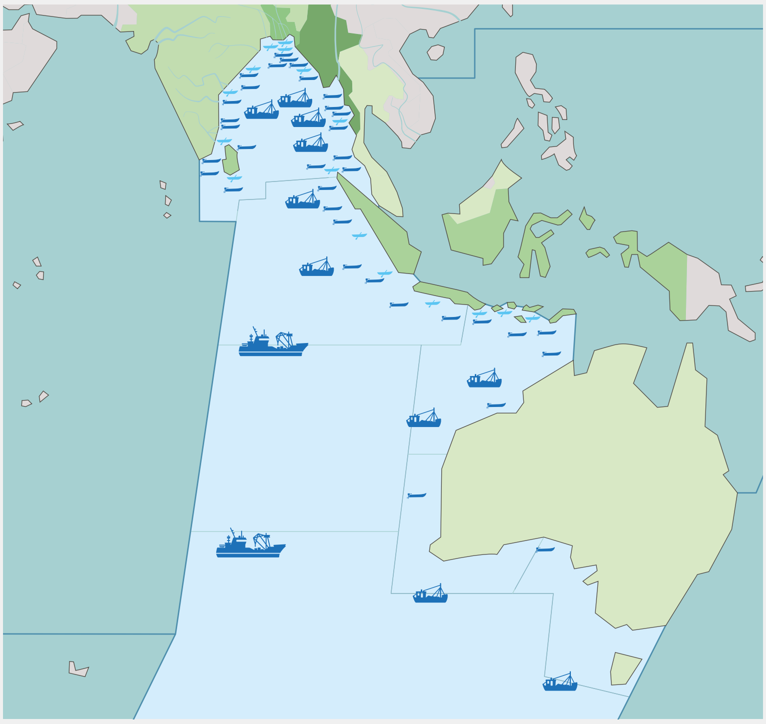
SOURCE: Author's own elaboration.

» of the FAO Technical Paper *Review of the state of world marine fishery resources* will describe the methodology and results in detail.

The Sub-Committee examined a detailed work programme to support achieving the objectives of updating the indicator of the status of marine resources. This programme illustrates examples of the tiered analysis and communication approaches (see the infographic in Box 28) that will be featured in the 2026 edition of this report after a full roll-out in all FAO statistical »

BOX 28 (Continued)

INFOGRAPHIC FOR AREA 57 ILLUSTRATING THE IMPORTANCE OF FISHERIES IN ECONOMIC VALUE, EMPLOYMENT, FISHING EFFORT AND THE STATE OF STOCKS IN THE REGION



Map shows preliminary analysis of the relative importance of fisheries employment in national labour forces and effort in the region (based on regional expert opinion).

RELATIVE IMPORTANCE OF FISHERIES EMPLOYMENT

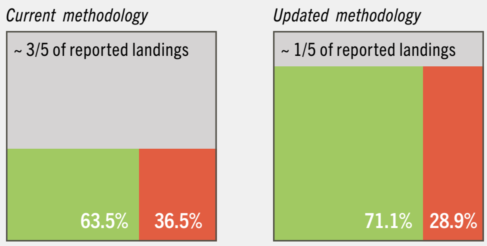
– +

KEY MESSAGES

- The region's share of artisanal fleets is one of the largest in the world. Millions of people in this area depend on fisheries for livelihoods and food security.
- The increase in landings up to 2017 can be attributed to higher catches and improved data collection, while the recent decrease appears to be due to a reduction in fishing pressure.
- The small-scale and multispecies nature of the majority of the region's fisheries, especially in the Bay of Bengal, poses challenges for both data collection and management systems.
- There is a growing social awareness, technological capacity and political will to manage fisheries sustainably.
- Fisheries in this region are important economically, nutritionally and culturally – but climate change poses a significant future risk.

STOCK STATUS (reported landings)

FAO estimates, 2021

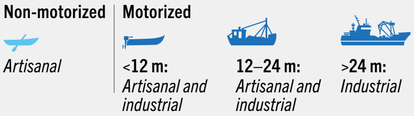


Biologically sustainable
Biologically unsustainable
Unassessed reported landings

FLEET SIZE AND COMPOSITION

FAO data, 2021

Active vessels ~ 1.8 million



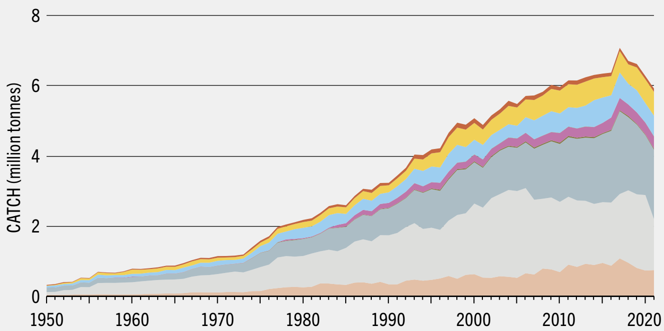
Non-motorized: 20%
Motorized: 80%

Data on fleet refer to the countries bordering the fishing area. Data do not include fishing vessels from distant water fleets operating in this area.

SPECIES COMPOSITION

FAO data, 2021

Composition of stocks by taxonomic group



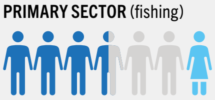
Data refer to aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, sponges, corals, pearls and algae.

EMPLOYMENT

FAO data, 2021

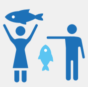
Fishers ~ 7 million

PRIMARY SECTOR (fishing)



Male: 49%
Unspecified: 38%
Female: 13%

= 1 MILLION PEOPLE



Women account for half of those employed in the full value chain of capture fisheries at global level.*

Data on employment refer to the countries bordering the fishing area. Data do not include fishers from distant water vessels fishing in this area.

* FAO. 2022. *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation.* Rome. https://doi.org/10.4060/cc0461en

LANDINGS

FAO data, 2021

Reported landings ~ 5.9 million tonnes

Unidentified: 25%
Identified at species group level: 75%

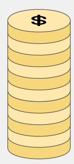
Data refer to aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, sponges, corals, pearls and algae.

ECONOMIC VALUES

FAO preliminary estimate, 2021

Value of landings ~ USD 11 billion

Shrimps and prawns are among the most valuable species caught in the fishing areas.



Tunas are also high-value export species.

= USD 1 BILLION

» areas. The updated methodology process will leverage the efforts of the RFBs and other partners within the Fisheries and Resources Monitoring System (FIRMS) Partnership (see Box 26, p. 155) to collate, share and disseminate on a timely basis the published assessments and to manage a unique list of assessed stocks through a dedicated database that archives the State of Stocks analysis. The process also aims to increase the capacity of national and regional fisheries institutions for assessing the state of stocks, using innovative tools and virtual platforms, such as the i-marine Virtual Research Environment. The programme will encourage a more active involvement of national institutions, empowered to regularly present their analyses as inputs to the FAO flagship publication in conjunction with reporting of national progress on SDG Indicator 14.4.1. This can support a progressive convergence between reporting procedures and would allow an expansion in the use of this indicator for multiple purposes.

Management priorities for inland fisheries

Inland fisheries are almost entirely small-scale, often remote, seasonal or occasional in nature. They are often multispecies, and many species are migratory, often travelling large distances. Furthermore, inland fisheries are affected by both fishing pressure and environmental factors, which may, in turn, be affected by external factors including climate change, hydropower and irrigation development, pollution, and water abstraction. Given the diversity and dispersion of inland fisheries, they are often managed by local groups and Indigenous Peoples using traditional knowledge and management practices. These practices typically adapt to change, including in other livelihood opportunities. Spotlighting the knowledge and experience inherent within these practices will enable greater participation and transdisciplinarity in assessments, uncovering new insights into the often-hidden contributions of inland fisheries to food security and poverty alleviation (see Box 25, p. 154).

Catch data alone are not very informative regarding the status of inland fisheries. It is necessary to address the linkages and connections that exist in many fisheries, both to the wider aquatic environments and to communities and food systems. This requires methodological approaches that broaden the assessment's scope and are relevant to its practical realities.

Participatory and integrated assessments

The ecosystem approach to fisheries addresses these needs, broadening the scope of an assessment to include ecological, social, economic, legal and institutional aspects. Furthermore, the EAF also recognizes the importance of Indigenous Peoples' and local knowledge for planning and co-management. Approaches and methods need to address this connectivity, supporting the assessment requirements of fisheries that are dynamic and dispersed with limited data and resources. This is the case of length-based and empirical modelling approaches that can be expanded to capture the roles and values of inland fisheries and their relationships to other livelihood activities and locations. These need to portray the diverse economic practices evident in inland fisheries, including cooperation, gifting, reciprocity and collective investments in management that can reduce conflict and facilitate social protection.

Basin-scale assessment

Inland fisheries managers tend to have little influence or only a limited role in decisions related to water and land use at the catchment or basin scale. Marginalization of fisheries interests can have significant consequences for aquatic habitats and dependent communities, and it is therefore crucial to develop integrated and inclusive forms of assessment at the basin scale. One such basin-scale approach assesses and presents the types of threats and their level (see **The status of fishery resources**, p. 42); it can help prioritize interventions and show how different parts of a basin may contribute to the overall threat level, revealing priorities for management, conservation and ecosystem restoration.

Indicator inland fisheries

Building on the basin threat assessment, another priority is to develop methods to track a set of globally important fisheries through a network of indicator inland fisheries. Each of these would contribute information about the status and trends in aquatic environments in the basin concerned. Using a common framework for these indicator inland fisheries provides the basis for global-level assessments and opportunities for local, national and basin organizations to actively contribute. The criteria for selecting indicator inland fisheries can include those that are already monitored and those where monitoring is likely to generate information on status and trends, including examples where fisheries are predicted to be impacted by change. Criteria should also include contributions to food security, economies and livelihoods. Priority should be given to reliable and simple data collection protocols, for example, monitoring the catch composition by species or ecological guild (e.g. migratory species, long-living species, non-native species).

Technology and innovation for sustainable fisheries

The last decade has witnessed a wide range of technological advances with regard to sustainable fisheries. Innovations in fishing technologies, for example in fishing gears, vessels, propulsion systems and on-board equipment for handling and preserving the harvest, have improved global fishing efficiency, and both the catchability and the quality of fish. Fisheries management and legislation processes cannot always keep up with the rate of change. Economic incentives and efficiency gains are major drivers of innovation in gears. For example, fish aggregating devices (FADs) may include fish finders and transponders to inform fishers via satellite on the abundance of fish nearby. Improvements in gears address fisheries regulations to reduce the impact of fishing operations on aquatic habitats and biodiversity. Trawl gear innovations generally focus on measures to reduce bycatch and improve economic efficiency. See for example the FAO overview of fishing gears by type (He *et al.*, 2021) and the FAO International Guidelines on Bycatch Management and Reduction of Discards (FAO, 2011c).

Fishing gear innovations from around the globe are shared annually by scientists of the Working Group on Fishing Technology and Fish Behaviour, supported by the International Council for the Exploration of the Sea (ICES) and FAO (FAO, 2024g). Additionally, under the auspices of ICES, European experts convene regular workshops on innovative fishing gear to produce factsheets on new gears and fishing methods.

Innovations coherent with the 2019 FAO Voluntary Guidelines on the Marking of Fishing Gear (FAO, 2019) and related manuals are being introduced worldwide to facilitate identification of gear ownership and address pollution from fisheries, including abandoned, lost or discarded fishing gear (ALDFG) (see **Fisheries and aquaculture in the context of global biodiversity agreements**, p. 205). The FAO manual for the marking of fishing gear (Einarsson, He and Lansley, 2023) provides practical guidance for complying with the gear marking requirements outlined in these international instruments and agreements.

Innovations in fishing vessels are often driven by economic incentives, which commonly lead to larger vessels with higher fishing capacity in terms of tonnage, length and engine power. FAO recently updated its overview of industrial fishing vessels by type (Thermes *et al.*, 2023), documenting the trends in design and supporting better statistical data collection on fishing vessels. Small-scale fishing vessels are increasingly made of fibreglass reinforced plastic instead of wood. Furthermore, small-scale vessels with hulls made of plastic (polyethylene/high density polyethylene) have recently entered fisheries. These provide increased safety, durability and opportunities for recycling. Technological innovations for increasing safety at sea also exist and are presented in Box 29.

Development in digital technologies has turned vessels, gears and FADs into data platforms for a wide range of purposes that include vessel monitoring systems, logbooks, sensors to detect fish, video recordings, fisheries management (Box 30) and remote sensing data such as the Automatic Identification System (AIS). These and other technologies, such as DNA profiling or satellite imagery, generate new and often big data flows, which offer novel opportunities to improve scientific and technical knowledge of fisheries and their interaction with their ecosystems.

More than ever, sustainable management of fisheries must rely on robust data collection systems, which require operational and »

BOX 29 TECHNOLOGICAL INNOVATIONS IN SUPPORT OF SAFETY AT SEA

Commercial fishing is one of the world's most dangerous occupations. In 2019, FAO estimated that 32 000 fatalities occurred worldwide per year in fisheries. However, new research suggests that the fatality rate in fisheries is three to four times higher (Willis and Holliday, 2022). Non-fatal injuries are also very common among fishers, fish farmers and fishworkers (e.g. arm or leg fractures, head and neck injuries, and finger, hand, arm and leg amputations), although they are grossly under-reported.

Most accidents and fatalities happen in small-scale fisheries, which are the largest source of employment in capture fisheries worldwide. Bad weather, engine failure, collision, fire, improper vessel construction, overloading, fatigue, and insufficient safety and training are among the many risks faced by fishers. As the demand for aquatic foods is growing worldwide and as climate change is impacting fishing conditions, fishing and related activities could become more dangerous.

Through field projects, FAO is working with regional organizations, Members, fishers and fishing communities to improve the design, construction and equipment of fishing vessels, including materials and methods, stability and safety. FAO advises that small-scale fishing vessels should carry safety equipment and tools including – as a minimum – life jackets, life rings, marine compass, radio communication, GPS for navigation, first aid kit, fire extinguisher, emergency flares, Emergency Positioning Indicating Radio Beacon, anchor, paddles, and navigation lights for safety at night.

The usefulness of safety technology depends on the reliability of equipment and the ability of crew to use it properly. When fishing offshore, the engine should be dependable, and the crew should know how to use navigation, communication and fire extinguishing equipment. Availability of life jackets and provision of targeted training are fundamental to develop safety awareness and build capacity for reducing risks at sea. Cooperation between authorities, boat builders, boat owners and crew – in addition to the involvement of insurers and communities – is essential to create a safety culture in fisheries. Community-owned digital platforms and information and communications technologies are increasingly being used to improve safety at sea, with a positive impact on saving lives and reducing injuries.

Recent technological innovations that improve fishing safety and working conditions on board include new net and trap hauling systems, underwater trawl cameras, self-righting and unsinkable vessels, safer life jackets, and navigation systems with expanded capabilities (integrating satellite data and maps with wave heights, ocean currents, weather services, electronic chart display and information systems, and multibeam sonars).

The sixth International Fishing Industry Safety and Health Conference, hosted by FAO in January 2024, reviewed recent technological innovations in industrial fisheries safety. In many parts of the world, marine safety regulators, fisheries managers, fishers and fishing safety experts work together to ensure that technological innovations to improve safety and working conditions on board also benefit small-scale fishers worldwide.

FAO-designed climate-resilient fishing boat, Sri Lanka
© FAO/Kolitha Bandara

Personal floating devices and safety equipment
© FAO/Kolitha Bandara

SOURCE: Willis, S. & Holliday, E. 2022. *Triggering Death – Quantifying the True Human Cost of Global Fishing*. Research Report, November 2022. FISH Safety Foundation. https://fishsafety.org/wp-content/uploads/2024/02/White-Paper-Triggering-Death-November-2022.pdf

BOX 30 ARTIFICIAL INTELLIGENCE IN SUPPORT OF FISHERIES MANAGEMENT IN SAUDI ARABIA

A fisheries electronic monitoring system developed by FAO and Saudi Arabia has permitted the evolution of analogic data collection into a completely digitalized fisheries management system in the country.

The Fisheries General Directorate of the Saudi Arabian Ministry of Environment, Water and Agriculture (MoEWA) worked with FAO to develop the new technology, which enables the government to automatize the collection of data and statistics across the different sectors linked to fisheries. Cameras installed on board fishing boats, at landing sites and in auction halls help fisheries officials receive data and information online; the data are then processed using deep learning algorithms and the results automatically analysed by statistical software. The Fisheries Statistics Department of MoEWA recognizes this as an important step forward in the country's fisheries statistics system, because it increases the quantity and quality of data collected by enumerators in landing sites, overcoming problems arising from extreme weather conditions, remote area locations and difficulties in species identification.

Capture fisheries in Saudi Arabia increased from 49 000 tonnes in 2000 to 79 500 tonnes in 2022. There are more than 30 000 fisherfolk directly involved in capture activities and around 150 000 people employed throughout the sector, which has expanded rapidly in the country in recent years, assisted by government support, incentives and strong market demand.

Camera with solar panel on board a fishing vessel in the Red Sea

Before the introduction of digital technology in 2021, fisheries officials were regularly deployed in the field to collect statistics and information manually – a costly process that delayed reporting, analysis and policy planning. At the end of 2021, a new digital system with mobile apps transformed this lengthy operation into a simple process, providing immediate updates on the sector through interactive maps, graphics and tables. A further step forwards in 2023 saw the introduction of cameras and deep learning algorithms that automatize data collection, thus completing the autonomous operation of the entire system.

The new system will provide the government with fast and accurate information and contribute to the sector’s sustainable growth, helping decision-makers when planning policies and investments in the sector.

This digital system – one of the key innovations in the ongoing FAO project "Strengthening MoEWA's capacity to implement its Sustainable Rural Agricultural Development (SRAD) programme (2019–2025)" – will improve the sustainable management of fisheries and aquaculture and help to ensure compliance with international standards in the management of marine ecosystems.

Sustainable aquatic foods can help address hunger and malnutrition and lower the environmental footprint of agrifood systems in Saudi Arabia, while providing income and revenue to those communities that depend on fisheries and aquaculture.

» statistical data of high quality and resolution (FAO, 2016). Today's data deluge must integrate big data concepts in design and analysis, implying also the successful integration of data across different domains. To ensure that data meet quality requirements, FAO recently produced the metadata standard on big data for fishery statistics. To promote scalable data-driven innovations, FAO collaborates with other stakeholders on the standardization and harmonization of statistical and operational systems (FAO, 2018b), for example: the Coordinating Working Party (CWP) on fishery statistics is considering how to integrate as a statistical standard the indicators derived from vessels transmitting (big) data such as AIS-based fishing activity. The Fisheries and Resources Monitoring System compiles through its Information Management Policy the standards, definitions and best practices underlying the data collated, stored and disseminated by FIRMS and their proper use in fisheries information systems.

FAO also provides tools for national fishery statistics and management information systems (e.g. Calipseo) (FAO, 2020), and supports databases of RFBs, which adopt the CWP standard for reference harmonization. These tools serve as examples of more efficient national systems for fisheries data collection and enhanced regional systems for data sharing. The innovations include data sharing and publishing open data through open platforms such as FAO's Hand-in-Hand Geospatial Platform, the FIRMS Global Tuna Atlas, the Western Central Atlantic Fisheries Information System and the Global Record of Stocks and Fisheries. Improved standardization fosters consultation among stakeholders on data quality and validity, resulting in collaborative analysis of higher quality fisheries data.

With the recent advent of data-intensive artificial intelligence (AI) tools, the data held by fisheries organizations can be re-used in entirely new contexts. Recently proposed tools include generative AI models such as ChatGPT, AI classification models for satellite imagery, and machine learning for invasive species distribution forecasting and traceability. Innovative data services come however with many challenges and questions regarding social equity, data accessibility and benefit-sharing of products; for this reason, tailored guidance and policies are required to ensure a positive contribution to the SDGs. FAO is active in several partnerships such as the Rome Call for AI Ethics (FAO, 2021c), with the aim of promoting the safe and equitable use of AI within an inclusive and mutually rewarding environment.

Today, there are more than 7 billion mobile phone users, and countless sensors and instruments using information technology and artificial intelligence to generate big data. These data can improve fisheries management, provided there is adherence to proper guidance along the entire information spectrum on responsible and equitable access and use. For example, indicators for data quality, reliability and completeness are essential for building trust among stakeholders. The development of citizen science, whereby fisheries actors also become data providers, further necessitates consideration of their access and benefit-sharing. FAO is continuously adapting its data management policies, in collaboration with its partners, to keep abreast of these changes, and to guide the responsible use of new technologies. ■

INNOVATIONS IN SUSTAINABLE TRADE AND VALUE CHAINS

This section covers priority actions undertaken to upgrade aquatic food value chains and guarantee their social, economic and environmental sustainability. In addition to the WTO Agreement on Fisheries Subsidies, the section covers guidance on social sustainability, innovative and technologically inclusive approaches to traceability and certification, reduction of fish loss and waste, and aquatic food safety. These aspects are illustrated in various boxes (Box 31, Box 32, Box 34, Box 35 and Box 37) presenting possibilities for improving trade and economic return from fisheries, reducing fish loss and waste, and strengthening aquatic value chain sustainability.

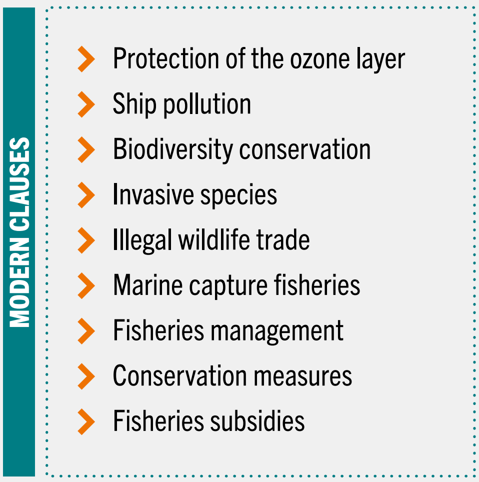
BOX 31 PREFERENTIAL ACCESS IN INTERNATIONAL TRADE AND SUSTAINABILITY

Preferential access can considerably facilitate market access and trade, and the participation of countries in regional trade agreements (RTAs) is a longstanding and traditional method of granting such access. Preferential access implies lower import duties for products imported from parties to the RTA and, in many cases, the simplification by mutual recognition of import requirements, subject to negotiated conditions. Historically, most of these conditions emerge from economic and trade rules, including rules regarding product origin based on specific criteria.

Several RTAs, however, have recently considered additional preferential access conditions beyond traditional economic and trade requirements. These include environmental and sustainability conditions to grant preferential access, directly impacting fisheries and aquaculture products.

At the request of its Members, FAO is developing a database of RTAs for fisheries and aquaculture products. The database is designed to increase transparency and knowledge about "modern clauses" in RTAs (see figure), considering their complexity; it also aims to facilitate preferential access, with a particular focus on developing countries and small-scale operators. The database thus seeks to mitigate the existing information gap on the topic and promote trade agreement discussions with the benefit of increased international responsible trade flows. The inclusion of these "modern clauses" in RTAs underscores the importance of the adoption of relevant international instruments such as the **FAO Port State Measures Agreement** (see p. 146), the **FAO Code of Conduct for Responsible Fisheries** and the **WTO Agreement on Fisheries Subsidies** (see p. 168).

NEW PREFERENTIAL CONDITIONS IN REGIONAL TRADE AGREEMENTS



NOTE: The list of conditions is not exhaustive.
SOURCE: Authors' own elaboration.

The WTO Agreement on Fisheries Subsidies, the sustainability of fishery stocks and the role of FAO

In June 2022, the World Trade Organization (WTO) adopted an agreement to regulate fisheries subsidies at its 12th Ministerial Conference. Upon its entry into force, the Agreement on Fisheries Subsidies will be the first WTO instrument to address environmental issues by establishing a global regulatory framework for the provision of fisheries subsidies, recognizing that certain types of subsidies may have a negative impact on the long-term sustainability of marine ecosystems.

In addition to trade and administrative requirements, the agreement also includes three main prohibitions on the provision of fisheries subsidies granted or maintained by countries for: (i) vessels or operators engaged in IUU fishing or related activities; (ii) fishing of overfished stocks; and (iii) fishing outside the jurisdiction of a coastal country and beyond the authority of a relevant regional fisheries management organization or arrangement, which includes ABNJ.

With the adoption of the agreement, fisheries management and stock monitoring has become even more critical, especially given the emphasis on sustainability and notification obligations. In fisheries management, a complex and comprehensive collection of data allows for assessing the state of living aquatic resources to ensure maximum benefits for individuals, communities and countries from the sustainable exploitation of these resources.

Implementing fisheries management systems is essential for ensuring that countries comply with the WTO Agreement on Fisheries Subsidies framework, particularly considering the prohibition of subsidies linked to overfished stocks and IUU fishing operations.

FAO has regularly assessed the world's marine fishery resources, reporting biennially aggregated data since 1971. However, considering the evolving and changing nature of marine fisheries, evaluation techniques and data accessibility, FAO has regularly revised its stock assessment methodology. The latest revision was launched in 2022 (see **Evolving the way we assess the status of marine fishery stocks**, p. 159).

The updated methodology seeks to revise the list of assessed fishery stocks to better reflect the dynamics of global fisheries and implement a more transparent, tiered approach, based on the quality of the information available, fostering a more direct relationship with the growing community of assessment and management institutions and experts in many countries.

At the same time, FAO continues to implement capacity-building programmes to assist countries in collecting, managing and processing data and information for assessing and reporting on the status of fisheries and fishery stocks, in line with the revised methodology and process.

The other "fisheries pillar" of the WTO Agreement on Fisheries Subsidies addresses the prohibition of subsidies for IUU fishing operations. Illegal, unreported and unregulated fishing refers to fishing operations conducted in contravention of applicable laws and regulations and of the applicable reporting procedures or conducted without a fisheries governance framework. It significantly impacts the depletion of natural resources, thereby jeopardizing the ecological integrity that supports fishery stocks and threatening natural capital. Moreover, it undermines sustainable and responsible fishing practices, diminishing the effectiveness of fisheries management programmes.

Generally, there is an underestimation of total losses associated with IUU fishing, particularly considering that many studies have only focused on estimating illegal and unreported catches, not analysing unregulated fisheries. The initial assessment by Agnew *et al.* (2009) estimated the yearly global loss caused by illegal and unreported fishing at between 11 million and 26 million tonnes of catch from 2000 to 2003, valued at USD 10–23.5 billion. A recent review of this study and its methodology for the period 2005–2014 estimates the yearly value of illegal and unreported captures at USD 9–17 billion. Furthermore, additional financial consequences ranging from USD 34 billion to USD 67 billion may occur due to secondary economic effects, income ramifications and tax revenue losses (Sumalia *et al.*, 2020).

The WTO Agreement provisions prohibiting fisheries subsidies linked to IUU fishing have the potential to reduce this harmful and illegal practice. The agreement needs to be complemented at the national level with the effective implementation of the other existing instruments combating IUU fishing and illegal practices at all value chain stages. **Progress in implementing the FAO Port State Measures Agreement** (p. 146) describes the implementation status of the FAO Port State Measures Agreement and the FAO Voluntary Guidelines for Transshipment. **FAO's standard setting on traceability and certification** (p. 176) informs on the progress in implementing the FAO Voluntary Guidelines for Catch Documentation Schemes.[az]

Finally, the WTO Agreement on Fisheries Subsidies deals with subsidies involving ABNJ. These are high seas zones extending beyond 200 nautical miles from any coastline and not subject to the jurisdiction of any single country or RFMO. Areas beyond national jurisdiction

az See: https://www.fao.org/3/i8076en/I8076EN.pdf

BOX 32 UNDERSTANDING FISHERIES ACCESS ARRANGEMENTS FOR MAXIMIZING SUSTAINABLE BENEFITS

Fisheries access arrangements are a recognized mechanism within the framework of the United Nations Convention on the Law of the Sea that aims to optimize the sustainable utilization of fishery resources within the exclusive economic zone (EEZ) of coastal countries. These arrangements enable coastal countries to grant other countries access to fisheries in their EEZs, subject to specific conditions.

The economic assessment of fisheries access arrangements can propose prospective strategies to enhance the trade of fisheries-related services for coastal countries permitting access to their EEZs, particularly for developing countries. Fisheries access arrangements can provide a wide range of economic opportunities centred around various fishing and post-harvest operations. Enterprises of coastal countries can potentially generate additional economic benefits by supporting activities associated with third-party fishing authorizations, provided there is a comprehensive understanding of the overarching structure, conditions and terms linked to these arrangements to ensure that their outcomes benefit food security and nutrition, enhance the sustainability of their fisheries and protect the livelihoods of the coastal communities that depend on them. To maximize social, economic and environmental benefits for coastal countries, fisheries access arrangements should operate by observing conservation and management boundaries, being transparent and equitable, and promoting the local landing and processing of catches.

In this context, FAO is undertaking a series of studies to conduct a comprehensive economic and historical analysis of fisheries access arrangements. These studies aim to improve the overall understanding of the various types and economic conditions of existing arrangements, and to assess the potential for the engagement of domestic and international enterprises with correlated fishing and post-harvest activities.

The first part of the study (FAO, 2022) provides an analysis of the different structures of access arrangements, considering the involved actors, the type of framework, and the dynamic nature of goals and objectives. This report identifies specific countries and businesses engaged in fisheries access arrangements, categorizing them based on the presence of financial compensation and the participation of domestic businesses.

It concludes that access arrangements are subject to various factors, including the targeted fishery and its operational characteristics and regional context, as well as historical, institutional and political relationships. Additionally, the constantly evolving regulatory, commercial and sustainability conditions significantly influence how they are crafted.

In 2024, FAO published the second part of its study (FAO, forthcoming), which covers the institutional and economic aspects of fisheries access arrangements by analysing case studies from selected countries. The report emphasizes the ever-changing nature of access arrangements, which constantly evolve to meet goals and objectives that depend on geopolitical and economic dynamics.

These studies on fisheries access arrangements aim to expand the knowledge base and disseminate information on a diverse and intricate array of arrangements on a global scale. They communicate the economic reasoning behind these arrangements and enable coastal countries to generate further economic advantages by sustainably supporting related activities.

SOURCES: FAO. 2022. *Mapping distant-water fisheries access arrangements*. FAO Fisheries and Aquaculture Circular, No. 1252. Rome. https://www.fao.org/3/cc2545en/cc2545en.pdf
FAO. (forthcoming). *Institutional and economic perspectives on distant-water fisheries access arrangements*. Rome.

are frequently managed by specific instruments or global and regional arrangements, each with clear objectives and goals, including regional fishery bodies. In this regard, RFBs, which play a critical role in the preservation and governance of fishery stocks across various maritime areas, can be a practical means to enforce the prohibition of fisheries subsidies associated with unregulated ABNJ in the WTO Agreement on Fisheries Subsidies.

Social sustainability in fisheries and aquaculture

Fishing is one of the world's most hazardous occupations. Ensuring safe and decent working conditions for all in fisheries and aquaculture remains one of the sector's biggest challenges. The absence of, for example, adequate social protection or health care, the lack of formal working relationships, and inadequate working conditions are structural problems that persist in fisheries and aquaculture value chains, particularly in developing countries, where failure to enforce pertinent labour laws remains a significant problem in the sector.

Furthermore, human and labour rights abuses are still observed throughout fisheries and aquaculture value chains, mainly in fishing, farming and processing. These practices have social implications, particularly for the most vulnerable, such as migrant workers, women and children. Children engage in various activities in capture fishing and aquaculture and in associated downstream and upstream operations, for example, processing, marketing, net making and boatbuilding (FAO and ILO, 2013). Migrant workers are particularly exposed to modern slavery, bondage, forced labour and other abuses, which have been associated with IUU fishing.

The role of women is vital in the sector, but often insufficiently recognized. Women constitute a large percentage of the informal, lowest paid, least stable and less skilled segments of the workforce, and often face gender-based constraints. For example, they are often informal workers and therefore lack access to social protection schemes. Recognizing women's crucial role, in particular in small-scale artisanal fisheries and aquaculture, is crucial for advancing women's empowerment and ensuring sustainable development and social protection (Box 33).

The COVID-19 pandemic caused considerable disruption to fisheries and aquaculture activities, uncovering new hazards in already precarious employment conditions. Many companies lacked the resources for personal protective and sanitation equipment or could not reorganize the workspace to allow effective social distancing. Trade disruptions also reduced sales turnover and income, affecting both workers and employers, sometimes leading to bankruptcy and its social consequences.

Various international instruments are available to address human and labour rights, and to ensure decent working conditions and equitable social practices. However, their diversity, fragmentation and complexity pose a challenge for stakeholders, making their implementation and enforcement very demanding.

FAO guidance on social responsibility in fisheries and aquaculture value chains

To address the challenges for enforcing existing international instruments, Members gave FAO a specific mandate in 2017 to address labour rights, decent working conditions and social protection, including human rights.[ba] Since then, FAO has been developing guidance documents on social responsibility in fisheries and aquaculture value chains. For this purpose, several multistakeholder consultations have been conducted worldwide to identify the limitations and requirements of the sector. The participation of representatives from industry, government, UN agencies, NGOs, trade unions, international organizations, and academia enables FAO to better understand the needs of the sector and the actions required.

Members requested that the FAO guidance should be supportive but non-binding, written in simple language and based on the wide range of existing international conventions, agreements and standards. The guidance will apply to all fisheries and aquaculture value chains, and take into account different national contexts and capacities, with a focus on developing countries and small-scale fisheries and aquaculture. While the target audience will be industry, the FAO guidance could also be a valuable reference for policymakers, RFMOs and civil society, for securing the social sustainability of the sector, including protecting workers' rights, ensuring decent working conditions and improving access to social protection systems in fisheries and aquaculture value chains.

Using a transparent and inclusive process, the FAO guidance will comprise a general »

ba See: https://www.fao.org/3/i8157t/i8157t.pdf#page=16

BOX 33 TRANSFORMING WASTE TO WEALTH IN SMALL-SCALE FISHERIES IN TOGO

In Togo, the women's cooperative ALOWODO* has successfully broadened its fish-processing activities in the fishing port of Lomé. In an interview conducted for the International Year of Artisanal Fisheries and Aquaculture 2022,** the president of ALOWODO proudly described how the group, following a training course, had reduced food loss and waste by recuperating the processing leftovers (that would otherwise have been discarded) and transforming them into a marketable new product: fishmeal for livestock.

The backdrop to ALOWODO's success is the support provided by FAO to 166 women processors in Togo during the COVID-19 pandemic, providing women's groups with targeted capacity development and knowledge for improving hygiene standards and strengthening good practices in manufacturing and product traceability in order to cope with the restrictions imposed by the pandemic. Consultations and training sessions provided a good baseline mapping of the women's organizations, cooperatives, unions and informal groups engaged in the post-harvest sector. New groups and collectives were formed by women and, in addition, some organizations that had ceased to be active revived their activities and operations. Common challenges were also identified, for example, the phenomenon of loans with prohibitively high interest rates.

Building on this baseline mapping, women's groups have been included in the GloLitter Partnerships Project.*** Marine plastic litter (MPL) is widespread in coastal communities around the world, degrading ecosystems, contributing to ocean pollution and biodiversity loss, and threatening public health (see Box 42, p. 188). Men's and women's exposure to and role in litter reduction are shaped by the gendered division of labour. Women tend to be engaged in the gleaning and fishing of shellfish and smaller fish and in post-harvest activities, while men are more involved in vessel-based fishing. Women can integrate MPL in their harvest and post-harvest activities; men, on the other hand, can contribute to reducing MPL caused by abandoned, discarded and lost fishing gear.

In Togo, the GloLitter Partnerships Project is working with women's cooperatives in fishing communities to strengthen women's remuneration through the collection and recycling of MPL. The trailblazing women's group, ALOWODO, was already engaged in collecting and selling plastic waste, but the activity is poorly remunerated and does not make a substantial contribution to women's income. To increase economic opportunities in the sector, ALOWODO and other women's cooperatives are now participating in FAO training sessions on how to recycle plastic litter into other usable products, such as bags and shoes. They are well organized and are confident that with the training and support of the GloLitter Partnerships Project, they will be able to find profitable markets for their recycled products.

Cooperative members recycling plastic, Togo

NOTES: * ALOWODO is a women's collective with around 20 members working out of the port of Lomé, Togo; it was formed for women working in the post-harvest sector and also focuses on collecting, transforming and selling marine plastic waste.
** See: https://wildaf-ao.org/2022/12/22/au-port-de-peche-de-lome-les-mareyeuses-donnent-une-seconde-vie-aux-dechets-de-poissons/
*** For further details, see: https://www.fao.org/responsible-fishing/marking-of-fishing-gear/glolitter-partnerships-programme/en/

BOX 34 PESCATOURISM IN JINSHANZUI: CONNECTING THE PAST WITH THE PRESENT

Pescatourism offers an innovative solution for providing additional income to fishing communities. It can bring multiple benefits, reducing environmental pressure while generating additional returns for these communities, with a potential positive impact on gender balance, youth employment, culture and heritage. The scope of pescatourism goes far beyond recreational fishing, as is demonstrated in Jinshanzui.

Jinshanzui is a modern fishing village in the municipality of Shanghai, 69 km from Shanghai city centre. As coastal marine fishery resources were depleted – negatively impacting local development and fishers' incomes – the village witnessed the rapid rise of pescatourism. Its success is attributed to strong policy support from national and local governments, a favourable investment environment, and improved infrastructure, as well as its proximity to an important market and easy access by public transport.

In 2010, funds were allocated to improve the infrastructure in and around the village and to restore the old fishing centre. In April 2011, the local township government established Jinshanzui Investment Management Ltd, with a full mandate for numerous interventions to promote tourism: development of the old town centre, creation of the ocean culture innovative development park, as well as the fishers' tea house, marine fishery culture centre, fishing gear house and fishing boat museum.

Furthermore, the fishing cultural festival was conceived to attract tourists. A good business environment has been created and Jinshanzui Investment Management Ltd acts as mediator to settle any disputes between fishers and tenants. The development programme includes the provision of quality services, and private sector investment has been attracted to create luxury accommodation in the fishing village, complementing the already existing standard hotels.

Jinshanzui fishing village brings together traditions, culture and modern civilization; moreover, thanks to the excellent connections with Shanghai market, it successfully links pescatourism with sustainable fishing outcomes.

Marine fishery culture centre
© Wei Yang

Fishing gear house
© Wei Yang

» section addressing its nature and scope – including emphasis on the role of the private sector, internationally agreed principles, and cross-cutting aspects (e.g. gender, child labour) relevant to fisheries and aquaculture value chains – in addition to six specific sections covering fisheries and aquaculture value chains: (i) industrial fishing; (ii) small-scale fishing; (iii) aquaculture production; (iv) processing; (v) distribution; and (vi) retailing.

GLOBEFISH: 40 years of market monitoring and marketing intelligence

About GLOBEFISH

GLOBEFISH is a long-standing multi-donor project located within the FAO Fisheries and Aquaculture Division. Created in 1984, its primary mission remains the provision of unbiased price and market data and reliable analysis of international trade and markets for aquatic food products.[bb]

GLOBEFISH collects, analyses, generates and disseminates market- and trade-related data and information from private and public sources all over the world. It also contributes to the global organization of technical and trade events, conferences, and capacity-building initiatives designed to facilitate trade, improve access to markets, promote communication among critical stakeholders of the fisheries and aquaculture chains, and foster cooperation between countries, international organizations and private companies.

GLOBEFISH generates and distributes publications, reports and statistical data on its website for the fisheries and aquaculture sector. For example:

- *GLOBEFISH Highlights* – the project's flagship publication – provides in-depth analysis of thirteen important aquatic food commodities. It is widely acknowledged as one of the most authoritative sources of information on the global market for aquatic food products and forms the basis for the "Fish and fishery products" section of FAO's *Food Outlook* publication.[bc]
- *European Price Report (EPR)* and *Chinese Fish Price Report (CFPR)* publish detailed price information for major species and product forms for Europe and China.
- Trade Statistics are centred on trade flows between the most important markets and suppliers for specific major product groups, including catfish, groundfish, salmon, small pelagics, shrimp, tilapia and tuna.
- *European Price Dashboard* – launched in June 2021 – puts current market prices for around 350 products into an easily accessible interface on the GLOBEFISH website. Prices are automatically updated weekly on Mondays, drawing from large European wholesale and first-sale markets.
- Regular reports provide updates on GLOBEFISH activities to FAO Members of the COFI Sub-Committee on Fish Trade.

GLOBEFISH's coverage continues to expand with the regular introduction of new information and publications on aquatic products with a specific focus on emerging issues and areas lacking sufficient disseminated data, such as:

- information on trade and production at a glance by country (Market Profiles);
- regulatory information, tariffs and trade data by country (Market Access);
- border rejections of aquatic products by food control authorities in major importing countries (Import Notifications);
- current regulatory requirements impacting trade of aquatic products by country (Food Safety Regulation for Fishery and Aquaculture Products); and
- data on prices and trade of aquatic products.

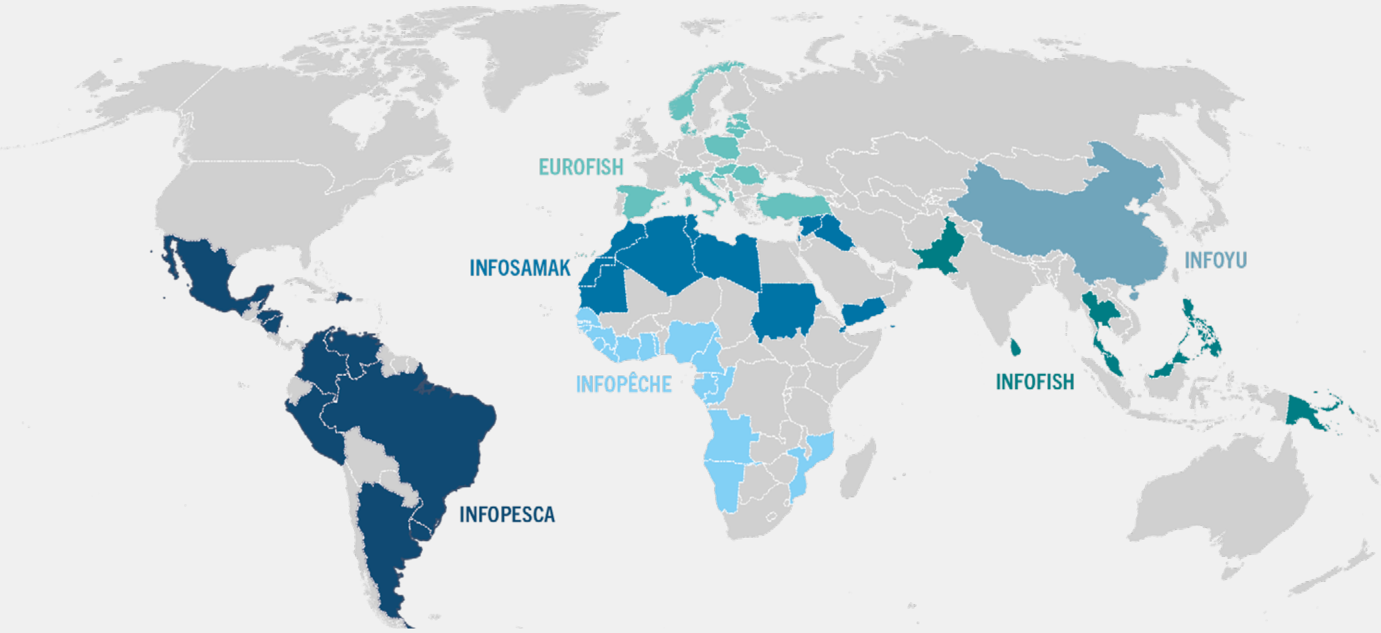
GLOBEFISH and the FISHINFO Network

GLOBEFISH fosters international cooperation and industry development through the global FISHINFO Network (FIN), linking six regional networks across the world: INFOPESCA (Latin America and the Caribbean), INFOFISH (Asia and the Pacific), INFOPÊCHE (Africa), INFOSAMAK (Arab countries), EUROFISH (Europe) and INFOYU

bb Available at: https://www.fao.org/in-action/globefish/globefish-home/en/

bc For the most recent edition of the biannual *Food Outlook*, see: https://doi.org/10.4060/cc8589en

FIGURE 57 **THE FISHINFO NETWORK**



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.

NOTES: EUROFISH – International Organisation for the Development of Fisheries and Aquaculture in Europe; INFOFISH – Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region; INFOPÊCHE – Intergovernmental Organization for Marketing Information and Cooperation Services for Fishery Products in Africa; INFOPESCA – Centre for Marketing Information and Advisory Services for Fishery Products in Latin America and the Caribbean; INFOSAMAK – Centre for Marketing Information and Advisory Services for Fishery Products in the Arab Region; INFOYU – China Fish Marketing Information and Trade Advisory Service Center.

SOURCE: Adapted from United Nations Geospatial. 2020. Map geodata [shapefiles]. New York, USA, United Nations.

(China) (Figure 57). GLOBEFISH coordinates the overall activities of these independent intergovernmental organizations forming the FIN, which it supports by delivering marketing information and technical services. The network represents the foremost source of up-to-date market and trade information, with periodical analysis reports in five different languages addressing all levels of the fisheries and aquaculture value chain.

FAO and GLOBEFISH have a coordinating role in the operations of the FIN, and the Director-General of FAO is also the depository for all formal documents regarding accession to membership of the regional networks.

GLOBEFISH partners and correspondents

GLOBEFISH partners (national government administrations, specialized agencies, academia, and other interested parties dealing with the marketing and trade of aquatic food products) play a significant role in the project's success. In addition to providing financial support, they collaborate in the collection and dissemination of data, and the analysis and distribution of market information. Through these partnerships, GLOBEFISH enhances its global reach, credibility and impact, ultimately supporting the sustainable development of international trade in aquatic products.

BOX 35 FAO BLUE PORTS INITIATIVE

The FAO Blue Ports Initiative (BPI) is a platform established in 2019 to support fishing ports in promoting environmental, social and economic sustainability in all aspects of port operations and management. As of May 2024, it includes a network of 26 countries from Africa, Asia and Latin America, with eight of them represented by the Central American Integration System. It encourages diverse, cross-sectoral interventions and partnerships that improve sustainable development, achieve cost-effectiveness and foster the exchange of knowledge and best practices between associated fishing ports.

The BPI mid-term objectives are multifaceted:

- **Environmental:** promote the use of renewable energy and digital tools to enhance operational efficiency and reduce greenhouse gas emissions and pollution from waste in fishing port operations.
- **Economic:** strengthen fisheries value chains, recognizing that fishing port operations and services are crucial nodes for improving product quality and reducing fish loss and waste. The initiative is working to support ports to meet market demands effectively, conducting studies to integrate traceability standards into port operations and services.
- **Social:** upgrade the professional skills and capabilities of port workers and improve community welfare, in close partnership with partner organizations like the International Labour Organization.

These activities and efforts are bolstered by specialized working groups, generating actionable plans to address sustainability challenges. The BPI team collaborates with various institutions, for example, the Intergovernmental Oceanographic Commission to facilitate marine spatial planning, or the African Development Bank to include ports in sectoral development plans. The Blue Ports Initiative is also engaged with the International Maritime Organization, specifically contributing to marine litter reduction efforts in close collaboration with colleagues from the GloLitter Partnerships Project.

Through BPI activities, FAO aims to ensure that post-harvest sustainability practices are implemented as soon as marine products arrive at landing sites and that they are consistent across the value chain.

The network of GLOBEFISH correspondents comprises individuals and organizations located in various countries around the world; the valuable information and data they supply results in market intelligence that supports the project's objectives.

The world of information over the last 40 years

Over the past 40 years, the world of trade and market information has undergone tremendous changes with its availability increasing massively and in real time. However, new rules and regulations, including both regulatory and voluntary market-based measures, have brought fresh challenges for producers, exporters and importers. Access to neutral and up-to-date robust information on prices, market trends and market access requirements, together with market analysis, remains therefore of key importance to the sector in general and to exporters from developing countries in particular.

Together with its partners in the FIN, GLOBEFISH continues to provide capacity building on the major issues related to international trade in aquatic food products, supporting the sustainable development of global trade in aquatic products, facilitating market access, promoting social responsibility, and contributing to the achievement of the SDGs related to fisheries and aquaculture.

FAO's standard setting on traceability and certification

Traceability of aquatic foods faces various challenges, some emerging from the fragmentation and complexity of fisheries and aquaculture value chains. Despite the increased use of digital tools, many value chains still lack reliable traceability to support fully product quality, safety, legality and sustainability (Tripoli, 2020). Specific to aquatic foods, major gaps and inconsistencies in traceability fall within six main categories (FAO, 2016; Blaha, Vincent and Piedrahita, 2023):

1. **Standards gap.** There is a lack of specific requirements or published standards in the sector, and effective traceability therefore relies on the gathering and sharing of information.
2. **Awareness gap.** There can be a lack of understanding of what traceability is, what it does and how it differs from other principles addressing safety, quality, legality and sustainability standards.
3. **Commitment gap.** Companies sometimes consider mainly the legal requirement of traceability , not its overall benefits and financial returns. The commitment gap may be linked to the awareness gap.
4. **Implementation gap.** Industry implementation often does not meet regulatory or market requirements. This may be due to the complexity of the production process. Maintaining the integrity of a lot or batch can be challenging when mixing many products from different suppliers, with inadequate document security and, most often, a lack of management control.
5. **Technology gap.** Traceability practices tend to lack robustness, considering the importance companies place on their marketing strategy and the economic interests involved. Despite the availability of a wide range of technological innovations to develop reliable traceability, there is still a lack of affordable, functional and robust technology for automatic data capture and sharing. Manual data entry – in particular at the beginning of the value chain and especially when performed by small-scale operators – requires significant time, resources and capabilities.
6. **Economic gap.** It is widely documented that good traceability not only fulfils legislative and market requirements, but it also reduces operating costs and underpins company branding and marketing strategies. However, operators required to implement more record-keeping or change their working habits often question the nature of the resulting benefits. A cost–benefit analysis of investment in improved traceability can provide the necessary evidence.

To address these gaps, over a two-year period FAO conducted online and regional consultations (FAO, 2022d) to finalize the development of a guidance document (Blaha, Vincent and Piedrahita, 2023) on end-to-end traceability in capture fisheries and aquaculture. The document provides details on the identification of critical tracking events (CTEs) and key data elements (KDEs) across all supply chain steps, as well as their respective data sources (Table 13). When applicable, it also provides a benchmark against the Global Dialogue on Seafood Traceability (GDST) listing of KDEs. Specific guidance is incorporated in due recognition of the specific sanitary requirements for bivalves. Box 36 illustrates a traceability system deployed in Saudi Arabia.

Furthermore, in order to offer solutions to address these standard-setting and technology gaps in fisheries, FAO is leading a pilot initiative to develop the Global Record of Stocks and Fisheries (GRSF). The GRSF is a web-based system that assigns unique identifiers to stocks and fisheries. It is designed to support the monitoring of the status and trends of fishery resources and could eventually be used to reinforce traceability and ecolabelling schemes by connecting them to the scientific evidence of the status of stocks and fisheries.

The GRSF is proposing a global repository of uniquely identified stocks and fisheries with standard codifications, thus enabling the collation, standardization and sharing of marine resources and fisheries information. The standard stocks and fisheries identifiers are the pillars of this initiative aimed at boosting connected knowledge on stocks and fisheries. To date, the GRSF is probably the biggest collation of stocks and fisheries data in the world from national, regional and global sources.

FISH4ACP: transforming aquatic food systems through a value chain approach

Fisheries and aquaculture activities continue to expand in most African, Caribbean and Pacific (ACP) countries. But growth has been uneven and slow, and the benefits do not always reach those communities that rely on aquatic foods for their food security and livelihood. Where fisheries and

TABLE 13 EXAMPLE OF IDENTIFIED HARVESTING CRITICAL TRACKING EVENTS AND KEY DATA ELEMENTS TO BE OVERSEEN BY A FLAG STATE TO COMBAT IUU FISHING

Flag state				
Supply chain stop	**CTEs**	**Main KDEs**	**Data source**	**Comments**
Harvesting	Fishing vessel identity	National flag of vessel GDST KDE number W07	Vessel registration from flag state	Name or ISO two-letter country code list – ISO 3166 Small-scale fishing boats should bear some minimum form of identification. This identification should ideally be linked to an official registration/licence by the authorities of the flag state
		International Maritime Organization (IMO) number/ UVI GDST KDE number W06	Maritime authority on behalf of the IMO	Specific to a vessel and should not change when a vessel changes flag
		Vessel registration number GDST KDE number W05	Vessel registration from flag state	Specific to a vessel but changes when a vessel changes flag
		Name of fishing vessel GDST KDE number W04	Vessel registration from flag state	Databases tend to work on the Latin alphabet, numbers and punctuation, but the romanization of names in non-Latin alphabets is complex (e.g. the vessel name 嘉吉滿 can be written in at least 36 different ways in English)
		International radio call sign (IRCS)	Vessel registration from flag state	Up to seven characters assigned to the vessel by its country of registry; specific to a vessel but changes when a vessel changes flag
		RFMO vessel number	RFMO list of vessels	Specific to the vessels but changes when a vessel changes flag; in some cases is based on the IRCS

NOTE: CTE – critical tracking event; GDST – Global Dialogue on Seafood Traceability; KDE – key data element; IMO – International Maritime Organization; IRCS – international radio call sign; IUU fishing – illegal, unreported and unregulated fishing; RFMO – regional fisheries management organization; UVI – unique vessel identifier.

SOURCE: Adapted from Blaha, F., Vincent, A. & Piedrahita, Y. 2023. *Guidance document: Advancing end-to-end traceability – Critical tracking events and key data elements along capture fisheries and aquaculture value chains*. Rome, FAO. https://doi.org/10.4060/cc5484en

aquaculture management practices are deficient, these expansions challenge the ecological sustainability of aquatic resources.

The complexity of aquatic food systems calls for innovative approaches to address the root causes that are preventing these systems from performing to their potential.

In line with FAO's Blue Transformation Roadmap and its third pillar focusing on value chain improvement, FISH4ACP – a five-year programme developed by FAO in collaboration with the Organisation of African, Caribbean and Pacific States (OACPS) – proposes a new methodology to enhance the productivity and competitiveness of fisheries and aquaculture value chains, ensuring that economic improvements go hand in hand with environmental sustainability and social inclusiveness. FISH4ACP is implemented by FAO with funding from the European Union and the German Federal Ministry for Economic Cooperation and Development.[bd]

What sets FISH4ACP apart from other initiatives?

FISH4ACP promotes a holistic and participatory approach to value chain development. It focuses »

bd For additional information, see: https://www.fao.org/in-action/fish-4-acp/en/

BOX 36 BLOCKCHAIN TRACEABILITY OF SAUDI ARABIAN AQUATIC PRODUCTS THROUGH A DIGITAL AUCTION SYSTEM

An aquatic product auction system developed by FAO and Saudi Arabia has begun to transform fisheries and aquaculture trading and marketing in the country.

The Fisheries General Directorate of the Saudi Arabian Ministry of Environment, Water and Agriculture (MoEWA) worked with FAO to develop a digital auction system supported by appropriate operational equipment to improve the safety and quality of aquatic foods in the country. Applying the Guidelines in Operations and Management of Fish Auction Halls – elaborated jointly by MoEWA and FAO in 2022 – the new system enables the government to track aquatic food products all along the supply chain. Thanks to a mobile application and screens located in the auction halls, inspectors, traders and consumers can easily obtain full details and data on a given aquatic food, by simply scanning a QR code. The resulting blockchain auction digital system is bringing aquatic foods to a wide range of traders and consumers.

This new auction system will also enhance the biosecurity and aquatic food safety programme of Saudi Arabia by advancing the fisheries system, thus enabling marketing and trading of aquatic products from capture fisheries to improve by following strict biosecurity and safety protocols as in aquaculture.

In 2021, fish utilization in Saudi Arabia stood at 402 385 tonnes, including 220 436 tonnes imported, with local consumption accounting for 88 percent and exports 12 percent. The post-harvest sector employed over 120 000 people, thanks to rapid expansion in recent years, driven by a dynamic private sector with a strong market and high demand among youth.

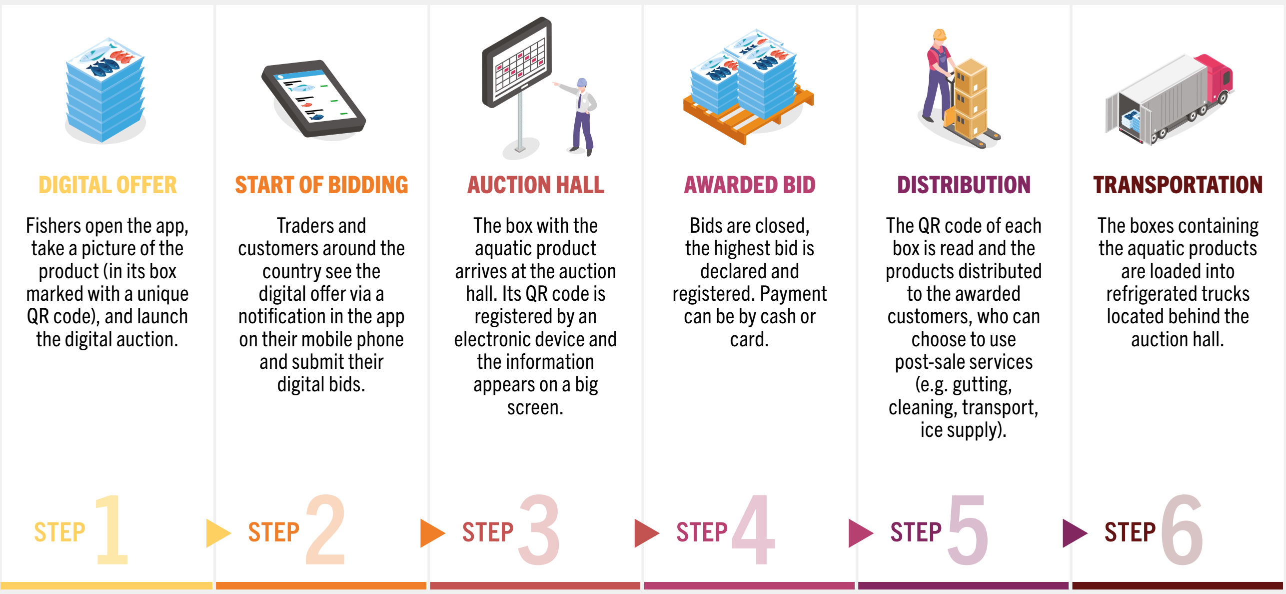
Before 2023 and the introduction of the digital system, fishers, auctioners and traders managed and operated the auctions manually – an inefficient process with deficiencies in conservation and quality, and limited participation of buyers. The advent of the blockchain auction in 2023 turned that operation into a more efficient and higher-quality process. A rapid scanning of the QR code on a box provides the history of the aquatic food – from harvesting or production location through to the end buyer. The system is complemented by new and innovative equipment including conveyor belts, apposite boxes and trolleys, as well as screens displaying the wares during auction.

The programme aims to improve the safety and biosecurity of the aquatic products and provide wider access to fisheries markets and products."

Safe and high-quality aquatic foods can help address malnutrition and diseases while providing income and revenue to those communities that depend on fisheries and aquaculture in the country.

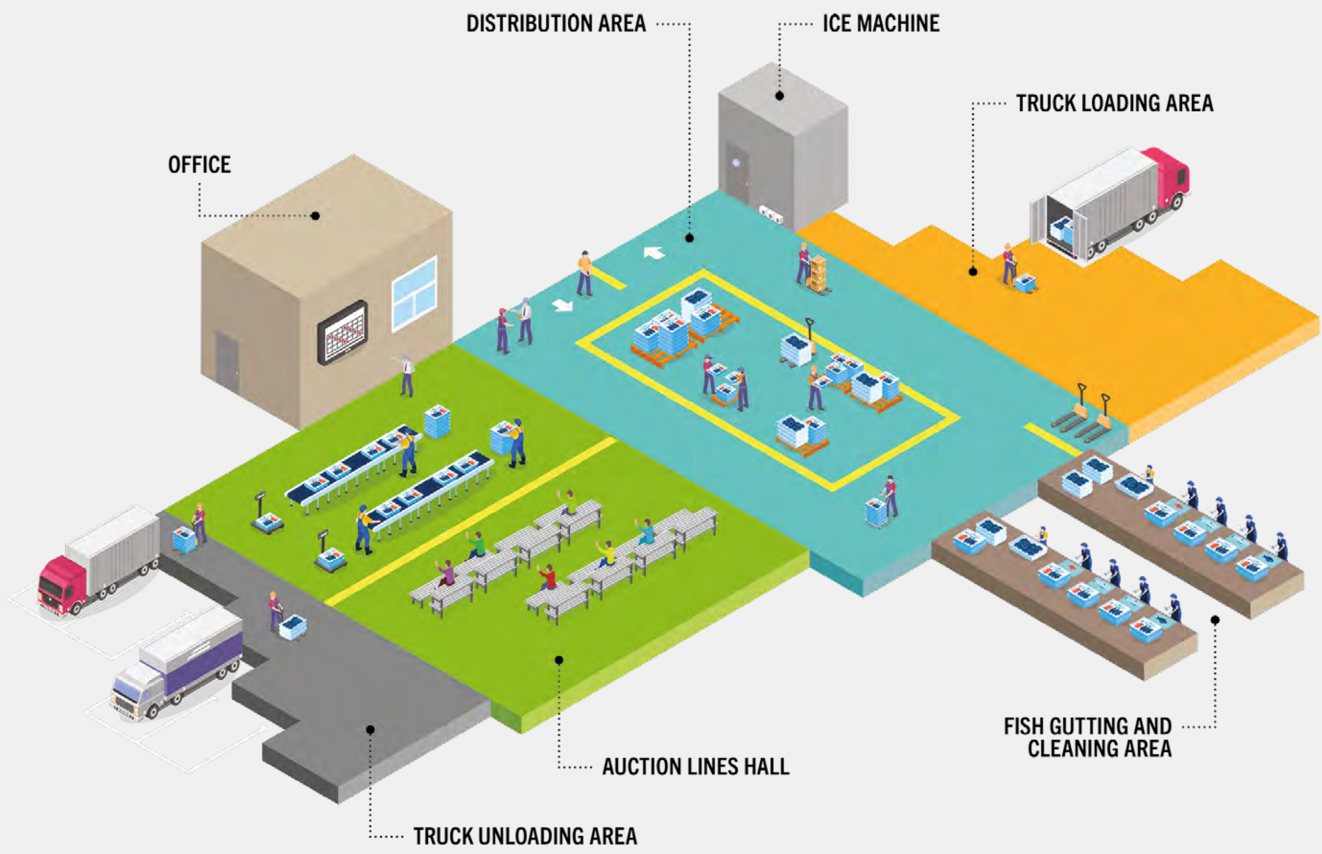
»

DIGITALIZING THE AUCTION OF AQUATIC PRODUCTS



SOURCE: Authors' own elaboration.

AUCTION OF AQUATIC PRODUCTS IN SAUDI ARABIA



SOURCE: Authors' own elaboration.

» equally on all three aspects of sustainability – the economic, the environmental and the social. FISH4ACP starts with an evaluation of each value chain by conducting a functional analysis and a sustainability assessment. The functional analysis examines all stages of the value chain; this includes identifying current and potential products, new market opportunities, incentives, behaviours and dynamics, as well as existing inefficiencies. The sustainability assessment uses qualitative and quantitative analyses to identify areas for improvement in selected value chains.

Stakeholder participation is ensured at every step of the process, from the collection of information for sector analysis, to the development of value chain upgrading strategies. Each strategy identifies opportunities to address inefficiencies along the value chain in order to achieve a common vision for the chain agreed on by the stakeholders themselves.

To further embed stakeholder involvement, the methodology supports the establishment of a multistakeholder partnership (MSP) – a collective approach to gather key actors within the value chain, from both the public and the private sectors, for regular coordination, information and knowledge exchange, and decision-making to help drive the strategic development of the value chain (Box 38).

Value chain upgrading indeed requires that different actors in the chain work together to achieve the desired improvements. These actors are linked through the professional and, in some cases, social relationships that bind them (commercial, regulatory, advisory, etc.). However, the depth and extent of these linkages vary from one value chain to another. Effective linkages between actors and overall value chain governance are essential to enhance the competitiveness of the value chain. The

BOX 37 TEN-YEAR ANNIVERSARY OF THE GLOBAL SUSTAINABLE SEAFOOD INITIATIVE

Since its inception in 2013 as a public–private partnership involving 30 leading seafood companies, several non-governmental organizations, FAO and the German Agency for International Cooperation, the Global Sustainable Seafood Initiative (GSSI) has grown into one of the largest global multistakeholder partnerships in sustainable aquatic foods. At the time of writing, the GSSI numbered 77 funding partners and 18 affiliated partners from more than 20 countries.

The GSSI was created to provide a mechanism for an objective and transparent assessment of the performance and recognition of credible and responsible certification schemes for aquatic products. In celebrating the 20th anniversary of the FAO Code of Conduct for Responsible Fisheries (CCRF) in 2015, the GSSI launched its Global Benchmark Tool for seafood certification schemes. After a series of expert and public consultations, the tool was revised in 2021.

The FAO Ecolabelling and Certification Guidelines, together with the CCRF and other internationally agreed instruments, form the backbone of the GSSI's efforts to develop a collective approach to ensure transparency in the eco-labelling and certification of aquatic products and give consumers and companies confidence in the certified aquatic products on offer. To date, nine credible fisheries and aquaculture schemes have achieved GSSI recognition,* and more are under consideration.

NOTE: * For further details, see: https://www.ourgssi.org/gssi-recognized-certifcation/

FISH4ACP methodology proposes to accompany and promote improved linkages, structure and governance mechanisms across the value chain with a view to improving its collective agency. Multistakeholder partnerships are a key tool in this respect.

After some delays linked to the COVID-19 pandemic, FISH4ACP has now reached cruising speed; implementation of the upgrading strategies is well underway with some promising preliminary experiences to share:

- First, timely value chain analysis (VCA) is key to ensure that the upgrading strategy focuses on critical bottlenecks preventing the chain from developing to its full potential. It helps maintain the momentum generated through the mobilization of motivated value chain stakeholders. Moreover, value chains are dynamic, with conditions and relationships evolving all the time. Prompt actions to address deficiencies or harness leverage points identified can generate more effective and positive impact.
- Second, stakeholder engagement is fundamental to ensure the sustainability of value chain development. However, the process may be gradual; starting with a motivated small core group of actors can help to initiate and generate a participatory dynamic that can gradually evolve into a fully-fledged MSP.
- Third, value chain upgrading does not happen in a vacuum. Many other public and private initiatives, projects and activities often take place within or around the value chain, with little or no coordination between them. Creating linkages between these various initiatives is key but challenging. In addition, mobilizing and connecting various efforts is critical to ensure a coherent value chain development process; the MSP as a platform for interaction is a great asset in this respect.

These learning points and many others are currently being used to adapt and reinforce the FISH4ACP methodology.

Beyond the methodological guidance, FISH4ACP is generating a wealth of information on the 12 value chains it supports (selected from the

BOX 38 COLLECTIVE ACTION FOR TRANSFORMATIVE CHANGE: FISH4ACP MULTISTAKEHOLDER PARTNERSHIP IN CÔTE D'IVOIRE

The farmed tilapia value chain in Côte d'Ivoire has been underperforming for several decades in comparison with other countries. Current annual production (estimated at 8 000 tonnes) does not meet domestic demand (estimated at 50 000 tonnes) despite suitable environmental conditions and the availability of technology and know-how.

Reinvigorating the value chain therefore requires an innovative approach. To create a new dynamic for the sector, FISH4ACP has supported the establishment of a multistakeholder partnership bringing together key public and private actors from the entire tilapia value chain with the objective of identifying and removing the bottlenecks hindering the sector's development.

This collaboration between producers, fishmongers, input suppliers and government officials has led to the development of a common value chain-upgrading strategy aimed at increasing national tilapia production ninefold over ten years. This will be done by focusing on four strategic areas:

- establishing new farms and developing the business models of existing ones;
- increasing the quality and availability of fish feed and seed;
- improving monitoring and overall management of the sector; and
- enhancing marketing of domestic tilapia.

To achieve this ambitious target, the partnership draws on expertise and financial resources from a broad range of stakeholders, projects and initiatives underway in the sector. With support from the FISH4ACP project (2020–2025), it aims to be a catalysing force for the development of the tilapia value chain in Côte d'Ivoire.

Farmer feeding tilapia, Côte d'Ivoire
© FAO/Sia Kambou

Processing workers smoking tilapia, Côte d'Ivoire
© FAO/Sia Kambou

79 cases submitted by cooperating countries), uncovering some of the hidden potential of fisheries and aquaculture in OACPS countries (Box 39). The findings of each VCA and the related upgrading strategies are presented in value chain reports available for all 12 countries. The development of knowledge products will continue over the coming years with the aim of sharing the knowledge generated by the programme as widely as possible. These knowledge products will focus on the most successful value chain upgrading practices and cover topics such as improved business environments, quality and safety of production, productivity, collective action, working conditions and energy efficiency.

BOX 39 THE POTENTIAL OF USING BLACK SOLDIER FLY TO PRODUCE AQUACULTURE FEED IN ZIMBABWE

Tilapia consumption in Zimbabwe has gained in popularity but it is more expensive than locally caught lake sardines and imported fish. Production costs are high mainly due to the reliance on imported feed and feed ingredients, which are affected by macroeconomic factors such as foreign currency exchange rates, inflation and competing demand from other industries.

Larvae of black soldier fly represent a promising and nutritious alternative – reducing both feed costs and the dependency on imported fishmeal – for small-scale producers in Zimbabwe, where the FISH4ACP initiative helps to strengthen tilapia aquaculture and promote livelihood opportunities for women, youth and marginalized groups without adversely impacting the environment.

Black soldier flies are widely recognized for their waste conversion efficiency, good nutritional value, and strong immune system that prevents the spread of diseases. In addition, the black soldier fly pilot initiative in Zimbabwe has a low carbon footprint, is pro-poor and supports the autonomy of local farmers as the larvae can be produced with local waste products, at small, medium or large scale.

FISH4ACP partnered with the Chinhoyi University of Technology to pilot black soldier fly production – and black soldier fly-based fish feed – with small- and medium-scale enterprises in Zimbabwe. The university has trained ten government extension officers and several feed suppliers and farmers to pilot black soldier fly production, feed formulation and feeding regimes. The results of the pilots will be evaluated using a cost–benefit analysis, and feedback from stakeholders will inform the potential for their upscaling in Zimbabwe.


Feed formulation trials mixing black soldier fly larvae (left) with various ingredients (right)
© FAO/Zingyange Auntony

Before its completion at the end of 2025, FISH4ACP is working to set off a chain reaction across the fisheries and aquaculture value chains it supports in OACPS countries. This will enable these countries to move towards more sustainable, productive and inclusive fisheries and aquaculture, contributing to a Blue Transformation that will convert aquatic value chains into drivers of long-term economic, environmental and social development.

Multidimensional solutions to food loss and waste

Food loss and waste (FLW) in aquatic food value chains is a major global issue, enshrined in SDG 12 (Responsible Consumption and Production) and Target 12.3 to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" by 2030. Reducing FLW and increasing the consumption of sustainable aquatic foods are also key targets of FAO's Blue Transformation Roadmap (FAO, 2022a). Reducing aquatic food losses requires complex and diverse actions by many participants in the supply chain, from production to consumption (Love *et al.*, 2015). Research can serve to monitor and evaluate these efforts, but interventions to prevent post-harvest losses should be appropriate to the socioeconomic, business and political context of a country (Fahrenkamp-Uppenbrink, 2016).

However, effective post-harvest fish loss reduction does not rely on a single factor or variable such as the introduction of a new technology. On the contrary, legislation, capacity building, services and infrastructure, together with appropriate technology, are critical to ensure not only that solutions to FLW reduction are adopted but that they are sustainable.

A multidimensional and multistakeholder approach is promoted by the FAO Voluntary Code of Conduct for Food Loss and Waste Reduction, which includes ideas and examples of general solutions to FLW reduction that can be translated into the fisheries context (FAO 2022e).

Pivotal to the multidimensional solutions (MDS) approach[be] promoted by FAO is the development of an MDS strategy which ties together the different aspects of the solutions. A key element of this strategy is the establishment and involvement of a multistakeholder FLW platform. The platform members are drawn from the public and private sectors, NGOs, civil society, food research and development institutes, investment and financial institutions, large retailers, and the media. The platform oversees the deployment of an MDS strategy, with members being actively involved in its development and validation as well as in monitoring and implementation.

With support from the Norwegian Agency for Development Cooperation, FAO has been actively promoting the MDS approach to address fish loss and waste. This necessitates multistakeholder involvement in the identification of multidimensional solutions and the development of FLW reduction strategies; these may be complex and cover not only policy and legislation, but also capacity development and technological and socioeconomic aspects. The MDS approach is echoed in the Food Loss and Waste in Fish Value Chains webpage, where further information on multidimensional solutions can be found.[bf]

Multidimensional solutions strategies have been developed with partners in Colombia, Sri Lanka and the United Republic of Tanzania to address FLW associated with, respectively, a particular geographical location, a specific fishery, and small pelagic fish species. An MDS strategy builds on an FLW assessment, which provides the necessary understanding of: (i) where and when FLW is occurring; (ii) what the causes are; (iii) the extent (i.e. the volume and the economic impact); and (iv) who the key stakeholders affected are (as well as the potential beneficiaries of the MDS strategy).

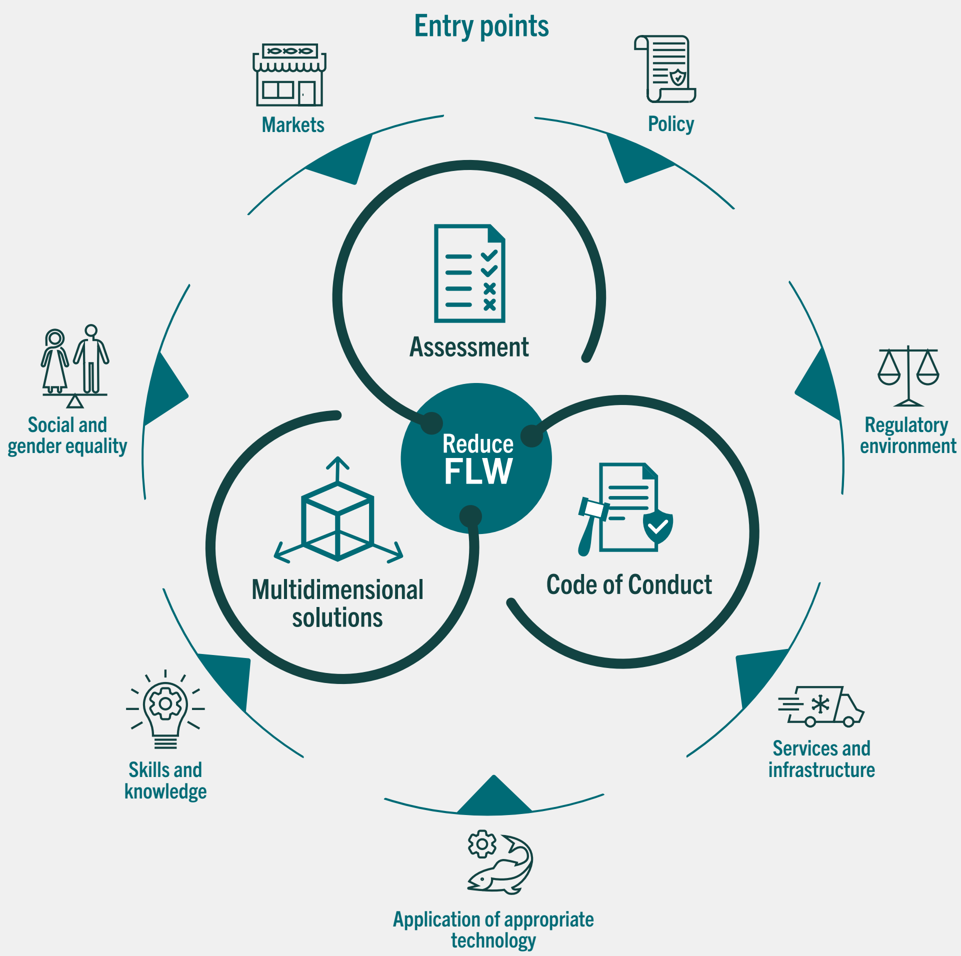
The development of an MDS strategy involves a multidisciplinary team systematically undertaking a "theory of change" process – as successfully used by the FISH4ACP project – that has been adapted to fish loss and waste. The steps in the process are shown in Figure 58. Multidimensional solutions strategies resulting from this process are validated with the FLW platform before roll-out. Box 40 presents aspects of an MDS strategy developed with Sri Lankan stakeholders and Box 41 illustrates how solar energy can support reducing FLW in small-scale fisheries.

Significant resources are required to implement an MDS strategy, using funding from the public and private sectors in addition to donor support. Certain outcomes – for example, those entailing infrastructure development and equipment upgrading – may require significant investment. In contrast, assessments, planning, and policy and regulatory reforms are likely to be easier

be For further details, see: https://www.fao.org/flw-in-fish-value-chains/projects/en/

bf See: https://www.fao.org/flw-in-fish-value-chains/en/

FIGURE 58 FISH LOSS AND WASTE MULTIDIMENSIONAL SOLUTIONS STRATEGY PROCESS



NOTES: FLW – food loss and waste. Addressing FLW in aquatic food value chains requires a multistakeholder approach focused on a combination of some or all of the entry points.

SOURCE: Authors' own elaboration.

and less costly to adopt. The importance of solutions centred on technology and renewable energy is gaining traction and they are actively promoted by FAO.

An MDS approach, such as that in Sri Lanka, is built on consultation and consensus to address sustainable FLW reduction and entails long-term strategies. For a successful outcome, it is important to monitor and report on MDS strategy implementation, reviewing and adapting as necessary. Finally, development organizations must be well placed to work in conjunction with national authorities to facilitate the development and uptake of MDS strategies.

Aquatic food safety

Aquatic foods are highly valued for their nutritional benefits, as well as for their contribution to livelihoods and food security. Their production and per capita consumption

BOX 40 MULTIDIMENSIONAL SOLUTIONS FOR REDUCING LOSS IN MULTI-DAY BOAT FISHERIES IN SRI LANKA

In Sri Lanka, long fishing trips and inadequate handling of catches at sea result in excessive fish losses. Thanks to support provided by FAO, public and private stakeholders have developed and adopted a shared vision that by 2033, the quality loss in the multi-day fishery of Sri Lanka will be reduced by 30 percent through the implementation of policies and the introduction of improved new technology, a strengthened regulatory framework, enhanced skills and knowledge, systems and practices as well as the development of infrastructure, contributing to an improved domestic and export sector and ultimately to the national economy and food security and nutrition. Sri Lanka will be a leading country in South Asia in fish loss and waste reduction (FAO, forthcoming).

This vision entails a multidimensional solutions approach whereby:

- boat owners, skippers and fishers apply improved technology and better practices;
- consumers demand better quality fish;
- ice producers supply better quality ice;
- regulatory bodies and the government are better able to implement legislation;
- supply chain actors (transporters, wholesalers, retailers) improve handling practices;
- processors and buyers supplying the domestic market demand better quality fish;
- local government authorities are empowered to invest in and apply fish loss and waste solutions; and
- research organizations disseminate and raise awareness of results at grassroots level.

In order to achieve each of these outcomes, outputs and activities focus on:

- plans and assessments;
- technology transfer, innovation and design;
- finance and investment;
- capacity building;
- policy and regulatory framework reviews and reform; and
- empowerment of stakeholders.

SOURCE: FAO. (forthcoming). *Multi-Dimensional Solutions Strategy for Reduction of the Food Loss and Waste in the Multiday Fisheries Sector in Sri Lanka.* Rome.

have grown significantly over the last decades and are predicted to play an increasingly significant role in providing food and nutrition globally.

As with many other foods, there are risks associated with their production and distribution. Understanding the food safety hazards linked to their consumption is key to managing the relative food safety risks. While most microbiological risks can be mitigated by practices such as good hygiene, heat processing or cooking, there are chemical risks that originate from the aquatic environment, or which depend on feeding ground, age or trophic level. Dioxins, dioxin-like polychlorinated biphenyls (dl-PCBs) and methylmercury are of increasing concern for the food safety of aquatic products.

To address the growing public concerns regarding the presence of these chemicals in aquatic foods, in 2006, the Codex Alimentarius Commission requested scientific advice from FAO and the World Health Organization (WHO) on the risks and benefits of fish[bg] consumption. FAO and WHO commissioned an analysis of the health benefits of fish consumption in comparison with the health risks associated with the potential presence of methylmercury and dioxins (including polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans and dl-PCBs) in aquatic products. Two expert consultations on the

bg The term "fish" is defined as finfish (vertebrates) and shellfish (invertebrates), whether of marine or freshwater origin, farmed or wild, for the purpose of this expert consultation. Marine mammals and algae, as well as sustainability issues and environmental impacts, although important, are considered to be outside the scope of the report.

BOX 41 SMALL-SCALE FISHERIES AND OPPORTUNITIES FOR RENEWABLE ENERGY

Sustainable Development Goal (SDG) 7 – Ensure access to affordable, reliable, sustainable and modern energy for all – is highly relevant for small-scale fisheries (SSF). Access to reliable, sustainable and affordable energy is critical for the utilization, processing and preservation of aquatic foods and the protection of the associated livelihoods. In contrast, a lack of access to energy stifles social, economic and human development, and this is especially true in SSF, where energy is required for many activities such as ice making and refrigerated storage and yet often the electricity required is not available, is unreliable or prohibitively expensive.

FAO is promoting the uptake of renewable energy solutions in SSF by raising awareness of good practices and providing technical guidance. Renewable energy contributes to reducing greenhouse gas emissions and can provide fishers, processors and traders with access to sustainable energy. Solar energy, for example, has become an increasingly practical alternative to conventional sources of electricity. Solar photovoltaic systems can provide a clean, renewable and cost-effective solution to meet the energy needs of SSF, particularly in regions with abundant sunlight throughout the year. Solar energy can power ice makers, freezers, cold stores, fish feeders, pumps, aerators, packaging equipment and lighting. Although the up-front costs of solar installations can be high, the low running costs can offset them over time, especially in off-grid locations and where business plans show economic viability. Supported by essential careful planning and incentives, solar energy interventions not only provide environmental and social benefits, but also help reduce fish loss and waste and provide new income and employment opportunities for SSF communities.

More information on FAO's work on renewable energy and small-scale fisheries can be found in:

- https://www.fao.org/energy/news/news-details/en/c/1641163/

SOURCE: Rincon, L., Ward, A., Vaskalis, I., Milani, M., Gallego, J. & Morese, M. 2024. *Solar energy and the cold chain: A guide for small-scale fisheries interventions*. FAO, Rome.

risks and benefits of fish consumption were held by FAO and WHO in 2009 and 2023 to provide recommendations and food safety guidance based on the latest scientific evidence.

The expert panel examined the benefits of fatty and lean fish consumption for several human health outcomes including, but not only, allergy and immunological disorders, cancer, cardiovascular disease, neurodevelopment and neurological disorders, and overweight and obesity. Potential adverse effects of dioxins were investigated with respect to chloracne and other dermatological conditions, male and female reproduction, birth outcomes, thyroid disease and thyroid hormones, type 2 diabetes and obesity, cardiovascular diseases, hepatic disorders, cancers, and impacts on teeth, bones and the digestive, immune and nervous systems. Exposure to methylmercury from fish consumption was considered for effects on growth, and for neurological, cardiovascular and other health outcomes. Furthermore, a possible health-protective role of selenium with respect to the health-adverse effects of methylmercury was investigated with regard to cardiovascular outcomes, oxidative stress, the immune system, reproduction, thyroid hormones, birth outcomes, neurodevelopment and cognition, vision, and motor function.

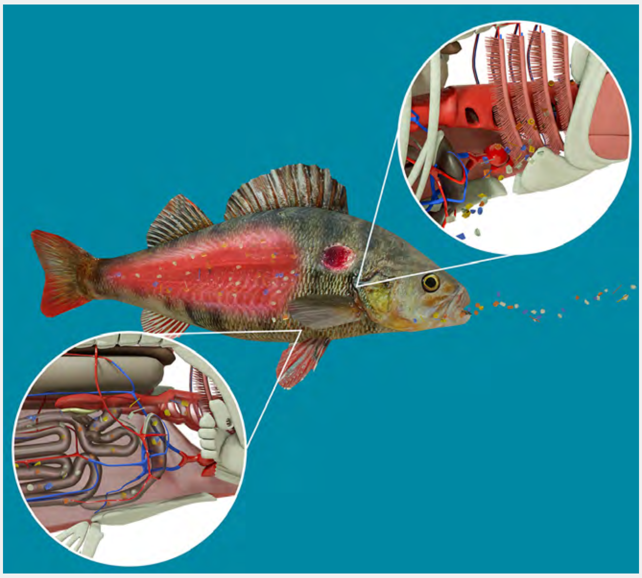
Conclusions from the 2023 expert consultation clearly indicate that there are considerable health and nutrition benefits of fish consumption, and strong evidence exists for the benefits of whole fish consumption during all life stages. For example, there are associations between fish consumption by women during pregnancy and improved birth outcomes; and there are connections between fish consumption by adults and reduced

BOX 42 THE IMPACTS OF MICROPLASTICS ON THE SAFETY OF AQUATIC FOODS

Microplastics (0.1 µm – 5 mm in diameter) and nanoplastics (< 0.1 µm in diameter) result from the degradation of plastic waste and can pose a threat to aquatic organisms, food safety and public health. Foods are an important pathway of human exposure to microplastics. Exposure to the plastic polymers themselves is cause for concern because, although they are generally considered to be biologically inert, reactive compounds may still be embedded in their structure; in addition, microplastics may also absorb contaminants from their environment.

Microplastics have been found to be widespread in a variety of foods, and their presence in aquatic products has been the focus of several studies. Reports in the scientific literature identify various harmful health effects, with neurotoxicity, oxidative stress and immunotoxicity among the main consequences of exposure to microplastics.

Although the reported hazards and their associated exposure levels are currently considered low in aquatic foods, significant challenges – data limitations for other food commodities, knowledge gaps on the toxicity of micro- and nanoplastics, and a lack of standardized analytical methods – hamper the formulation of definitive conclusions on the public health significance of these particles. An FAO report (Garrido Gamarro and Costanzo, 2022) analyses these issues and identifies the need for the development and harmonization of reliable analytical techniques for micro- and nanoplastics in foods; further investigation into the occurrence and toxicity of these substances in food value chains; and evaluation of acute and chronic exposure to microplastics in various foods to understand the overall impact and propose effective preventative measures.



Microplastics: their ingestion and presence in fish
SOURCE: Adapted from Barboza, L.G.A., Lopes, C., Oliveira, P., Bessa, F., Otero, V., Henriques, B., Raimundo, J., Caetano, M., Vale, C. & Guilhermino, L. 2020. Microplastics in wild fish from North East Atlantic Ocean and its potential for causing neurotoxic effects, lipid oxidative damage, and human health risks associated with ingestion exposure. *Science of the Total Environment*, 717: 134625. http://doi.org/10.1016/j.scitotenv.2019.134625

SOURCE: Garrido Gamarro, E. & Costanzo, V. 2022. *Microplastics in food commodities – A food safety review on human exposure through dietary sources*. Food Safety and Quality Series, No. 18. Rome, FAO. https://www.fao.org/documents/card/en/c/cc2392en

risks of cardiovascular and neurological diseases. Methylmercury exposure from fish consumption in early life has been associated with reduced neurodevelopmental benefits; and there is heterogeneous evidence regarding selenium intake potentially providing some protective measures against the adverse health effects of methylmercury.

The results of the expert consultation set a framework for assessing the health benefits and risks of fish consumption and will provide guidance to the Codex Alimentarius Commission in its work on managing risks, considering the existing data on the risks and benefits of consuming fish. The consultation's report presents detailed conclusions,

BOX 43 ENSURING THE SAFETY OF SEAWEED FOODS

World seaweed production has more than tripled since 2000, reaching around 38 million tonnes in 2022, mostly from aquaculture. Between 30 percent and 38 percent of production is used for human consumption, and seaweed aquaculture provides significant employment opportunities for coastal communities, in particular for women and youth (Cai *et al*., 2021).

Recent decades have seen growing interest globally in seaweeds thanks to their great potential for improved nutrition, pharmaceutical and cosmetics uses, carbon sequestration, and ecosystem services. It is therefore necessary to consider carefully the food safety implications of seaweed production and utilization and develop adequate legislation, codes and guidelines to manage the associated hazards.

Ingredients for pickled seaweed
© FAO/David Hogsholt

Hazards potentially posed by seaweed consumption depend on, *inter alia,* the type of seaweed, its physiology, the water and season in which it grows, and the harvesting and processing methods adopted. Hazards caused by microorganisms and toxic levels of heavy metals and marine biotoxins have been associated with seaweeds, but there are limited data on their occurrence across the wide variety of seaweed species.

An FAO–WHO report (2022) indicates that heavy metals (principally inorganic arsenic and cadmium), microbial hazards (e.g. *Salmonella* spp.) and high iodine levels might raise food safety concerns in seaweed products. However, the limited national and regional seaweed intake data make it difficult to evaluate populations' exposure from seaweed to these potentially toxic components. More data are necessary to conduct a risk assessment of potential hazards, to establish their public health significance, and to provide evidence for the development and subsequent enforcement of food legislation. The report provides basic information and guidance to Codex Alimentarius for the development of a Codex standard or guidelines that specifically address food safety during seaweed production, processing and utilization. Such guidelines will be key for unlocking the potential – economic, nutritional and environmental – of seaweeds.

SOURCES: FAO & WHO. 2022. *Report of the expert meeting on food safety for seaweed – Current status and future perspectives. Rome, 28–29 October 2021.* Food Safety and Quality Series, No. 13. Rome. https://doi.org/10.4060/cc0846en
Cai, J., Lovatelli, A., Aguilar-Manjarrez, J., Cornish, L., Dabbadie, L., Desrochers, A., Diffey, S. *et al.* 2021. *Seaweeds and microalgae: an overview for unlocking their potential in global aquaculture development.* FAO Fisheries and Aquaculture Circular, No. 1229. Rome, FAO. https://doi.org/10.4060/cb5670en

identifies research needs and data gaps, and recommends a series of steps that Members should take to better assess and manage the risks and benefits of fish consumption. The summary report of the Ad hoc Joint FAO/WHO Expert Consultation on Risks and Benefits of Fish Consumption contains key conclusions and recommendations.[bh] Examples of emerging concerns for the safety of aquatic foods are presented in Box 42 and Box 43. ■

bh See: https://www.fao.org/3/cc8503en/cc8503en.pdf

BANGLADESH
Community-based
inland fish farming.
© FAO/Saikat Mojumder

PART 3
OUTLOOK AND CONTEMPORARY ISSUES

AQUATIC FOODS: AN UNTAPPED POTENTIAL FOR HEALTHY DIETS

Aquatic foods can be an integral part of a healthy diet that is environmentally, socially and economically sustainable. Unfortunately, their role in sustainable food systems is often under-recognized. This section highlights this role and how simple solutions can improve the contribution of aquatic foods to healthy diets and to the four betters (better production, better nutrition, a better environment and a better life) through the Blue Transformation Roadmap.

Why aquatic foods

Aquatic food systems are unique in many ways. Compared to other animal food systems, they on average have a lower carbon footprint and fewer environmental impacts. Almost half of aquatic animals are harvested from wild fisheries, while the remainder are farmed. Well-managed fisheries can ensure a sustainable supply of healthy aquatic foods. However, fishery resources are limited and the increasing global demand for aquatic foods requires a well-managed aquaculture sector to fill the gap. The growth rate of aquaculture production exceeds that of most other food production systems and still has great potential for expansion. Yet, most food production is still terrestrial. Annual growth of supply of aquatic animal foods has increased globally faster than annual population growth, boosting global per capita annual consumption from 9.1 kg in 1961 to 20.6 kg in 2021. It varies greatly between countries, and depends on many factors such as availability, accessibility, seasonality, and cultural and individual preferences. Likewise, expansion of aquatic food production and consumption requires upgraded value chains that ensure the social, economic and environmental viability of aquatic food systems.

Aquatic foods for better nutrition, a better environment and a better life

Recognized as an excellent source of protein, aquatic foods are an even more important source of other nutrients, in particular long-chain omega-3 fatty acids and various micronutrients difficult to find in many other foods, such as iodine, selenium, calcium, iron and zinc. Aquatic foods are considered among the healthiest foods and their consumption is linked to improved public health outcomes (UN Nutrition, 2021). Both iodine and long-chain omega-3 fatty acids are important for a child's brain development. Moreover, omega-3 fatty acids play an important role in protecting against coronary heart diseases (FAO and WHO, 2010), and aquatic foods are low in saturated fats known to contribute to several non-communicable diseases (see **Nutritional benefits of aquatic animal foods**, p. 78).

It is increasingly recognized that consumption of whole fish (not only the fillet) provides important essential nutrients in local diets, in particular minerals and vitamins, as well as being relatively affordable for low-income populations, ensuring access to nutritious foods for some nutritionally vulnerable populations (Robinson *et al*., 2022) (Box 44). Studies on the nutrient density of aquatic foods and their greenhouse gas emissions have demonstrated their exceptional nutritional value and low climate impact (Bianchi *et al*., 2022; Hallstrom *et al*., 2019; Hillborn *et al*., 2018). Small pelagic fish such as anchovies, sardines and low

BOX 44 SMALL FISH FOR FOOD SECURITY AND NUTRITION

In the struggle to reduce food insecurity and malnutrition, the role of small-scale producers is crucial, as is the importance of diversifying foods. The Illuminating Hidden Harvests study showed that small fish (less than 25 cm in length) constitute the bulk of the small-scale fisheries catch globally and could provide 20 percent of the recommended nutrient intake of calcium, selenium and zinc to 137 million women in Africa and 271 million women in Asia (FAO, Duke University and WorldFish, 2023). Small fish are nutrient dense and a rich source of omega-3 fatty acids, micronutrients and protein, particularly when consumed whole. The diversity of small fish species and the fact that consumers can purchase them in small quantities make them often an affordable food in many low-income communities in the developing world. Consuming adequate quantities of small fish together with other foods contributes to a diverse, healthy diet for addressing malnutrition. In addition, small fish are often easier to process and preserve using low-cost technologies such as drying, salting and smoking, because of their size and lipid composition, allowing for quicker moisture reduction to increase shelf-life (Fitri *et al*., 2022). Informal marketing, together with appropriate and affordable technologies for processing, preservation and storage of small fish, ensures year-round availability, accessibility and affordability of small fish for low-income consumers (Bavinck *et al*., 2023).

It is therefore vital to value small fish beyond economic terms and recognize their contribution to food systems and to healthy and resilient communities, particularly in low- and middle-income countries. However, it is fundamental to support those working in small fish supply chains and aquatic food systems and to foster collaboration among governing actors across sectors if aquatic food systems are to be developed for the benefit of food security and nutrition (Bavinck *et al*., 2023). Governance plays a central role in improving aquatic food systems and supply chains of small fish, not only managing fishery stocks to ensure food security and nutrition now and in the future, but also supporting small-scale producers to meet food safety standards while maintaining the affordability of products to ensure equitable food systems which deliver nutrients to all.

SOURCES: Bavinck, M., Ahern, M., Hapke, H.M., Johnson, D.S., Kjelevold, M., Kolding, J., Overå, R. & Schut, T., eds. 2023. *Small fish for food security and nutrition*. FAO Fisheries and Aquaculture Technical Paper, No. 694. Rome, FAO. https://doi.org/10.4060/cc6229en
FAO, Duke University & WorldFish. 2023. *Illuminating Hidden Harvests – The contributions of small-scale fisheries to sustainable development*. Rome. https://doi.org/10.4060/cc4576en
Fitri, N., Chan, S.X.Y., Che Lah, N.H., Jam, F.A., Misnan, N.M., Kamal, N., Sarian, M.N. *et al*. 2022. A Comprehensive Review on the Processing of Dried Fish and the Associated Chemical and Nutritional Changes. *Foods*, 11(19): 2938. https://doi.org/10.3390/foods11192938

trophic level species (known for their nutritional richness) generate fewer greenhouse gases than, for example, fed aquaculture. Non-fed farmed species like bivalves and seaweeds have an even lower carbon footprint and can have positive environmental impacts. Overall, aquaculture remains a good nutritional and environmental alternative compared to production of meats such as beef, pork and chicken.

Improving food security, nutrition and livelihoods through processing

When aquatic foods are processed, parts not considered edible are often removed – for example, the head, bones, skin, scales and trimmings, which represent 30–70 percent of the whole fish weight. They are rich in micronutrients, but some need further processing to become edible. Simple low-cost technologies such as drying, smoking, fermentation and milling can transform these parts into affordable and nutritious products, with even higher nutritional value than the fillet (Glover-Amengor *et al*., 2012; Toppe *et al*., 2007). These aquatic foods are high in omega-3 fatty acids, minerals such as iron, zinc and calcium, and vitamins such as A, D and B12 (UN Nutrition, 2021).

Improved utilization of fish by-products can reduce negative impacts on the environment and create additional economic activities among

BOX 45 HOME-GROWN SCHOOL FEEDING

Home-grown school feeding (HGSF) aims to provide schoolchildren with safe, diverse and locally sourced nutritious foods. Simultaneously, it yields benefits for smallholder farmers and the broader community. What distinguishes HGSF from traditional school feeding initiatives is its focus on sourcing foods locally from smallholder farmers, thereby fostering a mutually beneficial relationship. In essence, HGSF programmes aim to fortify local agricultural and food markets through direct procurement from small-scale farmers. In order to retain HGSF's "home-grown" identity, at least some of the foods must be locally sourced to highlight the additional objective of supporting local communities.

By procuring a diverse range of nutritious foods from local small farmers and producers, schools become catalysts for growth within their community's agriculture sectors, encouraging diversity in food production that benefits the entire region. These programmes transcend the nourishment of children to forge sustainable agrifood systems.

Moreover, HGSF adopts a multifaceted approach, addressing various aspects of community well-being, including production, processing, distribution, nutrition, and waste management. This multifunctional approach makes it a versatile tool for achieving the Sustainable Development Goals. It also contributes to sustainability by actively endorsing practices that help preserve the local environment, as well as curtailing pollution associated with handling, transportation and storage by streamlining the supply chain and ultimately reducing its carbon footprint. Sustainable production of aquatic foods actively contributes to the preservation of aquatic ecosystems and biodiversity. This approach inspires communities to protect their water resources and adopt eco-friendly practices in food production.

The incorporation of aquatic foods into HGSF programmes improves their nutritional value and their sustainability. Aquatic foods are a rich source of high-quality protein, essential fatty acids, vitamins and minerals, making them invaluable for the improvement of children's diets, nutrition and health. Proper nutrition plays a pivotal role in cognitive development and school performance. By sourcing locally produced, nutritious foods, schools ensure that children receive balanced meals that not only support their physical growth but also enhance their ability to focus and learn effectively.

In summary, HGSF programmes can address a broad spectrum of challenges encountered by communities. By sourcing foods locally, bolstering support for local farmers and fishers, and integrating a wide range of nutrient-rich aquatic foods, these initiatives not only nurture the physical and intellectual well-being of children, but also improve economic growth and strengthen communities – reducing their reliance on external food sources. Home-grown school feeding makes meaningful contributions to food security, sustainability, community stability, and the well-being of the ecosystems on which it relies, exemplifying an effective approach for positive change at the intersection of education, food production and nutrition.

coastal populations (see **Multidimensional solutions to food loss and waste**, p. 183, **Products: fishmeal and fish oil**, p. 68 and **By-product utilization**, p. 71). FAO has supported home-grown school feeding (HGSF) programmes to encourage local production of fish and fish products such as underutilized locally produced small fish and fish powders produced from fisheries by-products. This promotes inclusive economic growth and better livelihoods for small-scale producers, as well as better nutrition in pilot schools where fish is served as part of a healthy school meal (Ahern *et al.*, 2021; Toppe *et al.*, 2021) (Box 45). An FAO study in Ghana (Glover-Amengor *et al.*, 2012) promoted the use of dried fish powder produced from tuna frames. The product showed a high level of acceptability when included in traditional dishes in a school meal programme. In Guatemala, tilapia was included in school meals; in addition to fillets, other products like fish cakes were produced and had a high level of acceptability. Rather than contributing to just one meal, a single fish could provide two or three meals – improving the level

BOX 46 FOOD COMPOSITION DATA OF AQUATIC FOODS

Aquatic foods are a key source of essential omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), micronutrients such as iodine, iron, zinc, calcium, vitamins B12 and D, and protein. Despite recognition of the potential of aquatic foods to nourish people around the world in a sustainable manner, they still tend to be overlooked in efforts to end hunger and malnutrition. More up-to-date and accurate food composition data on aquatic foods are needed to increase awareness on their nutritional benefits and to allow for evidence-based nutrition policies and programmes.

To help address this gap, FAO has developed a global nutrient conversion table (NCT) for application to the FAO Supply Utilization Accounts (SUAs), based on national or regional food composition data. Until 2023, SUA statistics (available through FAOSTAT) included only energy and macronutrients (protein and fats), while the global NCT provides data required to generate statistics for energy, macronutrients, vitamins (vitamins A, B6 and B12, thiamin, riboflavin and vitamin C), minerals (calcium, iron, magnesium, phosphorus, potassium, zinc, copper and selenium) and fatty acids (total saturated, mono- and polyunsaturated fatty acids, EPA and DHA) for fish and other aquatic products.

The FAO/INFOODs (International Network of Food Data Systems) global food composition database for fish and shellfish (uFISH) was developed in 2016. Currently, the database includes 78 species of finfish, crustaceans and molluscs. Unfortunately, it is still lacking the much-needed data on whole small fish species, important for food security and nutrition in many low-income countries. The full nutrient profiles for the broader diversity of aquatic foods consumed worldwide are also incomplete, and especially lack reliable statistics on vitamins and minerals. Databases that house this information are valuable for nutritionists, health practitioners, fisheries managers, researchers and policymakers.

To better understand data on the food composition of aquatic foods and recognize the strengths of various available databases, FAO and partners conducted a review of databases containing nutrient composition data on aquatic foods (see figure). Following this work, FAO began leading a three-year project to update uFISH aiming to expand information on the nutrient composition of, in particular, small fish species consumed whole and seaweed species not included in the current uFISH. »

of micronutrients in meals and reducing both cost and environmental impact.

Several studies have reported high levels of food loss and waste (FLW) in the fish value chain (see **Innovations in sustainable trade and value chains**, p. 167). Most of these focus on physical losses of fish, and only a few have estimated the loss of nutrients. This, in part, is due to the limited data on the composition of aquatic foods consumed globally in different forms (i.e. fresh, sun-dried, smoked and fermented fish, as well as fish sauces and pastes) and including all parts (i.e. bones, eyes, muscle tissue). FAO and other partners are currently deploying efforts to expand food composition data on aquatic foods for better understanding of intake and loss (Box 46).

The paradox

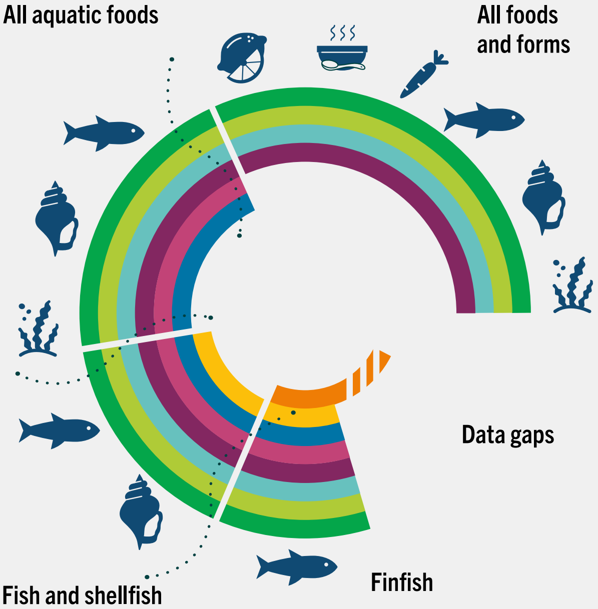
There has recently been an increased focus on reducing FLW – estimated at 30–35 percent of production – including from aquatic environments (FAO, 2011b). Fish by-products are usually not considered as food; indeed, they are often utilized for non-food purposes and therefore not regarded as food loss. Reducing FLW while increasing the utilization of by-products for food purposes offers potential for increasing access to and availability of aquatic foods, complementing the expansion of aquaculture production to meet the increasing demand. Most importantly, processing fish by-products for human consumption can address deficiencies in nutrients such as iron, calcium and several other micronutrients. Figure 59 shows the potential for utilizing tilapia by-products to address food security and nutrition needs and the potential for reducing FLW. ■

SUMMARY OF SELECT DATABASES CONTAINING NUTRIENT COMPOSITION DATA ON AQUATIC FOODS

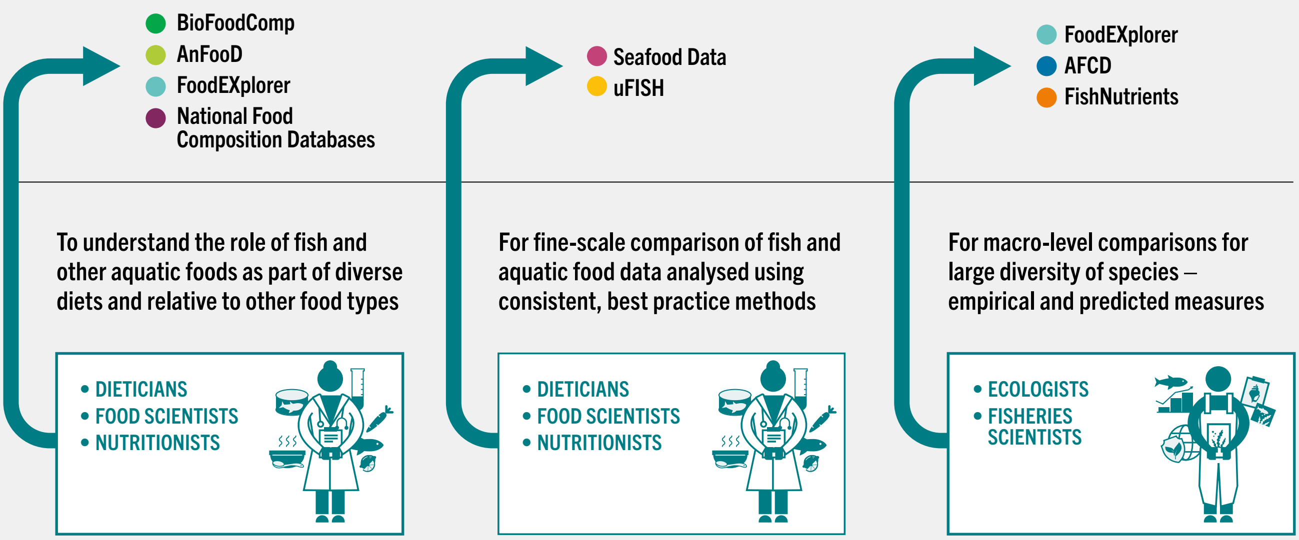
SERVING UP DATA ON NUTRIENT COMPOSITION OF AQUATIC FOODS

The nutrient values of fish and other aquatic foods can alleviate "hidden hunger" or micronutrient deficiencies for many people in a range of geographies. But nutrient measures for many species, food types and geographies are unavailable, and are prohibitively expensive to determine. Therefore, databases that house the data that do exist are incredibly valuable for health practitioners, fisheries managers, researchers and policymakers. There are many databases out there – each useful, overlapping and distinct in different ways. Here is a summary of these powerful databases, with the users they best serve, the types of data they hold and how they compare.

DATA COVERAGE ACROSS FOOD TYPES

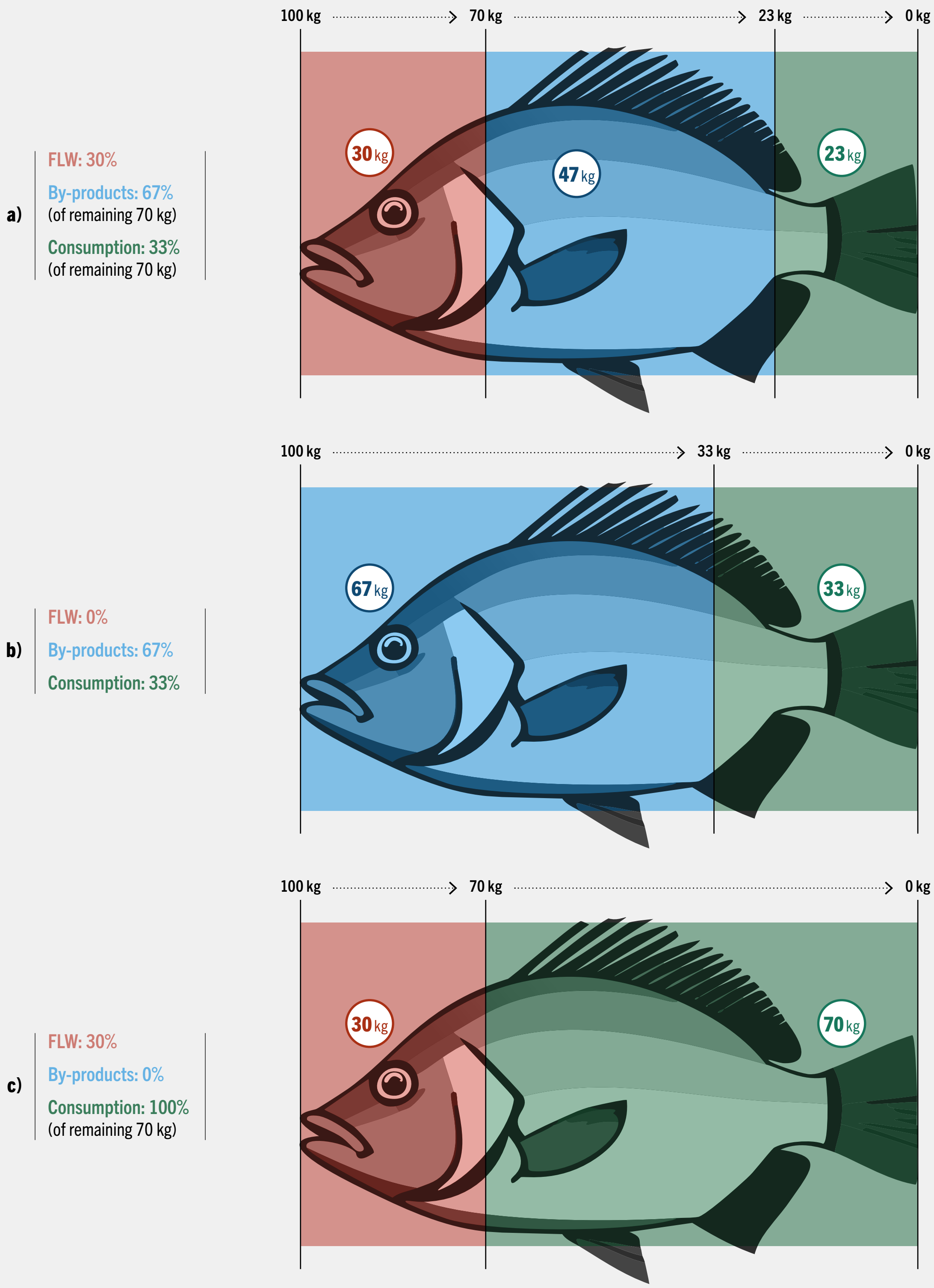


DATA SOURCES CONTRIBUTING TO EACH DATABASE



SOURCE: Adapted from Cohen, P., Consalez, F., Ahern, M., Masangwi, S., Rittenschober, D., Holmes, B., Kjellevold, M., Golden, C. & Hicks, C. 2022. *Serving up Data on Nutrient Composition of Aquatic Foods*. Bayan Lepas, Malaysia, WorldFish. [Cited 9 January 2024]. https://digitalarchive.worldfishcenter.org/handle/20.500.12348/5329

FIGURE 59 ELIMINATING LOSS AND WASTE FOR TILAPIA AND UTILIZING ITS BY-PRODUCTS FOR FOOD PURPOSES



NOTES: Considering 100 kg of fish: a) food loss and waste (FLW) is 30 kg and only 23 kg are consumed as food, with the volume of by-products representing 47 kg; b) eliminating FLW would increase fish for consumption from 23 kg to 33 kg (an increase of about 40 percent); c) converting all by-products into food would increase fish for consumption from 23 kg to 70 kg (an increase of about 200 percent).

SOURCE: Authors' own elaboration.

THE KEY ROLE OF AQUATIC FOODS IN CLIMATE ACTION

The vulnerability of the aquatic food sector to climate change impacts is gaining increased recognition. Through the FAO Strategic Framework 2022–2031 and its Blue Transformation Roadmap, FAO and partners support the development of robust, resilient and sustainable aquatic food systems that contribute significantly to global food security and poverty alleviation. This section maps the trajectory of discussions on aquatic foods under the United Nations Framework Convention on Climate Change (UNFCCC). Global policy on how aquatic food systems should adapt to climate change is supported by field projects to implement climate solutions, with examples featured in this section, including the estimated cost to replicate and upscale them.

The journey of aquatic foods under the UNFCCC

Policies of recent years have increasingly focused on the nexus between climate change, aquatic ecosystems and food production, as a result of pivotal consultations initiated within the UNFCCC. The journey began in 2009 when the 15th UNFCCC Conference of the Parties (COP15) launched Oceans Day; in 2016, COP22 saw Oceans Day integrated in the official "blue zone" where negotiations occur. Mandated by COP25, the first Ocean and Climate Change Dialogue (hereinafter Ocean Dialogue) was held in 2020; it highlighted the critical role of ocean-climate action, harnessing insights from the 2019 Intergovernmental Panel on Climate Change Special Report on the Ocean and Cryosphere.[bi]

The outcomes of the first Ocean Dialogue were presented at COP26 in 2021, leading to a historic decision to hold annual Ocean Dialogues during the UNFCCC Subsidiary Body for Scientific and Technological Advice sessions and include ocean-related topics in the UNFCCC multilateral process. Further progress was made at the 2022 Ocean Dialogue by underscoring the importance of strengthened national ocean-climate action and synergies between ocean and climate policies, culminating in a dedicated section on the ocean in the COP27 Sharm el-Sheikh Implementation Plan.

In 2023, the Ocean Dialogue selected "fisheries and food security" as one of two topics for deep-dive discussions, recognizing the significant potential of the aquatic food sector for providing critical climate solutions coherent with boosting food security. The dialogue emphasized the need for integrating aquatic food climate solutions into both national and multilateral climate processes. Special attention was also given to empowering vulnerable small-scale fishers and fish farmers to adapt to climate change.

A public call to inform the Ocean Dialogue resulted in the submission of about 100 case studies (Figure 60) that demonstrate the vital role of the aquatic food sector in providing adaptation and mitigation solutions. These examples also contributed valuable input to the Global Stocktake (GST)[bj] that aims to assess and accelerate the collective progress towards the achievement of the Paris Agreement goals, thereby informing on the preparation, updating and implementation of country-led instruments such as nationally determined contributions (NDCs) and National Adaptation Plans (NAPs).

Overall, these efforts led to an increased prominence of aquatic foods in COP28 decisions. For example, climate-resilient food systems and management of inland, marine and coastal ecosystems were highlighted as suitable climate solutions.[bk] Moreover, over 150 countries endorsed a political declaration on sustainable agriculture, resilient food systems, and climate action that refers to promoting sustainable aquatic foods.[bl]

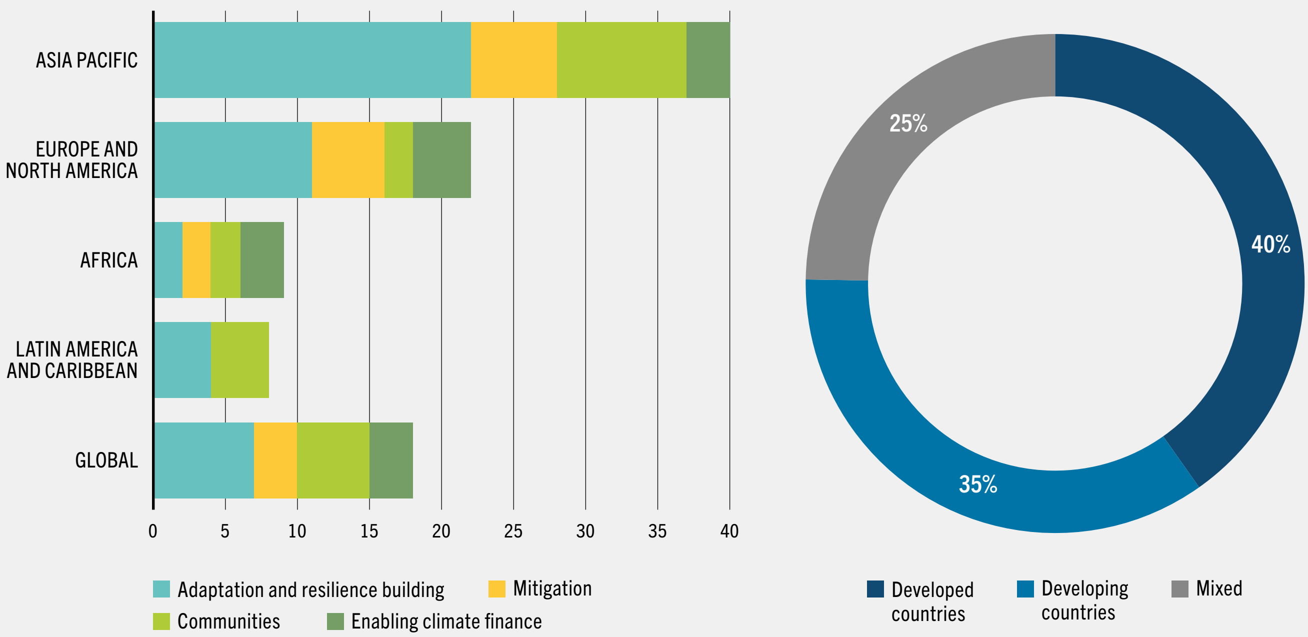
bi For further details, see: https://www.ipcc.ch/srocc/

bj The GST is a party-driven process under the UNFCCC conducted in a transparent manner with the participation of non-party stakeholders, aiming at taking stock of where the world stands on climate action, identifying the gaps and developing solutions pathways to 2030 and beyond.

bk For further details, see: https://unfccc.int/sites/default/files/resource/cma2023_L17_adv.pdf

bl For further details, see: https://www.cop28.com/en/food-and-agriculture

FIGURE 60 OVERVIEW OF AQUATIC FOOD-RELATED CASE STUDIES AND INITIATIVES SUBMITTED TO THE 2023 UNFCCC ANNUAL OCEAN AND CLIMATE CHANGE DIALOGUE



NOTES: UNFCCC – United Nations Framework Convention on Climate Change. Countries and organizations submitted around 100 case studies and initiatives. The Asia Pacific region leads with 41 percent of the submissions, followed by Europe and North America (23 percent). The Africa region and the Latin America and Caribbean region contributed 9 percent and 8 percent of the submissions, respectively. Submissions in relation to adaptation and resilience building ranked highest (47 percent), followed by those addressing communities (23 percent), mitigation (13 percent), and enabling climate finance (17 percent). Overall, developing countries made fewer submissions (35 percent) than developed countries (40 percent). The development status is categorized based on the United Nations Conference on Trade and Development statistics classification page (available at: https://hbs.unctad.org/classifications/).

SOURCE: Authors' own elaboration.

Building good practices from the ground

The first GST highlighted the urgent need for increased adaptation action to reduce and respond to growing impacts, particularly for those who are least prepared to cope with and recover from climate change impacts, climate variability, and weather-related disasters (Box 47). The 2023 Ocean Dialogue featured FAO field projects and programmes implementing climate change adaptation solutions for aquatic food systems across regions (Figure 61).

These projects are instrumental in providing support to highly vulnerable coastal and riparian fisheries and aquaculture communities[bm] to reduce their vulnerability and boost their adaptation capacity and resilience. They leverage approaches such as the ecosystem approach to fisheries (EAF) and to aquaculture (EAA), while integrating gender issues, strengthening information management and monitoring capacities, improving safety at sea, enhancing national policies and existing legal frameworks, diversifying livelihoods, and promoting biodiversity conservation capacity and practices in fishing and fish farming. In some instances, early warning systems have been

bm For example, in Belize, the Gambia, Grenada, the Lao People's Democratic Republic, Mozambique, the Philippines, Saint Lucia, Solomon Islands, South Africa, Sri Lanka, Timor-Leste and Vanuatu.

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BOX 47 PREVENTION, PREPAREDNESS AND REHABILITATION OF AQUATIC FOOD SYSTEMS AFTER CLIMATE-RELATED SHOCKS AND DISASTERS

Intense climate-related disasters – floods, storms and tropical cyclones, droughts and heatwaves – have been on the rise worldwide with significant socioeconomic impacts. Disaster risk drivers include climate change, poverty and inequality, population growth, health emergencies caused by pandemics, practices such as unsustainable land use and management, armed conflicts, and environmental degradation (FAO, 2023). Intense climate-related shocks and disasters now account for more than 80 percent of all disaster events. Over the past 50 years, the cumulative death toll from all recorded disasters stands at 2 million, with a shocking 90 percent of these deaths occurring in developing countries (WMO, 2023).

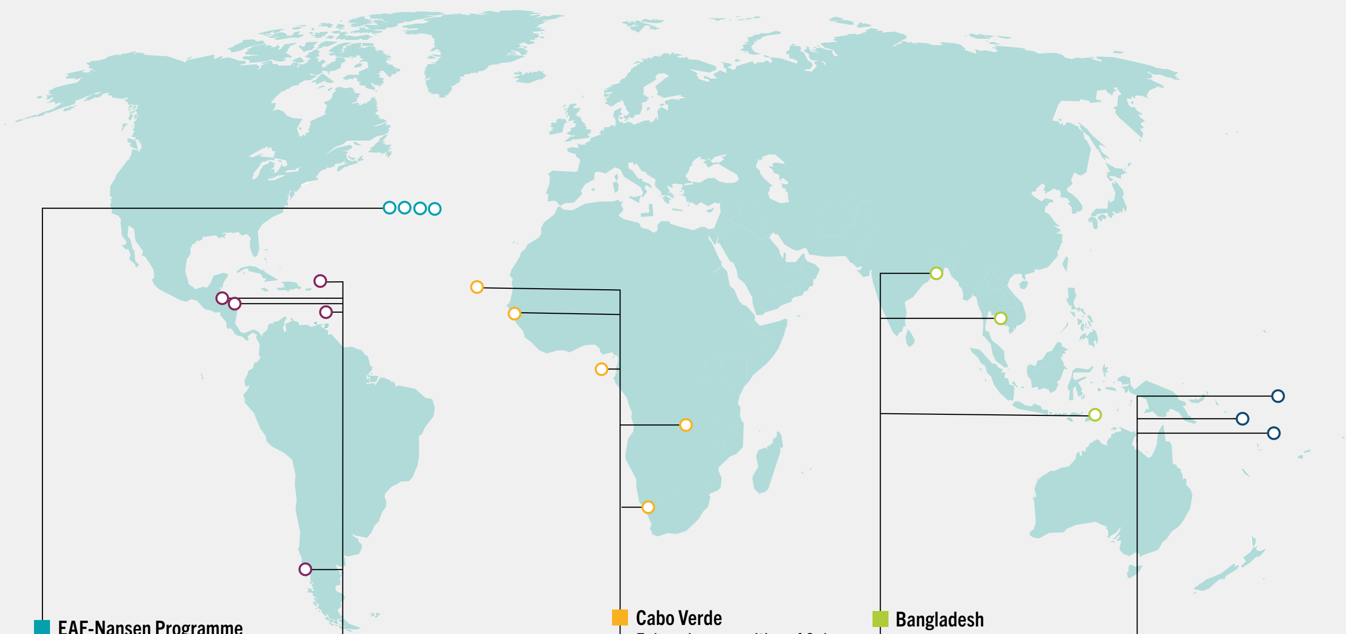
Not all extreme events necessarily result in a disaster, and the extent of their impacts on the fisheries and aquaculture sector depends on how exposed and vulnerable aquatic food systems are, as well as their capacity to respond. Poverty, unequal access to resources, and governance structures all play a pivotal role in determining the risks and impacts of disasters. Disasters can cause damage to boats, engines, fishing gears, landing sites, post-harvest facilities, and aquatic habitats. They can also cause loss of livelihoods and disruption to aquatic food chains, decrease availability of aquatic foods, and result in loss of export revenues.

Fortunately, compared with other sectors, rapid restoration of activities in fisheries and aquaculture after a disaster can, in some circumstances, quickly provide nutritious foods and employment, and fast-track a community's return to normal economic activity. Although FAO's interventions to date have largely been reactive in response to disasters, a proactive approach is progressively being deployed. Over the last few years, FAO has, for example, supported fishers with fishing gears and processing and engine repair equipment to restart fishing activities in the Bahamas (after Hurricane Dorian in 2019), Tonga (after a volcanic eruption and consequent tsunami in 2022) and South Sudan (annually, after floods). FAO has also developed guidelines to support the fisheries and aquaculture response to emergencies, training seven Caribbean Small Island Developing States institutions in the use of these guidelines with further training planned for Africa, Asia and Latin America. This allows for more holistic assessments and quicker responses, with rehabilitation of the entire aquatic value chain. However, data for assessing the impact of disasters on fisheries and aquaculture remain partial and inconsistent, making it more difficult to assess the damage and losses to the sector and often leaving the sector excluded from assessments and consequent response and rehabilitation funding. It is therefore essential to continue improving data collection tools and systems and to further implement the FAO loss and damage assessment tool.

Developing proactive and timely interventions by anticipating, preventing and reducing future risks is crucial. Urgent action is needed to prioritize the integration of multi-hazard disaster risk reduction (DRR) strategies into fisheries legislation to reduce mortality and loss of assets, as well as to develop policies and programmes and align them with global frameworks for DRR and disaster risk management. Such strategies include areas of work that FAO has been supporting, for example, in building climate-resilient infrastructure, enhancing safety at sea, establishing comprehensive fisher and vessel registries, and formulating early warning systems for shock-responsive social protection to deploy anticipatory action. They also include developing disaster risk preparedness and response plans at the national and local level, integrating "building back better" principles for the fisheries and aquaculture sector in Grenada and Saint Vincent and the Grenadines.

SOURCES: FAO. 2023. *The Impact of Disasters on Agriculture and Food Security 2023 – Avoiding and reducing losses through investment in resilience*. Rome. https://doi.org/10.4060/cc7900en
WMO (World Meteorological Organization). 2023. Economic costs of weather-related disasters soars but early warnings save lives. In: *WMO*. [Cited 16 November 2023]. https://wmo.int/media/news/economic-costs-of-weather-related-disasters-soars-early-warnings-save-lives

FIGURE 61 EXAMPLES OF FAO FIELD PROJECTS AND PROGRAMMES ON CLIMATE CHANGE ADAPTATION FOR THE AQUATIC FOOD SECTOR



EAF-Nansen Programme
Supporting the application of the EAF to fisheries management considering climate and pollution impacts

Responsible resource use
Responsible use of fisheries and aquaculture resources for sustainable development

Implementing adaptation measures
Supporting Members to implement climate change adaptation measures in fisheries and aquaculture

Tuna Project under Common Oceans Program
Modelling the impact of climate change on distribution of tuna stocks to inform management responses

Eastern Caribbean SIDS
Climate change adaptation in the Eastern Caribbean fisheries sector (CC4Fish)

Belize
Enhancing adaptation planning and increasing climate resilience in the coastal zone and fisheries sector

Honduras
Support for preparation of a proposal to the GCF on fishing and aquaculture in coastal and island areas

Saint Lucia
Improving the capacity of the fisheries sector to enhance resilience to climate change

Chile
Strengthening the adaptive capacity to climate change in the fisheries and aquaculture sector

Cabo Verde
Enhancing capacities of Cabo Verde in addressing effects of climate change in key sectors of the blue economy

Gambia
Climate-resilient fisheries initiatives for livelihood improvement

Sao Tome and Principe
Enhancing capacities of Sao Tome and Principe in addressing effects of climate change in key sectors

Malawi
Building climate change resilience in the fisheries sector in Malawi

Benguela Current
Enhancing climate change resilience in the Benguela Current fisheries system

Bangladesh
Community-based climate-resilient fisheries and aquaculture development in Bangladesh

Cambodia
Climate adaptation and resilience in Cambodia's coastal fisheries-dependent communities
CapFish Capture: Pursuing resilient fisheries systems through improved management

Timor-Leste
IkanAdapt: Strengthening the adaptive capacity and resilience of fisheries- and aquaculture-dependent livelihoods

Kiribati
Resilient islands resilient communities

Fiji, Solomon Islands, Vanuatu
Adaptive fisheries management

Fiji
Building resilience in Fiji's fisheries sector through improved DRR and DRM

NOTES: DRM – disaster risk management; DRR – disaster risk reduction; EAF – ecosystem approach to fisheries; GCF – Green Climate Fund; SIDS – Small Island Developing States. Projects and programmes were implemented with financial support from the Green Climate Fund, the Global Environment Facility, and the Norwegian Agency for Development Cooperation in collaboration with partners (e.g. WorldFish, South Pacific Commission).

SOURCE: Authors' own elaboration.

» developed, climate-proofing has been applied to fisheries infrastructure and assets (e.g. landing sites and fishing vessels), and local food systems have been diversified.

In South Sudan, FAO is supporting freshwater fishing communities to alleviate the impacts of climate change and civil unrest. It involves innovation in canoe building – using fewer timber products while increasing the canoe's lifespan. Efforts are also made to increase the efficiency of connections between production hubs and markets, review aquatic food value chains, develop management plans, and adopt improved post-harvest techniques.

A key strength of the ongoing FAO projects and initiatives lies in the integration of traditional knowledge for adapting to changing climatic conditions in specific areas, offering key insights into local species most suited to adapting to evolving conditions. Additionally, emphasis is placed on stakeholder engagement, as well as the involvement of youth, women and Indigenous Peoples. These elements are essential in supporting vulnerable communities to build resilience to climate change and adapt livelihoods through management and technology improvements and diversification of local food systems.

Considering the experience of several Latin American and Caribbean countries where aquaculture is well developed and climate change plans have been successfully implemented, FAO is developing a conceptual framework for assessing strategies for adapting aquaculture to climate change. The framework will guide countries in establishing strategies for climate-proof aquaculture by identifying innovative solutions to cope with climate change impacts. Preliminary case studies for farming salmon and oysters are underway to validate the effectiveness of the framework and its use to support countries in defining strategies under their NAPs. FAO is also identifying feasible climate-smart aquaculture technologies based on the best scientific knowledge for adoption by Members to make aquaculture more carbon-efficient, resilient and productive, thereby aligning with the Paris Agreement's preamble that recognizes the fundamental priority of safeguarding food security and ending hunger.

The cost of scaling up climate action

Accelerating climate action requires adequate financing. A review of NDCs and NAPs estimated the costs of adaptation for the aquatic food sector in all developing countries at USD 4.8 billion per year by 2030. These costs are estimated to rise significantly towards 2050. Unfortunately, public international adaptation finance flows to the aquatic food sector have averaged only USD 0.2 billion per year (2017–2021) underscoring a significant adaptation finance gap.

Ensuring access to climate finance for the aquatic food sector – especially its small-scale producers – emerged as a significant issue during the 2023 UNFCCC Ocean Dialogue, highlighting the need to provide the know-how to effectively access funds, and to enhance the awareness of funding institutions such as the Global Environment Facility and Green Climate Fund on climate risks and solutions within the sector. In line with this objective, FAO has developed climate finance training materials to help governments and other stakeholders assess climate risks, build climate rationale, develop adaptation actions, and formulate adaptation finance proposals. In addition, FAO is developing guidance, frameworks and tools to facilitate access to climate finance for fisheries and aquaculture projects.

Conclusion

Blue Transformation stresses the need for increased mobilization in the planning and implementation of climate action in the aquatic food sector. To improve the current situation, where most efforts are incremental and unequally distributed across regions, there must be a significant upscaling of climate action. Such action must be sustained, transformative and equitable, as well as adequately financed, particularly for climate-vulnerable communities reliant on aquatic food systems. Furthermore, while the ocean has been a primary entry point for the aquatic food sector's engagement under the UNFCCC, it has become evident that this engagement must expand to encompass food production from freshwater systems, and give due consideration to aquaculture, post-harvest activities, trade and consumer education. To this end, it is essential to support vulnerable stakeholders to gain insights on the UNFCCC structure and participate in the climate negotiation process. This requires enabling them to access practical entry points to contribute to the climate negotiation process and to level the playing field for the sector's effective engagement in multilateral climate policymaking processes. ■

IMPACTS OF EL NIÑO ON MARINE FISHERIES AND AQUACULTURE

Overview of El Niño and related risks in FAO Major Fishing Areas

The El Niño Southern Oscillation (ENSO) is a natural climate phenomenon that periodically causes Pacific Ocean warming (El Niño) and cooling (La Niña) and influences air surface temperature change and precipitation across the globe. During El Niño events, natural ocean conditions are considerably altered due to changes in sea surface temperature (SST) and upwelling, which affect the availability of foods and suitable habitats for fish and other marine species.

El Niño events have been linked to changes in fish catch from a variety of fisheries. Key events include those in the Tropical Pacific and Indian Ocean, in fisheries for highly migratory species like tuna, and Peruvian anchoveta in the Eastern Pacific. They also affect aquaculture infrastructure and cultured organisms; for example, increases in temperature and salinity associated with dry conditions resulting from El Niño events can strongly affect the growth and survival of Elkhorn sea moss, a popular seaweed farmed in the Philippines (see Box 21, p. 145). This industry supports around 200 000 family farms. El Niño impacts have important consequences as they affect livelihoods, food security and exports.

According to FAO's retrospective analysis (1950 to 2023), strong to extraordinary Eastern Pacific El Niño events impacted marine fisheries in 11 of the 19 marine FAO Major Fishing Areas. The highest risk was in the Southeast Pacific, followed by the Indian Ocean and the Western and Eastern Central Pacific (Figure 62). The figure shows the analysis of El Niño-related risks for fisheries in each FAO Major Fishing Area as a function of hazard, exposure and vulnerability levels.

El Niño 2023–2024 – changes in ocean conditions

La Niña conditions prevailed in the Tropical Pacific Ocean from September 2021 to January 2023. In February 2023, the SST increased in the far Equatorial Eastern Pacific, suggesting the initiation of an El Niño event. By early March 2023, waters had warmed, especially in the Peruvian nearshore waters. From March to July 2023, the anomalous warming in the Equatorial Southeast Pacific continued to increase.

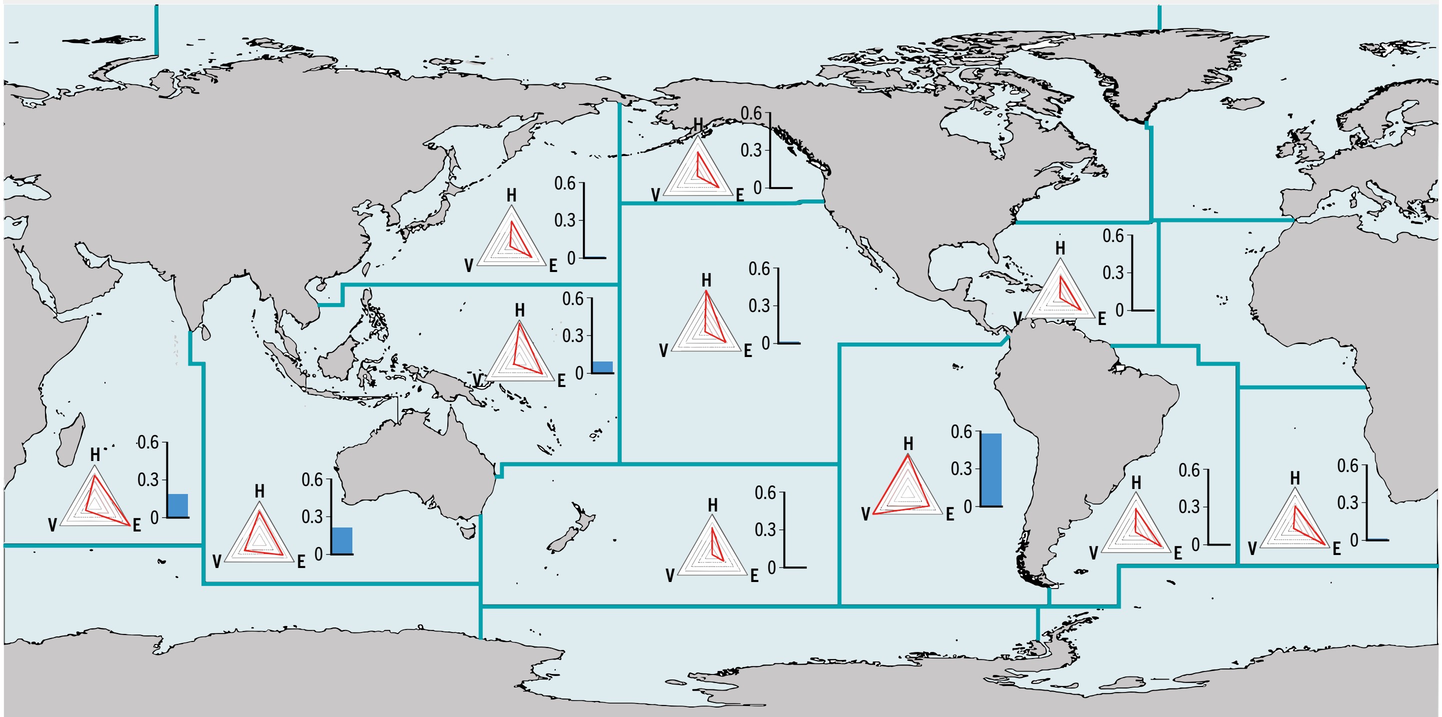
Subsequently, the warm SST anomalies spread westwards, expanding El Niño conditions into the Central Equatorial Pacific in May 2023. The increase in SST anomalies peaked in the Equatorial Southeast Pacific in August 2023 and then gradually decreased; in contrast, in the Central and Western Equatorial Pacific, anomalies were still increasing during the spring of 2023. Between November and December 2023, El Niño attained a strong to very strong intensity in SST in the Central Equatorial Pacific. Nevertheless, SST anomalies were still higher in the Eastern Pacific than in the Western Pacific, through to February 2024. Figure 63 summarizes the spatial and temporal features of El Niño 2023–2024.

El Niño intensity declined during the first quarter of 2024, ending in the spring. However, the impacts on the fisheries and aquaculture sector will likely remain for a longer period, as some fishery stocks and key fish habitats such as coral reefs might take years to recover.

El Niño 2023–2024 – impacts on fishery resources

The impacts of El Niño differ across different geographical areas, target species, types of fishing or aquaculture, and can have both negative and positive impacts. For example, in 2023, El Niño conditions diminished the habitat of cold coastal water species like Peruvian anchoveta. The anchoveta fishery is the world's largest monospecific fishery, yielding on average 4.4 million tonnes annually and 75 percent of total Peruvian landings in the past five years.

FIGURE 62 EL NIÑO RISK ANALYSIS IN FAO MAJOR FISHING AREAS



NOTES: Risk (blue bars) is the product of the hazard (H) (an event's potential to cause negative repercussions, computed here as the compound probability that a major El Niño event occurs and that it has a significant physical manifestation in the sea surface temperature); exposure (E) is the number of fisheries at risk (the proportion of fisheries with significant catch reduction during an event); vulnerability (V) is the severity of the impact on the fisheries at risk (estimated as the average catch reduction in the significantly affected fisheries). Areas with no risk graph correspond to those where no significant physical presence of El Niño was detected.

SOURCES: Risk analysis based on NOAA PSL. 2024. NOAA OI SST V2 High Resolution Dataset [Accessed on 12 November 2023]. https://psl.noaa.gov Marine fisheries global capture data from FAO. 2023. FishStatJ. [Accessed on 12 November 2021]. https://www.fao.org/fishery/en/statistics/software/fishstatj. Licence: CC-BY-4.0.
FAO. 2024. FAO Major Fishing Areas for Statistical Purposes. In: *Fisheries and Aquaculture*. [Cited 12 November 2021]. https://www.fao.org/fishery/en/area/search

During strong Eastern Pacific El Niño events such as in 2023–2024, anchoveta experiences reduced habitat and food availability, with impacts on distribution, reproduction and recruitment, resulting in biomass reductions that can extend beyond the event's end. For Peru, negative effects included a reduction of 50 percent in industrial landings in 2023 compared to 2022, although a recovery is expected during 2024. As the fishery is used to produce fishmeal and fish oil used for fed aquaculture, catch losses not only impact local livelihoods, employment and national export revenues, but also impair aquaculture production globally.

Due to El Niño, the warm pool usually located in the Western Pacific started moving eastwards into the Central Pacific in the 2023 summer. During the El Niño demise in the first quarter of 2024, the warm pool was still more eastward than during non-El Niño years. On the other hand, marine heatwaves increased in the Western and Central Pacific during the mature phase of the event. As a result, coral reef communities at islands located in this area were exposed to extended periods of thermal stress that increased mortality risks for corals and associated coastal fishing resources.

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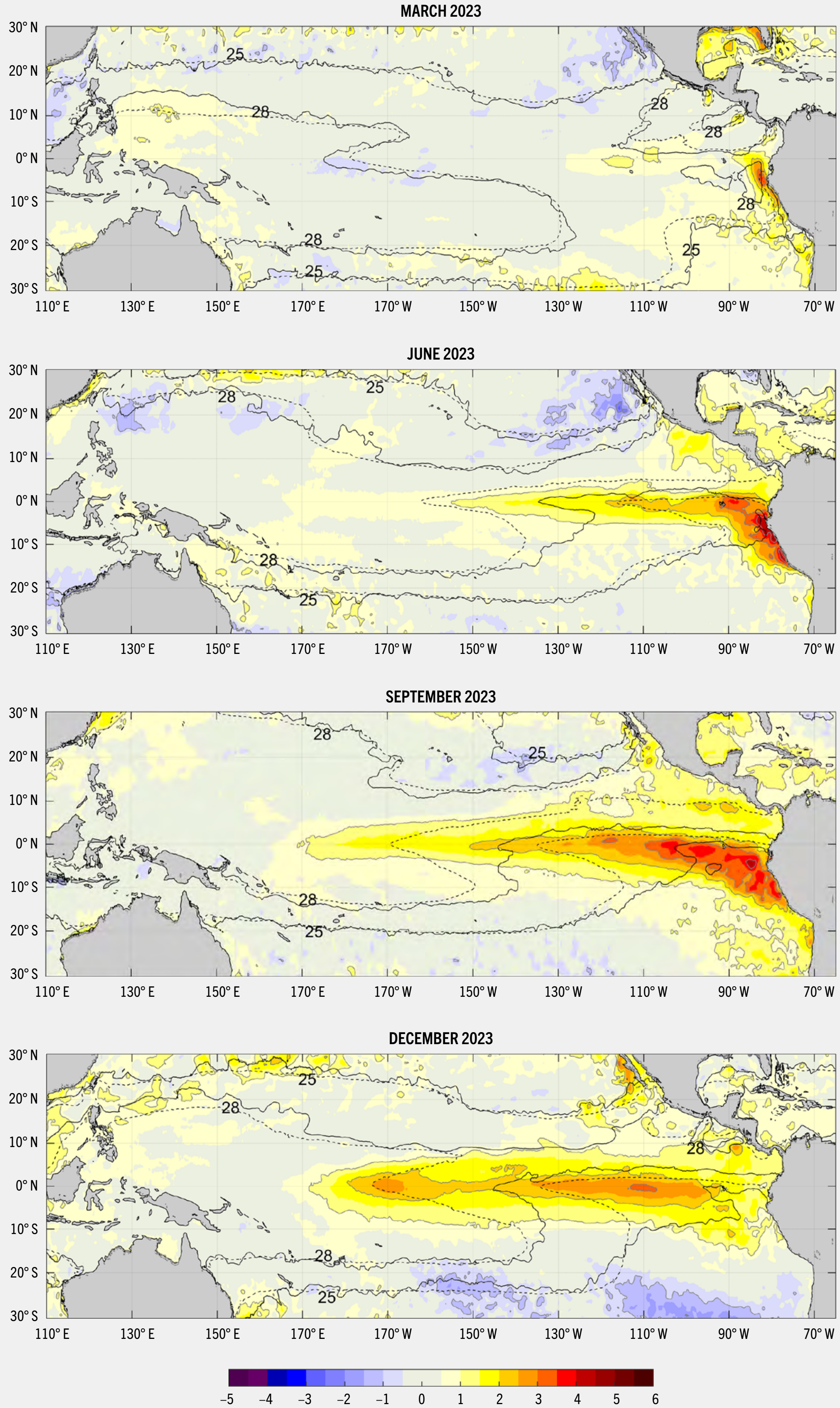
FIGURE 63 AVERAGE MONTHLY SEA SURFACE TEMPERATURE ANOMALIES DURING THE EVOLUTION OF THE 2023–2024 EL NIÑO



SOURCE: Elaborated by IMARPE (Peruvian Institute of Marine Research) based on UK Met Office. 2024. OSTIA: OSTIA-UKMO-L4-GLOB-v2.0. [Accessed on 9 January 2024]. https://doi.org/10.5067/GHOST-4FK02

» El Niño also impacts tuna fisheries in Pacific Island Countries and Territories (PICTs) where tuna fishing is a significant contributor to the GDP. El Niño-driven changes in habitat conditions favour an eastward shift in the distribution of skipjack tuna but tend to increase the catchability and recruitment of yellowfin tuna in the Western Pacific. As a result, to the end of 2023, El Niño had a positive impact on skipjack fishing in the easternmost PICTs' exclusive economic zones (EEZs). Increased availability for purse seiners of yellowfin tuna was observed in 2023, arguably due to the shoaling of the mixed layer in the most western EEZs, thus improving livelihoods and income in some areas of the Pacific while reducing them in others.

These findings emphasize the need to implement adaptive fisheries management measures, particularly since climate models project more frequent extreme ENSO events due to global warming. Practices such as dynamic adjustment of the fishing season and limiting effort and access to fishing grounds based on near real-time monitoring will help managers, fishers and coastal communities cope with ENSO-related impacts, and will enhance their adaptive capacity, improving early warning systems, strengthening risk assessments and raising awareness on ENSO. In addition, disaster preparedness and response at the local and national level – while promoting the diversification of livelihoods – are of crucial importance. ■

FISHERIES AND AQUACULTURE IN THE CONTEXT OF GLOBAL BIODIVERSITY AGREEMENTS

A number of global biodiversity agreements exist that are relevant to the fisheries and aquaculture sector. The Convention on Biological Diversity (CBD) is a multilateral treaty to conserve biological diversity (or biodiversity) while ensuring sustainable and fair use of its components and equitable sharing of the benefits arising from genetic resources.

Under the CBD's 2050 vision of "Living in harmony with nature", Parties to the Convention came together in 2022 to finalize a new framework that defines a global ambition for people and nature. The Kunming-Montreal Global Biodiversity Framework[bn] (GBF) will now be used by countries to plan National Biodiversity Strategies and Action Plans. Additionally, it will influence the delivery of other multilateral agreements focused on conservation (e.g. CITES,[bo] BBNJ Agreement[bp]), as well as business and civil society conservation efforts.

Given the urgent transformational change needed to safeguard, restore and invest in biodiversity, this new agreement better links the CBD's objectives. The framework centres around reducing threats to biodiversity and ensuring people's socioeconomic needs are met. It comprises four goals with 23 targets that support a broad range of objectives for nature and people – covering ecosystems, species and genetic diversity, and equitable sharing of benefits from nature – and establish the enabling conditions for its implementation. At the seventh Global Environment Facility assembly in 2023, members unanimously ratified the creation of the Global Biodiversity Framework Fund to finance and deliver on the implementation of the GBF.

In contrast to previous CBD plans, many of the 23 targets concern fisheries and aquaculture, and aquatic food systems more generally. Some of the objectives are due for delivery in 2030, while others extend to 2050. Targets 1–3 address spatial management, including planning, restoration or protection of aquatic spaces. Species-focused approaches look to significantly reduce extinction risk (Target 4), strengthen safety, legality and sustainability of use and trade of wild species (Target 5), and increase actions

bn Kunming-Montreal Global Biodiversity Framework: https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf

bo Convention on International Trade in Endangered Species of Wild Fauna and Flora: https://cites.org/eng

bp Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisidiction: https://www.un.org/Depts/los/bbnj.htm to deter and mitigate the impacts of invasive alien species (Target 6). Targets 7 and 8 respond to pollution and climate change, other targets seek to strengthen management of production systems and ensure the fair and equitable sharing of benefits that arise from use of biodiversity (Targets 9–13). "Biodiversity mainstreaming" across sectoral governance is only mentioned in Target 12, but it remains an important consideration across most targets, and is especially relevant for Targets 10–23 aimed at strengthening sustainability and resilience of ecosystem services across business practices.

In order to build a common narrative for fisheries and aquaculture and contribute to reaching the above targets, FAO is working with stakeholder groups to obtain feedback on the opportunities and challenges in the timely delivery of the GBF in aquatic food systems. Collation and documentation of the sector's priorities will help identify investments needed for transitioning fisheries and aquaculture policies and practices.

Over the next decade and beyond, indicator(s) proposed by countries will be used to monitor global progress in delivery of the GBF.[bq] Ensuring these are well aligned will be an ongoing task for the CBD, international organizations, NGOs, academia, businesses and civil society organizations. Regular sharing of data and information (including Indigenous Peoples' knowledge) and transfer of technology are needed to support local actors in progressing conservation of biodiversity, and to facilitate adaptive management in delivery of the GBF and global reporting.

The expansive vision for "100 percent management" is a rallying call across UN entities, Indigenous Peoples and local communities to countries now transitioning their national biodiversity conservation plans (CBD, 2019). Under Blue Transformation (FAO, 2022a), FAO aims to reach 100 percent management of all fisheries to deliver healthy stocks, restore ecosystems and secure equitable livelihoods – all part of delivering positive change for biodiversity. To realize the change agreed in the framework's goals and targets, the task of mobilizing funding commensurate to the ambition of the GBF and achieving equitable distribution of these resources requires a global coordinated response.

In parallel to the CBD processes and under the auspices of the United Nations General Assembly,[br] in 2023 UN Member States agreed to an international legally binding instrument under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisidiction (BBNJ Agreement). This agreement covers 64 percent of the total ocean surface area and around half the surface area of the planet. Fragmented legal frameworks have left biodiversity in these areas vulnerable to ever-growing threats, including climate change, plastic pollution, oil spills, overfishing, habitat destruction, ocean acidification and underwater noise.

The BBNJ Agreement is expected to be a game changer in open-ocean governance, elevating global efforts in promoting sustainable use of marine biological diversity and channelling resources to strengthen capacity to promote marine biodiversity conservation in areas beyond national jurisdiction (ABNJ).

The agreement contains provisions on marine genetic resources, including the fair and equitable sharing of their benefits; the establishment of a comprehensive system of area-based management tools (ABMTs); environmental impact assessments; and capacity building and the transfer of marine technology to assist parties, in particular developing countries, to develop their scientific and technological capacity towards the conservation and sustainable use of biodiversity beyond national jurisdiction. In addition, the agreement contains robust provisions on institutional arrangements, financial resources, implementation, compliance, and settlement of disputes.

A key principle of the agreement is that it should not undermine existing organizations and initiatives; its actions must promote coherence

bq For further details, see: https://www.cbd.int/gbf/monitoring/

br United Nations General Assembly Resolution 72/249 of 24 December 2017.

and coordination with relevant legal instruments and frameworks and relevant global, regional, subregional and sectoral bodies, including regional fishery bodies. In this context, the agreement represents an opportunity to build on existing policy instruments, processes and works of sectoral bodies. There is an urgent need for governments to ratify the new agreement, as 60 instruments of ratification need to be deposited for it to enter into force. Also, if states that are major actors in high seas activities do not join the new agreement, its effectiveness will be severely compromised.

Cooperation and synergies between bodies with relevant mandates and initiatives to implement instruments will be critical to the agreement's success. In some cases, the BBNJ Agreement and the GBF have parallel goals, in particular, the aim to conserve 30 percent of the Earth's land and sea through the establishment of protected areas and other ABMTs by 2030. In other cases, ensuring efficient synergies may prove more challenging, requiring further clarification of the provision on "not undermining", for example, by striving for a common vision between the new agreement and regional fisheries management organizations and other relevant legal instruments, frameworks and bodies. Lastly, implementation will require financial resources significantly greater than those currently devoted to ocean governance.

It should be noted that there are currently two international fora progressing towards the establishment of legally binding measures to address plastic pollution:

1. The United Nations Environment Programme (UNEP)-led Intergovernmental Negotiating Committee (INC) convened to develop an international legally binding instrument on plastic pollution, including in the marine environment,[bs] which adopts a comprehensive approach addressing the full life cycle of plastic. The Fourth Session of the INC discussed the revised draft text,[bt] which included a provision on waste management, where fishing and aquaculture gear made of plastic material and abandoned, lost or discarded fishing gear (ALDFG) are explicitly addressed. During the discussions, some members stressed the need for the instrument to address fishing and aquaculture gear throughout its life cycle and existing pollution from such, with proposals for alternative placement of the related provisions, while others called for the deletion of these provisions from the draft text.
2. The International Maritime Organization Marine Environment Protection Committee and its Sub-Committee on Pollution Prevention and Response[bu] are developing specific measures within Annex V of the International Convention for the Prevention of Pollution from Ships to prevent and reduce abandonment and discarding of fishing gear at sea.

Fishing gear is usually made of plastic polymers that are hazardous or problematic when they are lost, abandoned or discarded at sea. Abandoned, lost or discarded fishing gear can cause direct and indirect harm and degradation to the marine environment and biodiversity, commercial and non-commercial species, human health, food security and livelihoods. It also presents a hazard to navigation and safety at sea and contributes to plastic pollution of the ocean (GESAMP, 2021).

FAO is actively participating in both processes, providing technical advice to effectively address fisheries issues. FAO promotes the establishment of fishing gear marking systems based on the Voluntary Guidelines on the Marking of Fishing Gear (FAO, 2019) as the most effective fisheries management measure to prevent and reduce ALDFG and its impacts on biodiversity and fishers' safety and livelihoods. ■

bs For further details, see: https://www.unep.org/inc-plastic-pollution

bt The revised draft text can be downloaded in all six UN languages as document UNEP/PP/INC.4/3, available at: https://www.unep.org/inc-plastic-pollution/session-4/documents#WorkingDocuments

bu For further details, see: https://www.imo.org/en/About/Pages/Structure.aspx#4

FISHERIES AND AQUACULTURE PROJECTIONS, 2022–2032

This section[bv] presents the medium-term trends and prospects using the FAO fish model (FAO, 2012, pp. 186–193), developed in 2010 to inform 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.[bw] The FAO fish model considers the set of macroeconomic assumptions and selected prices used to generate the agricultural projections, in addition to specific assumptions and data related to the fisheries and aquaculture sectors. An ad hoc analysis was carried out by FAO for the years 2022–2032 to obtain the following fisheries and aquaculture projections.

These projections provide an outlook of the ten-year prospects for fisheries and aquaculture production, utilization, trade and prices, and highlight key issues that might influence future supply and demand of aquatic products. These projections are not forecasts, but plausible scenarios that provide insight into how these sectors may develop in light of a set of macroeconomic, policy and demographic assumptions. These assumptions consider the enhancement of fisheries and aquaculture management, including catch limitations, but do not consider the occurrence of severe events such as tsunamis, tropical storms (cyclones, hurricanes and typhoons), floods, emerging diseases of aquatic species and market shocks. These projections were generated assuming that consumer preferences and technologies will likely continue to develop and that current policies will remain in place, including the continuation of the Chinese policy implemented since 2016 to promote sustainable and environmentally friendly fisheries and aquaculture (FAO, 2018c). Population and economic growth, urbanization, technological developments and dietary diversification are expected to expand the demand for aquatic foods.

Production

World fisheries and aquaculture production of aquatic animals is expected to grow further reaching 205 million tonnes (live weight equivalent) in 2032 (Figure 64), an additional 19 million tonnes or 10 percent increase relative to 2022 (Table 14). Both the rate and absolute level of growth are projected to decline compared with the 22 percent growth (33 million tonnes) during the period 2012–2022. Most of the increase will come from aquaculture, expected to break the 100 million tonnes threshold for the first time in 2027, reaching 111 million tonnes in 2032, with an overall growth of 17 percent or nearly 16 million tonnes compared with 2022.

The continuous increase in aquaculture production projected over the period 2022–2032 will occur at an average annual growth rate of 1.6 percent, less than half the 4.0 percent rate observed in 2012–2022 (Figure 65).[bx] This reduced growth rate will depend on several factors such as wider adoption and enforcement of environmental regulations; reduced availability of water (both quality and quantity) and suitable aquaculture sites; increasing impact of aquatic animal diseases in intensive aquaculture; and reduced productivity gains. Chinese policies are expected to account significantly for the overall reduced growth. Initiated in 2016, these policies[by] aim to continue integrating environmental considerations in aquaculture production to improve its sustainability by promoting the adoption of ecologically sound technological innovations and water recycling; not extending the areas dedicated to aquaculture; and reducing the use of antibiotics in production. All these

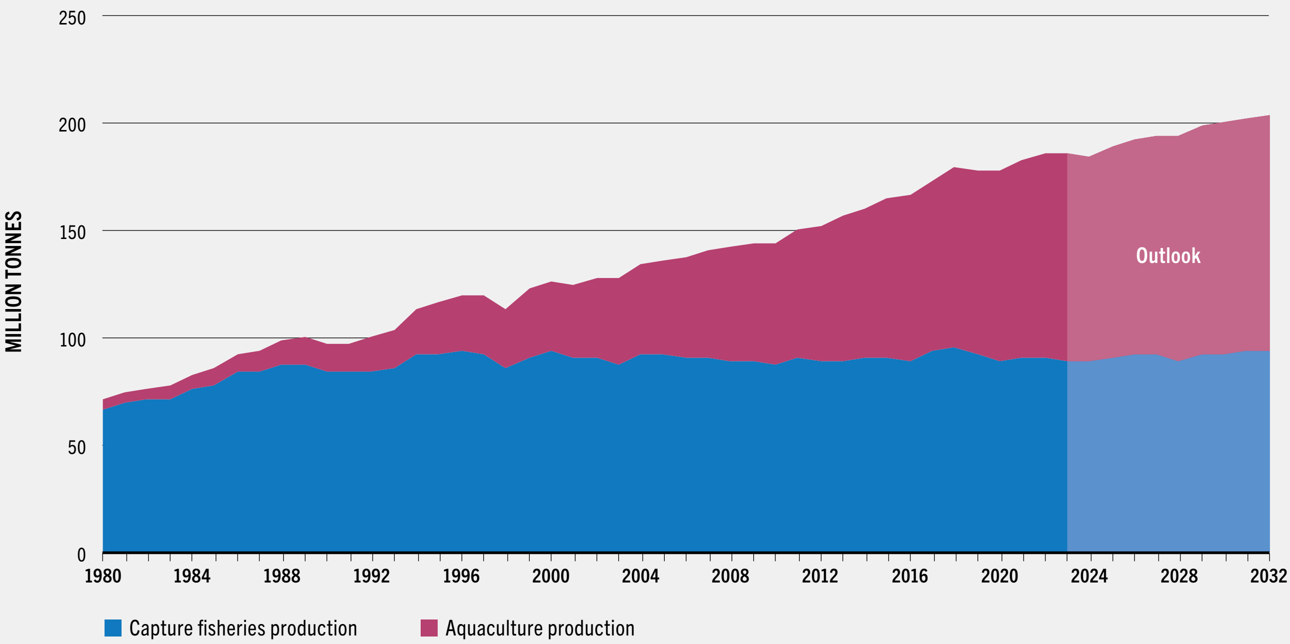
bv In **Fisheries and aquaculture projections, 2022–2032**, the statistical analysis on production, utilization, consumption and trade only covers aquatic animals (excluding aquatic mammals and reptiles). Detailed coverage of species is indicated in the Glossary.

bw For more information about the OECD-FAO Agricultural Outlook and the work on the models see: https://www.agri-outlook.org/

bx 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.

by Thirteenth (2016–2020) and Fourteenth (2021–2025) Five-Year Plans.

FIGURE 64 WORLD FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS, 1980–2032



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Data expressed in live weight equivalent.

SOURCE: FAO estimates.

actions will cause an initial capacity reduction, followed by faster growth. Despite these changes, China will remain the world's leading aquaculture producer, with an expected increase of 14 percent (or about 8 million tonnes) by 2032, nearly half the increase in 2012–2022 (15 million tonnes or 39 percent). China's contribution to world aquaculture production in 2032 is projected to reach 55 percent (compared with 56 percent in 2022). It will however contribute 83 percent of total Chinese fisheries and aquaculture production, increasing from 80 percent in 2022. The resource rent tax on salmon and trout farming introduced by Norway in 2023 can decrease the farming profitability of these species and affect their future production, Norway being the largest producer in the world of Atlantic salmon. The decadal projection assumes that the tax is eliminated in 2026, with Norway increasing its aquaculture output by 7 percent up to 2032. If the tax is kept, Norwegian aquaculture production would decrease by about 9 percent by 2032.

The projected deceleration of China's aquaculture production will be partially compensated for by a production increase in other countries. Growth of aquaculture production is projected for all continents, except a 1 percent decline in Europe, with variations in the range of species and products across countries and regions. By 2032, the sector is projected to expand most in Africa (up 21 percent from 2022), Asia (up 18 percent), Oceania (up 17 percent) and Latin America and Caribbean (up 14 percent). Aquaculture growth in Africa will result from the additional farming »

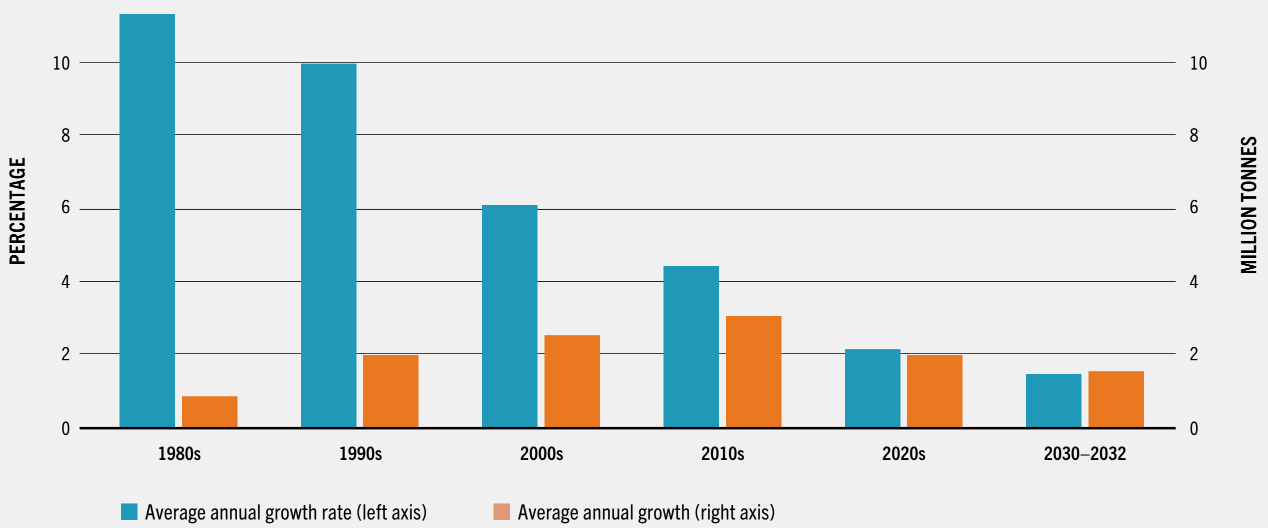
TABLE 14 PROJECTED FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS TO 2032

	Production			Of which aquaculture		
	(thousand tonnes, live weight equivalent)		%	*(thousand tonnes, live weight equivalent)*		%
	2022	2032	Growth of 2032 vs 2022	2022	2032	Growth of 2032 vs 2022
Africa	**12 936**	**14 165**	**9.5**	**2 317**	**2 813**	**21.4**
Egypt	1 993	2 282	14.5	1 552	1 860	19.8
Nigeria	1 043	1 169	12.1	259	278	7.5
South Africa	474	545	14.8	8	13	66.5
Americas	**23 023**	**24 914**	**8.2**	**4 958**	**5 569**	**12.3**
Northern America	**5 904**	**6 225**	**5.4**	**645**	**664**	**2.9**
Canada	859	1 007	17.3	166	212	27.4
United States of America	4 735	4 853	2.5	478	441	–7.9
Latin America and Caribbean	**17 120**	**18 689**	**9.2**	**4 314**	**4 905**	**13.7**
Argentina	854	903	5.8	6	6	–0.4
Brazil	1 496	1 575	5.3	738	794	7.6
Chile	3 735	3 769	0.9	1 509	1 669	10.6
Mexico	1 968	2 013	2.3	290	284	–1.8
Peru	5 458	6 182	13.3	141	175	23.9
Asia	**130 461**	**145 790**	**11.7**	**83 399**	**98 350**	**17.9**
China	65 869	73 016	10.9	52 884	60 516	14.4
India	15 717	18 122	15.3	10 230	12 766	24.8
Indonesia	12 721	14 601	14.8	5 414	6 956	28.5
Japan	3 529	3 423	–3.0	617	629	1.9
Republic of Korea	1 830	1 915	4.6	578	615	6.4
Philippines	2 572	2 881	12.0	804	965	20.0
Thailand	2 387	2 597	8.8	1 001	1 147	14.6
Viet Nam	8 750	8 902	1.7	5 160	5 102	–1.1
Europe	**17 173**	**18 010**	**4.9**	**3 503**	**3 819**	**9.0**
European Union*	4 683	5 056	8.0	1 120	1 220	8.9
Norway	4 091	4 079	–0.3	1 648	1 699	3.1
Russian Federation	5 303	5 565	4.9	320	334	4.5
Oceania	**1 752**	**1 799**	**2.7**	**235**	**276**	**17.3**
Australia	288	310	7.5	125	140	11.7
New Zealand	452	507	12.2	106	127	19.7
World**	**185 442**	**204 678**	**10.4**	**94 413**	**110 827**	**17.4**

NOTES: Aquatic animals, excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
* Cyprus is included in Asia as well as in the European Union but not in Europe.
** For 2022, the aggregate includes also 40 498 tonnes of not identified countries, data not included in any other aggregates.

SOURCE: FAO estimates.

FIGURE 65 ANNUAL GROWTH OF WORLD AQUACULTURE PRODUCTION BY VOLUME, 1980–2032



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Based on live weight equivalent.
SOURCE: FAO estimates.

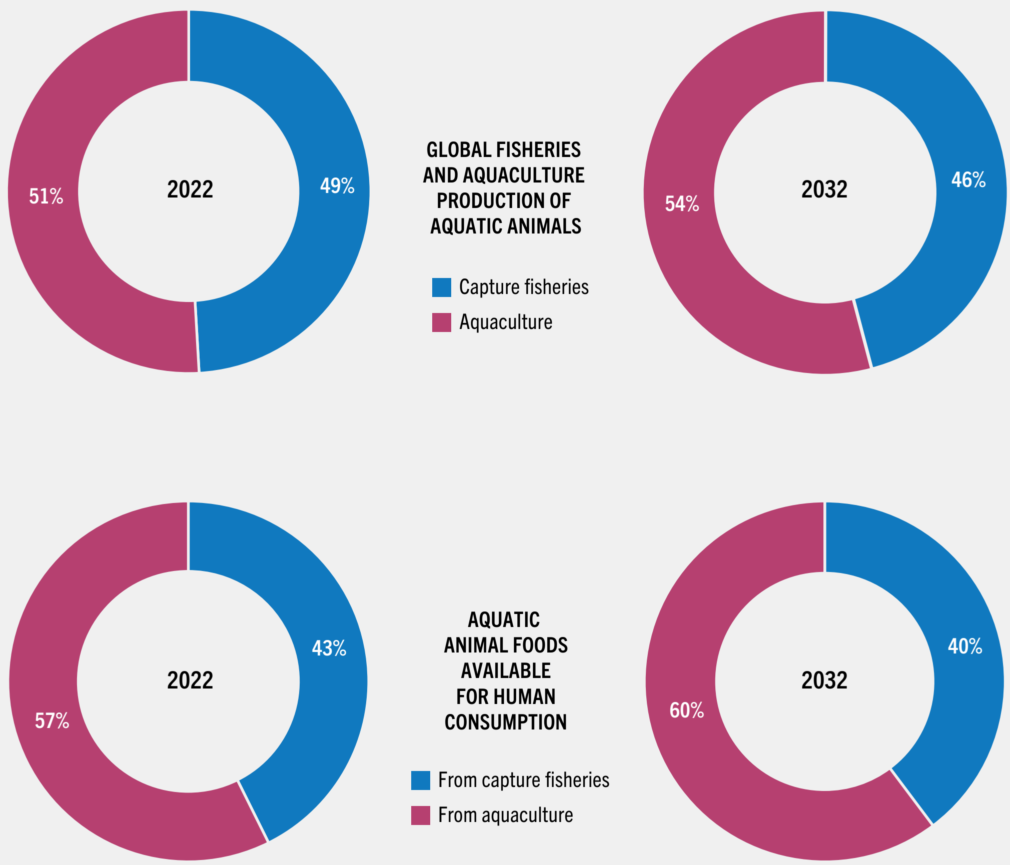
» capacity installed in recent years, following national policies promoting aquaculture and the rising local demand. However, this projected growth of aquaculture production in Africa will remain limited, slightly over 2.8 million tonnes in 2032, with the bulk (1.9 million tonnes) produced by Egypt. Asian countries should continue to dominate the aquaculture sector in 2032, producing 89 percent of the world output of aquatic animals (up from 88 percent in 2022) and generating more than 91 percent of the increase in production by 2032.

The share of farmed species in global fisheries and aquaculture production of aquatic animals is projected to grow from 51 percent in 2022 to 54 percent in 2032 (Figure 66). Excluding China, the world share will grow from 35 percent in 2022 to 38 percent in 2032. The role of aquaculture in total fisheries and aquaculture production will increase in all continents, except Northern America where it will remain around 11 percent, the lowest share among all major regions. In 2032, these shares will reach 15 percent in Oceania (up from 13 percent in 2022), 22 percent in Africa (up from 18 percent), 21 percent in Europe (up from 20 percent), 26 percent in Latin America and the Caribbean (up from 25 percent) and 67 percent in Asia (up from 64 percent) – but excluding China, growth in Asia will increase from 47 percent to 52 percent (Figure 67).

Production of all major groups of farmed species will continue to increase, but at uneven rates of growth across groups, consequently modifying the importance of different species. In general, species needing large proportions of fishmeal and fish oil in their diets are projected to grow more slowly owing to expected higher prices and reduced availability of fishmeal. Carp is likely to remain the main group of species produced in 2032, but with a declining share in the total production volume. Taxation in Norway will likely reduce slightly the share of salmonoids in total production.

Capture fisheries is projected to increase by 3 million tonnes to reach about 94 million tonnes

FIGURE 66 INCREASING ROLE OF AQUACULTURE

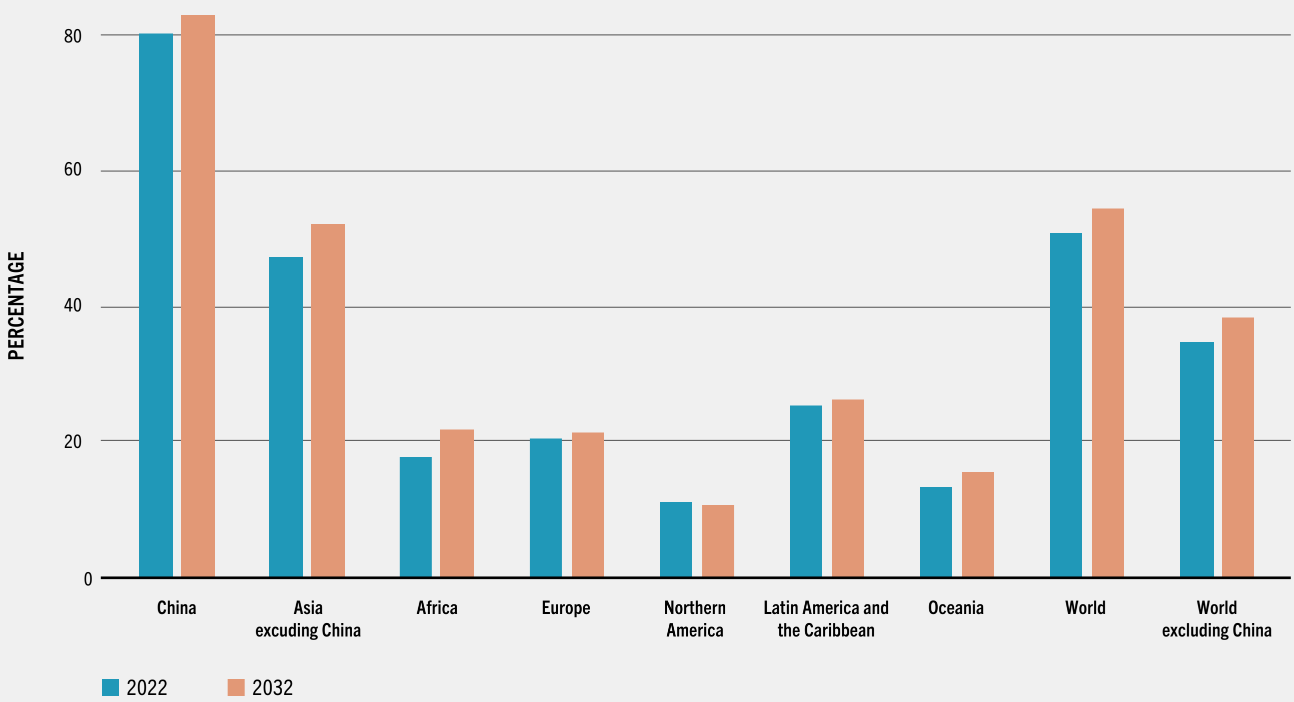


NOTE: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae.
SOURCE: FAO estimates.

in 2032, with an overall increase of 3 percent from 2022.[bz] Some fluctuations are expected in selected years of the next decade linked to the El Niño phenomenon that will reduce catches in South America, especially for anchoveta, with a resulting decrease in world capture fisheries production of about 2 percent in those years. The overall increase in capture fisheries production by 2032 is expected to be 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, including for species not subject to strict production quotas; (iii) technological improvements; and (iv) reduced discards and

bz 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 occurs might not be exact, but the trends 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. 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 these rates decline as the size of the base grows.

FIGURE 67 SHARE OF AQUACULTURE IN TOTAL FISHERIES AND AQUACULTURE PRODUCTION OF AQUATIC ANIMALS BY REGION AND VOLUME, 2022 VS 2032



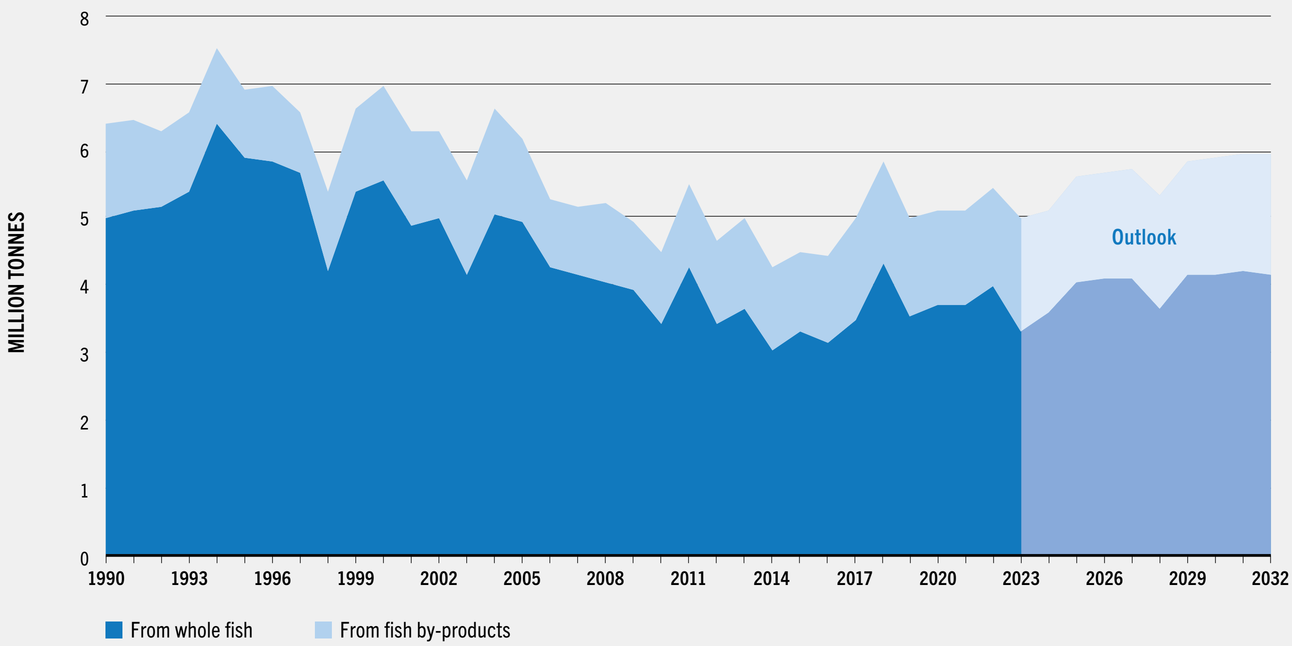
NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, aquatic products (corals, pearls, shells and sponges) and algae. Based on live weight equivalent.

SOURCE: FAO estimates.

bycatch, enforced by changes in legislation or higher market prices (including for fishmeal and fish oil). Similarly to aquaculture, China will remain the major producer of capture fisheries. Yet, its overall production should decline by 4 percent by 2032, as it continues implementing its environmental policies into the next decade, reducing domestic catches through enforcement of controls on licensing, reduction in the number of fishers and fishing vessels, and implementation of output controls. Other measures 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 restocking, artificial reefs and seasonal closures. However, the projected decline in domestic catches is expected to be compensated for by an increase in distant-water fleet catches.

By 2032, production of both fishmeal and fish oil is projected to increase by, respectively, 9 percent and 12 percent compared with 2022, but the share of capture fisheries production reduced into fishmeal and fish oil should remain stable at around 19 percent. These increases in fishmeal and fish oil production will use whole fish resulting from the growth in capture fisheries production in 2032 compared with 2022, combined with by-products (see **Products: fishmeal and fish oil**, p. 68) of the processing industry (Figure 68). Between 2022 and 2032, the proportion of total fishmeal obtained from fish by-products is projected to increase from 27 percent to

FIGURE 68 WORLD FISHMEAL PRODUCTION, 1990–2032



NOTE: Data expressed in product weight.
SOURCE: FAO estimates.

30 percent, while the proportion of total fish oil is projected to remain stable at about 57 percent. Peru and Chile will continue to be the top producers of, respectively, fishmeal and fish oil.

Apparent consumption of aquatic foods

Food remains the primary use for aquatic production, with most fisheries and aquaculture production of aquatic animals destined for human consumption.[ca] This share will grow from 89 percent in 2022 to 90 percent by 2032. Overall, by 2032, aquatic foods for human consumption are projected to increase by 19 million tonnes compared with 2022, reaching 184 million tonnes, but expanding less rapidly than over the previous decade. This represents an overall increase of about 12 percent, compared with 24 percent in 2012–2022. This slowdown mainly reflects the reduction in availability of additional fisheries and aquaculture production, higher prices of aquatic foods in nominal terms, a deceleration in population growth, and saturated demand in some countries, particularly high-income countries, where aquatic food consumption is projected to show little growth. In 2032, about 60 percent of the aquatic foods available for human consumption are expected to originate from aquaculture production, up from 57 percent in 2022 (Figure 66).

Trends in consumption will differ between countries and regions due to different dynamics in population, income, consumer preferences, and rapid urbanization in many emerging economies. In low-income countries where food represents a high share of household expenditure, changes in income and food prices will have a larger impact on consumption than in high-income countries. Demand will also be stimulated by

ca As in **Apparent consumption of aquatic foods** (p. 73), consumption is expressed in live weight equivalent and refers to the apparent aquatic food consumption.

changes in dietary trends, with more variety of foods consumed, and a greater focus on better health, nutrition and diet, with aquatic food playing a key role in this regard. Overall, growth in demand of aquatic foods will stem mostly from Asian countries, which are expected to account for 78 percent of the increase in consumption by 2032, consuming 73 percent of the aquatic foods available in 2032 (compared with 72 percent in 2022). Between 2022 and 2032, total apparent consumption of aquatic food is expected to increase in all regions, except in Europe, with higher growth rates projected in Africa (23 percent), Asia (13 percent), Latin America and the Caribbean (10 percent), Oceania (9 percent) and Northern America (8 percent). Despite these regional trends, the overall tendencies in quantity and variety of aquatic foods consumed will vary among and within countries.

Per capita apparent consumption of aquatic animal foods is projected to reach 21.3 kg in 2032, up from about 20.7 kg in 2022. It will increase in all regions except Africa and Europe. In Africa – which in 2019–2022 experienced a decline in per capita consumption (from 9.9 kg to 9.4 kg) due to the effects of the COVID-19 pandemic – the expected increase in total supply of aquatic foods up to 2032 will not be sufficient to compensate for population growth, projected at over 25 percent between 2022 and 2032. The decline will be mainly in sub-Saharan Africa, while in Northern Africa per capita consumption will marginally increase. In fact, one of the few exceptions will be Egypt, which is expected to expand its aquaculture production by 21 percent between 2022 and 2032. This projected decline in per capita consumption of aquatic foods in Africa, in particular in sub-Saharan Africa, raises food security concerns because of the region's high prevalence of undernourishment and the importance of aquatic proteins in total animal protein intake in many African countries (see **Apparent consumption of aquatic foods**, p. 214). The decline weakens the ability of countries that are more dependent on aquatic products to meet the nutrition targets (2.1 and 2.2) of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture). This trend can only be modified through a substantial increase in the aquatic food supply to be obtained through increased production and imports (Box 48).

Trade

Trade of aquatic products will continue to enhance the role of fisheries and aquaculture for economic development, world food supply and food security. The expansion of trade in aquatic products will continue over the outlook period, bolstered by improvements in post-harvest technology and distribution channels that will support the expansion of the commercialization of aquatic products. Yet, trade of aquatic products is expected to grow at a slower pace (in volume) 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. As a result, the share of aquatic products exported over the total fisheries and aquaculture production will decline from 38 percent in 2022 to 34 percent in 2032 (30 percent, excluding intra-European Union trade). In quantity terms, the bulk of the growth in exports of aquatic foods will continue to originate from Asia, which will account for about 44 percent of the additional exported volume by 2032. Asia's share in total exports of aquatic products for human consumption will remain stable at about 50 percent in 2032 (Figure 69). In quantity terms, China will continue to be the major exporter of aquatic foods, followed by Viet Nam and Norway. The European Union, the United States of America, China and Japan will be the main importers, absorbing 50 percent of total imports for aquatic food consumption in 2032, compared with 52 percent in 2022.

Trade of fishmeal and fish oil is expected to increase by 4 percent and 11 percent respectively. Peru and Chile will continue to be the main exporters of fish oil, and Norway and the European Union 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, with China the major importer.

Prices

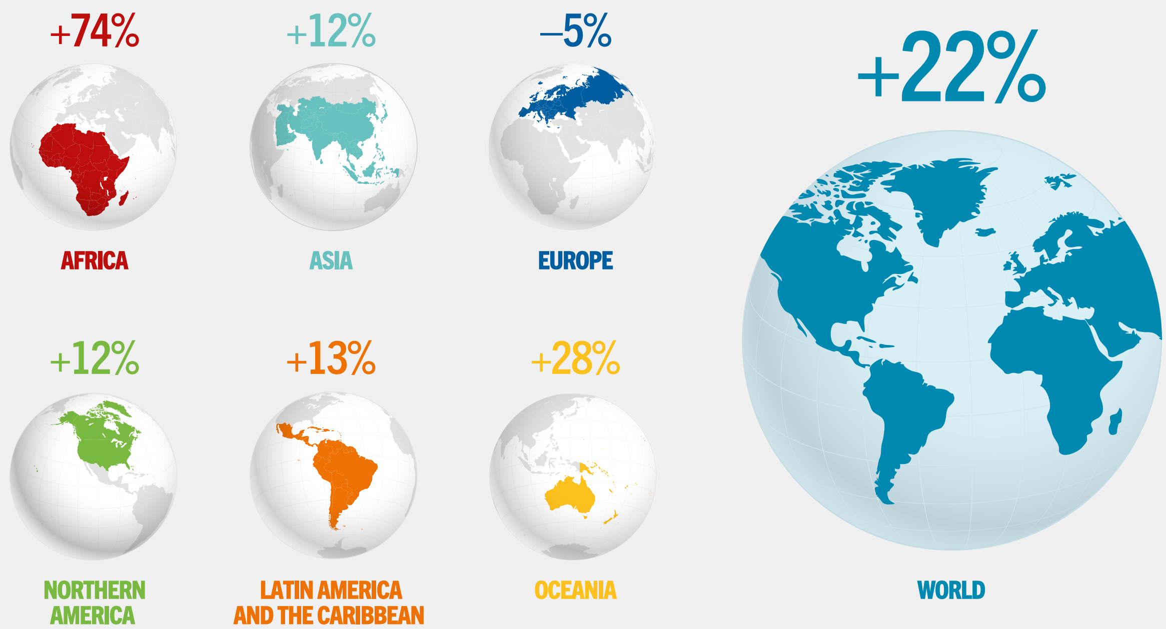
After soaring in 2022, fisheries and aquaculture prices declined in 2023 and are expected to continue falling slightly in both nominal and real »

BOX 48 MEETING THE CHALLENGE OF RISING POPULATION: IMPLICATIONS FOR SUPPLY OF AQUATIC ANIMAL FOODS

The world population is projected to reach 9.7 billion by 2050, up by 1.7 billion compared with 2022. This will have significant implications for the supply of aquatic animal foods. To maintain through to 2050 per capita apparent consumption of aquatic animal foods at the 2022 estimated level of 20.7 kg would require an increase in the total supply of aquatic animal foods of 36 million tonnes (live weight equivalent), representing a 22 percent rise. Asia would require the largest increase – 14 million tonnes, that is a 12 percent rise – followed by Africa (10 million tonnes, +74 percent), Northern America (1.0 million tonnes, +12 percent), Latin America and the Caribbean (0.9 million tonnes, +13 percent) and Oceania (0.3 million tonnes, +28 percent). On the other hand, in Europe, where the population is projected to decline by 2050, the supply of aquatic animal foods required to sustain per capita consumption at the same level would be 0.9 million tonnes lower (–5 percent).

On the worldwide scale, meeting the demand for greater availability of aquatic animal foods necessitates higher production. Depending on the region, the required increase in supply may be sourced from increased domestic production, supplemented by imports as and where needed – and when possible. For example, in Africa achieving through domestic production alone the 74 percent increase in supply of aquatic animal foods required to maintain current per capita levels is a major challenge. It requires major investments and transformation of the sector, which is unlikely to occur over a short time based on historical and recent trends. A more likely scenario is that Africa would import from other regions, assuming additional supply is available and affordable. Failure to access this supplementary supply would pose a risk for the region of declining per capita consumption levels, which are already significantly lower than the world average, despite the key role of aquatic nutrients in many African countries.

REQUIRED GROWTH IN SUPPLY OF AQUATIC ANIMAL FOODS TO SUSTAIN 2022 PER CAPITA CONSUMPTION LEVELS THROUGH TO 2050



SOURCE: FAO estimates.

BOX 48 (Continued)

Such a substantial increase in Africa's supply of aquatic animal foods would nevertheless barely maintain the current level of consumption of aquatic animal foods per capita, which is still much lower than that in other regions. To raise African per capita annual consumption from the current 9.4 kg to the 2022 world average of 20.7 kg, supply of aquatic animal foods in Africa would need to increase by about 38 million tonnes or +285 percent.

Each region will encounter unique needs and challenges based on population growth projections. Strategic planning is essential to ensure that food supply aligns with demand, involving expansions in aquaculture, enhancements in fishing practices, investments in sustainable resource management, and the upgrading of aquatic value chains.

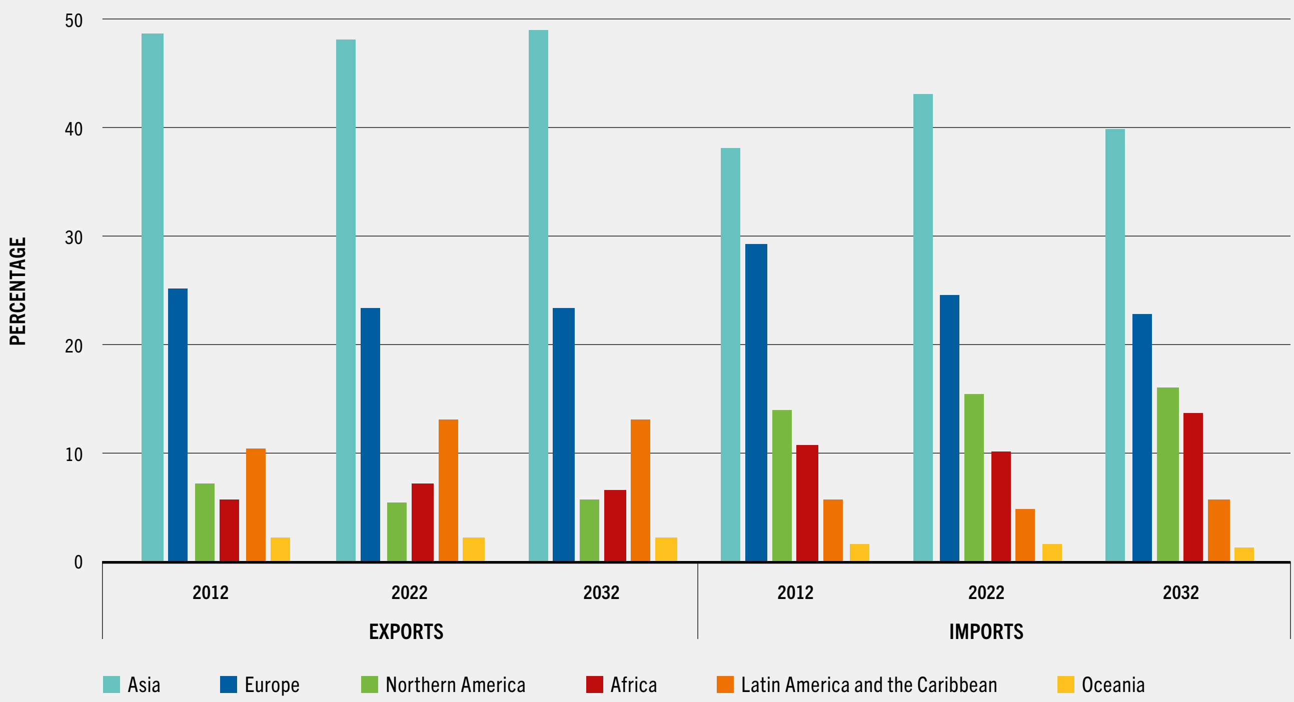
These data consider only population growth, with no changes in the amount for non-food uses, which are expected to remain at current levels. This analysis does not predict the future but provides an indication of the requirements for maintaining the status quo in world consumption of aquatic animal foods per capita.

Cognizant of these challenges, FAO launched the Blue Transformation Roadmap in 2021 (FAO, 2022) to support expansion and intensification of aquaculture, putting world fisheries under effective management and optimizing aquatic food value chains to reduce loss and waste and add value.

SOURCE: FAO. 2022. *Blue Transformation – Roadmap 2022–2030: A vision for FAO's work on aquatic food systems*. Rome. https://doi.org/10.4060/cc0459en

» terms until 2025–2027, before then increasing. Overall, prices are expected to grow moderately in nominal terms from 2022 to 2032, driven on the demand side by improved income, population growth and higher meat prices, and on the supply side by marginal increase in capture fisheries production, slower growth in aquaculture production and cost pressure from crucial inputs such as feed, energy and fish oil. With a growth of 7 percent, the average price of aquaculture products will rise more than that of captured products (when excluding aquatic products for non-food uses), which will grow by 5 percent. Prices of farmed aquatic species will also increase owing to higher fishmeal and fish oil prices, both of which are expected to rise by 12 percent by 2032. High feed prices could also influence the composition of farmed species, shifting towards species requiring less feed, cheaper feed or no feed at all. The higher prices at the production level, coupled with high demand for aquatic foods, will stimulate an estimated 5 percent growth in the average price of internationally traded aquatic products by 2032 relative to 2022. In real terms, it is assumed that all prices will decline over the projection period, while remaining relatively high. For individual aquatic products, price volatility could be more pronounced due to fluctuations in supply or demand. 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. Major decreases are expected for capture fisheries (excluding non-food uses) and traded products (each declining by 16 percent), as well as for aquaculture (15 percent). Average prices of fish oil and fishmeal are projected to decrease by, respectively, 11 percent and 10 percent. However, since both prices have been at historically high levels, by 2032 fishmeal prices will still be 33 percent higher than in 2005, when major price increases began. This situation is even more pronounced for fish oil, where the real price in 2032 is expected to be over 160 percent higher than in 2005. Considered together, and all else remaining equal, this suggests that converting

FIGURE 69 **EXPORTS AND IMPORTS OF AQUATIC ANIMAL FOODS BY REGION AND VOLUME**



NOTES: Aquatic animals excluding aquatic mammals, crocodiles, alligators, caimans, frogs, turtles, aquatic products (corals, pearls, shells and sponges) and algae. Data refer to aquatic animals, but excluding all non-food products, including fishmeal and fish oil. Based on live weight equivalent.
SOURCE: FAO estimates.

capture fisheries and fish waste to 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 2032 emerge from the analysis:

- World fisheries and aquaculture production, consumption and trade are expected to increase, but growth rates will slow over time.
- Overall production should increase by 10 percent, reaching 205 million tonnes by 2032.
- With an increase in aquaculture production of 17 percent compared with a growth in capture fisheries of 4 percent, aquaculture is anticipated to fill most of the supply–demand gap.
- Trends in capture fisheries production are expected to remain similar to those in the past few decades, with moderate growth projected in overall output, mainly in areas where resources are properly managed.
- Aquatic food supply will increase in all regions, except Europe, while per capita consumption is expected to decline slightly in Europe and Africa, in particular in sub-Saharan Africa, raising concerns about food security.
- Trade in aquatic products is expected to increase more slowly than in the past decade, with a decline in the share of world fisheries and aquaculture production that is exported.
- While prices will all increase in nominal terms, they are all expected to decline in real terms.

Main uncertainties

The projections presented in this section 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 overall economic and geopolitical situation, including recent conflicts, major changes in the aquatic environment, availability of resources, macroeconomic conditions, international trade rules and tariffs, and market characteristics. These aspects may affect production, markets and trade in the medium term. Whether the World Trade Organization negotiations on fisheries subsidies succeed can have an impact on capture fisheries production. In addition, market access requirements related to food safety, quality, sustainability, and traceability and product legality will continue to regulate international trade of fisheries and aquaculture products.

Climate variability and 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 suitable sites and water resources and access to credit, seed and expertise. 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 (FAO, 2022a). FAO Blue Transformation and its Roadmap provide pathways for progressive and effective management of living aquatic resources that reconcile food security and poverty alleviation with environmental sustainability. ■

GLOSSARY

Abundance. In ecology, local abundance is the relative representation of a species in a particular ecosystem. It is usually measured as the number of individuals found per sample.

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.[a]

Apparent food consumption and apparent food consumption per capita. Proxy measure to indicate the supply of food available in a country for the indicated reference period. Apparent food consumption refers to the amount of food available for human consumption and differs from effective food consumption, which is the actual quantity of food eaten and can be measured through household or individual food consumption surveys.[b, c]

Aquaculture expansion. In the context of Blue Transformation, sustainable aquaculture expansion refers to increased scale, scope and/or area for aquaculture activities. This expansion can include extension of aquaculture to new geographical areas or expansion/enlargement of existing aquaculture operations; diversification of farmed species; adoption of new and diversified farming systems and use of aquaculture in supporting ecosystem services including biodiversity conservation and management, environmental restoration or enhancement of climate change resilience, and integration of aquaculture with ecotourism.

a Include multicellular macro-algae (e.g. *Eucheuma* spp.), unicellular micro-algae (e.g. *Chlorella* spp.) and cyanobacteria, not true algae but informally known as "blue-green algae" (e.g. Spirulina).

b Apparent food consumption refers to a country's total food production plus food imports, minus food exports and minus non-food uses. Data are expressed in live weight equivalent. Apparent food consumption per capita is obtained by dividing apparent food consumption by total population.

c Apparent food consumption data are derived from FAO Food Balance Sheets and have been available on an annual basis at country level since 1961. Currently, the FAO Food Balance Sheet data only refer to aquatic animal foods, excluding algae.

Aquaculture intensification. In the context of Blue Transformation, sustainable aquaculture intensification refers to improved resource-use efficiency in aquaculture, increasing production and decreasing losses while minimizing waste and negative environmental impacts. Sustainable aquaculture intensification can include improved production and management practices for feed and feeding; enhanced seed supply and genetic resource management; biosecurity management and better animal health; effluent (water and nutrient) management and reuse through integration; adoption of modern technology and digitalization; and efficient energy use and management.

Aquafeed. Also known as aquaculture feeds, aquafeeds are feeds used to farm aquatic species. Semi-commercial feeds comprise a number of ingredients that are mixed in various proportions to complement one another and form a simple compound feed. These feeds are manufactured using simple production technologies such as grinding, cooking and drying, and are distributed and sold via local market chains. Aquafeeds in this category may be made by farmers or by small- and medium-scale feed manufacturers.

Aquatic animals. Animals grown in, or harvested from, water, whether brackish water or freshwater. They include fish, crustaceans, molluscs and other aquatic animals, with the exception of aquatic mammals, reptiles and other aquatic products (corals, shells, pearls and sponges). Trade statistics on aquatic animals also exclude data on amphibians and turtles (FAO, 2024i).

Aquatic animal foods. Foods for human consumption originating from animals grown in, or harvested from, water. They include foods from all types of aquatic animals, with the exception of aquatic mammals and reptiles (FAO, 2024i).

Aquatic foods. All foods for human consumption grown in, or harvested from, water. They include foods from all types of algae and aquatic animals (fish, crustaceans, molluscs and other aquatic animals, with the exception of aquatic mammals and reptiles).

Aquatic food systems. Food systems encompassing the entire range of actors and their interlinked value-adding activities involved in the production, processing, distribution, consumption and disposal of aquatic food products that originate from fisheries and aquaculture and parts of the broader economic, societal and natural aquatic environments in which they are embedded.

Aquatic products. The outputs of fisheries and aquaculture production presented whole or in parts, processed or unprocessed, in various product forms, regardless of their final utilization. They include all aquatic animals (fish, crustaceans, molluscs and other aquatic animals), algae (macro-algae, micro-algae, and cyanobacteria) and other aquatic products (e.g. corals and sponges).[d] Equivalent term: fisheries and aquaculture products (FAO, 2024i).

Aquatic value chain. The full range of operations required to bring a fisheries and aquaculture product or service from production to the final consumer at the local, regional or global level. Aquatic value chains include activities such as fishing, farming, processing, transportation, and wholesale and retail marketing, as well as support services (FAO, 2024j).

Biodiversity mainstreaming. The progressive, interactive process of recognizing the values of biodiverse natural systems in the development and management of fisheries and aquaculture, accepting full accountability for, and effectively responding to, the broader impacts of farming, fishing and fisheries-related activities on biodiversity and the related structure and functions of the ecosystem.

Biofloc technology. Use of aggregates of bacteria, algae or protozoa, held together in a matrix along with particulate organic matter for the purpose of improving water quality, waste treatment and disease prevention in intensive aquaculture systems. Consumption of bioflocs also provides nutritional value to cultured species.

Biologically sustainable stock. A fishery stock of which abundance is at or greater than the level that can produce the maximum sustainable yield.

Biologically unsustainable stock. A fishery stock of which abundance is below the level that can produce the maximum sustainable yield.

Biosecurity. The management of all biological and environmental risks associated with food and agriculture, including forestry and fisheries and aquaculture.

Blue Transformation. The targeted process by which FAO and its Members and partners use existing and emerging knowledge, instruments, tools and practices to sustainably expand the contribution of aquatic food systems to food security, resilient aquatic ecosystems and healthy diets for all, leaving no one behind.

Capture-based aquaculture. The practice of collecting "seed" material – from early life to adult stages – from the wild, and its subsequent ongrowing in captivity to marketable size, using aquaculture techniques (Ottolenghi *et al.*, 2004).

Capture fisheries production/catch/landings. The nominal landings, converted into a live weight basis, of aquatic organisms harvested for all purposes and by all types of fishing units operating both in inland waters (freshwater and brackish water) and marine areas. Data do not include discarded catches, live escapements or losses prior to landings (FAO, 2024i).

Certification. Procedure by which a certification body or entity gives written or equivalent assurance that a product, process or service conforms to specified requirements. Certification can be based, as appropriate, on a range of audit activities that may include continuous audit in the production chain (FAO, 2009a).

d 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, and other aquatic products.

Ecolabelling. Logo or statement that certifies that the fish has been harvested in compliance with conservation and sustainability standards. It is intended to make provision for informed decisions of purchasers whose choice can be relied upon to promote and stimulate the sustainable use of fishery resources (FAO, 2009a).

Ecosystem approach to aquaculture. A strategy for integrating the activity within the wider ecosystem such that it promotes sustainable development, equity and resilience of interlinked socioecological systems (FAO, 2010).

Ecosystem approach to fisheries. An approach that strives to balance diverse societal objectives by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO, 2009b).

El Niño Southern Oscillation. The El Niño Southern Oscillation (ENSO) is a natural recurring climate phenomenon that periodically causes Pacific Ocean warming (El Niño) and cooling (La Niña) and influences air surface temperature change and precipitation across the globe. El Niño and La Niña are the extreme phases of the ENSO cycle; between these two phases is a third phase called ENSO-neutral (Bertrand *et al.*, 2020; Trenberth, 1997).

FAO Major Fishing Areas for statistical purposes. Arbitrary areas, the boundaries of which have been determined in consultation with international fishery agencies since the 1950s. The rationale is that each area should coincide, where possible, with the areas of competence of fishery commissions (when existing). There are currently 26 FAO Major Fishing Areas; seven are for inland waters. For statistical purposes, capture fisheries and aquaculture production are assigned to the areas where the catch/harvest took place according to this classification (FAO, 2024h).

Farmed type. A descriptor applied to farmed aquatic organisms at a level below species, including strain, variety, hybrid, triploid, monosex group, other genetically altered forms or wild-sourced type.

Fish silage. Liquid product produced from the whole fish or parts of it, to which acids, enzymes or lactic acid-producing bacteria are added, with the liquefaction of the mass provoked by the action of enzymes from the fish (Olsen and Toppe, 2017).

Fisheries access arrangement. An arrangement that provides access to marine resources of a coastal State in exchange for a fee or other benefits determined within the arrangement.

Fishery management. The integrated process of information gathering, analysis, planning, decision-making, allocation of resources and formulation and enforcement of fishery regulations by which the fishery management authority controls the present and future behaviour of interested parties in the fisheries, in order to ensure the continued productivity of the living resources (FAO, 1995b).

Hybrid introgression. The infiltration of alleles or genes from one species into another via hybridization. First generation hybrids (F1 hybrids) have equal genetic contribution from both parents but genes from the two species begin to segregate differentially in subsequent generations (Basavaraju, Penman and Mair, 2004).

Illegal, unreported and unregulated fishing (IUU fishing). A broad term that describes a wide variety of unacceptable fishing activities that can be found in all types and dimensions of fisheries. It occurs both on the high seas and in areas within national jurisdiction. It concerns all aspects and stages of the capture and utilization of fish, and it may sometimes be associated with organized crime.[e]

Integrated multitrophic aquaculture. The practice that combines, in appropriate proportions, the cultivation of fed aquaculture species

e For full details, please refer to paragraphs 3.1–3.3 in the International Plan of Action to prevent, deter and eliminate illegal, unreported and unregulated fishing available at: https://openknowledge.fao.org/server/api/core/bitstreams/a80c3bfb-1d5b-4ee6-9c85-54b7e83986a2/content (e.g. finfish, shrimps) with aquaculture species that extract inorganic food (e.g. seaweeds) and organic food (e.g. suspension feeders such as bivalves and deposit feeders such as sea cucumbers) from their surroundings. Such practices create a balanced ecosystem management approach to aquaculture for environmental sustainability (biomitigation), economic stability (product diversification and risk reduction) and societal acceptability (better management practices) (FAO, 2010).

Inbreeding depression. The decrease in fitness with increased genome-wide homozygosity that occurs with accumulation of inbreeding (Huisman *et al*., 2016).

Indicator inland fishery. An inland fishery whose status provides information on the overall condition of the ecosystem and of other fisheries in that ecosystem (Hesselink *et al*., 2007).

Integrated water resource management. A process that promotes the coordinated development and management of water, land and related resources to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (FAO, 2022f).

Market access. The conditions countries impose to allow specific products to enter their markets, including tariff and non-tariff measures (WTO, 2024).

Maximum sustainable yield. The maximum sustainable yield (MSY) is the highest theoretical equilibrium yield that can be continuously taken (on average) from a stock under existing environmental conditions without significantly affecting the reproduction process. It is estimated using surplus production models (e.g. the Schaefer model) and other methods. In practice, however, MSY and the level of effort needed to reach it are difficult to assess (FAO, 1999).

Other aquatic products. Corals, pearls, shells, sponges and other inedible products such as fish waste.

Overfished stocks. Fishery stocks having abundance lower than the level that can produce maximum sustainable yield (FAO, 2018c).

Precision farming. A management approach that focuses on (near real-time) observation, measurement and responses to variability in crops, ponds, cages and animals. It can help increase yields and animal performance, reduce costs, including labour costs, and optimize process inputs (EIP-AGRI, 2024).

Preferential access in international trade. Preferential access occurs when there are benefits in market access between two or more countries, whether of a tariff or non-tariff nature, resulting from a particular trade agreement entered into for trade-incentive and beneficial purposes (Fugazza and Nicita, 2010).

Recirculating aquaculture system. Technology to farm fish or other aquatic organisms in a closed system where the culture medium (i.e. water) undergoes mechanical and biological filtration to adequately control the environmental parameters through the removal and transformation of the waste produced by the farmed organisms (Bregnballe, 2022).

Seaweed cultivar. A variety of seaweed produced and maintained by cultivation. Cultivar is a contraction of the words "cultivated" and "variety".

Stock assessment. The process of collecting and analysing biological and statistical information to determine the changes in the abundance of fishery stocks in response to fishing and, to the extent possible, to predict future trends of stock abundance.

Stock maximally sustainably fished. Fishery stock with abundance at or close to maximum sustainable yield (FAO, 2018c).

Traceability. The ability to trace the history, application or location of any given product (FAO, 2009a).

Transshipment. The direct transfer of any quantity of fish onboard from one vessel to another vessel regardless of the location of the event, without the fish being recorded as landed (FAO, 2023j).

Underfished stocks. Fishery stocks with abundance above the level corresponding to maximum sustainable yield (FAO, 2018c).

Vulnerable marine ecosystems. Assemblages of marine benthic organisms or habitats which are susceptible to anthropogenic disturbance, especially that arising from the impact of fishing gear used in bottom fishing.

Water basin/catchment basin. The area of land drained by a particular river system, reservoir or other body of water; a drainage basin.

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THE STATE OF THE WORLD

2024 THE STATE OF WORLD FISHERIES AND AQUACULTURE

BLUE TRANSFORMATION IN ACTION

The 2024 edition of *The State of World Fisheries and Aquaculture* features the Blue Transformation in action, illustrated by activities and initiatives, led by FAO in collaboration with Members, partners and key stakeholders, to integrate aquatic foods into global food security and sustainability, enhance policy advocacy, scientific research and capacity building, disseminate sustainable practices and technological innovations, and support community involvement.

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