United Nations A/CONF.230/2025/12

Distr.: General
30 April 2025

Original: English

2025 United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Nice, France, 9–13 June 2025
Item 9 of the provisional agenda*
Ocean Action panels

Ocean Action panel 9: Promoting the role of sustainable food from the ocean for poverty eradication and food security

Concept paper prepared by the Secretariat

Summary

The present concept paper was prepared pursuant to paragraph 24 of General Assembly resolution 78/128, in which the Assembly requested the Secretary-General of the 2025 United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development to prepare concept papers on each of the themes of the Ocean Action panels, taking into account the relevant ocean-related processes of the Assembly and other possible contributions. The present paper relates to Ocean Action panel 9, on the theme "Promoting the role of sustainable food from the ocean for poverty eradication and food security". In the paper, the status, trends, challenges and opportunities for the achievement of relevant targets of Sustainable Development Goal 14 are set out, under the overarching theme of the Conference: "Accelerating action and mobilizing all actors to conserve and sustainably use the ocean".

* A/CONF.230/2025/1.

I. Introduction

1. Aquatic foods are fundamental to food security and poverty alleviation, [1] especially as climate change and biodiversity loss increasingly threaten global food systems and livelihoods. Ocean-based food sources are rich in essential nutrients, including iodine, selenium, iron, zinc, calcium and vitamins A, B12 and D. They also provide high-quality proteins and long-chain polyunsaturated fatty acids, which play a critical role in health and are vital for cognitive development and heart disease prevention. Moreover, fisheries and aquaculture generate jobs, income and livelihoods for millions of people. When properly managed, many aquatic food systems have a lower environmental footprint and offer climate-resilient alternatives to traditional land-based food systems.

2. To maintain current per capita consumption of aquatic animal foods through 2050, a 22 per cent increase in total supply will be necessary. However, this increase must be achieved through responsible practices to safeguard food security [2] and health for present and future generations. The required supply growth will vary by region, achieved through a combination of increased domestic production and, where feasible, strategic imports. It is crucial to thoroughly evaluate the challenges and opportunities to maximize the role of aquatic foods in achieving food security and poverty reduction, while also building resilience to future disruptions. While capture fisheries production has remained relatively stable since the mid-1990s, aquaculture continues to be the fastest-growing food production system, and it is expected that this trend will continue in future decades. Effective management of the fisheries sector is essential, and the expansion of aquaculture must occur in an environmentally sustainable and socially responsible manner. Furthermore, efficiently using fisheries by-products and minimizing food loss and waste, while maintaining food safety, present key opportunities to enhance access to aquatic foods.

3. Sustainable fisheries management and support for small-scale fishers, as well as women, who play a vital role in the post-harvest sector, are crucial for maximizing the contributions of aquatic foods to food security and poverty eradication. The effects of climate change are already evident, particularly in vulnerable coastal communities, highlighting the urgent need for action to ensure food security, nutrition, and poverty reduction efforts. Aquatic foods are among the most traded food commodities, often viewed primarily through economic objectives, with less emphasis on their critical roles in providing food security and nutrition, sustaining livelihoods and eradicating poverty, especially for vulnerable populations. While increasing the availability of aquatic foods is important, it is essential to ensure access to these foods. The potential of aquatic food systems to efficiently nourish millions while maintaining a low environmental footprint is well documented. However, to fully realize this potential, these systems must be transformed to align with current global realities, as set out in the Food and Agriculture Organization of the United Nations (FAO) Blue Transformation road map, which outlines strategies to enhance the sustainability, resilience and equity of aquatic food systems and maximize their contribution to the Sustainable Development Goals.

[1] See https://doi.org/10.1038/s41586-021-03917-1.

[2] A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: food availability, economic and physical access to food, food utilization, and stability over time (Food and Agriculture Organization of the United Nations (FAO)).

II. Status and trends

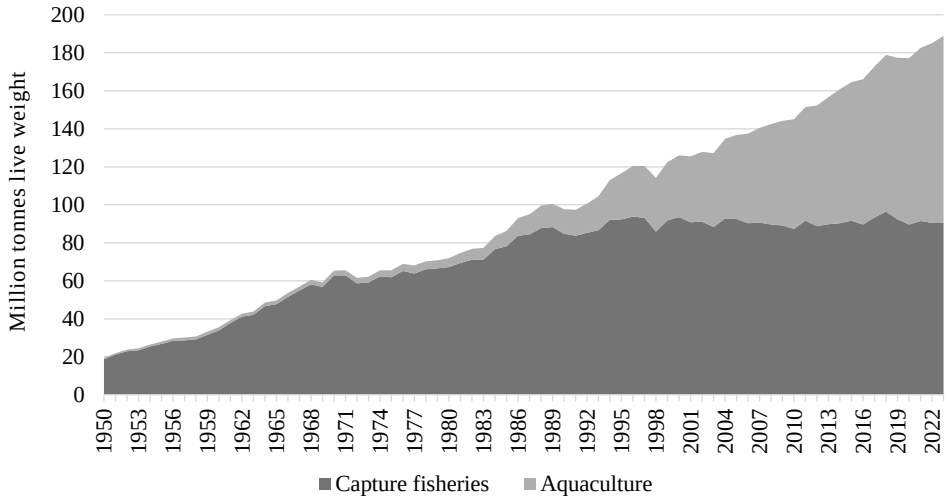
Production

4. Total fisheries and aquaculture production has grown steadily since 1950. Since the late 1980s, aquaculture has become a key driver of growth in global fisheries and aquaculture production (reaching 60 per cent of total production in 2023), playing a critical role in addressing the rising demand for aquatic foods (see figure I). Despite the increasing role of aquaculture, capture fisheries remain dominant for a number of species and are vital for domestic and international food security. Small-scale fisheries are responsible for about 40 per cent of global capture fisheries production, with two thirds of small-scale fisheries catches occurring in marine fishing areas.[3]

5. Total fisheries and aquaculture production (marine and freshwater) reached a record high of 227.9 million tonnes in 2023, comprising 188.9 million tonnes (live weight equivalent) of aquatic animals and 39.0 million tonnes (wet weight) of algae. It is estimated that 66 per cent originated from marine species, whether captured or farmed.

6. Since 2000, fisheries and aquaculture production of marine species has increased by 1.5 per cent per year on average, while total production has increased by 2.3 per cent over the same period. As a result, the share of production of marine species in total production has been decreasing over time, from 78 per cent in 2000 to 66 per cent in 2023. The main driver for production of marine species has been aquaculture.

Figure I
World fisheries and aquaculture production of aquatic animals, 1950–2023



Source: FAO, 2025.

International trade

7. International trade in aquatic products plays a significant role in food security, through imports by enhancing access to aquatic foods, and through exports by generating employment and income in the fisheries and aquaculture sector in response to foreign demand. Given regional disparities in production, trade facilitates the global distribution of aquatic foods and their nutrients.

[3] See https://doi.org/10.4060/cc6062en.

8. In 2023, exports of all aquatic products totalled $194 billion, with an estimated 76 per cent originating from marine products. Among marine products, it is estimated that approximately 91 per cent of the value in 2023 corresponds to marine food products.

9. While international trade in marine products has increased steadily, it has grown at a slower pace than total trade in aquatic products. Since 2000, the annual growth rate of trade in marine products has averaged 4.7 per cent, while total trade in aquatic products has grown by 5.3 per cent annually. In 2000, marine products represented 87 per cent of all traded aquatic products, but this share decreased to 76 per cent by 2023.

10. In addition to goods, services related to fisheries and aquaculture are also traded internationally, generating income and supporting economies, although they are difficult to isolate in existing data on trade in services. To address this, the United Nations Conference on Trade and Development (UNCTAD) has developed a classification of trade in fisheries services, based on the Central Product Classification,[4] as part of its ocean economy classification,[5] that could be used when gathering country-level data for this sector to provide a more complete picture of the importance of international trade in fisheries services.

Consumption

11. The supply of aquatic animal foods available for human consumption has increased over time, due to higher production levels and a reduction in the share used for non-food purposes. In 2022, 89 per cent of aquatic animal production was for human consumption, up from 67 per cent in the 1960s. The remaining 11 per cent was used mainly to produce fishmeal and fish oil. Considering marine production only, the share of non-food purposes increases to about 18 per cent, as the bulk of the raw material used to produce fishmeal and fish oil consists of marine fish.

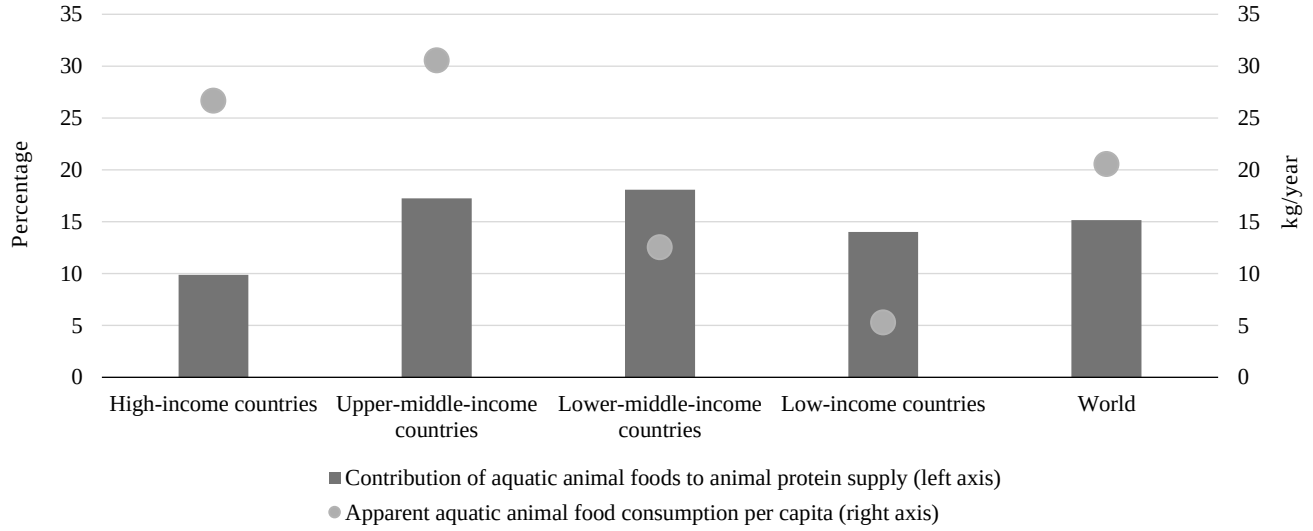
12. By-products that have traditionally been discarded as waste are increasingly being repurposed for both food and non-food uses. For instance, in 2022, by-products accounted for 34 per cent and 53 per cent of the total production of fishmeal and fish oil, respectively.

13. In 2021, aquatic animal food destined for human consumption was estimated at 20.6 kg per capita. Approximately 60 per cent came from marine species, while the remainder was sourced from freshwater and diadromous species.

14. Globally, aquatic animal foods provided 15 per cent of animal proteins in 2021, but are increasingly recognized for their important contribution to minerals, vitamins and omega-3 fatty acids. Low- and middle-income countries rely more on aquatic animal proteins and other nutrients than high-income countries, although absolute per capita consumption of aquatic animal foods is significantly lower in low-income countries (see figure II). For example, in Africa, where consumption averaged just 9.4 kg per capita in 2021, aquatic animal foods provided 18 per cent of animal proteins, above the global average.

[4] See https://unstats.un.org/unsd/classifications/unsdclassifications/cpcv21.pdf.
[5] See https://unctad.org/system/files/official-document/ditcted2020d4_en.pdf.

Figure II
Apparent consumption of aquatic animal foods per capita and contribution to supply of animal proteins by economic class, 2021



Source: FAO, 2024.

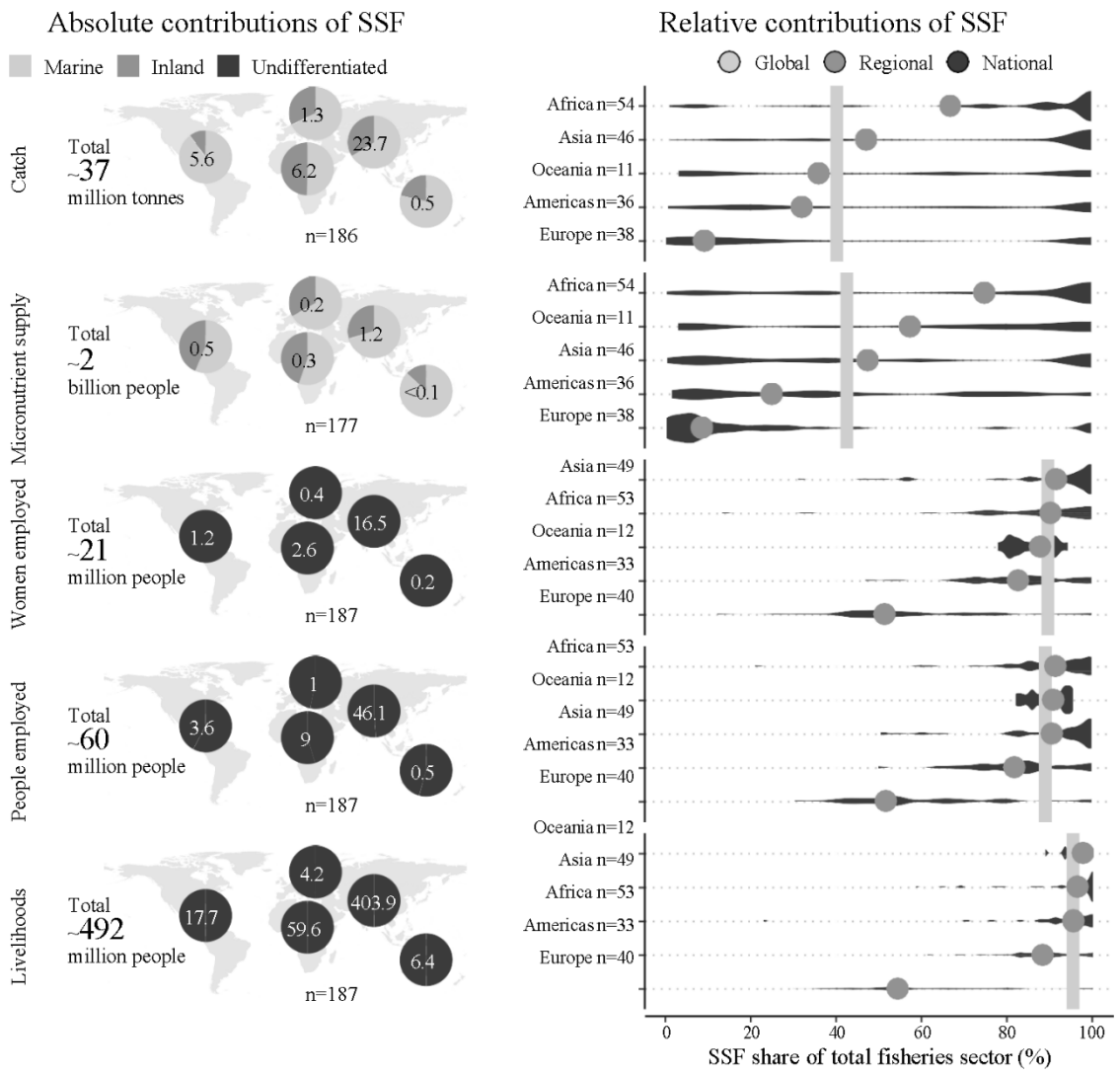
Supporting livelihoods

15. The fisheries and aquaculture sectors, both marine and inland, support the livelihoods of approximately 600 million people globally, including 62 million directly employed in the fisheries and aquaculture primary sector. For capture fisheries, almost 500 million people depend at least partially on small-scale fisheries to support their livelihoods.[6]

16. According to the Illuminating Hidden Harvests global initiative, an estimated 27.5 million people are employed part-time or full-time in the harvesting segment of the value chain, of whom 47 per cent are engaged in marine small-scale fisheries. Despite their vital role in nutrition, livelihoods and global fisheries, small-scale fisheries lack sufficient recognition and technical and economic support. This is particularly the case for women.

[6] See https://doi.org/10.4060/cc6062en.

Figure III
Multidimensional contributions of small-scale fisheries to sustainable development



Source: www.nature.com/articles/s41586-024-08448-z.
Abbreviation: n, sample size; SSF, small-scale fisheries.

17. In small-scale fisheries, women constitute 40 per cent of the workforce (see figure III), especially in the post-harvest sector.[7] Indeed, women play a crucial role in fisheries and aquaculture, not only as key players in the post-harvest sector but also in leadership and decision-making, as well as unpaid labour, subsidizing the fishing economy.[8,9] They also play a critical role in ensuring food security for their family and community. However, women often face disadvantages in accessing resources

[7] Ibid.
[8] See https://digitalarchive.worldfishcenter.org/server/api/core/bitstreams/fcbcc3b0-1dcf-4d0b-853c-344a46f47a0d/content.
[9] Nilanjana Biswas, "Where have all the women gone?", *Yemaya Newsletter*, vol. 57 (July 2018).

and services, including credit, transport, training, information, technologies and extension services.[10]

Food loss and waste

18. A report by the World Economic Forum from April 2024 revealed that global edible aquatic food loss and waste totalled approximately 23.8 million tonnes in 2021, representing 14.8 per cent of the total aquatic food produced that year. This figure does not include losses associated with processing at sea, aquaculture production and small-scale fisheries, due to the lack of reliable data.[11] This may be a conservative figure as estimates made by FAO in 2011 suggest that aquatic food value chains globally encounter loss and waste of about 35 per cent. This share may be higher in low-income rural areas which lack cold-chain technologies, and in areas with high climatic variability, such as heavy rainfalls.[12]

III. Challenges and opportunities

Stock status

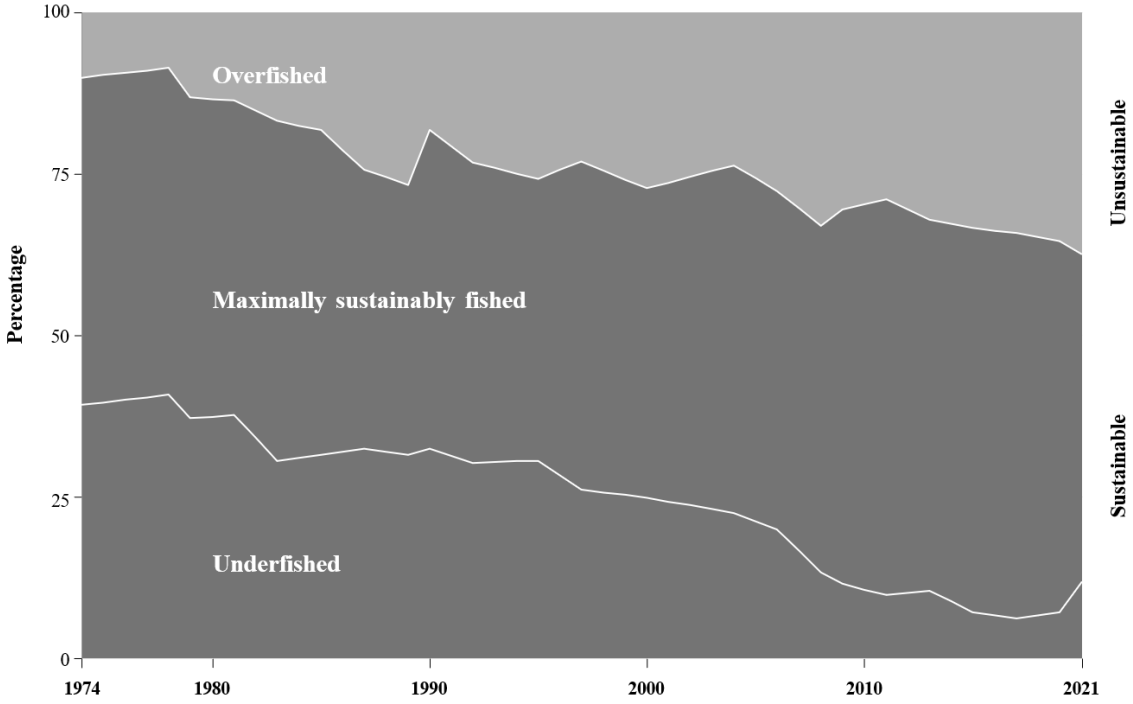
19. Overfishing remains a critical issue that threatens the long-term viability of aquatic food systems and global food security. Despite notable improvements in some regions, the state of marine fisheries resources remains a concern. The proportion of marine fishery stocks within biologically sustainable levels fell to 62.3 per cent in 2021 (see figure IV). However, when weighed by their production levels, an estimated 76.9 per cent of 2021 landings from FAO-monitored stocks came from biologically sustainable stocks. Similarly, 86 per cent of major tuna stocks were within biologically sustainable levels. These results highlight that effective fisheries management can lead to stock recovery and increased catches, underscoring the urgent need to expand enforcement efforts to reverse the downward trend in marine fishery stocks.

[10] See www.fao.org/fileadmin/templates/cfs/Docs2223/Gender/Guidelines_Final_Agreed_Version_June_2023_CLEAN/GEWGE_Guidelines_Final_Agreed_Version_June_2023_CLEAN.pdf.

[11] See www3.weforum.org/docs/WEF_Investigating_Global_Aquatic_Food_Loss_and_Waste_2024.pdf.

[12] See www.fao.org/4/mb060e/mb060e00.pdf.

Figure IV
Global trends in the state of the world's marine fishery stocks, 1974–2021



Source: FAO estimates.

Trade opportunities and barriers

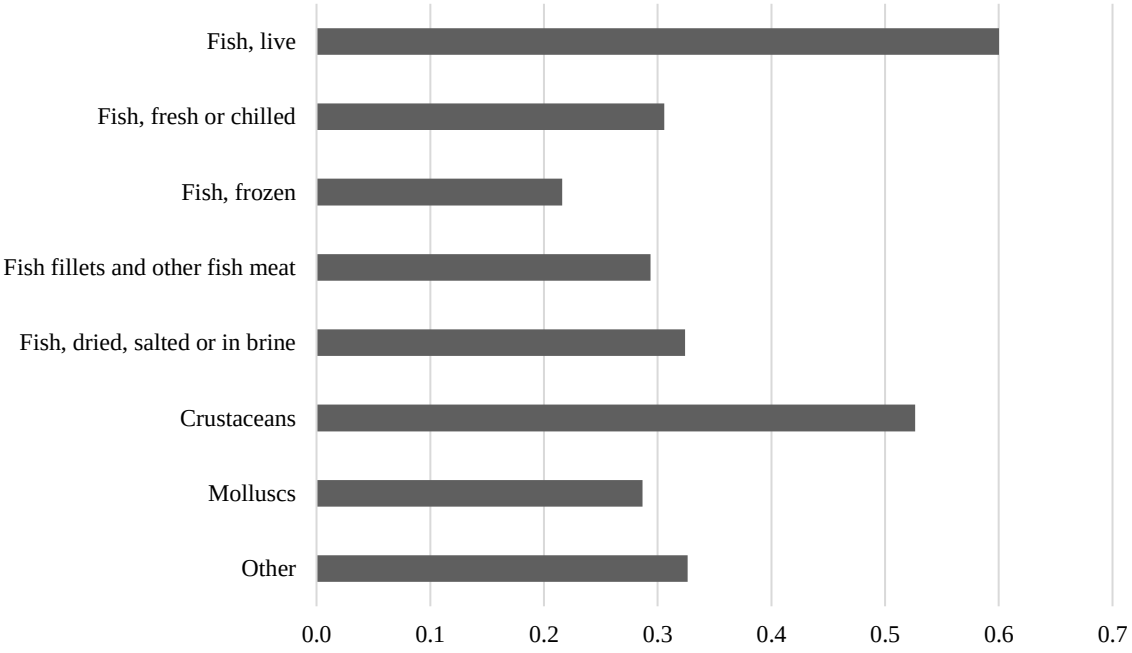
20. International trade in aquatic products has considerable potential to enhance food security and nutrition. Export growth not only improves a country's balance of payments but can also bolster food security by increasing local production capacity and generating income in the most vulnerable countries. Countries such as Chile, China, India and Viet Nam have developed a strong export sector, and other countries are developing their exports and building on their comparative advantages. [13] However, some countries face challenges, including tariff and non-tariff measures, such as sanitary and technical barriers and transport costs, which increase compliance expenses and restrict market access, particularly for small-scale operators.

21. One of the main obstacles to exporting aquatic products is the comparatively high transport costs relative to the traded volume. In 2021, the average cost for international transport of 1 kg of fish, crustaceans, molluscs or other aquatic invertebrates amounted to $0.30, compared with $0.10 for the international transport of agricultural commodities in general.

22. High transport costs make it challenging, in particular for poorer economies, to sell fish and other aquatic products on the global market. As shown in figure V, it is especially costly to transport live fish ($0.60 per kg) and crustaceans ($0.53 per kg), whereas transporting frozen fish is considerably cheaper ($0.22 per kg). In 2021, transporting aquatic commodities by air was on average six times more costly ($2.44 per kg) than transporting them by sea ($0.34 per kg).

[13] See https://unctad.org/publication/south-south-trade-marine-fisheries-and-aquaculture-sectors.

Figure V
Transport costs for international trade of aquatic commodities, 2021 (dollars per kg)



Source: UNCTAD and World Bank (2024), Trade-and-Transport Dataset, UNCTADstat.
Notes: Commodities in Chapter 03 of the Harmonized System classifications are considered. Insurance and freight costs are included in transport costs.

Supporting livelihoods and eradicating poverty

23. The sustainability of fisheries, in particular small-scale fisheries, is critical for the communities that rely on them for food security, income and economic stability. Overfishing threatens small-scale fisheries by depleting marine resources, which jeopardizes livelihoods. Many small-scale fisheries operate in overexploited waters where fish stocks decline due to poor management and slow adoption and limited enforcement of regulations. Illegal, unreported and unregulated fishing exacerbates this problem, undermining legitimate small-scale fishers, while also limiting development aid inflows from the donor community.

24. Climate change has a significant impact on small-scale fisheries and increases the vulnerability of coastal communities. Efforts to address climate resilience and promote the adaptation of small-scale fisheries are essential to maintaining the sustainability and long-term contribution to food security of such fisheries. The UNCTAD BioTrade Principles and Criteria provide guidelines for the conservation, sustainable use and equitable benefit-sharing of marine biodiversity-based products. Addressing socioeconomic barriers is crucial for empowering small-scale fisheries and enabling them to thrive in competitive markets.

25. Socioeconomic challenges, limited access to markets and financial services, and inadequate infrastructure hinder sustainable practices, economic improvement and participation in value-added activities. Marginalization from policymaking further entrenches poverty and inequality. Social protection mechanisms play a vital role in fostering resilience among vulnerable fishing communities. By addressing both immediate needs and long-term stability, social protection programmes not only enhance livelihoods but also promote sustainable fishing practices. Social protection mechanisms are crucial for supporting small-scale fisheries.

26. Through enhanced capacity-building efforts, communities can be empowered to not only protect their livelihoods but also contribute to broader environmental and economic objectives. The implementation of the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication provides a framework for integrating small-scale fisheries into national and regional development strategies. Capacity-building initiatives, including training in sustainable fishing practices, financial management, gender-related issues and advocacy, empower fishers to participate more effectively in governance and market systems.

Ensuring food security and nutrition for a growing population

27. All food production systems face the challenge of meeting future demand, and aquatic food systems are no exception. With the global population projected to reach 9.7 billion by 2050, demand for high-quality foods, including aquatic foods, will intensify. At the same time, climate change poses additional challenges and threats, affecting the health of aquatic ecosystems, altering fish migration patterns, and influencing the availability of marine and freshwater resources, further complicating efforts to meet the growing demand.

Exploiting the full potential of aquaculture

28. Aquaculture has emerged as a major contributor to global food supply. It currently accounts for over 57 per cent of the aquatic animal supply available for human consumption and this share is expected to grow in the coming decades. This growth has helped to alleviate pressure on overfished stocks, while meeting rising demand for animal-sourced foods. However, aquaculture production is geographically concentrated, with 89 per cent located in Asia in 2023. The underdevelopment in other areas may limit regional and global accessibility of aquaculture products and affect food security and economic opportunities.

29. Farmed marine finfish rely on feed that contains certain levels of marine ingredients, which is increasingly used selectively at specific stages of production due to the high cost of such feed. Future increased production of fishmeal and fish oil will mainly need to come from fish by-products and other sources. Research is being conducted on alternative sources of marine ingredients, such as fish silage, as well as insect and bacterial meals, vegetable alternatives and algae. In addition, marine zooplankton, such as krill (*Euphausia superba*) or copepods (*Calanus finmarchicus*), are being harvested to produce oil-derived products for human consumption as well as feed.

30. In 2023, about a quarter of the aquaculture production of aquatic animals consisted of non-fed species. Farming of bivalves and other low-trophic species is an alternative with less impact on the environment that can provide highly nutritious foods as well as increased diversification.

Algae

31. Aquatic foods come from more than just animals. Seaweed is a low-calorie food that can be a rich source of essential vitamins (A, B, C, D, E and K), minerals (iodine, calcium, iron and magnesium), dietary fibres, and bioactive compounds such as antioxidants and omega-3 fatty acids,[14] with some species even high in proteins.

32. Consumption of seaweed can help to mitigate deficiencies in iodine, vitamin A and iron, which affect billions of people worldwide, in particular children and

[14] See https://unctad.org/publication/ocean-opportunities-potential-seaweed-advance-food-environmental-and-gender-dimensions.

pregnant women in low- and middle-income countries. Its ability to provide iodine – a key nutrient often lacking in terrestrial crops – makes it a sustainable alternative for regions vulnerable to nutritional deficiencies.[15]

33. Interest in the production and utilization of algae (seaweed, microalgae and cyanobacteria) has increased greatly in recent years. Algae production contributes to food security and provides employment opportunities for coastal communities. Production of seaweed and other marine algae has increased significantly during the past decades, from 12 million tonnes (wet weight) in 2000 to 39 million tonnes in 2023, with 97 per cent of the 2023 production from aquaculture. The sector has the potential to expand further, thanks to rising demand for both food and non-food uses, reflecting the growing role of algae in both food security and economic resilience. Innovations such as seaweed cultivation further enhance the sector's potential. Between 2000 and 2021, the global seaweed market tripled, from $5 billion in 2000 to $17 billion in 2021. Investment in 10 new and emerging markets, including biostimulants, animal and pet foods, bioplastics, methane reducing additives, and fabrics could increase the value of the seaweed sector by $11.8 billion by 2030.[16] About 40 per cent of all seaweed start-ups globally are led by women.[17]

34. Heavy metals and marine biotoxins have been associated with some algae and seaweed.[18] However, there is generally a lack of legislation and guidance regarding the production and use of seaweed.[19] There are currently no Codex Alimentarius standards establishing any food safety criteria for seaweed or other algae.

Access to aquatic foods for nutritionally vulnerable populations

35. One of the biggest challenges in realizing food and nutrition security is that nutritious foods from the ocean often do not reach the most nutritionally vulnerable people. In a number of countries where malnutrition persists, the nutrients available in marine catches exceed the dietary requirements of the coastal population.[20] If these countries prioritized even a portion of the catch for domestic consumption, several micronutrient deficiencies could be alleviated. Further efforts are required, particularly across more countries, to support evidence-based policymaking connecting aquatic food system policies with health politics.

36. Although most fishmeal and fish oil produced from whole fish originate from well-managed fisheries, there are concerns about the sustainability of certain fisheries. In some countries, fishmeal production is increasingly occurring in areas inhabited by impoverished coastal communities that rely on fish for their sustenance and livelihoods. In West Africa, for example, increasing amounts of catch are reduced into fishmeal for export purposes, competing with their traditional use for domestic human consumption. While the sale of fish for fishmeal and fish oil may result in increased income, greater income does not always result in improved food security and nutrition. The sale of fish for fishmeal and fish oil not only increases the pressure on fishery resources in the absence of proper resource management, but also negatively affects food security and livelihoods. It is essential to improve governance

[15] Ibid.
[16] World Bank, *Global Seaweed New and Emerging Markets Report 2023* (Washington, D.C., 2023).
[17] See https://unctad.org/publication/ocean-opportunities-potential-seaweed-advance-food-environmental-and-gender-dimensions.
[18] See doi.org/10.2903/j.efsa.2023.7798.
[19] See https://doi.org/10.4060/cc0846en.
[20] Christina C. Hicks and others, "Harnessing global fisheries to tackle micronutrient deficiencies", *Nature*, vol. 574 (2019).

and fisheries management, while prioritizing the utilization of aquatic species for human consumption and food security.[21]

37. Access to aquatic foods may be limited at the household or community level. For example, aquatic food consumption is limited for vulnerable groups, such as infants, young children and schoolchildren.[22,23] Existing distribution networks, such as school feeding programmes, offer an opportunity to deliver aquatic foods to nutritionally vulnerable populations. Homegrown school feeding programmes can source fish from small-scale fisheries. Fish products that are culturally acceptable, age-appropriate and cost-effective have been developed for infants, young children and adolescents benefiting from school feeding programmes, to help address this challenge.

38. Innovative aquatic foods, such as fish powder processed using whole fish or fisheries by-products, can be added to other foods. Local recipes have been developed under research projects supported by FAO and the United Nations Industrial Development Organization (UNIDO). Fish powders have a long shelf life, allowing transportation and distribution to areas further away from fisheries, and have been shown to contribute to improved child growth outcomes, particularly in the first 1,000 days of life.[24,25] Dried or powdered fish-based products are comparable to commercially produced complementary food supplements, such as small-quantity lipid-based supplements, in their iron, zinc, calcium and fatty acid content.[26] These innovations may be a solution for reaching nutritionally vulnerable, low income and non-fish consuming populations, if done in an environmentally, economically and socially sustainable way, to ensure that products meet consumer needs.

39. An analysis of Demographic and Health Survey data in five countries found that distance to waterbodies was a good predictor for whether children consumed fish, and that a greater percentage of children living within 10 km of a marine coastline consumed fish.[27] The percentage of children consuming fish decreased drastically the further away they lived from marine coastlines (unless within 5 km of inland water bodies).[28] This highlights the need to adopt cost-effective technologies for improving fish processing and extending the shelf life to allow for distribution to rural, non-fishing areas. Such technologies enable the distribution of marine foods to inland areas and stabilize consumption during seasonal shifts in fish availability. Studies have found that markets in urban centres in low-income countries are an important distribution point for aquatic foods, particularly in their dried form.[29,30]

40. Certification of fish-based products can lead to improvements in safety and quality. However, certification processes are costly, leading to products that are less affordable to low-income groups that are often nutritionally vulnerable. Small-scale producers may be deterred from participating, further limiting the availability of affordable fish-based products. While certification enhances food safety, it can inadvertently contribute to food insecurity by limiting access to essential nutrients for economically disadvantaged populations. Alternatives such as innovative certification models – voluntary certification schemes that ensure the minimum

[21] See www.fao.org/4/mb060e/mb060e00.pdf.
[22] See www.sciencedirect.com/science/article/pii/S030691921630001X.
[23] See https://doi.org/10.3390/foods10092080.
[24] See https://doi.org/10.3390/nu14112191.
[25] See https://doi.org/10.1093/advances/nmac102.
[26] See https://onlinelibrary.wiley.com/doi/full/10.1111/mcn.13192.
[27] See https://doi.org/10.4060/cd2169en.
[28] See www.sciencedirect.com/science/article/pii/S030691921630001X.
[29] See https://onlinelibrary.wiley.com/doi/10.1111/faf.12597.
[30] See https://doi.org/10.1038/s43016-022-00642-4.

hygiene standards and do not require significant investments – and government subsidies could be explored to overcome these challenges.

Reduction of loss and waste and utilization of by-products

41. Loss and waste of aquatic foods negatively affects food security by diminishing the availability of nutritious, high-quality food for human consumption. Reduction of food loss and waste is a target of the Sustainable Development Goals (target 12.3) and a FAO programme priority area, highlighting the role of waste reduction in sustainable food systems.

42. Fish processing generates a significant volume of by-products, representing over 50 per cent of the fish, and by-products are often not optimally utilized.[31] The by-products are of high nutritional value but are often used for non-food purposes.

43. Processing fish by-products for human consumption is increasingly being recognized as a contributor to greater fish availability for consumption and to addressing deficiencies in nutrients such as iron and calcium. Greater use of processing by-products can provide more food without increased capture or harvest and has potential to reduce negative impacts on the oceans and create additional economic activities for fish processors.

44. Developing efficient, cost-effective technologies to process aquatic by-products into value-added products remains a significant challenge, particularly in regions with limited infrastructure or technical expertise. Furthermore, inconsistent regulations governing the use of by-products can also limit innovation and market expansion. Informed decision-making regarding solutions to food loss and waste and the utilization of by-products is hampered by a lack of robust, evidenced-based data, particularly on the impact of solutions. Reliable and timely data and information is crucial to design realistic solutions and strategies and to further implementation, monitoring and evaluation.

Food safety

45. Food safety, nutrition and food security are interconnected. Unsafe food can contribute to disease and malnutrition, particularly affecting vulnerable populations. However, in most cases, the benefits of consuming aquatic foods outweigh the risks associated with their consumption.[32] Nevertheless, in many places, food safety issues remain a barrier to the consumption of aquatic foods by the general population, due to lack of consumer confidence, and by vulnerable groups such as infants and children through nutrition programmes such as school meals. Interventions throughout the aquatic food value chain, such as use of ice on-board fishing vessels and proper handling and hygiene during processing, storage and transportation can make large improvements to food safety, particularly in small-scale aquatic food value chains.

46. Unsafe food containing chemical contaminants, toxins, harmful bacteria, viruses or parasites can cause diseases ranging from diarrhoea to cancers, but this is not specific to aquatic foods. Certain food safety hazards are linked to mismanaged waste or emissions, while others are intrinsically linked to the aquatic environment. For example, each year, norovirus is estimated to cause 125 million cases of foodborne illness and 35,000 deaths globally. Meanwhile, hepatitis A is estimated to

[31] Ragnar L. Olsen, Jogeir Toppeand Iddya Karunasagar, “Challenges and realistic opportunities in the use of by-products from processing of fish and shellfish”, *Trends in Food Science and Technology*, vol. 36, No. 2 (April 2014).

[32] See https://doi.org/10.4060/cd2394en.

cause 14 million cases of foodborne illness and 28,000 deaths globally annually.[33] It is important to note that the risk of illness is linked to the consumption of raw, undercooked or cross-contaminated foods. Improved hygienic handling and proper cooking will minimize these risks.

47. Excess intake of essential nutrients can also be harmful. For example, iodine in some seaweed species can reach levels that might be harmful if consumed frequently. An excess of iodine can cause thyroid problems, increasing the risk of developing hyperthyroidism, hypothyroidism and goiter, similar to symptoms of iodine deficiency. However, 35–45 per cent of the global population is estimated to suffer from iodine deficiency, so excess consumption may pose more concern for high consumers of seaweed.[34]

48. Harmful algal blooms can also have significant impacts on food safety and security through contamination or mass mortalities of aquatic organisms. If not properly controlled, aquatic products contaminated with harmful algal bloom biotoxins can be responsible for foodborne diseases such as paralytic shellfish poisoning, amnesic shellfish poisoning, ciguatera poisoning and others.[35] The consequences of harmful algal blooms, when rapidly growing, include reduced dissolved oxygen in the ocean, dead zones, and mass mortalities of aquatic organisms.[36]

49. Other hazards, such as heavy metals (methylmercury, cadmium and lead), persistent organic pollutants (dioxins and dioxin-like substances, including polychlorinated biphenyls and perfluoroalkyl and polyfluoroalkyl substances) and microplastics are often linked to human activities. Factors such as species, fat content, geography, size, age and trophic position might influence the concentration in aquatic products and eventually raise food safety concerns.

50. Parasites can also be a public health concern when consuming aquatic products. Human fishery product-borne parasitic diseases can be caused by cestodes, trematodes and nematodes. Freezing or cooking will kill the parasites but not allergic (hypersensitivity) reactions against parasite antigens.

51. Contemporary climate warming is modifying the marine environment and may result in an extension of time during which parasitic eggs can persist. As a result, there may be an increase in the extent of distribution of the parasites.[37] In general, climate change is accelerating the propagation of pathogens and toxins and contributing to the bioavailability of certain chemicals such as mercury. Understanding of the impact of climate change and anthropogenic activities on food safety for aquatic products is limited due to the lack of monitoring data on contaminants, harmful algal blooms and toxins, as well as pathogenic bacteria, viruses and parasites.

52. The establishment of monitoring and early warning systems by Governments and businesses could help to understand the links between various parameters and the presence and concentration of hazards. This could prevent food safety outbreaks due to the consumption of aquatic products and support the implementation of initiatives to mitigate these issues. Increased scientific knowledge and research for ocean health can support decision-making for the reduction of marine pollution, which is key for

[33] See https://openknowledge.fao.org/server/api/core/bitstreams/4b51630e-c354-4af1-9ec1-78243bd18c29/content.

[34] Adrienne Hatch-McChesney and Harris R. Lieberman, “Iodine and iodine deficiency: a comprehensive review of a re-emerging issue”, *Nutrients*, vol. 14, No. 17 (2022).

[35] See https://openknowledge.fao.org/items/61b95c70-6790-48fb-a6b6-e41a29792520.

[36] See https://doi.org/10.4060/cc4794en.

[37] See https://doi.org/10.1016/j.polar.2009.06.002.

food safety for aquatic products and therefore for achieving food security (Sustainable Development Goal 2).

IV. Solutions to challenges and opportunities

Methods for ensuring sustainable supply

53. Ensuring a stable and sustainable supply of aquatic products is critical for advancing global food security, especially in regions where inadequate infrastructure and environmental pressures hinder aquatic food production. To maintain a consistent supply throughout the year, it is essential to mitigate seasonal variations by processing aquatic products during periods of abundance. This makes them shelf-stable and available when fresh products are scarce. An important initiative is the FAO Blue Transformation road map, which focuses on sustainable fisheries and aquaculture, promoting innovative solutions to expand aquatic food systems and enhance their contribution to food security and nutrition, conserve marine and freshwater ecosystems, foster inclusive economic growth and support the livelihoods of coastal and riparian communities.

Improve fisheries management

54. Improving fisheries management is a fundamental requirement to ensure a sustainable supply of aquatic foods from capture fisheries. In the long term, effectively managed fisheries can provide a more stable and resilient aquatic food supply, especially for vulnerable populations reliant on aquatic foods for healthy diets and livelihoods.[38]

55. Effective fisheries management relies on robust local, national and global frameworks that reflect the realities of the countries and communities that participate in the sector. This can be achieved through the adoption of the ecosystem approach to fisheries and increasing capacity for accurate data and statistics, strengthened fisheries governance at all levels and participatory management, while fostering collaboration among stakeholders to achieve both biodiversity and food security, in a highly collaborative and transparent process.

56. Accurate data that encompass the entire value chain are key to both sound policymaking and to assessing and tracking the performance of responsible fisheries. Innovative data systems must support regular assessments of fisheries, tracking the impacts of management interventions across ecological and socioeconomic dimensions.

57. For an in-depth discussion of the benefits, challenges and opportunities for fostering sustainable fisheries management, particularly those related to small-scale fisheries, please refer to the concept paper for Ocean Action panel 5, on the theme “Fostering sustainable fisheries management, including supporting small-scale fishers”.

Sustainable aquaculture

58. Sustainable aquaculture offers a viable solution to increasing food security, while contributing to economic growth and livelihoods. There is a need for policies and practices that balance production growth with ecological sustainability, including the responsible use of land, water, and feed resources. Selecting nutrient-dense, low-cost species with greater environmental outcomes should be given high priority.

[38] See http://hdl.handle.net/10986/24056.

59. The FAO Guidelines for Sustainable Aquaculture provide a framework for policies and practices that minimize environmental impacts, such as habitat degradation and pollution, while promoting efficiency and resilience in aquaculture systems. They provide valuable direction for strengthening resilience through better water management, species diversification, and improved value chains.[39]

60. The widespread adoption of alternative feed ingredients, such as microalgae and black soldier fly larvae, may potentially support sustainable aquaculture production while significantly reducing reliance on fishmeal. However, extensive research is required to optimize the large-scale production of these alternative ingredients and to evaluate comprehensively their impact on food safety and on fish health. In the absence of wide-scale alternatives, the targeting of aquatic foods for non-food uses in regions where they are important for food and nutrition security should be regulated, to avoid disruptions in aquatic food markets for human consumption.[40,41]

61. Another method of stabilizing aquatic food supply is by integrating aquaculture with land-based agriculture, through aquaponics for example. Integrated systems, such as rice-fish systems, serve as "storage" for fish, which farmers harvest periodically for home consumption.[42] This practice is sometimes referred to as a "poor man's fridge" because it ensures a constant supply of fresh fish and aquatic animals without requiring costly storage infrastructure. Likewise, integrating species with complementary ecological roles, such as in integrated multi-trophic aquaculture systems, where different aquatic species, including seaweeds, are reared at different trophic levels, promotes year-round productivity, as each species has distinct growth cycles and harvest periods.[43]

Enhanced value chains

62. Supportive policy measures are vital for stabilizing aquatic food availability, accessibility, and utilization, and balancing trade-offs to ensure food and nutrition security. To support small-scale fisheries and low- and middle-income countries, it is essential to reduce non-tariff barriers, such as sanitary and technical measures, that elevate compliance costs and restrict market access. In addition, solutions to cut transport costs are critical. Improving data and information on international trade, markets and transport networks can reduce information asymmetries, enabling better access to markets and empowering small-scale operators to navigate complex market requirements.

63. Enhancing value chains is key to boosting the social, economic and environmental viability of aquatic food systems. By strengthening these value chains, small-scale fisheries can better meet the import requirements of major markets, unlocking opportunities for growth and development. In addition, it is vital to recognize the essential role of small-scale fisheries, which employ millions of people globally, a significant proportion of whom are women.

64. Lastly, traceability systems can be introduced and strengthened to improve control over the whole traceability chain from harvest to export, and to provide necessary credibility to processed fish products, leading to enhanced transparency

[39] See https://doi.org/10.4060/cd3785en.
[40] See https://doi.org/10.4060/cc6229en.
[41] Food and Agriculture Organization of the United Nations (FAO), *Aquaculture Development: 5. Use of Wild Fish as Feed in Aquaculture*, FAO Technical Guidelines for Responsible Fisheries, Suppl. 5 (Rome, 2011).
[42] Matthias Halwart, "Biodiversity, nutrition and livelihoods in aquatic rice-based ecosystems", *Biodiversity*, vol. 9, Nos. 1–2 (2008).
[43] See https://doi.org/10.3389/fsufs.2024.1412919.

and compliance with international standards. This will in turn allow for the opening of new markets and may attract new buyers willing to pay higher prices.

Reduce loss and waste and improve utilization of by-products

65. Reducing loss and waste and 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. Enhancing the utilization of fish by-products offers a sustainable solution for reducing environmental impacts while creating new economic opportunities. By applying simple, low-cost technologies, such as drying, smoking, fermentation and milling, by-products can be transformed into affordable and highly nutritious products, often with greater nutritional value than the fillet itself.

66. In many rural areas, the absence of reliable electricity leads to high post-harvest loss of aquatic products. One solution involves solar-powered freezers for cold storage to extend the shelf life of products. Similarly, solar drying tents (with or without solar panels for electricity supply) with improved aeration and protective racks can improve the shelf life of products, increase productivity and address the drawbacks of traditional open-air drying, such as pest infestation and other food safety risks. Smoking technologies, such as the FAO-Thiaroye processing technique, may offer innovative ways to preserve fish and retain its nutrients.[44] However, in order for technologies to address food security, they should be designed with the consumer in mind, and their use should not inadvertently increase the price beyond that which low-income users can pay.[45]

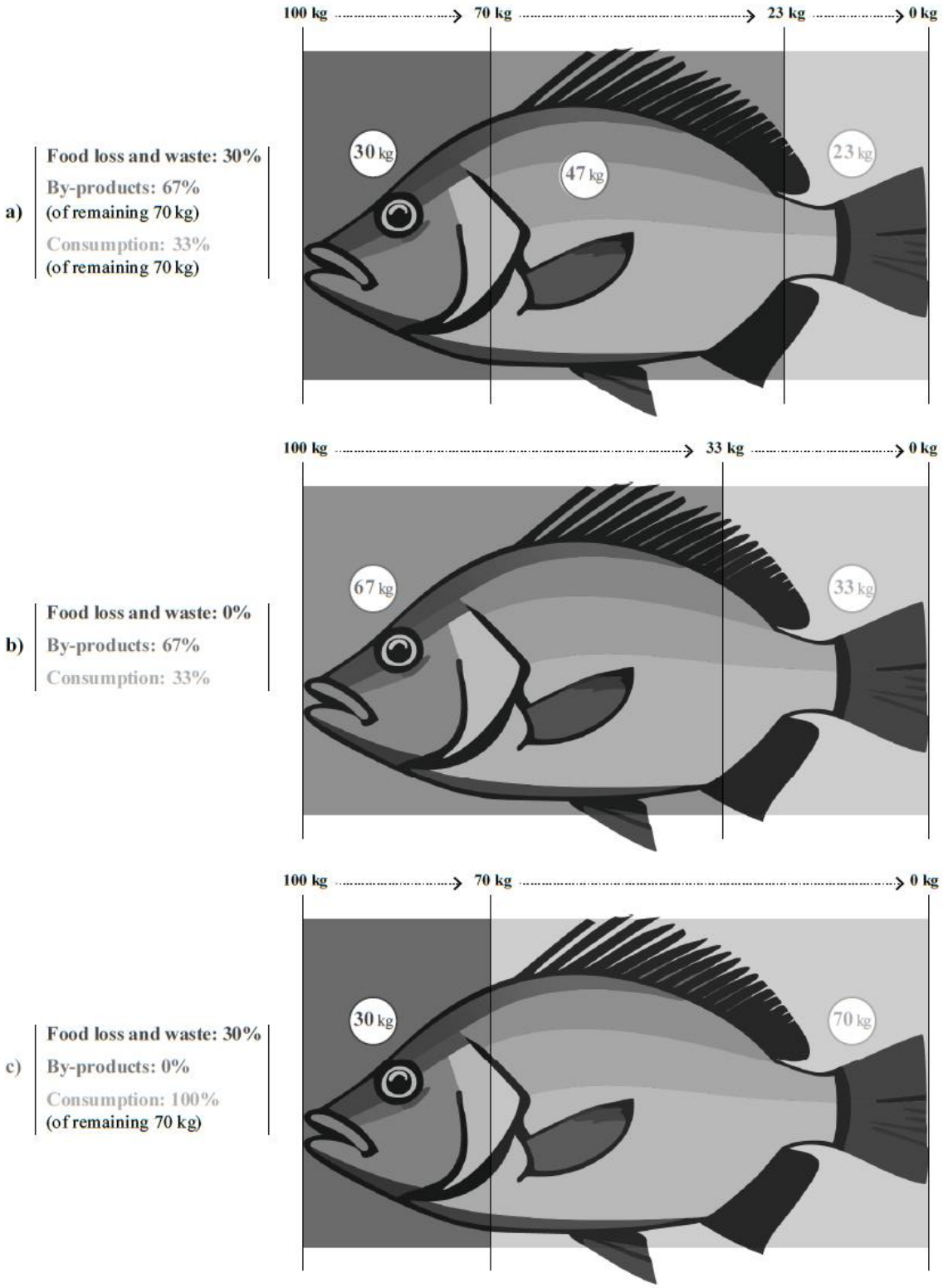
67. Potential in utilizing fish by-products for food purposes has until recently not been sufficiently considered as a solution to meet nutritional needs to improve food security. However, in terms of volumes, cost and nutritional value, the potential is big. In some cases, by-products represent 70 per cent of the fish and are considered the least economically valuable parts. In terms of nutrients, in particular micronutrients (minerals and vitamins), these parts are the most valuable ones. The potential in converting by-products into food could in many cases be greater than even eliminating food losses and waste (see figure VI).

68. Effective post-harvest fish loss reduction does not rely on a single factor or variable such as the introduction of a new technology. Rather, it often requires a combination of the right policy, legislation, capacity-building, services, infrastructure and effective technology, if solutions are to be long-lasting and adopted by beneficiaries. This multidimensional and multistakeholder approach is also promoted in the FAO Voluntary Code of Conduct for Food Loss and Waste Reduction, which provides solutions to food loss and waste reduction that can be adapted for aquatic food value chains.

69. In Colombia, Sri Lanka and the United Republic of Tanzania, FAO and its partners have promoted sustainable aquatic food systems through multidimensional solutions to reduce aquatic food loss and waste. These include adopting circular economy technologies, improving infrastructure, capacity-building and aligning with markets and policies. Addressing food loss and waste can provide economic benefits, have a positive impact on food and nutrition security, improve natural resource use efficiency, and reduce environmental impacts.

[44] See https://doi.org/10.4060/CA4667EN.
[45] See https://doi.org/10.4060/cc6229en.

Figure VI
Eliminating loss and waste for tilapia and utilizing its by-products for food purposes



Source: www.fao.org/4/mb060e/mb060e00.pdf.

Technological improvements in the value chain

70. The FAO Blue Transformation road map highlights the need to upgrade aquatic food value chains to fight hunger and malnutrition. This is a challenge in low-income countries, where value chains already experience many inefficiencies related to spoilage rates, storage needs, and aquatic food and by-product availability, all of which can also be exacerbated by weather and temperature changes caused by climate change. Upgrades in aquatic food value chains require significant investment in supply chains, storage, transportation and processing systems to improve the efficiency of distribution, ensuring that more aquatic products reach consumers in good condition.

71. Technological improvements in aquatic food value chains must consider the needs of the end market. For example, if low-income and nutritionally vulnerable populations demand low-cost fish, technological improvements should keep costs low to ensure sustainability and avoid driving up the cost of production for producers and, consequently, for consumers. Promoting expensive technologies without the end market in mind may inadvertently divert fish from low-income consumers to higher-income consumers or export markets, or lead to the disuse of such technologies.

72. In the absence of sophisticated equipment and cold rooms, aquatic by-products can be converted into feed, fertilizer or fish silage rich in hydrolyzed proteins and essential amino acids. A growing share of fishmeal and fish oil is being produced using fish by-products from capture and aquaculture processing, with a positive impact on waste reduction. These technologies are also used to process low-value fish and bycatch into value-added products, which may enhance human nutrition and health, mitigate environmental pollution and provide livelihoods and economic returns.

73. Technological improvements can decrease waste even for non-food uses, for example through the development of biodegradable packaging materials made from aquatic food waste. This is currently done with chitin, which is found in crustacean shells and squid feathers, and combined with lignin waste, and offers a solution to address issues of microplastic pollution in foods and packaging needs.[46] The FAO Voluntary Code of Conduct for the Reduction of Food Loss and Waste includes a food material hierarchy, which provides a ranking of recovery alternatives for dealing with food material deemed surplus, based on their impact or benefits from an environmental, social or economic perspective.[47]

Improve market access for small-scale fishers and fish farmers

74. Improving market access for small-scale fishers can enhance their incomes and resilience. Small-scale fishers and fish workers often face barriers accessing markets, such as financial constraints, capacity-building needs and regulatory hurdles. Developing direct marketing channels, such as community-supported fisheries and certification schemes, helps fishers to secure better prices and reduce their reliance on intermediaries.

75. For example, in Buenaventura, Colombia, the FAO SocPro4Fish project worked directly with *platoneras*, Afro-Colombian women vendors, who play a crucial role in providing essential nutrition for local families. These women are not only critical to the community's food security but also serve as role models for economic empowerment. Through capacity-building efforts, the project empowered *platoneras* to formalize their operations, thereby improving their access to public procurement

[46] Koro de la Caba and others, "From seafood waste to active seafood packaging: an emerging opportunity of the circular economy", *Journal of Cleaner Production*, vol. 208 (January 2019).

[47] See https://doi.org/10.4060/cb9433en.

processes and enhancing their economic stability. This initiative highlights the importance of supporting local entrepreneurs in achieving sustainable development.

76. In Senegal, the “Label Rouge” certification for artisanal fisheries has improved market access and prices for local fishers, significantly increasing their incomes.[48] This certification not only enhances the market value of fish products but also promotes sustainable fishing practices.

77. In Cambodia, the Cambodia Quality Seal, a voluntary food safety certification scheme, has helped small-scale fish processors, the majority of which are women-owned or women-led, to reach new markets, improve working conditions and significantly increase production volumes (by around 70 per cent). Strengthening value chains through investments in processing, storage and transportation infrastructure can increase the economic benefits of small-scale fisheries.

Monitoring systems to prevent food safety outbreaks

78. Although cost is always a consideration when establishing monitoring systems, an efficient approach is to use a tiered monitoring strategy. This involves deploying the most frequent, informative and expensive sampling effort during the most sensitive times, and gradually reducing monitoring efforts during low-risk periods. Tools and technologies (and corresponding data) of increasing specificity, resolution and expense can be used with increasing frequency at times where food hazards are expected to occur, such as in advance of the fishing or harvesting season or after an incident. The resulting data can help to find predictive relationships that could serve for the implementation of early warning systems for a variety of hazards.

Social safety nets

79. Social security systems, including health insurance and pensions, offer long-term benefits by providing financial security and access to essential services. These systems ensure that fishers, fish farmers, fish workers and their families can rely on support during times of need, fostering resilience in their communities. Investing in social protection not only safeguards the livelihoods of those in aquatic food systems but also contributes to the overall stability of coastal economies and the aquatic food supply. Integrating social protection into fisheries and aquaculture policies can mitigate socioeconomic barriers, promoting sustainable and equitable development. Many roles predominantly held by women in aquatic value chains are informal and invisible, and therefore not eligible for some social safety net programmes.

80. Improved access to unemployment insurance during closed seasons, health insurance, pensions and other social security measures not only enhances the well-being of fishers and fish workers but also supports sustainable fisheries management. Social assistance programmes, such as conditional cash transfers and food aid, provide immediate relief, helping fishers, fish farmers and fish workers cope with income fluctuations and unforeseen shocks.

81. In the Philippines, the Pantawid Pamilyang Pilipino Programme includes specific provisions for fishing communities, offering conditional cash transfers that help stabilize incomes during lean fishing periods.[49] In Mexico, a programme provides unemployment insurance during seasonal fishing bans,[50] and in Brazil, the Bolsa Verde provides financial support to fishers in protected areas. These financial supports are crucial for enhancing food security and improving socioeconomic

[48] See https://doi.org/10.1016/j.marpol.2016.05.009.
[49] See https://www.dof.gov.ph/world-bank-financing-for-4ps-to-accelerate-poverty-reduction/.
[50] See https://www.oecd.org/content/dam/oecd/es/publications/reports/2010/07/fisheries_g1ghc166/9789264219281-es.pdf.

conditions in coastal communities. By safeguarding the incomes of fishers, these initiatives in turn play a crucial role in preserving marine ecosystems. Ultimately, such programmes can lead to more resilient communities capable of thriving despite environmental challenges.

82. Subsistence fishing has also been found to provide a form of safety net, providing income to mitigate poverty, as well as nutrition through the provision of aquatic foods for consumption.[51] In addition, school meal programmes and other institutional procurement can offer a nutritional safety net for children and families who struggle with food insecurity. School meal programmes have traditionally been a tool of the education sector to promote enrolment and reduce absenteeism, but they are also a powerful tool to promote healthy diets from a young age and can support community development when foods are sourced locally. There are few examples of local procurement of aquatic foods for home-grown school feeding programmes,[52] which may improve the overall nutrient content of school meals for children and provide livelihood benefits to aquatic food producers.

V. Conclusions and recommendations

83. There are many opportunities to enhance the contribution of marine food systems to food security, nutrition and poverty eradication. The above sections have outlined these, including the opportunities to ensure sustainable supply by improving fisheries sustainability, fully developing sustainable aquaculture practices and enhancing aquatic food value chains. We must continue to apply monitoring systems to understand both the nutritional contribution of aquatic foods and prevent food safety outbreaks. Social safety nets for those working in aquatic food systems may also increase resilience and ensure food security and nutrition in coastal populations. Investments that support sustainable aquaculture practices and upgrade aquatic food value chains in developing economies can significantly improve local food security and livelihoods.

84. **Enhance data collection and analysis**. Strengthen national and regional capacities to collect, validate and analyse data on fisheries, aquaculture, food loss and waste, and aquatic food composition and consumption. Improve monitoring systems for aquatic foods, ensuring data are granular and accurate, and include key metrics such as species, losses throughout the supply chain and nutritional information.

85. **Support sustainable aquaculture and fisheries**. Promote the development of sustainable aquaculture through improved practices, technologies and adherence to FAO guidelines. Enhance governance frameworks, including management plans for fisheries, and encourage the implementation of sustainability criteria in trade systems. Support the development of community-based and co-management plans for better resource management.

86. **Ensure access to aquatic foods for nutrition**. Ensure the affordability and accessibility of nutritious aquatic foods, especially for vulnerable populations, through policies that address food prices, storage, transportation, distribution and food safety. Promote innovative practices such as seaweed farming and improved aquaculture biosecurity. Invest in programmes such as school meal initiatives and social protection for small-scale aquatic food producers.

87. **Promote gender equality and inclusivity**. Foster gender-transformative policies in fisheries and aquaculture, ensuring equitable opportunities and benefits for

[51] See https://doi.org/10.1038/s43016-023-00844-4.
[52] See https://doi.org/10.3390/foods10092080.

both genders. Encourage the inclusion of women in decision-making and leadership roles and integrate gender-sensitive perspectives into all aquatic food-related interventions.

88. **Improve market access and utilization**. Strengthen market access for small-scale fisheries and aquaculture by investing in infrastructure, low-cost certification schemes, and product innovation. Address food loss and waste by enhancing value chain practices such as processing and preservation, as well as by-product utilization, and implement climate resilience measures to adapt to environmental challenges.

VI. Guiding questions

Promoting aquatic foods for food security and nutrition

1. What are the key actions required to maximize the contribution of aquatic foods to eliminating hunger and malnutrition?

2. How can we ensure that consumers, especially the most vulnerable, have access to quality aquatic foods at affordable prices, while securing the livelihoods of fishers, fish farmers and fish workers?

Sustainable production

3. What best practices can be adopted to minimize environmental impacts from fisheries and aquaculture while ensuring that they can produce enough aquatic foods to satisfy increased demand?

4. How can we sustainably expand aquaculture to expand opportunities for increased incomes and support the consumption of aquatic foods?

Research and monitoring

5. How can data collection and research be used to understand the impact of small-scale actors on local food security, explore actual food consumption patterns and composition of aquatic foods, and determine loss and waste and by-product utilization throughout aquatic food value chains, especially in low- and middle-income countries?

Legal and policy frameworks and management plans

6. How can policy frameworks be strengthened or reinforced to ensure sustainable access to aquatic foods, especially for the most vulnerable?

7. What are the most effective community-based management models for ensuring sustainable resource use for food and nutrition security?

Livelihoods and poverty reduction

8. What role can social protection measures play in supporting small-scale actors and reducing poverty in fishing communities?

9. What strategies can be implemented to ensure a sustainable supply of aquatic foods and secure aquatic food livelihoods in the face of climate change?

Post-harvest issues, including food loss and waste and access to markets

10. How can innovation and technology be used to make aquatic food value chains more sustainable in social, economic and environmental terms?

11. How can Governments and businesses work together to minimize the risk of aquatic food-borne illnesses and other hazards for consumers?

12. How can market access be improved for small-scale fishers, in particular in remote or marginalized areas?

Consumer access and nutrition strategies

13. How can food safety and profitability for fisherfolk be enhanced, and environmental impact and fish loss and waste reduced, while ensuring affordability for low-income food- and nutritionally insecure consumers?

14. What are the barriers to implementing food safety monitoring and early warning systems and how can they be overcome? How can these systems build consumer trust and mitigate the impact of climate change and pollution on aquatic food safety?