ADVANCE UNEDITED REPORTING MATERIAL

I. Introduction

1. Technology is recognized, in particular through Sustainable Development Goal 17 of the 2030 Agenda for Sustainable Development, as one of the major pillars of the means of implementation of the 2030 Agenda and of the Rio+20 follow-up processes.[1] Innovations in marine technology, improved access to, and exchange of, ocean technologies are part of what is needed to improve the management of human uses of the ocean to ensure sustainability.[2] All maritime industries are highly reliant on technology to operate efficiently, safely and without damaging the marine environment.[3]

2. The importance of maritime technologies to sustainable development, including of the ocean, as well as challenges linked to the development of new technologies is underlined by the decision of the General Assembly in its resolution 77/248, paragraph 378, that the twenty-third meeting of the Informal Consultative Process would focus its discussions on the topic "New maritime technologies: challenges and opportunities".

3. To facilitate discussions of the twenty-third meeting of the Informal Consultative Process, the present report provides an overview of maritime technologies on a sectoral basis focussing on new technologies, it also outlines challenges in each sector as well as opportunities. Also covered are technologies which are cross-sectoral, or which are not inherently maritime technologies, but which enable or enhance the sustainable development of the ocean. The report draws upon the contributions submitted by States and relevant organizations and bodies,[4] as well as upon other reports and studies related to the topic of focus.

II. New Maritime Technologies

A. Marine science technologies

4. Marine science, which is underpinned by ocean observations,[5] is important for eradicating poverty, contributing to food security, conserving the marine environment and resources, helping to understand, predict and respond to natural events, and promoting the sustainable development of oceans and seas.[6] New maritime technologies in ocean observing such as next-generation sensors, novel analytical tools and uncrewed systems dramatically enhance our ability to explore and observe

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[1] United Nations, Department of Economic and Social Affairs, "Technology", available at https://sdgs.un.org/topics/technology.

[2] Second World Ocean Assessment, Vol I. p. 5.

[3] Second World Ocean Assessment, Vol I. p. 21.

[4] The full text of the contributions is available from the website of the Division for Ocean Affairs and the Law of the Sea: https://www.un.org/depts/los/consultative_process/consultative_process.htm.

[5] Report of the Secretary General on Oceans and the law of the sea, A/77/68, para. 4.

[6] General Assembly resolution 77/248 of 30 December 2022, preamble.

the ocean at unprecedented temporal and spatial scales. They have the potential for transformative advancements in the quality and timeliness of maritime products and services, provide more comprehensive knowledge about the ocean, inform sustainable management and improve environmental intelligence for decision-making and growing the blue economy.[7] These technologies span all other sectors covered within this report.

5. Advances in sensor development, from lab-on-chip technology[8] to acoustic sensing,[9] enable cost-effective low-carbon measurements of an increasing range of essential ocean variables (EOVs)[10] and other physical, chemical, biological and anthropogenic impact parameters with greater accuracy.[11] Innovative methods in marine biotechnology, also known as omics technologies,[12] such as the analysis of environmental DNA and RNA (eDNA/eRNA) in seawater or sediment samples, have the potential to revolutionize the monitoring and understanding of marine biological communities including fish stocks.[13] They can be faster, cheaper and less invasive and provide more information than traditional methods.[14] Enhancing traditional platforms, including ships of opportunity, with these new sensors is key, but has not yet been sufficiently realized.[15]

6. Uncrewed systems, including remotely operated, autonomous or hybrid aerial, surface and underwater vehicles and platforms, such as floats, gliders, drones, and smart buoys as well as animal-borne sensors and tags, have dramatically expanded the collection and utilization, often in real-time, of critical, high accuracy and time-sensitive data.[16] They have proven to be particularly adept at facilitating missions in remote, data-sparse locations, harsh or inaccessible environments and for sampling efforts of long duration.[17] Such systems are becoming increasingly important for bathymetric mapping, habitat characterization, shipwreck localization, real-time monitoring of harmful algae blooms, detection and tracking of oil seeps and spills, monitoring of marine plastics, weather predictions, traffic monitoring, as well as hydrographic, oceanographic, atmospheric, meteorological, biodiversity, fishery, ecosystem, and geographic surveys augmenting more expensive and environmentally burdensome conventional methods that use crewed systems.[18] Among the newest technologies are modular and customizable suites of automated systems that provide an ‘end-to-end’ approach from monitoring design to data collection, analysis and reporting, and translate field data into comprehensive information.[19]

7. New autonomous underwater vehicles (AUVs) have advanced navigational and obstacle avoidance sensors and artificial intelligence (AI) capabilities, allowing them to complete georeferenced and repeatable surveys and to automatically detect and

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[7] Contributions of Australia, Portugal, the United States, GFCM, IOC-UNESCO, and NPAFC. For an overview of tools and frameworks for ocean observation, see also the Report of the Secretary-General on Oceans and the law of the sea, A/77/68, and Second World Ocean Assessment, Vol. I, pp. 50-51.

[8] Contribution of IOC-UNESCO.

[9] Contributions of Australia, Portugal, the United States, NPAFC, and OceanCare.

[10] “Essential Ocean Variables”, GOOS, available at: https://www.goosocean.org/index.php?option=com_content&view=article&id=14&Itemid=114.

[11] Contributions of GFCM, IOC-UNESCO, NPAFC.

[12] Contribution of the United States.

[13] Contributions of the European Union, Portugal, the United States, IOC-UNESCO, and NPAFC.

[14] Contributions of the European Union, the United States, and IOC-UNESCO.

[15] Contribution of IOC-UNESCO.

[16] Contributions of the European Union, Portugal, the United States, GFCM, IOC-UNESCO, and NPAFC.

[17] Contributions of the European Union, Portugal, the United States, and IOC-UNESCO.

[18] Contributions of Mauritius, Portugal, the United States, GFCM, and IOC-UNESCO.

[19] Contributions of Australia, and GFCM.

follow contours and slopes.[20] Sail drones, powered by wind and solar energy, can transmit oceanic and atmospheric data in real-time, while hybrid versions can also operate underwater.[21] Solar-powered smart buoys provide customized monitoring of multiple parameters from permanent locations, with a view to obtaining high-definition time series.[22] Autonomous systems carrying hydrophones have provided new opportunities for passive acoustic monitoring of vocalizing marine mammals facilitating the avoidance of ship collisions.[23] In this context, equipping ARGO floats with acoustic sensors could represent a major opportunity to enhance global passive ocean observation and improve ocean acoustic models.[24]

8. The integration of environmental sensors into undersea telecommunications cables, known as SMART[25] cables, is expected to boost ocean monitoring, tsunami and earthquake early warning for disaster risk reduction.[26] A pilot SMART cable system is expected to be operational off Portugal in 2025.[27]

9. Advanced seabed mapping instrumentation allows faster collection of large quantities of high-quality data to be collected in 3D at any depth.[28] Uncrewed vehicles can complement the work of crewed research vessels equipped with echo-sounders, side-scan sonar, and other mapping technologies,[29] furthering efforts to produce a complete map of the world ocean floor by 2030.[30]

10. Improved ocean and coastal observing requires a sustained, persistent, and affordable presence in the ocean, with a densified global observation network, both at sea and from space.[31] To achieve these ambitious goals, it will be necessary to enhance existing infrastructure to meet the analytical demands of emerging technologies, and to overcome the engineering challenges associated with developing novel technologies, like decreasing weight and size of instrumentation, lowering costs in terms of deployment, acquisition and maintenance, increasing resistance to corrosion and biofouling, and finding innovative solutions regarding energy supply and data transfer for example by subsea acoustical, optical, and electromagnetic networks (see para. 62).[32] In this context, dedicated facilities to safely test and evaluate new maritime technologies offer an opportunity to verify that they are fit-for-purpose, safe to operate and environmentally compliant.[33] Fostering the operationalization of successfully tested emerging technologies, strengthening research, expanding partnerships, integrating AI and other computing tools (see para. 63) and increasing workforce proficiency in the operation and use of new technologies are also important.[34] The integration of new technologies into long-term

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[20] Contribution of Australia.

[21] Contributions of the United States, and NPAFC.

[22] Contribution of GFCM.

[23] Contributions of the United States, and OceanCare.

[24] Contribution of Portugal.

[25] Science Monitoring and Reliable Telecommunications.

[26] Contributions of Portugal, IOC-UNESCO, and the ITU/WMO/UNESCO IOC Joint Task Force on SMART cable systems.

[27] Contributions of Portugal, and the ITU/WMO/UNESCO IOC Joint Task Force on SMART cable systems.

[28] Contributions of Australia, and Mauritius.

[29] Contribution of Mauritius.

[30] New Seabed 2030 partnership strengthens autonomous ocean mapping in support of a complete map of the entire seafloor”, The Nippon Foundation-GEBCO Seabed 2030 Project (9 February 2023) at https://seabed2030.org/news/new-seabed-2030-partnership-strengthens-autonomous-ocean-mapping-support-complete-map-entire.

[31] Contribution of Portugal.

[32] Contributions of the European Union, Portugal, the United States, GFCM, IOC-UNESCO, and NPAFC.

[33] Contributions of Australia, and Portugal.

[34] Contributions of the United States, and Mauritius.

datasets that inform policy decisions has been identified as a challenge which needs to be addressed.[35]

11. The "Ocean of Things" is a program which seeks to enable persistent maritime situational awareness over large ocean areas by deploying thousands of small, low-cost floats that form a distributed sensor network.[36] Upcoming cutting-edge technologies include the adaptive collaboration of networked multiple uncrewed systems, which will require improved interoperability and international cooperation, addressing legal challenges of autonomous navigation, and implementing formal command and control architectures with advanced tools for distributed mission and motion planning, navigation, and real-time decision making, the combination of which is still in its infancy.[37]

12. Marine genetic resources are at the cutting edge of marine science and the focus of an expanding range of applications, including in the pharmaceutical, nutraceutical, antifouling and cosmetic industries,[38] with significant methodological innovations, including sampling, screening and analytical techniques.[39] Decreasing costs of sequencing and advances in the biotechnology sector have led to an increased reliance on public databases of genetic sequence data, rather than physical samples.[40] Developments in molecular technologies, such as DNA sequencing, are enabling new scientific discoveries,[41] whilst developments in omics approaches, including high-throughput DNA sequencing and bioinformatics analyses, could be used in diverse applications, including the discovery of natural products that may have medical or other commercial value.[42]

13. Methodological challenges include difficulties in obtaining high-quality near-complete genomes from uncultured microorganisms, with further advances needed to improve their completeness.[43] Significant knowledge gaps remain regarding the extent of genetic diversity in the ocean.[44] With most research in this field being carried out by a small number of countries, many States, in particular developing States, face challenges of limited capacity and financial resources to conduct such research.[45] In addition to the challenges inherent to deep-sea sample collection, downstream processing and analysis require specialized expertise and tools, which are often limited in developing countries.[46] Capacity-building initiatives, including the transfer of marine technology, are key to addressing such challenges.[47]

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[35] Contribution of IOC-UNESCO.

[36] Contribution of IOC-UNESCO; Waterston, J., et al., "Ocean of Things: Affordable Maritime Sensors with Scalable Analysis", Conference "OCEANS 2019 - Marseille" (17-20 June 2019), at https://ieeexplore.ieee.org/document/8867398.

[37] Contribution of Portugal.

[38] Second World Ocean Assessment, Vol. II, p. 365-367. See, e.g., Rachel Wynberg, "Marine Genetic Resources and Bioprospecting in the Western Indian Ocean", in United Nations Environment Programme, *Regional State of the Coast Report: Western Indian Ocean* (United Nations, 2016), available at www.un-ilibrary.org/content/books/9789210601573.

[39] Second World Ocean Assessment, Vol. II, p. 366.

[40] Second World Ocean Assessment, Vol. II, p. 365 and 369.

[41] Contribution of IOC-UNESCO.

[42] Contribution of the United States; see also NOAA 'Omics Strategy: Strategic Application of Transformational Tools' (February 2020), available at https://sciencecouncil.noaa.gov/Portals/0/2020%20Omics%20Strategy.pdf?ver=2020-09-17-150026-760.

[43] Second World Ocean Assessment, Vol. II, p. 373.

[44] Second World Ocean Assessment, Vol. II, p. 369.

[45] Second World Ocean Assessment, Vol. I, p. 21 and Vol. II, p. 371.

[46] Contribution of the ISA.

[47] Second World Ocean Assessment, Vol. II, p. 372.

14. Systemic barriers and lack of representation in leadership roles have contributed to an under-representation of women in ocean science. To fully utilize the significant contributions and potential of women to the development of new technologies as well as the protection and preservation of the marine environment, this under-representation needs to be addressed and gender-balance achieved.[48]

B. Technologies to mitigate the climate change

15. As the ocean continues to absorb most of the excess heat caused by increasing concentrations of greenhouse gases (GHG), as well as a significant proportion of anthropogenic carbon dioxide emissions,[49] it is warming, rising, and becoming more deoxygenated and acidified.[50] New maritime technologies can play a crucial role in monitoring, better understanding, preventing and potentially reversing these negative impacts[51] and global and regional initiatives enact these innovations (see para. 70).

16. The United Nations Framework Convention for Climate Change (UNFCCC) has identified the need to further strengthen sustained systematic observations of the ocean and address gaps[52] with new ocean observing techniques being developed or employed to monitor the ocean and better understand climate change impacts.[53] For example, *ReefCloud* is a cloud-based, open-source technology powered by AI to facilitate the management, analysis, and reporting of coral reef monitoring data.[54] Satellite imagery and independent autonomous underwater gliders can assist with forecasting and understanding ocean acidification by monitoring the behaviour of phytoplankton.[55]

17. Ocean-based mitigation options, including ocean-based renewable energy (see paras. 31-38), decarbonization of ocean industries and ocean-based carbon capture and storage, would help States achieve the goals of the Paris Agreement.[56] Advancements in modelling are also helping in this regard (see para. 64). Investments in the development of new technologies to lower GHG emissions from shipping[57] and fishing vessels[58] are ongoing and need to be scaled up. Regional fisheries management organizations and arrangements (RFMO/As) could facilitate the identification and testing of technologies aimed at decarbonizing the fishing sector.[59] The Global Centre for Maritime Decarbonisation has been conducting research on

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[48] ISA, Empowering Women from LDCs, LLDCs and SIDS in Deep-Sea Research (2022).

[49] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–35. https://doi.org/10.1017/9781009157964.001.

[50] IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–35. https://doi.org/10.1017/9781009157964.001, at pp. 9-10.

[51] Contributions of Australia, Côte d'Ivoire, Portugal, Singapore, and the United States.

[52] Contribution of UNFCCC.

[53] Contributions of the European Union, Australia, Singapore, United States, GFCM, Smart Cables JTF.

[54] Contribution of Australia.

[55] Contributions of the United States and GFCM.

[56] Contributions of the European Union, and UNFCCC, see also: https://oceanpanel.org/publication/the-ocean-as-a-solution-to-climate-change-five-opportunities-for-action/.

[57] See section on Shipping for more information on the decarbonization of the shipping sector.

[58] Contributions of the European Union, Singapore, and GFCM.

[59] Contribution of GFCM.

technologies to decarbonize the maritime sector more generally.[60] Research continues on developing new technologies for the sequestration of those maritime emissions that could not be avoided,[61] and on potential CO_2 removal (CDR) in coastal and marine settings.[62]

18. Emerging technologies for carbon capture and sequestration in sub-seabed formations as well as geoengineering are being addressed within the International Maritime Organization (IMO).[63] Four geoengineering techniques have been identified for priority evaluation.[64] The need to apply the precautionary approach and the utmost caution in the consideration of these techniques has been underscored.[65]

19. With regard to adaptation, the UNFCCC reported that one of the ten key messages from the Ocean and Climate Dialogue 2022, was that marine technology and marine and coastal nature-based solutions should be integrated to ensure that action is more robust, comprehensive and cost-effective.[66] The 2022 dialogue outcome called for hybrid approaches, including restoration of coastal vegetation alongside engineered seawalls to reduce the impacts of storm surges and sea level rise, investments in nature-based infrastructure, and new technologies to reduce harmful fishing practices.[67] It also noted that offshore renewable technologies could be paired with adaptation strategies, for example mangrove protection with wave energy, to create synergies to protect coastal and marine communities at risk.[68] Finally, the outcome highlighted the need to build cross-sectoral partnerships,

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[60] Contribution of Singapore.

[61] Contributions of the European Union, and the United States.

[62] Contribution of the United States.

[63] Contribution of IMO.

[64] Statement adopted at the 44th Consultative Meeting of Contracting Parties to the London Convention and the 17th Meeting of Contracting Parties to the London Protocol, LC 44/17, annex 2: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/LC_LP/LP%20LC%20Statement%20on%20Marine%20Geoengineering_%20LC%2044-17%20annex%202.pdf. The four techniques are enhancing ocean alkalinity [CDR], macroalgae cultivation and other biomass for sequestration including artificial upwelling [CDR], marine cloud brightening [solar radiation modification (SRM)], and microbubbles/reflective particles/material [SRM].

[65] Statement adopted at the 44th Consultative Meeting of Contracting Parties to the London Convention and the 17th Meeting of Contracting Parties to the London Protocol, LC 44/17, annex 2: https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/LC_LP/LP%20LC%20Statement%20on%20Marine%20Geoengineering_%20LC%2044-17%20annex%202.pdf.

[66] Contribution of UNFCCC; see also: see also: decision 1/CP.26 (the Glasgow Climate Pact), para. 61, the Chair of the Subsidiary Body for Scientific and Technological Advice was invited to hold an annual dialogue to strengthen ocean-climate action. See FCCC/CP/2021/12/Add.1, p. 7 at: https://unfccc.int/sites/default/files/resource/cp2021_12_add1E.pdf; see also: Informal summary report by the Chair of the Subsidiary Body for Scientific and Technological Advice, p. 13: https://unfccc.int/sites/default/files/resource/OceanAndClimateChangeDialogue2022_summary%20report.pdf?download; and UNFCCC and IUCN. 2022. Innovative Approaches for Strengthening Coastal and Ocean Adaptation – Integrating Technology and Nature-based Solutions. United Nations Climate Change Secretariat. Bonn: https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/2020_coastalzones/08d67ce24afd44c8b02826c54201bed5/516c3ce4be94470cbd9c28ba44add8ec.pdf.

[67] Contribution of UNFCCC, see also: Informal summary report by the Chair of the Subsidiary Body for Scientific and Technological Advice, p. 13: https://unfccc.int/sites/default/files/resource/OceanAndClimateChangeDialogue2022_summary%20report.pdf?download.

[68] Contribution of UNFCCC, see also: Informal summary report by the Chair of the Subsidiary Body for Scientific and Technological Advice, p. 11: https://unfccc.int/sites/default/files/resource/OceanAndClimateChangeDialogue2022_summary%20report.pdf?download.

including with the private sector, to, inter alia, develop innovative technologies and bolster the business case for integrated adaptation solutions.[69]

20. The lack of financing and capacity building continues to present challenges for the development and implementation of new maritime technologies to address climate change.[70] It is noted that despite the pressing adaptation needs of coastal and island communities, knowledge, capacity, and financing gaps prevent the widespread implementation of integrated solutions, including those incorporating new technologies.[71] "Funding for ocean-climate action needs to increase and access to funding must be supported" was another key message of the 2022 ocean climate dialogue. Perceived risks in investments in marine technologies continue to be a challenge.[72] However, advances in ocean observation and knowledge could ameliorate those risks.[73] States could identify and promote innovative financing and risk-reduction mechanisms, including, but not limited to, capital investment support and revenue support mechanisms.[74] The Joint Work Programme of the UNFCCC Technology Mechanism for 2023–2027 Activity on Innovative Ocean Climate Solutions continues to enhance action on technology development and transfer in support of mitigation and adaptation to climate change.[75]

C. Technology to mitigate the impacts of anthropogenic activities

21. Land-based sources are the biggest contributors to marine pollution.[76] A wide variety of pollutants enter the marine environment from land-based sources, including nutrient run-off, hazardous substances such as heavy metals, solid waste such as plastics, as well as sewage sludge and organic and inorganic waste.[77]

22. Innovative sensor technology allows for better monitoring of human impact variables such as marine plastics.[78] Satellites are also playing an increasingly important role in monitoring,[79] and modelling can be used to identify and predict the impact of anthropogenic pollution.[80] New technologies may also play a role managing the full life cycle of plastics, including in removing plastic pollution from the ocean.[81]

23. Introduced anthropogenic noise may interfere with many functions of marine species,[82] and it may also cause physical damage to marine mammals, fish and invertebrates.[83] Solutions for shipping noise include propellor and hull design,

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[69] Contribution of UNFCCC, see also: Informal summary report by the Chair of the Subsidiary Body for Scientific and Technological Advice, p. 13: https://unfccc.int/sites/default/files/resource/OceanAndClimateChangeDialogue2022_summary%20report.pdf?download.

[70] Contributions of IOC-UNESCO, and UNFCCC.

[71] Contribution of UNFCCC.

[72] Contributions of IOC-UNESCO, and UNFCCC.

[73] Contribution of IOC-UNESCO.

[74] Contribution of UNFCCC.

[75] Contribution of UNFCCC, see also Joint Work Programme of the UNFCCC Technology Mechanism for 2023–2027: https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_Members_doc/6e2131a43af146249224a8122f1341d8/580e6bccc30f4c69a4745d88bc9dd29f.pdf.

[76] Report of the Secretary General on Oceans and the law of the sea, A/76/311, para. 72.

[77] Second World Ocean Assessment, Vol. I, pp. 8-9.

[78] Contribution by IOC-UNESCO, page 1.

[79] Contributions of the European Union, the United States, Portugal, GFCM, and IOC-UNESCO.

[80] Contribution of the European Union.

[81] UNEP/EA.5/Res.14, preamble; see also: https://theoceancleanup.com/oceans/.

[82] Report of the Secretary General on Oceans and the law of the sea, A/73/68, para. 25.

[83] Report of the Secretary General on Oceans and the law of the sea, A/73/68, paras. 1, 3, 5, 25-27.

improving hull insulation and damping, and better maintenance of these parts.[84] New quieting technologies and low-noise concepts have been developed for pile-driving, including surrounding the pile driving with bubble curtains, using vibrohammers, and dampening systems.[85] New technologies are also assisting in the conduct of research to fill knowledge and data gaps on ocean noise and its impacts.[86]

24. Beyond decarbonization of the shipping sector (see paras. 39-41) new technologies are being developed to address other impacts of the sector caused by discharge of ballast water, biofouling and marine plastic litter. The GloFouling project promotes new technologies to prevent and manage marine biofouling, including in-water cleaning systems, new anti-fouling components and the use of robotics for monitoring and inspecting surfaces.[87] The GloLitter Partnerships Project addresses marine plastic litter from ships, including by targeting waste management in ports.[88] Follow up activities to minimize the transfer of invasive aquatic species for technology demonstration and capacity building are also planned.[89]

25. Capacity-building is needed to reduce the input of pollutants into the ocean, in particular through the introduction of cleaner production, quieter technologies and cheaper and readily deployable wastewater-processing technologies.[90] Demonstration pilots to reduce biofouling and related emissions from shipping will assist developing countries to build their knowledge on control and management of biofouling, including to prevent the transfer of invasive aquatic species.[91]

E. Technology for sustainable exploration and exploitation of non-living resources

26. New technologies to enable the sustainable exploration and exploitation of non-living resources are constantly emerging or planned, including for regional identification, local confirmation and characterisation, and assessment of prospective areas as well as for deep-sea mining.[92]

27. In terms of exploration technologies, recent innovations include high-resolution remote sensing techniques, ranging from photographic surveys to geophysical measurements, as well as combined AUV photographic surveys, automated object-based image analysis and multibeam backscatter recording, with the potential to

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[84] Contribution of OceanCare, Attachment 1: Weilgart, L., “Best Available Technology (BAT) and Best Environmental Practice (BEP) for three noise sources: Shipping, Seismic Airgun Surveys, and Pile Driving”, in Journal of Ocean Technology 14 (3), 2019, pp. 2-3.

[85] Contribution of OceanCare, Attachment 1: Weilgart, L., “Best Available Technology (BAT) and Best Environmental Practice (BEP) for three noise sources: Shipping, Seismic Airgun Surveys, and Pile Driving”, in Journal of Ocean Technology 14 (3), 2019, pp 7-8.

[86] Contribution of OceanCare, Attachment 1: Weilgart, L., “Best Available Technology (BAT) and Best Environmental Practice (BEP) for three noise sources: Shipping, Seismic Airgun Surveys, and Pile Driving”, in Journal of Ocean Technology 14 (3), 2019, at p. 9.

[87] Contribution of IMO; see also: https://www.imo.org/en/OurWork/PartnershipsProjects/Pages/GloFouling-Project.aspx.

[88] Contribution of IMO; see also: https://www.imo.org/en/OurWork/PartnershipsProjects/Pages/GloLitter-Partnerships-Project-.aspx.

[89] See: https://www.imo.org/en/OurWork/PartnershipsProjects/Pages/TEST-Biofouling.aspx.

[90] Second World Ocean Assessment, Vol I. p. 10.

[91] See https://www.imo.org/en/OurWork/PartnershipsProjects/Pages/TEST-Biofouling.aspx for more on Accelerating Transfer of Environmentally-Sound Technologies (TEST) Biofouling project.

[92] Contribution of Portugal, p. 14; ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

increase the density of observational data in the exploration of marine polymetallic nodules.[93]

28. As regards exploitation, new machinery has been developed for the seafloor extraction of marine polymetallic sulphides, including cutting and collector machines and subsea slurry lift pumps for transport to the surface.[94] Exploitation technologies have also been successfully tested to retrieve polymetallic nodules from significant depths, however, further improvements with a view to scalability and additional field testing are needed.[95] New technologies currently under development seek to selectively harvest polymetallic nodules individually using image sensing and employ robotic technology to minimize plumes, avoiding nodule fauna and impacts to sediment structure or fauna.[96] Low-energy and selective techniques currently under development also include bioprocessing using microbes and reusable eutectic liquid solvents.[97] Relevant mining technologies are still at an early stage of development for marine cobalt-rich ferromanganese crusts.[98] Research is looking into the extraction of uranium from seawater, though it is not yet near practical application.[99]

29. Technology development and innovation supported a series of International Seabed Authority (ISA) activities, including implementation of unique trainings by exploration contractors, development of research and publications and engagement of expert groups to inform future policy dialogue.[100]

30. Notwithstanding this technological progress, many challenges remain in connection with deep-sea mining or have newly emerged,[101] including the limited knowledge of the impacts of deep-sea mining on the marine environment and gaps in overall knowledge of the deep-sea environment, including deep-sea ecosystems.[102] Specific concerns have been raised over the known effects of deep-sea mining, including disturbance of sediment and seafloor ecosystems during extraction and processing, the energy-intensity of certain extraction methods and potential environmental impacts of chemical leaching agents during processing.[103] While the need to balance environmental protection with economic progress has been underscored, a moratorium, or precautionary pause, before deep-sea mining

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[93] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

[94] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

[95] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

[96] Impossible Metals, “Seabed harvesting without destroying the habitat”, at https://impossiblemetals.com.

[97] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

[98] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

[99] Contribution of Côte d’Ivoire; Tian, G., Liu T., and Yang S., “Review and Perspective on Technology for Uranium Extraction from seawater Using Amidoxime-based Materials”, Atomic Energy Science and Technology 57(1) (2023) https://www.aest.org.cn/EN/10.7538/yzk.2022.youxian.0885.

[100] Contribution of ISA.

[101] Contributions of Portugal, p. 10 and ISA, pp. 3-4.

[102] Amon, D.J. *et al*, “Assessment of scientific gaps related to the effective environmental management of deep-seabed mining”, Marine Policy 138 (2022) 105006.

[103] ISA, Marine Mineral Resources: Scientific and Technological Advances, ISA Technical Study No. 30 (2021).

exploration progresses, or a deferment or extension of the deadline for the adoption of regulations at ISA has been put forward.[104]

31. Extraction of many mineral resources requires advanced technology and is thus largely limited to those able to access such technology.[105] Other challenges concern the limited capacity of developing countries and tools required for downstream steps in sample processing, taxonomic or functional description, data analysis and ecosystem characterization, which hamper their contributions to deep-sea assessments.[106] Acquiring the infrastructure and knowledge required to assess the potential for exploration and sustainable exploitation of deep-sea mineral resources, while ensuring marine environmental protection, remain a challenge particularly for small island developing States (SIDS).[107] Identifying key priorities for scientific research and technology development as well as mobilizing resources for internationalized sciences are also a critical challenge for developing States.[108]

F. Energy production technologies

32. By 2050, the electricity sector will account for two-thirds of energy use.[109] Unlocking the potential of offshore renewable energy sources is necessary to meet this demand,[110] as they would also support the decarbonization of the power sector.[111] Clean and renewable energy can be generated from the ocean to provide electricity and contribute to emissions reductions from the energy sector.[112] The development of offshore renewable energy sources could open the potential of other sectors of the blue economy.[113]

33. Offshore wind turbine installations and operations have moved further offshore into deeper waters to obtain the best potential wind resources.[114] The most mature wind farm technology uses fixed foundations as the base structure[115] with floating wind farms installed in waters more than 60 metres in depth.[116] A number of EU Member States have announced large commercial floating wind energy projects.[117] Some States have a legal framework in place, based on the ecosystem approach, to address the potential negative impacts of offshore renewables on marine life and seabirds.[118] Spatial modelling has also been used within the United States to determine offshore wind installations sites in order to limit the impact on fisheries

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[104] Report of the thirty-second Meeting of States Parties, SPLOS/32/15, para. 44; statements made during the general debate on the General Assembly on oceans and the law of the sea, held on 8 and 9 December 2022.

[105] Second World Ocean Assessment, Vol I. p. 20.

[106] Contribution of ISA, p. 3.

[107] Contribution of Mauritius, p. 1.

[108] Contribution of ISA, p. 4.

[109] International Energy Agency (2022), World Energy Outlook 2022, IEA, p. 72.

[110] International Energy Agency (2022), World Energy Outlook 2022, IEA, p. 45.

[111] International Energy Agency (2022), World Energy Outlook 2022, IEA, p. 72.

[112] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 27.

[113] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 27.

[114] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 31; Second World Assessment, Vol I, p. 325.

[115] Contribution of the European Union, p. 2; IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 32; Second World Assessment, Vol I, p. 324.

[116] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 32.

[117] Contribution of the European Union, p. 2.

[118] Contribution of the European Union, p. 3.

and endangered species whilst also resulting in stronger stakeholder support.[119] Another form of offshore wind energy that is currently in the early stage of development is airborne wind energy systems, which produce electricity through propeller turbines and generators mounted on a flying wing at 200 to 450 metres altitude.[120] The expansion of offshore wind also supports the development of green hydrogen with commercial scale offshore wind parks coupled with battery storage or hydrogen production envisaged in the near future.[121]

34. Ocean energy is currently largely unrealised, despite its significant potential.[122] Global ocean energy is projected to contain an annual energy potential which is more than enough to meet the current global electricity demand.[123] Ocean energy technologies such as tidal and wave energy are the most advanced with about 75% of global capacity in European waters.[124] Singapore has commenced work on the MAKO Tidal Energy Site through a two-year project involving academia, industry, and government agencies to harness tidal energy.[125] Ocean thermal energy conversion only has a few existing demonstration plants available[126] and salinity gradient technology had only one project operational in 2020.[127] Projects are often decommissioned after successfully completing the testing phase.[128]

35. Placing solar photovoltaic panels on a floating platform has become a viable alternative, in particular for islands or densely populated countries with limited land area.[129] Floating nuclear power plants are being explored in several countries, with research being done to design reactors which can accommodate the highly variable movement of the vessel upon which the reactor would be situated.[130]

36. The development of offshore renewables is projected to bring socio-economic benefits and enhance the livelihoods of developing states, in particular, SIDS and least developed countries (LDCs), through the creation of jobs, local value chains, and synergies among different actors in the blue economy.[131]

37. Clear and long-term policy frameworks are needed to enhance the adoption of most offshore renewable technologies into a nation's energy mix, including in energy roadmaps or nationally determined contributions.[132] Global and regional initiatives also assist in this regard (see para 70).

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[119] Contribution of the United States of America, p. 7.

[120] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, pp. 34-35.

[121] Contribution of the European Union, pp. 2-3; IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, section 02.5.

[122] Contribution of the European Union, p. 2.

[123] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 51.

[124] Contribution of the European Union, p. 3.

[125] Contribution of Singapore, p. 2.

[126] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 54.

[127] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 56.

[128] Contribution of the European Union, p. 3.

[129] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 65.

[130] Ren Li, Minjun Peng, Genglei Xia, Lin Sun, The natural circulation flow characteristic of the core in floating nuclear power plant in rolling motion, Annals of Nuclear Energy, Vol. 142, 2020, 107385, ISSN 0306-4549, https://doi.org/10.1016/j.anucene.2020.107385, p. 1.

[131] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 27.

[132] Contribution of UNFCCC, p. 2; see also IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 93.

38. Offshore renewables are often located far from demand centres requiring long distance grid infrastructures.[133] Another challenge for clean energy technologies such as offshore renewables, particularly in developing countries, is the high cost of upfront capital.[134] In this regard, the UNFCCC Ocean and Climate Change Dialogue called on parties to promote innovative financing and de-risking mechanisms.[135] Bringing the cost of capital down, particularly in developing economies, could help provide clean and affordable energy as a way to ensure public support for offshore renewables projects.[136]

39. More investment is needed to reach the level where clean energy technologies can replace fossil fuels.[137] The EU has a number of frameworks to help mobilise necessary funds such as InvestEU, the Connecting Europe Facility or the Innovation Fund.[138] However, there are also challenges in that, except for the offshore wind, most ocean-based renewable sources are not at a commercial stage and more research, development, and demonstration is required to bring those technologies to maturity.[139]

G. Shipping technologies

40. International shipping is an integral part of the global economy, carrying over 80 per cent of world trade and providing the most economic and environmentally sustainable way of transporting cargo,[140] yet it is heavily reliant on fossil fuels.[141] Decarbonization of the maritime sector, in line with the Paris Agreement temperature goal, thus remains a significant challenge. In support of a greener transition, the World Maritime theme for 2022 was ‘New technologies for greener shipping'.[142] The revision of the International Maritime Organization’s Initial Strategy on Greenhouse Gas Emissions from shipping, due to take place in July 2023, is an important opportunity to increase sectoral ambition and align the industry’s decarbonization pathway with a 1.5-degree Celsius trajectory. It will be important for decarbonization targets to be supported by agreement on a set of mid-term measures that encourage an equitable transition, including technical standards and market-based incentives that support the maritime workforce. While innovation in the global blue economy will help to reduce overall GHG emissions from shipping, technological innovation in the maritime industry is also critical to realize this potential. Significant investment on the part of governments and industry, including in the form of subsidies and loans, will help to promote the technological innovation needed to facilitate the sector’s rapid decarbonization.

41. Investment in research and innovation is planned in the European Union towards zero emissions in waterborne transport by 2050.[143] In this regard, technological advances have been made to reduce GHG emissions in shipping through the use of alternative or renewable energies to power vessels,[144] trials with biofuel-powered

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[133] International Energy Agency (2022), World Energy Outlook 2022, IEA, pp. 315 and 318.

[134] International Energy Agency (2022), World Energy Outlook 2022, IEA, p. 200; Second World Assessment, Vol I, p. 333.

[135] Contribution of UNFCCC, p. 3.

[136] International Energy Agency (2022), World Energy Outlook 2022, IEA, pp. 197 and 202.

[137] Contribution of the European Union, p. 3; International Energy Agency (2022); World Energy Outlook 2022, IEA, p. 186.

[138] Contribution of the European Union, p. 3.

[139] IRENA (2021), Offshore renewables: An action agenda for deployment, International Renewable Energy Agency, Abu Dhabi, p. 27.

[140] Contribution of IMO, p. 1.

[141] UNEP, “The Closing Window: Climate crisis calls for rapid transformation of societies” (2022).

[142] Contribution of IMO.

[143] Contribution of the European Union, p. 1.

[144] Contributions of the European Union, p. 1, and Singapore, pp. 2-3.

shipping and preparations are underway to operate container ships that run on carbon-neutral “green” methanol[145] and ferries that run on hydrogen.[146] Engines that utilize novel fuels are also being developed.[147] Research[148] and development[149] on technologies related to hull design, power, propulsion, and energy efficiency as well as operational, coordination and support measures to decrease the impact of waterborne transport GHG emissions are also underway.

42. Green shipping corridors to spur early and rapid adoption of fuels and technologies that deliver low- and zero-emissions across the maritime sector in order to put the sector on a pathway to full decarbonization have been underscored. Signatories to the Clydebank Declaration recognised that fully decarbonised fuels or propulsion technologies should have the capability to not add additional GHGs to the global system through their lifecycle, including during production, transport or consumption. Over 20 initiatives were initiated and tracked by the Global Maritime Forum with its Annual Progress Report on Green Shipping Corridors.[150]

43. In addition to mitigating sources of other ship-based pollution, such as invasive species and biofouling (see para. 22), new maritime technologies can help addressing other challenges facing the maritime industry, including risks to navigation and the safety of life at sea.

44. AI has been introduced on smart ships that aim to limit human error and avoid collision, save fuel by optimizing routes and limiting waiting times, efficiently distribute goods in ports and optimize cargo distribution by avoiding unused cargo space.[151] Trends towards more efficient and autonomous systems in shipping, including by employing energy harvesting and advanced battery technologies are noted.[152]

45. More broadly, cloud computing has increased the exchange of real-time data with operational and forecast services and big data analytics have increased navigational efficiency by factoring weather trends into navigational decision-making.[153] Blockchain technology has the potential to limit paperwork and processing time and smart contracts may enable tracking shipments through the value chain.[154] Improvements in sensor technology have reduced the need for examining equipment aboard ships and increased automation of alerts for necessary maintenance.[155] 3D printing technology can contribute to the availability of spare parts on vessels and aerial drones can help supply goods to ships or assist with route inspections, as well as other aspects of security and surveillance.[156] In addition to contributing to security,

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[145] Contribution of Australia, p. 8; “ANL: Completes Biofuel Powered Voyage in Oceania”, ANL (13 April 2022).

[146] “Hydrogen to Power New Gladstone Ferry”, Queensland Government (4 May 2022), at https://statements.qld.gov.au/statements/95079.

[147] Contribution of Finland, p. 9.

[148] Contribution of the European Union, p. 1.

[149] Contribution of Finland, p. 9.

[150] Contribution of UNFCCC, p. 5. Also see: www.globalmaritimeforum.org/publications/annual-progress-report-on-green-shipping-corridors.

[151] ORCA AI, “Enabling the Smart Shipping Future, Today”, at https://www.orca-ai.io/; “Smart Ship Technologies for the Maritime Industry”, Marine Insight (18 June 2021); “Technology Trends Transforming the Maritime Industry”, KnowHow (21 December 2021); Contribution of Finland, p. 9.

[152] Contribution of IOC-UNESCO, p. 6.

[153] Contribution of USA, p. 3; “Smart Ship Technologies for the Maritime Industry”, Marine Insight (18 June 2021).

[154] “Trending Technologies Used in Shipping Management”, Orderhive (19 October 2020).

[155] “Technology Trends Transforming the Maritime Industry”, KnowHow (21 December 2021).

[156] “Technology Trends Transforming the Maritime Industry”, KnowHow (21 December 2021).

maintenance and inspection operations, industrial robots can also assist with delivery, inspection and firefighting.[157]

46. Efforts to enhance the collection and availability of data to facilitate safety of navigation are on-going.[158] In this regard, Australia made bathymetric data freely available,[159] and the European Union made GNSS data available in commercial shipping, including for use in search and rescue beacons and high accuracy navigation.[160] Real-time data to improve congestion in ports, including to reduce vessel waiting times and improve environmental monitoring and identify sources of pollution was also called for.[161]

47. Singapore has been working with like-minded countries, as well as research and industry stakeholders, to develop green and digital shipping corridors as valuable testbeds to trial new technologies and fuels in a sandbox environment, gain operational and safety experience, and optimise route planning.[162] Tools and approaches to support safe navigation, including aerial drone technology to fill data gaps in nearshore coastal seafloor mapping and technology to process voluminous data produced by modern sonar systems has also been developed.[163]

48. In terms of future challenges, the availability and affordability of innovative technologies represents a cross-cutting challenge[164] and requires a balancing of the potential benefits of efficiencies, against safety and security concerns, as well as environmental and trade impacts, costs to the maritime industry and effects on workers, both on board and ashore.[165] It has also been suggested that new technologies should be developed that will assist seafarers in their work instead of replacing them.[166]

49. New innovations will be needed in the maritime industry to facilitate scalability, affordability and availability of low-emission propulsion technology and fuel, increase integration and inter-connectedness of new technologies, including for data collection and evaluation,[167] and improve observation capabilities to monitor and address the consequences of climate change.[168] Enhanced coordination and cooperation, as well as capacity-building, will also be needed to harness technological progress at regional and global levels.[169] In this regard, IMO has stressed the need to promote inclusive innovation, especially in the context of developing countries, and in particular SIDS and LDCs.[170]

H. Technologies for sustainable fisheries and aquaculture

50. The lack of sufficient scientific knowledge regarding fish stocks and the ecosystems they are part of, as well as associated data gaps, hamper fisheries

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[157] "Technology Trends Transforming the Maritime Industry", KnowHow (21 December 2021); "The Shipping Revolution", Cogoport (28 April 2020).

[158] Contributions of the European Union, p. 7; Australia, p. 5; Côte d'Ivoire p. 7; United States, pp. 2-3; Singapore, p. 2.

[159] Contribution of Australia, p. 5.

[160] Contribution of the European Union, p. 7.

[161] Contribution of Côte d'Ivoire, p. 7.

[162] Contribution of Singapore, p. 2.

[163] Contribution of the United States, p. 3.

[164] Contribution of Türkiye, p. 2.

[165] Contribution of IMO, p. 2.

[166] Contribution of Finland, p. 9.

[167] Contribution of Finland, p. 9.

[168] Contribution of Portugal, p. 10.

[169] Contribution of Portugal, p. 10.

[170] Contribution of IMO, p. 1.

management based on the best available scientific information. New marine technologies are being developed to address some of these challenges, including through remote or automated monitoring of environmental conditions, automated collection of fish data and advanced modelling.

51. Earth observation (EO) data helps both the fisheries industry by using satellite imagery, coupled with ocean modelling techniques, to provide information services such as ocean forecasts and zooplankton observations for fish stock detection; and aquaculture businesses for farm siting and production.[171] Satellites, aerial and underwater surveys from ships and autonomous platforms, including smart buoys, as well as tagging are being used to assess the abundance of marine mammal and fish populations.[172] Emerging genetic technology promises to inform fisheries management through a range of advances[173] including fit-chips which allow non-invasive samples to identify the physiological condition of a fish, as well as the presence of pathogens, and environmental conditions that are affecting it.[174]

52. New technologies can also contribute to making fishing activities more sustainable, for example, electronic gear tagging can help reduce illegal, unreported and unregulated (IUU) fishing, track lost gears, thereby diminishing pollution and curbing ghost fishing.[175] The incorporation of marine protected area information in vessel monitoring systems (VMS) charting/plotting systems could further enhance their functionality to regulate fishing in such areas.[176] The “Singapore Food Story R&D” initiative was launched in 2019 to support the development and use of productive, climate-resilient, innovative and sustainable technologies for aquaculture.[177]

53. Monitoring, control and surveillance (MCS) are essential to combatting IUU fishing but have historically proven labour and resource intensive. New marine technologies, such as drones, uncrewed surface vessels and sound traps, as well as improvements to existing monitoring tools, have rendered these activities easier and less expensive, and are thereby allowing their scope to be expanded to small scale fisheries.[178] The progressive evolution of on-board transponders for fishing vessels to reduce upfront costs, size of equipment and technical requirements while enhancing their effectiveness, reliability and functionality, has allowed for improved tracking and control by coastal States and flag States over a greater range of vessels, including small-scale fishing vessels.[179] Technology, including improvements in cloud computing, has also improved the efficiency and interoperability of VMS and

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[171] Contribution of the European Union.

[172] Contributions of the United States, GFCM and NPAFC.

[173] Friedman, K.J., Bartley, D.M., Rodríguez-Ezpeleta, N., Mair, G.C., Ban, N., Beveridge, M., Carolsfeld, J., Carvalho, G., Cowx, I., Dean, G., Glazov, E., Leber, K., Loftus, R., Martinsohn, J., Olesen, I., Soto, D., Van Eenennaam, A.L. & Vigar, J.R.J. 2022. Current and future genetic technologies for fisheries and aquaculture: implications for the work of FAO. FAO Fisheries and Aquaculture Circular. No. 1387. Rome, FAO. https://doi.org/10.4060/cc1236en.

[174] Contribution of NPAFC.

[175] Contribution of GFCM.

[176] Contribution of GFCM.

[177] Contribution of Singapore.

[178] Contributions of Australia and GFCM. Sound traps are compact self-contained underwater sound recorders for ocean acoustic research which can help understand the activities of small vessels in marine protected areas. Uncrewed Surface Vessels (USVs) can be equipped with 360-degree day and night infrared cameras, radar and satellite communications and can autonomously monitor designated vehicles for months at a time, as they can be powered by solar, wind and wave energy and can carry up to 300 kilos of sensors and equipment.

[179] Contribution of GFCM.

platforms used by States and RFMO/As to track and analyse fishing vessel activities in real time, so as to identify potential IUU fishing activity.[180]

54. VMS and electronic monitoring systems can monitor vessel movement and activity, as well as onboard activities.[181] New advanced tools for fisheries control include closed-circuit television; sensor data in real-time, automatic species recognition software; AI; machine learning; robotics, remotely piloted surveillance platforms; high resolution satellite imagery; internet connected systems and real-time transmission of catch and traceability records; improved systems for data analysis, data cross-checking, and data sharing; radio-frequency identification; traceability for labelling, rapid DNA-based assays, and open access to ship owner register and flag data enabled by blockchain technology; digitalisation of catch documentation schemes; intelligent supply chains enabling traceability systems from vessel to market; and handheld vessel positioning, and logbook systems suited to small-scale and recreational vessels.[182]

55. To combat the use of tampered or spoofed automatic identification system (AIS) signals, some MCS data providers are already able to combine resulting data with satellite imagery to spot vessels that may purposefully have deactivated or tampered with their VMS and AIS transponders.[183]

56. In the field of fisheries, some of the challenges associated with the introduction of new technologies include: the high cost and technical complexity of new technology, which may exacerbate capacity gaps; the high level of diversity amongst fisheries and fishers in particular between commercial and small-scale and artisanal fishers; and the lack of harmonized technical specification frameworks and data sharing protocols.[184]

I. Technologies in the field of maritime safety and security

57. In the area of maritime safety and security, new technologies such as marine autonomous surface ships (MASS),[185] aerial surveillance including drones,[186] satellite surveillance,[187] satellite-based search and rescue,[188] underwater communication systems,[189] remote sensors and sensor platforms,[190] can be applied. For example, the Copernicus Maritime Surveillance Service, provides earth observation products with operational functions that include maritime safety and security.[191] The development of these technologies presents considerable opportunities but also give rise to various challenges and concerns.[192]

58. New technologies may present many opportunities to improve maritime domain awareness, including the integration of new satellite-based technologies to create a

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[180] Contribution of GFCM.

[181] Contribution of Australia. Electronic monitoring is a system of sensors and video cameras that are capable of monitoring and recording fishing activities which can later be reviewed against logbook data. E-monitoring can be a cost-effective option in generating accurate data and higher rates of compliance in fisheries, which in turn can lead to more sustainable fishing practices.

[182] Contribution of the European Union.

[183] Contribution of GFCM.

[184] Contributions of GFCM and NPAFC.

[185] Contribution of IMO.

[186] Contribution of UNHCR.

[187] Contribution of the European Union.

[188] Contribution of UNHCR.

[189] Contribution of Portugal.

[190] Contribution of Portugal.

[191] Contribution of the European Union.

[192] Contributions of Côte d’Ivoire and IMO.

single common operating picture and supplement automatic identification systems in identifying and tracking so called "dark shipping".[193] Such technologies present opportunities in ensuring stability and peace in the maritime domain,[194] including for enhanced and less costly monitoring.[195]

59. Coordination of national efforts in respect of data exchange standards (see para. 66) with larger regional and global initiatives is stressed.[196] Among these initiatives, the S-100 data standard[197] and the IMO Global Integrated Shipping Information System, which includes a specific sub-section for information sharing in respect of maritime security,[198] are examples of the integration of maritime security considerations in modern data exchange.

60. Maritime cyber risk presents a multitude of challenges for information technology and operational technology systems, including in shipping, ports, navigation and monitoring systems, which can be as vulnerable to attack as other systems[199] as evidenced by an increase in the number of cyber-attacks across the maritime industry.[200] In 2017, the IMO already undertook the initiative to raise awareness of how to tackle emerging risks through its maritime cyber risk management approach.[201]

61. New technologies may facilitate the commission of maritime crimes, including terrorist acts against shipping and maritime installations,[202] drug trafficking by sea, and piracy and armed robbery against ships. Various methods can be employed to manipulate automatic identification systems, so-called "AIS spoofing", which allows for more sophisticated ways to conceal illegal operations. At the same time, new technologies can also be used in the detection of criminals and prevention of crimes, as well as for maritime law enforcement. In this respect, UNODC's Global Maritime Crime Programme supports the innovative use of technology to counter maritime crime and assist maritime law enforcement.[203] Similarly, AI powered security systems may present a wide range of opportunities for maritime law enforcement.[204]

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[193] https://www.aspistrategist.org.au/new-satellite-based-technologies-a-game-changer-for-indo-pacific-maritime-security/.

[194] Contributions of Australia and Côte d'Ivoire.

[195] Contribution of Côte d'Ivoire.

[196] Contribution of Portugal.

[197] Contributions of Australia and IHO.

[198] https://gisis.imo.org/Public/Default.aspx.

[199] https://www.imo.org/en/OurWork/Security/Pages/Cyber-security.aspx.

[200] Farah, M.A.B, Ukwandu, E., Hindy, H., Brosset,D., Bures, M., Andonovic, I., and Bellekens, X., "Cyber Security in the Maritime Industry: A Systematic Survey of Recent Advances and Future Trends", MDPI (2022), p. 5, available at https://www.mdpi.com/2078-2489/13/1/22.

[201] See also IMO Doc MSC-FAL.1/Circ.3 Guidelines on maritime cyber risk management, available at https://wwwcdn.imo.org/localresources/en/OurWork/Security/Documents/MSC-FAL.1-Circ.3%20-%20Guidelines%20On%20Maritime%20Cyber%20Risk%20Management%20(Secretariat).pdf.

[202] Singh, A., "Maritime Terrorism in Asia: An Assessment", ORF Occasional Paper 215 (2019), available at https://www.orfonline.org/research/maritime-terrorism-in-asia-an-assessment-56581/.

[203] UNODC Global Maritime Crime Briefing Package 2021, https://www.unodc.org/documents/Maritime_crime/UNODC_GMCP_Briefing_Package.pdf.

[204] https://www.dhs.gov/science-and-technology/day-3-border-maritime-security-and-artificial-intelligencemachine-learning.

J. Associated technologies

62. *Remote sensing* EO satellite technologies and global navigation satellite systems (GNSS) have fundamentally changed the maritime domain.[205] Remotely sensed data, obtained by satellites or aircraft, is available at increasingly higher resolutions and include a range of EOVs.[206] Satellite imaging and modelling technology, as well as aerial drones can also assist in mapping the nearshore coastal seafloor and facilitate marine spatial planning,[207] whilst telecommunication satellites also support the tracking of tagged marine animals.[208] The development of next-generation high-performance micro- or nanosatellites conducting higher frequency and lower latency observations is needed to improve applications such as monitoring of natural disasters and extreme weather events, fishery protection, search and rescue operations or detailed modelling of ocean phenomena.[209] The Galileo High Accuracy Service GNSS has started to provide free-of-charge decimetre accuracy data globally which can be used for more accurate navigation, positioning and timing applications.[210]

63. *Communications* The increase in volume and density of data collected and transmitted using new maritime technologies requires an enhancement of high-throughput communications hardware and software.[211] Research and development of multimodal underwater communication networks which combine acoustic, optical, and electromagnetic communication channels have been put forward in this regard.[212] This communication framework is known as the Internet of Underwater Things which has the capacity to revolutionise industry, business and scientific research.[213]

64. *Advanced technologies* Advanced technologies such as AI, machine learning and cloud computing have significantly improved data acquisition and processing of the vast amounts of data generated today, including making it simpler and cheaper.[214] Although the true potential of AI methods has not yet been realized, they have already enabled data correlation and forecasting of unprecedented accuracy and complexity, and are finding increasingly wide application in areas such as weather, ocean and ice modelling, operations of uncrewed systems, and reliable and enhanced processing, and interpretation of observations.[215] Cloud-based data management services allow for increased data sharing and integration in near real-time thus facilitating operational and forecasting services, but require strong cloud governance to mitigate risks.[216] Management of critical marine ecosystems has been aided by AI-powered machine-learning and automated image analysis,[217] and AI-enabled mobile marine

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[205] Contribution of the European Union.

[206] Contributions of the European Union, Australia, GFCM, and NPAFC; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, paras. 11-12.

[207] Contributions of the European Union, Australia, and the United States.

[208] Contribution of GFCM.

[209] Contribution of Portugal.

[210] Contribution of the European Union; “Galileo High Accuracy Service goes live!”, EUSPA (24 January 2023) at https://www.euspa.europa.eu/newsroom/news/galileo-high-accuracy-service-now-operational.

[211] Contribution of IOC-UNESCO.

[212] Contribution of Portugal.

[213] Mohsan, S. A. H. M., et al., “Recent Advances, Future Trends, Applications and Challenges of Internet of Underwater Things (IoUT): A Comprehensive Review”, Journal of Marine Science and Engineering 2023, 11, 124, https://www.mdpi.com/2077-1312/11/1/124.

[214] Contributions of Australia, the United States, GFCM and IOC-UNESCO; Second World Ocean Assessment, Vol. I, p. 50.

[215] Contributions of Portugal and the United States.

[216] Contribution of the United States.

[217] Contribution of Australia.

protected areas, which adapt their position in real-time as endangered species migrate through the ocean, is emerging.[218]

65. *Modelling* The European Union's Digital Twin of the Ocean initiative will integrate historical and real-time data to create digital interactive high-resolution models of the ocean capable of simulating various interrelationships between human activities and the ocean and its ecosystems and will thus advance knowledge-based decision-making about the use and management of ocean resources, help mitigate impacts of human activity and natural hazards and support a sustainable blue economy.[219]

66. *Standardised best practices* The harmonisation and standardisation of data acquisition and processing, focused on priority observations is of particular importance but remains challenging,[220] and projects such as the Observing Air-Sea Interactions Strategy and the Ocean Best Practices System aim to address this.[221] The benefits of applying standardised best practices in ocean operations include interoperability, compatibility, and reproducibility of ocean data, which allows data comparison, change detection and improved modelling and forecasting, and creates opportunities for collaboration.[222] In order to facilitate a more consistent approach in the classification of seabed features, a new glossary of seabed morphology features was developed which provided the opportunity to develop new tools to automate portions of the workflow.[223]

67. *Data exchange standards* Developing and adopting common standards for data and metadata from multiple sources can facilitate data compatibility, interoperability and machine-readability, which is essential to their effective exchange and use.[224] The S-100 universal hydrographic data model, and the suite of marine data product specifications developed under its framework, can be applied in a variety of ocean disciplines linked to the protection and sustainable use of the ocean,[225] for example, the S-121 Maritime Limits and Boundaries Product Specification is used to encode digital information related to maritime limits, zones and boundaries.[226] The United Nations Fisheries Language for Universal eXchange is a standard which underpins sustainable fisheries management in line with Sustainable Development Goals 12

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[218] Bakker, K., "Smart Oceans: Artificial intelligence and marine protected area governance", Earth System Governance 13 (2022) 100141, https://doi.org/10.1016/j.esg.2022.100141.

[219] Contributions of the European Union, and Portugal; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 56.

[220] Contribution of Portugal, IHO, IOC-UNESCO and NPAFC; Second World Ocean Assessment, Vol I, p. 51.

[221] "Streamlining ocean observing around the world: Ocean Best Practices", IOC-UNESCO (23 January 2023) at https://ioc.unesco.org/news/streamlining-ocean-observing-around-world-ocean-best-practices; OBPS at https://www.oceanbestpractices.org/; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 61.

[222] Contribution of IHO; "Streamlining ocean observing around the world: Ocean Best Practices", IOC-UNESCO (23 January 2023) at https://ioc.unesco.org/news/streamlining-ocean-observing-around-world-ocean-best-practices; OBPS at https://www.oceanbestpractices.org/; Second World Ocean Assessment, Vol I, p. 51; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 60.

[223] Contribution of Australia.

[224] Contributions of Mauritius, Portugal, GFCM, IHO and NPAFC; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 34.

[225] Contribution of IHO.

[226] Contributions of Australia and IHO; S-121 Maritime Limits and Boundaries Product Specification at http://s100.iho.int/product%20specification/division-search/s-121-maritime-limits-and-boundarieshttp://s100.iho.int/product specification/division-search/s-121-maritime-limits-and-boundaries.

and 14, harmonises data exchange needs of fisheries and contributes to tracking fisheries activities.[227]

68. *Databases and data management* New maritime technologies generate benefits for society through a data value chain, supported by data management that enables unprecedented amounts of data from many validated sources to be discovered, integrated, shared in open databases and used in near real-time.[228] Data management and analysis is increasingly moving towards using Geographic Information Systems in interactive online geoportals, with open source and commercial systems available for setting up marine spatial data infrastructures.[229] In order to maximize the value of data, the development of data strategies is helpful to maximize openness and transparency, and deliver results while protecting quality, integrity, security, privacy, and confidentiality, as well as being flexible and adaptable to external influences and new technologies.[230] Effective data management also relies on data being findable, accessible, interoperable and reusable.[231] Efforts are needed by all relevant stakeholders to enhance quantity and quality of data shared as well as the conditions under which access to data is granted, particularly with data being at the core of opportunities that new technologies offer.[232]

69. ISA's DeepData database includes cutting edge data on deep-sea biodiversity and ecosystems[233] and the European Marine Observation and Data Network recently launched its fully centralised marine data service, thus supporting new technologies and approaches such as AI.[234] Data collected in expeditions under the International Year of the Salmon are available via a dedicated data portal.[235]

III. International cooperation and coordination

70. Enhanced cross-sectoral cooperation and coordination at the national, regional and global levels is crucial to ensure the continued development and effective application of new maritime technology, and to harness such technologies for the attainment of the 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14.[236]

71. On a global and regional scale, initiatives including the Global Marine Technologies Cooperation Centres Network, GreenVoyage2050 and IMO's Coordinated Actions to Reduce Emissions from Shipping rely on coordinated actions to accelerate the adoption of new technologies globally and thereby advance energy efficiency in the shipping sector.[237] In the renewable energy sector, coordinated action is carried out through initiatives such as the Collaborative Framework on Offshore Renewables of the International Renewable Energy Agency, the Global Offshore

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[227] Contribution of GFCM.

[228] Contributions of Portugal, IOC-UNESCO and NPAFC; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 31.

[229] Contribution of Mauritius.

[230] Contribution of the United States.

[231] Contribution of NPAFC; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, para. 31; Second World Ocean Assessment, Vol. I, p. 51.

[232] Contributions of ISA and NPAFC.

[233] Contribution of ISA.

[234] "One Ocean, One EMODnet", EMODnet (25 January 2023) at https://emodnet.ec.europa.eu/en/one-ocean-one-emodnet-european-marine-observation-and-data-network-emodnet-launches-its-fully.

[235] Contribution of NPAFC; IYS Data Mobilization Portal at https://international-year-of-the-salmon.github.io/about/.

[236] Contributions of Cote d'Ivoire and Mauritius.

[237] Contributions of the European Union, and IMO.

Wind Alliance, and the Global Ocean Energy Alliance, with the latter focusing on the needs of SIDS and LDCs to access ocean energy technologies.[238] The Technology Executive Committee of the UNFCCC works with United Nations entities and other organizations on integrating technological innovations for climate adaptation and mitigation.[239]

72. Maritime aerial surveillance, data visualization tools and satellite technology have provided opportunities to work collaboratively to advance the protection of life at sea.[240] RFMO/As play an important role in promoting cooperation in the use of new MCS technologies, essential for fisheries management and combating IUU fishing.[241] Collaboration between RFMO/As and member States offers an opportunity to identify regional MCS needs, while considering the unique characteristics of national fleets and enabling local technology start-ups to offer customized solutions.[242]

73. In the field of ocean observing, collaborative platforms and partnerships, such as those under GOOS, are essential for coordinating global action on the development and application of new technologies.[243] The International Seabed Authority coordinates international efforts to develop innovative tools and technologies, best practices for data collection, and scientific capacity with respect to the international seabed area, including through its recently launched Sustainable Seabed Knowledge Initiative.[244]

74. Improved access to technology, finance and expertise is crucial to allow developing countries, especially SIDS and LDCs, to fully harness the benefits of new maritime technology[245] and there are numerous activities and programmes aimed at building capacity in this regard.[246] Needs include training of personnel, provision and maintenance of equipment, access to data generated by new technologies, capabilities to manage and process such data and the transfer of technology.[247]

75. Coordination and cooperation between governments, intergovernmental and regional organizations, the private sector and academia, including though public-private partnerships and industry dialogues, as well as in the context of the United Nations Decade of Ocean Science for Sustainable Development, could stimulate investment in new maritime technologies by determining shared needs, aggregating demand, reducing market risk and promoting standardization for technology and data.[248] Such collaboration can help identify opportunities for efficient modular and mass production of technical solutions to improve the availability of low-cost, small and easy-to-deploy instruments, making the technology more accessible to developing countries.[249] This can also stimulate their participation in emerging sectors of the blue economy, including marine renewable energy, marine biotechnology and ocean observation.[250]

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[238] Contribution of UNFCCC.

[239] Contribution of UNFCCC.

[240] Contribution of UNHCR.

[241] Contributions of the European Union, GFCM, and NPAFC.

[242] Contribution of GFCM.

[243] Contribution of IOC-UNESCO; Report of the Secretary-General on Oceans and the law of the sea, A/77/68, paras. 13-14.

[244] Contribution of ISA.

[245] Contributions of Côte d'Ivoire, IMO, GFCM, NPAFC and UNFCCC.

[246] Contributions of Australia, Côte d'Ivoire, Portugal, IHO, IMO, ISA, UNFCCC.

[247] Contributions of Côte d'Ivoire, Mauritius, Portugal, UNFCCC.

[248] Contributions of GFCM and IOC-UNESCO.

[249] Contributions of GFCM and IOC-UNESCO.

[250] Contributions of the European Union, Portugal, the United States, GFCM, and IOC-UNESCO.

76. Coordination could also enhance co-design, involving end-users to tailor marine technologies to their needs,[251] and align national efforts with regional and global initiatives, particularly in the fields of data and process standardization.[252] Ensuring data protection and privacy is key to overcoming stakeholder resistance in this regard.[253] Improved connections between public institutions, private actors and academia can also help to bridge the divide between ocean science, technology and policy.[254]

77. Developments in miniaturized, affordable and user-friendly systems of robots, sensors and communication devices, also provide new opportunities for engaging the general public, enhancing ocean literacy and involving new actors in ocean science, for example through the Ships of Opportunity Programme and the GOOS Odyssey project, which mobilize commercial and private vessels for ocean observing, and national citizen science initiatives.[255]

IV. Legal and regulatory aspects

78. New maritime technologies have great potential to increase the safety, efficiency and sustainability of ocean-related activities, and facilitate the implementation of existing international legal obligations.[256] For instance, it was reported that such technologies constituted basic working tools for fulfilling the mandate of the ISA under the Convention.[257] Furthermore, the use of maritime aerial surveillance assets, including drones, and satellite-based search and rescue distress-alert detection systems can advance the protection of persons at sea.[258] Also, recent technological advancements relating to fishing are supporting efforts to conserve and sustainably use marine living resources and to decarbonize fishing activities.[259] On the other hand, technological constraints can hinder the implementation of a State's obligations,[260] including owing to the significant costs associated with the use and maintenance of new maritime technologies.[261]

79. The international legal regime for the ocean consists of a wide range of global, regional, and bilateral legal instruments, as well as national laws and regulations[262] adopted within the overarching legal framework set out in the Convention. These binding instruments are complemented by non-binding instruments such as standards[263] and declarations[264] adopted by competent international organizations[265] international conferences and other fora, as appropriate, with regard to activities in the ocean, including, where applicable, activities undertaken with new maritime technologies. Taken together, the Convention and these instruments provide a comprehensive legal and regulatory framework for the effective governance and management of maritime technologies, as well as for their development and transfer.

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[251] Contributions of GFCM and IOC-UNESCO.
[252] Contributions of the European Union, Portugal, and IHO.
[253] Contribution of the European Union.
[254] Contribution of IOC-UNESCO.
[255] Contributions of Portugal, the United States and IOC-UNESCO.
[256] See, e.g., contributions of Finland, Türkiye, United States, IHO, IMO, ISA and UNHCR.
[257] Contribution of ISA.
[258] Contribution of UNHCR.
[259] Contribution of GFCM.
[260] Second World Ocean Assessment, Vol. I, p. 23.
[261] Contributions of Mauritius and GFCM.
[262] Contributions of Finland, GFCM, and IMO.
[263] Contribution of IHO.
[264] Contribution of UNFCCC.
[265] Contributions of Finland, Mauritius, IHO, IMO, ISA and UNFCCC.

80. Technologies such as uncrewed vessels and electronic bills of lading were reported as giving rise to legal issues to be addressed in international maritime law.[266] IMO reported that, in order to ensure that its regulatory framework kept pace with technological developments concerning MASS, it conducted a regulatory scoping exercise to assess how existing IMO instruments might apply to ships with varying degrees of automation,[267] with further work underway on the development of a goal-based instrument regulating their operation.[268] It was noted that greater regulation of MASS will enable higher levels of maritime automation to be introduced safely and sustainably.[269]

81. Other efforts of significant relevance in this regard include the work of the intergovernmental conference on an international legally binding instrument under the Convention on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction.[270] The text of the draft agreement, which was finalized at the recently held resumed fifth session of the conference, held from 20 February to 3 March 2023, addresses a package of issues, in the context of which new maritime technologies will be relevant.

82. While the legal and regulatory framework may respond and adapt to new maritime technologies, this framework may also drive innovation and technological developments.[271] Such innovations may go towards addressing the "triple planetary crisis" of climate change, biodiversity loss and pollution, which is causing severe and unprecedented damage to our ocean. For example, in the context of climate change mitigation, it was noted that regulatory initiatives under the respective auspices of IMO and UNFCCC to decarbonize international shipping had accelerated these efforts.[272] In this regard, it was observed that in response to priorities expressed by member States, RFMO/As could test innovative decarbonization solutions and their impact on, inter alia, fuel consumption and emissions, towards the achievement of the targets set by the Paris Agreement.[273]

83. With regard to the protection and preservation of the marine environment, IMO regulations and guidelines were reported to drive innovation in the areas of ballast water management, biofouling and marine plastic litter.[274] Noise limits set by some States for the construction of offshore wind farms and pursuant to the Mediterranean Action Plan[275] led to the development of new quieting technologies to protect sensitive marine species.[276] Also at the regional level, the Mediterranean Sea Emission Control Area for Sulphur Oxides and Particulate Matter, which was adopted in 2022 and due to come into effect in 2025, will further limit air pollution from ships, pursuant to Annex VI to the International Convention for the Prevention of Pollution

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[266] Contribution of Côte d'Ivoire.

[267] Contribution of IMO.

[268] Contribution of IMO; see also https://www.imo.org/en/MediaCentre/HotTopics/Pages/Autonomous-shipping.aspx.

[269] Contribution of Finland.

[270] General Assembly resolution 72/249 of 24 December 2017.

[271] Contributions of IMO, ISA and UNFCCC.

[272] Contributions of IMO and UNFCCC; see also https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors.

[273] Contribution of GFCM.

[274] Contribution of IMO.

[275] The Mediterranean Action Plan was established in 1975 as a multilateral environmental agreement in the context of the Regional Seas Programme of the United Nations Environment Programme (UNEP). For more information, see their website: https://www.unep.org/unepmap/.

[276] Contributions of Türkiye, and OceanCare attachment 1: Weilgart, L., "Best Available Technology (BAT) and Best Environmental Practice (BEP) for three noise sources: Shipping, Seismic Airgun Surveys, and Pile Driving", in Journal of Ocean Technology 14 (3), 2019, pp. 7-8.

from Ships, with Contracting Parties also encouraged to explore the feasibility of a similar initiative for nitrous oxides.[277]

V. Conclusions

84. Technological innovations increase efficiency, expand markets and enhance economic growth. Future technological advances offer the potential for greater exploitation of ocean resources but also the promise of greater protection.[278] Science, technology and innovation will continue to play a growing role in managing the responsible development of the ocean economy. The economic activity in the ocean is expected to continue to accelerate, growing to US$3 trillion by 2030 with activities including aquaculture, capture fisheries, fish processing, offshore wind and port activities expected to grow at rates faster than the global economy.[279]

85. However, technological advances carry their allotment of negative impacts as highlighted in this report, including with respect to achieving the 2030 Agenda. In particular, access to technologies that can assist in the conservation and sustainable use of marine resources remains inequitable. The resulting technological and digital divide against the goal of "No one left behind" particularly affect LDCs and SIDS, including their ability to implement international law as reflected in the Convention. The bringing of women and other marginalized groups into technology as a means to ensure more creative solutions and promote gender equality also needs to be addressed.[280] Increased international cooperation and coordination is necessary to address the various gaps relating to the development and access to maritime technologies, including through capacity-building, transfer of technology and sustainable investments, whether in human resources and or institutional frameworks.

86. As to the legal framework and as recognized by the General Assembly, the Convention sets out the legal framework within which all activities in the oceans and seas must be carried out,[281] and as such, it continues serving as the foundation for the governance and management of new maritime technologies.[282] As a framework instrument, the Convention appears to be of sufficient breadth and flexibility to apply to new and emerging technologies[283] and this has proven true even through a period of significant technological advancement. This framework is critical to maximize the benefits offered by new maritime technologies, and to minimize any potential adverse impacts that may result from their use, including on marine living resources, biodiversity, maritime safety and security, and the protection and preservation of marine environment. It is also critical that new maritime technologies must be used in a manner that respects international law, including human rights and humanitarian law.

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[277] Contribution of Türkiye; see also UNEP Press Release, "The Mediterranean reaches a historic milestone in the regional endeavour for greener shipping", 16 December 2022, available at https://www.unep.org/unepmap/news/press-release/mediterranean-historic-milestone-MedSOxECA.

[278] Contribution of Australia.

[279] Contribution of IOC-UNESCO; GOOS Dialogues with Industry, Dialogue 4 "Looking ahead: New technology for the Ocean Decade" (11 January 2023), available at https://goosocean.org/index.php?option=com_content&view=article&id=400&Itemid=448; https://www.noaa.gov/news-release/new-noaa-report-shows-us-ocean-enterprise-sector-grew-60-percent-since-2015.

[280] https://eca.unwomen.org/en/stories/announcement/2023/01/international-womens-day-2023-digitall-innovation-and-technology-for-gender-equality.

[281] See, e.g., General Assembly resolution 77/248 of 30 December 2022, preamble.

[282] Contribution of Australia.

[283] Contribution of Australia.

87. However, new maritime technologies can pose legal and regulatory challenges,[284] as well as with respect to how current instruments may be effectively implemented in relation to new maritime technologies. There is an array of efforts underway to strengthen the legal and regulatory framework, including by clarifying the scope of existing legal instruments. The legal and regulatory framework will therefore need to continuously evolve to respond and adapt to new maritime technologies.

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[284] See e.g., contributions of Côte d'Ivoire, Finland, GFCM, IOC-UNESCO and IMO.