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Item 9 of the provisional agenda*
Interactive dialogues

Interactive dialogue 6: Increasing scientific knowledge and developing research capacity and transfer of marine technology

Concept paper prepared by the Secretariat

Summary

The present concept paper was prepared pursuant to paragraph 23 of General Assembly resolution 73/292, in which the Assembly requested the Secretary-General of 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 to prepare concept papers on each of the themes of the interactive dialogues, taking into account the relevant ocean-related processes of Assembly and other possible contributions. The present paper relates to interactive dialogue 6, entitled "Increasing scientific knowledge and developing research capacity and transfer of marine technology". In the paper, the status, trends, challenges and opportunities for the achievement of relevant targets of Sustainable Development Goal 14 are set out, under the overarching theme of the Conference: "Scaling up ocean action based on science and innovation for the implementation of Goal 14: stocktaking, partnerships and solutions".

* A/CONF.230/2022/1.

I. Introduction

1. Scientific knowledge across a range of natural and social science disciplines, together with a strong capacity to undertake and use scientific research and with access to marine technology, is essential to sustainable ocean management and the transformations of humankind's relationship with the ocean. They are prerequisites for the achievement of Sustainable Development Goal 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) and are crucial to humanity's ability to ensure a sustainable and equitable recovery from the coronavirus disease (COVID-19) pandemic (see A/76/311, para. 60). The importance of ocean science is recognized in the United Nations Convention on the Law of the Sea, in particular in part XIII thereof, which sets out the obligations of States and international organizations to promote international cooperation in marine scientific research, to create favourable conditions for conducting such research, to make available by publication and dissemination knowledge resulting from marine scientific research, and to promote the flow of scientific data and information and the transfer of knowledge.

2. As noted by the General Assembly in a number of resolutions, marine science is important for eradicating poverty, contributing to food security, conserving the world's marine environment and resources, helping to understand, predict and respond to natural and anthropogenic events and promoting the sustainable development of the oceans and seas, by improving knowledge through sustained research efforts and the evaluation of monitoring results and applying such knowledge to management and decision-making.

3. With over 3 billion people heavily reliant on marine ecosystems for food and livelihoods,[1] and the growing understanding of the pivotal role that the ocean will play in achieving global ambitions for climate action, a healthy ocean is also a foundation for achieving many other Sustainable Development Goals. These include Goal 1 (no poverty); Goal 2 (zero hunger); Goal 3 (good health and well-being); Goal 5 (gender equality); Goal 7 (affordable and clean energy); Goal 8 (decent work and economic growth); Goal 11 (sustainable cities and communities); Goal 13 (climate action); and Goal 17 (partnerships for the goals). Development and deployment of solutions to reach Goal 14 targets as well as the targets of other ocean-related Goals depend on the generation and uptake of relevant ocean science including observations and monitoring of the physical, biogeochemical, biological and socioeconomic aspects of the state of the ocean and human connections with the ocean.

4. While there has been recent progress in ocean observations, marine research, data generation, information flows and knowledge production, current understanding of the ocean – including across the land-sea and ocean-atmosphere interfaces – is not adequate and has not kept pace with rapid changes in its state and use. Gaps in human and institutional capacities, unsustained or inadequate resources, gaps between knowledge that is being generated and priority policy needs, and weak governance still impede a large number of countries, including many developing States, from participating in ocean science or benefiting from existing knowledge. Indigenous and local knowledge is often undervalued as a complementary source of knowledge needed to achieve sustainable ocean management.[2] While the full impacts are not yet known, initial information shows that the COVID-19 pandemic has had a significant impact on many research activities, resulting in declining trends in data flow and irreversible observational gaps (see A/75/340, paras. 12 and 66; and A/76/311, para. 16).

[1] See www.un.org/sustainabledevelopment/oceans/.

[2] See IOC-UNESCO, Global Ocean Science Report 2020: Charting Capacity for Ocean Sustainability, K. Isensee, ed. (Paris, 2020). Available at https://unesdoc.unesco.org/ark:/48223/pf0000375147.

5. Aligning ocean science more closely with a current worldwide transition towards "open science", which is aimed at making science more open, accessible, efficient and transparent, will contribute to addressing some capacity and governance barriers. However, challenges remain in the production and use of scientific knowledge that is aligned with the needs of users, whether they be policymakers, resource managers or industry. This hampers the ability of policymakers and other actors to make science-based decisions in support of sustainable development. Furthermore, overlap in activities carried out by intergovernmental organizations as well as other partners can prevent synergies and create duplication of efforts.

6. The United Nations Decade of Ocean Science for Sustainable Development, which commenced on 1 January 2021, offers a historic opportunity to improve the state of ocean science. It provides a framework across the United Nations system and beyond for convening diverse stakeholders to focus on common ocean science priorities, leveraging further investment and partnerships for ocean research and developing a robust enabling environment for ocean science, including capacity development and transfer of marine technology. Momentum is also generated by other global efforts to promote the use of marine science and technology for ocean sustainability such as the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects, which began its third cycle on 1 January 2021.

II. Status and trends

7. Ocean science is expanding in magnitude and scope, resulting in greater scientific output.[3] Areas of particular focus and knowledge generation have included marine pollution (notably plastics) and the ocean-climate nexus. The World Ocean Assessment, under the Regular Process, provides a synthesis of scientific knowledge regarding the state of the marine environment, including socioeconomic aspects. Numerous other initiatives such as the Ocean Biodiversity Information System, the collection of deep-sea environmental and minerals data by exploration contractors through the International Seabed Authority, the description of ecologically or biologically significant marine areas under the Convention on Biological Diversity and the fisheries databases maintained by the Food and Agriculture Organization of the United Nations (FAO) provide crucial data and information. However, scientific knowledge on many parts of the ocean remains limited and the use of science for management and policymaking is uneven.[4]

8. Disparities persist in scientific capacity in terms of financial, technological and human resources, in particular between developed and developing countries, and contribute to the uneven distribution of scientific knowledge. States that have a pressing need for rigorous and relevant ocean science often have the least scientific capacity or the least access to ocean science and technology. Human resources that drive ocean science are concentrated in certain countries and vary worldwide by age and gender. There is a predominance of ocean scientists from developed countries and a shortage of experts in least developed countries, landlocked developing countries and small island developing States.[5] There is also a generational bias towards older generations which dominate ocean science in many countries, although many least developed countries have a relatively young ocean researcher community.[6]

[3] Ibid.

[4] See www.un.org/regularprocess.

[5] See IOC-UNESCO, *Global Ocean Science Report 2020*.

[6] Ibid.

Prioritization of support to early career ocean professionals is a central element of the Ocean Decade and will be pivotal in ensuring its post-2030 legacy.

9. Ocean science has stimulated technological advancements which have in turn increased scientific knowledge of the ocean. The application of advanced technology to ocean science and the development of new technology, including satellites and remote sensing techniques, enhanced computing power to process big data, autonomous underwater vehicles and remotely operated vehicles, floats and sensors and new measurement devices and techniques, have enhanced the range of technical options available to improve knowledge of the ocean, in particular in remote or difficult-to-access environments such as the polar regions, the deep ocean and mangroves. However, many such technologies remain out of reach of scientists from developing States who struggle to access basic laboratory or research equipment and technology. Both the vast scale of the ocean and the persisting gaps in knowledge and capacity require continued technological innovation. Increased access to existing and new technology, particularly in least developed countries, landlocked developing countries and small island developing States, is needed to avert a widening of the existing knowledge and capacity gaps. Furthermore, to optimize the use of resources, stronger links need to be established and maintained between the scientific community, Governments, and industry partners who often drive investment in innovation and technology. The Ocean Decade provides one such framework for building these connections.

10. While ocean science generates a vast amount of data, the sheer volume of ocean data creates challenges for its collation, storage, analysis and effective use for management and decision-making. Regionally and globally, there is a diverse array of organizations, partnerships and programmes working in the area of data and information compilation, sharing and management. Interoperability of diverse data storage and management systems is a common goal but will require significant collaboration and investment. Globally, 63 per cent of data centres restrict access to certain data types and 40 per cent apply a restriction during a certain period.[7] Moreover, much ocean-related data, including those collected by individual scientists, students and industry, are never shared at all.[8] Consequently, fully open access to data has not yet been widely achieved nor is there equitable access to the technology and skills needed to use ocean data. Capacity development is therefore paramount.

11. There is increased recognition of the need to embrace indigenous and local knowledge as a complementary and invaluable source of data and knowledge. Engaging indigenous peoples and local communities as partners across ocean science disciplines ensures that their knowledge and priorities guide research, monitoring and reporting of results within their own homeland.[9] This enhances the effectiveness, impact and pertinence of ocean assessments and ensures that indigenous and local knowledge can inform policy. A number of actors including within the framework of the Ocean Decade are making efforts to build collaboration between scientists and local and indigenous knowledge holders.

12. Efforts to increase scientific knowledge will not be fully optimized if the knowledge generated is not relevant to local, national and global priorities and is not taken up through the science-policy interface. A large number of initiatives are working to develop tools and methodologies with which to increase the uptake of science into policy and management decisions and the Ocean Decade has placed a strong focus on facilitating the co-design and co-delivery of ocean science between generators and users of knowledge. Several initiatives under the Decade focus on

[7] Ibid.

[8] Ibid.

[9] See www.ipcc.ch/srocc/.

strengthening this interface, including in small island developing States.[10] Scientific assessments and syntheses are being prepared continuously to provide policymakers with up-to-date knowledge on various issues. A notable example is the Regular Process and its outputs, including the Second World Ocean Assessment,[11] which was launched in April 2021. Other recent assessments that have achieved significant visibility include *The Ocean and Cryosphere in a Changing Climate: Special Report of the Intergovernmental Panel on Climate Change*; the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services publication entitled *Global Assessment Report on Biodiversity and Ecosystem Services*, which includes a section on the open ocean; the United Nations Environment Programme (UNEP) publication entitled *From Pollution to Solution: A Global Assessment of Marine Litter and Plastic Pollution*; the report of the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (IOC-UNESCO) entitled "Global harmful algal bloom: status report 2021"; and *The State of World Fisheries and Aquaculture*, produced biennially by FAO.

13. Finally, increasing scientific knowledge, developing research capacity and facilitating the transfer of marine technology requires resource mobilization. Government funding for ocean science remains modest overall and faces sustainability-related challenges in most countries.

III. Challenges and opportunities

A. Scientific knowledge

14. Sustainable management of the ocean, including through the development and implementation of sustainable ocean plans, requires relevant ocean data, information and knowledge to be generated, integrated and rendered accessible. While ocean knowledge gaps persist across numerous themes, particular attention is drawn to the following priorities.

15. The human-ocean relationship presents numerous challenges in terms of scientific knowledge. While the level of knowledge concerning the socioeconomic aspects of the oceans remains limited, the development of a sustainable ocean economy should nevertheless be firmly grounded in scientific knowledge. Developments in ocean accounting, including through the Global Ocean Accounts Partnership,[12] are increasing knowledge on the economic value of the ocean. Increased collaboration between natural and physical ocean science disciplines and social science disciplines, including through the framework of the Ocean Decade, will be important for enabling a better understanding of socioeconomic and socioecological linkages between humanity and the ocean, the multiple cultural and social values of the ocean and the impacts of human use on ocean health.

16. While understanding of the ocean-climate nexus is improving, continued research on the ocean's role in energy, carbon and water cycles as well as the impact of climate change and the ocean-biodiversity nexus is critical to understanding opportunities and options for ocean-based mitigation and adaptation and co-benefits. There is a pressing need to better understand the effects of multiple natural and human-induced climate change and other anthropogenic activities on marine ecosystems, fisheries and wildlife and the resulting ecological, social and economic impacts. Further knowledge is required to understand the carbon mitigation potential

[10] See http://oceandecade.org.

[11] *The Second World Ocean Assessment*, vols. I and II (United Nations publication, Sales No. E.21.V.5).

[12] See www.oceanaccounts.org/the-ocean-accounts-framework/.

of the seabed and marine ecosystems. Nature-based solutions to adaptation and resilience are proliferating throughout the world and mechanisms for exchanging knowledge and facilitating replication and scaling of successful approaches are required. As geoengineering approaches develop, there is also a need to build a better understanding of the impacts on the marine environment of carbon capture and storage.

17. Knowledge of the deep waters and the seabed in areas beyond national jurisdiction, including the interaction between the physical structure and the biota in those areas, is limited at the regional and global scales. Although important progress has been made in recent years through the International Seabed Authority, including through the adoption of a dedicated Action Plan for Marine Scientific Research in support of the United Nations Decade of Ocean Science for Sustainable Development in 2020, further efforts are needed in the fields of deep-sea observation systems and interdisciplinary studies to support risk and impact assessment. The mapping of the ocean seabed by 2030 is a major undertaking led by the Nippon Foundation and the General Bathymetric Chart of the Oceans Seabed 2030 project, operating under the auspices of the International Hydrographic Organization and IOC-UNESCO. It is aimed at bringing together all available bathymetric data to produce the definitive map of the world ocean floor by 2030 and making it available to all. The proportion of the global seafloor mapped in high resolution stands currently at 21 per cent but major efforts are still required for the goal of the project to be achieved. This knowledge is fundamental for understanding ocean circulation, tides, tsunami forecasting, fishing resources, sediment transport, environmental change, underwater geohazards, infrastructure construction and maintenance, and cable and pipeline routing, among many other subjects.

18. There is a need to better understand marine biodiversity including ecosystem processes and functions and their implications for the protection, preservation and restoration of ecosystems, ecological limits, tipping points, socioecological resilience and ecosystem services and their valuation. Specific challenges remain in terms of knowledge on impacts caused by multiple stressors, including knowledge gaps on the extent, distribution and sources of multiple stressors related to human uses of the oceans and climate change and their interactions across space and time and with natural change/variability.[13] There is a need for increased knowledge on drivers of biodiversity loss, including in relation to the interactions between population growth and consumption, particularly in developing countries. Collaboration within the contexts of the Ocean Decade and the United Nations Decade on Ecosystem Restoration (2021–2030) will lead to better understanding of the gaps in the knowledge needed to support large-scale and sustainable ocean and marine ecosystem restoration.

19. Challenges remain with respect to knowledge on marine pollution. There is a lack of integrated assessment of pollution and, in particular, of interactions and exchange between land-based sources of pollution, the coastal zones and the open ocean. Although it is generally agreed that most of the pollution ending up in the ocean comes from land, establishing a detailed understanding/quantification of the contribution to marine litter of sea-based sources (shipping, dumping, fisheries, etc.) is important.

20. Important knowledge gaps exist in relation to fisheries, aquaculture and other potential sources of food from the ocean. To promote sustainable fisheries and aquaculture, increase food security and nutrition and protect biodiversity, there is a need for fisheries and aquaculture to adopt an ecosystem approach grounded in

[13] IOC-UNESCO, "Multiple ocean stressors: a scientific summary for policy makers", P.W. Boyd and others, eds. (Paris, 2022).

science while allowing for a precautionary approach enabling decisions to be taken based on best available knowledge, including local and traditional knowledge. Risk-based approaches are particularly useful in this regard.

21. The need to improve scientific knowledge related to maritime industries is important with regard to atmospheric discharges from ships and their spatial and temporal distribution; effects of industrial uses of the oceans on human well-being; potential impacts of seabed mining, including on deep-sea species and ecosystems; long-term effects of the decommissioning of oil and gas platforms and other marine infrastructure on the environment; and long-term impacts of marine renewable energy installations.

22. It is also necessary to better connect to the field of archaeological and historical ocean research, taking into account cultural aspects as well as underwater cultural heritage. Changes in the world's climate over different millenniums have influenced human life and data on these historical impacts and reactions can prove valuable in informing future actions. The historical importance of the oceans for humanity can also greatly inform ocean literacy and raise public awareness of the need to act to protect its health and that of humanity.

B. Ocean observations, data and knowledge management and use

23. To fill many of the critical knowledge gaps mentioned above, a value chain approach to ocean science is required starting with observations, data collection and management and continuing through to modelling and prediction activities which include demand-driven applications and services for delivery of knowledge.

24. The value of ocean observation systems as the first step in the value chain of ocean-related scientific knowledge cannot be overemphasized. The Global Ocean Observing System 2030 Strategy recognizes the existing challenges and provides a framework for expanding and strengthening the ocean observing system to meet the growing demands of policymakers, private sector users and the public.[14] There remain significant gaps both in the coverage of existing networks, spatially and in terms of variables, and in the form of barriers to accessing, sharing and using the acquired data.[15] Challenges exist in terms of the need for a global carbon ocean observing system, coastal observations and observations in exclusive economic zones, marine biodiversity observations and deep ocean observing.[16] Coordination challenges exist at national levels, where multiple agencies may be involved in ocean observations and research. International coordination is essential, particularly in areas beyond national jurisdiction. A fundamental challenge also exists in terms of an unsustained resource base for GOOS which provides the only global collaborative system of ocean observations, encompassing in situ networks, satellite systems, Governments, United Nations entities and individual scientists.

25. Further innovation and technological developments, coupled with co-design of observing systems and scientific programmes, will provide opportunities to expand ocean observations. For instance, environmental baseline and monitoring surveys undertaken by deep-sea exploration contractors through the International Seabed Authority generate annually a significant amount of data and information on physical,

[14] See www.goosocean.org/index.php?option=com_oe&task=viewDocumentRecord&docID=24590.

[15] See document entitled "Contribution of the Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO) to the Secretary-General's report on oceans and the law of the sea pursuant to the topic of 'ocean observing' being addressed by the twenty-second meeting of the Open-ended Informal Consultative Process on Oceans and the Law of the Sea". Available at www.un.org/depts/los/consultative_process/contribution22/IOC.pdf.

[16] Ibid.

chemical, biological and geochemical parameters for deep pelagic and benthic environments and contribute significantly to high-resolution mapping of the seabed.

26. Developing research capacity and transfer of marine technology for sustained ocean observations requires investing in people and their institutions so that they can build infrastructure and long-term support networks with better access to data, tools and technologies. While this can be facilitated by international initiatives, it needs support nationally and internationally if it is to be sustained. Capacity development needs to occur at all stages of the ocean observing process, from identifying needs and designing systems through to the transformation of data into products and information. This includes the use of best practices at all levels of the process, extending from instrument deployment to data collection, data analysis and data modelling and management, and in the final reporting.

27. Access to data, information and knowledge is critical for an integrated, science-based approach to the management of human activities in coastal and open ocean areas. Lack of quality control in data sets, lack of interoperability of different data platforms and portals, "hidden" or unexploitable data sets, lack of data sets tailored to regional or national scales and a lack of skills in accessing and analysing data are among the challenges faced for understanding ocean processes and making informed decisions about human activities in light of the present and estimated future state of the ocean.

28. There is a need to further develop technology and infrastructure and to ensure their interoperability as part of a holistic digital ecosystem; to acquire, process and disseminate relevant data in an accessible manner; to adopt and implement internationally accepted standards and best practices for the management and exchange of data; and to adopt and implement data policies that support open access. The aim under the Ocean Decade is for all data generated throughout the Decade to adhere to the following "FAIR" principles: findability, accessibility, interoperability and reusability. The International Ocean Data Exchange programme of IOC-UNESCO provides a global framework for addressing some of these issues that includes facilitating the exchange of oceanographic data and information between participating Member States. Further investments are required at the national level to strengthen national ocean data infrastructure.

29. While new technologies for ocean data collection platforms and sensors will open up new possibilities for collecting data on the environment and human uses of the ocean, sufficient long-term resources will be needed to ensure the sustainability of such efforts. Artificial intelligence could become a powerful tool for the analysis of ocean data. Public-private collaborations on data management will be important, particularly for unlocking industry-held data sets in such a manner as to overcome commercial or legal obstacles to data sharing. There is also a need for significant efforts in capacity development and technology transfer to developing countries to ensure access to new technologies and data.

30. Prediction, forecasting and modelling applications and services are essential for delivering societal outcomes and benefits of ocean knowledge including, for example, early warning systems for ocean hazards. There is increased interest and investment in infrastructure such as digital twins that focuses on the applications and services end of the ocean science value chain. Investment in such initiatives should be balanced with investment in the data-collection and management initiatives that are essential underpinnings of prediction, forecasting and modelling.

C. Research capacity, transfer of marine technology and ocean literacy

31. Transfer of marine technology includes activities that increase not only access to facilities and equipment, but also expertise, skills and knowledge that enhance research capacity.[17] The provisions of part XIV of the United Nations Convention on the Law of the Sea, which relate to the development and transfer of marine technology, require States to cooperate in accordance with their capabilities to actively promote the development and transfer of marine science and marine technology on fair and reasonable terms and conditions. In part XIV of the Convention, it is also provided that States shall promote the establishment of national and regional marine scientific and technological centres, in particular in developing States, in order to stimulate and advance the conduct of marine scientific research and foster marine technology transfer. The *Global Ocean Science Report* is a pivotal and unique mechanism for regularly analysing the state of ocean science capacity. *Global Ocean Science Report 2020* provides baseline information against which to assess progress in the development of capacity in the area of ocean science in the course of the Ocean Decade. However, further engagement and support are nevertheless required at the national level to enhance the coordination of data collection and thus ensure rigorous monitoring of ocean science investments and capacity at the national, regional and global scales through application of the indicators defined in the report.[18]

32. Ad hoc, poorly coordinated and unsustainable capacity development and transfer of marine technology activities exacerbate the geographical, gender and generational disparities in human resources noted in the previous section.[19] A recent survey of IOC-UNESCO member States[20] identified the following priorities for research capacity and transfer of marine technology needs globally: (a) development of a body of qualified ocean professionals; (b) professional development opportunities; (c) data access and management skills and tools; and (d) equipment and infrastructure, including observation equipment. It also identified the five highest priorities for capacity development and marine technology transfer mechanisms: (a) organization of training courses, workshops and summer schools; (b) establishment of intern/fellowship programmes; (c) establishment of travel grant funds; (d) sharing of training materials; and (e) establishment of regional training and research centres. Respondents in least developed countries and small island developing States highlighted more strongly than other respondents the importance of increasing access to equipment and facilities. These needs align with data from *Global Ocean Science Report 2020* which revealed the high concentration of equipment and facilities, including research vessels and marine research centres, in the global North when compared with the global South, in particular in small island developing States.

33. In 2020, members of the International Seabed Authority were invited to assess their capacity priority needs in the field of marine scientific research in the Area in line with the mandate assigned to the International Seabed Authority under the United Nations Convention on the Law of the Sea and the 1994 Part XI Agreement.[21] The

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[17] See IOC-UNESCO, "Transfer of marine technology: knowledge sharing and capacity development for sustainable ocean and coastal management" (Paris, 2015). Available at https://unesdoc.unesco.org/ark:/48223/pf0000232586.locale=fr.

[18] See IOC-UNESCO, *Global Ocean Science Report 2020*.

[19] See IOC-UNESCO, "Transfer of marine technology".

[20] See IOC-UNESCO, "Results of the IOC Capacity Development Needs Assessment Survey and Transfer of Marine Technology Clearing House Mechanism Needs Survey" (2021). IOC circular letter No. 2846. Available at https://unesdoc.unesco.org/ark:/48223/pf0000377289.locale=fr.

[21] International Seabed Authority, "National capacity development priorities identified by members of the International Seabed Authority in 2021", policy brief 01/2021.

outcomes of this survey together with some recommendations presented through a multi-stakeholder review of the implementation of the capacity-building initiatives implemented by the Authority since 1994[22] led to the adoption by the Assembly of the International Seabed Authority of a key decision endorsing a programmatic approach to capacity development where transfer of technology is identified as an essential part of the work to be done in 2022 and beyond (see ISBA/26/A/18).

34. The success of efforts to improve research capacity and transfer of marine technology will depend on continuous professional development, facilitated access to infrastructure, information-sharing and ocean literacy, development of national marine management procedures and policies, and long-term and sustainable financial support. Investment in research capacity and transfer of marine technology needs to target early career ocean professionals, given the generational bias among ocean scientists and identified challenges confronted by young researchers seeking to actively engage in ocean science, including identification of and participation in professional networks; access to information and knowledge transfer mechanisms; professional development opportunities; engagement in international policy processes; and access to resources. Efforts also need to focus on end users of knowledge and data so that there is consistent uptake into policymaking and management. This includes the transfer of technology, services and applications for marine spatial planning, environmental impact assessments, regional environmental management plans and other tools that are essential for facilitating the development of a sustainable blue economy.

35. Ocean literacy is a concept that has gained significant traction in recent years given the recognized need to improve public understanding of the importance of the ocean and its relation to humans and the need to train the next generation of decision makers, marine scientists, policymakers and managers. There are numerous target groups of ocean literacy which range from children in schools through to industry and government decision makers. Cultivation of ocean literacy has numerous potential benefits including encouragement of greater engagement in ocean science as a career path, increasing visibility of the importance of ocean science as part of funding decisions and catalysing behaviour change. While numerous actors from civil society, the private sector and United Nations entities are supporting actions in ocean literacy, challenges remain with respect to avoidance of duplication of efforts which can be achieved through, for example, increased sharing and exchange of common resources.

D. Uptake of science in policymaking and management

36. Strengthening the science-policy interface to ensure that knowledge is analysed and communicated to policymakers and managers and ultimately incorporated into policy and decisions is critical to the sustainable development of the ocean and its resources. Despite increased recognition of the need for science to inform policymaking and management, a divide remains between the science community on one side and policymakers and managers on the other. While there are numerous national and regional examples of bridges being successfully constructed between these two communities,[23] there is a need to further increase efforts to systematically strengthen the science-policy interface so as to ensure that science is responsive to the needs of policymakers and other stakeholders and that policymaking and management are informed by science. One challenge is the lack of an agreed,

[22] International Seabed Authority, *Review of Capacity-building Programmes and Initiatives Implemented by the International Seabed Authority 1994–2019*, report by the secretariat (July 2020).

[23] See IOC-UNESCO, *Global Ocean Science Report 2020*.

standardized method for measuring the effectiveness of the science-policy interface. An outreach and engagement strategy is being developed in the context of the Regular Process during its third cycle, with a view to reaching and engaging stakeholders, including policymakers and the public, more effectively. A second major challenge is associated with capacity and skills gaps among policy- and decision makers in terms of their capacity to access and interpret relevant and timely ocean science.

37. Sustainable ocean planning, as advocated and committed to by the members of the High-level Panel for a Sustainable Ocean Economy,[24] is an emerging framework for strengthening the science-policy interface. Sustainable ocean planning is a broad concept which incorporates diverse tools and approaches while relying fundamentally on participatory, multisectoral approaches to using natural, economic and social science for spatial and temporal decision-making in coastal and marine areas. Marine spatial planning is one example of a tool that offers an important opportunity for improved integrated management through adoption of a multi-stakeholder participatory process for decision-making. Another focus for the use of science in management comprises area-based management tools including "other effective area-based conservation measures" and marine protected areas. Many other examples of science-based planning tools exist across the United Nations system. Areas where further research is needed to improve the science-policy interface include existing and new technologies for compliance and ecological monitoring in remote areas (such as satellites for combating illegal, unreported and unregulated fishing or tracking abundance or migration of marine fauna).

E. Resource mobilization for increasing scientific knowledge and developing research capacity and transfer of marine technology

38. Addressing the challenges and seizing the opportunities identified in previous sections will require significant resources. Currently, challenges exist in terms of both the volume of funding and its lack of sustainability. Ocean science expenditure remains highly variable worldwide and increased awareness on the part of funding agencies of the role of ocean science in numerous facets of sustainable development and climate action is crucial. Overall, national ocean science funding remains extremely low when compared with funding in many other fields of research and innovation. The share of gross domestic expenditure on research and development dedicated to ocean science was only approximately 1.7 per cent of total gross domestic expenditure on research and development in 2017. Disparities exist across the globe: Peru (with a share of 11.8 per cent) is the leading country in this respect, followed by South Africa (5.6 per cent), Ireland (5.3 per cent), Norway (4.4 per cent) and Portugal (3.5 per cent).[25] Global crises – including the COVID-19 pandemic – are expected to have an adverse effect on the funding available for ocean science and future editions of the Global Ocean Science Report will track and report on such trends.[26]

39. Ocean science continues to benefit from funding outside of national government research funding. In the period from 2009 to 2020, philanthropic foundation grants for marine science totalled about $2.1 billion and in the same period approximately $290 million was made available for marine science in multi- or bilateral official development assistance grants.[27] However, many of these funding sources are structured around relatively short project-based funding cycles. It remains

[24] See http://oceanpanel.org.

[25] See IOC-UNESCO, *Global Ocean Science Report 2020*.

[26] Ibid.

[27] See IOC-UNESCO, *The United Nations Decade of Ocean Science for Sustainable Development (2021–2030): Implementation Plan* (Paris, 2021). Available at https://unesdoc.unesco.org/ark:/48223/pf0000377082.locale=fr.

challenging to align such resources with the recurrent, long-term operational and coordination costs of essential observing or data management systems. Duplication of efforts (e.g. re-collecting raw data that already exists) and poorly coordinated investments (e.g. ad hoc training courses that poorly target beneficiaries) lead to waste of resources and a lack of return on investment which in turn creates disincentives for funding partners. While innovative blue financing initiatives such as blue bonds, blue carbon financial instruments and debt-for-nature swaps do exist, many of these instruments are in the early stages of development and/or are used primarily to finance conservation and management rather than ocean science.

40. Initiatives such as observations, monitoring, capacity development and/or data management programmes which require long-term sustained funding for recurrent activities are particularly impacted by a lack of sustainable funding. The resources available for sustained ocean observation programmes and for international coordination are insufficient to deliver all of the required advances, as the system is currently largely supported by short-term, research-based funding. Recent reports of the Intergovernmental Panel on Climate Change highlight the opportunity for high returns on investments in improving observation and monitoring systems, including those needed for (a) context-specific ocean and cryosphere monitoring; (b) biodiversity monitoring; (c) improved context-specific forecasts (e.g. for the El Niño-Southern Oscillation (ENSO), marine heatwaves, tropical cyclones); (d) risk reduction, managing losses and adverse impacts; and (e) opportunities associated with new information and communications technologies.

41. Increased capacity on the part of the ocean science community to understand and access a wide range of resource mobilization opportunities is needed. Donors and ocean science practitioners need to have mechanisms for communicating about needs in terms of both scientific priorities and the form of financing that is required and the available resources. Innovative solutions with respect to sharing scarce resources (e.g. through equipment and infrastructure sharing platforms and effective matchmaking services between resource supply and demand within clearing-house mechanisms) would increase the overall efficiency of resource use. UNEP is working with other partners, including the Statistics Division of the Department of Economic and Social Affairs of the Secretariat, to develop tools for ocean accounting which may provide data to underpin future innovative financing mechanisms. International collaborations in the form of joint ocean science projects and expeditions and shared infrastructure and new technology development will reduce the costs of field expeditions and enable countries to strengthen their range of scientific expertise.

F. Advancing women’s empowerment and leadership in marine scientific research

42. Female scientists account for on average 38 per cent of the researchers in ocean science and while this proportion is higher than in many other scientific disciplines, gender equity remains elusive.[28] Given that women are underrepresented in ocean science and, in particular, highly technical fields,[29] collective actions are required to ensure gender equality in the ocean science community. A good illustration of strategic partnerships for transformative actions can be found in the context of implementation of the Women in Deep-Sea Research project, a joint initiative of the International Seabed Authority and the United Nations Office of the High

[28] See IOC-UNESCO, *Global Ocean Science Report 2020*.

[29] Ibid.

Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States.[30]

IV. Existing partnerships

43. The Ocean Decade, whose implementation commenced on 1 January in 2021 and is coordinated by IOC-UNESCO, is aimed at catalysing new partnerships and strengthening existing partnerships between diverse ocean actors to achieve a common vision of "the science we need for the ocean we want".[31] The Ocean Decade, which is being implemented in the context of the United Nations Convention on the Law of the Sea, is investing significant efforts in convening and facilitating partnerships within the scientific community and between United Nations entities, the scientific community and other ocean actors including business and industry, philanthropy, Governments, policymakers, non-governmental organizations and civil society.

44. In the context of the Ocean Decade mechanisms are deployed for catalysing collaborations between these different groups both in terms of co-design and co-delivery of scientific knowledge that is relevant to societal objectives and in terms of activities related to strengthening of research capacity and transfer of marine technology. Structured around 10 Ocean Decade challenges, multidisciplinary international teams are regularly solicited, comprising both generators and users of ocean science. The identification of strategic ambitions and targets for each Ocean Decade challenge through a participatory process involving multiple stakeholders is a priority for the next phase of implementation of the Ocean Decade.

45. The priority knowledge gaps that exist in relation to a number of the issues identified in the present concept paper are recognized in the Ocean Decade. Ocean Decade challenges relating to marine pollution, ecosystem management and restoration, blue food, the sustainable ocean economy and the ocean-climate nexus will be used as the basis of a framework to solicit transformative, co-designed ocean science initiatives to fill critical knowledge gaps.

46. The Ocean Decade is structured around a value chain approach to ocean science moving from observations to understanding and to tools for decision-making for sustainable development. Three of the Ocean Decade challenges relate to the improvement and sustainability of fundamental ocean science infrastructure, including ocean observations, infrastructure for community resilience and the creation of an interoperable digital ecosystem for ocean science.

47. Both capacity development and behaviour change are recognized as important in the Ocean Decade and are identified as individual Ocean Decade challenges. Ocean Decade actions integrate capacity and capability development initiatives as fundamental prerequisites for improved scientific knowledge and for enhanced research capacity and transfer of marine technology. Such initiatives focus on partners in small island developing States, least developed countries and landlocked developing countries, and on gender equality as well as on early career ocean professionals who are all priority targets of capacity development in the context of the Ocean Decade. Numerous ocean literacy initiatives are being carried out as part of the Ocean Decade and further investments will be made to ensure that the Ocean Decade acts as a common framework to facilitate the sharing and replication of resources as well as the deployment of common methods for measuring the impact of

[30] See www.isa.org.jm/vc/enhancing-role-women-msr/WIDSR-project.

[31] See IOC-UNESCO, *The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) Implementation Plan*.

ocean literacy efforts with respect to triggering individual and institutional behaviour change.

48. At the time of writing, 31 global Ocean Decade programmes, close to 100 Ocean Decade projects and 15 United Nations-led Ocean Decade actions are being implemented across all 10 Ocean Decade challenges. This portfolio will increase over time, including following endorsement decisions on programmes submitted during the call for Decade actions No. 02/2021, which will be announced in June 2022. Gaps remain in terms of leadership from partners in least developed countries, small island developing States and landlocked developing countries and specific efforts are being made to engage and build capacity in these regions, including the provision of resources and support to facilitate co-design of relevant Decade actions.

49. The High-level Panel for a Sustainable Ocean Economy convenes 16 Governments which have committed to an ambitious transformative agenda, including sustainable management of their exclusive economic zones by 2030 through the development and deployment of sustainable ocean plans. Ocean science, capacity development and transfer of marine technology, including within the framework of the Ocean Decade, will be essential to the achievement of the ambitions of the High-level Panel.

50. There are currently 666 voluntary commitments registered under the "Scientific knowledge, research capacity development and transfer of marine technology" Community of Ocean Action. This accounts for over 40 per cent of the entire voluntary commitment registry.[32] Voluntary commitments range from large-scale, multi-country government-led initiatives to local community-led actions, illustrating the range of actors and types of activities relevant to this interactive dialogue.

51. There are numerous examples of successful capacity-building activities that are being implemented including delivery of training courses by the Division for Ocean Affairs and the Law of the Sea of the Office of Legal Affairs of the Secretariat and IOC-UNESCO on the conduct of marine scientific research under the United Nations Convention on the Law of the Sea. Joint activities are also being identified and implemented by the Division for Ocean Affairs and IOC-UNESCO with a view to ensuring synergies between the third cycle of the Regular Process and the Ocean Decade, including a joint programme aimed at developing the capacities of States in strengthening the science-policy interface at national, regional and global levels. The World Meteorological Organization (WMO) is leading capacity development for least developed countries and small island developing States which is designed to strengthen their understanding of the scientific and marine technology required in marine and coastal weather and climate forecasts. The International Seabed Authority has engaged in the organization of dedicated webinars on marine scientific research-related issues for Africa and least developed countries, landlocked developing countries and small island developing States. Initiatives such as the IOC Ocean Teacher Global Academy and regional training and research centres have been designed to overcome identified challenges associated with dispersed and ad hoc capacity-building efforts and capacity-building activities that are poorly adapted to the local context.

52. Bilateral and multilateral cooperation, including North-South, South-South and triangular cooperation, are under way in a number of areas, such as seabed mapping, deep-sea exploration, oceanographic observation, ocean innovation and data-related cooperation and exchange. Other matters addressed through cooperative initiatives include ocean acidification, the ocean-climate nexus, deoxygenation, eutrophication and nutrients, plastics and the conservation and sustainable use of marine biological

[32] See https://sdgs.un.org/partnerships/action-networks/ocean-commitments.

diversity as well as, more generally, oceanographic observation. Such initiatives include global climate observing systems and global ocean observing systems. Strategic partnerships, including among international organizations and between such organizations and their stakeholders, including the scientific community and academia, are an important interdisciplinary and cross-sectoral collaborative tool.

53. Scientific collaboration to promote the integrated and cross-sectoral management of human activities that rely on and affect the ocean and seas is supported by various organizations and bodies of the United Nations system, including through inter-agency cooperation. For example, the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection serves as a mechanism for coordination and collaboration for the provision of scientific advice to the United Nations system on marine environmental protection. UN-Oceans, an inter-agency mechanism that currently comprises 28 members and seeks to strengthen and promote the coordination and coherence of United Nations system activities on coastal and ocean issues, is facilitating contributions from its members to the Decade and the third cycle of the Regular Process.

54. In relation to improved data sharing and management, IOC-UNESCO is developing the Ocean Data and Information System to integrate existing data exchange systems using common data exchange formats and protocols in order to facilitate access to the vast amounts of ocean knowledge. Other online platforms have been established to facilitate information sharing and scientific collaboration, for example, on marine biodiversity and deep-sea ecosystems. This is notably the case with regard to the International Seabed Authority Deep Seabed and Ocean Database (DeepData) launched in 2019, which collects and disseminates environmental data, including biological, physical and geochemical parameters of the seafloor and water column ecosystems, acquired by contractors during exploration activities.

55. IOC-UNESCO is also developing a global clearing-house mechanism with the potential to inform several communities and ocean-related intergovernmental processes (e.g. the 2030 Agenda for Sustainable Development, the Convention on Biological Diversity and an international legally binding instrument on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction). This mechanism will aim towards facilitating access to information and providing a matchmaking service for capacity development and the transfer of marine technology across numerous different data platforms and repositories including those internal to United Nations entities and those held by Governments, non-governmental organizations and private sector partners. It will build on a successful regional pilot recently developed for Latin America. UNEP is working to develop a global platform, through the World Environment Situation Room, to bring together data, including geospatial data and other types of data (e.g. citizen science), on oceans. It is also building the capacity of countries to use methodologies related to marine indicator data collection, including data collection for the Goals. WMO, through the Year of Polar Prediction, has contributed to improvement in environmental prediction capabilities for the polar regions and beyond.

56. In 2019, the World Meteorological Congress approved a new collaborative framework on the ocean to streamline and enhance WMO ocean activities, boost inter-agency coordination and cooperation and contribute to the United Nations Decade of Ocean Science for Sustainable Development 2021–2030. It endorses a cross-cutting approach, embracing research, observations and forecasting, and service delivery in line with the drive of WMO towards a more integrated Earth systems strategy.

57. Members of the World Climate Research Programme are actively involved in various cross-cutting climate-ocean research projects which help to build links with

the vision and high-level objectives of IOC.[33] Specifically, the Programme's CLIVAR (Climate Variability and Predictability) core project has been contributing to the scientific design and implementation of regional and global ocean observing systems as well as the synthesis/reanalysis of global ocean, atmosphere and coupled climate information which are all relevant to one of the objectives of IOC, namely, enhancing scientific knowledge of emerging ocean science issues. CLIVAR, through its regional panels, has good connections to global and regional partners which also include IOC-UNESCO in ocean observations, as exemplified by the CLIVAR/IOC-Global Ocean Observing System (GOOS) Indian Ocean Region Panel which led the development of the Indian Ocean Observing System (IndOOS) and the Road Map to Sustained Observations of the Indian Ocean for 2020–2030 (IndOOS-2). It plays an active role in promoting sustainable design and implementation of the Indian Ocean Observing System along with other partner programmes.

58. Under the action "Digital innovation hand-in-hand with fisheries and ecosystems scientific monitoring", FAO intends to create a digital fisheries and environmental atlas using open data and open science. The atlas will include information from FAO fishery country profiles and data from a range of diverse technologies, with topical environmental maps and data for "FAIR" analysis. The atlas will work hand in hand with countries and regional fishery bodies to disseminate comprehensive open data pages on the state, impacts and management of fisheries, which can enable countries' progress towards the Goals and targets under the United Nations Decade of Ocean Science for Sustainable Development.

V. Possible areas for new partnerships

59. Advancing science to improve knowledge of the ocean requires increased cooperation and coordination at the global, regional and local levels. The interrelated nature of the Goals and the manner in which ocean science underpins the targets of many of the other Goals require multidisciplinary and transdisciplinary research on oceans and cross-sectoral cooperation. Enhancing such cooperation and coordination will enable all actors to engage in ocean research and ultimately increase scientific output and impact.

60. The Ocean Decade Alliance has been established in the context of the Ocean Decade to mobilize resources and stimulate support for the Decade and participation by a wide range of actors across government, industry, philanthropy and United Nations entities. The Alliance will stimulate ambitious action in ocean science to address societal needs. Through the promotion of scientific innovation, a science-based approach to ocean management and targeted investment in ocean research infrastructure and capacities, the Alliance aims towards creating a movement for delivering fit-for-purpose ocean knowledge for all components of the ocean science value chain and benefiting all users ranging from citizens to policymakers.

61. Partnerships with the private sector present another positive opportunity. For example, while new inventions offering low-cost solutions, such as wave measurements from drifting buoys, are helping to close the gaps in ocean-related technology, specific needs remain in the transfer of marine technology to improve management of the oceans, including advancements in ocean observing instruments, computing, sensors and robotics to expand ocean monitoring capabilities. Collaboration with industry will be important to realize these advancements. As regards ocean observations and research, in-kind contributions from private sector partnerships such as deployments are very important, as a growing number of private

[33] See https://ioc.unesco.org/index.php/about/mission-vision.

or commercial ships are equipped with ultramodern underway measurement equipment. These opportunities attract media attention, offering examples of capacity-building and partnership.

62. Public contributions to scientific knowledge, research capacity and transfer of marine technology can be achieved through citizen science, engaging indigenous peoples and local communities as partners, and crowdfunding partnerships. Such initiatives can be important mechanisms for allowing engagement of a diverse range of non-traditional stakeholders and can also function as powerful communication tools. Links to museums and aquariums could be explored within the context of these initiatives as part of ocean literacy initiatives.

VI. Conclusions and recommendations

63. Recent years have seen increased scientific output and growing recognition of the importance of ocean science in contributing to multiple facets of sustainable development. A vast range of initiatives, applications and services tools have been developed and are being implemented by United Nations entities, national Governments, civil society and the scientific community. Innovative partnerships exist, including with industry and philanthropy, to support ocean science. There are increased efforts to embrace alterative knowledge systems as a complement to ocean science.

64. However, inequities still exist both in terms of capacity to generate and use ocean science and in terms of access to data, information and technology. Early career professionals, women and actors from least developed countries and small island developing States are all underrepresented in ocean science. Capacity development is required within the scientific community and for diverse actors who use science in policy development, area-based and resource management and decision-making.

65. Available resources for generating and using ocean science are inadequate. National spending for ocean science is on average less than 2 per cent of national research budgets. Global crises, including the COVID-19 pandemic, have affected both ocean science activities and investment in science. The low level of national investment runs contrary to the ambitions of numerous countries to promote a sustainable ocean economy as a pillar of future economic development.

66. The Ocean Decade provides a global framework for convening actors to co-design, co-deliver and resource transformative and relevant ocean science to contribute to national, regional and global ambitions for sustainable ocean management. Strong engagement and ownership by diverse stakeholders will be essential for optimizing the unique opportunity provided by the Ocean Decade and contributing to fulfilment of Goal 14 and broader facets of the 2030 Agenda for Sustainable Development.

VII. Guiding questions

67. The following guiding questions may be used to inform the dialogue:

(a) How can partnerships help the international community enhance scientific understanding of the ocean and its interactions with human society and in what ways can the United Nations Decade of Ocean Science for Sustainable Development serve as a framework for this cooperation?

(b) How can scaling up actions to increase scientific knowledge and develop research capacity and transfer of marine technology, including within the context of the Ocean Decade, facilitate achievement of Sustainable Development Goal targets, including targets under Goal 14 and under other Goals?

(c) What are the major or priority gaps in scientific knowledge and capacity which need to be addressed to achieve Goal 14 and other ocean-related Goals, bearing in mind the challenges of climate change? How can indigenous and local knowledge holders be included in this process and contribute to addressing these gaps?

(d) How can a closer link be ensured between science and policy and management decisions, including ways to improve co-design and co-delivery of relevant ocean science interaction between scientists and users to ensure decision-making informed by science? How can the effectiveness of the uptake of science in policymaking be best measured?

(e) How can funding entities (including international financial institutions, Governments, the private sector and philanthropies) be incentivized to recognize the value of investing in ocean science through traditional and innovative mechanisms, including in capacity-building for least developed countries and small island developing States?

(f) How can those countries and communities that are most vulnerable to ocean changes and impacts and dependent on marine resources, in particular small island developing States and coastal African countries, be supported in generating new knowledge, achieving more robust science and knowledge co-production and the capacity needed to apply science in decision-making? How can a digital divide-type outcome be avoided and how can strategies that are inclusive of women and vulnerable groups be achieved?