Brief on the second *World Ocean Assessment* and marine biodiversity

1. The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, produces the only integrated assessment of the world's oceans at the global level, covering environmental, economic and social aspects. The assessment of biodiversity status and trends varies widely across taxa and habitats.[1] However, the analysis reveals several commonalities discussed in the second World Ocean Assessment: the socioeconomic value of biodiversity, increasing pressures on biodiversity, overall trends in status, capacity and knowledge needs and the need to integrate available knowledge to support policymaking.

2. The biodiversity assessment will be of interest for many ocean-related intergovernmental processes and bodies, including the Intergovernmental Panel on Climate Change, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, the United Nations Decade of Ocean Science for Sustainable Development and the United Nations Decade on Ecosystem Restoration.[2] Regular Process assessments of biodiversity status and trends are also relevant in supporting the 2030 Agenda for Sustainable Development through the full attainment of the Sustainable Development Goals, in particular Goals 2 (zero hunger), 6 (clean water and sanitation), 12 (responsible consumption and production), 13 (urgent action to combat climate change), 14 (life below water) and 15 (life on land).

3. The present brief provides a synthesis of the information on biodiversity, and its status, across a number of topics identified by the Group of Experts of the Regular Process, as presented in the second World Ocean Assessment and approved by the Ad Hoc Working Group of the Whole of the General Assembly on the Regular Process, and also identifies key activities to support and interact with related processes.

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[1] These approaches are specifically discussed in chapters 6 and 7 of the second World Ocean Assessment.

[2] Linkages with the Sustainable Development Goals and the United Nations decades are discussed in separate briefs.

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I. Background to the Regular Process

4. The Regular Process was created by the General Assembly with the aim of providing, at regular intervals, assessments and reports on the state of the marine environment, including socioeconomic aspects, to inform ocean policymaking.

5. The First Global Integrated Marine Assessment established a baseline for the state of the marine environment, whereas the second World Ocean Assessment was aimed at evaluating trends, supporting ocean policymaking at all levels and identifying aspects not fully covered in the first Assessment, such as inputs of anthropogenic noise, marine hydrates, cumulative effects, marine spatial planning and management approaches.

6. In preparation for the first and second World Ocean Assessments, a series of regional workshops was organized with a view to raising awareness of the Regular Process, identifying regional priorities and making progress in writing individual chapters. The workshop results were the basis for, inter alia, obtaining data at the regional level, contributing to the scoping exercise and facilitating discussion of relevant content.

7. The programme of work for the third cycle covers three main outputs:

(a) Output I: assessments of the state of the marine environment, including socioeconomic aspects. Regional workshops will be held in support of the scoping exercise and the preparation of the assessments. The objective of the workshops will be to identify regional priorities and make progress in writing individual chapters, which will be finalized by late 2025;

(b) Output II: Regular Process support for and interaction with other ocean-related intergovernmental processes. The third cycle includes the identification of key activities to support and interact with other ongoing ocean-related intergovernmental processes, as appropriate. Outputs will be specifically tailored to the requests and needs of the processes. Consultations will be held on relevant processes regarding the preparation of these outputs;

(c) Output III: capacity-building. The aim of the programme on capacity-building would be to develop the capacities of States to strengthen the ocean science-policy interface at the national, regional and global levels. The focus will also be on institutional arrangements and legal frameworks that help to ensure the integration of science and policy.

8. A series of workshops is planned for 2022 and 2023 in support of the Regular Process, providing opportunities for interaction with other ocean-related processes.

9. In 2022, five regional workshops will be held from April to December with a view to, inter alia, informing the scoping exercise and the development of annotated outlines for the assessments.

10. In 2023, the workshops to be held from April to December will be aimed at, inter alia, raising awareness, collecting regional-level data for the drafting of the assessments, preparing draft chapter outlines and facilitating discussions of the writing teams on the drafting of chapters.

11. Capacity-building for strengthening the ocean science-policy interface will define the objectives of five regional workshops in 2022 and 2023 according to regional needs, in consultation with other organizations and processes.

II. Interactions with United Nations agencies and intergovernmental processes

12. A number of mechanisms to promote and facilitate interaction with other ocean-related processes is envisaged, including the following:

(a) Participation, including co-hosting, of ocean-related intergovernmental processes in the workshops organized by the Regular Process. The regional workshops will provide an opportunity for members of the scientific community to interact with the Regular Process and other relevant ocean-related processes and organizations;

(b) Participation by relevant ocean-related processes and organizations in the workshops will allow their contribution to shape the contents of the third World Ocean Assessment;

(c) Several international forums also provide the opportunity for interaction between the Regular Process and policymakers, such as the high-level political forum on sustainable development and the 2022 United Nations Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development;

(d) Preparation and holding of briefings or presentations in the margins of events of other ocean-related intergovernmental processes;

(e) Preparation of outreach and awareness-raising material on the Regular Process to be shared with stakeholders of other ocean-related intergovernmental processes;

(f) Participation by representatives of the Regular Process in meetings and proceedings of other ocean-related intergovernmental processes;

(g) Establishment of mechanisms to strengthen and maintain on a regular basis coordination and cooperation with the secretariats of other ocean-related intergovernmental processes, including through UN-Oceans;

(h) Identification and implementation of other activities to support and interact with other ocean-related intergovernmental processes.

III. Results of the second World Ocean Assessment

13. The second World Ocean Assessment follows a modified approach to the driver-pressure-state-impact-response framework, supported through a series of regional workshops aimed at identifying region-specific information and input for the Assessment, a peer-review process and a process of review by States.

14. In applying the driver-pressure-state-impact-response approach, the Assessment characterizes drivers as from social, demographic, economic development and cultural changes and the associated consumption and production mechanisms, recognizing drivers that have the greatest influence on the marine environment and its sustainability: (a) population growth and demographic changes; (b) economic activity; (c) technological advances; (d) changing governance structures and geopolitical instability; and (e) climate change.

15. Relationships between drivers and pressures (and their impacts) are complex and dynamic, with interlinkages between drivers leading to cumulative interactions and effects of pressures.

16. Drivers vary regionally as a result of global variability in population distribution and demographics, the degree of economic development, technological capacity and the uneven effects of climate change. Therefore, human activities and pressures vary globally. The most notable differences are between temperate and tropical regions and developed and least developed regions.

17. Integrated modelling frameworks, within which scenarios can be explored – including changes to people and economies, governance structures and the effects of climate change on maritime industries and the environment that are multisectoral and therefore provide whole-of-system approaches – allow for the identification of sustainable ocean use.

IV. Key points from the second World Ocean Assessment

18. Ocean habitats, owing to the existence of relatively few barriers to dispersal, are highly interconnected. Since all species are interdependent, impacts at any level will result in losses of biodiversity across trophic levels, food webs, taxa and habitats.

Habitat pressures

19. Marine biodiversity threats result mainly from habitat modification. About 40 per cent of the world's population lives in the coastal zone, within 100 km of the coast, and the proportion is increasing. This might increase the extent and risk of eutrophication,[3] with consequent habitat losses.

20. The recovery of benthic communities after the use of heavy equipment used in the deployment of large bottom-trawling nets will take several decades. General Assembly resolution 61/105 of 8 December 2006 on sustainable fisheries, in which the Assembly called for fisheries using bottom-contacting gear to avoid significant adverse impacts on vulnerable marine ecosystems, has been particularly influential on marine fisheries.

Resource extraction

21. The precautionary approach to management, enshrined in many international agreements, requires that the development of prospective fisheries, such as those for mesopelagic fish, be regulated before they are allowed to start operating.

22. Invertebrate fishery catches have rapidly expanded globally to more than 10 million tons annually and contribute significantly to global seafood provision, export, trade and local livelihoods. The harvesting of scallops, sea cucumbers and crabs is altering biogenic habitats at the regional level.

Pollution and contamination

23. The principal sources of marine debris are located inland and need to be reduced. Dumping at sea is decreasing but there is a lack of harmonized reporting.

Ecosystem approach to management

24. Achieving the targets of the Sustainable Development Goals needed to implement the 2030 Agenda requires full consideration of ecosystem-based management approaches. This will provide a framework for due consideration of interactions between the Goals, the benefits associated with achieving the targets of the Goals and their compatibilization.

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[3] Increase in nutrient concentration resulting in excessive plant and/or algal growth.

25. Management, including the establishment of marine protected areas, reduces the impact of pollution and fisheries.

V. Main results on biodiversity presented in the second World Ocean Assessment

Overview of marine biodiversity status

26. Microbial food webs account for most living biomass and nutrient recycling in the ocean, while metazoan food webs support most fisheries and the biological pump.[4] Accurate estimates of plankton diversity at the regional and global levels based on microscopic examination are not possible at the present time, owing to severe undersampling.

27. About 6 per cent of known fish species and nearly 30 per cent of elasmobranch species are listed as near-threatened or vulnerable. Globally, the status of marine mammals varies, with 75 per cent of species in some groups (sirenians, freshwater dolphins, polar bears and otters) being classified as vulnerable, endangered or critically endangered. Many large whale species are now recovering from past harvesting as a result of prohibitions on and the regulation of commercial catches and national recovery plans. The conservation status of marine reptiles has varied greatly: protection in certain regions has increased some populations, while those in other areas are declining because of continuing or increasing threats. The global conservation status of seabirds has worsened, with over 30 per cent of species now listed as vulnerable, endangered or critically endangered.

28. Overall, some efforts to mitigate or reduce pressures on the oceans have improved since the first World Ocean Assessment was published. In 2020, marine protected areas covered 18 per cent of the ocean within national jurisdictions, representing approximately 8 per cent of the entire ocean, while about 1 per cent of marine areas beyond national jurisdiction were protected.

29. Management approaches are increasingly including diverse links between ecological and social, economic and cultural aspects. The ecosystem approach integrates environmental, social and economic aspects at the global, regional, national or local level. Cultural information is becoming an integral part of management frameworks, both in the context of community-based management and for safeguarding the cultural dimension of the marine environment.

30. However, ocean degradation, including of important habitats, such as mangroves and coral reefs, continues to occur. Pressures include those associated with global processes (e.g. climate change, atmospheric pollution, temperature increase, acidification and deoxygenation) and those resulting from local or regional human activity, including the introduction of invasive species, overfishing, nutrients and hazardous substance inputs, microplastics and nanoplastics, extraction of mineral resources, agricultural run-off and municipal waste.

31. Despite their relative inaccessibility, the high seas provide essential marine ecosystem goods and services. Furthermore, great potential for mineral, energy and living resources from the pelagic areas exists, although such areas were poorly studied spatially and temporally.

Main pressures on marine biodiversity

[4] The process of transforming carbon from surface waters into living matter, distributing it into deeper water and sediments.

Climate change

32. The open ocean, including the abyssal habitats, is under pressure from global warming, with marine heatwaves increasing in frequency and intensity. Around 90 per cent of the heat from global warming is stored in the oceans; the warming trend has been observed since the 1950s and has reached as far as 2,000 m. Salinity is increasing near the surface and in the subtropical regions. In the poles salinity is decreasing.

33. The increase in carbon dioxide is reflected in the ocean's chemistry, including acidification, with negative impacts on many organisms, in particular those with calcium carbonate parts, altering biodiversity and ecosystem structure.

34. Oxygen concentrations decreased in most ocean regions. Oxygen solubility decreases with temperature, a phenomenon responsible for near-surface reduced concentrations, expanding to the water column in many areas.

35. Climate change will alter the biological pump and the ocean's ability to take up anthropogenic carbon. In association, deoxygenation is leading to habitat reduction in pelagic waters, and the ocean acidification impact is greater in calcareous plankton in the open ocean. It also affects the food web structure of marine communities and exhibits substantial differences between latitudes. Thus, biodiversity is affected as a result of climate change, through both a reduction in the number of species and changes in distribution.

36. Plankton species depend on circulation systems for their recruitment and dispersion, which are being affected by warming and changes in salinity. Meridional circulation in the Atlantic has weakened. While predicting the impacts of changes in circulation is uncertain, they will include changes in carbon uptake, nutrient distribution and exchanges with the atmosphere.

37. The total sea ice extent has been declining rapidly in the Arctic, but trends are insignificant in the Antarctic. In the Arctic the summer trends are most striking in the Pacific sector of the Arctic Ocean, while in the Antarctic the summer trends show increases in the Weddell Sea and decreases in the West Antarctic sector of the Southern Ocean. Variations in sea ice extent depend on ocean warming and changes in wind and ocean currents and the impact on ecosystems adapted to the presence of large extensions of sea ice.

Economic activities

38. Fishing pressure is not limited to target species; it also applies to by-catch species, such as non-commercial fish species and seabirds, which are also affected by prey depletion and pollution.

39. Bottom trawling and lost or discarded fishing gear have an impact on seabeds, seamounts and, in general, marine habitats, reducing biodiversity at the local and regional scales.

40. Vessel subsidization, lost or discarded gear, ineffective management, by-catch and illegal, unreported and unregulated fishing are factors contributing to habitat degradation. Subsidies contribute to overcapacity, excessive fishing and stock depletion. About 54 per cent of high seas fishing grounds would be unprofitable without subsidies. Illegal, unreported or unregulated fishing weakens fisheries governance, contributing to illicit trade and increasing pressure on marine biodiversity.

41. Coastal ecosystems support high pressures from human activities. These populations depend on the ocean for a range of social, economic and cultural values and are key to conservation, climate change mitigation and adaptation.

42. Coastal and marine infrastructures may substantially damage marine ecosystems, reducing biodiversity while creating new opportunities for human development in coastal areas through economic development.

Cumulative impacts

43. Multiple stressors affect biogenic reefs and sandy, muddy and rocky shores that support high biodiversity: ocean warming, storms and land reclamation are the main pressures.

44. Owing to their proximity to the shore, slopes and canyons are subject to pressures from the expansion of deep-water oil and gas activities, offshore energy installations, bottom fisheries and, potentially, mineral mining activities, as well as subject to increasing contamination, including litter and mine tailings from land.

Observed changes to marine biodiversity

45. From satellite determinations of the sea surface, chlorophyll has not yet revealed a long-term trend in net primary production, but the biomass of planktonic algae has declined relative to microbial plankton in most regions, a trend that appears to be related to upper ocean warming.

46. A comparison of known toxic events in 1970 with those observed in 2017 suggests that the public health and economic impacts of toxic events have increased in frequency and have spread globally. While there is reason to suspect that the combined effects of increases in coastal eutrophication, sea surface temperature and vertical stratification may favour the growth of dinoflagellates, the underlying causes of those trends remain a matter of speculation.

47. On average, seasonal spring peaks in plankton biomass have advanced by 4.4 days per decade and the leading edges of species distributions have extended polewards by 72 km per decade. In the Antarctic, krill (*Euphausia superba*) recruitment to the adult population, which depends on the survival of larval krill during winter, is the parameter most likely to be altered by climate change. *E. superba* has been found to be more abundant following winters with extensive sea ice cover, while salps have been more abundant following winters in which the spatial extent of sea ice is relatively low. The observed decrease in sea ice extent portends a long-term shift from a food web dominated by *E. superba* to one dominated by salps, with unknown cascading effects on the abundance of vertebrate predators.

48. In the Arctic, as the vertical stratification of the water column increased, net primary production has also increased. This has also been associated with increases in the biomass of microbial plankton at the expense of microscopic algae. Warming has also influenced the relative abundance of krill species, with the boreal species *Meganyctiphanes norvegica* increasing and the cold-water species *Thysanoessa raschii* decreasing. Furthermore, the effects of temperature may also be abrupt in polar ecosystems owing to more frequent and extreme marine heatwaves.

49. The loss of Arctic sea ice and Antarctic ice shelves changes the distribution of open water and ice-covered marine habitats. Many ice-dependent species are decreasing in abundance and reducing their distributions, in particular in the Arctic.

50. Since 2012, researchers have described 10,777 new marine benthic invertebrate species; at the same time, biodiversity is changing globally at rates unprecedented in human history, creating the potential for the extinction of species before they have been described. A number of species are likely to become extinct by 2100, such as the vaquita (*Phocoena sinus*), the Maui dolphin (*Cephalorhynchus hectori maui*) and several freshwater dolphins.

51. Marine species distributions, overall, are shifting to the poles as a result of warming waters. Regionally, shifts are driven by circulation changes such as the El Niño Southern Oscillation.[5] Invertebrate biomass has declined in areas of the Alaska seas. Marine heatwaves have led to severe bleaching and mass mortality of corals around Australia, the Central American coast and the South China Sea.

52. Invasive species (see also chapter 22 of the second World Ocean Assessment) can become a dominant pressure on native benthos. Extensive blooms of *Sargassum* algae have recently regularly covered beaches and inshore coastal habitats. Extensive *Sargassum* rafts can alter the abundance of many native marine invertebrates and may provide a suitable habitat for further invasions.

53. Regional seas, notably the Mediterranean, are bearing the brunt of the importance of shipping as a major introduction pathway for marine non-indigenous species, with high numbers of new species entries registered through the world's largest shipping canal – the Suez Canal. Some of the established marine non-indigenous species, including the nomadic jellyfish (*Rhopilema nomadica*) and the silver-cheeked toadfish (*Lagocephalus sceleratus*), exert a considerable socioeconomic impact by virtue of their venomous and toxic nature, respectively.

54. Ocean warming has induced changes in coral reef ecosystems (coral bleaching), reducing biodiversity, impairing the habitability of islands and affecting the health, productivity and function of coastal ecosystems.

55. Consequently, coral cover continues to decline globally, with negative effects on biodiversity, and is also affected by extractive activities, pollution, diseases, physical destruction, outbreaks of several species and the increasing time required to recover after major disturbances such as storms.

56. From 2010 to 2020, newly developed, upgraded or renovated coastal infrastructure increased. Defences, urban development and port and tourist facilities greatly improved economic development in coastal regions, in particular in East Asian countries.

57. Seagrass meadows continue to decline at alarming rates, in particular where they are in conflict with human activities.

58. Globally, mangroves are still decreasing and have been heavily affected by deforestation. Recently the speed of mangrove losses has decreased from about 2 per cent per year to less than 0.4 per cent per year. Increasing human population density and unplanned development in the coastal zone are the main threats to mangrove forests.

59. Since the first World Ocean Assessment was published, estimated yearly catches in marine capture fisheries increased by 3 per cent to 81 million tons, amounting to an increase of 1 per cent in landing value ($127 billion), while excessive fishing efforts, leading to lower biomass, resulted in estimated annual lost net benefits of $88.9 billion.

60. Of the world's marine capture fisheries for which data existed, about 60 per cent were "maximally sustainably fished", and that proportion has been increasing since 1990. The combined sum of the proportions of maximally sustainably fished and underfished stocks was reflected in indicator 14.4.1 of the Sustainable Development Goals (proportion of fish stocks within biologically sustainable levels).

[5] The fluctuation of the sea surface temperature in the equatorial Pacific Ocean and of the air pressure of the atmosphere.

61. Illegal, unreported or unregulated fishing weakens fisheries governance, contributes to illicit trade and continues to be a cause of concern in fisheries worldwide.

62. Small-scale fisheries, destined mainly for local consumption, are critical for the food security of small developing States and the achievement of the Sustainable Development Goals. These fisheries continue to be at risk owing to illegal, unreported or unregulated fishing and distant fleets (subsidized or not). Distant-water fleets' catches grow faster than catches by home States, displacing home fleets in low-income economic zones.

63. Global aquaculture production (animals and plants) in 2017 was recorded at 111.9 million tons, with an estimated first-sale value of $249.6 billion. Since 2000, world aquaculture has ceased to enjoy the high annual growth rates of the 1980s and 1990s (11.3 and 10.0 per cent, respectively).

64. Aquaculture continues to grow at a faster rate than other major food production sectors. However, annual growth declined to 5.8 per cent during the period from 2000 to 2016.

Expected changes to marine biodiversity

65. Climate change and its impact on the ocean are expected to continue, with further alterations in areas such as ocean circulation, warming, acidification and deoxygenation. Human activities such as resource extraction, pollution, the introduction of invasive species and contamination also present negative impacts on marine biodiversity and are expected to increase in the future, in particular in areas beyond national jurisdiction; not only will they exert growing pressure on natural resources, but they may also threaten marine biodiversity and therefore the benefits that people obtain from ecosystem services.

66. The expected changes in the upper ocean in the twenty-first century will affect the diversity and productivity of plankton at the regional and global levels, mainly as a result of climate change. These changes include the expansion of subtropical gyres, ocean warming and acidification, decreases in salinity, increases in vertical stratification and decreases in inorganic nutrient supplies to the euphotic zone, which are likely to result in decreases in phytoplankton productivity and cell size. These changes will expand to the deep sea, affecting the whole water column.

67. Future projected declines in coral abundance (including cold-water corals) will reduce the habitat available to commercially significant species, reducing carbon sequestration in deep waters and eliminating potential genetic resources.

68. Nutrient inputs are expected to increase as a result of population and economic activities, fuelling the global increase in eutrophication from anthropogenic sources, exceeding those of natural origin.

69. Microbial food webs will increase their importance relative to metazoa, decreasing the export of biological production to the deep ocean. The ability of the ocean to absorb carbon dioxide will be reduced, accelerating global atmospheric warming.

70. The biological responses would include the following:

(a) The relative abundance of microbial plankton is likely to increase at the expense of microscopic algae, and net primary productivity is expected to decrease. It is likely that these changes will propagate through food webs, resulting in decreased fisheries production and reduced capacity of the ocean to sequester carbon;

(b) Plankton in the polar oceans and upwelling regions will be most affected by ocean acidification;

(c) Increases in net primary production will occur in the Arctic and Antarctic.

71. Future trends in coastal upwelling regions are less certain owing to interactions between upwelling favourable winds and upper ocean warming and their effects on the relative abundance.

72. Human recreational activities, coastal infrastructure development, ship anchoring and bunkering would continue to have an impact on vulnerable habitats and associated invertebrate assemblages, as discussed in the first World Ocean Assessment.

73. It is predicted that there will be an increase in the frequency and severity of marine heatwaves in the coming decades, even if emission reduction targets established under the Paris Agreement are met. This warming could eliminate key biogenic habitats in coastal regions of temperate and high-latitude seas worldwide and affect reef ecosystems, kelp forests and seagrasses, with damage to an unknown extent.

74. Persistent organic pollutants will remain present globally with biological consequences, as will pharmaceutical and personal care products, which have been detected in the Arctic and Antarctic, with physiological effects on the biota. Marine microplastics and nanoplastics will also continue to increase in the marine environment.

75. Around 30 per cent of world fisheries continue to experience overexploitation, affecting biodiversity and their economic value. This trend is expected to remain stable.

76. Stock assessment and fisheries management will increase participation in decision-making, leading to more sustainable outcomes. Many stocks are expected to be rebuilt at the decade scale while past impacts on biodiversity will recover over longer time scales.

77. High-seas fisheries are expected to improve with regard to enforcing catch limits, observer coverage, by-catch and discard control. World Trade Organization negotiations on the elimination of illegal, unreported or unregulated fishing, including subsidies to fishing vessels, were expected to finish by 2020 but are still under discussion. Both developments will reduce fishing pressure on marine ecosystems.

78. Increases in the frequency of extreme natural hazards would affect the local distribution of target species, affecting fishery-dependent developing States.

79. The predicted increase in the global population will require more efficiency in the food sectors. To respond to this demand, the aquaculture industry needs to implement good governance addressing environmental concerns to prevent impacts on wild populations.

80. Deep-water seabed mineral resources are typically located far from human communities and the social impacts of their exploitation may be less than those of terrestrial mining. However, significant concerns exist about the loss of biodiversity and ecosystem services, including the role of the deep ocean in climate regulation.

Capacity-development needs

81. Scientific understanding of marine biodiversity is improving through the development of sensors, observation platforms and autonomous systems, which have significantly increased the ability to obtain information. Regional programmes are now better coordinated and integrated with more standardized methods. However,

there is a need for: (a) assessing the responses to pressures; (b) understanding the cumulative effects of multiple pressures; (c) management development; (d) data collection; and (e) development and transfer of scientific expertise.

Assessment of responses to pressures

82. The vulnerability of many species, including macroalgae, microbial plankton and benthic invertebrates, to changing climate and ocean conditions has not been assessed. Studies are needed to determine the effects on ecosystems of reduced or lost biodiversity, in particular in the context of food web interactions.

83. On top of the need to evaluate vulnerabilities, emerging pressures such as the presence of plastics, in particular microplastics, which have been identified in more than 1,400 marine species, also need to be evaluated. Very little is known about the resilience of marine organisms, their ability to adapt to the environment and the implications of such adaptations.

84. In the high seas, the large-scale protection of the seabed, at both the national and international levels, if implemented effectively, would support the sustaining of benthic biodiversity and avoid the extirpation of species before they have even been recorded.

Understanding the cumulative effects of multiple pressures

85. Pressures, including changes to physical and biogeochemical processes associated with climate change, physical impacts on the seabed, the extraction of living and non-living resources, coastal development and use, invasive species and pollution, all have varying effects on marine biodiversity. The simultaneous effect of these pressures needs to be evaluated.

86. Studies of cumulative effects tend to be focused on existing and past activities in the marine environment. Assessments that allow foresighting are needed to inform planning of future activities and support adaptive management. Such assessments will require increased transboundary cooperation, the strengthening of science-policy links, greater coordination between social and natural sciences and between science and civil society, including industry, and the recognition of traditional knowledge.

87. Failure to achieve the integrated understanding of human pressures on the ocean is increasing the risks to the benefits that people draw from the ocean, including in terms of food safety and security, material provision, human health and well-being, coastal safety and the maintenance of key ecosystem services.

Management development

88. The number and complexity of human activities, especially in coastal regions, requires approaches other than strict conservation, considering the full set of stakeholders and their interests. Integrated ocean management provides a mechanism through which conservation and management among all relevant human activities can be prioritized and coordinated. Failure to integrally manage coastal activities is increasing risks for the sustainability of ecosystem services, including food security and general human well-being.

89. Marine spatial planning is an effective way of resolving such conflicts, while requiring further research on its application, management systems and adapting to varying legal status and systems in different jurisdictions. Over the past two decades, marine spatial planning has been instituted to a growing extent in many jurisdictions in a variety of forms. Some are simply zoning plans; others include more complex management systems. Marine spatial planning allows for the allocation of space to

different activities by optimizing the use of resources while minimizing the environmental impact.

90. Marine protected areas are conservation tools designed to improve biodiversity protection by encompassing spatial scales that reflect the life history distributions of species. They preceded the concept of marine spatial planning, and both are frequently developed in parallel.

91. Integrating a pre-existing marine protected area into a marine spatial planning exercise, or establishing marine protected areas within marine spatial planning as multiple use areas, are options to link both management options.

92. Studies on the effect of protected areas remain limited. Reviews do not break down impacts (e.g. climate change, resource exploitation and pollution) by species group.

93. Apart from the spatially-based management implied in marine spatial planning and marine protected areas, the ecosystem approach is one of the most significant approaches to ocean management. It consists of the environmental, social and economic management of human interactions with oceans and coasts at multiple levels (regional, national and local). It allows transboundary application without explicitly defining jurisdictions and focusing policy decisions on the conservation and sustainable use of marine resources. Further research and capacity-building are needed to realize the full potential benefits of this approach across the oceans.

Data collection

94. Baseline biodiversity studies (for ecoregions or for habitats that are hotspots for biodiversity) are lacking for the mesophotic zone, underwater caves and many of the thousands of global seamounts. Moreover, at the regional level, large disparities in knowledge of marine biodiversity remain, in particular in Oceania, Africa and South America. Many observation networks do not cover the socioeconomic aspects of the ocean. There is a need for public sociocultural observations at the regional and global levels.

95. Listing species with restricted geographical ranges, often arising from specialized habitat requirements, represents the most urgent need. Even describing 100 taxonomic units every year over the next decade would add just 1,000 species.

96. The planet’s largest ecosystem comprises the bathypelagic domain, a dark and cold zone (0–5°C) found between 1,000 and 4,000 m, comprising almost 75 per cent of the ocean volume. The deep pelagic ocean is underobserved and undersampled owing to a combination of factors: (a) limited access to open ocean sampling platforms for obtaining deep-water samples; (b) the large ocean volume involved; and (c) the widely dispersed populations. Thus, a critical knowledge gap exists for deep pelagic (e.g. mesopelagic and bathypelagic) environments. Slopes and canyons represent a large source of deep-sea biodiversity, in part owing to high geomorphic, geochemical and environmental heterogeneity. That biodiversity is still in a discovery phase and largely unprotected, but it is increasingly vulnerable to the confluence of changing climate and growing human extractive activity, contamination and waste disposal on continental margins. Improved ocean observation, biodiversity characterizations, taxonomic knowledge and technology transfer are needed, in particular in the southern hemisphere.

97. In mining operations, the direct physical removal of sea floor fauna and secondary effects from sediment plumes or the release of ecotoxins will potentially affect benthic environments and will require careful evaluation. There is little or no information on the impacts of seabed mining on biodiversity and ecosystem services.

Baseline data are necessary for informed decision-making with regard to mineral extractions from the seabed.

Development and transfer of scientific expertise

98. At the regional level, large disparities remain, in particular in Oceania, Africa and South America, on the understanding of the ocean because of differences in the capacities of regional infrastructure and in specialized professional human capacity. Such disparities therefore affect possibilities for engaging in competitive ocean research and, in turn, lead to the observed disparities in scientific understanding of the oceans at the regional level. Capacity-building, shared scientific knowledge and collaboration to develop and transfer innovative marine technology will empower States to fully participate in and benefit from the conservation and sustainable use of the ocean and its resources and assist them in meeting their obligations.

99. Few people study to become systematists in spite of the fact that taxonomic and systematic studies are critical tools to monitor marine biodiversity, which is the foundation for development, in particular in small island States and archipelagic countries.

100. Geographic bias in slope and canyon research towards the exclusive economic zones of developed States bordering the North Atlantic Ocean and the North Pacific Ocean and around Oceania reflects the reality of access, financial resources and the interests of the industries involved in resource extraction. That leads to limited global understanding of biodiversity patterns and drivers and has consequences for the distribution of expertise, which, for slopes and canyons, is based in developed regions, as well as in China, India and, to a lesser extent, Brazil and Chile. It has also resulted in the uneven distribution of the technology, analytical tools and methodologies required to advance a global understanding of slope and canyon ecosystems.

Socioeconomic aspects of biodiversity

101. The ocean provides for the livelihoods of millions of people across the globe, as well as a range of ecosystem services and benefits, including oxygen production, food provision, carbon storage, minerals, genetic resources and cultural and general life support services. The distribution around the world of the benefits drawn from the ocean is still very uneven. Efforts by less developed countries to take advantage of what the ocean can offer are hampered by gaps in capacity-building and resource and financial constraints.

102. As an example, in 2016, 79.3 million tons of marine fish were caught, and 28.7 million tons of marine aquaculture species were farmed, supplying an average of 14.6 kg of seafood per person. Seafood is essential for food security: it provides more than 20 per cent of the average per capita animal protein intake for 3 billion people, and more than 50 per cent in some developing countries.

103. The most direct benefit that marine and coastal ecosystems provide is their primary productivity and the resulting products, such as fish, plants, animals, structural materials, natural medicines, pharmaceuticals and biochemicals, including fossil fuels. All these services are heavily dependent on the conservation of biodiversity, which is threatened by human activities such as food harvesting, shipping, seabed mining, offshore hydrocarbon exploration and exploitation, tourism and recreation, use of marine genetic resources, production of fresh water by desalinization and salt production. Thus, ecosystem services from marine and coastal ecosystems are deteriorating at an alarming rate, owing to several human pressures, including climate change.

104. Biodiversity changes have both direct and indirect impacts on human well-being. Unfortunately, there is a lack of large-scale and long-term monitoring of large marine areas, even though some Arctic and North Atlantic nations have established long-term monitoring of invertebrate fisheries and by-catch from trawls within existing scientific national fish assessment surveys. Changes in the distribution of many species may cause an increase in food resources or a decrease, including local extinction, or even new species becoming available to dependent coastal communities.