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Shekk P.V., Burhaz M.I., Soborova O.M., Kudelina O. Yu

WORLD FISHERIES

Tutorial

Odessa State Environmental University
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В навчальному посібнику “Світове рибне господарство” висвітлені питання розподілу, розвитку та сучасного стану рибного господарства у Світовому океані.

Розкриті основні поняття сучасних теоретичних основ і практичних знань у розвитку світового рибного господарства. Викладаються аспекти основних етапів розвитку рибної галузі народного господарства і рибогосподарської науки в Світі.

Висвітлені питання біологічно-географічного районування Світового океану, сировинної бази рибальства, розподілу світового улову країнами і контингентами, дана характеристика основних промислових районів Світового океану.

Навчальний посібник для студентів I року навчання денної та заочної форми навчання за спеціальністю “Водні біоресурси та аквакультура”, рівня вищої освіти «магістр».

Shekk P.V., Burhaz M.I., Soborova O.M., Kudelina O.Yu
World Fisheries: tutorial. Odesa: Odessa State Environmental University, 2023. 141 p.

The tutorial "World Fisheries" clarifies the issues of distribution, development and the current state of fisheries in the World Ocean.

The main concepts of modern theoretical foundations and the practical knowledge in the development of world fisheries are revealed. The aspects of the main stages of developing the fishing industry and fisheries science in the world are expounded.

The issues of biological and geographical zoning of the World Ocean, the fishing raw material base, the distribution of the world catch by countries and contingents are highlighted, the characteristics of the main industrial areas of the World Ocean are given.

Tutorial for the students of the 1st year full-time and part-time studying in the specialty "Water bioresources and aquaculture" at the master's level of higher education.

UDC 369.2

Reviewers:
Shotova-Nikolenko A.V., associate professor, candidate of philology sciences, Odessa State Environmental University
Loboiko Y.V., Doctor of Science, associate professor, Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytsk

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CONTENT

FOREWORD

The world ocean is very often compared to the main repository of the wealth of our planet. It contains all known chemical elements, as well as colossal deposits of minerals. The ocean annually produces a huge amount of biological matter, which from a utilitarian point of view can be considered as a potential raw material base to meet the various needs of mankind.

Aquatic living resources play an extremely important role not only in the processes of the functioning of aquatic ecosystems, taking part in the formation of water quality, self-purification of water bodies and acting as a natural feed base for fish, but also in providing a significant share of human vital needs in nutrients contained in hydrobionts However, fish and fish products are of the greatest importance in human life. A significant part of these resources, which include organisms occupying lower trophic levels, constitutes the food base for those objects standing at the top of the trophic pyramid. Thus, by purpose, three groups of hydrobioresources can be distinguished - food, fodder and raw materials.

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

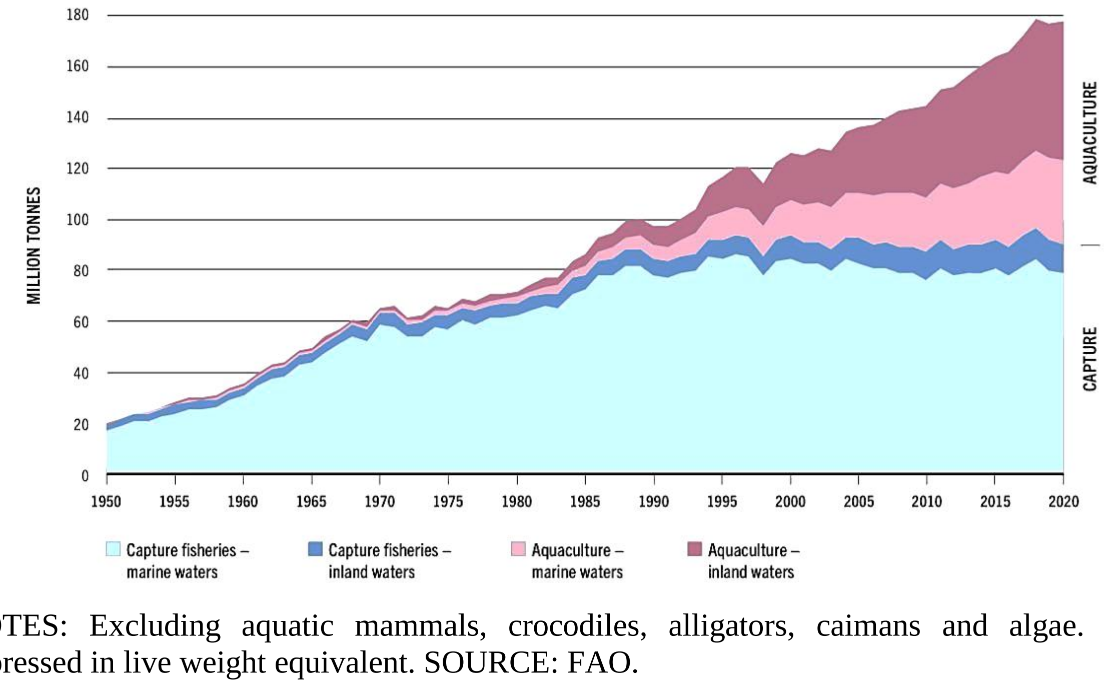
Tens of millions of tons of fish, molluscs and crustaceans are caught in the oceans every year. In some parts of the oceans, extraction using modern floating fish farms is very intensive. Some species of whales have been almost completely exterminated. Intensive fishing can harm such valuable commercial fish species as tuna, herring, cod, sea bass, sardine, hake.

In the preparation of this synopsis of lectures, reference literary sources, manuals and textbooks of domestic and foreign authors were used.

1 GLOBAL FISHERIES AND AQUACULTURE AT A GLANCE

The fisheries and aquaculture sectors have been increasingly recognized for their essential contribution to global food security and nutrition in the twenty-first century. Further expansion of this contribution requires the acceleration of transformative changes in policy, management, innovation and investment to achieve sustainable and equitable global fisheries and aquaculture.

*The State of World Fisheries and Aquaculture 202*1 presents updated and verified statistics of the sector and analyses its international policy context and selected high-impact initiatives and actions undertaken to accelerate international efforts to support achievement of the Sustainable Development Goals. It looks at the impact and implications of the COVID-19 pandemic on fisheries and aquaculture production,3 utilization and trade. Global production of aquatic animals was estimated at 178 million tonnes in 2020, a slight decrease from the all-time record of 179 million tonnes in 2018 (Table 1.1 and Figure 1.1).



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

Figure 1.1 – World capture fisheries and aquaculture production

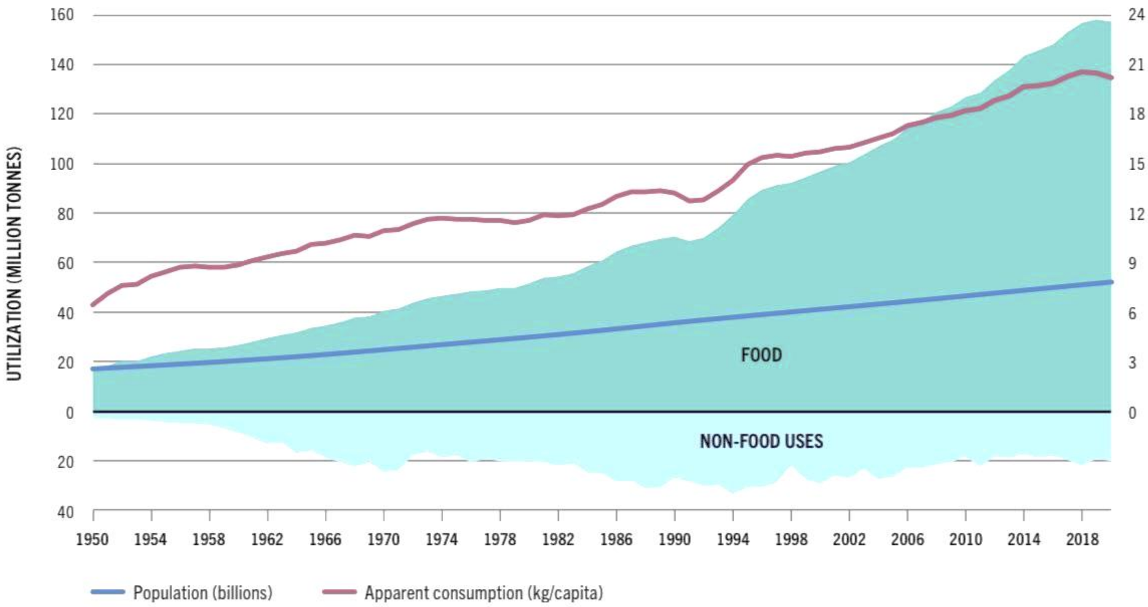
Capture fisheries contributed 90 million tonnes 51 percent) and aquaculture 88 million tonnes (49 percent).

Table 1.1 – World fisheries and aquaculture production, utilization and trade

	1990s	**2000s**	**2010s**	**2018**	**2019**	**2020**
Production						
Capture:						
Inland	7.1	9.3	11.3	12.0	12.1	11.5
Marine	81.9	81.6	79.8	84.5	80.1	78.8
Total capture	88.9	90.9	91.0	96.5	92.2	90.3
Aquaculture:						
Inland	12.6	25.6	44.7	51.6	53.3	54.4
Marine	9.2	17.9	26.8	30.9	31.9	33.1
Total aquaculture	21.8	43.4	71.5	82.5	85.2	87.5
Total world fisheries and aquaculture	110.7	134.3	162.6	178.9	177.4	177.8
Utilization						
Human consumption	81.6	109.3	143.2	156.8	158.1	157.4
Non-food uses	29.1	25.0	19.3	22.2	19.3	20.4
Population (billions)	5.7	6.5	7.3	7.6	7.7	7.8
Per capita apparent consumption (kg)	14.3	16.8	19.5	20.5	20.5	20.2
Trade						
Exports – in quantity	39.6	51.6	61.4	66.8	66.6	59.8
Share of exports in total production	*35.8%*	*38.5%*	*37.7%*	*37.3%*	*37.5%*	*33.7%*
Exports – in value (USD 1 billion)	46.6	76.4	141.8	165.3	131.8	150.5

Of the total production, 63 percent (112 million tonnes) was harvested in marine waters (70 percent from capture fisheries and 30 percent from aquaculture) and 37 percent (66 million tonnes) in inland waters (83 percent from aquaculture and 17 percent from capture fisheries). The total first sale value of the global production was estimated at USD 406 billion, comprising USD 141 billion for capture fisheries and USD 265 billion for aquaculture.

Of the overall production of aquatic animals, over 157 million tonnes (89 percent) were used for human consumption. The remaining 20 million tonnes were destined for non-food uses, to produce mainly fishmeal and fish oil (16 million tonnes or 81 percent) (Figure 1.2).



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

Figure 1.2 – World fisheries and aquaculture production: Utilization and apparent consumption

Global apparent consumption of aquatic foods increased at an average annual rate of 3.0 percent from 1961 to 2019, a rate almost twice that of annual world population growth (1.6 percent) for the same period. Per capita consumption of aquatic animal foods grew by about 1.4 percent per year, from 9.0 kg (live weight equivalent) in 1961 to 20.5 kg in 2019.

Preliminary data for 2020 point to a slight decline to 20.2 kg. In the same year, aquaculture accounted for 56 percent of the amount of aquatic animal food production available for human consumption.

During recent decades, per capita consumption of aquatic foods has been influenced most strongly by increased supplies, changing consumer preferences, advancements in technology and income growth.

Aquatic foods remain some of the most traded food commodities in the world, with 225 states and territories reporting some trading activity of fisheries and aquaculture products4 in 2020.

World exports of aquatic products4 in 2020, excluding algae, totaled about 60 million tonnes live weight, worth USD 151 billion. This represents a major decline (8.4 percent in value and 10.5 percent in volume) from the record high of 67 million tonnes, worth USD 165 billion, reached in 2018.

Overall, from 1976 to 2020, the value of global exports of fisheries and aquaculture products (excluding algae) increased at an average annual growth rate of 6.9 percent in nominal terms and 3.9 percent in real terms (adjusted for inflation), corresponding to an annual growth rate of 2.9 percent in terms of quantity over the same period.

Questions for self-testing

1. Describe world fisheries and aquaculture production.
2. World fisheries and aquaculture production, utilization and trade.

2 TOTAL FISHERIES AND AQUACULTURE PRODUCTION

Total fisheries and aquaculture production (excluding algae) has significantly expanded in the past seven decades going from 19 million tonnes (live weight equivalent) in 1950 to an all-time record of about 179 million tonnes in 2018, with an annual growth rate of 3.3 percent.

Production then declined marginally in 2019 (a fall of 1 percent compared with 2018), before increasing by a mere 0.2 percent to reach 178 million tonnes in 2020. The total first sale value of fisheries and aquaculture production of aquatic animals in 2020 was estimated at USD 406 billion, of which USD 265 billion came from aquaculture production.

The stagnation experienced in the last two years is mainly linked to a slight decline in capture fisheries, which decreased by 4.5 percent in 2019 compared with the 2018 peak of 96 million tonnes, and then by a further 2.1 percent in 2020. This decline was due to various factors, including fluctuating catches of pelagic species, particularly anchoveta, the recent reduction in China’s catches and the impacts of COVID-19 on the sector in 2020.

Furthermore, aquaculture production (the main driver of the growth of total production since the late 1980s) continued to expand, albeit at a slower rate in the last two years (3.3 percent in 2018–2019 and 2.6 percent in 2019–2020 versus an average of 4.6 percent per year during the period 2010–2018) (see the section Aquaculture production).

These lower growth rates are due to a range of factors, including the impact of policy changes in China focused on environmental protection and various issues linked to COVID-19 in 2020 that not only impacted production for export markets, but also reduced availability of workers, supplies and inputs (including feed, fingerlings and ice), while disruption to transportation and marketing, plus sanitary measures, also left their mark. As aquaculture has grown faster than capture fisheries during the last two years, its share of total fisheries and aquaculture production has further increased.

Of the 178 million tonnes produced in 2020, 51 percent (90 million tonnes) was from capture fisheries and 49 percent (88 million tonnes) from aquaculture.

This represents a major change from the 4 percent share of aquaculture in the 1950s, 5 percent in the 1970s, 20 percent in the 1990s and 44 percent in the 2010s.

Of the total production, 63 percent (112 million tonnes) was harvested in marine waters (70 percent from capture fisheries and 30 percent from aquaculture) and 37 percent (66 million tonnes) in inland waters (83 percent from aquaculture and 17 percent from capture fisheries) (Figure 2.1).

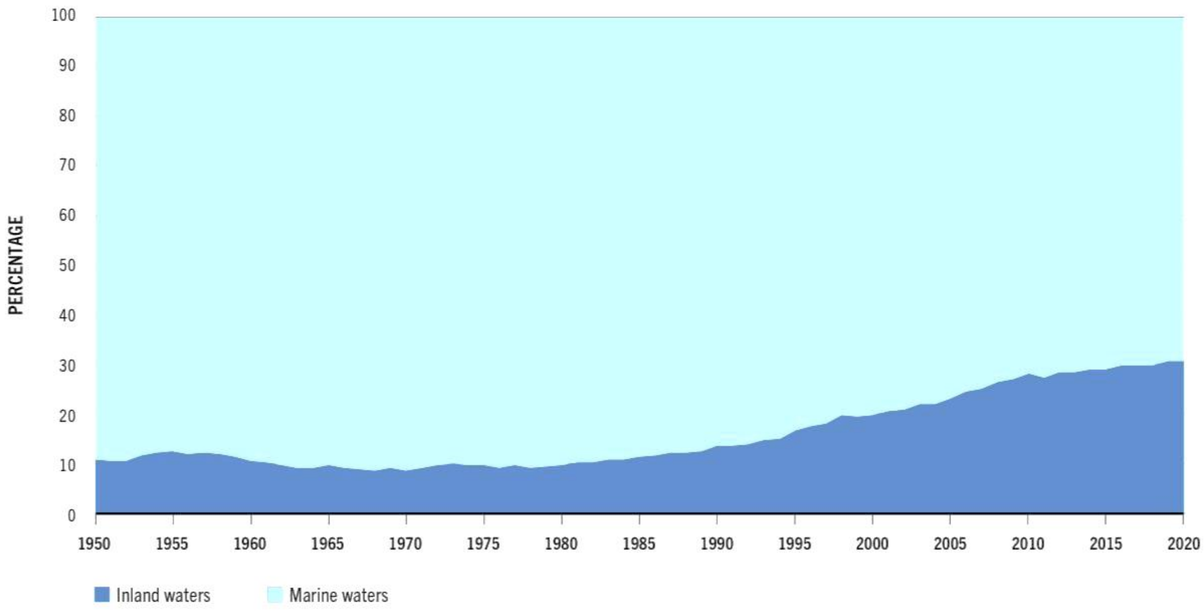
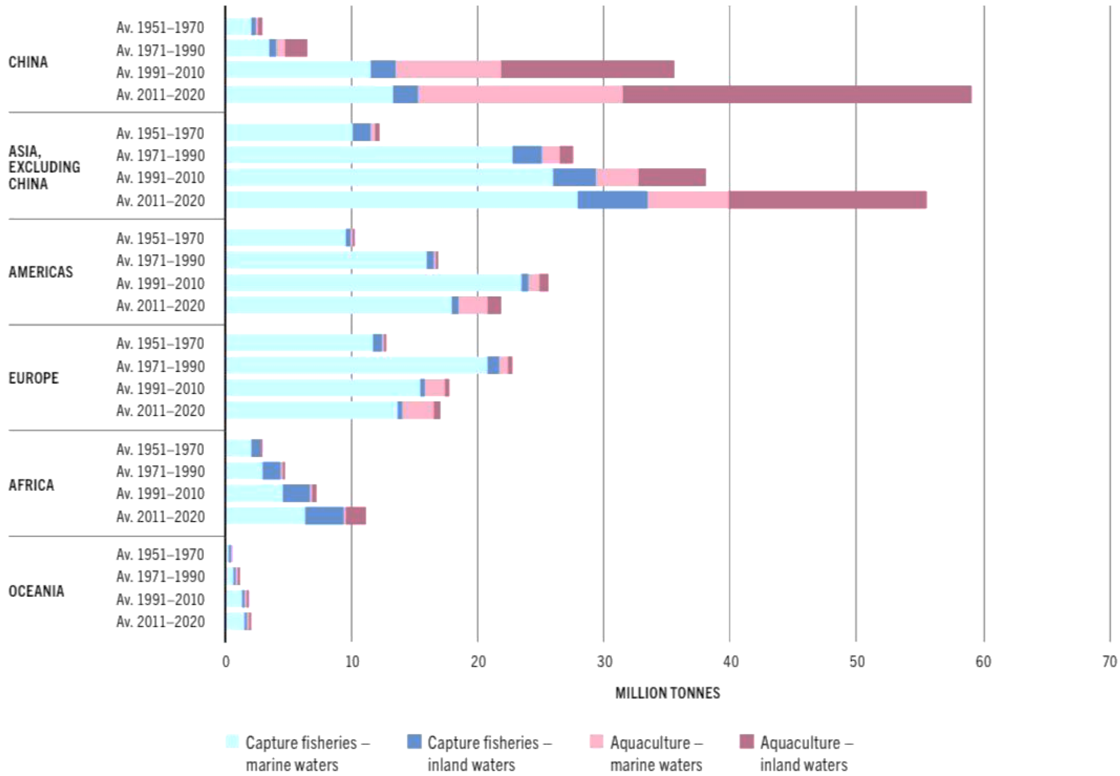


Figure 2.1 – Share of world total fisheries and aquaculture production by inland and marine waters

The expansion of aquaculture in the last few decades has boosted the overall growth of production in inland waters. In 1950, production in inland waters represented only 12 percent of the total fisheries and aquaculture production and, with some fluctuations, this share remained relatively stable until the late 1980s. Then, with the growth of aquaculture production, it gradually increased to 18 percent in the 1990s, 28 percent in the 2000s and 34 percent in the 2010s. Despite this growth, capture fisheries in marine waters still represent the main source of production (44 percent of total aquatic animal production in 2020, compared with about 87 percent in the 1950–1980 period) and the dominant method of production for several species. Following several decades of sustained growth, marine capture fisheries have remained fairly stable since the late 1980s at around 80 million tonnes, with some interannual fluctuations (up and down) in the range of 3–4 million tonnes.

This general trend masks considerable variations between continents, regions and countries. In 2020, Asian countries were the main producers, accounting for 70 percent of the total fisheries and aquaculture production of aquatic animals, followed by countries in the Americas (12 percent), Europe (10 percent), Africa (7 percent) and Oceania (1 percent). Overall, total fisheries and aquaculture production has seen important increases in all the continents in the last few decades (Figure 2.2).



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

Figure 2.2 – Regional contribution to world capture fisheries and aquaculture production

The exceptions are Europe (with a gradual decrease from the late 1980s, but recovering slightly in the last few years to 2018, to then decline again) and the Americas (with several ups and downs since the peak of the mid-1990s, mainly due to fluctuations in catches of anchoveta), whereas it has almost doubled during the last 20 years in Africa and Asia. Yet, compared with 2019, total production of aquatic animals in 2020 declined by 3 percent for African countries and 5 percent for countries in Oceania, most probably as a result of COVID-19.

In 2020, China continued to be the major producer with a share of 35 percent of the total, followed by India (8 percent), Indonesia (7 percent), Viet Nam (5 percent) and Peru (3 percent). These five countries were responsible for about 58 percent of the world fisheries and aquaculture production of aquatic animals in 2020.

Differences exist also in terms of the sector's contribution to economic development. In recent decades, a growing share of total fisheries and aquaculture production has been harvested by low- and middle-income countries (from about 33 percent in the 1950s to 87 percent in 2020).

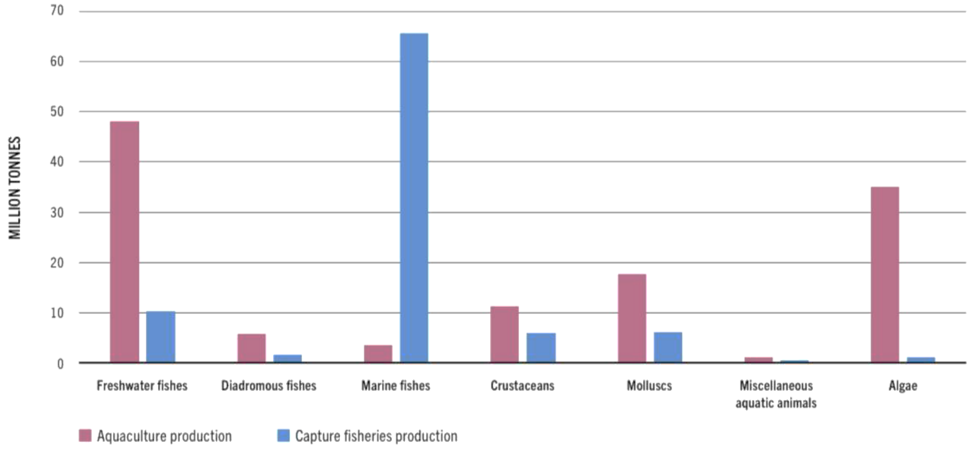
In 2020, upper-middle-income countries, including China, were the main producers, responsible for 49 percent of the total production of aquatic animals, followed by lower-middle-income countries (32 percent), high-income countries (17 percent) and, finally, low-income countries (2 percent). Major differences can be noticed when analyzing the data by FAO Major Fishing Area.

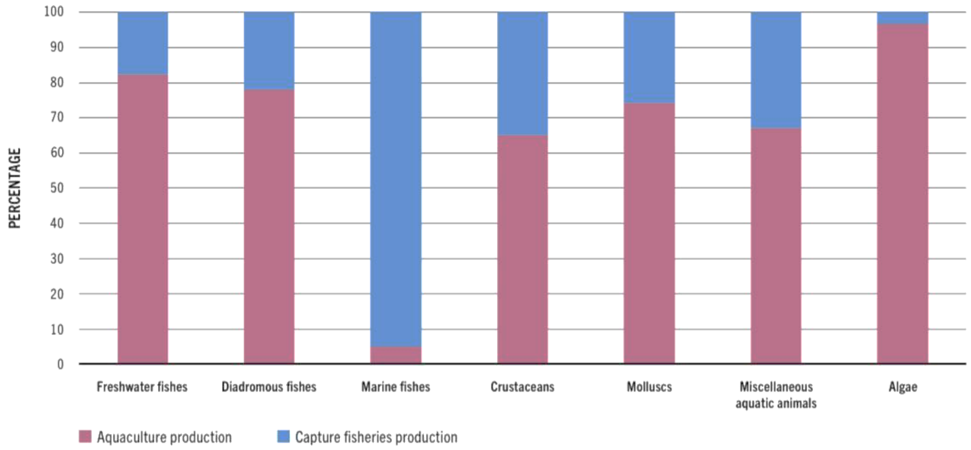
In 2020, about 33 percent of the total production of aquatic animals was produced in inland waters in Asia, followed by 22 percent in the Pacific Northwest and 10 percent in the Western Central Pacific. Production differs from area to area depending on several factors, including the level of development of the countries surrounding those areas, the fisheries and aquaculture management measures implemented, the amount of illegal, unreported and unregulated (IUU) fishing, the status of fishery stocks, the availability and quality of the inland waters, and the composition of the species harvested.

For example, for some fishing areas, capture fisheries can fluctuate more when catches comprise a high proportion of small pelagic fish, which are more prone to large fluctuations – linked, in some areas, to climatic variability, as is the case for catches of anchoveta in the Pacific Southeast in South America. A large number of species are harvested every year, with the number and species varying from region to region.

In 2020, finfish represented 76 percent of the total production of aquatic animals, with marine fishes representing 51 percent of the total finfish and 39 percent of the total aquatic animal production, followed by freshwater fishes, representing 43 percent of the total finfish and 33 percent of the total aquatic animal production5 (Figure 2.3).

Carps, barbels and other cyprinids represented the main group of species produced in 2020, with a share of 18 percent of the production of aquatic animals, followed by miscellaneous freshwater species and *Clupeiforms* such as herrings, sardines and anchovies. At the level of species, with 5.8 million tonnes, white leg shrimp (*Penaeus vannamei*) was the top species produced in 2020, closely followed by grass carp (white amur; *Ctenopharyngodon idellus*), cupped oysters (*Crassostrea* spp.), silver carp (*Hypophthalmichthys molitrix*) and anchoveta (Peruvian anchovy; *Engraulis ringens*). In addition to the 178 million tonnes of aquatic animals, 36 million tonnes (wet weight) of algae were produced in 2020, of which 97 percent originated from aquaculture. Production of algae has experienced an impressive growth in the past few decades as it was at 12 million tonnes in 2000 and 21 million tonnes in 2010.





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

Figure 2.3 – World capture fisheries and aquaculture production by isscaap divisions, in absolute values and percentage, 2020

However, it increased by only 2 percent in 2020 compared with 2019. Asian countries confirmed their role as major producers with a share of 97 percent of the total production of algae.

China alone as leading producer accounted for 58 percent of the overall total in 2020, followed by Indonesia (27 percent) and the Republic of Korea (5 percent). If production of algae is added to that of aquatic animals, fisheries and aquaculture production reached an all-time record of 214 million tonnes in 2020, with an overall growth of only 0.4 percent compared with 2019 and of 0.3 percent compared with the previous record of 2018.

Of this overall total, Asian countries produced 75 percent in 2020, followed by countries in the Americas (10 percent), Europe (8 percent), Africa (6 percent) and Oceania (1 percent). In the total fisheries and aquaculture production of aquatic animals and algae, aquaculture had already overtaken capture fisheries as the primary source of aquatic production in 2013, and its share in total production reached 57 percent in 2020.

2.1 Impacts of covid-19 on global fisheries and aquaculture production and related statistics

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

Many fishing fleets or aquaculture operations stopped running or reduced their activities, as their work became unprofitable, in particular during the 2020 pandemic waves. In some cases, fisheries quotas were not filled due to low demand, market closures and/or lack of cold storage capacity. Movement restrictions impacted professional seafarers, including at-sea fisheries observers and marine personnel in ports, thereby preventing crew changes and repatriation of seafarers. In aquaculture, unsold produce resulted in higher costs for feeding and increased mortality rate among aquatic animals.

Fisheries and aquaculture production relying on export markets was more impacted than that serving domestic markets due to market closures, increased freight costs, flight cancellations and border restrictions. Globally, the impact varied with many countries reporting sharp drops in capture and aquaculture production during the first weeks and months of the crisis followed by improvements as the sector adapted. For example, at the height of the COVID-19 crisis in the United States of America, it is estimated that catches dropped by up to 40 percent across the country. Similarly, reductions in fishing effort were noted in Africa, Asia, Europe and Oceania, particularly in the case of fleets relying extensively on export markets of higher-value species such as lobster or tunas.

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

In some cases, alternative data collection approaches and methods were implemented, while in other countries data were not collected for several months or only partially collected.

For some countries, there is a risk that the different approaches adopted or the partial coverage may have affected the quality and comparability of their data for 2020. In terms of the data reported to FAO, COVID-19 exacerbated ongoing issues of late or non-reporting of fisheries and aquaculture statistics in 2020 and 2021.

In addition, data reported by a few countries included anomalous trends that necessitated direct follow-up with the countries concerned, as well as cross-checking with other sources to ensure the quality and consistency of the data disseminated by FAO.

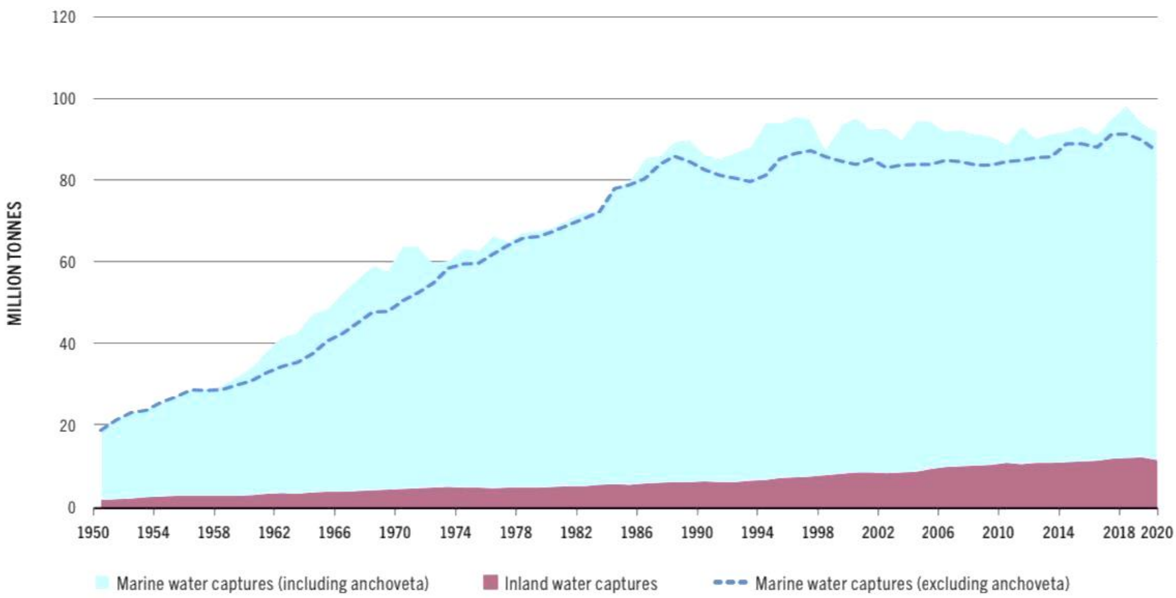
Questions for self-testing

1. What is the share of total world fisheries and aquaculture production in inland and marine waters?
2. What is the impact of COVID-19 on global fisheries and aquaculture production?

3 CAPTURE FISHERIES PRODUCTION

In 2020, global capture fisheries production (excluding algae6) was 90.3 million tonnes – a fall of 4.0 percent compared with the average of the previous three years. The decrease concerned both marine capture fisheries and inland waters (3.9 percent and 4.3 percent, respectively) and is most likely due to both the disruption in fishing operations because of the COVID-19 pandemic and the ongoing reduction in China's catches (10 percent lower in 2020 compared with the average of the previous three years).

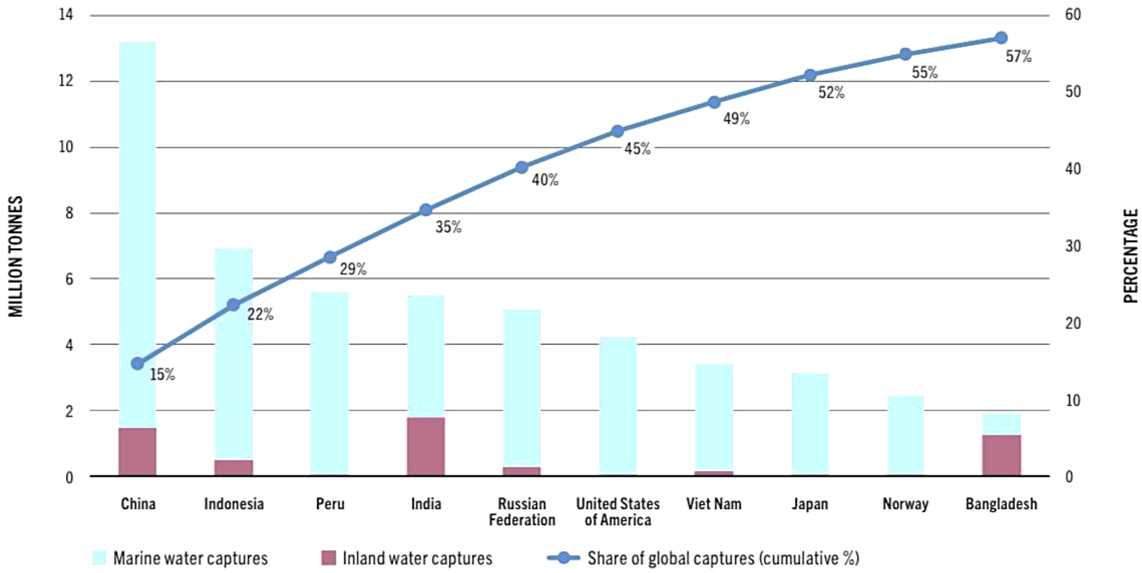
The 2017–2019 average was high because of the peak experienced in 2018 (96.5 million tonnes) due to relatively high catches of anchoveta (*Engraulis ringens*). However, the long-term trend in global capture fisheries continues to be relatively stable. Catches have generally fluctuated between 86 million tonnes and 93 million tonnes per year since the late 1980s (Figure 3.1).



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

Figure 3.1 – Trends in global captures

China remains the top capture producer despite the downward revision of its catches for the period 2009–20167 and a decline of around 19.3 percent between 2015 and 2020. China accounted for almost 15 percent of global captures in 2020, more than the total captures of the second- and third-ranked countries combined. The top seven capture producers (China, Indonesia, Peru, India, Russian Federation, United States of America and Viet Nam) accounted for almost 49 percent of total global capture production (Figure 3.2), while the top 20 producers accounted for over 73 percent.



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

Figure 3.2 – Top ten global capture producers, 2020

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

3.1 Marine capture production

In 2020, global marine captures were 78.8 million tonnes, a decline of 6.8 percent from the peak of 84.5 million tonnes in 2018, when relatively high catches of anchoveta were reported by Peru and Chile (Table 3.1). Marine captures were severely affected by the disruption to fishing operations caused by the COVID-19 pandemic during 2020. However, assessing the impact of the crisis on marine water catches is difficult and needs to be considered in the context of longer-term trends in the sector, including the ongoing reduction in catches reported by China in recent years.

Table 3.1 – Marine capture production: major producing countries and territories

Country of territory	Production				
	2017	2018	2019	2020	Percentage of total, 2020
China	13.19	12.68	12.15	11.77	15
Indonesia	6.56	6.71	6.56	6.43	8
Peru (total)	4.13	7.15	4.80	5.61	7
United States of America	5.01	4.77	4.81	4.23	5
India	3.94	3.62	3.67	3.71	5
Viet Nam	3.15	3.19	3.29	3.27	4
Japan	3.19	3.26	3.16	3.13	4
Norway	2.39	2.49	2.31	2.45	3
Chile (total)	1.92	2.12	1.98	1.77	2
Philippines	1.72	1.65	1.67	1.76	2
Thailand	1.30	1.39	1.41	1.52	2
Malaysia	1.47	1.45	1.46	1.38	2
Republic of Korea	1.35	1.39	1.41	1.36	2
Morocco	1.36	1.36	1.44	1.36	2
Mexico	1.46	1.47	1.42	1.35	2
Iceland	1.18	1.26	1.04	1.02	1
Argentina	0.81	0.82	0.80	0.82	1
Spain	0.94	0.93	0.88	0.80	1
Canada	0.81	0.81	0.75	0.71	1
Total all other producers	17.16	17.27	16.69	15.62	20
World total	81.48	84.51	80.09	78.79	100

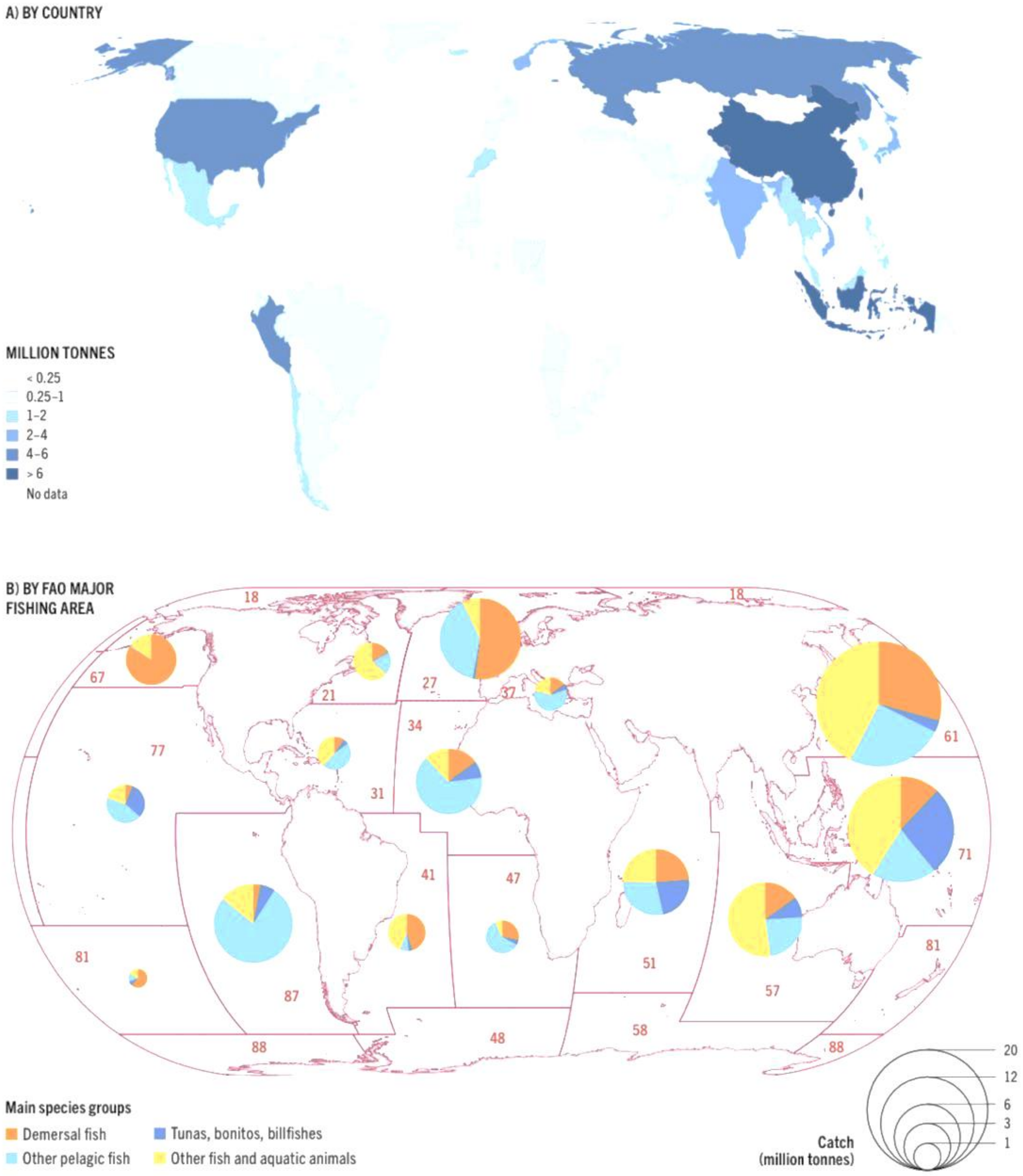
The abundance of species such as anchoveta, Pacific sardine (*Sardinops sagax*) and Pacific jack mackerel (*Trachurus symmetricus*), which are substantial but highly variable due to El Nico events and variations in oceanographic conditions, is also a major influence on interannual changes in global marine captures. Compared with 2019 (i.e. prior to the COVID-19 pandemic), global marine captures decreased by 1.6 percent in 2020, well within the limits of interannual fluctuations in previous years. Of the top ten producers for global capture production, most reported catches in 2020 were either at the same level as or higher than the catches for 2019 (e.g. Peru, India, Russian Federation and Norway). Catches of major species have undergone marked variations over the years, as well as fluctuations in the catches among the top producing countries. A case in point is Indonesia, which reported an increase in marine catches from under 4 million tonnes in the early 2000s to over 6.7 million tonnes in 2018; these increases are in part explained by changes to the country's data collection, processing and open data access with the implementation.

Despite the initiatives to improve Indonesia's data collection, there are still major fluctuations in its marine catches, in addition to issues of late or non-reporting of data to FAO. Global production of marine capture fisheries continues to be highly concentrated among a small number of producers (Figure 9a). In 2020, similar to previous years, the top seven producers accounted for over 50 percent of total marine captures, and China alone accounted for 14.9 percent of the world total, followed by Indonesia (8.2 percent), Peru (7.1 percent), the Russian Federation (6.1 percent), the United States of America (5.4 percent), India (4.7 percent) and Viet Nam (4.2 percent).

While China remains the world's top producer of marine captures, its catches declined from 14.4 million tonnes in 2015 to 11.8 million tonnes in 2020, representing a decrease of 18.2 percent from 2015 and 7.2 percent from 2018 (an average annual decrease of 3.9 percent). A continuation of a catch reduction policy beyond the Thirteenth and Fourteenth Five-Year Plans (2016–2020 and 2021–2025) is expected to result in further decreases in coming years.

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

The FAO global marine capture database includes catches for more than 2 600 species (including "not elsewhere included" categories); finfish represent about 85 percent of total marine capture production, with small pelagics as the main group, followed by gadiformes and tuna and tuna-like species. An overview of marine catch data by main species group and by FAO Major Fishing Area is shown in Figure 3.3.



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

Figure 3.3 – Marine capture production, average 2018–2020

Of the 11.8 million tonnes reported by China in 2020, a total of 2.3 million tonnes came under “distant-water fishery”, with details on species and fishing area only provided for distant-water catches marketed in area 61, the Northwest Pacific.

A portion of the remainder of China’s distant-water fishery catches was attributed to other fishing areas through data available from the regional fisheries management organizations (RFMOs) and the remaining 1.8 million tonnes were entered in the FAO database under “marine fishes not elsewhere included” in area 61, possibly overstating the catches occurring in this area and the overall amount of unspecified marine fish caught by China.

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

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

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

jumbo flying squid (*Dosidicus gigas*), Argentine shortfin squid (*Illex argentinus*) and Japanese flying squid (*Todarodes pacificus*).

- ✓ Shrimp and prawn catches recorded a new high in 2017 of almost 3.4 million tonnes, mostly due to the continued recovery in catches of Argentine red shrimp (*Pleoticus muelleri*), which offset declines in the other main shrimp species, notably akiami paste shrimp (*Acetes japonicus*) and southern rough shrimp (*Trachysalambria curvirostris*). In 2020, catches were 3.2 million tonnes, continuing the trend of recent years with catches fluctuating between 3.1 million tonnes and 3.4 million tonnes per year.
- ✓ Lobster catches decreased to 255 000 tonnes in 2020 – the lowest level since 2009 – as lobster was one of the high-value species most impacted by COVID-19 restrictions and the closure of global export markets. As restrictions are eased, catches are expected to recover to the levels above 300 000 tonnes seen in recent years, particularly of American lobster (*Homarus americanus*), which accounts for over half of catches in this group.

In 2020, catches in temperate areas were 35.2 million tonnes, marginally lower than in previous years. Otherwise, catches have generally remained stable at between 36.2 million tonnes and 39.6 million tonnes per year since the early 2000s, following the two highest peaks in catches (about 45 million tonnes) in 1988 and 1997. Area 61, the Northwest Pacific, recorded the highest production at 19.2 million tonnes, or 24 percent of global marine landings, in 2020. As stated above, catches for this area include a proportion of China’s distant-water fishing fleet catches (recorded as “marine fishes not elsewhere included”), which are caught in other fishing areas but are assigned to area 61 in the absence of detailed information on where they were effectively caught.

Catches in other temperate areas have been mostly stable in the last ten years, with the exception of recent decreases in areas 41 and 81, the Southwest Atlantic and the Southwest Pacific, partly the result of greatly reduced catches by distant water fishing nations targeting cephalopods in the Southwest Atlantic and various species in the Southwest Pacific.

In tropical areas, catches in the Indian Ocean (areas 51 and 57) and the Western Central Pacific (area 71) reached their highest levels recorded at, respectively, 12.5 million tonnes (2017) and 13.3 million tonnes (2018). Catches have since decreased but remain only marginally below the peak catches of recent years.

In the Indian Ocean, catches have increased steadily since the 1980s, particularly in area 57, the Eastern Indian Ocean, with catches of small pelagics, large pelagics (tunas and billfish) and shrimps driving most of the increase. Area 71, the Western Central Pacific, reported the second largest landings by area in 2020 with 13.3 million tonnes.

Catches have also increased steadily since the 1950s, with tuna and tuna-like species accounting for most of the increase. Skipjack tuna in particular has increased from 1.0 million tonnes to almost 1.9 million tonnes in the last 20 years, while catches for the other main species groups have mostly remained stable.

In area 31, the Western Central Atlantic, catches have declined from the peak catches of 2.5 million tonnes in the mid1980s, but have been relatively stable since the mid-2000s, fluctuating between 1.2 million tonnes and 1.6 million tonnes per year. Trends in total production are largely dependent on catches by the United States of America of Gulf menhaden (*Brevoortia patronus*), a clupeoid species that is processed into fishmeal and fish oil and accounts for over 30 percent of the total catches.

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

The long-term trend in area 87 has been one of declining catches since the mid-1990s, even taking into account the fluctuation in catches of anchoveta. Annual catches have decreased from over 20 million tonnes in 1994 to between about 7 million tonnes and 10 million tonnes in recent years – driven by decreasing catches of two of the main species: anchoveta and Chilean jack mackerel (*Trachurus murphyi*).

However, high-value catches of jumbo flying squid have grown significantly since the early 2000s, partially offsetting the decline in catches of other species. Catches of jumbo flying squid grew from about 128 000 tonnes in 2000 to peak at 1 million tonnes in 2015, before fluctuating in subsequent years and reaching 880 000 tonnes in 2020.

In area 34, the Eastern Central Atlantic Ocean, catches have increased almost continuously, reaching 5.5 million tonnes in 2018, the highest catches recorded, before declining to 4.9 million tonnes in 2020.

In area 47, the Southeast Atlantic, the opposite trend is recorded, with catches progressively decreasing from the peak of 3.3 million tonnes in 1978 to 1.4 million tonnes in 2020. In area 77, the Eastern Central Pacific, catches have generally remained static, ranging from 1.6 million tonnes to 2 million tonnes per year. While total catches in Antarctic fishing areas (areas 48, 58 and 88) are relatively minor, catches have increased sharply in recent years, from 270 000 tonnes in 2017 to 462 000 tonnes in 2020, the highest catches since the early 1990s. Catches in the region are almost entirely driven by Antarctic krill (*Euphausia superba*), which increased from less than 100 000 tonnes in the late 1990s to 455 000 tonnes in 2020, following a decline in the early 1990s. Catches of the second-most important species, Patagonian tooth fish (*Dissostichus eleginoides*), continue to be relatively stable at between 10 500 tonnes and 12 200 tonnes per year.

3.2 Inland waters capture production

In 2020, total global catches in inland waters were 11.5 million tonnes (Table 3.2), a decrease of 5.1 percent from 2019. As with marine capture production, fishing operations in inland waters were severely impacted by the COVID-19 pandemic during 2020, and this was compounded by the decline in China’s catches. Despite the decrease in 2020, inland water catches remain at historically high levels and only marginally below the highest levels of 12.0 million tonnes recorded in 2019.

The long-term rising trend in inland fisheries production can partially be attributed to improved reporting and assessment at the country level. Nevertheless, many of the data collection systems for inland waters are still unreliable, or in some cases non-existent; furthermore, improvements in reporting may also mask trends in individual countries.

Equally important, many countries do not report catches for inland fisheries, or they report only partial catches, while FAO estimates a proportionately higher amount of the total catches for inland waters compared with marine waters.

Table 3.2 – Inland waters capture production: major producing countries and territories

Country	Production				
	2017	2018	2019	2020	Percentage of total, 2020
India	1.59	1.70	1.79	1.80	16
China	2.18	1.96	1.84	1.46	13
Bangladesh	1.16	1.22	1.24	1.25	11
Myanmar	0.89	0.89	0.89	0.84	7
Uganda	0.39	0.44	0.60	0.57	5
Indonesia	0.47	0.66	0.71	0.49	4
Cambodia	0.47	0.42	0.40	0.41	4
United Republic of Tanzania	0.33	0.31	0.38	0.41	4
Nigeria	0.42	0.39	0.37	0.35	3
Egypt	0.26	0.27	0.30	0.32	3
Brazil	0.27	0.27	0.25	0.28	2
Democratic Republic of the Congo	0.23	0.23	0.23	0.21	2
Malawi	0.20	0.22	0.15	0.17	1
Mexico	0.17	0.22	016	0.15	1
Mexico	0.17	0.22	0.16	0.15	1
All producers	11.88	11.99	12.09	11.47	100

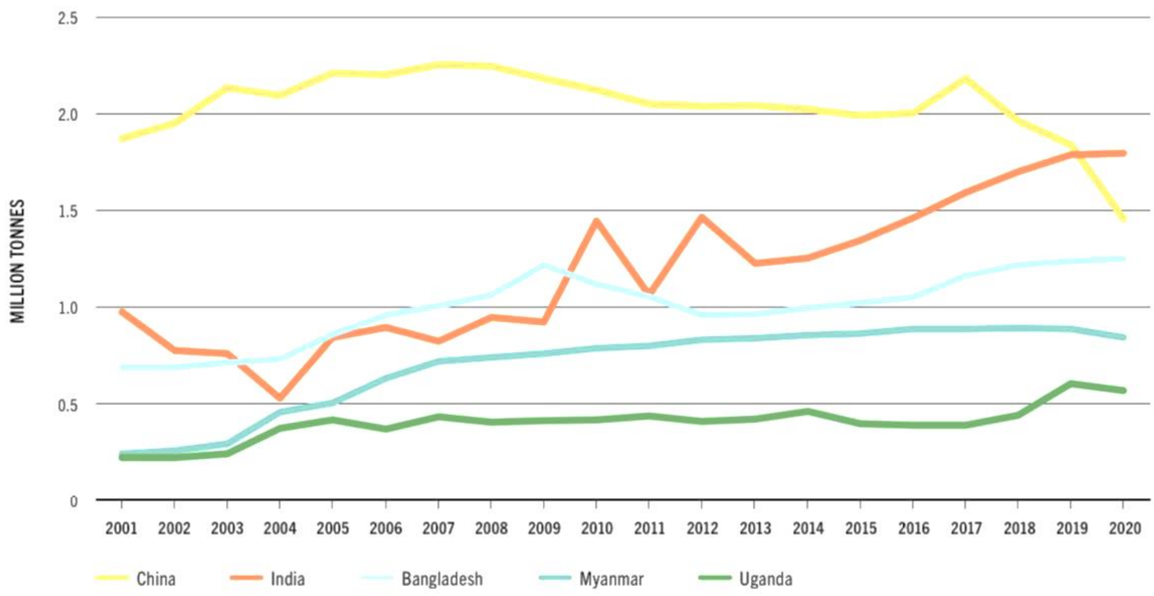
For the first time since the mid-1980s, China was not the top producer of inland water catches in 2020 and instead the highest catches were reported by India at 1.8 million tonnes.

While China continues to be one of the largest producers of inland water capture fisheries, reported catches have decreased by over 33 percent from 2.2 million tonnes in 2017 to 1.5 million tonnes in 2020.

This significant decrease is the result of recently introduced policies by China’s Ministry of Agriculture and Rural Affairs, most notably a ten-year fishing ban in the waters of the Yangtze River, that aim for conservation of living aquatic resources, with the underlying rationale that improvements in and expansion of inland aquaculture and culture-based fisheries can meet the increased demand for aquatic food9 arising from the reduction in catches from inland capture fisheries.

With the exception of China, the increase in inland water catches continues to be driven by several major producing countries – notably India, Bangladesh, Myanmar and Uganda (Figure 3.4).

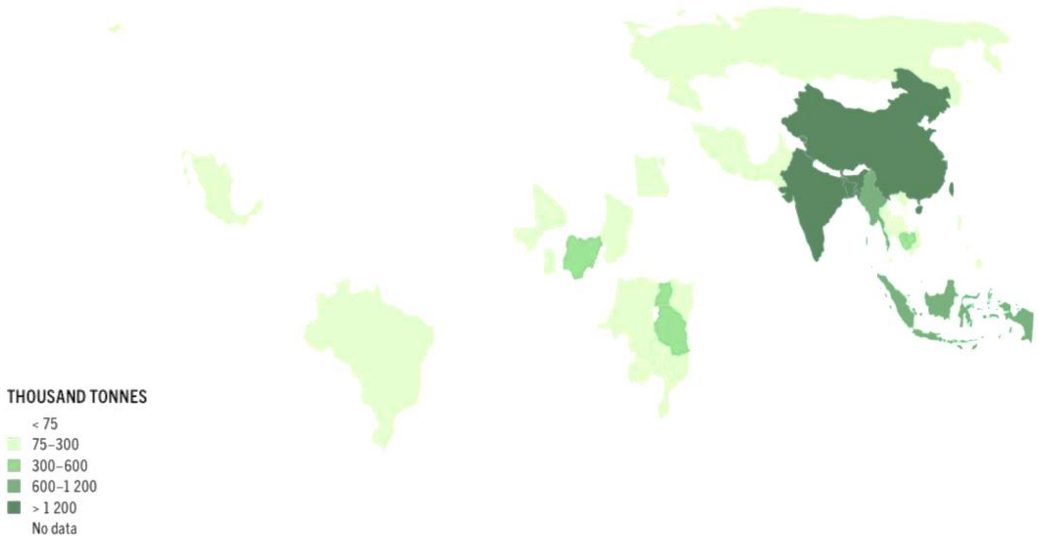
Most of the countries reporting declining catches represent a relatively low contribution to global production of inland water captures, although some supply important quantities to national or regional diets – in particular, Cambodia, Brazil, Viet Nam and Thailand.



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

Figure 3.4 – Top five inland waters capture producers

Inland water captures are more concentrated than marine captures among major producing nations endowed with important waterbodies or river basins (Figure 3.5). In 2020, 13 countries produced over 75 percent of total inland captures, compared with 20 countries for marine captures.



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

Figure 3.5 – Inland capture production by country, average 2018–2020

For the same reason, the top producers of inland water captures are also more concentrated geographically and are particularly important in terms of the contribution to total captures in Asia, where inland water catches provide an important food source for many local communities. Asia has consistently accounted for around two-thirds of global inland water production since the mid-2000s, while the top four producers are all located in Asia and accounted for over 46 percent of total inland water catches in 2020. The first group, "carps, barbels and other cyprinids", has shown a continuous increase, rising from about 0.7 million tonnes per year in the mid-2000s to almost 1.9 million tonnes in 2020, and explains most of the increase in catches from inland waters in recent years. Catches of the third-largest group, "freshwater crustaceans", have generally remained stable at between 0.4 million tonnes and 0.45 million tonnes per year; however, in 2020, catches fell to 0.3 million tonnes, mostly as a result of the decrease in China's inland water catches.

Questions for self-testing

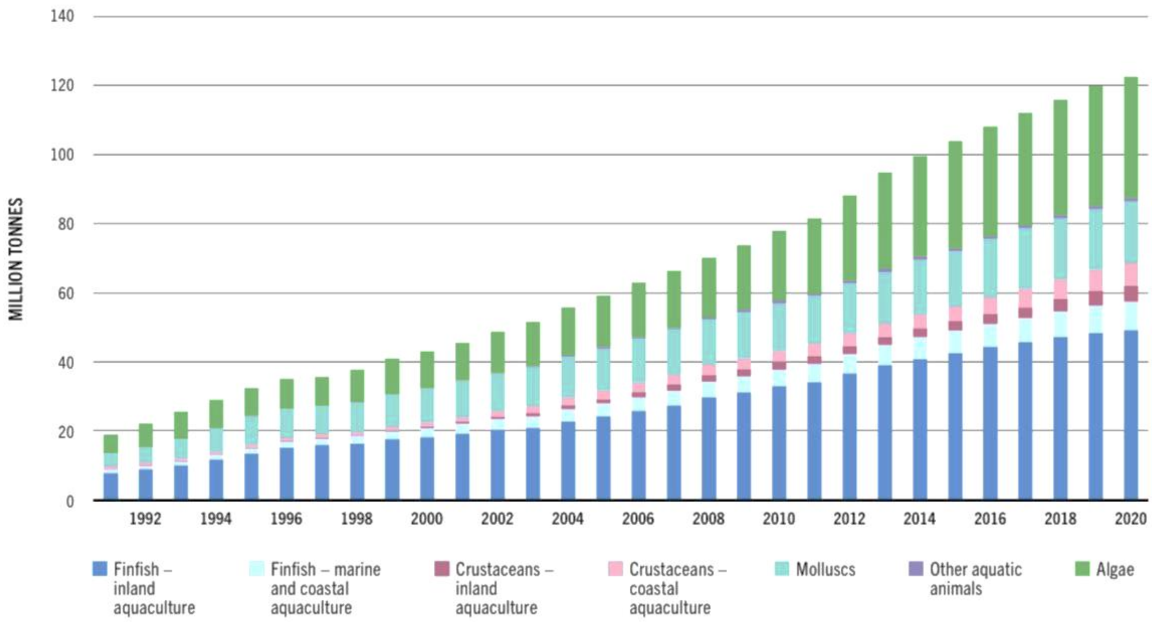
1. What are the main countries and territories producing marine catch?
2. What inland waters capture the production of the world's fisheries?

4 AQUACULTURE PRODUCTION

4.1 Overall production status and trend

Global aquaculture production retained its growth trend in 2020 amid the worldwide spread of the COVID-19 pandemic, albeit with differences among regions and among producing countries within each region.

The total aquaculture production comprised 87.5 million tonnes of aquatic animals mostly for use as human food, 35.1 million tonnes of algae10 for both food and Non-food uses, 700 tonnes of shells and pearls for ornamental use, reaching a total of 122.6 million tonnes in live weight in 2020 (Figure 4.1).



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

Figure 4.1 – World aquaculture production, 1991–2020

This represents an increase of 6.7 million tonnes from 115.9 million tonnes in 2018. The estimated total farm gate value was USD 281.5 billion in 2020, an increase of USD 18.5 billion from 2018 and USD 6.7 billion from 2019. World aquaculture production of animal species grew by 2.7 percent in 2020 compared with 2019, an all-time low rate of annual growth in over 40 years.

However, the net increase of 2.3 million tonnes in the same period was comparable to some years in the last decade. Finfish farming remained steady with minimal fluctuation around 66 percent and accounting for the largest share of world aquaculture for decades. In 2020, farmed finfish reached 57.5 million tonnes (USD 146.1 billion), including 49.1 million tonnes (USD 109.8 billion) from inland aquaculture and 8.3 million tonnes (USD 36.2 billion) from mariculture in the sea and coastal aquaculture on the shore.

Production of other farmed aquatic animal species reached 17.7 million tonnes of molluscs (USD 29.8 billion) mostly bivalves, 11.2 million tonnes of crustaceans (USD 81.5 billion), 525 000 tonnes of aquatic invertebrates (USD 2.5 billion) and 537 000 tonnes of semi-aquatic species including turtles and frogs (USD 5 billion).

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

At the regional level, African aquaculture (excluding algae) suffered from a slight contraction in its annual output (down 1.2 percent in 2020 compared with 2019), mainly the result of the drop in production in Egypt, Africa’s major producer.

In Nigeria, the largest producer in sub-Saharan Africa, the declining trend since 2016 worsened in 2020 with a sharp decrease of 9.6 percent. Aquaculture in the rest of Africa enjoyed a double-digit growth of 14.5 percent reaching 396 700 tonnes in 2020 from 346 400 tonnes in 2019. All other regions experienced continued growth in 2020. Chile, China and Norway – the top producers in the Americas, Asia and Europe, respectively – all experienced growth in 2020, offsetting the decreased output that occurred in some countries in their respective regions.

In the period 1990–2020, total world aquaculture expanded by 609 percent in annual output with an average growth rate of 6.7 percent per year. The average annual growth rate had decreased gradually from 9.5 percent during the period 1990–2000 to 4.6 percent during 2010–2020.

The growth rate reduced further to 3.3 percent per year in the most recent years (2015–2020). Next to the falling trend in growth rate in relative terms, it is important to note the net increase in world production in absolute terms over three decades. Additional details of world aquaculture growth are presented in Table 4.1.

Table 4.1 – World aquaculture production and growth

	2000-2010	2010-2020	2015-2020
All aquaculture			
A. Starting annual output (million tonnes)	43.0	77.9	104.0
B. Ending year's annual output (million tonnes)	77.9	122.6	122.6
C. Accumulated increase in annual output (million tonnes)	34.9	44.6	18.6
D. Overall increase	81%	57%	18%
E. Average annual growth rate	6.1%	4.6%	3.3%
Aquatic animals			
A. Starting annual output (million tonnes)	32.4	57.8	72.9
B. Ending year's annual output (million tonnes)	57.8	87.5	87.5
C. Accumulated increase in annual output (million tonnes)	25.3	29.7	14.6
D. Overall increase	78%	51%	20%
E. Average annual growth rate	5.9%	4.2%	3.7%
Algae			
A. Starting annual output (million tonnes)	10.6	20.2	31.1
B. Ending year's annual output (million tonnes)	20.2	35.1	35.1
C. Accumulated increase in annual output (million tonnes)	9.6	14.9	4.0
D. Overall increase	90%	74%	13%
E. Average annual growth rate	6.7%	5.7%	2.5%

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

4.2 Source of aquaculture data for analysis

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

For example, in 2020, FAO's aquaculture data on farmed animal species covered 207 countries and territories, including national data reported or retrieved from official sources for 122 of them (59 percent). However, total production data of these countries reached over 85.4 million tonnes, representing 97.6 percent of world production in 2020. At the species or species group level, to distinguish between inland and coastal aquaculture and to take into account the type of water used, FAO corrected omissions in statistical details in official data that were questionable or available in highly aggregated form in line with internationally established standards of classification and identification.

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

4.3 Production distribution and major producers

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

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

Data in Table 7 illustrate the global distribution of aquaculture production by region, reflecting the lingering situation of dominance by a small number of major producers at the global, regional and subregional levels. Since 1991, China (mainland) has produced more farmed aquatic animals and algae than the rest of the world.

Its share in world aquaculture production was 56.7 percent for aquatic animals and 59.5 percent for algal farming in 2020 – similar to recent years.

Production of the main groups of farmed species differs significantly across regions and countries. Some middle-income countries dominate inland aquaculture production of finfish species. Some such as Norway and Chile (endowed with large areas of fjords protected from rough sea), plus China from the middle-income group, dominate world mariculture of finfish species with sea cages. Atlantic salmon is representative of sea cage culture of cold water species, while finfish produced by sea cage farmers in China are mostly warm water species and their composition is more diverse. Marine shrimps dominate the production of crustaceans from coastal aquaculture in brackish-water ponds. They are an important source of foreign exchange earnings for a number of developing countries in Asia and Latin America.

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

4.4 Aquaculture contribution to total fisheries and aquaculture production

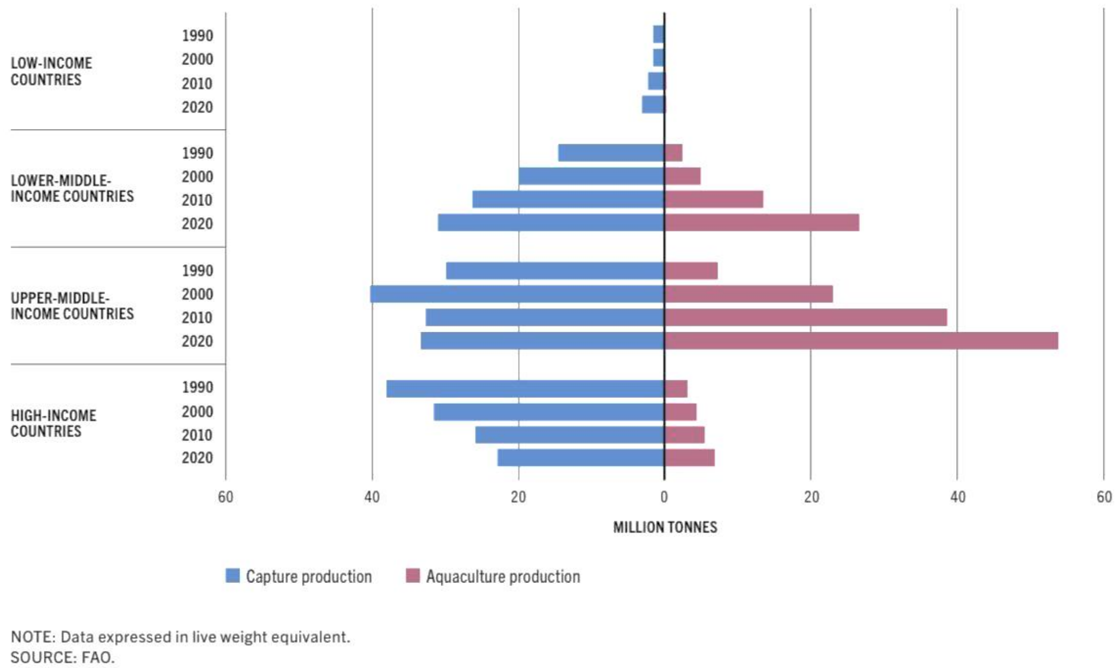
Most major aquaculture producing countries are highly populated developing countries where aquaculture contributes more than half of total fisheries and aquaculture production, benefiting half of the global population. These countries, such as Egypt in Africa, and Bangladesh and Viet Nam in Asia, set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

On a world scale, the contribution of aquaculture to total fisheries and aquaculture production (excluding algae) has climbed steadily, reaching 49.2 percent in 2020 on a par with capture, compared with just 13.4 percent in 1990.

This contribution varies greatly among and within regions. Asia produces more from aquaculture (61.9 percent) than from capture, and when the top producer is excluded in each region, Asia still has a high aquaculture share of 44.7 percent. In contrast, if Egypt is excluded, Africa's contribution to world aquaculture production was a mere 6.6 percent in 2020, the lowest among regional and subregional groups represented in the figure.

Using the World Bank's income level classification, the period 1990–2020 witnessed rapid development in aquaculture in 51 of the lower-middle-income countries and 53 of the upper-middle-income countries reporting aquaculture production.

In 2020, aquaculture contributed 61.7 percent to total production in upper-middle-income countries (2.76 billion population), up from 19.8 percent in 1990. The share of aquaculture in lower-middle-income countries (3.13 billion population) increased from 14.7 percent to 46.2 percent in the same period (Figures 4.2).



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

Figure 4.2 – Fisheries and aquaculture growth comparison by country group by income level (excluding algae), 1990–2020

In the 67 high-income countries reporting aquaculture data (1.32 billion population), although aquaculture production more than doubled reaching 6.8 million tonnes in 2020 from 3.1 million tonnes in 1990, its contribution to total fisheries and aquaculture production was just 23 percent in 2020 (up from 7.6 percent in 1990).

However, its contribution would be even lower without the 40.1 percent decrease in capture production in the same period (from 38.1 million tonnes to 22.8 million tonnes).

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

4.5 Inland aquaculture

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

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

Farming of finfish species dwarfs all other species groups in inland aquaculture at the regional and global levels. However, the development status and composition pattern of non-finfish groups differ greatly from region to region (Table 4.1).

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

Table 4.2 – Inland aquaculture and marine and coastal aquaculture production by region and by main species group, 2020

	Africa	Americas	Asia	Europa	Oceania	World	Share in world total (%)
Finfish	1857209	1179727	45526599	551802	5124	49120461	90.2
Crusta-ceans	2	72541	4401336	3145	177	4477201	8.2
Molluscs	….	….	192671	….	….	593707	0.4
Other aquatic animals	….	370	593161	176	….	593707	1.1
(Aquatic animals subtotal)	(1857211)	(1252638)	(50173767)	(555123)	(5301)	(54384040)	(99.9)
Algae	150	1321	62670	349	….	64490	0.1
Inland aqua-culture	1857361	1253959	50776437	555472	5301	54448530	100
Finfish	379322	1240969	4502888	2121867	95587	8340633	12.2
Crus-taceans	7617	1193549	5549811	418	8420	6759815	9.9
Molluscs	5994	688077	16158709	578712	116363	17547855	25.8
Other aquatic animals	60	….	459185	6495	2844	468584	0.7
(Aquatic animals subtotal)	(392993)	(3122595)	(26670593)	(2707492)	(223214)	(33116887)	(48.6)
Algae	103941	23994	34853646	21443	10065	35013089	51.4
Marine and coastal aqua-culture	496934	3146589	61524239	2728935	233279	68129976	100

Cage culture and, to a lesser extent, pen culture are also widely used in inland aquaculture, but their relative importance varies greatly among countries. Worldwide data on inland cage and pen culture are unavailable.

Based on available data, presents cage culture and pen culture production, in comparison with national total inland aquaculture production of finfish in selected countries.

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

In the Philippines and Indonesia, cage and pen culture (including enclosures) in rivers, lakes and reservoirs has been undergoing significant development for decades. In recent years, authorities have started campaigns to reduce cage culture in some waterbodies.

In China, one of the focuses of the Thirteenth Five-Year Plan (2016–2020) was to “green” natural resource-based economic activities in the country, including aquaculture, especially in inland areas.

Implementation of the greening policy entailed locally coordinated clean-up plans together with a mitigation programme to protect the affected communities and individuals, and the vast majority of cages and pens were removed. Some provinces still grant a limited number of licenses based on the carrying capacity assessment of the waterbodies, but the permit process prioritizes environmental and conservation issues over the economic value of the remaining cage culture operations.

4.6 Mariculture and coastal aquaculture

Mariculture, or marine aquaculture, takes place in the sea for the entire cycle or only during the grow-out phase. In the first case, the production cycle takes place entirely in the seas for those species dependent on wild seeds from the sea, for example, sea mussels. Otherwise, mariculture refers only to the grow-out phase of the production cycle when a species is produced from a land-based hatchery and sometimes even in freshwater, as is the case for Atlantic salmon.

Coastal aquaculture, typically practised in constructed ponds onshore or in intertidal zones, plays an important role in livelihoods, employment and economic development among coastal communities in many developing countries particularly in Asia and Latin America.

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

It is relatively easy to separate mariculture and coastal aquaculture of crustaceans, molluscs and other marine invertebrates based on the biological characteristics of these species and the culture methods adopted to rear them.

However, this is not the case for finfish and those countries that grow different finfish species in both systems, due to the aggregation in production data. Based on information and data from alternative sources, a general picture of mariculture and coastal aquaculture is presented herein for the first time, showing mariculture and coastal aquaculture separately; caution should be exercised in interpreting this preliminary information. In 2020, finfish from coastal aquaculture was 3.1 million tonnes, representing 37.4 percent of the combined production of8.3 million tonnes from mariculture and coastal aquaculture. Crustaceans were almost entirely from coastal aquaculture. The share of coastal aquaculture was 19.4 percent for other aquatic animals, followed by marine algae (4.2 percent) and molluscs (0.5 percent).

4.7 Aquaculture production with and without feeding

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

In multi-species polyculture systems practiced in inland and coastal aquaculture, feeds intended for fed species also directly benefit filter-feeding species, especially when feeds in powder form are used or pellet feeds are low in water stability and dissolve quickly. Therefore, the border between fed and non-fed species under certain conditions becomes less clear-cut.

Regions such as Africa have not experienced aquaculture development of non-fed species. Although filter-feeding carps were introduced in some African countries in the 1950s and 1960s for aquaculture, they did not take off and faded before the arrival of the new millennium to be replaced by locally favorable tilapias and catfishes.

It has proven difficult, if not impossible, to identify and develop native finfish species to play the role of filter-feeding carps in developing low-cost inland polyculture aquaculture with improved efficiency in harnessing natural productivity of the rearing water. However, in coastal areas in Africa, joint efforts (such as setting up internationally owned hatcheries) to accelerate development in marine molluscs farming represent a realistic option for increasing aquatic food12 production.

Farmed aquatic species. Thanks to the vast range of conditions under which aquaculture is practiced across the world, a richly diverse pool of aquatic species and their hybrids are raised in different types of aquaculture farming systems using freshwater, brackish water, seawater or inland saline water.

The latest statistics compiled by FAO, based on national reports and estimates for non-reporting countries, cover all aquaculture productions worldwide in a 71-year period (1950–2020) under 652 units technically known as "species items" – an increase from the 622 reported in the 2020 edition of *The State of World Aquaculture and Fisheries*. They include 494 individual species, 7 finfish hybrids, 94 groups of species identified at genus level and 57 groups of species identified at family or higher levels. The 494 taxonomically recognized species ever farmed in the world include 313 species of finfish (in 186 genera), 88 species of molluscs, 49 species of crustaceans, 31 species of algae, 2 species of cyanobacteria, 6 species of marine invertebrates, 3 species of frogs (amphibians) and 2 species of aquatic turtles (reptiles). The real number of aquatic species farmed in the world is much greater, and the present record of finfish hybrids is only a fraction of many hybrids of not only finfish, but also molluscs, frogs, aquatic turtles and seaweeds. Limitation in the process of data collection does not enable the FAO statistics to capture all the necessary details. Studies on aquatic genetic resources and biodiversity should consider these limitations when using FAO's aquaculture data, whose original purpose is to monitor aquaculture development as an economic sector of agriculture. Despite the great diversity in farmed aquatic species, only a small number of "staple" species dominate aquaculture production, (Table 4.3).

Table 4.3 – World production of major aquaculture species (including species groups)

	2000	**2005**	**2010**	**2015**	**2020**	**Percentage of total, 2020**
Finfish in inland aquaculture						
Grass carp, *Ctenopharyngodon idellus*	2976.5	3396.6	4213.1	5315.0	5791.5	11.8
Silver carp, *Hypophthalmichthys molitrix*	3034.7	3690.0	3972.0	4713.6	4896.6	10
Nile tilapia, *Oreochromis niloticus*	1001.5	1721.3	2637.4	4000.9	4407.2	9
Common carp, *Cyprinus carpio*	2410.4	2666.3	3331.0	4025.8	4236.3	8.6
Catla, *Catla catla*	602.3	1317.5	2526.4	2313.4	3540.3	7.2
Bighead carp, *Hypophthalmichthys nobilis*	1438.9	1 929.5	2513.6	3109.1	3187.2	6.5
Carassius spp.	1198.5	1798.2	2 137.8	2644.1	2748.6	5.6
Striped catfish, *Pangasianodon hypophthalmus*	113.2	411.2	1749.4	2083.2	2520.4	5.1
Roho labeo, *Labeo rohita*	733.9	1435.9	1133.2	1785.3	2484.8	5.1
Clarias catfishes, *Clarias spp.*	48.8	149.5	343.3	923.7	1249.0	2.5

Table 4.3 continued

	2000	**2005**	**2010**	**2015**	**2020**	**Percentage of total, 2020**
Tilapias nei, *Oreochromis spp.*	123.9	199.3	449.6	929.9	1069.9	2.2
Wuchang bream, *Megalobrama amblycephala*	445.9	477.2	629.2	723.2	781.7	1.6
Rainbow trout, *Oncorhynchus mykiss*	340.4	360.0	464.7	546.5	739.5	1.5
Black carp, *Mylopharyngodon piceus*	149.0	280.7	409.5	541.2	695.5	1.4
Largemouth black bass, *Micropterus salmoides*	0.2	140.3	179.5	321.5	621.3	1.3
Subtotal of 15 major species	14618.2	19973.5	26689.7	33976.3	38970.1	79.3
Subtotal other species	3446.6	4260.1	6337.7	8535.7	10150.4	20.7
Total	18164.7	24233.6	33027.4	42512.0	49120.5	100

With 5.8 million tonnes produced in 2020, grass carp accounted for 11.8 percent of global inland aquaculture. Together with a further 23 individual species, they contributed 78.7 percent to total finfish production from inland aquaculture. Atlantic salmon and 21 other dominating species, such as milkfish, made up 75.6 percent of all finfish species of mariculture and coastal aquaculture. Atlantic salmon, with its production of 2.7 million tonnes in 2020, accounted for a high 32.6 percent of marine and coastal aquaculture of all finfish species.

Some finfish species living in freshwater or marine water are capable of bimodal respiration for oxygen uptake from the air, and the physiological mechanism varies.

About 30 different air-breathing fishes and their hybrids are raised in inland aquaculture worldwide. Global production of air-breathing fish seldom exceeded 3 percent in total production of inland finfish farming until the mid-2000s when the share started to rise to reach about 13 percent in recent years. In 2020, the production of air-breathing fishes was 6.2 million tonnes and the share was 12.6 percent, a slight drop from 2019 due mainly to the drop in production in Viet Nam.

Species from three families accounted for 83.9 percent of total production of air-breathing finfishes in 2020, including 47 percent from Pangasiidae (e.g. striped catfish, *Pangasianodon hypophthalmus*), 26.5 percent from Clariidae (e.g. North African catfish, *Clarias gariepinus*) and 10.5 percent from Channidae (e.g. snakehead, *Channa argus*).

Questions for self-testing

1. The general state of aquaculture production and trends.
2. What are the main directions of mariculture and coastal aquaculture?

5 THE STATUS OF FISHERY RESOURCES

5.1 Marine fisheries

Status of resources. Based on FAO's assessment,6 the fraction of fish stocks that are within biologically sustainable levels7 decreased from 90 percent in 1974 to 65.8 percent in 2017 (Figure 5.1).

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

Figure 5.1 – Reduction in scale of cage and pen aquaculture in inland waters in China (mainland) in recent years

In contrast, the percentage of stocks fished at biologically unsustainable levels increased, especially in the late 1970s and 1980s, from 10 percent in 1974 to 34.2 percent in 2017. This calculation treats all fish stocks equally regardless of their biomass and catch. In terms of landings, 78.7 percent of current landings come from biologically sustainable stocks. In 2017, the maximally sustainably fished stocks accounted for 59.6 percent and under fished stocks for 6.2 percent of the total number of assessed stocks.

The under fished stocks decreased continuously from 1974 to 2017, whereas the maximally sustainably fished stocks decreased from 1974 to 1989, and then increased to 59.6 percent in 2017. In 2017, among the FAO's 16 Major Fishing Areas, the Mediterranean and Black Sea (Area 37) had the highest percentage (62.5 percent) of stocks fished at unsustainable levels, followed by the Southeast Pacific 54.5 percent (Area 87) and Southwest Atlantic 53.3 percent (Area 41).

In contrast, the Eastern Central Pacific (Area 77), Southwest Pacific (Area 81), Northeast Pacific (Area 67), and Western Central Pacific (Area 71) had the lowest proportion (13–22 percent) of stocks fished at biologically unsustainable levels. Other areas varied between 21 percent and 44 percent in 2017.

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

(i) areas with a continuously increasing trend in catches since 1950;

(ii) areas with catches oscillating around a globally stable value since 1990, associated with the dominance of pelagic, short-lived species; and

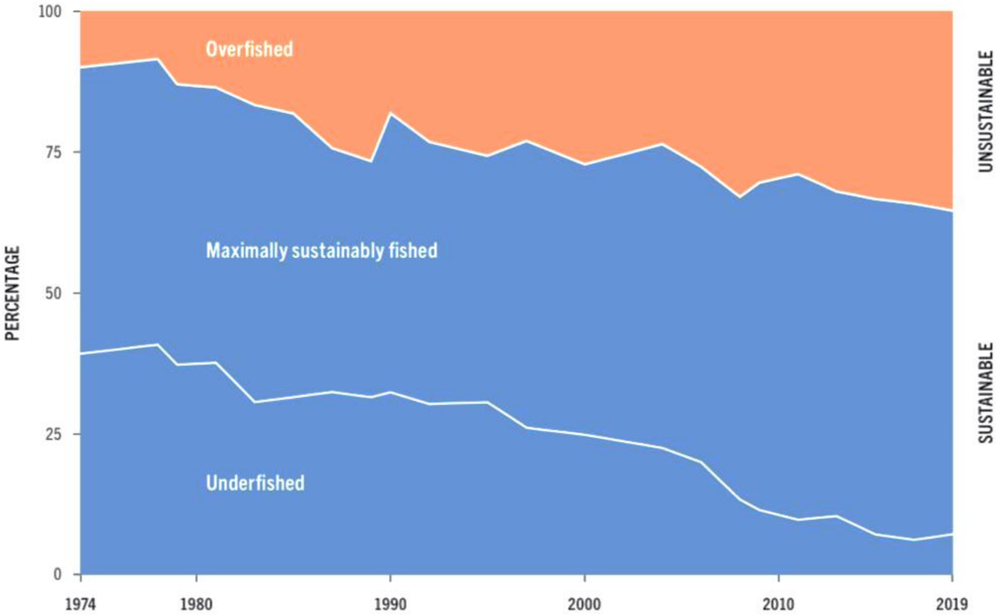
(iii) areas with an overall declining trend following historical peaks.

The first group had the highest percentage (71.5 percent) of biologically sustainable stocks in comparison with the second group (64.2 percent) and the third group (64.5 percent). Linking the catch pattern with stock status is not straightforward. In general, an increasing trend in catch usually suggests an improving stock status or an expansion in fishing intensity, whereas a decreasing trend is more likely to be associated with declines in abundance.

However, other causes, such as environmental changes and fisheries measures to reduce fishing intensity in order to rebuild overfished stocks, may also explain decreasing catch.

Based on FAO's assessment,13 the fraction of fishery stocks within biologically sustainable levels decreased to 64.6 percent in 2019, that is 1.2 percent lower than in 2017 (Figure 23).

This fraction was 90 percent in 1974. In contrast, the percentage of stocks fished at biologically unsustainable levels has been increasing since the late 1970s, from 10 percent in 1974 to 35.4 percent in 2019. This calculation treats all fishery stocks equally regardless of their abundance and catch. Biologically sustainable stocks account for 82.5 percent of the 2019 landings of assessed stocks monitored by FAO.

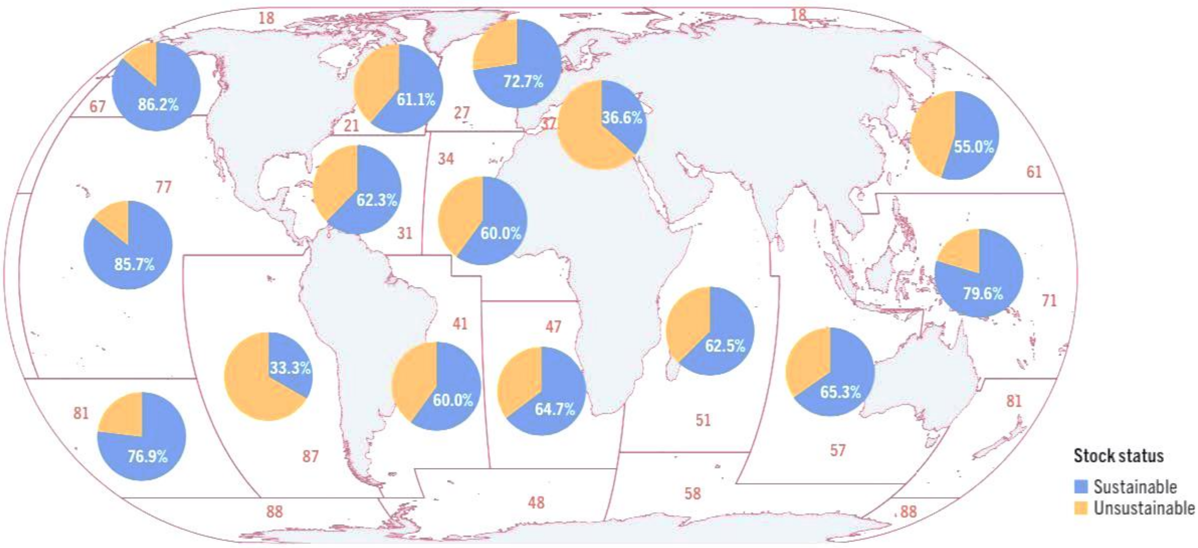


SOURCE: FAO.

Figure 5.2 – Global trends in the state of the world's marine fishery stocks, 1974–2019

Biologically sustainable stocks consist of the maximally sustainably fished and under fished stocks, accounting for, respectively, 57.3 percent and 7.2 percent of the total number of assessed stocks in 2019. The under fished stocks maintained a decreasing trend over the entire period (bouncing back slightly during 2018 and 2019), whereas the maximally sustainably fished stocks fell between 1974 and 1989, to then increase, reaching 57.3 percent in 2019. In 2019, among FAO's 16 Major Fishing Areas, the Southeast Pacific (Area 87) had the highest percentage (66.7 percent) of stocks fished at unsustainable levels, followed by the Mediterranean and Black Sea (Area 37) 63.4 percent (Figure 24). In contrast, the Northeast Pacific (Area 67), Eastern Central Pacific (Area 77), Western Central Pacific (Area 71) and Southwest Pacific (Area 81) had the lowest proportion (13–23 percent) of stocks fished at biologically unsustainable levels. Other areas varied between 27 percent and 45 percent in 2019 (Figure 5.3). Landings of fish varied greatly among fishing areas, and therefore, the significance of each area for global fishery sustainability may vary depending on its proportionate contribution to the global landings The temporal pattern of an area’s landings often reveals information about its ecological productivity, fishery development stage, management and fishery stock status.

In general, after excluding Arctic and Antarctic areas, which have minor landings, three groups of patterns can be observed: (i) areas with an overall declining landing trend following historical peaks; (ii) areas with catches oscillating around a globally stable value since 1990, associated with the dominance of pelagic, short-lived species; and (iii) areas with a continuously increasing trend in catches since 1950. The first group has the lowest percentage of biologically sustainable stocks (59.2 percent), the second group the highest (76.1 percent), while the third is in between (67.0 percent).



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

Figure 5.3 – Percentages of biologically sustainable and unsustainable fishery stocks by FAO major fishing area, 2019

When management intervention is not strong, an increasing trend of catch (the third group) suggests development of fishing and lack of control, with resource sustainability most likely in good shape. However, when there is an increasing trend, stock assessment may involve great uncertainty and be unreliable due to the lack of contrast resulting from the one-way-trip pattern in catch or catch per unit of effort.

In contrast, a decreasing trend in catch (the first group) usually suggests worsening sustainability of fishery stocks or implementation of strict regulations but lack of recovery. The highest level of sustainability (the second group) is likely to be associated with the full development of fisheries, mature management and effective regulation in fishing. However, other issues, such as environmental changes and social factors, can also influence catch trends. Box 3 illustrates the FAO plan to revise the current assessment methodology to better reflect the major changes that have occurred in the relative dominance of different fisheries resources.

5.2 Status and trends by major species

Productivity and stock status also vary greatly among species. For the ten species that had the largest landings between 1950 and 2017 – anchoveta (*Peruvian anchovy*), Alaska pollock (*walleye pollock*), Atlantic herring, Atlantic cod, Pacific chub mackerel, Chilean jack mackerel, Japanese pilchard, Skipjack tuna, South American pilchard, and capelin – 69.0 percent of stocks were fished within biologically sustainable levels in 2017, slightly higher than the world average. Of these ten species, Chilean jack mackerel, Atlantic cod and Japanese pilchard had higher than average proportions of overfished stocks.

Tunas are of great importance because of their high catches, high economic value and extensive international trade. Moreover, their sustainable management is subject to additional challenges owing to their highly migratory and often straddling distributions. The seven species of tunas of global commercial importance are albacore (*Thunnus alalunga*), bigeye (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*) and three species of bluefin tuna (*Thunnus thynnus*, *Thunnus maccoyii* and *Thunnus orientalis*). Their combined landings were 5.03 million tonnes in 2017, a 5 percent increase from 2015 but 1 percent below the historical peak of 2014. In 2017, among the seven principal tuna species, 33.3 percent of the stocks were estimated to be fished at biologically unsustainable levels, while 66.6 percent were fished within biologically sustainable levels. Three stocks have seen their status improve from unsustainable to sustainable, including Eastern and Western Pacific bigeye tuna and Eastern Pacific yellowfin tuna.

Tuna stocks are generally well assessed, and very few stocks of the principal tuna species are of unknown status. In contrast, most minor tuna species and/or tuna-like species remain unassessed or assessed under high uncertainty. Market demand for tuna remains high, and tuna fishing fleets continue to have significant overcapacity. Effective management, including the implementation of harvest control rules, is needed to restore overfished stocks and to maintain others at sustainable levels. Moreover, substantial additional efforts on data collection, reporting and assessment for minor tuna and tuna-like species are required.

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

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

Tuna stocks are closely monitored and extensively assessed, and the status of the seven above-mentioned tuna species is known with moderate uncertainty. However, other tuna and tuna-like species remain mostly unassessed or assessed under high uncertainty. This represents a major challenge, as tuna and tuna-like species are estimated to account for at least 15 percent of the total global small-scale fisheries catch (FAO, Duke University and World Fish, forthcoming).

Furthermore, market demand for tuna remains high, and tuna fishing fleets continue to have significant overcapacity. Effective management, including better reporting and access to data and the implementation of harvest control rules across all tuna stocks, is needed to maintain stocks at a sustainable level and in particular rebuild overexploited stocks. Moreover, substantial additional efforts on data collection, reporting and assessment for tuna and tuna-like species other than the main commercial species are required.

5.3 Status and trends by fishing area

The Northwest Pacific has the highest production among the FAO areas, producing 25 percent of global landings in 2017. Its total catch fluctuated between 17 million tonnes and 24 million tonnes in the 1980s and 1990s, and was about 22.2 million tonnes in 2017. Historically, Japanese pilchard (*Sardinops melanostictus*) and Alaska pollock (*Theragra chalcogramma*) used to be the most productive species, with peak landings at 5.4 million and 5.1 million tonnes, respectively. However, their catches have declined significantly in the last 25 years. In contrast, landings of squids, cuttlefishes, octopuses and shrimps have increased greatly since 1990.

In 2017, two stocks of Japanese anchovy (*Engraulis japonicus*) were overfished, while for Alaska pollock two stocks were sustainably fished and another one overfished. Overall, in 2017, about 65.4 percent of the fish stocks monitored by FAO (hereinafter referred to as the assessed stocks) were fished within biologically sustainable levels, and 34.6 percent fished outside of these levels, in the Northwest Pacific. In recent decades, catches in the Eastern Central Pacific have oscillated between 1.5 million tonnes and 2.0 million tonnes. Total landings in 2017 were 1.7 million tonnes. A large proportion of the landings in this area are small and medium-sized pelagic fish (including important stocks of California pilchard, anchovy and Pacific jack mackerel), squids and prawns.

These stocks of short-lived species are naturally more susceptible to variations in oceanographic conditions, which generate oscillations in production even if the fishing rate is fixed at a sustainable level. Overfishing currently impacts selected coastal resources of high value, such as groupers and shrimps. The percentage of assessed stocks in the Eastern Central Pacific fished within biologically sustainable levels has remained unchanged since 2015 at

86.7 percent. The Southeast Pacific produced 7.2 million tonnes of fish in 2017, about 10 percent of global landings.

The two most productive species were Peruvian anchoveta (*Engraulis ringens*) and jumbo flying squid (*Dosidicus gigas*), with landings of almost 4.0 million tonnes and 0.76 million tonnes respectively. These species are considered to be within biologically sustainable levels, although some concerns about the status of the jumbo flying squid off the Chilean coast have been identified.

Chilean jack mackerel (*Trachurus murphyi*) and Pacific chum mackerel (*Scomber japonicus*) were also fished within biologically sustainable levels. In contrast, the South American pilchard (*Sardinops sagax*) continued to be severely overfished, and Patagonian toothfish (*Dissostichus eleginoides*) is currently being fished at unsustainable levels.

Overall, 45 percent of assessed stocks in the Pacific Southeast are being fished within sustainable levels. The Eastern Central Atlantic has seen an overall increasing trend in catches, but with fluctuations since the mid-1970s, reaching 5 million tonnes in 2017, the highest value in the time series. Sardine (*Sardina pilchardus*) is the single most important species, with reported catches of about 1 million tonnes per year since 2014 and its stocks remained under fished.

Round sardinella (*Sardinella aurita*) is another important small pelagic species. Its catches have been generally decreasing since 2001, to about 220 000 tonnes in 2017, only about 50 percent of its peak value.

The species is considered overfished. The demersal resources are known to be intensely fished in the region, and the status of the stocks varies – some are classes as being sustainable and others unsustainable). Overall, 57.2 percent of the assessed stocks in the Eastern Central Atlantic were within biologically sustainable levels in 2017. In the Southwest Atlantic, total catches have varied between 1.8 million tonnes and 2.6 million tonnes (after a period of increase that ended in the mid-1980s), reaching 1.8 million tonnes in 2017, a 25 percent decrease from 2015.

The most important species in the landings is the Argentine shortfin squid (*Illex argentinus*), representing 10–40 percent of the region's total catches. However, total landings of this species experienced a sharp drop from more than 1.0 million tonnes in 2015 to 360 000 tonnes in 2017. Patagonian grenadier (*Macruronus magellanicus*) and southern blue whiting (*Micromesistius australis*) have shown a continuous decrease in catches in the last 20 years.

Argentine hake (*Merluccius hubbsi*), the second-most important species in terms of landings in the region, has had stable landings at about 350 000 tonnes in the past decade, but its status has remained at unsustainable, although with signs of slow recovery.

Overall, 46.7 percent of the assessed stocks in the Southwest Atlantic were fished within biologically sustainable levels in 2017, a 4 percent improvement from 2015. In 2017, landings in the Northeast Pacific remained at the same level as 2013, at about 3.3 million tonnes. No significant changes have seen in species composition of the catches since then. Alaska pollock (*Theragra chalcogramma*) has remained the most abundant species, representing about 50 percent of total landings. Pacific cod (*Gadus microcephalus*), hakes and soles are also large contributors to the catches. Salmons, trouts and smelts have experienced great inter-year variations in the past decade, between 0.3 million tonnes and 0.5 million tonnes, with the catch being 480 000 tonnes in 2017.

All the assessed stocks in the Southwest Atlantic seem to be sustainably managed except salmon stocks. Overall, 83.9 percent of the assessed stocks in the area were fished within biologically sustainable levels in 2017.

The Northeast Atlantic had the third-largest production in 2017, with a catch of 9.3 million tonnes. Its landings reached a peak of 13 million tonnes in 1976, then dropped, recovered in the 1990s and stabilized at about 70 percent of the peak value. The resources in this area experienced extreme fishing pressures in the late 1970s and early 1980s. Since then, owing to resource depletion, countries have decreased fishing pressures in order to rebuild overfished stocks. Most stocks have retained the same status since 2015, with positive results of some stocks no longer being classed as overfished. In the Northeast Atlantic, 79.3 percent of the assessed stocks were fished within biologically sustainable levels in 2017.

The Northwest Atlantic produced 1.84 million tonnes of fish in 2017, and continued a decreasing trend from its peak of 4.5 million tonnes in the early 1970s. The group of Atlantic cod (*Gadus morhua*), silver hake (*Merluccius bilinearis*), white hake (*Urophycis tenuis*) and haddock (*Melanogrammus aeglefinus*) has not shown a good recovery, with landings remaining at about 0.1 million tonnes since the late 1990s, only 5 percent of their historical peak value of 2.2 million tonnes. Although fisheries have dramatically reduced catches, stocks have not recovered yet.

The lack of recovery may be largely caused by environmental factors, although further management actions are still needed. In contrast, American lobster (*Homarus americanus*) has seen a rapid increase in catches to 160 000 tonnes in 2017. Overall, 56.2 percent of the assessed stocks in the Northwest Atlantic were fished within biologically sustainable levels in 2017. Total catches in the Western Central Atlantic reached a maximum of 2.5 million tonnes in 1984, then declined gradually to 1.2 million tonnes in 2014, and rebounded slightly to 1.5 million tonnes in 2017.

Important stocks such as Gulf menhaden (*Brevoortia patronus*), round sardinella (*Sardinella aurita*) and skipjack tuna (*Katsuwonus pelamis*) have shown decreased catches, but are estimated to be biologically sustainable. Snappers and groupers have been intensively fished since the 1960s, but some of their stocks are now starting to recover in the Gulf of Mexico following tighter management regulations. Valuable invertebrate species such as Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Lobatus gigas*) appear to be fully fished, as do shrimp resources in the Gulf of Mexico. However, some stocks of penaeid shrimps in the Caribbean and Guianas shelf have not shown signs of recovery in recent years, despite reductions in fishing effort. Stocks of American cupped oyster (*Crassostrea virginica*) in the Gulf of Mexico are now experiencing overfishing. In the Western Central Atlantic, 61.4 percent of the assessed stocks were fished within biologically sustainable levels in 2017.

The Southeast Atlantic has shown a decreasing trend in landings since the early 1970s, from a total of 3.3 million tonnes to 1.6 million tonnes in 2017, a slight recovery from the 2013 value of 1.3 million tonnes. Horse mackerel and hake support the largest fisheries of the region, and their stocks, including both deep-water and shallow-water hake off Namibia and South Africa have recovered to biologically sustainable levels as a consequence of good recruitment and strict management measures introduced since 2006.

The Southern African pilchard (*Sardinops ocellatus*) is still very degraded, warranting special conservation measures from both Namibia and South Africa. The sardinella (*Sardinella aurita and S. maderensis*) stocks, very important off Angola and partially in Namibia, remained at biologically sustainable levels. Whitehead's round herring (*Etrumeus whiteheadi*) was under fished. However, Cunene horse mackerel (*Trachurus trecae*) remained overfished in 2017, and perlemoen abalone (*Haliotis midae*), targeted heavily by illegal fishing, continued to deteriorate and remained overfished.

Overall, 67.6 percent of the assessed stocks in the Southeast Atlantic were fished within biologically sustainable levels in 2017. After reaching a historical maximum of about 2 million tonnes in the mid-1980s, total landings in the Mediterranean and Black Sea declined to a low of 1.1 million tonnes in 2014, and since 2015 have been about 1.3 million tonnes per year.

Demersal stocks of the region have experienced higher fishing mortality rates than small pelagic stocks. Important commercial stocks of hake (*Merluccius merluccius*) and turbot (*Scophthalmus maximus*) show particularly high fishing pressure, while many stocks of anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) show biomass levels below biologically sustainable levels. Despite the decreasing trend in fishing rates of some stocks in recent years (e.g. turbot in the Black Sea), this region continues to face serious overfishing. In 2017, 37.5 percent of the assessed stocks in the Mediterranean and Black Sea were fished within biologically sustainable levels.8 The Western Central Pacific produced the second-largest landings, 12.6 million tonnes (16 percent of the global total) in 2017, continuing a linear increasing trend since 1950. Major species are tuna and tuna-like species, contributing about 21 percent of total landings. Sardinellas and anchovies are also important in the region. Fish species are highly diversified but catches are often not split by species.

Landings are often recorded as “miscellaneous coastal fishes”, “miscellaneous pelagic fishes”, and “marine fishes not identified”, which together constituted 6.1 million tonnes, almost 50 percent of the region’s total landings in 2017. Few stocks are considered to be under fished, particularly in the western part of the South China Sea.

The high reported catches have probably been maintained through expansion of fishing to new areas or through changes in trophic levels of targeted species. The tropical and subtropical characteristics of this region and the limited data availability make stock assessment challenging with great uncertainties. Overall, 77.6 percent of the assessed fish stocks in the Western Central Pacific were fished within biologically sustainable levels in 2017.

The Eastern Indian Ocean continues to show a steady increase in catches, reaching an all-time high of 7 million tonnes in 2017. It is unclear whether the continued increase in catches was caused by changes in fishing patterns and resource productivity or an artefact created by problems in catch data collection and reporting.

The monitoring of capture fisheries production is particularly problematic in the Bay of Bengal and Andaman Sea regions owing to inherent characteristics of small-scale and multispecies fisheries. Due to data limitations, the status of most stocks in the region has not been well assessed (involving high levels of uncertainty) and should be treated with caution.

The available information indicates that stocks of toli shad (*Tenualosa toli*), croaker and drums (*Sciaenidae*), hairtails (*Trichiurus*), catfish (*Ariidae*), sardinellas (*Sardinella spp.*) and Indian oil sardine (*Sardinella longiceps*) are likely to be overfished, but anchovies (*Engraulidae*), hilsa shad (*Tenualosa ilisha*), Indian mackerel (Rastrelliger kanagurta), scads (Decapterus spp.), banana prawn (*Penaeus merguiensis*), giant tiger prawn (*Penaeus monodon*), squids (*Sepiidae*) and cuttlefish (*Sepiolidae*) are being fished sustainably.

The current assessment indicates that 68.6 percent of the assessed stocks in the Eastern Indian Ocean were fished within biologically sustainable levels in 2017. In the Western Indian Ocean, total landings continued to increase and reached 5.3 million tonnes in 2017. Recent assessments have shown that the main Penaeidae shrimp stocks fished in the South West Indian Ocean, a main source of export revenue, continue to show clear signs of overfishing, prompting the countries concerned to introduce more stringent management measures. The Southwest Indian Ocean Fisheries Commission continues to update the assessment of the status of the main fished stocks in the region.

The 2017 assessment estimated that 66.7 percent of the assessed stocks in the Western Indian Ocean were fished within biologically sustainable levels, while 33.3 percent were at biologically unsustainable levels.

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

In recent decades, catches in the Eastern Central Pacific have oscillated between 1.5 million tonnes and 2.0 million tonnes (Figure 25). Total landings in

2019 were 1.9 million tonnes, close to the maximum seen in history. A large proportion of the landings in this area are small and medium-sized pelagic fish (including important stocks of California pilchard (*Sardinops sagax*), anchovy and Pacific jack mackerel (*Scomber japonicas*), squids and prawns. The productivity of these stocks of short-lived species are naturally more susceptible to interannual variations in oceanographic conditions, which generate oscillations in catches despite sustainable exploitation rates. Catches of California pilchard in the Gulf of California stock have for instance recovered dramatically in the last three years, most likely in response to favourable environmental conditions. As noted in previous years, overfishing impacts selected coastal resources of high value, such as groupers, snappers and shrimps. However, the status of these stocks is considered highly uncertain due to the limited information available.

The percentage of assessed stocks in the Eastern Central Pacific fished within biologically sustainable levels has remained stable since 2015 at 85.7 percent, the second highest among fishing areas.

The Southeast Pacific produced 7.8 million tonnes of aquatic animals in 2019, accounting for about 10 percent of global landings, with a clear decreasing trend since the 1990s.

The two most productive species were anchoveta and jumbo flying squid (*Dosidicus gigas*), with landings of almost 5.0 million tonnes and 0.9 million tonnes, respectively. These species are considered to be within biologically sustainable levels, mostly due to a decrease in landings since the early 1990s as part of a more precautionary and effective fisheries management of anchoveta. Araucarian herring (*Strangomera bentincki*) was also harvested within sustainable levels.

In contrast, South American pilchard (*Sardinops sagax*), South Pacific hake (*Merluccius gayi*) and Southern hake (*Merluccius australis*) continued to be overfished, and Patagonian toothfish (*Dissostichus eleginoides*) is currently being fished at unsustainable levels. Although the majority of the catch (approximately 95 percent) within this region comes from stocks at sustainable levels, overall, just 33.3 percent of the assessed stocks in the Pacific Southeast were fished within sustainable levels in 2019.

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

In the Southwest Atlantic, total catches have varied between 1.8 million tonnes and 2.6 million tonnes (after an early period of increase that ended in the mid-1980s), reaching 1.7 million tonnes in 2019, a 5 percent decrease from 2017 (Figure 25). The species with the largest landings is the Argentine shortfin squid (*Illex argentinus*), representing 10–30 percent of the region's total catches historically. However, landings of this species decreased to 250 000 tonnes (14 percent) in 2019, and in contrast, Argentine red shrimp (*Pleoticus muelleri*) catch has grown significantly since 2005.

Both were fished within biologically sustainable levels. In 2019, Argentine hake (*Merluccius hubbsi*) catch increased by 26 percent from 2017 and thus represents the most important species in terms of catch volumes for the region with 449 000 tonnes.

One of the hake stocks had recovered to biologically sustainable levels in 2019 as a result of significant efforts to improve assessment and management, including reductions in fishing mortality. Moreover, Patagonian grenadier (*Macruronus magellanicus*) and white mouth croaker (*Micropogonias furnieri*) have shown an increase in catches of about 70 percent and 20 percent, respectively, since 2017. Overall, 60.0 percent of the assessed stocks in the Southwest Atlantic were fished within biologically sustainable levels in 2019, a 20 percent improvement from 2017.

In 2019, landings in the Northeast Pacific remained at the same level as 2013, at about 3.2 million tonnes. Alaska Pollock remains the most abundant species, representing about 50 percent of total landings. Pacific cod (*Gadus microcephalus*), hakes and soles are also large contributors to the catches. Most species except salmon stocks in this region are healthy and well managed, primarily due to the science-based advice from the North Pacific Fisheries Commission and North Pacific Fishery Management Council and to good governance that has helped reduce fishing pressure from distant water fishing nations.

However, stocks of Pacific salmon (chinook, coho, sockeye and chum in southern parts of British Columbia in Canada, and the states of Washington, Oregon and California in the United States of America) were overfished in 2019. Overall, 86.2 percent of the assessed stocks in the area were fished within biologically sustainable levels in 2019, the highest among fishing areas.

The Northeast Atlantic is the third most productive area and had a catch of 8.1 million tonnes in 2019, a decline of 1.2 million tonnes from 2017. Its landings reached a peak of 13 million tonnes in 1976, then dropped, recovered slightly in the 1990s and have been decreasing since.

Its fishery resources experienced extreme fishing pressures in the late 1970s and early 1980s. Since then, countries have managed better fishing pressure to rebuild overfished stocks. Recovery was seen in Atlantic mackerel (*Scomber scombrus*), turbot (*Scophthalmus maximus*), European plaice (*Pleuronectes platessa*), common sole (*Solea solea*), Arctic cod (*Boreogadus saida*) and Atlantic cod (*Gadus morhua*) in the 2000s, and common sole (*Solea solea*) and whiting (*Merlangius merlangus*) in the late 2010s.

In the Northeast Atlantic, 72.7 percent of the assessed stocks were fished within biologically sustainable levels in 2019.

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

In general, invertebrate fisheries are in a better state than finfish fisheries. Overall, 61.1 percent of the assessed stocks in the Northwest Atlantic were fished within biologically sustainable levels in 2019.

Total catches in the Western Central Atlantic reached a maximum of 2.5 million tonnes in 1984, then declined gradually to 1.2 million tonnes in 2014, and rebounded slightly to 1.4 million tonnes in 2019. Small pelagic fishes, namely Gulf menhaden (*Brevoortia patronus*) and round sardinella are considered to be fully fished. Medium-sized pelagic fishes such as king mackerel (*Scomberomorus cavalla*) and Atlantic Spanish mackerel (*Scomberomorus maculatus*) appear to be fully fished, while the serra Spanish mackerel (*Scomberomorus brasiliensis*) appears to be overfished. Snappers and groupers are among the most highly valued and intensively fished in the region and, despite reductions in directed fishing effort thanks to management actions, some stocks continue to be overfished.

Highly valued invertebrate species such as Caribbean spiny lobster (*Panulirus argus*) and queen conch (*Lobatus gigas*) are considered fully fished. Penaeid shrimps are currently sustainably fished, as well as the Atlantic sea bob (*Xiphopenaeus kroyeri*) along the Guianas-Brazil shelf. In the Western Central Atlantic, 62.2 percent of the assessed stocks were fished within biologically sustainable levels in 2019.

The Southeast Atlantic has shown a decreasing trend in landings since the late 1960s, from a total of 3.3 million tonnes to 1.4 million tonnes in 2019 (Figure 25). Horse mackerel and hake support the largest fisheries of the region and have recovered to biologically sustainable levels following good recruitment and strict management measures.

The Southern African pilchard (*Sardinops ocellatus*) stocks are still very degraded, warranting special conservation measures from both Namibia and South Africa. The sardinella (*Sardinella aurita* and *Sardinella maderensis*) stocks, very important off Angola and partially in Namibia, remained at biologically sustainable levels.

Whitehead's round herring (*Etrumeus whiteheadi*) was under fished. However, Cunene horse mackerel (*Trachurus trecae*) remained overfished in 2019, and perlemoen abalone (*Haliotis midae*), targeted heavily by illegal fishing, continued to deteriorate and remained overfished. Overall, 64.7 percent of the assessed stocks in the Southeast Atlantic were fished within biologically sustainable levels in 2019.

After reaching a historical maximum of about 2 million tonnes in the mid-1980s, total landings in the Mediterranean and Black Sea declined to a low of 1.1 million tonnes in 2014; since 2015, they have recovered slightly, with a catch of 1.4 million tonnes in 2019. Most of the commercially important stocks regularly assessed continue to be fished outside biologically sustainable limits, including the stocks of hake (*Merluccius merluccius*), turbot (*Scophthalmus maximus*) and European pilchard.

A decreasing trend in the level of overfishing of some of these stocks has been observed in past years but according to the General Fisheries Commission for the Mediterranean (GFCM), the overall fishing mortality for all resources combined is estimated at nearly 2.5 times higher than sustainable reference points. In 2019, 36.7 percent of the assessed stocks in the Mediterranean and Black Sea were fished within biologically sustainable levels.

The Western Central Pacific produced the second largest landings, 13.9 million tonnes (17 percent of the global total) in 2019, continuing the linear increasing trend since 1950.

Aquatic species are highly diversified, but catches are not always split by species, often recorded as “miscellaneous coastal fishes”, “miscellaneous pelagic fishes” and “marine fishes not identified”, which together constituted almost 50 percent of the region’s total landings in 2019. Major species are tuna and tuna-like species, contributing about 21 percent of total landings. Sardinellas and anchovies are also significant in the region.

Few stocks are considered to be under fished, particularly in the western part of the South China Sea. The high reported catches have probably been maintained through expansion of fishing to new areas or through fishing down trophic levels of targeted species. The tropical and subtropical characteristics of this region and the limited data availability make stock assessment challenging with great uncertainties.

Overall, 79.6 percent of the assessed fishery stocks in the Western Central Pacific were fished within biologically sustainable levels in 2019.

The Eastern Indian Ocean continues to show a steady increase in catches, with 6.8 million tonnes in 2019. Stock status information is generally scarce and available only for a few coastal stocks in certain areas.

Most of the stocks monitored by FAO are assessed based on catch trends and other ancillary information rather than analytical stock assessments or fishery independent data. Therefore, the state of stocks in the region is considered highly uncertain and should be treated with caution.

Toli shad (*Tenualosa toil*), sardinellas (*Sardinella* spp.), Indian mackerel (*Rastrelliger kanagurta*) and Indian oil sardine (*Sardinella longiceps*) have highly fluctuating landings, most likely driven by the combined effect of fishing pressure and changing environment. Hilsa shad (*Tenualosa ilisha*) stocks are either fully fished or overexploited. Among the stocks considered within sustainable levels are anchovies, banana prawn, giant tiger prawn, squids and cuttlefish. Of the assessed stocks in the Eastern Indian Ocean, 65.3 percent were fished within biologically sustainable levels in 2019.

In the Western Indian Ocean, total landings continued to increase and reached 5.5 million tonnes in 2019. Main Penaeidae shrimp stocks fished in the South West Indian Ocean, a main source of export revenue, continue to show clear signs of overfishing, prompting the countries concerned to introduce more stringent management measures. The stocks of sea cucumber across the region are considered overexploited.

The Southwest Indian Ocean Fisheries Commission continues to update the assessment of the status of the main fished stocks in the region. The 2019 assessment estimated that 62.5 percent of the assessed stocks in the Western Indian Ocean were fished within biologically sustainable levels, while 37.5 percent were at biologically unsustainable levels.

5.4 Prospects for rebuilding the world's marine fisheries

In 2017, 34.2 percent of the fish stocks of the world's marine fisheries were classified as overfished. This continuous increasing trend warrants further effort and solid actions to combat overfishing. Overfishing – stock abundance fished to below the level that can produce maximum sustainable yield (MSY) – not only causes negative impacts on biodiversity and ecosystem functioning, but also reduces fish production, which subsequently leads to negative social and economic consequences.

One study has estimated that 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 US$32 billion. This would increase the contribution of marine fisheries to the food security, economies and well-being of coastal communities.

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

Regarding the Sustainable Development Goals (SDGs), the situation as at 2017 indicates that it is unlikely that SDG Target 14.4 (to end overfishing of marine fisheries by 2020) will be achieved. Achieving the target will require time and: „ stronger political will, especially at the national level; „ enhanced institutional and governance capacity, technology transfer and capacity building in science-based best management practices; „ controlling of fishing capacity and intensity at levels that do not impair resource productivity; „ transformation of consumers' perceptions through market mechanisms and education; „ strengthening of the global monitoring system to provide transparent and timely information to the public.

The continuous increase in the percentage of stocks fished at biologically unsustainable levels may mask regional differences in progress. In general, intensively managed fisheries have seen decreases in average fishing pressure and increases in stock biomass, with some reaching biologically sustainable levels, while fisheries with less-developed management are in poor shape.

This uneven progress highlights an urgent need to replicate and re-adapt successful policies and measures in the light of the realities of specific fisheries, and to focus on creating mechanisms that can effectively implement policy and regulations in fisheries with little management.

5.5 Prospects of achieving the SDG target on fisheries

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

Overfishing – stock abundance fished to below the level that can produce maximum sustainable yield (MSY) – not only causes negative impacts on biodiversity and ecosystem functioning, but also reduces fisheries production, which subsequently leads to negative social and economic consequences. Rebuilding overfished stocks to the biomass that enables them to deliver MSY could increase fisheries production by 16.5 million tonnes and annual rent by USD 32 billion. It would also increase the contribution of marine fisheries to the food security, nutrition, economies and well-being of coastal communities.

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The United Nations Sustainable Development Goals (SDGs) set a clear target on fisheries (SDG Target 14.4): to end overfishing of marine fisheries by 2020. The world fisheries are now diverging away from this target. However, this global picture may mask regional and intra-country differences in progress. A recent study shows that scientifically assessed and intensively managed stocks have, on average, seen abundance increasing or at proposed target levels and that in contrast, regions with less developed fisheries management have much greater harvest rates and lower abundance than assessed stocks.

This highlights the urgent need to replicate and re-adapt successful policies and regulations in fisheries that are not managed sustainably and to create innovative mechanisms that promote sustainable use and conservation around the world.

5.6 Inland fisheries

Basins that support inland capture fisheries can be found throughout the world. In some cases, these are major sources of inland fish as food in national or regional diets (e.g. the African Great Lakes, the Lower Mekong Basin, the Peruvian and Brazilian Amazon, and the Brahmaputra and Ayeyarwady river basins).

Elsewhere, their production may be modest but of strong local-importance in the diet (e.g. interior regions of Sri Lanka, and Sumatra and Kalimantan in Indonesia). Allocating national inland fishery catch data by basin, sub-basin and large waterbody provides a more realistic picture of the areas where inland fisheries are conducted.

Table 5.1 shows the 60 most important hydrological or river basins in terms of contribution to the global inland fish catch. The first 50 percent of total global inland fish catch can be attributed to the top 7 basins. These basins also represent some of the highest levels of per capita fish consumption in the world. Some of the world’s largest inland fisheries come from basins or river systems that are facing severe threats from anthropogenic and natural environmental pressures.

However, there is limited or no routine monitoring of the status of capture fisheries in most of these basins (see the section Improving the assessment of global inland fisheries). Inland fisheries are strongly influenced by fluctuations in environmental and climate conditions, in addition to the effects of fishing, and they experience high inter- and intra-annual variation as a result.

Table 5.1 – Percentage of global fish catch allocated to major hydrological/river basin

	Basin	Percentage of global catch		Basin	Percentage of global catch
1	Mekong (including Tonlé Sap Lake)	15.18	**31**	Orinoco	0.59
2	Nile (including Lake Victoria)	9.70	**32**	Zambezi (excluding Lake Malawi/ Shire sub-basins	0.57
3	Ayeyarwady	7.82	**33**	Mahanadi (India)	0.52
4	Yangtze	6.83	**34**	Volta	0.50
5	Brahmaputra River and floodplains	5.52	**35**	Gulf of Guinea	0.50
6	Amazon	4.26	**36**	Amur	0.49
7	Ganges	3.51	**37**	Sabarmati (India)	0.46
8	Xun Jiang (Pearl)	3.27	**38**	Sri Lanka (all basins)	0.44
9	China coast	2.75	**39**	La Plata Basin (including Parana River)	0.42
10	Hong (Red)	2.46	**40**	India – south coast	0.41
11	Chao Phraya	2.37	**41**	Java – Timor (Indonesia, Timor-Leste)	0.38
12	Niger	2.13	**42**	South peninsular Thailand (sub-basins)	0.34
13	Yasai (India)	1.64	**43**	Cauvery (India)	0.29
14	Indus	1.56	**44**	Volga	0.28
15	Sumatra (Indonesia)	1.42	**45**	Angola – coast	0.25

Table 5.1 continued

16	Philippine archipelago	1.33	**46**	India – west coast	0.41
17	Salween	1.27	**47**	Bay of Bengal – northeast coast	0.38
18	Krishna (India)	1.23	**48**	Finland (all basins)	0.34
19	Godavari (India)	1.20	**49**	Brahmani	0.29
20	Lake Tanganyika	1.09	**50**	Japan (all basins)	0.28
21	Mexican basins	0.99	**51**	Limpopo	0.25
22	Lake Chad	0.96	**52**	Senegal	0.23
23	Congo (excluding Lake Tanganyika)	0.94	**53**	Madagascar (all basins)	0.23
24	Pennar (India)	0.4	**54**	Danube	0.16
25	Kalimantan (Indonesia)	0.92	**55**	Ob	0.14
26	Lake Malawi/Nyasa	0.92	**56**	Laurentian Great Lakes	0.13
27	Caspian Sea	0.76	**57**	Sulawesi (Indonesia)	0.11
28	Huang He (Yellow)	0.71	**58**	Tocantins	0.10
29	Ziya He	0.71	**59**	Mahakam River	0.10
30	India – east coast	0.68	**60**	India – northeast coast	0.10

The fishing pressure exerted on an inland fishery is a function of: human population density; primary productivity and secondary production of the waterbody; accessibility of the fishery; and socio-economic dependence on inland fish and the availability of alternative foods and livelihoods. Both natural and anthropogenic environmental drivers affect aquatic habitats, water flows, habitat connectivity and water quality.

Climate variability and seasonal effects also influence both short-term annual cycles and longer-term trends. Human activities in agriculture (including irrigation), urbanization, industry and damming all have strong impacts on water and aquatic ecosystems.

The status of inland fisheries is driven by the interactions between all of these factors, typically within catchments and river basins, reflecting the linkage between water resources, aquatic ecosystems and fisheries. A comprehensive overview of global inland fisheries was published by FAO in 2018; this document also reviewed options for improved assessment of inland fisheries. Trends Based on FAO's inland fishery catch statistics for the decade 2007–2016, the aggregated global trend is one of steady growth. This global trend in inland fisheries production may be misleading, as it shows a continuous increase over time.

Some of this increase can be attributed to improved reporting and assessment at the country level and may not be increased production. The improvement in reporting may also mask trends in individual countries where fisheries are declining. To establish how this global inland fishery, catch trend was composed, an analysis was made of individual country catch for the decade 2007–2016.

Analysis at the national level (using the Mann–Kendall test for trend analysis, 90 percent confidence level) can indicate the catch trend of individual countries and thus the influence this has on the global inland fishery catch trend. This allows countries that are contributing positively to growth in inland fisheries to be identified, versus those countries for which inland fishery catch has no clear trend or is declining. It was not possible to include all the 153 countries that have an inland fishery catch.

This is because some countries do not report with sufficient regularity to FAO, requiring estimation of their national catch. In order to base the trend analysis on national reports (and not FAO estimates), the analysis excluded those countries that reported inland fishery catch to FAO seven or fewer times over the decade. The 43 countries so excluded represented 15.1 percent (1 756 309 tonnes) of the global inland fishery catch for 2016. For the remaining 110 countries, a Mann–Kendall trend analysis (90 percent confidence level) was performed to establish the trend in reported production.

Thirty-seven countries indicated an increasing production trend over the decade, representing 58.7 percent of global inland fish catch. The major drivers of this trend were China, India, Cambodia, Indonesia, Nigeria, the Russian Federation and Mexico. Twenty-eight countries indicated decreasing production, representing 5.9 percent of global inland fish catch, with the trend driven by Brazil, Thailand, Viet Nam and Turkey.

All four of these countries have significant aquaculture production. Inland fisheries remain extremely important at the subnational level in these countries (e.g. countries in the Mekong and the Amazon basins); hence, this decline should not be a cause for complacency. Twenty-seven countries demonstrated stable catches, indicating that there is little or no variation in their reported catch trend. The major contributors to group are the United Republic of Tanzania, the Democratic Republic of the Congo, Mali and Kazakhstan.

The group represents 7.7 percent of global inland fish catch. The remaining 17 countries had no discernible trend of increase or decrease in their catch. These countries represent 12.6 percent of global inland fish catch, and the group is dominated by Bangladesh and Egypt, followed by Zambia. The conclusion of this analysis is that growth in global inland fisheries is driven by 34 countries, and of these, about 8 relatively large producers drive this trend. The 24 countries reporting declining catches represent a relatively low contribution to global production, but some of these have significant inland food fisheries that are locally important.

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

The performance of fishery stocks or specific inland fisheries is intimately related to water quality and quantity and to the size and health of the habitats on which they rely to complete their life cycles and the connectivity between these. In tropical floodplains, which are home to some of the world’s largest inland fisheries, and on which large numbers of people depend for their livelihoods, food security and nutrition, inter-annual variability in flooding decides survival and growth rates of the aquatic species and thus the size of the stocks capable of recovering from high levels of mortality.

Fishing pressure in these systems can be significant but is not normally the principal driving factor that determines the status of the fisheries. Conversely, isolated stocks in temperate or Arctic lakes or streams may be very vulnerable to overfishing, although impacts on habitat, spawning grounds and connectivity may still be important or even overriding factors in determining the health of the stock.

The significant inland fisheries of the world’s tropical basins may be further characterized by the large number of species present and the highly diversified fisheries which exploit them.

As many of these important food fisheries lie within least developed or low-income food-deficit countries, there are limited human and financial resources to monitor and manage such fisheries.

Given the highly dispersed nature of many of these fisheries, the use of traditional assessment methods (length frequency surveys, catch and effort surveys, fishery independent surveys, etc.) is time-consuming and expensive and hard to justify considering the limited options for deriving revenue from the landings and the low return on investment to the State. Even in some developed countries, the low profile of inland waters means that assessment and monitoring may be a relatively low priority or seen as an unwarranted expense when there are so many other competing needs.

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

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

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

It has been recognized for some time that these limitations in national assessments and the basin nature of inland fisheries require a new assessment paradigm that can combine information from multiple sources, often collected remotely and using proxy measurements, but the tools and computer modelling power to do this have not been available. Starting in 2016,

FAO initiated a process in collaboration with the United States Geological Survey (USGS) and selected fishery experts to develop a global threat map for inland fisheries that combined 20 identified anthropogenic pressures acting across catchments and basins to create a composite threat indicator. The relevant pressures on each basin and sub-basin that affect inland fisheries were weighted according to their importance in each basin. The initial results of this model were presented in the 2020 edition of *The State of World Fisheries and Aquaculture* (FAO, 2020a) with the intention of providing an update in the 2022 edition.

The threat assessment method has now been further refined by USGS and automates boosted regression model outputs from over 150 spatial data layers across the threat categories which affect inland fisheries. This was achieved by improving the weighting approach to make the spatial data meaningful and assign relative importance values. The approach combines weights from literature, boosted regression trees and expert opinions. More than 9 000 peer-reviewed articles on documented threats, responses and impacts from 45 basins most important to inland fisheries catch were reviewed. The results were complemented with a survey among 536 inland fisheries professionals from 79 countries with expertise on 93 basins, who were asked to apply threat scores at the local level to the fisheries with which they were most familiar. The threat assessment represents a fully transparent, reproducible framework that will permit an objective assessment of inland fisheries with a high level of confidence. An accompanying web portal will summarize assessment outcomes for fishery managers and other users. Figure 26 summarizes threats by continent according to aggregated pressure categories.

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

5.7 Analysis of individual basins

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

The advantage of this approach is that it uses global, publicly available data, thus allowing coverage of countries that may have very limited capacity to collect and report data to FAO; by selecting a number of indicator basins in each region, it will be possible to gain insight into the state of the fisheries in different parts of the world. However, for calibration and improved interpretation, the findings should be “ground-truthed” using locally available data, local knowledge and, where possible, collection of complementary data in the field;

this is especially the case for large complex basins with several different fisheries in operation. Linking the threat maps to fishery data at a subnational level will enable more detailed national analysis and planning, especially pointing to areas where there is a need for greater understanding of primary threats and their relationship to fisheries production and biodiversity of aquatic species.

This would enable national fishery agencies to identify important inland fisheries (or aquatic biodiversity) that are at risk and prioritize appropriate fishery monitoring and management interventions. Where there are several different fisheries operating in the same body of water that respond differently to the drivers or respond to different drivers (this could, for example, be fisheries for large predatory species and small pelagic fish taking place in the same water body or fishing for floodplain resident and migratory species in a major river), the outcomes require careful interpretation as different groups of stakeholders may be affected in different ways.

An additional step in developing a more detailed report could involve the selection and systematic tracking of a number of indicator fisheries in some of the most productive basins. Each of these fisheries would convey important information about what is happening in the basin of concern – information that may be translated into meaningful management actions. The data could also be reported into a common framework that would allow FAO to further refine the global-level assessment. Box 4 is an illustration of how such a basin assessment could be presented. While information at the species level may not be essential, the number of species present in the catches contains an important message.

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

Questions for self-testing

1. What is the state of marine fish resources?
2. What are the prospects for the recovery of global marine fisheries?

6 THE STATUS OF THE FISHING FLEET

6.1 Estimate of the global fleet and its regional distribution

In 2018, the global total of fishing vessels was estimated to be 4.56 million, a 2.8 percent decrease from 2016. Between 2013 and 2018, China's fleet was reduced by almost 20 percent from 1 071 000 vessels to 864 000 vessels. Asia continues to have the largest fleet with 3.1 million vessels, 68 percent of the global total. These figures reflect a decline both in absolute numbers as well as in the relative proportion of Asia's fleet in the global total over the past decade.

Africa's fleet now accounts for 20 percent of the global total, while that of the Americas has held steady at about 10 percent. Europe's fleet accounts for just over 2 percent of the global total, while Oceania's share is less than 1 percent, although fishing remains an important activity in the respective regions, and particularly in the fishing communities that are home to these fleets and where the fleets operate. After reaching a peak number of fishing vessels in 2013, the fleet capacity of China has been steadily reduced. This decline in the number of vessels drives the trend for Asia, but also globally due to the large size of the Chinese fleet.

Moreover, the European Union has been following a policy of reducing fleet capacity since 2000. The European region as a whole has the highest percentage of motorized vessels – 99 percent of its fleet. The global total of motorized vessels has remained steady at an estimated 2.86 million vessels, or 63 percent of the total fleet. The figure shows each region's relative share of the motorized and non-motorized vessels. Note that the totals sum to 100 percent across categories, not by region.

The motorized fleet is distributed unevenly around the world, with Asia having almost 75 percent of the reported motorized fleet in 2018 (2.1 million vessels), followed by Africa with about 280 000 motorized vessels. The largest absolute number of non-motorized vessels was in Asia, with more than 947 000 vessels estimated in 2018, followed by Africa (just over 643 000 non-motorized boats), Latin America and the Caribbean, Oceania, North America and Europe.

These undecked vessels were mostly in the length overall (LOA) class of under 12 m and included the smallest boats used for fishing. The substantial proportion of unclassified vessels, both in terms of motorization status, but also as found for length categories and vessel types, points to the need to support further improvements in reporting granularity.

There has both been a global downward trend in the number of fishing vessels, but also an adjustment in national and regional totals as an outcome of a comprehensive process conducted by FAO to revise and improve the fleet data for the period of 1995–2017. This period was selected as the focal time frame as it allows for the development and presentation of more than 20 years of historical data in more detailed form. The workflow followed a routine of working in close communication with Members to revise historical data, uncover new data sources, control data errors, and make imputations as necessary.

The world had an estimated 4.1 million fishing vessels in 2020. This number has been on a downward trend in the last two decades, mainly driven by fleet reduction programmes in Europe and China, which started in 2000 and 2013, respectively, and were accounted for in a recent revision of FAO fleet data. The global fleet size was reduced by just under 10 percent between 2015 and 2020 and by just under 4 percent between 2019 and 2020. Asia hosts the world's largest fishing fleet, estimated at 2.68 million vessels or about two-thirds of the global total in 2020.

This proportion fell by 8 percent between 2015 and 2020. Africa's fleet has been increasing relative to the rest of the world, and now comprises 23.5 percent of the world's fishing vessels, up 10 percent from 2015. The Americas now account for under 9 percent of the world's fleet, down 1.5 percent from 2015. Europe and Oceania have retained a stable share of 2 percent and less than 1 percent, respectively, of the world's total. At an estimated 564 000 vessels, China has the world's largest fishing fleet. This fleet is being scaled down and has been reduced by about 47 percent since 2013, when it totaled 1 072 000 vessels. This is motivated by the long-stated objective of reducing the size of the Chinese fishing sector.

The European Union, whose fleet totalled about 74 000 vessels in 2020 – a 28 percent reduction compared with 2000 – has implemented similar programmes through its common fisheries policy for the past two decades. Figure 28 and Figure 29 illustrate these changes in fleet sizes for China and the European Union. However, reductions in fleet size alone do not necessarily guarantee more sustainable outcomes, since changes in fishing efficiency can offset the sustainability gains of fleet reductions, as reported by Di Cintio *et al*.

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

In terms of fleet motorization, the world has about 2.5 million vessels equipped with engines, making up 62 percent of the global fishing fleet. Figure 30 shows how motorized and non-motorized vessels are distributed across continents. The figure shows that the distribution for both types of vessels is uneven, with Asia having almost three-quarters (1.9 million) of the world's motorized vessels in 2020. The vast majority of the world's non-motorized vessels (about 97 percent) are spread between Asia and Africa, which are respectively estimated to have 815 000 and 702 000 such vessels.

These non-motorized vessels are mostly categorized in the length overall (LOA) class of under 12 m, though many country reports continue to lack classification in terms of length, motorization status and vessel type.

Importantly, the countries affected by this issue include some of the world's largest fishing fleets, representing a significant limitation of the data.

6.2 Size distribution of vessels and the importance of small boats

In 2018, about 82 percent of the motorized fishing vessels (which had a known length classification) in the world were in the LOA class of less than 12 m, the majority of which were undecked, and those small vessels dominated in all regions. Asia had the largest absolute number of motorized vessels under 12 m, followed by the Americas (particularly Latin American and the Caribbean). Only about 3 percent of all motorized fishing vessels were 24 m and larger (roughly more than 100 gross tonnage) and the proportion of these large boats was highest in Oceania, Europe and North America.

Worldwide, FAO estimated there were about 67 800 fishing vessels with an LOA of at least 24 m. One area of particular note is that the reporting of vessels of unknown size and type remains a significant factor, with Members that have some of the largest fleets not reporting their fleet statistics by size classification. Despite the global dominance of small vessels, estimations of their numbers are likely to be less accurate, as, unlike industrial vessels, they are often not subject to licensing and registration requirements. Moreover, even when registered, they may not be reported in national statistics. The lack of information and reporting is particularly acute for inland water fleets, which are often entirely omitted from national or local registries. Regarding the reporting of inland vessels for Europe, although the data trend appears to show an increase in the number of inland vessels, this only reflects a change in reporting. Data reporting still does not allow for accurate disaggregation between marine and inland water fleets.

However, work is under way to improve this through efforts such as those described in the section Illuminating Hidden Harvests, focusing on small-scale fisheries and ongoing FAO work conducted on improving data quality and reporting. Information on vessels (best collected through registries) not only allows countries to report on the numbers of vessels, supporting the development of more informed fisheries management, but also constitutes a critical first step in recognizing and formalizing small-scale fishery activities and their actors at the regional and global level.

Table 6.1 shows the number of vessels reported by selected countries and territories from each region, categorized by LOA class and motorization status. These selected countries and territories provide reliable data and offer a good regional representation. Usually, non-motorized vessels were a minor component of the total national fleet, with the exception of Benin, where they constituted the large majority, and Cambodia and Sri Lanka, where they were up to 50 percent of the total.

Table 6.1 – Reported number of motorized and non-motorized vessels by LOA class in fishing fleets from selected countries and territories, 2018

	Non-motorized < 12 m	**Non-motorized 12–24 m**	**Non-motorized > 24 m**	**Motorized < 12 m**	**Motorized 12–24 m**	**Motorized > 24 m**
Africa						
Angola	5244	83	188	3585	-	-
Benin	40869	-	-	582	7	21
Mauritius	130	-	-	1800	44	2
Senegal	-	-	-	-	29	94
Sudan	-	-	-	1120	-	60
Tunisia	6506	-	-	5469	1198	303
Latin America and the Caribbean						
Bahamas	-	-	-	751	160	23

	Non-motorized < 12 m	Non-motorized 12–24 m	Non-motorized > 24 m	Motorized < 12 m	Motorized 12–24 m	Motorized > 24 m
Chile	1607	-	-	10873	1765	136
Guatemala	-	-	-	75	22	2
Guyana	19	-	-	728	475	-
Mexico	-	-	-	74339	1728	240
Saint Lucia	-	-	-	815	7	-
Suriname	69	-	-	926	439	68
Asia						
Bangladesh	34810	-	-	32859	45	210
Cambodia	39726	-	-	172622	-	-
Kazakhstan	916	-	-	605	23	3
Lebanon	119	-	-	2048	46	-
Myanmar	6802	-	-	15228	1858	971
Oman	4899	62	2	23084	1362	121
Republic of Korea	790	27	-	55470	8283	1336
Sri Lanka	28546	3	-	29212	2578	20
Taiwan Province of China	368	1	1	14493	6207	837
Europe						
Iceland	-	-	-	1192	173	171
Norway	-	-	-	4936	779	303
Poland	68	-	-	597	113	49
Oceania						
New Caledonia	-	-	-	707	21	4
New Zealand	4	-	-	665	427	72
Vanuatu	119	-	-	95	7	59

Of the selected countries in Latin America and the Caribbean, the great majority of the vessels were motorized, and a similar pattern was observed with Oceania and Europe. A recent study has confirmed that although the small vessels in the motorized category make up a significant share of the global motorized fleet in numbers, they still do not represent the largest share of total engine power. The study also found that the large vessels making up about 5 percent of the fleet constituted more than 33 percent of the total engine power.

While small vessels make up most of the world's fleets, the estimation of their numbers is particularly challenging. Indeed, while industrial vessels are usually subject to licensing and registration requirements, this is less often the case for small vessels. Additionally, small vessels may not always be reported in national statistics even when registries exist. Another challenge has to do with inland water fleets, for which reporting and data availability in local and national registries is rarely adequate, complicating further disaggregation and comparison between marine and inland water fleets.

This highlights the need for FAO to accelerate its efforts to improve data quality and reporting in fisheries, with a major focus on small-scale fisheries around the world, also through dedicated capacity-building activities in fisheries statistics. Indeed, information on vessels (best collected through registries) is critical for countries because it allows them to assess the size of their fleets, supports fisheries management and constitutes a critical first step in recognizing and formalizing small-scale fishery activities and their actors.

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

Questions for self-testing

1. Assessment of the world fleet and its regional distribution.
2. Distribution of vessels by size and value of small boats.

7 CONSUMPTION OF AQUATIC FOODS

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

7.1 Trends in aquatic food consumption

Global consumption of aquatic foods, excluding algae, 20 has increased significantly, with the world now consuming more than five times the quantity consumed nearly 60 years ago (Figure 7.1). Per capita consumption was influenced most strongly by increased supplies, changing consumer preferences, advancements in technology and income growth.

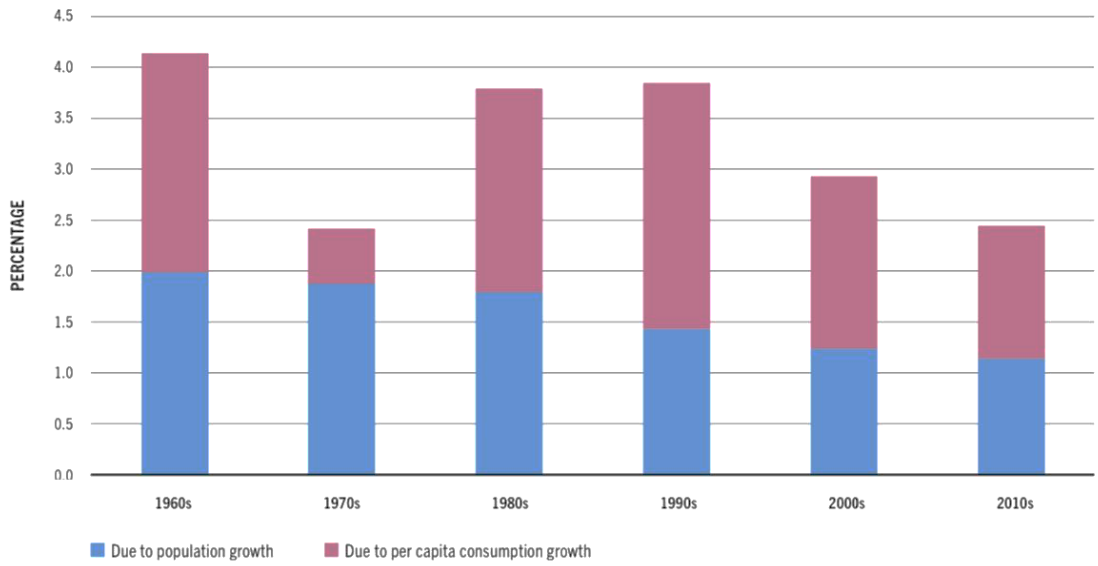


Figure 7.1 – Average annual growth in aquatic food consumption

Of the 158 million tonnes of aquatic foods available for human consumption in 2019, Asia accounted for 72 percent of the total while its population represented 60 percent of the world population. As a comparison, in

1961, Asia consumed 48 percent of all aquatic foods available for food consumption. In parallel, the proportion of aquatic foods consumed in Europe and the United States of America decreased over time.

The respective shares of Europe and the United States of America went from 32 percent and 9 percent in 1961 to 10 percent and 5 percent in 2019. The growing importance of Asian countries as consumers of aquatic products is the result of a combination of factors. First, Asia became the main producer of aquatic products in 1993, mainly thanks to the development of aquaculture production.

Second, the continent experienced significant economic growth in recent decades, which resulted in income growth, a larger middle class and the migration of rural populations to the cities where aquatic foods are more accessible.

Finally, higher imports and a diversion of some exports towards the Chinese domestic market increased the diversity of aquatic foods available to Chinese consumers, further boosting their consumption. Over the years, half or more of the aquatic food produced has been consumed by only a small number of countries. In 1961, the five largest consuming countries of aquatic foods (Japan, the former Union of Soviet Socialist Republics, China, the United States of America and the United Kingdom of Great Britain and Northern Ireland) accounted for half of global consumption.

However, in 2019, the share of the five largest consuming countries (China, Indonesia, India, the United States of America and Japan) rose to 59 percent. This concentration reflects the emergence of major players such as China, which on its own, consumed 36 percent of all aquatic foods available for food consumption in 2019.

7.2 Per capita consumption of aquatic foods

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

Despite a few exceptions, of which the most notable is Japan, most countries saw a rise in their aquatic food consumption per capita during the period 1961–2019. However, the rate of change across countries was highly variable with upper-middle-income countries experiencing the strongest annual growth (3.2 percent). Among these, China was the main driver for growth also due to its major expansion in fisheries and aquaculture production24 and increase in population. In 2019, China's population accounted for 56 percent of the total population of all upper-middle-income countries. In China, per capita consumption grew from 4.2 kg in 1961 to 40.1 kg in 2019.

Lower-middle-income countries experienced slower annual growth (1.9 percent), but this was still higher than high-income countries (0.5 percent). The moderate growth observed in high-income countries mainly reflects already high levels of consumption of aquatic foods.

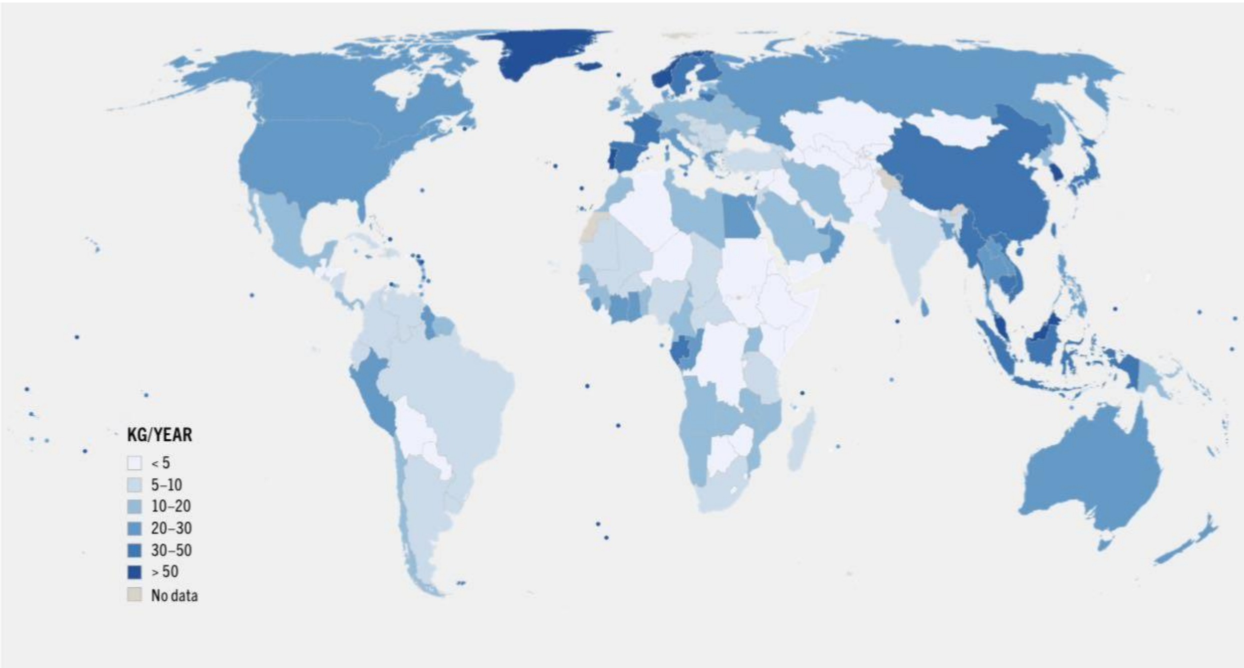
Low-income countries experienced a negative growth, decreasing by 0.2 percent per year over the period 1961–2019. In addition to a high variability in the growth rates, huge differences exist in aquatic food consumption per capita among countries.

The quantities consumed vary between countries, reflecting the different levels of availability of both aquatic and other foods (including proximity and access to aquaculture facilities, fish landings and markets), as well as differences in price, income level, nutrition consciousness, food traditions and consumer preferences. It is important to note that differences also exist within countries, with higher consumption levels generally occurring in coastal areas.

In 2019, of the 227 countries for which FAO estimated the per capita consumption of aquatic foods, 133 countries were below the world average and 94 countries above. In terms of population, those countries consuming less than the world average accounted for 54 percent of the world population in 2019. The countries where consumption is highest include Iceland, the Faroe Islands and Maldives, which consume over 80 kg of aquatic foods per capita per year (Figure 7.2). This is in stark contrast to countries consuming under 1 kg per capita per year, such as Afghanistan, Tajikistan and Ethiopia.

In 2019, the world average per capita consumption was 20.5 kg. This varied from an average of 5.4 kg in low-income countries, to 15.2 kg in lower-middle-income countries, 28.1 kg in upper-middle-income countries and 26.5 kg in high-income countries. However, if China is not included, the average consumption of upper-middle-income countries drops to 13.0 kg per capita.

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



SOURCE: FAO.

Figure 7.2 – Apparent aquatic food consumption per capita, average 2017–2019

These include: high population growth, which in most cases outpaces the growth of capture fisheries production; the relatively small aquaculture sector, which reduces the potential for increasing production in the near future; poor landing, road and market infrastructures, which limit the movement of good quality aquatic products across borders within the continent; and high post-harvest losses due to underdeveloped cold chains.

Moreover, as described in the section Fisheries and aquaculture projections, the situation is expected to worsen in Africa, with consumption per capita projected to decline in the next ten years. Were this to occur, it would represent a serious threat in terms of food security given the high prevalence of undernourishment in the region and the key role played by aquatic foods in terms of contribution to total intake of animal proteins across many African countries.

7.3 Nutritional and environmental benefits of aquatic food consumption

Aquatic foods are important for a healthy and balanced diet. Even small quantities of aquatic foods can have a significant positive nutritional impact by providing essential nutrients that are scarce in plant-based diets. Aquatic foods provide high-quality proteins and essential amino acids, vitamins (particularly A, B and D), phosphorus, and minerals such as iron, calcium, zinc, iodine, magnesium, potassium and selenium, and are a primary dietary source of heart-healthy omega-3 fatty acids. Depending on the species, aquatic foods can provide varying levels of nutrients.

The most significant difference is fat content: species such as sardines, salmon and tuna are considered fatty, while cod and catfish are lean. The two omega-3 fatty acids found in aquatic species are acid (EPA) and docosahexaenoic acid (DHA). The human body does not produce omega-3 fatty acids so they must be sourced through food. Omega-3 fatty acids are found in every kind of aquatic food, but are especially high in fatty species. Regular consumption of aquatic food helps maintain a healthy heart by lowering blood pressure and reduces the risk of stroke, depression, Alzheimer’s disease, and other chronic conditions. Controlled trials and observational studies demonstrated that the omega-3 fatty acids in aquatic food are important for optimal development of a baby’s brain and nervous system, and that the children of women who consume lower amounts of aquatic food or omega-3s during pregnancy and breastfeeding have evidence of delayed brain development.

Many non-high-income countries, including some SIDS, rely on subsistence fishing as a key source of food. Kiribati is a good example: the country is a SIDS yet has one of the highest levels of per capita consumption of aquatic foods worldwide.

For these countries, proteins sourced from aquatic foods are essential in the diet, particularly when the total protein intake is low. In addition, the share of proteins from aquatic foods in the diet of non-high-income countries tends to be greater than in the diet of high-income countries. This reflects the fact that aquatic foods often represent an affordable source of animal protein, cheaper and more accessible than other animal protein sources, highly preferred and part of culinary traditions.

In 2019, aquatic food consumption per capita was much lower in low-income countries than in high-income countries. However, aquatic foods contributed to a greater share of animal protein intake in low-income countries than in high-income countries.

Globally, aquatic foods provided about 17 percent of animal proteins and 7 percent of all proteins in 2019. In the same year in low-income countries, they provided 17 percent of animal proteins, in lower-middle-income countries 23 percent, in upper-middle-income countries 17 percent and in high-income countries 13 percent. Moreover, for 3.3 billion people, aquatic foods provided at least 20 percent of the average per capita intake of animal protein. In Cambodia, Sierra Leone, Bangladesh, Indonesia, Ghana, Mozambique and some SIDS, aquatic foods contributed 50 percent or more of total animal protein intake.

7.4 Trade and access to aquatic foods

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

For example, in Uganda, imports of aquatic products accounted for only 1 percent of total consumption of aquatic foods in 2019. The bulk of its supply is sourced from domestic production, mainly from freshwater sardines, perches and tilapias fished or farmed in Lake Victoria.

7.5 Fish consumption

For over 60 years, global apparent food fish consumption12 has increased at a rate significantly above that of world population growth. In the period 1961–2017, the average annual growth rate of total food fish consumption was 3.1 percent, outpacing annual population growth rate (1.6 percent). In the same period, the average annual growth rate of total food fish consumption also outpaced that of all other animal proteins (meat, eggs, milk, etc.), which increased at an average of 2.1 percent per year, and of all terrestrial meat combined (2.7 percent per year) or by individual groups (meat of bovine, mutton and goat, pig), with the notable exception of poultry, which grew at 4.7 percent per year.

In per capita terms, food fish consumption rose from 9.0 kg (live weight equivalent) in 1961 to 20.3 kg in 2017, at an average rate of about 1.5 percent per year, while total meat consumption grew by 1.1 percent per year in the same period. Preliminary estimates for per capita fish consumption in 2018 currently stand at 20.5 kg.

The expansion in consumption has been driven not only by increases in production, but also by a combination of many other factors. These include: technological developments in processing, cold chain, shipping and distribution; rising incomes worldwide, which strongly correlate with increased demand for fish and fish products; reductions in loss and waste; and increased awareness of the health benefits of fish among consumers.

Given the wide diversity of aquatic life, the nutritional composition of fish varies significantly according to species and the way in which they are processed and marketed. Although they are not calorie dense, fish and fish products are appreciated and important for their high-quality proteins and essential amino acids, PUFAs and micronutrients, such as vitamins and minerals.

Fish provided an average of only about 35 calories per capita per day in 2017, exceeding 100 calories per capita per day in countries where a preference for fish has developed and endured traditionally (e.g. Iceland, Japan, Norway and the Republic of Korea) and where alternative proteins are not easily accessible (e.g. the Faroe Islands, Greenland, and several small island developing States [SIDS] such as the Cook Islands, Kiribati, Maldives and Tokelau).

The dietary contribution of fish is more significant in terms of high-quality animal proteins, PUFAs and micronutrients of fundamental importance for diversified and healthy diets. Fish proteins are essential in the diet of some densely populated countries where the total protein intake is low, particularly in SIDS. For these populations, fish often represents an affordable source of animal protein that may not only be cheaper than other animal protein sources, but preferred and part of local and traditional recipes.

In 2017, fish accounted for about 17 percent of total animal protein, and 7 percent of all proteins, consumed globally. Moreover, fish provided about 3.3 billion people with almost 20 percent of their average per capita intake of animal protein.

In Bangladesh, Cambodia, the Gambia, Ghana, Indonesia, Sierra Leone, Sri Lanka and some SIDS, fish contributed 50 percent or more of total animal protein intake. Average daily consumption of total fat supplied by fish is also relatively low, at about 1.2 g per capita, but fish is an important source of healthy long-chain omega-3 fatty acids, essential amino acids, vitamins (particularly A, B and D) and minerals such as iron, calcium, zinc and selenium.

This unique nutritional composition means that fish represents a valuable source for healthy dietary diversification, even in relatively small quantities. This is more important for many low-income food-deficit countries (LIFDCs) and least developed countries (LDCs), where populations may be overly dependent on a relatively narrow selection of staple foods, which cannot provide adequate amounts of essential amino acids, vitamins, micronutrients and healthy fats. According to the 2019 edition of The State of Food Security and Nutrition in the World about 11 percent (more than 820 million people) of the world's population remain undernourished, up from 10.6 percent in 2015.

While, in absolute terms, the majority of undernourished people are located in South Asia, in Africa, and in particular in sub-Saharan Africa, this indicator has been pointing to deteriorating global food security. This is due to many factors, including the pressure of increasing population, conflicts and instability, income inequalities, poverty and ineffective nutritional policies. At the same time, progress towards World Health Organization global malnutrition reduction targets for 2030, now aligned with the timeline of the SDGs, in particular of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture), has also been slower than hoped.

Notably, some malnutrition problems such as anaemia in women of reproductive age and prevalence of obesity, including in children, are following an upward trend at the global level. Excessive consumption of sugar-rich, high-fat foods and their negative health impact is a growing problem in many countries, both developing and developed.

Increased consumption of fish, with its diverse and valuable nutritional attributes, can directly reduce the prevalence of malnutrition and correct imbalanced high-calorie and low-micronutrient diets.

This requires the adoption of proper nutrition policies to increase fish consumption and addresses many of the most severe and widespread nutritional deficiencies in the developing world, in particular deficiencies of iron, iodine, vitamin A and zinc. Full nutritional benefits can result from the consumption of the entire fish of small species, as their head, bones and skin are rich in micronutrients.

This also helps to reduce waste and enhance global food security. Beyond meeting basic nutritional requirements, studies have also identified multiple health benefits associated with regular consumption of fish. For pregnant women and very young children in particular, fish consumption contributes to cognitive development during the most crucial stages of an unborn or young child's growth (the first most critical 1 000 days). In addition, there is evidence of beneficial effects of fish consumption on mental health and prevention of cardiovascular diseases, stroke and age-related macular degeneration. Global data on fish consumption hide considerable regional variation both between and within countries.

Annual per capita fish consumption varies from less than 1 kg to more than 100 kg because of the influence of cultural, economic and geographical factors, including the proximity and access to fish landings and aquaculture facilities. To a large extent, this explains why island nations such as Iceland, Kiribati, Maldives and several SIDS continue to record levels of fish consumption that are in some cases hundreds of times higher than many landlocked States such as Ethiopia, Mongolia and Tajikistan.

These inland countries still consume less than 1 kg of fish despite the fact that advances in logistics and supply chain infrastructure have made it progressively easier to access fish products harvested and processed thousands of kilometers away. Differences in income levels represent another important factor underlying differences in fish consumption, as do the availability and price of substitutable proteins. Other determinants include climate, market penetration, regional demographic characteristics, as well as the density and quality of transportation and distribution infrastructure.

Despite persistent differences in levels of fish consumption between world regions and between individual States, some clear trends can nevertheless be identified. In developed countries, annual apparent fish consumption increased from 17.4 kg per capita in 1961 to peak at 26.4 kg per capita in 2007, and gradually decline in the following years to 24.4 kg in 2017.

In developing countries, the corresponding value is lower, although it grew significantly from 5.2 kg in 1961 to 19.4 kg in 2017, at an average annual rate of 2.4 percent. Among these, the LDCs, most of which are located on Africa, increased their annual per capita fish consumption from 6.1 kg in 1961 to 12.6 kg in 2017, at an average annual rate of 1.3 percent.

This growth rate has increased significantly in the last 20 years, reaching an average of 2.9 percent per year, explained primarily by the expansion of fish production and imports, in particular of small pelagic species, by a number of African States. In LIFDCs, where annual per capita fish consumption increased from 4.0 kg in 1961 to 9.3 kg in 2017, the growth rate has remained approximately stable at some 1.5 percent.

Despite their relatively lower levels of fish consumption, consumers in developing countries record a higher share of fish protein in total animal proteins in their diets than do those in developed countries. In 2017, fish consumption accounted for about 29 percent of animal protein intake in LDCs, 19 percent in other developing countries, and about 18 percent in LIFDCs. This share, although it has increased since 1961, has stagnated in recent years because of the growing consumption of other animal proteins.

The share of fish in animal protein intake grew consistently in developed countries, from 12.1 percent in 1961 to a peak of 13.9 percent in 1989, then decreased to 11.7 percent in 2017, while consumption of other animal proteins continued to increase. in 1961 to peak at 26.4 kg per capita in 2007, and gradually decline in the following years to 24.4 kg in 2017. In developing countries, the corresponding value is lower, although it grew significantly from 5.2 kg in 1961 to 19.4 kg in 2017, at an average annual rate of 2.4 percent.

Among these, the LDCs, most of which are located on Africa, increased their annual per capita fish consumption from 6.1 kg in 1961 to 12.6 kg in 2017, at an average annual rate of 1.3 percent. This growth rate has increased significantly in the last 20 years, reaching an average of 2.9 percent per year, explained primarily by the expansion of fish production and imports, in particular of small pelagic species, by a number of African States. In LIFDCs, where annual per capita fish consumption increased from 4.0 kg in 1961 to 9.3 kg in 2017, the growth rate has remained approximately stable at some 1.5 percent. Despite their relatively lower levels of fish consumption, consumers in developing countries record a higher share of fish protein in total animal proteins in their diets than do those in developed countries.

In 2017, fish consumption accounted for about 29 percent of animal protein intake in LDCs, 19 percent in other developing countries, and about 18 percent in LIFDCs. This share, although it has increased since 1961, has stagnated in recent years because of the growing consumption of other animal proteins. The share of fish in animal protein intake grew consistently in developed countries, from 12.1 percent in 1961 to a peak of 13.9 percent in 1989, then decreased to 11.7 percent in 2017, while consumption of other animal proteins continued to increase.

Moreover, low income levels contribute to low fish consumption, as do inadequate landing, storage and processing infrastructure and the lack of marketing and distribution channels necessary to commercialize fish products. However, it should be stressed that in Africa actual values are probably higher than indicated by official statistics, in view of the under-recorded contribution of subsistence fisheries, some small-scale fisheries and informal cross-border trade.

The broad trends that have driven growth in global fish consumption in recent decades have been paralleled by many fundamental changes in the ways consumers choose, purchase, prepare and consume fish products. The globalization of fish and fish products, propelled by increased trade liberalization and facilitated by advances in food processing and transportation technologies, has expanded supply chains to the point where a given fish may be harvested in one country, processed in another and consumed in yet another. International trade has helped to reduce the impact of geographical location and limited domestic production, broadening the markets for many species and offering wider choices to consumers.

Imports make up a substantial and increasing portion of fish consumed in Europe and North America (about 70–80 percent) and Africa (35 percent in 2017, down from over 40 percent in previous years) because of solid demand, including that for non-locally produced species, in the face of static or declining domestic fish production.

This development has allowed consumers to access species of fish that are caught or farmed in regions far from their point of purchase, and it has introduced new species and products to what were previously only local or regional markets.

Although the choices available to an individual consumer have multiplied, at the global level they are increasingly similar among countries and regions. Seasonal shortages of individual species in certain markets are also mitigated to some extent by the international diversification of supply sources and advances in preservation technologies. As a result, major supply shocks affecting key species are likely to affect consumption for a greater number of people in more geographically dispersed markets.

Increasing consumer awareness of sustainability, legality, safety and quality issues is driving demand for traceability systems and certification schemes of a growing range of fish and fish products. Urbanization has also shaped the nature and extent of fish consumption in many countries. Since 2007, the urban population has accounted for more than half of the world's people, and it continues to grow. The number of megacities (cities with more than 10 million inhabitants) reached 33 in 2018, of which more than 15 are in developing countries.

Urban inhabitants typically have more disposable income to spend on animal proteins such as fish, and they eat away from home more often. In addition, the infrastructure available in urban areas allows for more efficient storage, distribution and marketing of fish and fish products. Hypermarkets and supermarkets are developing rapidly throughout Africa, Asia and Latin America, and fish products are increasingly sold through these channels as opposed to traditional fishmongers and fish markets.

At the same time, the ease of food preparation represents an increasingly important consideration for urban dwellers with fast-paced lifestyles and higher demands on their time. As a result, the demand for fish products prepared and marketed for convenience, through both retail and fast-food services, is rapidly increasing.

The dietary preferences of modern urban consumers are also characterized by an emphasis on healthy living and a relatively high interest in the origin of the foods they eat – trends likely to continue to influence fish consumption patterns in both traditional and emerging markets.

Although fish producers and marketers can maintain a degree of responsiveness to the evolution of consumer preferences, natural resource availability and biological considerations are key in determining which species and products are made available to consumers. Significant expansion of aquaculture since the mid-1980s has resulted in a sharp increase in the proportion of farmed fish consumed relative to wild-caught alternatives, even if differences exist among countries and regions in terms of preference, with a higher share of farmed fish being consumed by Asian countries, the main producers.

At the global level, since 2016, aquaculture has been the main source of fish available for human consumption, a remarkable increase considering that this share was only 4 percent in 1950, 9 percent in 1980 and 19 percent in 1990.

In 2018, this share was 52 percent, a figure that can be expected to continue to increase in the long term. It is also important to mention that these figures do not refer to the quantity effectively eaten. If the edible amount is taken into account (e.g. excluding shells and other inedible parts, which can differ also according to traditions), capture fisheries should be still the main source of the fish eaten due to the higher share of farmed bivalves and crustaceans compared with wild ones, but the gap is narrowing. The dominance of aquaculture in global fish markets has significant implications for fish distribution and consumption.

Fish farming allows greater control over production processes than do capture fisheries, and it is more conducive to vertical and horizontal integration in production and supply chains.

As a result, aquaculture has expanded fish availability to regions and countries with otherwise limited or no access to the cultured species, often at cheaper prices, leading to improved nutrition and food security. The expansion in aquaculture production, especially for species such as shrimps, salmon, bivalves, tilapia, carp and catfish, has resulted in a steady increase in the rates of per capita consumption of these species groups in recent years.

From 1990, at the start of the expansion in aquaculture production, average annual growth rates of per capita consumption up to 2017 were most significant for freshwater and diadromous fish (3.9 percent), crustaceans (2.9 percent) and molluscs, excluding cephalopods (2.7 percent). Meanwhile, species categories comprised mainly of wild fish (cephalopods, pelagic fish, demersal fish and other marine fish) saw zero or negative growth in the same period, with the exception of cephalopods, for which per capita consumption increased slightly at an average annual growth rate of 0.1 percent in the period 1990–2017.

In 2017, more than two-thirds of the fish consumed were finfish. However, since 1961 the share of total finfish (freshwater and marine) in total food fish supply has decreased from 86 percent to 74 percent. This is mainly due to decline in the share of marine fish (from 69 percent to 34 percent), the increase in that of freshwater and diadromous fish (from 17 percent to 40 percent), crustaceans (from 5 percent to 10 percent) and molluscs, excluding cephalopods (from 7 percent to 13 percent) in the period 1961–2017.

The main group of species consumed in 2017 were freshwater and diadromous fish, at 8.1 kg per capita, followed by pelagic fish (3.1 kg), molluscs, excluding cephalopods (2.6 kg), crustaceans (2.0 kg), demersal fish (2.8 kg), other marine fish (1.0 kg), cephalopods (0.5 kg) and other aquatic animals and invertebrates (0.2 kg).

It should be noted that the same calculation done using values instead of volumes would be significantly different, as a large proportion of freshwater species are of low value, e.g. carp, whereas crustaceans such as shrimps and lobsters, for example, are much more expensive. Seaweeds and other aquatic plants, the majority being farmed, are not currently included in the FBS, but they are important components of national cuisines in many parts of Asia, in particular East Asia.

Cultivated species include red seaweed nori (*Pyropia and Porphyra species*), used to wrap sushi, Japanese kelp (*Laminaria japonica*), which is a popular snack in East Asia in dried or pickled form, and Eucheuma seaweeds used for food processing as well as an ingredient in cosmetics. Seaweeds contain micronutrient minerals (e.g. iron, calcium, iodine, potassium and selenium) and vitamins (particularly A, C and B-12) and are the only non-fish sources of natural omega-3 long-chain fatty acids.

FAO food balance sheets of fish and fish products. The FAO Food Balance Sheets (FBS) present a comprehensive and consolidated methodological approach to assess the pattern of a country's food supply and its utilization on an annual basis. The compilation of the FBS, according to FAO's current methodology, is a statistical exercise drawing together data from various sectors on the basis of information available on an annual basis.

Fish and fish products contained in the FBS do not represent individual commodities, but the aggregation of different species and products. About 2 400 species produced and 1 000 items traded are conveyed into eight main groups of similar biological characteristic, reflecting FAO's International Standard Statistical Classification of Aquatic Animals and Plants.

Products are then balanced according to the following equation, valid for each series of primary and processed fishery commodities, prepared on a calendar-year and country-by-country basis: domestic production (capture fisheries and aquaculture), minus non-food uses (including amount used for reduction into fishmeal and fish oil and other non-food uses), minus food fish exports, plus food fish imports, plus or minus variation in stocks Specific food composition factors are then applied to the related supply of each product type in order to obtain calories, proteins and fats.

In order to have data-comparable statistics in homogeneous units applicable to all countries in the world, data are then converted into primary equivalent (live weight equivalent, i.e. the weight of the fish at the time of harvest) using specific technical conversion factors.

The result corresponds to total apparent food fish consumption, which can be expressed in per capita terms when divided by population on a country-by-country basis. In analyzing FBS data, it is important to consider that they refer to "average food available for human consumption" and not to the amount effectively eaten. The latter can only be monitored through other types of analysis and surveys, such as household surveys or individual food consumption surveys. Moreover, data for production from subsistence and recreational fisheries, as well as for cross-border trade between some developing countries, may be incomplete, which may lead to underestimation of consumption.

Questions for self-testing

1. What are the main trends in aquatic food consumption?
2. What are the nutritional and environmental benefits of consuming aquatic food?

8 FISHERIES AND AQUACULTURE PROJECTIONS

This section presents the medium-term outlook using the FAO fish model (FAO, 2012), developed in 2010 to shed light on potential future developments in fisheries and aquaculture. The fish model has links to, but is not integrated into, the Aglink - Cosimo model used to generate the ten-year-horizon agricultural projections elaborated jointly by the OECD and FAO each year and published in the OECD-FAO Agricultural Outlook. The FAO fish model uses a set of macroeconomic assumptions and selected prices used to generate the agricultural projections. The fish projections presented in this section have been obtained through an ad hoc analysis carried out by FAO for the years 2019–2030.

The future of fisheries and aquaculture will be influenced by many different factors and interconnected challenges of global, regional and local relevance. Population and economic growth, together with urbanization, technological developments and dietary diversification, are expected to create an expansion in food demand, and in particular for animal products, including fish. The projections illustrated in this section depict an outlook for fisheries and aquaculture in terms of projected production, utilization, trade, prices and key issues that might influence future supply and demand.

These results are not forecasts, but rather plausible scenarios that provide insight into how these sectors may develop in the light of a set of specific assumptions regarding: the future macroeconomic environment; international trade rules and tariffs; the frequency and effects of events on resources; the absence of other severe climate effects such as tsunamis, tropical storms (cyclones, hurricanes and typhoons), floods and emerging fish diseases; fisheries management measures, including catch limitations; and the absence of market shocks. In view of the major role of China in fisheries and aquaculture, the assumptions consider policy developments in China, which are expected to continue along the path outlined by its Thirteenth Five-Year Plan (2016–2020) towards more sustainable and environmentally friendly fisheries and aquaculture, away from the past emphasis on increasing production.

Production. On the basis of the assumptions used, total fish production (excluding aquatic plants) is expected to expand from 179 million tonnes in 2018 to 204 million tonnes in 2030. In absolute terms, the overall increase up to

2030 is 15 percent (26 million tonnes) over 2018, a slowdown compared with the 27 percent growth in the period 2007–2018. Aquaculture will continue to be the driving force behind the growth in global fish production, extending a decades-old trend.

Aquaculture production is projected to reach 109 million tonnes in 2030, an increase of 32 percent (26 million tonnes) over 2018. Yet, the average annual growth rate of aquaculture should slow from 4.6 percent in 2007–2018 to 2.3 percent in 2019–2030. A number of factors should contribute to this slowdown.

These include: broader adoption and enforcement of environmental regulations; reduced availability of water and suitable production locations; increasing outbreaks of aquatic animal diseases related to intensive production practices; and decreasing aquaculture productivity gains. The projected deceleration of China's aquaculture production is expected to be partially compensated by an increase in production in other countries. As initiated with China's Thirteenth Five-Year Plan (2016–2020), the country's policies in the next decade are expected to continue the transition from extensive to intensive aquaculture, aiming to better integrate production with the environment through the adoption of ecologically sound technological innovations, with capacity reduction, followed by faster growth.

However, the share of farmed species in global fishery production (for food and non-food uses), is projected to grow from 46 percent in 2018 to 53 percent in 2030. Asia will continue to dominate the aquaculture sector and will be responsible for more than 89 percent of the increase in production by 2030, making the continent account for 89 percent of 2030 global aquaculture production.

While China will remain the world's leading producer, its share in total production will decrease from 58 percent in 2018 to 56 percent in 2030. Overall, aquaculture production is projected to continue growing on all continents, with variations in the range of species and products across countries and regions. The sector is expected to expand most in Africa (up 48 percent) and in Latin America (up 33 percent). The growth in Africa's aquaculture production will be driven by the additional culturing capacity put in place in recent years, as well asby local policies promoting aquaculture fuelled by rising local demand from higher economic growth.

However, despite this expected growth, overall aquaculture production in Africa will remain limited, at slightly more than 3.2 million tonnes in 2030, with the bulk of it (2.2 million tonnes) produced by Egypt. In terms of species, the majority (62 percent) of global aquaculture production in 2030 will be composed of freshwater species, such as carp and Pangas catfish (including *Pangasius spp*.), as compared with 60 percent in 2018. Production of higher-value species, such as shrimps, salmon and trout, is also projected to continue to grow. In general, species that require larger proportions of fishmeal and fish oil in their diets are expected to grow more slowly owing to expected higher prices and reduced availability of fishmeal. Capture fisheries production is projected to stay at high levels, reaching about 96 million tonnes in 2030, with some fluctuations over the next decade linked to the El Niño phenomenon with reduced catches in South America, especially for anchoveta, resulting in an overall decrease in world capture fisheries production of about 2 percent in those years.

Factors influencing sustained capture fisheries production include: (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 under fished resources, where new fishing opportunities exist or where fisheries management measures are less restrictive; and (iii) improved utilization of the harvest, including reduced onboard discards, waste and losses as driven by legislation or higher market fish prices, both for food and non-food products. The projections also include a 9 percent decrease in capture fisheries in China, owing to the implementation of the policies that started with the above-mentioned Thirteenth Five-Year Plan (2016–2020), and are expected to continue into the next decade. For capture fisheries, China’s policies aim to reduce its domestic catches through controls on licensing, reduction in the number of fishers and fishing vessels, and output controls.

Other objectives include: the modernization of gear, vessels and infrastructure; regular reduction of fuel subsidies; elimination of IUU fishing; and restoration of domestic fish stocks through the use of restocking, artificial reefs and seasonal closures. However, it should be noted that the current policies also point to developing the country’s distant-water fleet, which might partly offset reductions in its domestic catches. The share of capture fisheries production reduced into fishmeal and fish oil should decline slightly in the next decade (18 percent by 2030 compared with 19 percent in 2018). However, in 2030, the total amount of fishmeal and fish oil produced is expected to be higher than in 2018, by 1 percent and 7 percent, respectively, owing to an increased amount of the production being obtained from fish waste and by-products of the processing industry. Between 2018 and 2030, the proportion of total fish oil obtained from fish waste is projected to increase from 40 percent to 45 percent, while for fishmeal this proportion will grow from 22 percent to 28 percent.

Prices. In nominal terms, prices in the fishery and aquaculture sector are expected to rise in the long term up to 2030. A number of factors explain this tendency. On the demand side, these include improved income, population growth and higher meat prices. On the supply side, stable capture fisheries production, slowing growth in aquaculture production, and cost increase for inputs (feed, energy and oil) are likely to play a role. In addition, the slowdown in China's fisheries and aquaculture production will stimulate higher prices in China, with repercussions on world prices.

The increase in the average price of farmed fish (24 percent over the projection period) will be greater than that of captured fish (23 percent, when excluding fish for non-food uses). Prices of farmed fish will also grow owing to higher fishmeal and fish oil prices, which are expected to increase by 30 percent and 13 percent, respectively, in nominal terms by 2030, as a result of strong global demand.

High feed prices could also have an impact on the species composition in aquaculture, with a shift towards species requiring less feed, cheaper feed, or no feed at all. The higher prices at the production level, coupled with high demand of fish for human consumption, will stimulate an estimated 22 percent increase in the average price of internationally traded fish by 2030 relative to 2018.

However, in real terms (i.e. adjusted for inflation), all average prices are expected to decline slightly over the projection period, while remaining relatively high. For individual fishery commodities, price volatility could be more pronounced as a result of supply or demand fluctuations. Moreover, because aquaculture is expected to represent a higher share of world fish supply, it could have a stronger impact on price formation in national and international fish markets.

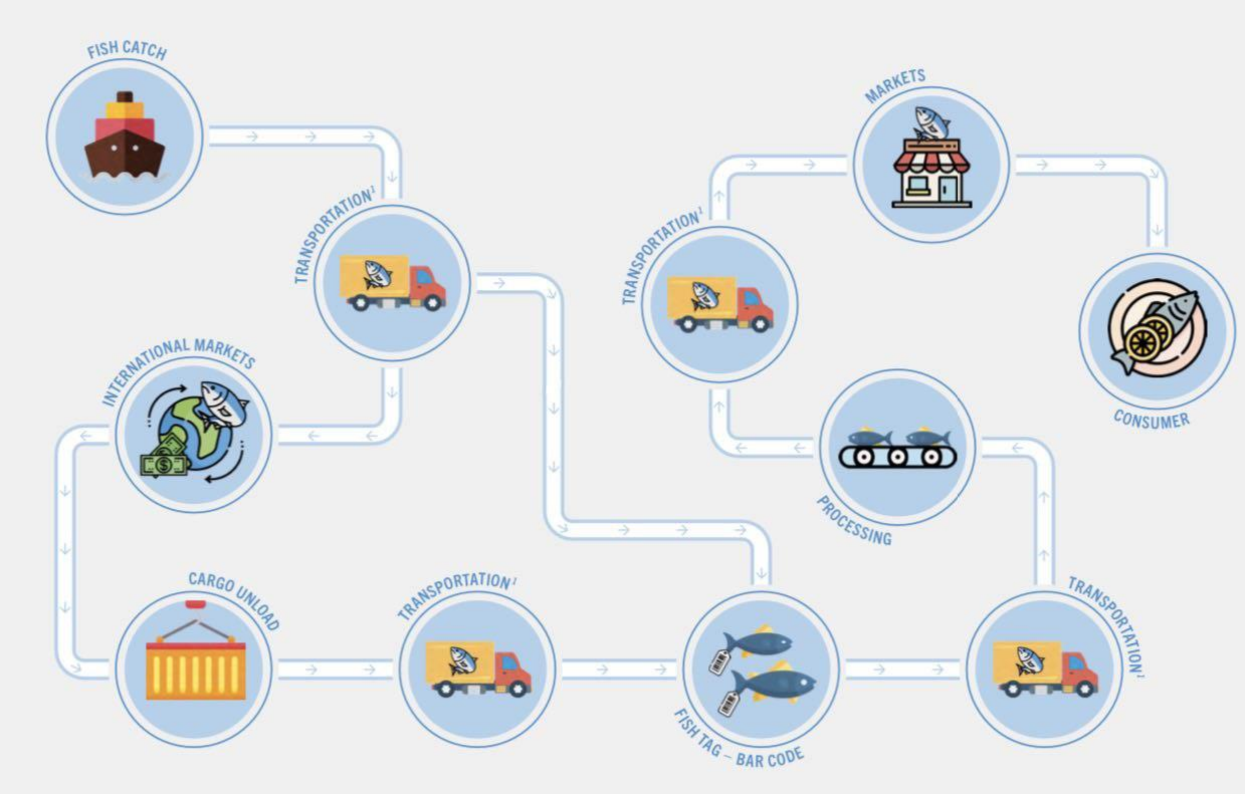
Consumption. The share of fish production destined for human consumption is expected to continue to grow, reaching 89 percent by 2030. The main factors behind this increase will be a combination of high demand resulting from rising incomes and urbanization, linked with the expansion of fish production, improvements in post-harvest methods and distribution channels expanding the commercialization of fish. Demand will also be stimulated by changes in dietary trends, pointing towards more variety in the typology of food consumed, and a greater focus on better health, nutrition and diet, with fish playing a key role in this regard. World food fish30 consumption in 2030 is projected to be 18 percent (28 million tonnes live weight equivalent) higher than in 2018.

Overall, its average annual growth rate will be slower in the projection period (1.4 percent) than in the period 2007–2018 (2.6 percent), mainly because of reduced production growth, higher fish prices and a deceleration in population growth. About 71 percent of the world's fish available for human consumption in 2030 (183 million tonnes) will be consumed in Asia, while the lowest quantities will be consumed in Oceania and Latin America.

In per capita terms, world fish consumption is projected to reach 21.5 kg in 2030, up from 20.5 kg in 2018. However, the average annual growth rate of per capita food fish consumption will decline from 1.3 percent in 2007–2018 to 0.4 percent in 2019–2030. Per capita fish consumption will increase in all regions except Africa (with a decline of 3 percent). The highest growth rates are projected for Asia (9 percent), Europe (7 percent), and Latin America and Oceania (6 percent each). Despite these regional trends, the overall tendencies in quantities and variety of fish consumed will vary among and within countries. In 2030, about 59 percent of the fish available for human consumption is expected to originate from aquaculture production, up from 52 percent in 2018 (Figure 8.1).

Farmed fish will continue to meet the demand for, and consumption of, species that have shifted from being primarily wild-caught to being primarily aquaculture-produced. In Africa, per capita fish consumption is expected to decrease slightly by 0.2 percent per year up to 2030, declining from 10.0 kg in 2018 to 9.8 kg in 2030. The decline will be greater in sub-Saharan Africa (from 8.9 kg to 8.1 kg in the same period).

The main reason for this decline is the growth of Africa's population outpacing the growth in supply. Increasing domestic production (by 13 percent over the period 2019–2030) and higher fish imports will not be sufficient to meet the region's growing demand. The share of imports of fish for human consumption in total food fish supply is expected to grow from 37 percent in 2018 to 40 percent in 2030. However, this increase, together with the expansion of aquaculture production (by 48 percent in 2030 compared with 2018) and capture fisheries production (by 5 percent), will only partially compensate for the population growth. One of the few exceptions will be Egypt, as the country is expected to further increase its already substantial aquaculture production (up 42 percent in 2030 compared with 2018).



Note that other means of transportation – land, water and air – also exist.
NOTE: This infographic is a generic and simplified representation of a value chain and associated traceability, not containing all its linkages and related services. Traceability and value chains of aquatic products are a comprehensive, globalized and complex system.
SOURCE: FAO.

Figure 8.1 – Traceability in value chains of aquatic products: a simple representation

The projected decline in per capita fish consumption in Africa raises food-security concerns because of the region's high prevalence of undernourishment (FAO et al., 2019) and the importance of fish in total animal protein intake in many African countries.

The decline may also weaken the ability of more fish-dependent countries to meet nutrition targets (2.1 and 2.2) of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture).

Trade. Fish and fish products will continue to be highly traded. It is projected that about 36 percent of total fish production will be exported in 2030 in the form of various products for human consumption or non-edible goods. In quantity terms, world trade in fish for human consumption is expected to grow by 9 percent in the projection period, and to reach more than 54 million tonnes in live weight equivalent in 2030 and 47 million tonnes if trade within the European Union is excluded. Overall, the average annual growth rate of exports is projected to decline from 2 percent in 2007–2018 to 1 percent in 2019–2030.

This can be partly explained by: (i) the slower expansion of production; (ii) stronger domestic demand in some of the major producing and exporting countries, such as China; and (iii) rather high fish prices, which will restrain overall fish consumption.

Aquaculture will contribute to a growing share of international trade in fishery commodities for human consumption. China will continue to be the major exporter of fish for human consumption, followed by Viet Nam and Norway. The bulk of the growth in fish exports is projected to originate from Asia, which will account for about 73 percent of the additional exported volumes by 2030. Asia's share in total trade of fish for human consumption will increase from 48 percent in 2018 to 50 percent in 2030.

Advanced economies are expected to remain highly dependent on imports to meet their domestic demand. The European Union, Japan and the United States of America will account for 38 percent of total imports for food fish consumption in 2030, a slightly lower share than in 2018 (40 percent).

Summary of main outcomes from the projections. The following major trends for the period up to 2030 emerge from the analysis: „

1. World fish production, consumption and trade are expected to increase, but with a growth rate that will slow over time. „

2. In spite of reduced capture fisheries production in China, world capture production is projected to grow moderately owing to increased production in other areas if resources are properly managed. „

3. The world's growth in aquaculture production, despite its deceleration, is anticipated to fill the supply–demand gap. „

4. While prices will all increase in nominal terms, they should decline but remain high in real terms. „

5. Food fish supply will increase in all regions, while per capita fish consumption is expected to decline in Africa, in particular in sub-Saharan Africa, raising concerns in terms of food security.

6. Trade in fish and fish products is expected to increase more slowly than in the past decade, but the share of fish production that is exported is projected to remain stable. „

7. The new fisheries and aquaculture reforms and policies to be implemented by China as a continuation of its Thirteenth Five-Year Plan (2016–2020) are expected to have a noticeable impact at the world level, with changes in prices, output and consumption.

Main uncertainties. The projections presented in this section are based on a series of economic, policy and environmental assumptions. A shock to any of these variables would result in different fish projections. Many uncertainties and potential issues may arise over the projection period. In addition to the uncertainties caused by COVID-19, the projections reported here can be affected by the policy reforms in China and a multitude of other factors. The next decade is likely to see major changes in the natural environment, resource availability, macroeconomic conditions, international trade rules and tariffs, market characteristics and social conduct, which may affect production, markets and trade in the medium term. 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 fish and fish products, making countries more vulnerable to risks.

These risks can be exacerbated by: (i) poor governance causing environmental degradation and habitat destruction, leading to pressure on the resource bases, overfishing, IUU fishing, diseases and invasions by escapees and non-native species; and (ii) aquaculture issues associated with the accessibility and availability of sites and water resources and access to credit, seeds and expertise.

However, these risks can be mitigated through responsive and effective governance promoting stringent fisheries management regimes, responsible aquaculture growth and improvements in technology, innovations and research. In addition, market access requirements related to food safety, quality and traceability standards and product legality will continue to regulate international fish trade.

Questions for self-testing

1. What are the main trends for the period until 2030?
2. What are the forecasts for fisheries and aquaculture?

9 ILLUMINATING HIDDEN HARVESTS: THE CONTRIBUTION OF SMALL-SCALE FISHERIES TO SUSTAINABLE DEVELOPMENT

Illuminating Hidden Harvests (IHH) is a new global study into the contributions and impacts of small-scale fisheries in the context of sustainable development. With its release due in late 2020, the study has been led by FAO, Duke University and the CGIAR Research Program on Fish Agri-Food Systems led by World Fish. The Norwegian Agency for Development Cooperation, Swedish International Development Cooperation Agency, Oak Foundation and CGIAR Trust Fund have provided funding for the study.

The IHH study represents one of the most extensive efforts to compile available data and information on small-scale fisheries around the world. It aims to contribute evidence to inform global dialogues and policy-making processes to enable fishers, civil society organizations and NGOs to advocate for productive, sustainable and equitable small-scale fisheries.

9.1 Sustainable development and the contributions and impacts of small-scale fisheries

From roadside drainage channels in Southeast Asia, to the mega-deltas of the world's large river systems and the near shore waters of oceans and seas, small-scale fisheries play an important role. While small-scale fisheries can look very different in each of these contexts, they have in common that they provide livelihoods for millions, essential nutrition to billions, and contribute substantially to household, local and national economies and economic growth. It is estimated that small-scale fisheries provide 90 percent of the employment in the marine fisheries sector. Inland rivers, lakes and floodplains support even more fishers, processors and traders than do marine sectors, often as a crucial component of a complex and seasonally variable livelihood. In addition, small-scale fisheries are often culturally important to the identity of those involved, and can be central to coastal communities' social structures, cultural heritage and trade. However, owing to the highly diverse and dispersed nature of small-scale fisheries, quantifying and understanding their multiple contributions to and impacts on sustainable development is difficult.

As a result, despite at times impressive headline statistics, small-scale fisheries are too frequently marginalized in social, economic and political processes and not given due attention in policy. This invisibility is becoming increasingly problematic as growing pressure from outside the sector (e.g. through competition for coastal/marine space and aquatic resources, and impacts of climate change) and from within (e.g. rising fishing effort, limited investment in management, and expansion of certain types of conservation measures) and the costs of marginalization are increasingly apparent.

The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines) represent a global, highly participatory multi-stakeholder framework to redress this issue. The SSF Guidelines have the goal of supporting the development of small-scale fisheries and fishing communities through a human-rights-based approach to fisheries that is socially, economically and environmentally sustainable. Achieving this goal will require substantial support and collaboration from a variety of partners, including governments, small-scale fisheries organizations, development partners, research/ academia and NGOs.

A key element in building the case for this support is better illuminating the diverse contributions and impacts of these fisheries, and providing credible evidence in a way that communities and advocates can use to make a strong case for support to the sector, also supporting the achieving of the SDGs, in particular SDG Target 14.b on providing access for small-scale artisanal fishers to marine resources and markets.

The 2012 Hidden Harvest study was a first attempt to synthesize information on the diverse and misreported contributions of capture fisheries globally (World Bank, 2012). It produced detailed case studies from countries with important inland and marine small-scale fisheries, and used these to estimate global contributions. This synthesis produced some valuable estimates of the relative importance of large-scale and small-scale fisheries, including:

1. Millions of tonnes of fish from the small-scale fisheries are “hidden” – in the sense of being invisible and unreported – with the inland fisheries catch estimated to be underreported by about 70 percent.
2. Of the 120 million people who depend on capture fisheries, 116 million work in developing countries. Of these, more than 90 percent work in small-scale fisheries, and women are almost 50 percent of the workforce.
3. In developing countries, small-scale fisheries produce more than half the fish catch, and 90–95 percent of this is consumed locally in rural settings where poverty rates are high and good-quality nutrition is sorely needed.

4. Employment in small-scale fisheries is several times higher per tonne of harvest than in large-scale fisheries.

9.2 Shedding new light on hidden harvests

To support the growing momentum in implementing the SSF Guidelines – and in response to the SDGs – FAO, World Fish and Duke University have been working in partnership with experts globally to revisit and build on the initial Hidden Harvest study.

The IHH study is using a case study approach to engage with local expertise in priority countries that have substantial small-scale fisheries sectors or notable nutritional dependence on small-scale fisheries, both from marine and inland systems. A global synthesis will be built from country case study data, available global and regional datasets and responses to an FAO ad hoc questionnaire to all countries.

The IHH study seeks to reflect the need for more comprehensive approaches to sustainable development by expanding the scope of analysis compared with the 2012 Hidden Harvest study by also providing new synthesis on social and nutritional benefits, governance characteristics, and social differentiation in the flow of benefits from different fisheries sectors. A series of thematic studies will highlight available information on important themes, for example: gender, indigenous peoples and cultural identity.

Country case studies. The IHH study includes about 50 country case studies. The countries were chosen for the absolute importance (global level) and/or relative importance (country level) of their small-scale fisheries, considering fisheries production, estimated small-scale fisheries production, employment in fisheries, role of fish for food security, and geographical representation.

The case-study countries represent 76 percent of the global marine catch, 83 percent of the global small-scale fisheries catch, and 86 percent of marine fishers. For inland fisheries, the countries account for 89 percent of global inland catch and 96 percent of inland fishers and post-harvest workers. By continent, the breakdown of the case-study countries is: Africa, 26; Asia-Pacific, 18; America, 10; and Europe, 5.

National governments and fisheries institutions: With primary responsibility for policy and as central actors in fisheries management, government institutions are an important target group as well as collaborators in the IHH study. For case-study countries, the study is expected to offer expert synthesis of existing survey and research data that can provide new, policy-relevant understandings of the diverse contributions and impacts of the national inland and marine small-scale fisheries sectors. Fisheries administrations actively contribute to the IHH study by completing an FAO ad hoc survey on small-scale fisheries that will feed into both national case studies and global synthesis.

This survey includes specific questions about the small-scale fisheries sector and the availability of data. It also complements the existing section on small-scale fisheries of the FAO questionnaire on the implementation of the Code (see the section Progress on the road to sustainability) and related instruments. Small-scale fisheries advocates, in particular small-scale fisheries organizations: Small-scale fisheries organizations and related civil society organizations and NGOs supporting small-scale fisheries actors at the national, regional and international level are important voices in advocating for a productive, equitable and sustainable future for small-scale fisheries grounded in the principles of the SSF Guidelines.

The development of the IHH study includes engaging directly with these groups to understand information needs and the best approaches to presenting outcomes of the study in a way that more effectively supports the inclusion of small-scale fisheries in relevant processes within and beyond fisheries. Science and development communities: For both advocates and research partners in the sector, local contextual and high-level synthesized data and information on the contributions of small-scale fisheries are important in setting the priorities, direction and design of research.

Questions for self-testing

1. What are the social, environmental, economic and governance contributions and impacts of small-scale fisheries at the global and local scales?

What are the key drivers of change in these sectors, including both threats and opportunities?

10 AQUACULTURE BIOSECURITY

Disease emergence. Aquatic animal disease is one of the most serious constraints to the expansion and development of sustainable aquaculture. Globally, a trend in aquaculture is that a previously unreported pathogen that causes a new and unknown disease will emerge, spread rapidly, including across national borders, and cause major production losses approximately every three to five years. Such serious transboundary aquatic animal diseases are most often caused by viruses, but occasionally a bacterium or a parasite may be the causative agent.

A long time lapse (usually years) then ensues, from the time that a serious mortality event is observed in the field, to the subsequent identification and confirmation of its causative agent, to global awareness, and to the establishment and implementation of surveillance and reporting/notification systems and effective risk management measures.

In this regard, as stated in the previous edition of this publication, "a paradigm shift is needed in dealing with aquaculture biosecurity risks." By the time the pathogen has been identified and its host range determined, it may have already become widespread globally (including to wild populations), through the movement of live animals of uncertain health status, most often for aquaculture development.

In recent years, the understanding of the drivers for disease emergence in aquaculture has increased, and the factors and pathways involved can be grouped in four general categories, namely:

✓Trade and movement of live animals and their products: Fish, shrimp and other cultured aquatic animals (and aquatic plants) have become food commodities, traded globally as live aquatic organisms (e.g. eggs, larvae, fry and adults) and products (fresh, frozen, dried, salted and smoked), often in huge volumes. When adequate national biosecurity is lacking, pathogens (and invasive aquatic species) may be transferred at the same time.

✓ Knowledge of pathogens and their hosts: Due to their unique aquatic medium, the health of cultured populations of aquatic animals is not readily apparent. The large number of species reared under a variety of aquaculture systems (more than 600 species are farmed globally) means that knowledge on new diseases and the range of susceptible host species often lags behind aquaculture development. Moreover, there is often a slow collective awareness of new threats among relevant stakeholders and entities responsible for maintaining biosecurity. Basic knowledge on the pathogen (e.g. pathogenicity and transmission routes) and its host(s) (e.g. species, life stages infected, immunity and genetics) is often lacking, as are sensitive, specific, and rapid diagnostic tests for identification.

✓Aquatic animal health management: A lack (or insufficient number and quality) of institutional and technical capacities limits the application of effective biosecurity measures. Some of the more important ones are: (i) weak regulatory frameworks, enforcement and implementation of international standards and guidelines for biosecurity best practices; (ii) weak coordination between the multiple institutions involved in aquaculture production and aquatic animal health management (i.e. fisheries, aquaculture and veterinary authorities); (iii) a lack of adequate and well-implemented biosecurity strategies at the farm, sector and national levels; and (iv) absent or insufficient capacity for response to emergencies;

✓Ecosystem changes: Aquatic ecosystems are dynamic, changing through both direct human activity (dams, community expansion, pollution, shipping, tourism, new species introductions, etc.) and non-human impacts (climate change, hurricanes, algal blooms, etc.). In these evolving situations, achieving successful aquaculture is complicated by the physiology of the animals (e.g. poikilothermic constraints to adaptation), emergence of pathogens, and changing geographical ranges of wild stocks, and microbes and parasites as environmental factors change near the tolerance levels for hosts and disease agents.

The environmental, social and economic impacts of disease outbreaks in aquaculture are many, and can be very substantial. They can include: direct costs of lost production due to mortalities and slow growth; temporary or permanent closure of aquaculture facilities, causing loss of employment in aquaculture and related upstream and downstream industries; and decreased trade and loss of markets due to bans on exportation, and loss of domestic sales due to public concerns over the safety of consuming fish and shellfish (with spillover into capture fisheries).

A recent study (Shinn et al., 2018) estimated the economic losses in Thailand due to acute hepatopancreatic necrosis disease in the period 2010–2016 at USD 7.38 billion, with a further USD 4.2 billion in lost exports. Also for Thailand, losses due to Enterocytozoon hepatopenaei could be up to USD 180 million per year. According to the China Fisheries Statistics Yearbook, disease outbreaks caused a direct production loss to Chinese aquaculture of 205 000 tonnes, worth USD 401 million (CNY 2.6 billion), in 2018.

In the questionnaire for the Census of Aquaculture 2018 carried out by the Department of Agriculture in the United States of America, disease was listed ahead of all other causes of production losses. Biosecurity has been challenging the aquaculture sector for the last three decades.

Stakeholders from national competent authorities, producer and academic sectors, regional and international entities and development institutions as well as donors agree that actions need to be taken, and they have exerted great efforts in addressing biosecurity. However, very often, such actions have been reactive and costly because less-costly preventative approaches based on international biosecurity best practices have not been implemented.

Challenges and solutions. To assist its Members in supporting the goals of FAO's BGI, in particular that of promoting sustainable aquaculture development for food security and economic growth, the COFI Sub-Committee on Aquaculture endorsed the Progressive Management Pathway for Improving Aquaculture Biosecurity (PMP/AB) at its tenth session held in Trondheim, Norway, August 2019.

This new paradigm, introduced in The State of World Fisheries and Aquaculture 2018, focuses on building management capacity through combined bottom-up and top-down approaches with strong stakeholder engagement, leading to co-management of biosecurity and promotion of long-term commitment to risk management.

Using the PMP/AB platform, a participating country or enterprise may progress through four stages, as appropriate to its specific situation:

1. Biosecurity risks identified and defined.
2. Biosecurity systems developed and implemented.
3. Biosecurity and preparedness enhanced.
4. Sustainable biosecurity and health management systems established to support the national aquaculture sector.

As countries and aquaculture enterprises advance along the biosecurity pathway, the following outcomes can be expected: reduced burden of diseases; improved aquatic health at the farm and national levels; minimized global spread of diseases; optimized national socio-economic benefits from aquaculture; attraction of investment into aquaculture; and achievement of One Health goals. These outcomes will provide benefits at the enterprise, national, regional and global levels.

This process will include the development of PMP toolkits to support its implementation, for example: governance and national application guidelines; risk-based surveillance; decision trees for investigating aquatic animal (including plant) mortality events; emergency preparedness and response system audits; aquatic animal disease burden; public–private-sector partnerships; and biosecurity actions plans specific to farms and commodities (sectors).

Another milestone decision reached at the tenth session of the Sub-Committee on Aquaculture was the recommendation to COFI to consider the development, as part of FAO's global aquaculture sustainability programme, of a multidonor-assisted, long-term component on aquaculture biosecurity and its five pillars:

1. Strengthening disease prevention at the farm level through responsible fish farming (including reducing antimicrobial resistance in aquaculture and application of suitable alternatives to antimicrobials) and other science-based and technology-proven measures.

2. Improving aquaculture biosecurity governance through implementing the PMP/AB, enhancing interpretation and implementation of international standards and strengthening the One Health approach by bringing together state and non-state (producers and value chain stakeholders) actors, international and regional organizations, and research, academic, donor and financial institutions to design and implement mandated biosecurity measures.

3. Expanding understanding of aquaculture health economics (burden and investments).

4. Enhancing emergency preparedness (early warning and forecasting tools, early detection, and early response) at all levels.

5. Actively supporting Pillars 1–4 with several cross-cutting issues such as capacity and competence development, disease intelligence and risk communication, education and extension, targeted research and development and innovation.

The PMP/AB emphasizes the need to understand aquaculture health economics (burden and investments, costs and benefits). With respect to Pillar 3, FAO is collaborating with the University of Liverpool and partners to address diseases in aquaculture within the Global Burden of Animal Diseases programme. This programme, coupled with guidance for the estimation of losses due to aquatic diseases, is expected to support more consistent and accurate estimates of the cost of diseases at the national, regional and global levels. This information will demonstrate the potential economic benefits to be gained by implementing the PMP/AB.

The need for long-term biosecurity management strategies, including implementation of international standards on aquatic animal health of the World Organization for Animal Health, has long been emphasized, including in the previous edition of this publication.

Among such strategies, the mandatory development of domesticated, specific pathogen-free (SPF) stocks for aquaculture species targeted for sustainable industrial production is becoming essential. It is now timely to optimize the use of SPF stocks. While the use of SPF shrimp stocks varies greatly between regions and farming practices, evidence is increasingly showing that they have reduced the introduction of pathogens and disease expression in farms, and provided a means for the safe introduction of Penaeus vannamei around the world – the species of choice and the dominant species in shrimp farming. Moreover, SPF shrimp has become an important asset in laboratory-based studies such as disease challenges and other nutritional and biochemical studies.

The use of infected bloodstock perpetuates disease problems all along the production cycle.

In conclusion, to meet the ever-growing demand for fish and seafood for human consumption, aquaculture systems must become more efficient by increasing production and profitability through prevention and long-term biosecurity management strategies that can greatly reduce the economic and environmental losses caused by diseases.

Creating healthy and resilient hosts through good biosecurity – in combination with good genetics and nutrition – is needed for a maturing aquaculture industry. It is now time to pursue multi-stakeholder commitment and multidonor support towards a coherent, cooperative and coordinated aquaculture biosecurity component of the global aquaculture sustainability programme.

10.1 Towards a new vision for capture fisheries in the twenty-first century

The capture fisheries sector is at a crossroads. On the one hand, fish and fish products make a crucial and increasing contribution to economic growth, food, nutrition and livelihood security. For example, of the 34 countries where fish contributes more than one-third of the total animal protein supply, 18 are LIFDCs. Moreover, per capita fish consumption has doubled in the last 50 years (see p. 65); and dietary recommendations include a significant increase in fish consumption.

On the other hand, 34 percent of assessed fish stocks are fished at levels that exceed biological sustainability. Furthermore, the fish stock status in developed countries is improving, while many developing countries face a worsening situation in terms of overcapacity, production per unit of effort and stock status.

The capture fisheries sector is therefore in need of significant management action in some regions, particularly in the context of the expected impacts of climate change in coming decades. Navigating this crossroads demands a vision that outlines how the sector can respond to the complex and rapidly changing challenges facing society. This vision needs to recognize the crucial role of fisheries in future economic development, food, nutrition and livelihood security, in the context of the multiple environmental impacts that humans have to address, on land and in water, in order to place humanity on a more sustainable footing. To develop this vision, FAO hosted the International Symposium on Fisheries Sustainability, on 18–21 November 2019 in Rome (FAO, 2020f). The event attracted almost 1 000 attendees from more than 100 countries, including academia, the private sector, governments, and intergovernmental, non-governmental and civil society organizations, to discuss a number of strategic questions addressed in eight topical sessions. The recommendations emerging from the debates are summarized below, by topic, for information and consideration by all stakeholders. These recommendations do not constitute a set of necessary steps agreed by all, and they are not geographically or temporally explicit or prioritized in any way. They represent a collective set of views on issues that need consideration in order to drive sustainability forward.

On the challenges to achieving ecological sustainability of global and regional fisheries:

- ✓ Promote assessment and monitoring of individual stocks and improve transparency at the stock and country level to better understand the status of fisheries at relevant geographical scales.
- ✓ Encourage the development and implementation of simpler stock assessment methods that require less-detailed data and less technical

expertise to reduce the proportion of unassessed stocks around the globe.

- ✓ Improve the monitoring of inland fisheries and the collection of biological, fishery and habitat information in a cost-efficient and rigorous manner.
- ✓ Mobilize resources and provide financial support for continued capacity development programmes aimed at strengthening stock and fisheries assessment and monitoring systems, particularly in developing-world, small-scale and inland fisheries.
- ✓ Consider adoption of a new global target for sustainable management that would be more conservative or precautionary in data-limited situations and/or where governance is weaker.
- ✓ Data-poor does not always mean information-poor. Develop and implement better mechanisms to incorporate multiple. types of available information, including local knowledge and expertise, and their integration into assessment and management approaches.
- ✓ Collect basic data needed for a particular fishery and capture local knowledge to help design empirical, simple harvest control rules.
- ✓ Encourage appropriate communication, knowledge mobilization and education across all actors (fishers, scientists and managers) involved in decision-making to improve transfer of information and buy-in compliance to regulations to achieve effective management systems.
- ✓ Promote appropriate communication and awareness about the impact of illegal fishing on overfishing and fish stock recovery.
- ✓ Encourage mechanisms to improve and reward compliance with management regulations.

On how to better link biodiversity conservation and food security objectives:

- ✓ Support the development of joint biodiversity and food security objectives that recognize trade-offs and are nationally and locally relevant.
- ✓ Engage and influence existing and emerging policy frameworks (for example, the CBD’s post-2020 global biodiversity framework, and the SDGs) that represent opportunities to design, implement and monitor joint objectives.
- ✓ Continue developing inclusive integrated management frameworks that rapidly move to reference points consistent with ecosystem sustainability

goals, promoting stewardship and participatory management that effectively translate into action at all scales.

- ✓ Enhance the ability to monitor and report on ecological, economic and social sustainability by incorporating information on ecosystems (including people), drawing on diverse sets of knowledge (social, economic and biological sciences, and local and traditional knowledge), disaggregated by gender.
- ✓ Promote and strengthen diverse, inclusive and accountable partnerships to effectively manage ecosystems for both biodiversity and food security.
- ✓ Integrate market-based mechanisms that advance sustainability in fisheries management. „ The tools (including new technologies) exist to help achieve joint objectives. Implementation should build on previous experiences using these tools and remain mindful of the specific context.

On the contribution of fisheries to food security and nutrition:

- ✓ Use best available science to make food policy and nutrition action plans.
- ✓ Improve data collection and analysis of aquatic food consumption and analysis of nutrients and food safety (at species level, considering parts used, processing and preparation methods).
- ✓ Ensure that aquatic foods are reaching those who need them most, across diverse communities within regions, and diverse individual needs within households – to ensure that essential micronutrients, fatty acids and bioavailable proteins reach children, women and men.
- ✓ Deploy context-specific messaging through appropriate channels to encourage consumption of diverse nutritious and sustainably produced aquatic foods. „ Include aquatic foods in food systems policies, given their potential contribution to addressing malnutrition in all forms.
- ✓ Improve the utilization and stability of the aquatic food supply by supporting disruptive technologies, social innovations and targeted risks to unleash new networks of supply chain governance capable of being inclusive and socially just.

On how to secure sustainable fisheries livelihoods:

- ✓Highlight the contribution and support the role of fisheries, in particular small-scale fisheries, in income, culture, and food security and nutrition.
- ✓Recognize the role of women and prioritize achieving gender equality across the value chain, including decision-making.

- ✓ Empower fishing communities, strengthen participatory approaches and build capacity. Develop and support inclusive institutions and small-scale fisheries organizations, including those representing the rights of indigenous communities, women and marginalized sectors

10.2 Improving fisheries management

With less than ten years to achieve the Sustainable Development Goals (SDGs), accelerated transformative action is essential along the triple bottom line of ecological, economic and social sustainability. Blue Transformation9 offers significant opportunities to improve fisheries management to:

- ✓ achieve secure equal rights to access resources, services and infrastructure, decent work and economic growth;
- ✓ secure both nutritious foods and livelihood opportunities, with equal access to fisheries for women and men and reduced inequalities through social, economic and political inclusion of all;
- ✓ attain the sustainable and efficient use of inland and marine aquatic resources for responsible consumption and production (SDG 12).

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

Better governance and policy reform. The international community has adopted a legal framework for sustainable fisheries, recognizing the sector's important role for food security and nutrition, economic development, protection of the environment and the well-being of people.

The basic international instrument is the United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1982, which provides the legal framework for all maritime activities, including conservation and utilization of living marine resources.

In the early 1990s, the international community developed new approaches to fisheries and aquaculture management, embracing conservation and environmental as well as social and economic considerations. Under the auspices of FAO, several global instruments for fisheries management have been established. The Code of Conduct for Responsible Fisheries (the Code), adopted in 1995, provides detailed provisions for the responsible and sustainable management and use of living aquatic resources, with due respect for the ecosystem and biodiversity (FAO, 2021c).

Voluntary in nature, the Code is probably the most cited, high-profile and widely diffused and used global fisheries instrument after UNCLOS. In its framework, four international plans of action and six international guidelines for responsible fisheries management have been developed, and two FAO legally binding agreements have been adopted addressing the issues of: (i) flag State responsibility in the high seas (the FAO Compliance Agreement); and (ii) port State responsibilities to prevent, deter and eliminate illegal, unreported and unregulated (IUU) fishing (the Port State Measures Agreement).

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

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

The success of global instruments and normative processes depends on regional efforts; they must be implemented and translated into actions at the country and regional levels, as appropriate.

The United Nations Fish Stocks Agreement, an implementing agreement under UNCLOS, contains fisheries management principles and focuses on regional cooperation within regional fisheries management organizations (RFMOs) and regional fisheries advisory bodies (RFABs), collectively referred to as regional fisheries bodies (RFBs). RFBs play a central role in fisheries management, cooperating to ensure common approaches on various cross-cutting issues, at both the global and regional levels and on specific technical matters. Some RFBs are under the FAO constitutional framework, but FAO also supports other RFBs, including through the Regional Fishery Body Secretariats' Network, which fosters cooperation and facilitates consultation and sharing of experiences. FAO supports and oversees these processes and developments and assists with the strategic reorientation processes of some of its RFABs.

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

In a time of challenges caused by overexploitation of natural resources, continued food insecurity and poverty, and changing climate, the international community increasingly recognizes the importance of regional and international cross-sectoral collaboration and cooperation in facilitating achievement of the objectives set out by the 2030 Agenda for Sustainable Development. The outbreak of COVID-19 has strongly reaffirmed this and reasserted the central role of cross-sectoral cooperation to address the challenges of global fisheries governance.

Questions for self-testing

1. What are the challenges and solutions?
2. What better governance and policy reform?

11 UNITED NATIONS DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021–2030)

11.1 Science opportunities for fisheries and aquaculture management

Science is one of the key levers to accelerate progress in the transformation of food systems and achievement of the Sustainable Development Goals (SDGs), as scientific evidence is necessary to create sustainable solutions. A strong science–policy interface is crucial to help design these solutions and ultimately ensure that decisions, agreements and actions are based on the best available evidence. Several recent events facilitated by FAO specifically refer to and build on science.

The International Symposium on Fisheries Sustainability was held to identify pathways to strengthen the science and policy interplay in fisheries production, management and trade, based on solid sustainability principles for improved outcomes on the ground.

The symposium brought together a diverse group of experts and participants from around the world (around 1 000 attendees from more than 100 countries) and enabled an open dialogue and mutual understanding promoting science-based strategies for synergistic actions and supportive policies, at all levels.

The discussions held resulted in a set of science-based recommendations and overarching actions to help achieve sustainable, equitable and resilient aquatic food4 systems, while enhancing sustainable productivity to improve food security and nutrition and contribute to economic growth, raising living standards, and empowering women, youth and vulnerable communities.

The Global Conference on Aquaculture Millennium +20 was the fourth in a series of decadal development and science-oriented conferences that have shaped global aquaculture. It attracted over 1 700 delegates from more than 100 countries and a diverse set of sectors.

The conference identified key policy and technology innovations, scientific findings, investment opportunities and areas of cooperation that will promote the further development of sustainable aquaculture. It was informed by nine science-based thematic reviews, six regional reviews, and a global synthesis as well as over 100 academic posters. The Shanghai Declaration – a key output – took full account of the science-based information emerging from the thematic reviews and the conference to outline a common vision, key priorities and a call for actions for sustainable aquaculture.

With the increasing recognition of the importance of aquatic food comes the need to improve the scientific knowledge on its nutritional value and overall contribution to nourishing a growing population and addressing the objectives of the 2030 Agenda.

The outcomes of the above-mentioned events, as well as the dialogue on new research needs related to aquatic foods, should generate priority actions that will characterize science contributions to the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) and ultimately enhance the long-term sustainability of fisheries and aquaculture.

To foster integration of scientific advances and recognizing the achievements and challenges facing the sector since the endorsement of the Code of Conduct for Responsible Fisheries, the COFI Declaration for Sustainable Fisheries and Aquaculture was adopted unanimously at the Thirty-fourth Session of the Committee on Fisheries (COFI) in February 2021.

The Declaration recognizes that challenges in implementing effective fisheries management measures are complex, region-specific and multidimensional, further complicated by climate change and ocean acidification, and are often due to insufficient data to support science-based decisions. It recognizes the need to address these challenges through innovative, inclusive, effective and adaptive fisheries management measures based on the best available scientific information.

It also recognizes the key role of the ecosystem approach as an effective framework for integrating conservation and sustainable utilization objectives and the need to strengthen the scientific basis in support of fisheries and aquaculture management decisions.

This entails the use of new information and communication technologies with recent technological advances, such as interoperable fisheries information systems, which offer new opportunities to better monitor fisheries and aquaculture and generate comprehensive multidisciplinary data and information underpinning science to inform management policy while engaging a multitude of stakeholders.

Also key is the promotion of international scientific cooperation, capacity building, education and training. Finally, the Declaration recognizes the potential of aquaculture for further growth, and the need for innovative practices which support environmental stewardship, with particular attention to food-deficit regions.

11.2 COVID-19, a crisis like no other

Introduction. In March 2020, the World Health Organization (WHO) declared coronavirus disease 2019 (COVID-19) a global pandemic. Since then, the world has been shaken by a disease that has killed millions of people and rendered tens of millions ill.1 In a matter of weeks, the world's economy suffered a sharp contraction as a result of the measures implemented in urgency to prevent the spreading of the virus. This led to major consequences for sectors highly dependent on trade, including fisheries and aquaculture.

At the regional level, regional fishery bodies (RFBs) reported, *inter alia*, a negative impact on activities related to monitoring, control and surveillance (MCS) of fishing activities, fisheries and aquaculture research and management.

Most countries and regions experienced severe declines in fishery and aquaculture production, employment and prices.

Difficulties were reported for fisheries management decision-making and capacity-building owing to postponement of physical meetings, training sessions and workshops. China, Europe, Japan and the United States of America, the four great major markets for aquatic foods,2 were severely hit by the pandemic. Closed borders – with travel restrictions and disruption of imports – affected developing countries that rely on exports of aquatic products2 for foreign exchange earnings.

FAO estimates that 3 billion people cannot afford a healthy diet, with an additional 1 billion if a shock were to reduce their income by one-third. Indeed, the pandemic has posed major challenges to livelihoods, employment, food security and nutrition.

Vaccination campaigns and policy responses to COVID-19 enabled global economic recovery in 2021, with an increase in production, trade and consumption of aquatic products. The renewed interest in home cooking, food delivery services and digital retail channels driven by COVID-19 continues to expand, although uncertainty remains as to how the sector will reorganize to adapt to a changing market and face the future, given the risk of new variants requiring subsequent restriction measures.

11.3 Supply chain disruption and related risks

The entire fisheries and aquaculture value chain was severely disrupted as a result of the lockdowns. An external shock such as the COVID-19 outbreak had never before arrived with such speed, and the impact on consumer behavior and trade globally was unprecedented. The pandemic has revealed the fragilities of aquatic food systems on both the demand and supply sides. In European countries, in the short term, perishable food was sold off below cost and/or scrapped, while in the medium term, the capacity to restock was constrained by reduced production and transport capacity. There was a massive shift in sales from food services to retail, resulting in oversupply of food service products and shortages in retail with a subsequent impact on prices.

In many countries, mobility restrictions totally disrupted the fisheries and aquaculture supply chain, at least during the first months of the pandemic before the sector was gradually recognized as essential, and initiatives were implemented to bring the industry back on track. Mobility restrictions meant that essential production inputs, such as feeds and seed, could not reach farms regularly. Shrimp and tilapia farmers in Central America witnessed a 75 percent drop in demand in both local and international markets.

All this resulted in the paralysis of the industry, which experienced overstocking and unforeseen feeding and freezing costs with severe economic impacts, and some production units closed operations (OSPESCA and SICA, 2020).

The impacts of the pandemic on aquatic food systems have varied depending on species, markets and consumer demand, as well as labour force structure and adaptive capacity of both governments and the industry (Figure 67).

In general, supply chains dominated by small and medium enterprises (SMEs) were particularly vulnerable to COVID-19 restrictions. In Africa and South Asia in particular, prior to COVID-19, these supply chains were already constrained by insufficient cold storage and processing capacity, poor transportation infrastructure, disjointed input markets, and/or underfinanced suppliers. Large-scale vertically integrated supply chains, in contrast, have generally been less affected, as they are more able to control input and output delivery.

The labor-intensive small-scale sector was vulnerable to restrictions on movement affecting workers and to disruptions in input provisioning and transportation. In South and Southeast Asia, preliminary findings from a survey conducted by FAO and INFOFISH show that the COVID-19 pandemic and lockdowns greatly impacted small-scale fisheries and aquaculture farmers across countries.

The restrictions disrupted supply chains and markets, hampered business operations, affected employment, maintained certain inequalities such as that of gender participation, and contributed to fluctuating incomes for households, and to decreased tax revenue and foreign exchange earnings for governments.

Operators and markets are slowly recovering, but rising freight costs, new border procedures, reduced availability of shipping containers, bottlenecks in big international harbours, and the risk of new variants dampen the medium-term outlook. As a whole, the aquatic food system has managed to adapt and maintain flows of products and supply, but numerous enterprises have gone out of business or are in a precarious position.

Work, gender and food security. The pandemic has impacted work, income and associated purchasing power. Four in five workers worldwide have experienced partial or total unemployment or working from home. It has exacerbated the lack of access to adequate food for millions of people, making their food security a huge and persistent problem. Vulnerability to such income shocks is particularly worrisome in low-income countries, where a diet meeting basic energy requirements is beyond the reach of many.

Many studies concur that shocks disproportionately affect vulnerable and marginalized people, and the COVID-19 pandemic is no exception.3 Low-income households, small operators, women, infants and young children, the elderly, persons with disabilities, indigenous populations, refugees, migrants, displaced people and minorities are at greater risk of suffering the adverse effects of the pandemic around the world. Small-scale fishers and fish workers who rely on seasonal migration have been affected by prohibitions on travel and accommodation.

Crew change and reduced access to shore services have impacted seafarers, including migrant workers employed on long-distance industrial fishing vessels. Many workers in the processing, harvesting and marketing industries have lost their jobs. Moreover, working on board fishing vessels and in post-harvest handling, packaging and processing has entailed increased risks of virus transmission and outbreaks of COVID-19 among workers because of reduced space and humidity.

Women's relatively high representation in the sectors hardest hit by lockdowns has translated into greater declines in women's employment than in men's. Yuan investigated the impact on the livelihood of households engaged in the aquaculture value chain in China: family income decreased significantly due to lower wages and reduced business revenue (e.g. the income of all catfish seed producers fell by more than 50 percent), and the families of 30–40 percent of surveyed farmers encountered financial difficulties; furthermore, women faced the increased burden of caring for and educating children due to school closures and were under extra pressure to maintain the basic living conditions of the family.

Women account for half the workforce when both primary and secondary fisheries and aquaculture sectors are considered. Nevertheless, they are under-recognized in the industry, despite their crucial role throughout the value chain and in household livelihood and nutrition.

Moreover, the secondary sector has been hit particularly hard by the pandemic and this is where most women work. On the other hand, it cannot be understated that women have also emerged as agents of change and leaders in the COVID-19 response. In many cases, solidarity has formed the foundation for women to develop coping strategies during the COVID-19 crisis and they have used their skills, knowledge and networks to develop innovative solutions and support each other.

As in all sectors at a global level, concerted efforts are required within the fisheries and aquaculture sector to prevent the pandemic from turning back the clock on progress towards gender equality. To this end, it is vital to formulate appropriate gender-sensitive mitigation strategies that target economic and health aspects and enhance the resilience of people working in fisheries and aquaculture.

Adaptation strategies. The entire world and the industry (at all scales) were not prepared for such a shock. Nevertheless, some businesses have managed to adapt over time and innovate. Some small businesses have been able to adjust and survive by using e-commerce platforms and modifying their business operations. Small-scale fisheries organizations throughout Latin America have adopted innovative approaches to commercialize their products.

For example, they set up temporary selling points in spots located close to highly populated urban areas of Chile, Peru, Panama and Nicaragua, and small-scale fish farmers adopted e-commerce and home delivery to advertise and sell their products. Direct sales have developed as new and emerging markets in response to the closure of other markets. In Malaysia, online fish delivery intermediary, MyFishman.com, helped SMEs in fishing and aquaculture sell via fresh fish subscriptions and delivery services, thus avoiding wet markets and direct contact with consumers (IFPRI, 2021). Some changes seem here to stay and there are signs that COVID-19 may favour industry consolidation.

In South and Southeast Asia, small-scale fishers, aquaculture operators and fisheries-based business operators responded in various ways depending on the level of restrictions in place, government support (or lack of), and their own resilience and innovation. Overall, their businesses experienced a general decline.

However, resilience has been enhanced by diversifying or substituting household income with other agricultural activities, streamlining business costs to the necessary minimum, and embracing online marketing and direct delivery. This shift in business modus operandi is fostering new opportunities for small-scale fishers, aquaculture operators and fisheries-based business operators to have a closer and direct relationship with customers, enabling them to explore new markets and new products.

Examples of mitigation strategies provided by RFBs include the rapid increase in the adoption of enhanced electronic monitoring tools for MCS activities, development of ad hoc fishing vessel boarding and inspection procedures, adoption of virtual meetings, establishment of online decision-making processes, online marketing of aquatic products and provision of support for the transition from fresh to value-added processed aquatic food products.

Countries such as China launched a national demand and supply platform to connect fisheries and aquaculture producers to processors and buyers, streamlining production with demand, directing surplus production to freezing and cold storage, and facilitating national and international trade.

Government support measures. To contain the economic consequences of lockdowns and other restrictions, government support for households, businesses and markets took on dimensions not seen since the Second World War. Central banks responded to what the International Monetary Fund has called “a crisis like no other”, with unprecedented interventions to sustain government debt and banks.

The measures adopted to address the impacts of the pandemic were diverse and complex, reflecting the intricacy of the issues addressed, the order of priority and countries’ capacity and resources. They included health, social, economic, education and environmental measures.

According to Love *et al*. (2021), responses by aquatic food system actors and institutions mostly aimed to: (i) protect public health, including the health of fishery sector workers; (ii) support those whose enterprises, jobs and incomes were affected by COVID-19-related disruptions; and (iii) maintain supplies of aquatic products to consumers.

Government support in countries in Latin America ranged from availability of soft and interest-free loans for small-scale operators, tax and licensing fee relief, and fuel subsidies, to temporary suspension of credit obligations. In the United Kingdom of Great Britain and Northern Ireland, it took the form of income support, job retention schemes, bounce back loans and income tax deferral; there were also non-nation-specific measures, such as sea fisheries hardship funds in Scotland, support for the fishing industry in Northern Ireland and assistance from charities (e.g. The Seafarers' Charity).

Preliminary research in South and Southeast Asia reveals both positive and negative responses from governments. Survey results point to, *inter alia*, the need for customized and focused government intervention supported by proper regulations, improved gender participation, increased education and awareness on the potential of digital markets and online platforms, while maintaining quality produce and meeting consumer needs. Sustaining the livelihood of small-scale fishers, aquaculture operators and fisheries-based business operators requires concertation with all concerned stakeholders.

However, in most countries, support was complicated by limited public funds. Moreover, the fiscal and monetary responses to support vulnerable groups will have important consequences for indebtedness, debt servicing capacity, and debt sustainability more broadly.

For example, sub-Saharan Africa experienced a 4.5 percent increase in "pandemic debt"– the debt taken on above and beyond projections due to the COVID-19 crisis. This could have serious impacts on the governance and management of living aquatic resources.

Social protection. The COVID-19 responses show that countries with working social protection systems in place had greater flexibility and could respond by adapting social protection programmes to the impact of the pandemic. Other countries were unable to respond to the needs of community's dependent on living aquatic resources, especially where informality was predominant.

Many workers in the fisheries and aquaculture sector are informal with no social protection coverage; they are not registered in mandatory social security schemes, are paid less than the legal minimum wage, do not have a written contract or are self-employed. These individuals include small-scale fishers, migrant fish workers, ethnic minorities, crew members, harvesters, gleaners and vendors – especially women, who have been the most affected by the pandemic (FAO, 2021g).

Many people who lost their employment were also left without access to income support. Many countries implemented new schemes, while others expanded existing schemes, either horizontally or vertically, by, for instance, increasing the programmer’s coverage, relaxing access requirements, expanding the programmer’s duration or introducing extraordinary cash transfers.

The most common interventions targeting the fisheries and aquaculture sector were temporary social assistance measures, ranging from one-off payment schemes to unconditional cash transfer programmes lasting three months, and including in-kind food transfers. However, financial support was also provided through, for example, fee waivers and input subsidies for baits, ice and fuel, as well as for the provision of seed for aquaculture purposes and the building of aquaculture farms; in addition, technical support was made available to generate jobs and rebuild the sector.

Emerging lessons. The COVID-19 crisis is protracted; its effects are unfolding as new variants emerge. It is essential to continue monitoring, assessing and documenting both the impacts on and the responses of the fisheries and aquaculture sector, in order to inform short-, medium- and long-term strategies and be prepared for new waves.

Among the lessons learned, the COVID-19 pandemic has highlighted the interconnectivity of markets: the disruption of one or more stages of the aquatic supply chain can have impacts that span local, national and international boundaries. Market disruptions can lead to inflation risks. Key elements for building resilient aquatic food systems include improving processing, diversifying supply sources and markets, managing connectivity through more robust food transport network and logistics, and allowing a mix of different and heterogeneous suppliers.

Recognizing that fisheries and aquaculture is an essential sector and integral part of the food system in many countries, it is vital to maintain the smooth functioning of all points of the supply chains, supporting food security, income and employment with special regard for the specific challenges faced by vulnerable groups including women and migrant workers.

COVID-19 has exacerbated pre-existing inequalities. Small-scale fisheries and aquaculture, SMEs, women and other vulnerable groups (e.g. informal and migrant workers) are increasingly marginalized and need to be properly protected.

The pandemic highlights the need to expand social protection coverage through a comprehensive and inclusive national social protection system that is shock-responsive and adequately covers the sector. Policy coordination and coherence between a range of line ministries at the national level are essential. Social protection programmes should use a gender-sensitive approach throughout the design, implementation and evaluation phases, because they can affect gender dynamics. Social protection schemes can enhance households' adaptive capacity to shocks and reduce negative coping strategies that would result in long-term detriment to their livelihoods.

Social protection can contribute to improved welfare and fisheries management. Economic support measures enacted by governments depend on the available resources and capacity. In most developing countries, the economic responses have important consequences for national debts because of the pre-COVID-19 debt level, debt servicing capacity and debt sustainability. This could have some impact on the governance and management of aquatic resources. Some recommend revisiting existing institutional mechanisms for debt sustainability and restructuring.

The emerging literature on COVID-19 and climate adaptation suggests that the pandemic impacts the Paris Agreement's goals of "enhancing adaptive capacity", "strengthening resilience" and "reducing vulnerability" to climate change, as countries are prioritizing health and economic recovery.

It is critical to embed social and environmental considerations (e.g. low carbon, climate resilience) into COVID-19 recovery plans through investment in activities that support blue economic recovery and build adaptive capacity.

Furthermore, it is critical to prepare for multiple known or unknown risks. COVID-19 has added to diverse pre-existing pressures (e.g. fish/shellfish disease outbreaks, extreme weather events, chronic financial constraints), and fisheries and aquaculture management needs to address these through integrated risk management4 approaches.

Studying what types of measures and broader interventions have worked in different contexts and how systems have changed, and documenting both longer-term impacts and emerging lessons could help to build specific resilience to the COVID-19 pandemic and general resilience to future shocks or stressors.

On the positive side, the crisis has accelerated the digitalization of the sector, encouraged the e-monitoring and enforcement of capture fisheries, advanced the use of green and clean energies, contributed to the development of local markets, driven fish farmers to better manage scarce production factors such as feeds and highlighted the importance of domestic production.

Questions for self-testing

1. What are supply chain disruptions and associated risks?
2. What are the ways of adapting fish farming and aquaculture to climate change?

12 FISHERIES AND AQUACULTURE ADAPTATIONS TO CLIMATE CHANGE

Introduction. The Intergovernmental Panel on Climate Change (IPCC) reiterated the acceleration of global warming in the Sixth Assessment Report, stressing that increased warming has caused irreversible changes. The Glasgow Climate Pact coming out of the twenty-sixth session of the Conference of the Parties to the United Nations Framework Convention on Climate Change highlights the urgent need for ocean-based action, and the climate discussions reasserted the large capacity of aquatic ecosystems to store carbon. These recognitions call for strengthened and accelerated climate mitigation and adaptation in fisheries and aquaculture along the lines of developments that are progressively shaping up in the international climate dialogues.

Over the years, global climate discussions relating to fisheries and aquaculture have been supported by FAO guidance on adaptatio; this section underscores five priorities for fostering on-the-ground actions on fisheries and aquaculture adaptation that can significantly contribute to Blue Transformation.

12.1 Mainstreaming climate change into fisheries and aquaculture management

The increasing evidence of the impacts of climate change on aquatic ecosystems calls for the explicit consideration of climate stressors in fisheries and aquaculture management, as well as a better connection between adaptation plans and management or development actions.

For this purpose, the sector would benefit from shifting to flexible and adaptive management approaches allowing for continuous adjustments as climate impacts are detected. Typically, management cycles as theorized in FAO guidance would need to include additional feedback loops to respond to changes in a timely manner and shorten the management cycle to allow for adaptation to changing conditions.

Environmental monitoring systems using a risk-based approach can trigger effective adaptation action if they include local and context-specific proxies and indicators associated with climate stressors that are known to have significant impacts on fisheries and aquaculture (e.g. temperature increase, changes in precipitation patterns, oxygen level in the water).

In general, enhancing the reliance on risk-based approaches in fisheries and aquaculture management optimizes risk reduction related to climate change, whether in the planning or implementation phase of management.6

In addition, the spatial and temporal scale of management units of fishing or fish farming need to be properly designed so that they are aligned with the relevant climate mitigation and adaptation measures.

FAO initiated the analysis of case studies that successfully introduced flexibility in marine fisheries management; however, further work is needed, documenting and learning from practical examples addressing the impacts of climate change in freshwater fisheries or aquaculture management to ensure continued productivity and resilience.

12.2 Developing and implementing transformative adaptation plans

Fishers and fish farmers are already adapting to climate change by diversifying their livelihoods, adjusting to changes in the environment and modifying their fishing and fish farming techniques, but more rapid changes in institutions and management systems must be in place to foster autonomous adaptation7 and avoid maladaptation. This requires transformative adaptation plans at the national, subnational and local levels; these plans must enable autonomous adaptation in the medium and long term to ease the transition of fisheries and aquaculture to a future resilient to climate change. In response to this need, FAO released guidelines intended for policymakers from ministries and institutions governing fisheries and aquaculture to actively take part in and contribute to the recognition, promotion and inclusion of the sector in national adaptation planning processes. Other stakeholders can also make use of these guidelines to understand how to engage in and initiate adaptation planning at the subnational and local levels.

While transformative adaptation plans will be required to encapsulate the needs of all scales of fisheries and aquaculture, particular attention must be given to the most vulnerable if the sector is to continue to contribute to meeting global goals of poverty reduction and food security. Therefore, the formulation and implementation of adaptation plans must follow an inclusive and participatory approach and consider the needs and benefits of small-scale fishing and fish farming communities in developing countries who are most impacted by climate change. One example is the development of 120 community-based integrated management plans in Myanmar, as part of the FAO Fish Adapt project, to help increase the resilience of local fisheries and aquaculture communities and their livelihoods to climate change.

12.3 Adopting climate-informed spatial management approaches

Spatial management approaches provide a powerful framework for planning, adapting and mitigating the fisheries and aquaculture sectors to current and future climate risks and opportunities. In the absence of sound spatial management and planning, as oceans warm and acidify, geographic species distributions and habitats will shift, patterns of disease outbreak and spread will change, and social conflicts between inland waters or ocean users will worsen, among a myriad of other climate-induced changes.

Spatial planning and management provide a solutions-focused pathway whereby spatial data and models can be used to better understand and predict how climate change could affect fisheries and aquaculture, as well as provide insights into variability between locations so that appropriate area-based adaptation strategies can be deployed. Good spatial planning and best management practices at the farm- and area-management levels, supported by spatial technology such as satellite remote sensing, aerial surveys, global positioning systems, geographic information systems, and information and communication technology, can reduce vulnerability to the risks of climate change and facilitate adaptation. For example, in Chile, climate change risk maps for aquaculture from the ARClim project developed under the Ministry of Environment are being used to generate science-based harmful algal bloom warnings to help reduce farmed salmon mortality.

Climate-informed spatial management mechanisms in fisheries and aquaculture may require adaptive shifts in governance frameworks, tailoring approaches for diverse stakeholder participation and engagement and integrating local science and knowledge in the design and implementation of innovative climate mitigation and adaptation strategies such as nature-based solutions. Furthermore, it is important to: develop diverse spatial databases that capture both ecological and socio economic characteristics of the environment; strengthen oceanographic and climate-observing systems to provide local and real-time information; and develop national and regional capacities to implement early warning models and indicators that can support mitigation or adaptation of climate change impacts on fisheries and aquaculture.

Integrating equity and human rights considerations. The notion of equity should always be at the heart of climate discussions. Climate change may cause the most harm to those who have contributed the least to the climate crisis, such as small-scale fishing and fish farming communities, in particular those living in low-income countries and islands.

Ultimately, equity is also about human rights. Climate change can affect people's right to food, access to drinking water, education, health and housing, with disproportionate impacts on individuals, groups and people who are in vulnerable situations such as women, children, older persons, indigenous peoples, minorities, migrants and the poor. The Voluntary Guidelines for Securing Sustainable Small-scale Fisheries, the 2021 FAO Committee on Fisheries Declaration for Sustainable Fisheries and Aquaculture and the Paris Agreement recognize the importance of equity and human rights. Climate change adaptation in the fisheries and aquaculture sector must integrate equity and human rights considerations in both processes and outcomes. Key process considerations include transparency, participation, access to justice and non-discrimination. Key outcome considerations include the right to life and the supporting rights to food, housing, water and livelihoods.

The adaptation planning process needs to engage and empower vulnerable communities, including small-scale fishers and fish farmers. Countries should assess the vulnerabilities of the fisheries and aquaculture sector and act in line with equity and human rights considerations.

This requires countries to be proactive, preparing for future events, whether extreme or slow-onset, ensuring access to resilient infrastructure and public services (including health services).

Investing in innovation. Climate change has been posing new challenges to fisheries and aquaculture urging the sector to innovate through a synergetic combination of technological, policy and market transformations. In this regard, FAO has supported the design and implementation of novel interoperable information systems that systematize and integrate country-level data on fisheries, aquaculture and climate change, providing information for users and decision-makers, as well as early warning systems that contribute to the reduction of incidents and fatalities and the provision of humanitarian support in climate-related extreme events. Examples include an already operative framework recently consolidated in Chile (IFOP, 2021), the implementation of social media technologies to facilitate real-time information and enhance compliance in Lake Malombe, Malawi, and the enhancing of monitoring and assessment of climate change impacts to inform policy and planning and support the fisheries and aquaculture communities in Myanmar.

Similar innovative approaches are deployed in other regions of the world. For example, ISDApp8 in the Philippines converts collected localized weather data into simplified weather forecasts and sends them as text messages to the registered mobile numbers of fishers, even without a smartphone, while the Moana project9 in New Zealand supports the combination of traditional knowledge and fisheries sector data with cutting-edge ocean sensing and advanced numerical modelling to provide reliable ocean forecast systems to support marine industries. Fisheries and aquaculture make a minor contribution to global carbon emissions.

Nevertheless, there are opportunities for decarbonization along the fisheries and aquaculture value chain, increasing its efficiency by reducing fish wastes and losses, including for small-scale fishers and fish farmers. Decarbonization technologies already exist; however, access and upscaling remain a challenge due to the high costs. Innovative financial schemes and multipronged approaches are needed to ensure access to credit by entrepreneurs and local communities, including women and youth, as well as incentivizing policies to support the adoption of clean technologies and energies along the fisheries and aquaculture value chain together with marked innovations to promote their benefits.

Conclusion. Countries are showing a growing interest in adaptation of fisheries and aquaculture to climate change. According to the latest FAO report on nationally determined contributions (NDCs), of the 85 new or updated NDCs submitted (between 1 January 2020 and 31 July 2021) by countries as part of their commitment to the Paris Agreement, 62 of the 77 (81 percent) with adaptation components referred to adaptation in fisheries and aquaculture, including ocean and coastal zone management. The five priorities described above can provide very relevant guidance for countries in implementing their NDCs, to ultimately contribute to the achievement of the long-term adaptation goals of the Paris Agreement. With COP26’s decision that formally strengthens the ocean space within the UNFCCC discussions, it is important for fisheries and aquaculture to expand its contribution to global efforts, sharing adaptation and mitigation solutions that are pertinent to the sector, while progressively filling the important gap of insufficient attention to freshwater fisheries and aquaculture within the international climate discussions.

12.4 Fisheries and aquaculture projections

This section presents the medium-term outlook using the FAO fish model (FAO, 2012b, pp. 186–193), developed in 2010 to shed light on potential future developments in fisheries and aquaculture. The fish model has links to, but is not integrated into, the Aglink-Cosimo model used annually to generate the ten-year-horizon agricultural projections elaborated jointly by the Organization for Economic Co-operation and Development (OECD) and FAO and published each year in the OECD-FAO Agricultural Outlook. The FAO fish model uses a set of macroeconomic assumptions and selected prices to generate the agricultural projections.

The fisheries and aquaculture projections presented in this section have been obtained through an ad hoc analysis carried out by FAO for the years 2021–2030.

The projections illustrated in this section depict an outlook for fisheries and aquaculture production,13 utilizations, trade,14 prices and key issues that might influence future supply and demand. It is important to highlight that the projections are not forecasts, but rather plausible scenarios that provide insight into how these sectors may develop in the light of a set of specific assumptions regarding: the future macroeconomic environment; international trade rules and tariffs; the frequency of events and their effects on resources; the absence of other severe events such as tsunamis, tropical storms (cyclones, hurricanes and typhoons), floods and emerging diseases of aquatic species; improved fisheries and aquaculture management measures, including catch limitations; and the absence of market shocks. In view of the major role of China in the fisheries and aquaculture sectors, the assumptions consider continuation of the policy developments in China outlined in the Thirteenth (2016–2020) and Fourteenth (2021–2025) Five-Year Plans towards more sustainable and environmentally friendly fisheries and aquaculture. The future of the fisheries and aquaculture sectors will depend on many different factors of global, regional and local relevance. Population and economic growth, urbanization, technological developments and dietary diversification are expected to create an expansion in food demand, in particular for animal products, including aquatic food.

Production. On the basis of the assumptions used, total fisheries and aquaculture production (excluding algae13) is expected to expand further and reach 202 million tonnes in 2030. This represents an increase of 14 percent relative to 2020 and an additional 24 million tonnes in absolute terms. However, while the total quantity continues to increase, both the rate and absolute level of growth are expected to decline compared with the 23 percent growth (33 million tonnes) during the period 2010–2020. Most of the increase in world fisheries and aquaculture production will come from the aquaculture sector, where output should break the 100 million tonnes threshold for the first time in 2027.

Aquaculture production is expected to increase to 106 million tonnes in 2030, with an overall growth of 22 percent or nearly 19 million tonnes compared with 2020. The share of farmed species in global fisheries and aquaculture production (for food and non-food uses) is projected to grow from 49 percent in 2020 to 53 percent in 2030.

The average annual growth rate of aquaculture production should slow over the next decade to less than half the rate observed in the previous decade, dropping from 4.2 percent in 2010–2020 to 2.0 percent in 2020–2030. A number of factors should contribute to this slowdown.15

These include: broader adoption and enforcement of environmental regulations; reduced availability of water and suitable production locations; increasing outbreaks of aquatic animal diseases related to intensive production practices; and decreasing aquaculture productivity gains.

In particular, Chinese policies are expected to account significantly for the overall reduced growth. Initiated in 2016, these policies are expected to continue the transition from extensive to intensive aquaculture, while at the same time integrating better production with environmental considerations through the adoption of ecologically sound technological innovations, with initial capacity reduction, followed by faster growth.

Although China will remain the world's leading producer through to 2030, its aquaculture production is expected to increase by 21 percent in 2020–2030, nearly halving the 40 percent increase in 2010–2020. China accounted for 57 percent of global aquaculture production in 2020 and this is projected to decline slightly to 56 percent by 2030, despite aquaculture's contribution to total Chinese fisheries and aquaculture production as it increased from 79 percent to 82 percent in the same period. The projected deceleration of China's aquaculture production is expected to be partially compensated for by an increase in production in other countries.

Growth of aquaculture production is projected to continue on all continents, with variations in the range of species and products across countries and regions (Figure 73). The sector is expected to expand most in the Americas (up 29 percent from 2020), Africa (up 23 percent) and Asia (up 22 percent).

The growth in Africa's aquaculture production will be driven by the additional culturing capacity put in place in recent years, as well as by national policies promoting aquaculture fuelled by rising local demand as a result of higher economic growth. However, despite this expected growth, overall aquaculture production in Africa will remain limited, at slightly more than 2.8 million tonnes in 2030, with the bulk (1.9 million tonnes) produced by Egypt. Asian countries should continue to dominate the aquaculture sector (maintaining their share of 88 percent of 2030 global aquaculture production) and be responsible for more than 88 percent of the increase in production by 2030.

All farmed groups of species, will continue to increase, but rates of growth will be uneven across groups and the quantitative importance of different species will change as a consequence.

In general, species that require larger proportions of fishmeal and fish oil in their diets are expected to grow more slowly owing to expected higher prices and reduced availability of fishmeal.

In contrast to the slight decline experienced in 2019 and 2020, capture fisheries is projected to recover during the coming decades, resulting in world capture fisheries production at the end of the outlook period reaching 96 million tonnes, over 5 million tonnes more than in 2020, with an overall increase of 6 percent.

However, some fluctuations are expected over the next decade, linked to the El Nico phenomenon, with reduced catches in South America, especially for anchoveta, resulting in an overall decrease in world capture fisheries production of about 2 percent in those years.

The overall increase in capture fisheries production is driven by different factors including: (i) increased catches in some fishing areas where stocks of certain species are recovering owing to improved resource management; (ii) growth in catches in waters of the few countries with underfished resources, where new fishing opportunities exist or where fisheries management measures are less restrictive; and (iii) improved utilization of the harvest, including reduced discards, waste and losses as driven by legislation or higher market prices of aquatic species for food and non-food products. China is expected to remain the major producing country, even if its capture fisheries production should remain at the levels reached in 2020, as it continues its environmental policies into the next decade. For capture fisheries, China's policies aim to reduce domestic catches through controls on licensing, reduction in the number of fishers and fishing vessels, and output controls.

Other objectives include: modernization of gear, vessels and infrastructure; regular reduction of fuel subsidies; elimination of illegal, unreported and unregulated fishing (IUU fishing); and restoration of domestic fishery stocks through the use of restocking, artificial reefs and seasonal closures. However, this Chinese policy projects to compensate for the expected decline in domestic catches by an increase in distant-water fleet catches. In 2030, production of both fishmeal and fish oil is expected to increase over the outlook period by, respectively, 11 percent and 13 percent compared with 2020, although the share of capture fisheries production reduced into fishmeal and fish oil should decline slightly (17 percent by 2030 compared with 18 percent in 2020).

The expected increase in fishmeal and fish oil production is due to the overall growth in capture fisheries production in 2030 compared with 2020, combined with the increase in fishmeal and fish oil production obtained from fish waste and by-products of the processing industry.

Between 2020 and 2030, the proportion of total fishmeal obtained from fish waste is projected to increase from 27 percent to 29 percent, while the proportion of total fish oil is projected to slightly decline from 48 percent to 47 percent.

Consumption. Most fisheries and aquaculture production will be utilized for human consumption and this share is expected to continue to grow from 89 percent in 2020 to 90 percent by 2030. Overall, by 2030, the amount of aquatic food for human consumption is projected to increase by 24 million tonnes compared with 2020, reaching 182 million tonnes.

This represents an overall increase of 15 percent, a slower pace when compared with the 23 percent growth experienced in 2010–2020. This slowdown mainly reflects the reduced amount of additional fisheries and aquaculture production available, higher prices of aquatic foods in nominal terms, a deceleration in population growth and saturated demand in some countries, particularly high-income countries, where aquatic food consumption is projected to show little growth (an average annual increase of 0.3 percent in 2020–2030).

Overall, the main factors behind the increase in global consumption of aquatic food will be a combination of high demand resulting from rising incomes and urbanization, linked with the expansion of fisheries and aquaculture production, improvements in post-harvest methods and distribution channels expanding the commercialization of aquatic products.

Demand will also be stimulated by changes in dietary trends, pointing towards more variety in the typology of food consumed, and a greater focus on better health, nutrition and diet, with aquatic food playing a key role in this regard. Growth in demand will stem mostly from middle-income countries, which are expected to account for 82 percent of the increase in consumption by 2030 and to consume 73 percent of the aquatic food available for human consumption in 2030 (compared with 72 percent in 2020). About 72 percent of the world's fisheries and aquaculture production available for human consumption in 2030 will be consumed by Asian countries, while the lowest quantities will be consumed in Oceania.

Total consumption of aquatic food is expected to increase in all continents by 2030 in comparison with 2020, with higher growth rates projected in Africa and Oceania (26 percent in both regions), the Americas (17 percent), Asia (15 percent) and Europe (6 percent). In per capita terms, apparent consumption of aquatic food is projected to reach 21.4 kg in 2030, up from 20.2 kg in 2020. However, the average annual growth rate of per capita consumption of aquatic food will decline from 1.0 percent in 2010–2020 to 0.6 percent in 2020–2030. Per capita consumption of aquatic food will increase in all regions except Africa. The highest growth rates are projected for Oceania (12 percent), the Americas (9 percent), Asia (7 percent) and Europe (6 percent).

Despite these regional trends, the overall tendencies in quantity and variety of aquatic foods consumed will vary among and within countries. In 2030, about 59 percent of the aquatic food available for human consumption is expected to originate from aquaculture production, up from 56 percent in 2020.

In Africa, per capita consumption of aquatic food is expected to decrease slightly from 9.9 kg in 2020 to about 9.8 kg in 2030. The decline will be greater in sub-Saharan Africa (from 8.6 kg to 8.4 kg in the same period). Despite an expected overall increase in total supply of aquatic food due to increased production and imports, it will not be sufficient to outstrip the African population growth. One of the few exceptions will be Egypt, as the country is expected to further increase its already substantial aquaculture production (up 20 percent in 2030 compared with 2020). The projected decline in per capita consumption of aquatic food in Africa, in particular in sub-Saharan Africa, raises food security concerns because of the region's high prevalence of undernourishment and the importance of aquatic proteins in total animal protein intake in many African countries (see the section Consumption of aquatic foods, p. 81). The decline may also weaken the ability of countries that are more dependent on aquatic products to meet the nutrition targets of SDG 2 (End hunger, achieve food security and improved nutrition and promote sustainable agriculture), SDG Target 2.1 and SDG Target 2.2.

Trade. The expansion of trade in aquatic products will continue over the outlook period, but at a slower pace than in the previous decade, reflecting the slowdown in production growth, higher fisheries and aquaculture prices (which will restrain overall demand and consumption of aquatic species), and stronger domestic demand in some of the major producing and exporting countries, such as China, which is expected to increase its aquaculture production for the domestic market.

Aquaculture will contribute to a growing share of international trade in aquatic food products. In quantity terms, China will continue to be the major exporter of aquatic food, followed by Viet Nam and Norway. The bulk of the growth in exports of aquatic food will originate from Asia, which will account for about 52 percent of the additional exported volumes by 2030.

Asia's share in total trade of aquatic products for human consumption will increase from 47 percent in 2020 to 48 percent in 2030. High-income countries will remain highly dependent on imports to meet domestic demand. The European Union, Japan and the United States of America will account for 39 percent of total imports for aquatic food consumption in 2030, a slightly lower share than in 2020 (40 percent).

Trade of fishmeal and fish oil is expected to increase by 9 percent and 7 percent respectively. Peru and Chile will continue to be the main exporters of fish oil, while Norway and the European Union are the main importers, in particular for aquaculture production of salmonoids. Peru is also expected to remain the leading exporter of fishmeal, followed by the European Union and Chile, while China is the major importer.

Prices. The fisheries and aquaculture sectors are expected to enter a decade of higher prices in nominal terms. Factors driving this tendency include improved income, population growth and higher meat prices on the demand side; marginal increase in capture fisheries production, the slowing growth in aquaculture production and cost pressure from some crucial inputs such as feed, energy and fish oil on the supply side. In addition, the slowdown in Chinese fisheries and aquaculture production will stimulate higher prices in China, with repercussions on world prices.

The highest increase is expected in the average price of traded products (33 percent higher in 2030 than in 2020) followed by the average price of aquaculture products (29 percent higher) that will be greater than that of captured products (19 percent, when excluding aquatic products for non-food uses).

Prices of farmed aquatic species will also increase owing to higher fishmeal and fish oil prices, which are expected to increase by 11 percent and 1 percent, respectively, in nominal terms by 2030 as a result of strong global demand. High feed prices could also have an impact on the species composition in aquaculture, with a shift towards species requiring less feed, cheaper feed or no feed at all. The higher prices at the production level, coupled with high demand of aquatic food, will stimulate an estimated 18 percent growth in the average price of internationally traded aquatic products by 2030 relative to 2020.

In real terms, it is assumed that all prices, except those of aquaculture production and traded aquatic products, will decline slightly over the projection period, while remaining relatively high. For individual aquatic products, price volatility could be more pronounced as a result of supply or demand fluctuations. Moreover, because aquaculture is expected to represent a higher share of world fisheries and aquaculture supply, it could have a stronger impact on price formation in national and international markets of aquatic products.

The major decreases are expected for fishmeal and fish oil prices. Yet, both prices are coming from rather historically high levels and by 2030 fishmeal prices will still be 28 percent higher than in 2005, the year major price increases began. This situation is even more pronounced for fish oil, where the real price in 2030 is expected to be 70 percent higher than that observed in 2005.

Questions for self-testing

1. What are the forecasts for fisheries and aquaculture?
2. What are the applications of approaches to spatial management taking into account the climate?

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SUBJECT VOCABULARY

Навчальне електронне видання

ШЕКК Павло Володимирович
БУРГАЗ Марина Іванівна
СОБОРОВА Ольга Михайлівна
КУДЕЛІНА Ольга Юріївна

СВІТОВЕ РИБНЕ ГОСПОДАРСТВО

Навчальний посібник

(англійською мовою)

Видавець і виготовлювач
Одеський державний екологічний університет
вул. Львівська, 15, м. Одеса, 65016
тел./факс: (0482) 32-67-35
E-mail: info@odeku.edu.ua
Свідоцтво суб'єкта видавничої справи
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