

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

Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects

[0.1.](#) The Regular Process is a global mechanism established by Members States of the United Nations after the World Summit on Sustainable Development, held in Johannesburg, South Africa, in 2002¹. Its aims are to regularly review the environmental, economic and social aspects of the state of the world's ocean, both current and foreseeable, and identify current knowledge gaps and capacity needs. Its purpose is to contribute to the strengthening of the regular scientific assessment of the state of the marine environment in order to enhance the scientific basis for policymaking. The Regular Process is in its third cycle (2021–2025), with the first and second World Ocean Assessments published in 2016 and 2021, respectively.

[0.2.](#) The Regular Process is mandated by the General Assembly to provide scientific information that supports, inter alia, the 2030 Agenda for Sustainable Development², the development of an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction³, the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea⁴ and the United Nations Framework Convention on Climate Change⁵.

[0.3.](#) The main output of the first and second cycle of the Regular Process was a global integrated marine assessment (also known as the *World Ocean Assessment*), with the first *World Ocean Assessment* focused on establishing a baseline and the second on building on that baseline, evaluating trends and identifying gaps.

[0.4.](#) The first *World Ocean Assessment*, published in 2016, indicated that growing population, economies and agricultural and industrial requirements for feeding, clothing and housing the world's population were seriously degrading parts of the marine environment, especially near the coast. The assessment concluded that, without an integrated, coordinated, proactive, cross-sectoral and science-based approach to coastal and marine management, the resilience of coastal and marine ecosystems and their ability to provide vital services would continue to be reduced.

[0.5.](#) The second *World Ocean Assessment*, published in 2021, is structured around a slightly modified drivers-pressures-state-impact-response framework. It identifies the following overarching drivers influencing the marine environment: (a) population growth and demographic changes; (b) economic activity; (c) technological advances; (d) changing governance structures and geopolitical instability; and (e) climate change. The second assessment highlighted that although some improvements in some sectors and some regions had been made, ongoing decline in many aspects of the ocean as a result of the many unabated pressures humans were placing on the ocean had occurred.

[0.6.](#) The programme of work set out for the third cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, developed by the Bureau of the Ad Hoc Working Group of the Whole on the Regular Process and to be conducted during the period 2021–2025,

¹ www.un.org/regularprocess/content/about

² <https://sustainabledevelopment.un.org>

³ www.un.org/bbnj

⁴ www.un.org/Depts/los/consultative_process/consultative_process.htm

⁵ <https://unfccc.int>

consists of three main outputs. Output II is focused on supporting and interacting with ocean-related intergovernmental processes. The activities associated with this output include the preparation of policy relevant briefs specifically tailored to meet the requests and needs of a number of international agreements, intergovernmental initiatives and processes relevant to the Regular Process.

~~0.7.~~ Four briefs have been produced, addressing Climate Change, Biodiversity, the Sustainable Development Goals and both the UN Decade of Ocean Science for Sustainable Development and the UN Decade of Ecosystem Restoration, respectively.

Purpose and preparation of the four briefs

~~0.8.~~ The briefs provide a synthesis of relevant information from the second *World Ocean Assessment* related to two key global topic areas (climate change and marine biodiversity) and three United Nations processes (the Sustainable Development Goals of Agenda 2030, the United Nations Decade of Ocean Science for Sustainable Development and the United Nations Decade on Ecosystem Restoration). These key global issues and processes have been identified as priorities by the Group of Experts and the secretariat of the Regular Process, in consultation with the Bureau. The briefs have been prepared by the Group of Experts, with the assistance of the secretariat of the Regular Process. Outlines of the briefs have been reviewed by relevant UN agencies and intergovernmental processes. The briefs have been reviewed by member states, the Bureau of the Ad Hoc Working Group of the Whole on the Regular Process and considered by the Working Group at its sixteenth meeting.

~~1.9.~~ Central to the outputs produced by the Regular Process, including the present brief, are two components. The first is the utilization of ocean observation and monitoring outputs and research to temporally assess physical, chemical, biological, social, economic and cultural components of coastal and marine environments to establish their current state, impacts currently affecting such environments, responses to those impacts and associated ongoing trends. The second component is the knowledge-brokering role the outputs of the Regular Process provide in increasing awareness of the ocean, the changes occurring in it, the human activities causing those changes and the progress being made in reducing and mitigating the impacts of human activities on the marine environment. Through identifying both knowledge gaps and capacity needs, the Regular Process also provides direction to policymakers for the future development and deployment of sustained observation systems and delivery mechanisms that are required for enhancing knowledge and supporting national aspirations associated with the sustainable development of coastal and marine ecosystems.

Acknowledgements

Contributions to this brief under the programme of work of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects were made by:

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I. Key benefits and socioeconomic aspects of biodiversity **(Chapters: 8A, 8B, 15, 16, 28)**

~~10. (103.)~~ ~~The~~ 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. The ecosystem services provided to humans by the ocean 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.

~~11. (41.)~~ Coastal ecosystems are key to conservation, climate change mitigation and adaptation, and sustain large human populations that are dependent on the ocean for a range of social, economic and cultural values. Despite their relative inaccessibility, the high seas also provide essential marine ecosystem goods and services. Furthermore, great potential for mineral, energy and living resources from the high seas exists.

~~12. (102.)~~ 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. 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.

~~13. (59.)~~ ~~Since~~ In the period between the first World Ocean Assessment ~~was published~~ and second World Ocean Assessment, 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.

~~14. (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.

~~15. (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.

~~16. (63.)~~ Global aquaculture (animals and plants), including inland production 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).

17. (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.

II. ~~H~~ Key drivers and associated pressures impacting biodiversity (Chapters 2, 4, 5, 7B, 7F, 7H, 7N, 7-Q, 9, 10, 11, 12, 15, 18, 19, 20, 22, 25, 28)

18. (14.) In applying the driver-pressure-state-impact-response approach, the [second World Ocean Assessment](#) characterizes drivers ~~as~~ from social, demographic, economic development and cultural changes and the associated consumption and production mechanisms, recognizing [the following](#) 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.

19. (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.

20. (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. The most notable differences are between temperate and tropical regions and developed and least developed regions.

21. (19.) 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. As human populations grow, there are associated increases in the extent and risk of eutrophication⁶, ~~and~~ ~~**~~ [contamination through discharges of nutrients and hazardous substance inputs, marine debris, including microplastics and nanoplastics,](#) and human activities throughout coastal zones, [including coastal development \(including for tourism\), the introduction of invasive species, overfishing, extraction of mineral resources](#) with consequent habitat losses and subsequent impacts on marine biodiversity.

22. (23.) While the principal sources of marine debris are those derived from land (including atmospheric transport) maritime sources from industries such as fishing, tourism and maritime transport are also significant. In areas of high fishing intensity marine litter can be entirely composed of abandoned, lost or otherwise discarded fishing gear ([Pham et al., 2014](#)). Dumping at sea is decreasing but there is a lack of harmonized reporting. There is an important need to identify sources of marine pollution and debris. [New emerging contaminants of concern are pharmaceutical and personal care products and their physiological effects on the biota.](#)

23 (23 a)) [Noise does not persist in the marine environment once the sound source has been removed, although impacts can persist. The main anthropogenic noise sources in the ocean include vessels, industrial activity, including seismic exploration and renewable energy development, and sonar.](#) Understanding of the impacts of anthropogenic noise on marine biodiversity is increasing, in parallel with a growing recognition of the need to monitor and reduce anthropogenic sources of noise entering the marine environment.

⁶ Increase in nutrient concentration resulting in excessive plant and/or algal growth

24. (52.) Invasive species can become a dominant pressure on native biodiversity. Extensive blooms of *Sargassum* algae have recently regularly covered beaches and inshore coastal habitats and can alter fish and coral populations due to multiple factors; light depletion and decomposition processes that causes eutrophication and lack of oxygen⁷. Extensive *Sargassum* rafts can alter the abundance of many native marine invertebrates and may provide a suitable habitat for further invasions.

25. (53.) Regional seas, notably the Mediterranean, are bearing the brunt of impacts associated with shipping, in particular the introduction of invasive species with high numbers of species originating from the Red Sea being transported into the Mediterranean via the Suez Canal. Some of the established marine nonindigenous 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.

26 (75.) Around 30 per cent of world fisheries continue to experience overexploitation, affecting biodiversity and their economic value.

27. (40.) Vessel subsidization, lost or discarded gear, ineffective management, by-catch and illegal, unreported and unregulated fishing are factors contributing to habitat degradation, 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.

28. (38.) Bottom trawling and lost or discarded fishing gear have an impact on the ~~seabed, seamounts and, in general,~~ sea bottom habitats including those associated with continental slopes, canyons and seamounts, reducing biodiversity at the local and regional scales. ~~Improvements on fishing gear aimed to reduce gear losses are needed.~~ Empirical evidence has demonstrated that effective management could improve fish stocks, increasing biomass and biodiversity.

29. (39) Fishing pressure is not limited to target species; it also applies to by-catch species, such as non-commercial fish species, marine mammals and seabirds, which are also affected by prey depletion and pollution. ~~22 (part)~~ The harvesting of scallops, sea cucumbers and crabs is altering biogenic habitats at the regional level.

30. (44.) Continental slope and canyon habitats 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.

31. (56.) The development or improvement of coastal infrastructures, especially blue infrastructures, can bring huge benefits to coastal communities and create new opportunities for human development in coastal areas through economic development. However, the development of coastal and marine infrastructure may damage habitats and ecological systems, including their extent, structures and functions. From 2010 to 2020, newly developed, upgraded or renovated coastal infrastructure increased. Defences, urban development and port and tourist facilities have enhanced economic development in coastal regions, in particular in East Asian countries.

32. (32.) The open ocean including the abyssal habitats, similarly to other parts of the ocean, is under pressure from global warming, with marine heatwaves increasing

⁷ This addition does not reflect the content of the second World Ocean Assessment, but is additional information reflecting comments made by member countries to the content of the brief.

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 been observed to occur as deep as 2,000 m. Salinity is increasing near the surface in the subtropical regions while at the poles, salinity is decreasing.

33. (33.) Overall increases in atmospheric carbon dioxide and associated absorption by the ocean is reflected in the ocean's chemistry, through the process of acidification, with negative impacts on many organisms, in particular those with calcium carbonate parts, altering biodiversity and ecosystem structure.

34. (34.) Oxygen concentrations have 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. This deoxygenation is resulting in a reduction of the available habitat for some species in pelagic waters

35. (43.) Many marine ecosystems are affected by the cumulative effects of multiple stressors and their interactions. In the case of biogenic reefs and sandy, muddy and rocky shores that support high biodiversity: ocean warming, storms and land reclamation are the main pressures. ~~Increases in the frequency of extreme natural hazards would affect the local distribution of target species, affecting fishery-dependent developing States~~

36. (18.) Ocean habitats, owing to the existence of relatively few barriers to dispersal, are highly interconnected. Given the interdependencies between species, impacts in one part of a food web will result in losses of biodiversity across trophic levels, food webs, taxa and habitats. Changes to the food web structure of marine communities exhibit substantial differences between latitudes. Overall, changes to biodiversity as a result of climate change, include changes in distribution, local abundance and in some regions changes to productivity.

III. III The current state of biodiversity and recent trends (Chapters: 5, 6A, 6B, 6C, 6D, 6E, 6G, 7C, 7D, 7E, 7K, 15)

37. (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. 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.

38. (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 at risk, such as the vaquita (*Phocoena sinus*), while populations of the Maui dolphin (*Cephalorhynchus hectori maui*) and several freshwater dolphins have been significantly reduced. Invertebrate biomass has declined in areas of the Alaska seas as a consequence of water warming

39. (54.) Ocean warming and marine heatwaves ~~have~~ led to severe bleaching and mass mortality of corals around Australia, the Central American coast and the South China Sea ~~inducinge~~ changes in coral reef ecosystems ~~(coral bleaching)~~, reducing

biodiversity, impairing the habitability of islands and affecting the health, productivity and function of coastal ecosystems.

~~40. (55.)~~ Consequently, coral reefs continue to decline globally, with negative effects on biodiversity. ~~These habitats are,~~ also affected to ~~different~~ varying extents by extractive activities, pollution, diseases, ocean acidification, physical destruction, outbreaks of several species and the ~~increasing~~ time required to recover after major disturbances such as storms.

~~41. (57.)~~ Seagrass meadows continue to decline at alarming rates, in particular where they are in conflict with human activities.

~~42. (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.

~~43. (60.)~~ Of the world's marine capture fisheries for which data exist, 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).

~~44. (20.)~~ ~~The recovery of benthic communities that have been impacted by the use of heavy equipment 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 in reducing the impacts of bottom trawling on seabed habitats. However, the recovery of benthic communities that have been impacted by the use of heavy equipment in the deployment of large bottom-trawling nets will take several decades.

~~45. (51.)~~ Marine species distributions, overall, are shifting polewards as direct and mediated results of climate change. Regionally, shifts are driven by changes in circulation, such as that associated with the El Niño Southern Oscillation⁸ and weakening of meridional circulation in the Atlantic. While predicting the impacts of changes in circulation is uncertain, particularly for those species that depend on ocean currents for their recruitment and dispersion, such as plankton species, possible changes include in primary production, nutrient distribution and exchanges with the atmosphere.

~~46. (47.)~~ Microbial food webs⁹ account for most living biomass and nutrient recycling in the ocean, while metazoan food webs support most fisheries and the biological pump.¹⁰ 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. 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

⁸ The fluctuation of the sea surface temperature in the equatorial Pacific Ocean and of the air pressure of the atmosphere.

⁹ The microbial food web refers to the combined trophic interactions among microbes in aquatic environments. These microbes include viruses, bacteria, algae, heterotrophic protists (such as ciliates and flagellates), as opposed to metazoan food webs where multicellular organisms are included.

¹⁰ The process of transforming carbon from surface waters into living matter, distributing it into deeper water and sediments.

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. In the Antarctic, krill (*Euphausia superba*) recruitment to the adult population, which depends on the survival of larval krill during winter, is most likely to be altered by climate change. Antarctic krill 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 (attributed to climate change) portends a long-term shift from a food web dominated by ~~antarctic~~ Antarctic krill to one dominated by salps, with unknown cascading effects on the abundance of vertebrate predators.

48. (48.) In the Arctic, as the vertical stratification of the water column has increased, net primary production has also increased. Enhanced primary production has also been associated with increases in the biomass of microbial plankton at the expense of microscopic algae a trend that appears to be related to upper ocean warming and occurring in most regions. Warming has also influenced the relative abundance of krill species, with the boreal species *Meganctiphanes norvegica* increasing and the cold-water species *Thysanoessa raschii* decreasing.

49. (37.) The total sea ice extent has been declining rapidly in the Arctic, but overall trends are statistically 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.

50. (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 in association their distribution extent has also decreased, in particular in the Arctic.

IV. ~~IV~~ Management tools and approaches for biodiversity (Chapters: 4, 15, 26, 27)

51. (28.) Overall, some efforts to mitigate or reduce pressures on the oceans have improved since the first World Ocean Assessment was published. Marine protected areas are conservation tools designed to improve biodiversity protection by encompassing spatial scales that reflect the life history distributions of species in a defined marine area through specific, long-term conservation objectives¹¹. 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.

52. (93.) In addition to spatial approaches to management including marine protected areas, the ecosystem approach is one of the most significant developments in ocean management. It consists of the environmental, social and economic management of human interactions with oceans and coasts at multiple levels

¹¹ This addition does not reflect the content of the second World Ocean Assessment, but is additional information reflecting comments made by member countries to the content of the brief.

(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.

[53. \(24.\)](#) Achieving the targets of the Sustainable Development Goals needed to implement the 2030 Agenda requires full consideration of ecosystem-based and precautionary management approaches to account for scientific uncertainty.

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

[55. \(88.\)](#) Management approaches are increasingly including diverse links between ecological and social, economic and cultural aspects. 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. 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. Integrated ocean management provides a mechanism through which conservation and management among all relevant human activities can be prioritized and coordinated, and can incorporate area-based measures other than [protected areas](#) (CBD decision 14/8)¹².

[56. \(89.\)](#) Marine spatial planning is an effective way of resolving utilization 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 implemented 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. Careful planning, with the aid of evidence-based marine spatial planning and functional analysis and the use of blue infrastructures, can help to reduce negative effects.

[57. \(91.\)](#) 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.

[58. \(87.\)](#) Failure to integrally manage coastal activities is increasing risks for the sustainability of ecosystem services, including food security and general human well-being. Industries such as tourism depend on the good condition and biodiversity of the areas where the activity is developed.

[59. \(17.\)](#) 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.

¹² This addition does not reflect the content of the second World Ocean Assessment, but is additional information from CBD reflecting comments made by member countries to the content of the brief.

V. ~~V~~ Outlook for biodiversity

(Chapters: 5, 6A, 6G, 15, 18, 26)

~~60.~~ (65.) Climate change and its impact on the ocean are expected to continue, with further alterations in areas such as ocean circulation including expansion of the subtropical gyres, warming, acidification ~~and~~, deoxygenation decreases in salinity and increases in vertical stratification resulting in decreases in inorganic nutrient supplies to the euphotic zone. The ability of the ocean to absorb carbon dioxide will be reduced, accelerating global atmospheric warming. These changes will expand to the deep sea, affecting the whole water column.

~~61. Human activities such as r~~Resource extraction, pollution including nutrient inputs and associated eutrophication, 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, including marine biodiversity with negative impacts on the benefits that society obtain from the services provided by marine ecosystems.² Human recreational activities, coastal infrastructure development, ship anchoring and bunkering will continue to have an impact on vulnerable habitats and associated species assemblages.

~~62.~~ (74.) Persistent organic pollutants will remain present globally with biological consequences. Marine debris, including microplastics and nanoplastics, will continue to increase in the marine environment without improved policies.

~~63~~ (70.) ~~The biological r~~Expected responses by plankton would include ~~the following:~~

- (a) The relative abundance of microbial plankton is likely to increase at the expense of microscopic algae, ~~and~~with the result that net primary productivity is expected to decrease as is the export of biological production to the deep ocean. It is likely that these changes to phytoplankton productivity and cell size 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 as a consequence of decreased ice cover.

~~64.~~ (71.) Future trends ~~in~~for coastal upwelling regions are less certain owing to interactions between upwelling favourable winds and upper ocean warming and their effects on the relative abundances of the different species distributed throughout these regions.

~~65.~~ (73.) ~~It is predicted~~Climate models project that there will be an increase in the increased 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.

~~66.~~ (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.

67. (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.

68. (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.

69. (80.) Deep-water seabed mineral resources ~~can be, with some exceptions, are typically~~ located far from human communities¹³ ~~and as a result. Thus,~~ the social ~~impacts~~^{lications} of their exploitation may be ~~considered to be~~ less than those of terrestrial mining. However, significant concerns exist about possible environmental impacts, including loss of biodiversity and ecosystem services, including the role of the deep ocean in climate regulation.

VI. ~~VI~~ Knowledge and capacity gaps

(Chapters: 3, 6A, 6B, 7B, 7O, 8A, 21, 26, 27, 28)

70. (101.) The ocean provides for the livelihoods of millions of people across the globe, through a range of ecosystem services and benefits as identified in section I, including oxygen production, food provision, carbon storage, minerals, genetic resources and cultural and general life support services. However, 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.

71. (98.) At the regional level, large disparities in the understanding of the ocean remain, in particular in Oceania, Africa and South America, because of variability in regional infrastructure and in specialized professional human capacity. Such disparities therefore affect possibilities for engaging in ocean research and, in turn, lead to observed disparities in scientific understanding of the oceans at the regional level. Capacity-building should include means of enhancing cooperation sharing scientific knowledge building skills and the transfer of marine technology at all levels. Such capacity building 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.

72. (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; (e) implementation of ~~long-term~~long-term monitoring and (f) capacity development, including the development and transfer of scientific expertise.

73. (95.) Identifying and describing species with restricted geographical ranges, often arising from specialized habitat requirements, represents the most urgent need,

¹³ Noting that phosphorite minerals, sulfides at hydrothermal vents, ferromanganese crusts and some polymetallic nodules are located within exclusive economic zones, sometimes very close to land.

as well as monitoring rare and endangered species. Even describing 100 taxonomic units every year over the next decade would add just 1,000 species.

74. (94.) Baseline biodiversity studies (for ecoregions or for habitats that are hotspots for biodiversity) are lacking for the mesophotic zone, most of the deep sea including slopes and canyons, underwater caves and many of the thousands of global seamounts. Biodiversity in these regions is still in a discovery phase and is currently 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. Moreover, at the regional level, large disparities in knowledge of marine biodiversity remain, in particular in Oceania, Africa and South America. Improved ocean observation, biodiversity characterizations, taxonomic knowledge and technology transfer are needed, in particular in Oceania, Africa and South America.

75. (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. 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.

76. (96.) The bathypelagic domain, a dark and cold zone (0–5°C) found between 1,000 and 4,000 m, is the planet’s largest ecosystem and 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.

77. (99.) 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. There is a need for increased capacity in taxonomy and biosystematics for monitoring marine biodiversity, and supporting development reliant on biodiversity, in particular in small island States and archipelagic countries. Coupled with the integration of data from existing biodiversity collections, improvements in the analyses of biodiversity will enable their effective management.

78. (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. 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.

79. Similarly, very little is known about the resilience of marine organisms, communities and ecosystems; their ability to adapt to the environment and the implications of such adaptations needs to be investigated.

80. (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.

81. (97.) The direct physical removal of sea floor fauna by mining operations and secondary effects from sediment plumes or the release of ecotoxins can potentially

affect benthic environments and requires careful evaluation. There is little information on the impacts of commercial scale seabed mining on biodiversity and associated ecosystem services. Collection of baseline data are necessary and being collected for informed decision-making with regard to mineral extractions from the seabed.

82. (84.) In association, the large-scale protection of the seabed, at both the national and international levels, needs to be implemented effectively, to support the sustaining of benthic biodiversity and avoid the extirpation of species before they have even been recorded. Furthermore, great potential for mineral, energy and living resources from the high seas exists, although such areas are currently poorly studied spatially and temporally.

83. (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.

84. (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.

85. (79.) Continued growth in the global human populations will require ~~enhanced efficiencies~~ enhanced efficiencies to be found in the food sectors- to respond to associated increased demand. New technologies that support sustainable practices will need to be developed and implemented. The aquaculture industry needs to implement good governance as the sector further expands, intensifies and diversifies. This governance should recognize relevant environmental and social concerns and include conscious efforts to address them in a transparent evidence-based manner.

86. -Further research and capacity-building associated with the development and implementation on integrated management is needed to realize the full potential benefits of the ecosystem approach to management across the ocean. In association, 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 as well as technology development to support those observations.

87. (92.) ~~Studies on the effect of protected areas do not break down impacts (e.g. climate change, resource exploitation and pollution) by species group. Overall, the effectiveness of few MPAs is being evaluated with regard to their ability to mitigate pressures.~~ Knowledge of the key stages in implementing the planning and policy process for marine management, as well as the metrics for measuring and monitoring the effectiveness of management measures, are key requirements for countries that are starting to implement management approaches. However, at present few marine protected areas are being evaluated with regard to their ability to mitigate pressures and therefore their effectiveness. Further, studies on the effectiveness of protected areas do not break down impacts (e.g. climate change, resource exploitation and pollution)

VII. Considerations for the third cycle of the Regular Process

88. The programme of work for the third cycle of the Regular Process indicates that assessment(s) produced will build on the findings of the first and second Assessment. The focus of these assessment(s) will be developed in consultation with relevant stakeholders through a scoping exercise facilitated through regional workshops and under the guidance of the Ad Hoc Working Group of the Whole of the General Assembly on the Regular Process.

89. In preparing the four briefs on climate change, biodiversity, SDGs and the UN Decades on Ocean Science for Sustainable Development and Ecosystem Restoration, a number of key areas of focus for consideration during the third cycle of the Regular Process (and its associated outputs) were highlighted by member countries, United Nations agencies and intergovernmental organizations. These include the need for the Group of Experts in developing outputs of the third cycle, to consider more directly:

- (a) Emerging policy areas, including those associated with blue and aquatic foods and blue transformations;
- (b) Opportunities provided through the blue economy, including emerging and novel technologies and solutions;
- (c) Gaps in the enabling environment for the science needed to progress and deliver global initiatives, innovations and solutions, including finance, linkages with industry and support from Governments;
- (d) Progress on achieving the transformations committed to by the High-level Panel for a Sustainable Ocean Economy. These include commitments to a range of transformations associated with ocean health, ocean wealth, ocean equity, ocean finance and ocean knowledge required for achieving a sustainable ocean economy by 2030;
- (e) Progress on achieving Sustainable Development Goal 14: Life below water, and the impacts of the COVID-19 pandemic on achieving this Goal;
- (f) The impacts of the COVID-19 pandemic on ocean industries;
- (g) Progress on achieving Sustainable Development Goal 5, on gender equality, and achieving equal opportunities for women to participate, effectively contribute to and be recognised for their roles in maritime activities, ocean science and ocean governance systems;
- (h) Gaps in understanding of the role of law and policy in addressing and mitigating threats and restoring marine ecosystems, including capacity-building for countries to advance requisite skills to formulate and review appropriate legislation, and to provide effective oversight on the negotiation and implementation of internationally agreed environmental goals; development of knowledge guidance and information material tailored to parliamentarians to address legislative challenges related to the environment; sharing of best practices on legislation and oversight and providing platforms for dialogue between legislators and key stakeholders in the context of international environmental negotiations.

90. Further, a number of publications that have been produced since the finalization of the second *World Ocean Assessment* were highlighted by United Nations agencies and intergovernmental organizations as being relevant to the outputs of third cycle of the Regular Process. These include:

- (a) The proceedings of the 2019 FAO International Symposium on Fisheries Sustainability. The focus of this symposium was on identifying the need for a new vision for capture fisheries, including how fisheries need to transform in response to

the complex and rapidly changing challenges facing society. The proceedings provide a description of each of the sessions of the symposium, a summary of plenary discussions and key messages and recommendations identified during the symposium;

(b) The *Global Ocean Science Report 2020*, produced by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organisation (IOC-UNESCO) provides an assessment of ocean science being conducted globally, by whom and how, on the basis of the analyses of contributions provided from 45 countries. Key findings are that ocean science is underfunded, females are underrepresented among participants in ocean science, early career scientists are largely not recognized for their contributions, technical capacity is uneven and, as a result, countries are inadequately equipped to manage their ocean data and information. This is despite the number of ocean science publications increasing over the period of the report;

(c) A recent publication from the Intergovernmental Oceanographic Commission Global Harmful Algae Status Reporting initiative, which details the analysis of around 9,500 harmful algal bloom events over 33 years. It found that all ocean regions of the world were affected by multiple such blooms, but in varying proportions. The analysis also found that the negative impacts caused by harmful algal blooms had risen in step with the growth of the aquaculture industry and marine exploitation;

(d) The *Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, which updates scientific, technical and socioeconomic understanding of the climate system and climate change, including impacts on and implications to the ocean, the services it provides and human society, including the vulnerabilities and capacity to adapt to climate change.

[1] eutrophication** Increase in nutrient concentration resulting in excessive plant and/or algal growth.