White Paper 17

ocean

(in alphabetical order)

coordinators

Niki Aloupi
Professor (Public Law), University Paris-Panthéon-Assas

Gabriele Göttsche-Wanli
Independent ocean expert, former Director of the Division
for Ocean Affairs and the Law of the Sea, Office of Legal Affairs,
United Nations

assistants

Yanis Dekkiche
Phd Candidate, University Paris-Panthéon-Assas

Soraya Grigoriou-Gratton
Student, Magistère Law and Ecoomic Globalization,
Ecole Normale Supérieure (ENS), Rennes and Rennes 1 University (intern)

steering committee

Frida Maria Armas Pfirter
Professor of Public International Law at the University of Buenos Aires
and the Austral University

Juliette Babb-Riley

Former Co-chair of the second cycle of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socio-economic Aspects

Maria Gavouneli

Professor of International Law at the National and Kapodistrian University of Athens; Senior Policy Advisor of the Hellenic Foundation for European and Foreign Policy

Kristina Gjerde

Senior High Seas Advisor to IUCN's Global Marine and Polar Program; Adjunct Professor at the Middlebury Institute of International Studies at Monterey, California

Tafsir Malick Ndiaye

Former member of the International Tribunal for the Law of the Sea

Václav Mikulka

Former member of the International Law Commission; Former Director of the Division for Ocean Affairs and the Law of the Sea; Former Director of the Codification Division of the United Nations Office of Legal Affairs

Essam Yassin Mohammed

Global Lead for Climate and Sustainability with the WorldFish Centre

Clement Yow Mulalap

Legal Adviser at the Permanent Mission of the Federated States of Micronesia to the United Nations

Nilufer Oral

Director of the Centre for International Law, National University of Singapore; Professor of Public International Law at the Istanbul Bilgi University; Member of the International Law Commission

Bernard H. Oxman

Richard A. Hausler Professor of Law, University of Miami; member, Institute of International Law; former U.S. Representative to the Third U.N. Conference on the Law of the Sea; former co-editor in chief, American Journal of International Law

Melissa Walsh

Program Manager, Ocean Finance Initiative, Asian Development Bank

authors' information

1.

state of the art

The importance of the ocean for Earth is reflected in the latter's designation as the 'blue planet'. Indeed, the ocean covers around 70 % of the Earth surface, contains 97 % of all the water on its surface and represents over 95 % of the biosphere. The impact of the ocean and its ecosystems on the global community goes without saying. It plays a vital role in mitigating climate change and provides oxygen, food and water, minerals, oil and gas deposits, as well as biodiversity, while at the same time constituting the main natural medium through which 90 % of the world trade and 90 % of the electronic traffic of communication are conducted (United Nations, 'The First Global Integrated Marine Assessment: World Ocean Assessment I' (Cambridge, Cambridge University Press, 2017), Summary; hereinafter WOA I).

In 1609, when Grotius' *Mare liberum sive de jure quod batavis competit ad indicana commercia, dissertation* was published, the ocean and its resources were considered inexhaustible: what mattered was whether the ocean, or rather a significant part thereof, could be freely used and exploited by all States. But in the last two centuries, the real challenge has been inverted: humanity is adversely impacting the ocean and its future – either directly by polluting and overexploiting it or indirectly through climate change – thus challenging the ability of the ocean to continue to provide all the goods and services that we all very much depend on.

The multiple and diverse uses of the ocean by humans must therefore be adequately managed so that its future and its biodiversity can be conserved and sustainably used, a condition *sine qua non* for humanity's survival. Indeed, by the year 2050, even more than nowadays, the approximately 10 billion people on Earth will need the ocean to survive. The threats to the ocean must be urgently addressed through integrated ecosystem-based management and the sustainable development of the ocean and its resources. Such action needs to be based on a solid legal framework governing all ocean activities, as well as effective implementation of, compliance with and enforcement of that framework.

As annually emphasized by the United Nations General Assembly, the United Nations Convention on the Law of the Sea (UNCLOS) sets out the legal framework within which all activities in the ocean and seas must be carried out. As an umbrella treaty, it is complemented by a plethora of other multifaceted instruments – global and regional, general and sectoral, binding and non-binding – which aim to regulate all kinds of human activities in the ocean and together with the Convention constitute a comprehensive legal regime, a true 'law of the

sea'. However, although the 'law of the sea' as set out in UNCLOS and other legal instruments, and complemented by the jurisprudence of the International Tribunal for the Law of the Sea (ITLOS), the International Court of Justice (ICJ) and arbitral tribunals as well as by national laws and regulations adopted within the overarching legal framework of UNCLOS is very thorough, there are significant implementation, compliance and enforcement challenges and also regulatory challenges. These challenges need to be urgently identified and addressed in order to protect and restore the health, productivity and resilience of the ocean and marine ecosystems for present and future generations and not to lead to the ocean's further decline by 2050.

This is even more the case since 2022 marks the 40th anniversary of the adoption and opening for signature of UNCLOS. As stated in its preamble, UNCLOS aims to facilitate international communication, promote the peaceful uses of the seas and ocean, the equitable and efficient utilization of their resources, notably the conservation of their living resources, and the study, protection and preservation of the marine environment. 40 years later, one might well ask whether the goals set out in the preamble have been realized and whether the legal regime in UNCLOS is able to weather future storms? In 40 years, numerous technological, environmental, economic, social and cultural developments have had a great impact on the uses of the ocean, which is why the legal framework established by UNCLOS may not always suffice. Thus, UNCLOS has so far been complemented by two implementing agreements, the Agreement relating to the implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982 (Part XI Agreement) and the United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (Fish Stocks Agreement). A further agreement under UNCLOS on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ agreement) is currently being negotiated. While it is assumed that the new agreement will be adopted soon and enter into force by 2050, it will not be dealt with in detail in this White Paper since it is not possible to know what implementation, compliance and enforcement challenges and/or regulatory challenges may arise in the future.

Looking to the future, in particular 2050, this White Paper will aim to provide an overview of potential opportunities provided by the ocean's future uses and activities (economic, social,

cultural and ecological) on the one hand and the potential future issues and threats to the ocean and humanity on the other hand (for example, the impacts of climate change; threats to and loss of marine biodiversity resulting from individual and cumulative impacts; and threats to the peaceful, secure and safe uses of the ocean). An overview of those projections and general challenges which can be anticipated to occur between now and 2050 and the particular potential implementation, compliance, enforcement, legal, governance and management challenges which may arise as a result in order to achieve a peaceful, secure, safe, healthy, productive, sustainable and resilient ocean for present and future generations will be respectively presented in the next two Parts of the White Paper.

2.

projections and challenges

I. Introduction

This part of the White Paper attempts to project what developments could be taking place in the ocean between now and 2050 and the associated potential opportunities and issues which might arise. While it is not possible to foretell the future with any degree of certainty, there are nine main drivers of change in the ocean, described below, which are expected to apply pressures to the ocean and thereby impact opportunities provided by the ocean's future uses and activities.

The degree to which these will impact the future of the ocean's uses and activities also depend, however, on the socio-economic global context in the years to come and in particular on the level of greenhouse gas (GHG) emissions. Three general scenarios can be considered in this regard, the first two of which correspond to the global warming of more than 2°C, relative to 1850–1900 (intermediate, high and very high GHG emissions scenarios of the Intergovernmental Panel on Climate Change (IPCC); (IPCC (2021) 'Summary for Policymakers', in: Climate Change 2021: The Physical Science Basis; hereinafter IPCC 2021 report)) and to the 'low road' and 'business-as-usual' scenarios of the FAO (FAO (2022) 'The state of World Fisheries and Aquaculture, Towards Blue Transformation', Rome, p. 220; hereinafter FAO 2022 World Fisheries Report).The third would correspond to the at least less than 2° C (low and very low emissions scenario of the IPCC) and to the 'high road' scenario of the FAO. According to the IPCC, crossing the 2°C global warming level during the 21st century is very likely to occur, except under the low and very low GHG emissions scenario.

The scenario on which this White Paper will be mainly based on is the 'business-as-usual' scenario. Indeed, most long-term economic analyses available assume such a scenario, meaning no drastic or structural change by 2050 in the way global exchanges are conducted and more generally in economy and life as we know it. Corrective action could of course improve these projections, whereas at least four classes of risk could introduce major discontinuities and undermine them: 1. Geopolitical breakdown; 2. Financial crisis and depression; 3. Protectionism and 4. Climate change (U. Dadush & B. Stancil, 'The World Order in 2050', Carnegie Endowment for International Peace: Policy Outlook (April 2010)).

The combination of those could lead to a second potential future scenario by 2050, which is the 'collapse scenario'. A number of think tanks and scientists (see for instance J.-M. Jancovici's think tank 'The Shift Project') predict a catastrophe scenario with economy collapse, radical change of life and societies as we

know them, desertion of urban centers, lack of tourism and transportation because of depletion of fuel and/or exorbitant prices.

A third more optimistic scenario would be the 'sustainable path' scenario, according to which, with a radical immediate shift toward sustainable development, all announced national net zero emission pledges are achieved fully and on time, thereby leading to an improvement (or at least a non-degradation) of the climatic and environmental situation by 2050. This scenario is characterized by inclusive development, a multidimensional collaboration between different stakeholders (States, Indigenous Peoples and local communities, international organizations, the private sector, companies and civil society), a relatively low population due to investments in education and health, and sustainable economic choices (resource efficiency, development of renewable energy, low material growth). This scenario would represent a break with recent history. For it to be doable would require widespread innovation, both in industrialized and developing countries. The former would need to support the latter by providing human capacity and financial and technological means (B. C. O'Neill, E. Kriegler, K. L. Ebi, E. Kemp-Benedict, K. Riahi, D. S. Rothman, B. J. van Ruijven, D. P. van Vuureni, J. Birkmann, K. Kok, M. Levy, W. Solecki, 'The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century', Global Environmental Change 42 (2017), p. 169–180). Limiting human-induced global warming to a specific level would require limiting cumulative CO_2 emissions, reaching at least net zero CO_2 emissions by 2050, along with strong reductions in other GHG emissions.

Although advocating for the 'sustainable path' scenario, this White Paper will mainly focus on the 'business-as-usual' scenario. The reasons for this choice are twofold. Firstly, it is the most widely accepted scenario by international institutions and available long-term economic analyses. Secondly, the objective of the White Paper is to raise questions and propose potential solutions. Anticipating the 'collapse scenario' would drastically limit the scope of the Paper, although that scenario is not entirely unrealistic. As for the 'sustainable path' scenario, it will require a major paradigm shift which is not yet evident. Therefore, unless otherwise indicated in the White Paper, predictions are based on the 'business-as-usual' scenario. Predictions for 2050 in relation to the ocean are also mainly global in nature and for the most part based on official sources, in particular the First and Second World Ocean Assessments (United Nations, The Second Global Ocean Assessment: World Ocean Assessment II, vol. I and II, hereinafter WOA II).

II. Main drivers of change in the ocean between now and 2050

The main drivers of change that are expected to apply pressures to the ocean between now and 2050 are: (a) climate change; (b) population growth and demographic changes; (c) technological advances; (d) economic development; (e) food security concerns; (f) environmental degradation; (g) social aspects/human dimension; (h) threats to peace and security; and (i) ocean governance and management. The relationships between those drivers and pressures (and their impacts) are complex and dynamic, with interlinkages leading to cumulative interactions (WOA II, vol. I, p. 67). The degree to which the ocean and people dependent on the ocean are impacted will depend on the actions taken by the international community to address these drivers.

Response measures would need to be tailored as the global influence of the aforementioned drivers is not uniformly distributed. This Paper will explore each of the main drivers, the associated pressures and the possible changes which might take place in the ocean by 2050. While all drivers have transboundary effect, climate change is undoubtedly the most significant and developments within the other drivers will very much depend on the predominant prevailing GHG emission scenarios around the world.

A. Climate change

The IPCC stated that many changes in the climate system become larger in direct relation to increasing global warming (IPCC 2021 Report, p. 15). They include increases in the frequency and intensity of hot extremes and marine heatwaves amongst other impacts. The Arctic is likely to be practically sea ice-free in September at least once before 2050 (*ibid.*, p. 16), since the growth in emissions has resulted in widespread reduction of the cryosphere (WOA II, vol. I, p. 72). Under scenarios with increasing CO_2 emissions, the ocean and land carbon sinks are projected to be less effective at slowing the accumulation of CO_2 in the atmosphere. Over the rest of the 21st century, likely ocean warming ranges from 2–4 to 4–8 times the 1971–2018 change (*ibid*, p. 21). Based on multiple lines of evidence, upper ocean stratification, ocean acidification and ocean deoxygenation will continue to increase in the 21st century, and these changes will

be irreversible on centennial to millennial time scales (*ibid*). Ocean warming is causing significant damage to marine ecosystems and species by destroying their habitats, forcing them to either adapt or relocate to new temperatures, looking for new feeding, spawning or nursery areas. Acidification is also reducing the growth and survival of many organisms and degrading ecosystem resilience.

It is also virtually certain that global mean sea level will continue to rise over the 21st century (*ibid*). In 2050, many States will be directly affected by sea-level rise with land and island territory either reduced in size or, in extreme cases, having disappeared altogether. Even where there is no territory loss, an island could nonetheless become uninhabitable due to flooding causing seawater to contaminate freshwater supplies. There is ongoing discussion by the international community on the impact on baselines and maritime limits of loss of land territory resulting from sea-level rise[1], as well as on the implications of sea-level rise with regard to statehood and protection of persons (see Part 3).

Note 1 See the work of the International Law Commission (ILC) on sea level rise and the work of the ILA Committee on Baselines under the International Law of the Sea referenced in Part 3.

B. Population growth and demographic changes

By 2050, the Earth's population is expected to increase to 9.7 billion (WOA II, vol. II, p. 69). The world economy is projected to nearly quadruple, with growing demand for energy and natural resources (OECD (2021), 'Environmental Outlook to 2050: The Consequences of Inaction'; hereinafter OECD 2050). Nearly 70% of the world population is projected to be urban residents by 2050, magnifying challenges such as air pollution, transport congestion and waste management. As areas become increasingly unlivable as a result of declining precipitation, increasing temperatures, sea-level rise and the loss of ecosystem goods and services, people will redistribute themselves to more livable regions, increasing urban footprints in those regions (WOA II, vol. I, chapt. 4).

It is estimated that within coastal regions, there will be a 71% increase in the global human population across the period 2000–2050 to over 1 billion, as a result of overall global population growth as well as migration into those areas (J.-L. Merkens & al., 'Gridded population projections for the coastal zone under the shared socioeconomic pathways', 145 Global and Planetary Change (2016)). The extent to which an increasing global population places pressure on the marine environment depends on a range of factors, including how people live and their

consumption patterns as well as the technologies used to produce energy, food and materials, provide transport and manage waste (WOA II, vol. I, chapt. 4).

C. Technological advances[2]

During what has been termed as the 'fourth industrial revolution', it is expected that technological advances will lead to a substantial transformation of the various ocean sectors and activities by 2050. Enabling technologies, such as advanced sensors, internet of things, artificial intelligence (AI), robotics, algorithms, big data analytics, drones, augmented reality and virtual reality, distributed ledger technology, additive manufacturing, and propulsion technology will impact every aspect of ocean uses and activities, both existing and upcoming.

Ocean technologies can be used for a variety of purposes. They are notably expected to improve knowledge and understanding of marine ecosystems (L. Guidi, A. Fernandez Guerra, C. Canchaya, E. Curry, F. Foglini, J.-O. Irisson, ... & J. Coopman, 'Big Data in Marine Science' (2020)), which will in turn increase efficiency, expand markets and enhance economic growth. Advances in technology are prominent in all sectors examined in this White Paper (see sections D, E, F, G and H and Part 3), with sometimes positive and sometimes negative outcomes.

As far as marine scientific research is concerned, demand is increasing for ocean observations and research to address priority needs for climate and weather prediction, ecosystem health, management of marine resources, for marine and coastal operational decisions, and improved forecasting and early warning of extreme events. Technologies that are being used to provide data regarding the ocean (M. Lin & C. Yang, 'Ocean Observation Technologies: A Review', 33 Chinese Journal of Mechanical Engineering, 32 (2020)) currently include autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), sensors, submersibles, satellites, robots, rovers, data buoys, cabled seafloor observatories, argo floats, gliders and aerial drones. By 2050, there are likely to be many autonomous robots and an integrated network that will connect individual instruments and communication systems and provide real-time information about what is happening in the ocean (E. Lubofsky, 'Sea Ahead. The game changing ocean technologies that will transform our ability to understand – and manage – Earth's last great frontier' (27 July 2020)). It is anticipated that high level

Note 2 See also the White Paper 'Digital Challenges for International Law' in ADI/ILA 2023.

sensors will enable the extension of AUVs in more complicated missions without human intervention (M. Lin and C. Yang, *op. cit*). The future will also see data from AUVs being beamed up to satellites to transmit to laboratories on shore. Also fixed docking stations will likely be deployed in the open ocean that allow ocean vehicles to offload data and power up before heading to their next exploration site (E. Lubofsky, *op. cit.*). Furthermore, global ocean observing platforms are expected to be deployed in unexplored regions in the future and at greater depths (M. Lin and C. Yang, *op. cit.*). All these and other technological advances will result in a shift away from ship-based research. Virtual reality will continue to be used for training and consulting.

In an optimistic scenario, all ocean data, unless there are compelling security, proprietary or other interests, would by 2050 be shared by Governments, industry and scientists, and incorporated in a truly integrated and interoperable global data platform which makes diverse datasets available around the world and translates that data into actionable information for decision-makers (J. Leape, M. Abbott, H. Sakaguchi & al. (2020) 'Technology, Data and New Models for Sustainably Managing Ocean Resources'. Washington, DC: World Resources Institute).

In order to benefit from the aforementioned opportunities, it is necessary to have skilled human resources, technical and institutional infrastructure, financial support and international cooperation, among others, in place. Currently, human resources that drive ocean science are concentrated in certain countries and vary worldwide by age and gender (IOC Global Ocean Science Report). While it can be expected that the UN Decade for Ocean Science for Sustainable Development will lead to some improvement, inequities are expected to nevertheless increase even further under the 'business-as-usual' scenario in view of the rapid developments in technologies that not all States can access. The use of autonomous devices for marine scientific research also raises some challenges and legal questions (see Part 3).

D. Economic development

The few existing long term economic projections agree upon the following main trends: a continued slowdown in world trend GDP growth (that nevertheless remains positive), a shift of the economic center of gravity, towards Asia and Latin America, and a rise in living standards. China, India and the USA are projected to emerge as the three largest economies in 2050. Rapid growth in the emerging economies is expected to pull hundreds of millions of people out of absolute poverty, which will, however,

remain a significant, though much smaller, phenomenon in Africa (U. Dadush & B. Stancil, *op. cit*). Indeed, while average GDP growth rates are projected to slow in the other countries, Africa could see the world's highest growth rates between 2030 and 2050 (OECD 2050). Climate change is expected to have a significant impact on global economic development.

Ocean-based economic development and growth is not only dependent on global economic developments but also on the main drivers indicated in this part of the White Paper, including the health of the ocean and the pressures being placed on it (see section F below).

More than half of the ocean-based industries are projected to outperform the global economy. Particularly strong growth is expected in marine aquaculture, offshore wind, fish processing, and shipbuilding and repair.

This section will present some of the major industrial sectors (except for aquaculture and capture fisheries which are examined in section E) that are expected to continue to dominate the ocean economy in 2050, supplemented by new activities. While the projected growth of the ocean-based economy could generate more employment opportunities, it is at the same time expected that under a business-as-usual scenario, it would lead to increased degradation of the marine environment and biodiversity loss and thereby adversely impact human well-being and the enjoyment of human rights (see section G).

1. Energy

In 2050, the world economy is projected to use 80% more energy, assuming consumption patterns do not change. Emerging economies are projected to become major energy users (OECD 2050).

According to the International Energy Agency (IEA), in a 'business-as-usual' scenario, renewable energies would provide almost 55% of global electricity generation by 2050 (up from 29% in 2020). Global coal use would fall by 15%, but oil use would increase by 15%, and gas by 50%. However, in the sustainable path scenario, the share of renewables in electricity generation would rise to nearly 70% in 2050. Coal use would drop by 50% while oil would fall by 10% and natural gas use would expand by 10% (IEA, 'Net zero by 2050, A roadmap for the global energy sector').

However, when it comes to maritime activities, projections for 2050 do not anticipate complete decarbonization. Even in the net zero emissions scenario of the IEA, oil would still make up

15% of ships' fuel consumption in 2050 as explained in more detail in subsection 3 below.

Upscaling offshore renewables, including wind, wave, and tidal energy, can bring major benefits in terms of climate change mitigation as well as reduce dependency on fossil fuels imports (IRENA, (2022) 'Ocean Renewables: Powering the Blue Economy'; see also subsection 3 below). A 'sustainable path' would result in a massive growth of offshore wind, ocean energy and floating photovoltaic in the coming decades.

Offshore renewables can provide significant socioeconomic opportunities to countries with coastal areas and island territories, such as job creation (see section G), improved livelihoods, local value chains and enhanced synergies among blue economy actors. There are also potential environmental benefits from the installation of offshore artificial islands, installations, structures and devices since they can for example provide marine organisms with artificial reefs (see WOA II, vol. II, p. 330).

However, offshore renewables can also raise environmental concerns. Indeed, the underwater infrastructure of marine renewable energy installations could affect benthic habitats (reefs) and might pose a collision risk for fish and marine mammals. Also, noise created during pile-driving operations can involve sound pressure levels that are high enough to impair hearing in marine mammals (*ibid. p.* 331). Offshore wind farms may also threaten seabirds (through collisions and habitat loss mainly). In the case of floating turbines, abandoned, lost, or discarded fishing gear and other marine debris could become ensnared in mooring lines and cables, where it may entangle whales, dolphins, turtles, fish, and diving seabirds (R. Loomis & F. Kershaw, 'Floating Offshore Wind Brings Challenges and Opportunities'(2021)). As regards ocean energy, some estimate that the risks are currently quite low for this form of energy although more research is required (A. Copping, 'The state of knowledge for environmental effects: Driving consenting/permitting for the marine renewable energy industry', Report by Pacific Northwest National Laboratory (PNNL), 25(2018)). However, the large-scale development of marine renewable energy has the potential to alter the physical processes driven by waves, currents and tides (such as water circulation, wave height, salinity and water quality; see WOA II, vol. II, p. 332).

(a) *Offshore wind energy*

Offshore wind is one of the most dynamic and rapidly growing ocean-related industries as of today. According to the IEA, offshore wind power capacity is set to increase by at least 15-fold worldwide by 2040, becoming a USD 1 trillion business (IEA (2019), 'Offshore Wind Outlook 2019'). In the 'business-as-usual' scenario, the global offshore wind market is set to expand by 13%, but it would still only account for 3% of global electricity supply by 2040. Other studies estimate that by 2050, offshore wind will provide about as much energy as offshore oil, while others consider that offshore wind will overtake the oil and gas sector to receive the largest investments in the blue economy (DNV, 'Ocean's Future to 2050 Report' (December 2021)).

The growth in offshore wind installed capacity is expected to increase at a much more rapid rate than over the past two decades, following the latest technological developments in turbines and the deployment of floating wind units (IRENA (2021) 'Offshore Renewables. An action agenda for deployment', p. 37). Floating wind turbines are attracting increasing investment. In the near future, their accelerated emergence is expected due to the convenience of the technology for certain countries that lack access to shallow waters (*ibid.,* p. 42).

Apart from the aforementioned environmental issues, offshore wind also faces the traditional challenges of any emerging industries (efficient supply chain yet to be established, investors' trust to be won over) as well as specific, technical ones (notably, the development of a supporting grid infrastructure on land to deliver electricity produced offshore to consumers). Due to limited land availability and the higher wind resource availability offshore, offshore energy hubs are being developed on artificial islands in order to connect and distribute power from the surrounding offshore wind farms (for example in Denmark, *ibid.,* p. 46 and 47).

(b) *Floating solar photovoltaic (FPV)*

By 2050, it is projected that due to the pressing challenge of land availability as well as the large potential of FPV for islands and small island developing States (SIDS), this technology will be developed on a larger scale in open seawater. FPV is not being used only for electricity provision, but rather, similar to offshore wind and ocean energy, it is being evaluated for direct and indirect electrification of different blue economy activities, for example, desalination plants. Seawater desalination is becoming the primary source of potable water in the Middle East and North Africa and in various SIDS (*ibid.*, p. 70).

(c) *Ocean energy*

Ocean energy covers all forms of energy generation in which seawater forms the motive power. It comprises wave energy converters, tidal streams, ocean thermal energy conversion, salinity gradients and biomass energy, which involves the use of marine algae and other viable organic matter for the production of biofuels. Based on IRENA's analysis, ocean energy alone has the potential to meet more than twice the current global electricity demand (*ibid.*, p. 51).

Although currently an emerging industry, the 'sustainable path' scenario foresees a massive growth of ocean energy technologies (*ibid.*, p. 60). That being said, ocean energy is a less proven technology compared with other renewables. Moreover, it is technologically challenging to develop devices that can operate in harsh environments with widely varying conditions. There is also a risk of competition for ocean space (notably with commercial fishing, shipping and conservation). Co-benefits and additional revenues streams for ocean energy projects can be harnessed from coupling electricity generation with blue economy activities such as aquaculture, water desalination, shipping, and green hydrogen production (*ibid.* p. 83).

2. Mining

The shift to clean energy will drive a huge increase in the requirements for certain minerals. Solar photovoltaic (PV) plants, wind farms and electric vehicles (EVs) generally require more minerals to build than their fossil fuel-based counterparts. The types of minerals vary by technology. Lithium, nickel, cobalt, manganese and graphite are crucial to battery performance, longevity and energy density. Rare earth elements are essential for permanent magnets that are vital for wind turbines and EV motors. While electricity networks need a huge amount of copper and aluminum, with copper being a cornerstone for all electricity-related technologies (IEA, (2022) 'The Role of Critical Minerals in Clean Energy Transitions', Executive summary).

The production of the aforementioned minerals could increase by nearly 500% by 2050, to meet the growing demand for clean energy technologies. Indeed, over 3 billion tons of minerals and metals will be needed to deploy wind, solar and geothermal power, as well as energy storage, required for achieving a below 2°C future (K. Hund, D. La Porta, T. P. Fabregas, T. Laing, & J. Drexhage, 'Minerals for climate action: the mineral intensity of the clean energy transition', World Bank(2020)). In that regard, the seafloor is increasingly – but not uniformly – viewed as a potential source. In light of the exploration activities that are

already occurring in the Area (*i.e.* the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction), advances in deep seabed mining technology and processes, and the exploitation regulations that are being developed by the International Seabed Authority (ISA), it is currently suggested that much of the exploitation of mineral resources in 2050 will take place for minerals within the Area, such as copper, nickel, manganese and cobalt, although there are dissenting views insisting that a renewable energy future need not rely on minerals extracted from the Area. Future developments in the ISA are also likely to influence States' decision whether to carry out exploitation of mineral resources within areas under national jurisdiction.

Although there is no real-life data on how it might adversely impact marine ecosystems, as seabed mining has not yet started, potential risks to the marine environment must be carefully considered. Indeed, the importance of integrating environmental considerations in the early stages of project planning to help ensure sustainability and the protection and preservation of the marine environment cannot be overstated. Moreover, seabed mining holds social risks, as pollution could impact livelihoods (A. Koschinsky, L. Heinrich, K. Boehnke, J.C. Cohrs, T. Markus, M. Shani, ... & W. Werner, 'Deep sea mining: Interdisciplinary research on potential environmental, legal, economic, and societal implications. Integrated environmental assessment and management', 14(6), (2018), 672-691 ; see also Sénat, 'Abysses : la dernière frontière ? », Rapport d'information, 21 June 2022). Thus, there are increasing calls for a moratorium on seabed mining.

3. Maritime transport

Economic development and population growth will continue to drive future demand for maritime trade. Commensurate with a significant increase in international trade, the volume of maritime trade could substantially increase by 2050, between 40 and 115% in comparison with 2020 levels (IMO, The Fourth IMO GHG Study 2020). However, these estimates do not take into account a global economic downturn, shifts in trade patterns, pandemic-induced issues, as well as geopolitical tensions, all of which exert significant pressures on the industry.

Navigational routes can either cut or increase costs of trade and emissions from ships which carry around 90 percent of goods transported globally. In the case of the Arctic, the predicted ice-free summers by 2050 could open up the Northern Sea Route and Northwest Passage resulting in a shorter shipping route with cuts in both emissions and the costs of trade, but with risks of pollution and impacts on Indigenous Peoples.

Overall, the shipping industry is expected to undergo some major changes by 2050. The two major drivers for future changes in the shipping industry will be the transition to non-fossil fuels and technological advances. The regionalization of trade patterns will likely also have a substantial impact (International Transport Forum, (2020) 'Future Maritime Trade Flows: Summary and Conclusions', ITF Roundtable Report, No. 178, OECD Publishing, Paris).

The transition to non-fossil-fuel is critical. At present, about 99% of the energy demand from the international shipping sector is met by fossil fuels. If the international shipping sector were a country, it would be sixth or seventh-largest CO_2 emitter (IRENA (2021), A Pathway to Decarbonise the Shipping Sector by 2050 (International Renewable Energy Agency, Abu Dhabi). International shipping emissions fall outside national GHG emission accounting frameworks.

With the projected increase in shipping by 2050, GHG emissions associated with the shipping sector could grow between 50% and 250% by 2050 in comparison with 2008 emission levels. The International Maritime Organization's (IMO) Initial Strategy for reducing GHG emissions from international shipping, contains a clear commitment to a complete phase-out of GHG emissions from ships, a specific linkage to the Paris Agreement and a series of clear levels of ambition including at least a 50 percent cut in emissions from the sector by 2050 (https://www.ico.org/documents/cy2017-18/icc-122-13f-statement-secretary-general-imo.pdf). On 1st November 2022, amendments to Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL) will enter into force and introduce short-term measures to reduce carbon intensity of all ships by 40% by 2030, compared to 2008. There is a growing effort by the shipping industry to embrace alternative fuels to reduce emissions, but the industry needs the cooperation and collaboration of other stakeholders in order to find alternative fuels, particularly because it has been projected that a new fleet of low-carbon vessels will not be available for at least 20 years (A. McKinnon, Presentation to the ITF/OECD Decarbonization of Road Freight workshop held in Paris in June 2018).

A whole host of technologies are being explored in order to reduce the carbon footprint of the world's shipping fleets, including low carbon fuels, more streamlined hulls, more efficient propeller design, improved voyage planning to make savings on fuels, better hull coatings and even air cushions to reduce friction. While conventional oil-based fuels will continue to dominate in the near future, there is likely to be increased adoption of liquefied natural gas (LNG) for specialist vessels. The shipping industry is also exploring renewable energy to power the fleets

of the future and some of this technology is already being trialed and tested. Other technological advances could include systems that reduce fuel consumption and even bigger megaships, particularly within the container shipping industry (L. McLeman, 'Five future trends in the shipping industry'). When at port, these megaships would connect to electric shore power, lowering emissions in port (Bureau Veritas, 'What does the Future hold for Shipping'). Among other sustainable solutions, the marine industry is increasingly looking at carbon capture, utilization and storage, an emerging technology that enables CO_2 to be removed from emissions.

How fast the transformation takes place will depend on the willingness of owners and the preparedness of oil and gas producers and innovators alike to cooperate and invest in fuel cell technology and infrastructure in ports. It will also depend on container shipowners de-escalating the fight for size based on alleged economies of scale, where 80% of energy is consumed by 20% of the largest cargo vessels (P. Verhoeven, 'What will shape the Port Sector in the Next 50 Years?", in UNCTAD 50 years of Review of Maritime Transport, 1968–2018 (UNCTAD, 2018), p. 46-48).

Technological advances will also be used to optimize operations, enhance efficiency, drive down costs and increase the uptime of vessels (L. Kitack., 'Future Developments in Maritime Transport' in *ibid.*, p. 37). It is anticipated that commercial shipping processes will be digitized, and connected and automated transport will be operational. (C. Doumbia-Henry Cleo, 'Maritime Trade and Transport – An Outlook on the Issues and a Reflection on the Implications for Education and Research' in *ibid.,* p. 52-54). Autonomous vessels for use in coastal areas are already being developed and it is estimated that they will be widely used in all ocean areas by 2050 (O. Levander, 'Autonomous Ships on the High Seas', IEEE Spectrum, vol. 52-2, (2017), p. 26–31). Maritime autonomous surface ships (MASSs) comprise any ship which, to a varying degree, can operate independent of human interaction (IMO (2021), 'Outcome of the regulatory scoping exercise for the use of MASS').

The port sector is also expected to be transformed significantly. New docking facilities at ports are expected to include power generation facilities, communications networks, and shore control centers for remotely operated vessels. The impacts on seafarers of technological advances in ships and ports are described in section G and in Part 3.

There are also environmental considerations. It is anticipated that an increase in maritime trade and the use of MASS could increase the risk of pollution of the marine environment from

shipping as a result of an accident or maritime operations. Apart from GHG emissions, ships can cause pollution through the discharge of oil, noxious liquid substances carried in bulk, harmful substances carried by sea in packaged form, sewage and garbage; the emission of air pollution from ships; the transfer of aliens and the use of anti-fouling systems on ships. Recent studies also demonstrate that shipping is one of the main sources of increasing amounts of anthropogenic noise that continues to degrade the ocean (WOA II, vol. II, p. 301). The primary sources of underwater noise are propellers, hull form, on-board machinery and operational aspects.

4. Submarine cables[3]

It is estimated that 99% of all international internet, data, and telephone traffic is transmitted via submarine fiber optic cables. The number of cables is expected to increase significantly in the future in order to provide increased bandwidth for rising data requirements due to greater automation, big data and the Internet of things. The market for submarine cables is already a dynamic one where the private sector has been instrumental in delivering the infrastructure to date. (For example, a collaboration and joint ownership between Microsoft, Facebook and Telxius completed in 2017 the high-capacity submarine cable (MAREA) between Spain and the USA, see Marea: The future of subsea cables – Microsoft News; while Google completed in 2021 a new high-speed submarine cable (DUNANT) which connects France and the USA, see C. Ciauri, 'The Dunant subsea cable, connecting the US and mainland Europe, is ready for service', Google Cloud, webpage 3 February 2021).

It is also likely that there will be a greater focus on increased resilience against events – accidental and deliberate – which may bring outages, and connectivity cuts to cables carrying key data. The ability to transfer, re-route and ultimately build contingency into this sector, will see the need for the development of new cables (UK Department of Transport, 'Maritime 2050: Navigating the Future' (January 2019)).

In addition to submarine fiber optic cables, there are also the submarine power cables transferring electricity. The global submarine power cable market growth is driven by the increasing investment in offshore wind energy plants, rise in cross country submarine connections for power transmission, and the rising development of underwater data center. In the coming

Note 3 See the work of the ILA Committee on Submarine Cables and Pipelines under International Law.

decades, the effort to tackle climate change will confront increasing demands for electricity, particularly in developing countries, and it will be cheaper and more efficient for countries to lay cables to make use of each other's particular energy strengths than to try to do it all on their own (S. Reed, 'A Widening Web of Undersea Cables Connects Britain to Green Energy', New York Times, 4 January 2022).

The economic, social and cultural impacts resulting from damage to cables can be devastating. The majority of damage to submarine cables comes from human activity, primarily fish trawlers and ship anchors. This is the case even though submarine cables are marked on nautical charts and mariners are therefore able to avoid anchoring on or near them. Cables can also be cut accidentally or deliberately. Natural hazards may also affect cables (WOA, II, vol. II, p. 206-207).

Rapid expansion of submarine cables and growing demand for electric interconnections also raise environmental concerns. During installation, maintenance and decommissioning phases, these effects may include physical habitat disturbances and notably benthic habitat modification, sediment resuspension, chemical pollution and underwater noise emission. More long-term effects may occur during the operational phase, with changes in electromagnetic fields, heat emission, risk of entanglement, chemical pollution, and creation of artificial reef and reserve effects (T. Bastien & al, 'A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions'. Renewable and Sustainable Energy Reviews, November 2018, vol. 96, p. 380-391).

5. Marine biotechnology

Marine biotechnology is currently an emerging but dynamic industry, concentrated in a comparatively small number of countries. Industries involved are the waste, agriculture and the pharmaceutical and cosmetic industry. Interest in marine genetic resources (MGRs) has been increasing as demonstrated by the robust pipeline of marine-derived drugs in clinical trials given that the process of bringing a new drug to market can cost as much as USD 2.8 billion and take 10 to 15 years (WOA, II, vol. II, p. 370). MGRs have been the focus of an expanding range of commercial and non-commercial applications, with particularly encouraging results for example when it comes to anticancer chemotherapy (R. Calado, & others, 'How to Succeed in Marketing Marine Natural Products for Nutraceutical, Pharmaceutical and Cosmeceutical Markets', in Grand Challenges in Marine Biotechnology, Springer, (2018), p. 317-403). Sponges

and algae continue to attract significant interest for the bioactive properties of their natural compounds (WOA II, vol. II, p. 365).

Divergent views exist regarding the economic potential of MGRs, in particular those from areas beyond national jurisdiction. Currently, investments in marine biodiscovery are costly and risky due in part to the extreme expense of sampling in areas like the deep sea, the low chances of success and the significant regulatory hurdles for product approval (E. Morgera, 'Fair and Equitable Benefit-Sharing in a New Treaty on Marine Biodiversity: A Principled Approach towards Partnership Building?', Maritime Safety and Security Law Journal, (2018)). But technological advances in the area of marine scientific research (see section C) will increasingly facilitate the collection of samples by autonomous devices with the ability to undertake genetic analysis. Also, rapidly shrinking costs of gene sequencing and synthesis, as well as rapid advances in metabolic engineering and synthetic biology, are expected to continue to reduce dependency on the acquisition of physical samples from the ocean in the future (WOA II, vol. II, p. 365). The costs of molecular technologies have also decreased considerably in recent decades, alongside an increase in speed, efficiency and capacity.

Nonetheless, the considerable costs involved in research and development, alongside the advanced technologies and expertise required, have meant that most activities have been undertaken by high-income countries, but with the sampling often conducted in low- or middle-income tropical countries (T. Greiber, 'An Explanatory Guide to the Nagoya Protocol on Access and Benefit-Sharing', IUCN Environmental Policy and Law Paper 83, (2012)). It has been noted that patents citing marine genes originated from only 31 of the 195 countries in the world, with 10 countries responsible for 90 percent of them (S. Arnaud-Haond, J.M. Arrieta & C.M. Duarte, 'Marine Biodiversity and Gene Patents', Science 331 (6024), (2011), p. 521–522). Without transfer of marine technology and capacity-building, the business-as-usual scenario will continue in the future (WOA, II, vol. II, p. 366).

Many States face issues that hinder them from engaging directly in research on MGRs. Such issues include limited knowledge of biodiversity, limited capacity, in terms of both facilities and technological expertise, limited financial resources for research and development, a lack of experience with access and benefit-sharing mechanisms, and the need for increased collaboration across the academic, government and private sectors (C. C. Thompson & others, 'Unlocking marine biotechnology in the

developing world', Trends in Biotechnology, vol. 35, No. 12, (2017), p. 1119–1121).

Publicly accessible open-access databases, one of the cornerstones of capacity-building, do not solve the problem of limited scientific capacity to access and use genetic resources, or to use digital sequence information (H. Österblom, C. C.C. Wabnitz & D. Tladi & al., 'Towards Ocean Equity' Washington, DC: World Resources Institute, (2020)). Many developing States cannot explore commercially valuable potential benefits from open access information on the sole basis of information-sharing through open access databases. In fact, by itself, this needed step does not obviate the need for capacity-building in scientific disciplines (e.g., molecular biology), and research infrastructure– the main drivers of inequalities (S. Arnaud-Haond & al., *op. cit.*).

The opportunities and issues relating to technological advances in marine scientific research are also relevant to the implementation of the legal regime with respect to access and benefit-sharing of MGRs in areas within national jurisdiction. MGRs in areas beyond national jurisdiction, including the fair and equitable sharing of benefits from such MGRs, will be regulated by the future BBNJ agreement.

6. Tourism

The tourism industry is currently one of the world's largest industries. Developing countries in particular depend on tourism as a main driver of economic growth and as a major source of employment, especially SIDS. (R. Carlo-Asuncion & M. Lee, 'Impacts of Sea Level Rise on Economic Growth in Developing Asia', Asian Development Bank Economic Working Paper Series No. 507, (2017)). But the coastal tourist industry and the cruise industry can be affected in various ways by ocean and cryosphere related changes, as well by pandemics and the state of the world economy.

Beach tourism is particularly exposed to direct and indirect climate change stressors (UNCTAD, 'Trade and Environment Review 2021' and UNEP, 'Disaster risk management for coastal tourism destinations responding to climate change: A practical guide for decision-makers'). The sustainability of beach destinations depends partly on their ability to adapt planning and management practices to the impacts of climate change and also to increase their ability to effectively manage natural disasters. By 2050, it can be expected that coastal flooding, storms and damages to infrastructure will lead to tourism losses on the coast and a decrease in revenue. In the case of coral reefs for recreational activities and tourism (especially diving and

snorkeling), it is estimated that the global economic impact of the expected decline in reef coverage as a result of climate change will range from 1.9 to 12.0 billion USD yr (P.-Y. Chen, C.-C. Chen, L. Chu & B. McCarl, 'Evaluating the economic damage of climate change on global coral reefs', Global Environmental Change, 30, (2015), p. 12–20).

Nonetheless, estimating the effects on global-to-local tourism flows remains challenging. It will also depend on how tourists and tourism developers perceive the risks induced by ocean-related changes and this will combine with the influence of changes in climatic conditions in tourists' areas of origin (IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2019); hereinafter the IPCC 2019 Special Report).

Coastal tourism and the cruise industry are not only impacted by pressures on the ocean but can also themselves contribute to such pressures. The major impact on the marine environment from coastal tourism comes from coastal development. Where such development is not subject to effective planning and management, impacts on marine flora and fauna can be disastrous (WOA, II, vol II, p. 18). Tourist activities can also be unsustainable. Diving activities, for instance, can damage coral reefs if ineffective or no management measures are in place. A lot of recreational boating, high-speed boats, jet skis, etc. in an area, can generate ocean noise adversely impacting marine life. Cruise ships can also have a significant environmental impact, through collisions with marine mammals, pollution, for example, the release of wastewaters, bilge waters and ballast water, and unrestricted anchoring which can threaten coral reefs and sensitive sea areas (J. Lloret, A. Carreno, H. Caric, J. E. San, L. Fleming, 'Environmental and human health impacts of cruise tourism: A review', in Marine Pollution Bulletin 173, (2021)). Moreover, the cruise industry can be extremely wasteful: although cruisers make up only a small percentage (<1%) of the global shipping industry, it is estimated that a quarter of all waste produced by shipping comes from this sector (M. Herz, 'Cruise control: A report on how cruise ships affect the marine environment' (2002)).

7. Adaptation - coastal construction/infrastructure

In 2020, almost 896 million people – 11% of the global population – resided in cities and settlements within coastal areas below 10 m of elevation above sea level that are hydrologically connected to the sea and that number could increase beyond 1 billion by 2050 (IPCC (2021), 'Cities and settlements by the sea'). Moreover, 90 % of megacities worldwide are vulnerable to rising sea levels. If global temperatures were to rise to 2°C

by 2050 at least 570 cities and some 800 million people would be exposed to rising seas and storm surges (World Economic Forum's Global Risk Report (2019), p. 7). In terms of costs, it is estimated that between USD 7-14 trillion of coastal infrastructure assets would be exposed by 2100, depending on warming levels and socio-economic development trajectories. If sea level were to rise up to 1.2 m, the global costs of protecting coastal areas are estimated at USD 12–71 billion in 2100.

(a) Adapting coastal cities in the face of climate change

There are three main different adaptative strategies when it comes to protecting life on the coast in the face of climate change: hard engineering protection measures, sediment-based interventions and nature-based measures. According to the IPCC, a hybrid strategy is most effective, but even if put in place correctly, it will be insufficient, making exploring alternatives necessary (IPCC, 'Cities and settlements by the sea', *op. cit.*). Improperly designed or ageing coastal defence structures cannot function properly and may be abandoned or repaired. Nature-based solutions for coastal protection, including artificial wetlands or salt marshes, oyster reef creation and mangrove re-establishment and protection, have the advantage of being able to grow with sea level and increasing CO_2 storage capacity (WOA, II, vol. II, p. 204).

Financial, technological, institutional and other barriers exist for implementing responses to current and projected negative impacts of climate-related changes in the ocean and cryosphere, impeding resilience building and risk reduction measures. Whether such barriers reduce adaptation effectiveness or correspond to adaptation limits depends on context specific circumstances, the rate and scale of climate changes and on the ability of societies to turn their adaptive capacity into effective adaptation responses (IPCC 2019 Special report- C.1.4, p. 29).

But, as noted by the Secretary-General of the United Nations, the relative costs and benefits of coastal adaptation are distributed unevenly across countries and regions. By some estimates, the annual costs of protecting existing development and infrastructure from a 1m rise in sea levels could reach 20% of the total gross national product for some countries. The increased costs of reconstruction, rehabilitation and maintenance, as well as costs associated with adaptation, could be debilitating for many small island and low-lying developing States (Secretary-General's Report on Oceans and the Law of the Sea, UN document A/75/70 (2020)).

(b) Floating cities

Floating cities are likely to emerge as a housing alternative in the face of sea-level rise and by 2050 there are likely to be a number of floating cities in place (https://www.waterstudio.nl/projects/). Floating cities are being developed essentially as platforms that are anchored to the seabed in coastal areas. There are currently dozens of floating city models that are being tested and proposed around the world (see for example Oceanix, Busan, Republic of Korea, a prototype floating city that has UN approval and is expected to be constructed by 2025; Deputy Secretary-General Press Release, 3 April 2019 : 'Sustainable Floating Cities can offer solutions to climate change threats facing urban areas').

Floating cities have been presented as sustainable alternatives. For instance, in the case of the Maldives Floating City, whose construction has started, artificial coral banks will be attached to the underside of the city, which will stimulate coral to grow naturally; and renewable energy will power the city through a smart grid (https://www.dutchdocklands.com/). Comprehensive environmental impact assessments (EIAs) will nonetheless be critical in view of the large amount of ocean space that will be covered by floating cities and the need to anchor them securely to the seabed.

Underwater cities are also a theoretical possibility moving forward. However, even though the technology necessary to develop them is already available, a lack of sufficient interest (and thus funding) has kept them from becoming a reality for the time being.

8. Geoengineering

According to the IPCC, emissions reductions alone would not be enough to limit global warming to 1.5°C. Countries will also need to employ negative emission technologies (NETs) to draw gigatonnes of CO_2 out of the atmosphere each year (IPCC (2018): Summary for Policymakers).

The ocean already provides an invaluable service slowing the atmospheric growth of CO_2 and associated climate change, though at the cost of rising levels of ocean acidification. Nonetheless, many scientists are exploring the possibility of ocean-based CO_2 removal (CDR) and a number of CDR approaches may be common-place by 2050.

Seaweed cultivation and sequestration is currently considered a compelling CDR strategy, however scaling to CDR-worthy levels is considered challenging due to the large amount of farmed area required (National Academies of Sciences, Engineering,

and Medicine (2022), 'A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration', Washington, DC: The National Academies Press). Blue carbon ecosystems, such as saltmarshes, seagrass meadows, mangrove forests, macroalgae communities such as kelp forests, and freshwater tidal ecosystems, such as coastal bald cypress floodplain forests, all have the capabilities to sequester carbon (C.E Lovelock,. & C.M. Duarte, 'Dimensions of Blue Carbon and emerging perspectives', Biology letters, 15(3) (2019); see also https://geoengineering.global/blue-carbon/). Scientists are also studying how much net carbon sequestration would result from protecting and restoring ecosystems.

Carbon dioxide (CO_2) capture and storage (CCS) is a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere (IPCC (2005), 'Special report on carbon dioxide capture and storage'). The ocean has been considered as a potential storage location. According to the IPCC, ocean storage potentially could be done in two ways: by injecting and dissolving CO_2 into the water column (typically below 1,000 meters) via a fixed pipeline or a moving ship, or by depositing it via a fixed pipeline or an offshore platform onto the sea floor at depths below 3,000 m, where CO_2 is denser than water and is expected to form a 'lake' that would delay dissolution of CO_2 into the surrounding environment. Although there have been small-scale field experiments and 25 years of theoretical, laboratory, and modeling studies of intentional ocean storage of CO_2, ocean storage has not yet been deployed or thoroughly tested.

Other CDR approaches currently being considered include ocean nutrient fertilization, artificial upwelling/downwelling, ocean alkalinity enhancement and electrochemical processes which focus on activities that reduce the cost and environmental impact of the approaches ('A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration', *op. cit.*). Other geoengineering initiatives include marine cloud-brightening that increases the reflectivity or albedo of marine clouds by seeding them with seawater aerosol (J. Latham, P. Rasch, C.C. Chen, L. Kettles, A. Gadian, A. Gettelman, H. Morrison, K. Bower & T. Choularton, 'Global temperature stabilization via controlled albedo enhancement of low-level maritime clouds', Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366 (1882), (2008), p. 3969-3987. See also https://geoengineering.global/marine-cloud-brightening/); ocean albedo modification using microbubbles to increase the reflectivity or albedo of the surface of the ocean (https://geoen-

gineering.global/ocean-albedo-modification/); and the deposit of sand made of ground olivine – a volcanic rock – into the ocean in order to speed up the carbon dioxide capture process while de-acidifying the ocean (A. Fleming, 'Cloud spraying and hurricane slaying: how ocean geoengineering became the frontier of the climate crisis', The Guardian, 23 June 2021 and Project Vesta https://www.vesta.earth/the-project).

However, the present state of knowledge of many ocean-based CDR approaches is inadequate, based in many cases only on laboratory-scale experiments, conceptual theory, and/or numerical models. The lack of a comprehensive international or domestic legal framework specific to ocean CDR research creates a risk that ill-considered projects, including projects that do little to advance scientific knowledge and/or present significant risks, will be pursued ('A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration', *op. cit.*). Such projects could raise environmental risks. Indeed, experiments show that added CO_2 can harm marine organisms, by reducing rates of calcification, reproduction, growth, circulatory oxygen supply and mobility as well as increased mortality over time. Immediate mortality is expected close to injection points or CO_2 lakes. CO_2 effects on marine organisms would have ecosystem consequences, but it is unclear what these consequences would be exactly, as no controlled ecosystem experiments have been performed in the deep ocean. Broadly speaking, it seems that deep ocean storage could help reduce the impact of CO_2 emissions on surface ocean biology but at the expense of effects on deep-ocean biology (K. Caldeira & M. Akai & al., 'Ocean storage', IPCC 2005 Special Report on Carbon dioxide Capture and Storage, p. 279).

E. Food security concerns[4]

The future of fisheries and aquaculture will be influenced by many different factors and interconnected issues of global, regional and local relevance. Population and economic growth, together with urbanization, technological developments and dietary diversification, are expected to create an expansion in food demand, and in particular for animal products, including fish. But how fisheries and aquaculture production, utilization and trade will develop in the future will also depend on the future macroeconomic environment, international trade rules and tariffs, the frequency and effects of events on resources,

Note 4 See also the White Paper on Food and Agriculture in ADI/ILA 2023.

the absence of other severe climate effects such as tsunamis, tropical storms (cyclones, hurricanes and typhoons), floods and emerging fish diseases, fisheries management measures, including catch limitations and the absence of market shocks.

1. Aquaculture

Aquaculture, which accounts today for 46% of the world's fish used for food, is the fastest growing food producing sector. The FAO projects that aquaculture production (marine and inland) is likely to be superior to capture fisheries by 2050 (FAO 2022 World Fisheries Report, p. 220), although its growth rate is projected to slow down ('The Key Shaping Forces Impacting the Future Ocean Economy', Virtual OECD Workshop 31 May 2022). It will not replace fishing but will help meet the ever-increasing demand for food, supported in that goal by the mariculture of seaweeds, presumed to become the 'ultimate sustainable crop' (WOA II, vol. II, p. 254). Coastal aquaculture and mariculture not only provide food, but also contribute to livelihoods, employment and local economic development in coastal communities in particular in many developing countries.

Scientific and technological advances have improved remarkably, expanded and benefited almost every aspect of aquaculture and several pioneering technologies, such as catch-based aquaculture (which relies on the removal of young fish from the wild for fattening), have contributed significantly to the production of aquaculture. Other new technologies are also being developed and entering the aquaculture industry focusing for example on genetic improvements and digital technology. For instance, in 2050 robotics will likely carry out laborious work in feeding, cleaning ponds and nets, injecting vaccines and removing sick fish. Drones will likely be used for data collection and to monitor fish farms in the sea, especially offshore aquaculture sites. Sensors will likely be used to measure water parameters and monitor feeding and health status; in combination with cloud management and mobile connectivity, they would maintain the ideal environment for fish and supply optimal feeding for growth and feed conversion for the aquaculture industry. It is essential to develop real-time sensors to measure the stress level of individual fish and to detect pathogens in water. AI will empower rapid and precise decisions and increase the aquaculture production as it makes it a less labour-intensive field. It would provide complete control over the fish producing systems with less maintenance and reduced input cost.

Looking to the future, those and other technological advances will make it possible to gradually expand offshore aquaculture,

where fish are raised in solid cages. Offshore farming is regarded as one of the important means to ensure a sufficient and stable supply of seafood. It is also believed to minimize the negative effects of conventional marine aquaculture on the marine environment.

Offshore sites provide sufficient sea space for the culturing of fish and water quality is usually good enough for aquaculture. Factors to consider include location, cage types, vessel types and species, as well as cost, environment, affordability and sustainability. Most floating farms are heavily reliant on fossil fuels (J. F. Muir, 'Fuel and energy use in the fisheries sector', FAO Fisheries and Aquaculture Circular (FAO) eng no. 1080(2015)) but aquaculture farms could, moving forward, be powered by offshore renewable energy (see section D) as the infrastructures needed for both are quite similar. Combining offshore renewable energy and aquaculture or other marine uses could allow a sustainable and efficient use of ocean space. However, such combination also presents numerous issues, including higher safety risks (as the farms would be located in higher-energy and more exposed environments), a high cost (because offshore equipment is very expensive), potential cumulative impacts from both activities, and the lack of a clear regulatory framework within existing legal regimes (M.C. Freeman, L. Garavelli, E. Wilson, M. Hemer, M. L. Abundo, L.E. Travis, 'Offshore Aquaculture: a market for Ocean Renewable Energy', Report for Ocean Energy Systems (OES), (2022), p. 40).

A major challenge when it comes to the development of aquaculture more generally is biosecurity. Each year, the economic loss caused by diseases in the aquaculture industry is estimated at USD 6 billion. Immunization has started for over 50 years, but it still lags far behind the livestock industry. Other issues include environmental impacts (habitat destruction, particularly mangroves; water pollution; impact of escapees on wild stock) and competing overlapping ocean activities ('World Resources Report: Creating a Sustainable Food Future' (December 2018)). Environmental degradation (see section F) also impacts aquaculture and reduces the supply of fish meals and oils, and climate change seriously affects the capacity in producing enough aquaculture products to meet the demand for seafood.

2. Capture fisheries

By 2050, according to the FAO, there will be a modest increase in capture fisheries (resulting mainly from improved management) under the 'business-as-usual' scenario (FAO 2022 World Fisheries Report, p. 220). Currently, small-scale fisheries is

estimated to be 40% of total inland and marine capture fisheries. However, numbers can change since they only reflect changes in the capacity of the ocean to produce fish, and do not consider the management decisions that may or may not be taken in response (FAO (2018), 'Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options' Fisheries and Aquaculture Technical Paper 627, p. 22) Empirical evidence, along with modeling advances in fisheries science, has demonstrated that effective management could improve fish stocks, increasing yields and resource rents and providing increased food security in developing States.

A major challenge moving forward is overfishing. According to the World Bank, each year, global fisheries lose out on USD 83 billion in economic benefits due to overfishing (World Bank (2017), 'The Sunken Billions Revisited : Progress and Challenges in Global Marine Fisheries. Environment and Development', Washington, DC: World Bank). As of today, the global fishing fleet is two to three times larger than needed to catch the amount of fish that the ocean can sustainably support. The absence of effective and enduring governance in some of the world's fisheries has resulted in overexploitation, ongoing subsidization, illicit trading, by-catches and discarding, habitat damage due to bottom-trawling, post-harvest fish losses, gear abandonments and illegal, unreported or unregulated fishing (IUU).

IUU fishing currently accounts for 20 percent of the world's catch and up to 50 percent in some areas. It undermines sustainable fisheries, threatens the health of marine ecosystems and has negative socio-economic effects. IUU fishing is also often connected to human rights abuses, forced labour, smuggling activities and human trafficking (see section G) and illicit traffic in narcotic drugs and psychotropic substances (A. Mosteiro Cabanelas (ed.), G.D. Quelch, K. Von Kistowski, M. Young, G. Carrara, A. Rey Aneiros, R. Franquesa Artés, S. Ásmundsson, B. Kuemlangan & M. Camilleri, 'Transshipment: a closer look – An in-depth study in support of the development of international guidelines' FAO Fisheries and Aquaculture Technical Paper No. 661, (2020)). The underlying drivers of IUU fishing are economic incentives, weak governance, and poor enforcement (S. Widjaja, T. Long, H. Wirajuda, & al., 'Illegal, Unreported and Unregulated Fishing and Associated Drivers', Washington, DC: World Resources Institute, (2019)). Moreover, fraudulent papers, hidden ownership and a lack of transparency facilitate exploitation of fish in a way that is difficult to track.

New potential activities, such as fishing for mesopelagic species, which are largely unexploited fish that live at depths of 200–1,000m, may create opportunities but also raise concerns. Mesopelagic fish are generally unsuitable for human consumption but could potentially provide fishmeal for aquaculture or be used for fertilizers. However, the potential large-scale removal of mesopelagic fishes which sequester carbon by feeding in surface waters at night and release such carbon in deep waters during the day, could disrupt a major pathway of carbon transport into the ocean depths (J. E. Herbert-Read & al., 'A global horizon scan of issues impacting marine and coastal biodiversity conservation', Nature ecology & evolution, 2022).

F. Environmental degradation[5]

Climate change (see section A) and biodiversity loss continue unabated, and pollution due to human activities can be found everywhere in the ocean (see also in particular sections D and E). Rivers carry solid and liquid waste generated by land-based activities, and other potentially harmful substances, from source to sea. Sea-based activities can lead to discharges and spills from vessels, disposal of wastes, the transfer of alien species, abandoned, lost or otherwise discarded fishing gear and increasing levels of anthropogenic underwater noise (for example, from ships, oil and gas exploration and extraction, industrial activities and sonar). Bottom trawling and other adverse habitat disrupting activities also contribute to environmental degradation. Plastics and microplastics from numerous sources, untreated wastewater and nutrient run-off also continue to pollute the ocean: plastic pollution is now found everywhere in the ocean and represents the major share of marine litter or marine debris. Plastics have entered the marine food chain, which thus introduces microplastic and nanoplastic pollution and its associated chemical pollution into higher trophic levels including humans (M. B Tekman, B. A. Walther, C. Peter, L. Gutow, & M. Bergmann, 'Impacts of plastic pollution in the oceans on marine species, biodiversity and ecosystems', 1–221, WWF, (2022)). In the 'business-as-usual scenario', a four-fold increase of oceanic macroplastic concentrations is expected by 2050 and a 50-fold increase of ocean microplastic concentrations by 2100 (WOA, II, vol. II, p. 168). In contrast, the sustainable path would reduce annual plastic emissions by 36–91% but even such an optimistic scenario would mean further increases in

Note 5 See also the White Papers on Anthropocene and on SDGs beyond 2030 in ADI/ILA 2023.

marine pollution - albeit at lower rates (*ibid.*).

The greatest threat to the ocean is the failure to deal with the many pressures and stressors caused by human activities. Increasing levels of pollution undermine the ocean's ability to support climate stability, climate change mitigation, biological integrity, economic stability and coastal livelihoods (WOA I, Summary). According to scientists, while working with different scenarios is useful for keeping track of what sort of future is emerging (A. Merrie, P. Keys, M. Metian & H. Österblom, 'Radical ocean futures-scenario development using science fiction prototyping', 95 Futures, (2018), p. 22-32) only the 'sustainability path' can 'bring the ocean[s] back from the brink'. (B. C. O'Neill & al., 'The road ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century', *op. cit.*). If the 'business-as-usual' path is continued, it will not be possible to achieve sustainability and activities will lead to a further degradation of the marine environment. This would come at a high cost: it has been estimated that 66% of globally listed companies with some dependence on the ocean economy will collectively risk losing USD 8.4 trillion in ocean-based investments over the next 15 years due to declining ocean health and climate change if business-as-usual continues. On the contrary, USD 5.1 trillion could be saved if a transition is made to a more sustainable ocean-based economy (WWF (2021), 'Navigating ocean risk. Shaping the Transition to a Sustainable Blue Economy').

Moreover, under a business-as-usual scenario, continued environmental degradation, coupled with the impacts of climate change, will not only threaten the health of the ocean and its ecosystem, but would also adversely impact human health and survival.

G. Social aspects/human dimension[6]

Climate change and its impacts are projected to deeply affect marine resource-dependent communities, but also more generally all human lives and livelihoods as far as income, food security, services, tourism, culture, local and indigenous knowledge and several other social aspects are concerned (see the IPCC 2019 Special Report).

Ocean-based industries provide a source of employment for many people around the world. In 2030, the ocean-based industries in the business-as-usual scenario are anticipated to

Note 6 See also the White Papers on Labour and Human Rights in ADI/ILA 2023.

employ more than 40 million people, representing more than 1% of the global workforce of around 3.8 billion people. A majority would be working in the industrial capture fisheries sector and maritime and coastal tourism industry (OECD 2050). Furthermore, IRENA's energy transition modeling suggests that the wind industry, both onshore and offshore, may employ 3.74 million people by 2030 and more than 6 million people by 2050 (IRENA (2021), 'Offshore Renewables...', *op. cit.,* p. 84).

The achievement of the sustainable path scenario would not only depend on promoting full and productive employment and decent work for all but also on the achievement of gender balance and the empowerment of all people who identify as women. Major efforts would be needed to reverse the current gender inequality in all ocean-related sectors.

If gender inequality is not addressed effectively by 2050, the current practice of low representation of women employed at sea, estimated at about 2% by the International Transport Workers Federation (ITF) (mainly in the cruise ship), women being often segregated into low-skilled and unrecognized labour, such as fish processing, and denied a decision-making role or even having their voice heard, will continue. Moreover, women and more broadly the LGBTQIA+ community will continue to be victims of trafficking and smuggling, as well as sexual abuse or harassment at sea. Victims of such crimes often have no effective remedy for the violence they have been subjected to. In particular, while at sea, sexual crimes are not officially policed by many flag States who have exclusive jurisdiction and as a result such crimes are not properly investigated (Geneva Declaration on Human Rights).

As also indicated below, people at sea, whether employed or migrating, in particular those individuals who are not under the effective jurisdiction of States capable of protecting their basic human rights, often find themselves in a position of vulnerability and require protection against threats to such rights (Secretary-General's Report on Oceans and the Law of the Sea, UN document A/74/350 (2019)).

1. Migrants[7]

Global migration is expected to increase significantly by 2050. It will no longer be driven just by political conflicts and economics, but also by environmental degradation and climate change, including extreme weather events. (IOM (2014), 'Outlook on

Note 7 See also the White Paper on Migration in ADI/ILA 2023.

Migration, Environment and Climate Change'). Climate change and disasters are expected to have significant adverse effects on States and societal structures, as well as on individual well-being and the enjoyment of human rights (UN High Commissioner for Refugees (2020), 'Legal considerations regarding claims for international protection made in the context of the adverse effects of climate change and disasters').

By 2050, as many as 216 million people could be internally displaced in the context of climate change, with the largest number in the poorest and most climate-vulnerable regions (World Bank, 'Groundswell Report Part II'). For example, Indigenous Peoples are highly vulnerable to climate change and environmental degradation. Those who choose or are forced to migrate away from their traditional lands often face double discrimination as both migrants and as Indigenous Peoples. Indigenous Peoples may be more vulnerable to irregular migration such as trafficking and smuggling, owing to sudden displacement by a climactic event, limited legal migration options and limited opportunities to make informed choices (With UN For Indigenous People, 'Climate Change and Indigenous People'). At the same time, however, Indigenous Peoples must be seen as crucial agents of change because their livelihood systems, occupations, traditional knowledge and ways of life are essential for effective climate action (ILO (2017), 'Indigenous peoples and climate change: from victims to change agents through decent work'. International Labour Office, Gender, Equality and Diversity Branch). It is thus important to recognize their significant role, to grant them access to decent work opportunities and the ability to participate in the development, implementation and evaluation of sustainable policies and measures aimed at combating climate change.

The United Nations High Commissioner for Refugees (UNHCR) has highlighted that people seeking international protection in the context of the adverse effects of climate change or disasters may have valid claims for refugee status in certain situations, for example where the adverse effects of climate change interact with armed conflict and violence (UNHCR (2020), *op. cit.*).

However, the numbers of people that will be either forced to migrate or wish to do so voluntarily will likely result in even stricter immigration policies of destination countries. Refugees and migrants, especially women, children and vulnerable groups will likely be exposed to heightened risks of trafficking, kidnapping for ransom, sexual and gender-based violence and other forms of inhumane and degrading treatment.

People (refugees, asylum-seekers and migrants) travelling together by sea in large numbers and holding different legal statuses are likely to pose challenges to policymakers and practitioners. The likely increase in the exploitation of people by smugglers and large-scale crossings by sea in life-threatening conditions will lead to more distress calls at sea and necessitate large-scale search and rescue operations. Currently insufficient search and rescue, inadequate protection of asylum-seekers and refugees, refoulement and problems of disembarkation are common along many routes.

2. Seafarers

The number of people involved in operating a ship will likely reduce in the future with many aspects of the role of the seafarer being automated or moved ashore. It is likely that there will be a relatively small number of highly paid specialist professionals and a large number of low paid workers conducting maintenance operations on board ships. Port stays will be much shorter due to automation and there will be less access to and from vessels. With smaller crews, the seafarers of 2050 will face not just less opportunity for onboard socialising, but also less opportunity for on-board support if they are targets of bullying, harassment or assault. It is also important to consider that seafarers' safety and welfare will continue to be threatened by conflict, acts of piracy and armed robbery, and other criminal activities and terrorist acts, as well as by a violation of their rights. In addition, for the seafarer of 2050, an increase in events like storm surges and tropical revolving storms comes with obvious risks and challenges.

Furthermore, endemics and pandemics may be more common. Future potential pandemics may, as the COVID-19 pandemic did, continue to render those who work on board ships more vulnerable. During COVID-19, seafarers were more vulnerable and susceptible to the virus as a result of the closed environment aboard ships and lack of proper access to vaccinations and medical care. They also faced unprecedented issues as a result of protective measures imposed by States to control the spread of infection which prevented seafarers from disembarking to carry out crew changes and resulting in seafarers' service on board ship being extended for many months at sea, well beyond the established limits. Incidences of abandonment of seafarers without pay or compensation also increased during the pandemic (C. Doumbia-Henry, 'Shipping and COVID-19: protecting

seafarers as frontline workers', 19 WMU Journal of Maritime Affairs, 279, (2020)) and remains a major problem.[8]

3. Fishers

Fishing is one of the most dangerous occupations with a high number of fatalities. Extreme weather events due to climate change will make fishing at sea even more hazardous in the future as many fishers are going out further to sea in search of fish. Furthermore, unless fishers' human rights and labour rights are better protected in the future, the current widespread practice of exploitation, especially of migrant workers, will continue and may increase. The International Labour Organization (ILO) claims that although many fishing vessels treat their staff well, a lack of regulation and poor enforcement has led to numerous cases of exploitation, including low wages, inadequate living facilities, a lack of safety equipment and endless working hours (J. Baker, 'Fishing's dark side: the need to improve conditions for workers'. Analysis, 6 February 2018). In some cases, fishers are victims of human trafficking or forced labour, especially in the case of IUU fishing operations. Ensuring that vessels are inspected by port State control authorities is the obvious solution, but vessels are often at sea for long periods of time. When vessels do pull into port, the ILO says there are often insufficient inspectors to do the job. Those that are available are sometimes not trained to detect forced labour, do not speak the language of those on-board, or fail to check for issues such as passport confiscation or failure to pay wages (J. Baker, *op. cit.*).

H. Threats to peace and security

The prospect for peaceful uses in the ocean between now and 2050 is uncertain. Disputes and geopolitical instabilities threaten peace and security and adversely impact economic growth, social development and environmental protection. They generally impede implementation of and compliance with global and regional treaties, as well as effective ocean governance and management.

Note 8 During the first three months of 2022, 30 cases of abandonment had already been reported. In 2021, 95 cases were reported and in 2020, 85 cases. Of the cases reported in 2020, 21 were related to the consequences of the COVID-19 pandemic. IMO and ILO are developing guidelines for port State and flag State authorities on how to deal with seafarer abandonment cases. See IMO Media summary of the 109th session of the IMO Legal Committee (March 2022) https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/LEG-109th-session.aspx.

At the same time, conflict, poor economic development, economic disparity, unemployment and poverty, as well as climate change have the potential to lead to more conflict-affected, fragile or poorly governed States, increasing conditions conducive to terrorist and criminal activities, especially transnational organized crime.

In a most optimistic scenario, the different related issues would be resolved through bilateral and international cooperation and coordination, adherence to international law, including the peaceful settlement of disputes, capacity-building and the transfer of marine technology.

1. Maritime disputes

Maritime disputes exist on all continents. The majority relate to unresolved maritime boundaries, including overlapping claims to continental shelves that extend beyond 200 nautical miles from the baselines from which the territorial sea is measured. There are different estimates as to the total number of potential maritime boundaries that remain to be agreed upon, ranging from 250 to 320 in 2020 (A. Østhagen, 'Maritime boundary disputes: What are they and why do they matter?'. 120 Marine Policy, October 2020). Legal certainty regarding the limits of maritime zones is important for the exploration and exploitation of resources, the protection and preservation of the marine environment, as well as for the fight against climate change (see section A). Maritime disputes can also arise in other circumstances, including in the context of the projections for the future which are raised in this White Paper (see also Part 3). For example, such disputes can arise where it is alleged that the rights of the flag State or the coastal State have been violated, or where more broadly violations of environmental and other law of the sea related international obligations have been alleged. In an optimistic scenario, disputes would be settled by peaceful means including through the dispute resolution mechanisms provided for in UNCLOS and judgments would be complied with. Since the *ad hoc* consent of non-States parties will nevertheless remain necessary for a judicial dispute resolution, several maritime disputes could remain unresolved. Moreover, during a period marked by geopolitical tensions, the likelihood of disputes being settled peacefully is reduced.

2. Geopolitical tensions

While the Cold War and post-Cold War periods have been propitious for multilateral arms control and disarmament agreements, in recent years this cooperative approach has been

challenged by great-power politics and unilateralism (M. Finaud, 'OnlyTogether Multilateralism and arms control: the end of an era?', Geneva Centre For Security Policy, 16 October 2020). Such unilateralism is likely to increase in the foreseeable future, in a business-as-usual scenario, resulting in increased militarization and reduced international cooperation at the global level. Globally, it is expected that the naval arms race will lead more countries to increase their naval arms in response to increasing geopolitical tensions (A. Gatopoulos, 'The battle for the Pacific: The countries competing for supremacy', Al Jazerra, 19 April 2022; European Union, 'Questions and Answers: Defence Investment Gaps and measures to address them', 18 May 2022). Competition in the naval arena, including simmering conflicts that could become clashes between navies, represents some of the largest naval competitions since the Cold War and World War I (S. J. Frantzman, 'A new global naval arms race is underway', The Hill, 7 December 2021) The naval arms race could either increase the possibility of disputes and war or it could act as a deterrent. The prevention of incidents at sea will be critical.

3. Terrorist and criminal activities

Maritime security can be threatened by illicit traffic in narcotic drugs and psychotropic substances, the smuggling of migrants, trafficking in persons and illicit trafficking in firearms, piracy, armed robbery against ships at sea, terrorist acts against shipping, offshore installations and other maritime interests, illicit traffic in wildlife, as well as cyber attacks. In a business-as-usual scenario, these activities are likely to increase by 2050 and the scope of criminal activities is also expected to increase. For example, environmental crime is expected to change, with the trafficking of e-waste being increasingly important. (Europol (2015), 'Exploring Tomorrow's Organized Crime'). Organized Criminal Groups (OCGs) are also increasingly involved in trafficking in cultural property and so far efforts to combat such trafficking have not been in proportion to the gravity and extent of this criminal manifestation (UNODC, 'Emerging Crimes').

It is also likely that criminals will make extensive use of advances in technology for their illegal activities. New technologies enable the fast and often undetectable movement of large quantities of illicit commodities. As transportation and logistics infrastructures rely more and more on online systems and automated remote management, OCGs will increasingly rely on intrusion

into these systems to manipulate transport routes, infiltrate supply chains and gather valuable and sensitive data.

Currently, they are using 'self-propelled semi-submersibles (SPSS)' which combine substantial drug payload capacity, long-range transit, and a low or non-existent surface profile (B. Wilson, 'Submersibles and Transnational Criminal Organizations', 17 Ocean and Coastal Law Journal 35, (2011), p. 39). It is anticipated that drones and unmanned automated vehicles will be used by criminals to smuggle migrants, traffic persons as well as illicit goods, thus maintaining merely a virtual link to their criminal activities.

Just as criminals invent new *modi operandi*, law enforcement authorities also make use of technological innovation and develop new investigative measures to counter threats to maritime security. In the future, Governments are likely to use maritime autonomous vehicles (MAVs) in surveillance in order to enhance their law enforcement.

I. Ocean governance and management

Many of the activities and uses affecting the ocean and people at sea are global in nature and involve multiple actors, but when they are being addressed it is mainly done on a sectoral basis or less-than-global scale, creating a patchwork of policies and legislation. A general failure to achieve the integrated management of human uses of the ocean is increasing risks to the benefits that people draw from the ocean.

Currently, management of ocean activities and uses is often not motivated by sustainable development considerations, but rather by short-term economic gains. There has been no real integration of the three pillars of sustainable development in management approaches. Moreover, ineffective cooperation and coordination at all levels has led to fragmentation of ocean governance and also to competing or overlapping activities. A continuation of the current fragmented approach in a business-as-usual scenario can lead to conflicts among ocean users in the future since an exponential increase in the demand for ocean space is expected.

When it comes to area-based management tools (marine protected areas, marine spatial planning, and integrated coastal zone management, among other tools), it is expected that by 2050, at least 30% of the ocean will have been designated as marine protected areas. However, without effective management measures such areas will be nothing more than 'paper parks'. The conduct and scope of EIAs also need to be strengthened

in light of the main drivers and pressures on the ocean (see also Part 3, section B).

Management would be better equipped to achieve the fundamental goal of protecting and maintaining natural systems if it recognized the wide range of ecosystem services and benefits derived from the ocean. Challenging to most management systems is the need to accommodate the multiplicity of values, for which real or perceived benefits cannot be equated with each other or reconciled. The best opportunities to understand and address multiple values are those that engage affected communities in the management approach, as they are the most sensitive to the cultural value of the ocean.

3.

questions
and potential solutions

Based on the analysis provided in Parts 1 and 2, Part 3 will explore, notably through a series of questions, the particular implementation, compliance and enforcement challenges, legal challenges as well as ocean governance and management challenges which may arise between now and 2050 and which would need to be addressed. Some solutions will be suggested where these currently exist, but this Part mainly raises relevant questions.

A. Addressing implementation, compliance and enforcement challenges and legal challenges

When international norms exist, but are not effectively implemented, complied with and enforced and/or when several States are not bound by them because they are not parties to UNCLOS, its implementing agreements and other relevant treaties and the relevant provisions are not recognized as customary international law, implementation, compliance and enforcement challenges can arise. Legal challenges can arise when the legal questions raised are not addressed or are inadequately/insufficiently addressed by existing international law. At times, the identification of what is an implementation, compliance or enforcement challenge and what is a legal challenge is not so clear and can be the subject of divergent views and therefore this White Paper will address them jointly. The issues that have been identified are not intended to be exhaustive.

In addition to legally binding international instruments, general principles or customary international law, numerous important non-binding legal instruments have been adopted over the years, including the 2030 Agenda for Sustai-

nable Development and numerous General Assembly resolutions on oceans and the law of the sea and on sustainable fisheries. Soft law approaches have dominated the law of the sea in recent years[9].

Have soft law approaches been effective or should the international community focus its efforts more on the development of hard law, because of its legally binding nature? Are some soft law instruments more effective than others? If so, why?

1. General issues

First and foremost, universal participation in UNCLOS and its implementing agreements is needed and further action must be taken to promote universal participation. But progress in this area will not necessarily result in more efficient implementation of, compliance with, and enforcement of UNCLOS and its implementing agreements (UN, 'Interactive dialogue 7' UN document A/CONF.230/2022/7 (2022)). If not addressed, scientific, technical, financial, institutional and legal capacity constraints, in particular of developing countries, will continue to preclude significant progress in the effective implementation of, compliance with, and enforcement of international law as reflected in the Convention (UN, Preparatory process of the 2020 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. Note by the Secretary-General. UN document A/74/630 (2019)).

Note 9 A panel in June 2023 will address the new relationship between hard law and soft law.

Is there a need for a periodic dialogue on the implementation of, compliance with, and enforcement of UNCLOS focussed in particular on obstacles/challenges encountered by States, including resource and capacity-building needs and priorities (other than those relating to the implementation of the future BBNJ agreement)? If yes, how and where should such dialogue take place?

The future BBNJ agreement is still being negotiated. Following its adoption, it will be critical to ensure its early entry into force and effective implementation.

Universal participation in the plethora of other multifaceted legal instruments, which together with UNCLOS and its implementing agreements comprise the law of the sea, is equally important, as well as their effective implementation and enforcement. The speedy entry into force of treaties that have not attained that status is also essential, for example, the Cape Town Agreement of 2012 on the Implementation of the Provisions of the Torremolinos Protocol of 1993 relating to the Torremolinos International Convention for the Safety of Fishing Vessels, 1977 (Cape Town Agreement) which is critical for the safety of fishing vessels and fishers and the amendments to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (the London Protocol) which regulate marine geoengineering.

What action can be taken to promote universal participation in UNCLOS related treaties? How can States be encouraged to become parties to the Cape Town Agreement and the amendments to the London Protocol?

Effective implementation of, compliance with, and enforcement of the law of the sea by coastal and flag States is paramount. Concerns and questions have been raised in particular regarding the adequacy of the legal regime in UNCLOS relating to the high seas which effectiveness and that of other treaties relies almost exclusively on effective implementation, compliance and enforcement by flag States. However, the performance level of flag States varies. Indeed, it has been suggested that the increased use of maritime autonomous surface ships (MASSs) in the future might result in a further decrease in the ability of some flag States (mostly those that have been referred to as 'flags of convenience') to take enforcement measures.

What further actions can be taken to improve flag State implementation, compliance and enforcement, in particular on the high seas?

Where States are either unable or unwilling to take the required measures to ensure compliance with the law of the sea, enforcement measures taken by other States can also provide a very important security and safety net. This is particularly pertinent in combating and suppressing terrorist acts and criminal activities at sea in accordance with UNCLOS and other relevant treaties. In fact, in most cases, ineffective flag State jurisdiction has resulted in a heavy reliance on port States to carry out enforcement actions, including in relation to substandard shipping and violations of relevant IMO treaties, violations of the ILO Maritime Labour Convention and in the case of IUU fishing. Cooperation among port States is also crucial. It has been suggested that exchange of information among port States and harmonization of inspection and detention procedures can provide incentives to shipowners and flag States to improve their performance (Z. Oya Özçayir, 'The Use of Port State Control in Maritime Industry and the Application of the Paris MOU', 2008 14(2) Ocean and Coastal Law Journal, (2008), p. 201).

How can exchange of information on ships that have been inspected be further facilitated among port States? Should standards for inspection and detention of ships be harmonized among port States? Is port State control enough to ensure sustainable shipping and fisheries?

States must also be held accountable for lack of compliance with the law of the sea not only vis-à-vis other States, but also individuals whose rights may have been violated. However, port State, coastal State and *a fortiori* flag State liability cases for failure to fulfill their obligations are too rarely brought before international courts. Indeed, although the law of the sea provides for numerous and precise enough due diligence port, coastal and flag State obligations, as well as for a compulsory dispute resolution mechanism, and although the violations which could lead to referral to these mechanisms are numerous, States often remain reluctant to seek liability for damages resulting from action or inaction of their peers.

Are port, coastal and flag States' due diligence obligations enough? Is there a need for strict liability of States, especially when it comes to serious or significant environmental damage? Would a shift towards a more frequent engagement of States' liability before international courts for the violation of law of the sea obligations lead in fine to better implementation, compliance and enforcement?

Moreover, except in the case of seabed mining in the Area, UNCLOS only defines the legal responsibility and liability of States with respect to ocean activities and uses vis-à-vis other States. It does not address that of the private sector and corporate social responsibility. Furthermore, excluding the Seabed Disputes Chamber, no international tribunal has jurisdiction vis-à-vis private entities for violation of 'law of the sea' international obligations. However, as indicated in Part 2, an increasing number of private actors are already engaged in ocean activities and that number will very likely increase in the future. It has been argued that high levels of concentration of private sectors in the ocean economy pose clear risks to achieving widely shared goals for sustainability by contributing to inequality in access to ocean benefits and resources (E. Havice, L. M. Campbell, L. Campling, & M.D. Smith, 'Making sense of firms for ocean governance' One Earth, 4(5), (2021), p. 602-604). Plus, the dominance of a small number of transnational corporations, headquartered in a handful of countries and regions, can enable targeted lobbying of regulators to weaken social or environmental standards or to set barriers to entry in an industry that hinder sustainable practices across national or international levels. It has been suggested that solutions to ineffective implementation concerning environmental obligations should revolve around the idea of making pollution more costly than greener alternatives and encourage green innovation (OECD 2050).

Can activities by private actors always be attributed to a State? Is it always clear which State is exercising jurisdiction or control over an activity? Who is responsible and liable in the case of for example adverse impacts on the marine environment from cumulative sources where multiple actors are involved and which would be the appropriate forum for such cases?

How can the private sector be encouraged to sign up and endorse the Sustainable Ocean Principles of the United Nations Global Compact? How can financiers and regulators be encouraged to adopt and implement the Sustainable Blue Economy Finance Principles and associated UNEP Guidance? What legal responses can strengthen action towards effective implementation?

In terms of liability, compensation limits are not always implemented uniformly at the national level. Indeed, in some cases, national courts have set a higher compensation limit than what is provided for in the relevant international convention.

Should uniform compensation limits be promoted through the relevant international fora?

Lastly, the bodies established by UNCLOS and competent international organizations also bear a responsibility, within the specific limits of their mandate, to ensure the uniform and consistent application of the law of the sea. In particular, the role of the judicial bodies in also promoting the uniform and consistent interpretation of UNCLOS and other related treaties cannot be overstated.

2. Selective topical issues

(a) Fisheries

With regard to fisheries, the elimination of subsidies for IUU fishing and universal participation in and effective implementation of, compliance with and enforcement of relevant FAO treaties and the WTO Agreement on Fisheries Subsidies, adopted on 17 June 2022, is critical as is the implementation of the Code of Conduct for Responsible Fisheries (FAO 2022 World Fisheries Report, p. xxii). When it comes to fighting IUU fishing specifically, there is a need to establish a fully operational Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels which can make available, in a rapid way, certified data from State authorities about vessels and vessel-related activities. Current efforts by FAO to regulate, monitor and control transshipment events, particularly those taking place at sea, to mitigate the risk of supporting IUU fishing operations are also crucial (FAO (2020), 'Transshipment: a closer look – An in-depth study in support of the development of international guidelines', *op. cit.*). It remains to be seen whether the Voluntary Guidelines for the regulation, monitoring and control of transshipment to be submitted to the Committee on Fisheries for its endorsement in September 2022 will suffice (https://www.fao.org/iuu-fishing/tools-and-initiatives/transshipment/en).

What further measures should be taken to address IUU fishing?

In addition, there is also a need for responsive and effective stringent fisheries management, responsible aquaculture growth and improvements in technology, innovations and research (FAO 2022 World Fisheries Report, p. 223). Furthermore, it is also necessary to address the non-uniformity of regional fishery management organizations (RFMO) regulations and to improve coordination and data transparency between organizations, flag States, regional bodies, scientific establishments and coastal and market States. (S. Widjaja, T. Long, H. Wirajuda, & al., *op. cit.*). Moreover, if mesopelagic fishing (see Part 2, section E) were to take place in the future, it would certainly challenge the ability of the UN Fish Stocks Agreement and RFMOs to capture the potential climate change effects of interfering with the biological carbon pump through their existing approaches to new and exploratory fisheries.

How can implementation of, compliance with and enforcement of relevant international legal instruments requiring the sustainable management of the world's fisheries be enhanced? How can the role of regional fisheries management organizations/arrangements (RFMO/As) be strengthened? How can multi-stakeholder partnerships, which include RFMO/As, be fostered? How can technology be used to make seafood supply chains more sustainable but not create barriers to trade for small-scale fisheries and artisanal fisheries? How and by whom should the effects of mesopelagic fishing be assessed? How might the precautionary approach/principle and ecosystem approach be more effectively implemented in fisheries management?

(b) Environmental degradation

As far as environmental degradation is concerned, an essential action that States can take is to comply with their obligations under UNCLOS and many other related treaties and legal instruments that protect and preserve the marine environment. While there are many sources of pollution of the marine environment which need to be prevented, reduced and controlled, among them plastics, adopting source-to-sea approaches to marine pollution is much more effective than cleaning up afterwards. Other forms of habitat destruction may also require a broader mix of regulations including area-based management, in addition to pollution controls.

How can States be supported in the effective implementation of, compliance with, and enforcement of the legal regime governing the protection and preservation of the marine environment? [e.g. capacity-building and the transfer of marine technology]

Many conferences and other events have focused on encouraging registration of voluntary commitments to promote sustainable development of the ocean and its resources, e.g. UN Ocean Conferences 2017 and 2022 and Our Ocean Conferences.

How effective have voluntary commitments been in promoting sustainable development?

However, increasingly legal responses to lack of compliance with international obligations are being considered, including rights-based approaches. For example, it has been suggested that 'ecocide' should be included as an international crime in the Rome Statute (Stop Ecocide Foundation). Some countries have granted rights to nature itself and there has been growing

awareness that recognition of the rights of Nature is embedded in customary laws (UN (2020), 'Harmony with Nature. Report of the Secretary-General' and Supplement to the Report). These two approaches can be complemented by the obligation of the responsible State to make full reparation for the injury caused (see also the International Law Commission (ILC) articles on Responsibility of States for Internationally Wrongful Acts).

What legal responses can strengthen action towards effective implementation and compliance? Should 'ecocide' be considered an international crime? If yes, how would it be defined and what acts in the marine environment might constitute ecocide? Should the ocean or part thereof be granted rights protected by law?

Apart from implementation and compliance concerns, there are also some specific marine environmental issues which may not be adequately regulated or where there is a legal challenge. For instance, anthropogenic underwater noise, which is a form of energy and part of the definition of pollution of the marine environment under UNCLOS, has not been regulated at the global level. In particular, no mandatory international rules and standards have been adopted to prevent, reduce and control underwater noise pollution from vessels, which is a major source of noise pollution (see Part 2, section D). In 2014, IMO adopted Guidelines for the Reduction of Underwater Noise from Commercial Shipping to Address Adverse Impacts on Marine Life, but there has been limited uptake of the Guidelines and they have not been effective.

Is a global legally binding instrument required in order to regulate pollution from anthropogenic underwater noise from vessels? Are there other sources of anthropogenic underwater noise that might require regulation at the global and/or regional levels?

While it is not yet clear whether States will decide to undertake seabed mining within national jurisdiction in the future, consideration could nonetheless be given to the development, with the involvement of all relevant stakeholders, of global and regional rules, standards and recommended practices and procedures in accordance with UNCLOS, article 208. The experience of the ISA in developing seabed-mining regulations for commercial exploitation can provide useful guidance, although deep seabed mining and the prospect of industrial exploitation also continue to raise legal questions.

Should global and regional rules, standards and recommended practices and procedures for seabed mining within national jurisdiction be developed in accordance with UNCLOS, article 208? If yes, should they also include provisions on responsibility, liability and compensation? Can the advisory opinion of ITLOS on Responsibilities and obligations of States sponsoring persons and entities with respect to activities in the Area provide enough guidance for a comprehensive liability regime in case of industrial seabed mining?

It is not yet possible to forecast how a changing geopolitical landscape coupled with an increasing demand for minerals and the impact of climate change might play a major role in 2048 when there is a possibility to modify or amend the Protocol on Environmental Protection to the Antarctic Treaty and decide whether or not to continue with the moratorium on mining currently in place. The Convention on the Regulation of Antarctic Mineral Resource Activities is not in force.

(c) Climate change and sea-level rise

Climate change and in particular sea-level rise raise not only interpretation issues of existing international law, but also questions not yet covered by UNCLOS (ILC 2018 Report A/73/10). Many island States have stated that maritime zones as established and notified to the UN Secretary-General in accordance with UNCLOS, and the rights and entitlements that flow from them shall continue to apply, without reduction, notwithstanding any physical changes connected to climate change-related sea-level rise. It has notably been defended by the Pacific Islands Forum (Pacific Islands Forum, Declaration on Preserving Maritime Zones in the Face of Climate Change-Related Sea-Level Rise (6 August 2021)), as well as by the Alliance of Small Island States (Agreement for the Establishment of the Commission of Small Island States on Climate Change and International Law (Glasgow, 31 October 2021). The International Law Association (ILA) has considered questions of international law and sea level rise in 2018 (ILA (2012), Final report of the Committee on Baselines under the International Law of the Sea, Report of the Seventy-fifth Conference, vol. 75 ; ILA (2018) Report International Law and Sea Level Rise) and the ILC is currently working on a number of questions (see Secretary-General's Report on Oceans and the Law of the Sea, UN document A/75/70 (2020)

and ILC report A/73/10). In addition, several States have raised questions of damages and liability within the UN Framework Convention on Climate Change and the Paris Agreement.

Which responsibility and liability issues can be raised with regard to climate change and its harmful consequences or for failure to comply with obligations to protect the marine environment?

States particularly affected by sea-level rise are likely to seek, in the immediate future, directly or indirectly as the case may be, an advisory opinion from either the ITLOS or the ICJ (https://commonwealthfoundation.com/wp-content/uploads/2021/12/Commission-of-Small-Island-States-on-Climate-Change-and-International-Law.pdf).The framing of the legal questions in such a context, as well as the choice of *forum,* would be crucial (http://www.cambridgeblog.org/2021/12/judicial-proceedings-to-clarify-international-law-on-climate-change/).

(d) Technological advances

Various forms of technological advances have generated several questions, especially since laws have not always been able to keep pace with advances in technology.

(i) With regard to marine scientific research, concerns have been raised with respect to the use of autonomous devices (IOC/UNESO, Expert Meeting Report of 'Ocean Observations in Areas und National Jurisdiction (OONJ) Workshop, 12-13 February 2020', IOC Report No.: GOOS-246 (November 2021)): for instance, the advance notice of no less than 6 months as provided for in UNCLOS has been considered incompatible with the sustained ocean observing from some platforms; confusion has also arisen regarding the general process for obtaining the consent of the coastal State; some coastal States do not have a procedure in place to apply for marine scientific research clearance for some of the newer ocean observing technologies, leaving the operator of that technology without a mechanism under which to apply for consent from the coastal State. Coastal States have for their part expressed concerns regarding the taking of ocean observations within areas under national jurisdiction, revolving mainly around their rights, resources and security. However, the Argo notification scheme, which reflects a decision by the governing bodies of the Intergovernmental Oceanographic

Commission (IOC), has been described as successful in that all data is made freely available and accessible from open and publicized portals. The importance of raising awareness of the value gained from ocean observations has also been underlined.

Should a process equivalent to the Argo notification scheme be developed and applied to other autonomous platforms/variables? Should the UNCLOS article 247 process be used to undertake ocean observations after adoption of a project by the IOC?

The use of new technologies in the field of marine scientific research has also implications for the access and benefit-sharing regime under the Convention on Biological Diversity and its Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization.

What are the implications of the use of autonomous devices within areas under national jurisdiction for the implementation of the access and benefit-sharing sharing regime under the Convention on Biological Diversity and its Nagoya Protocol?

(ii) Concerns have also been expressed with respect to technological advances in the field of marine geoengineering, in particular since the amendments to the London Protocol regulating marine geoengineering are not yet in force. The development of a code of conduct for ocean CDR research by an international body, with input from the research community and other stakeholders has been proposed and it has been suggested that compliance with the code could be made a condition of government or private funding for ocean CDR research ('A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration', *op. cit.*).

Should a code of conduct for ocean CDR research be developed on an urgent basis by an intergovernmental body? Should all ocean CDR projects be prohibited pending the applicability of comprehensive international and national legally binding regulations?

(iii) Technological advances in the field of offshore renewable energies have also raised several questions, in particular in relation to floating offshore turbines and floating offshore substations. Many States assign the registration of ships and that of installations or structures to the same agency or authority. More generally, it has been suggested that international bodies such as the International Organization for Standardization and the International Electrotechnical Commission need to develop and update the international standards for offshore renewables and connection arrangements. Furthermore, there is a need to develop standards specifically for floating solar PVs (IRENA (2021), 'Offshore Renewables...', *op. cit.*, p. 77).

Do floating offshore substations fit the definition of artificial islands, installations and structures under UNCLOS? Who would have jurisdiction over offshore wind farms and floating offshore substations on the high seas? Should offshore renewable energy activities on the high seas be regulated? While not yet concluded, the future BBNJ agreement is expected to contain some relevant provisions in that regard.

(iv) Questions can also arise with respect to the legal status under UNCLOS of floating cities.

Do floating cities fit the definition of artificial islands, installations and structures under UNCLOS?

(v) Technological advances in the area of submarine cables (see Part 2, section D.4), including the increased use of submarine fibre optic cables and submarine power cables, their vital importance for international communications and for offshore renewable energy, the increasing involvement of private actors, and the limited number of States that have national laws and regulations in place to effectively protect submarine cables and render their willful damage or damage by culpable negligence

punishable offenses (R. Beekman, 'Protecting Submarine Cables from Intentional Damage', in Submarine Cables: the Handbook of Law and Policy (D. R. Burnett & al. eds., 2014), p. 287 n. 37 and UNGA Resolution 76/72 on Oceans and the Law of the sea (2021)) have raised questions as to the adequacy of the current legal regime to protect submarine cables (T. Davenport, 'Submarine Cables, Cybersecurity and International Law: An Intersectional Analysis', 24 Cath. U. J. L. & Tech. 1, (2015), 57, 83 and Y. Takei, 'Law and Policy for International Submarine Cables: An Asia-Pacific Perspective', Asian J. Int'L. L. 2, (2012), p. 228). It has been noted that it is also unclear what enforcement rights, if any, a coastal State has with respect to a foreign vessel suspected of damaging a submarine cable outside of its territorial sea (E. A. O'Connor, 'Underwater Fiber Optic Cables: A Customary International Law Approach to Solving the Gaps in the International Legal Framework for their Protection', Naval Law Review LXVI, (2020)).

Does UNCLOS or customary international law allow coastal States to extend their jurisdiction beyond the territorial sea to offenders who intentionally damage submarine cables? Does article 79 of UNCLOS apply to submarine cables on the continental shelf connecting fixed substations and the onshore grid? Is the current legal regime governing submarine cables adequate?

(vi) With regard to the shipping industry's technological advances, IMO Conventions will need to be evaluated to determine whether they need to be updated and whether new instruments are needed to ensure safe, secure and environmentally sound MASS. A range of multifaceted issues will need to be taken into account including jurisdiction, navigation and prevention of collisions at sea, protection of the marine environment, liability, compensation and insurance, seafarers of the future, construction requirements and the technical conditions of these ships. New regulations or amended regulations will be required through the IMO, the World Trade Organization, the United Nations Conference on Trade and Development and the World Customs Organization, and the ILO (C. Doumbia-Henry Cleo, *op. cit.*). MASS raise a number of legal questions. It has been observed that UNCLOS, IMO and other conventions are premised on human presence on board, or even those, like the International

Regulations for Preventing Collisions at Sea and the International Convention for the Safety of Life at Sea (SOLAS), which at times demand uniquely human judgments (J. Coito, 'Maritime Autonomous Surface Ships: New Possibilities—and Challenges—in Ocean Law and Policy', 97 Int'L. L. Stud., (2021), 259).

IMO completed a regulatory scoping exercise which provides the assessment of the degree to which the existing regulatory framework under several of its Committees (IMO document MSC.1/Circ.1638 (2021), IMO document LEG.1/Circ.11, annex, and IMO Media Centre summary of the 46th meeting of FAL (May 2022)) might be affected in order to address MASS operations. It has begun developing a non-mandatory Code to regulate the operations of MASS, to be adopted by 2024 and followed by a mandatory code expected to enter into force by 2028 (IMO Media Center summary of the 105th MSC meeting (April 2022)).

Do MASS meet the requirements of a 'ship', in particular the requirement of manning of ships in article 94 of UNCLOS?

Other legal issues raised by MASS include their implications for the duty to rescue at sea in accordance with UNCLOS, article 98, the International Convention on Maritime Search and Rescue and SOLAS; and flag State obligations under refugee law; as well as the implications of MASS for the genuine link 'requirement' and the interpretation of UNCLOS, article 94, concerning effective jurisdiction and control (IMO document LEG 109/6 (2022)).

Would the flag State of a MASS be able to comply with its obligations under UNCLOS, in particular article 94? If there is no 'master' on board a MASS, would the flag States be able to comply with the requirements under article 98 of UNCLOS?

(vii) Technological advances in naval vehicles, also raise legal questions in particular in relation to maritime autonomous vehicles (MAVs).

Does a MAV meet the definition of 'warship' under UNCLOS, which requires the ship to be 'under the command of an officer' and 'manned by a crew' at sea? Is a MAV, for example, a glider, clearly marked and identifiable as being in government service (for non-commercial purposes) a ship that has immunity?

It is important to also have a common understanding of the legal status of MAVs in the context of enforcement measures, including for the suppression and combating of criminal activities at sea.

Can MAVs be used on the high seas and in the EEZ to exercise the right of visit pursuant to article 110 of UNCLOS which permits a warship which encounters another ship (other than one entitled to complete immunity) to board the ship if for example, there are reasonable grounds to suspect that the ship is engaged in piracy, slave trade, or is without nationality? Can a MAV be considered a warship or other ship clearly marked and identifiable as being on government service and authorized to that effect as required by UNCLOS, article 111? Are MAVs able to meet the other requirements in article 111?

In the context of enforcement, legal questions also arise in relation to specific criminal activities that are addressed in UNCLOS and in other treaties that involve the use of MAVs.

Can an attack using MAVs with no crew on board be classed as an act of piracy and be subject to universal jurisdiction under UNCLOS? Also, can an unmanned ship whose controlling software has been hacked from the shore, another ship or an airplane, be regarded as a pirate ship?

Can a MAV be used in the context of enforcement measures under the United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances? Mutatis mutandis, *the same legal questions arise with regard to flag State consent in the context of the application of the Palermo Protocol against the Smuggling of Migrants by Land, Sea and Air, complementing the 2000 UN Convention against Transnational Organized Crime, and in the context of the application of the 2005 Protocol to the Convention for the Suppression of Unlawful Acts against the Safety of Maritime Navigation.*

(viii) More generally, when it comes to maritime security, the scope of what may be considered a threat to maritime security might need to be updated, especially in response to an increased emphasis on the link between security and environmental protection, including climate change, as well as security and offshore and underwater infrastructure, as well as in the light of the dynamic and expanding nature of criminal activities at sea. Currently there is no common understanding among States of what constitutes a threat to maritime security which can hinder international cooperation in suppressing and combating such threats. Regional strategies, such as the 2050 Africa Integrated Maritime Strategy, which takes a multidimensional and integrated approach to maritime security, can assist in fostering a common understanding.

Should a common understanding of threats to maritime security be reached at the global level? Should a global strategy or additional regional strategies which take a multidimensional and integrated approach to maritime security be developed? What other legal instruments might be required to strengthen international cooperation in dealing with threats to maritime security?

(ix) Last but not least, while technological advances related to the economic, environmental and social uses of satellites in the future will create great opportunities for inter alia, monitoring, control and surveillance of fishing activities and marine pollution, monitoring of sea-level rise and meteorological phenomena, and even for locating emergency signals, their use will also inevitably raise legal questions concerning data transmission and protection.

(e) Social aspects/human dimension

(i) With regard to social aspects and human rights, it can be noted that access to ocean resources is rarely equitably distributed, and discussions on environmental sustainability have largely overshadowed concerns about social equity. Also, full and productive employment and decent work for all and gender balance have not been realized. As indicted below and in Part 2, section G, people working at sea and migrants are particularly vulnerable to human rights violations.

While the principle of equal rights of people, including gender equality, is affirmed in the preamble of UNCLOS and is incorporated in a number of other provisions referring to 'mankind', the Convention, its implementing agreements and related law of the sea treaties mainly regulate ocean activities and uses by States, with the exception of those relating to maritime labour.

The law of the sea and human rights law have evolved separately and are generally self-contained. The law of the sea remains statocentric and does not recognize individuals as its subjects. Many flag States have not enacted legislation to ensure that they can meet their obligations under UNCLOS and international human rights law at sea or are unwilling or unable to police or enforce it (I. Papanicolopulu, A. Longo & D. Mandrioli, 'Written evidence (UNC0033) on UNCLOS: fit for purpose in the 21st century?' for the House of Lords, International Relations and Defence Committee_; A. Petrig, 'Oral evidence: UNCLOS: fit for purpose in the 21st century?' House of Lords, International Relations and Defence Committee/; N. Klein, 'Oral evidence: UNCLOS: fit for purpose in the 21st century?', House of Lords, International Relations and Defence Committee). Moreover, although a coastal State has under international human rights law jurisdiction over an individual whose human rights have been violated, it may pursuant to UNCLOS decide not to take any action in its territorial sea against the foreign ship where the individual is because it does not consider that the passage by the foreign ship is prejudicial to its peace, good order and security.

There is also a lack of expeditious procedural remedies for individuals to invoke the protection of their rights since victims are hardly able to bring a case against their oppressors (individuals or State) before domestic and international courts and when they managed to do this, this usually takes years and years (I. Papanicolopulu & al. *op.cit.*). Thus, as far as the rights of people at sea are concerned, it has been suggested that there is a need for a complementary and unified application of the various self-contained legal regimes concerning human rights at sea,

including UNCLOS, human rights law, refugee law and labour law standards (Human Rights at Sea, 'Written evidence (UNC0016) on UNCLOS: fit for purpose in the 21st century?' for the House of Lords, International Relations and Defence Committee). In this regard, it can be noted that the Geneva Declaration on Human Rights at Sea (*op. cit.*) recalls the existing legal obligations and provides guidelines for use by coastal, flag and other States.

What legal measures are required to protect human rights of people at sea? Is there a need to develop a global legally binding instrument?

Apart from the effective implementation of the current applicable legal framework comprised of human rights law, the law of the sea, maritime law, labour law and criminal law, as well as policy instruments, such as the 2030 Agenda for Sustainable Development and its Sustainable Development Goal 5, consideration could also be given as to whether additional legal measures are required to address gender inequality in the maritime industry (I. Papanicolopulu (ed.), *Gender and the law of the sea,* Brill, Nijhoff, 2019, 388 p.).

Are special legal measures required to achieve gender equality in an ocean context, as well as the empowerment of women, as well as the protection of women at sea?

Another human right that requires special consideration is the right to a clean, healthy and sustainable environment (Human Rights Council resolution 48/13 (8 October 2021).

How would a violation of the human right to a clean, healthy and sustainable environment, which includes the marine environment, be determined? Who could claim that such a violation took place and in front of which forum? How might international community interests be represented?

Apart from these more general questions, more specific questions can also be raised in the context of UNCLOS and other law of the sea instruments in particular in relation to the rescue of migrants and the working conditions of seafarers and fishers, as indicated below:

(ii) With regard to migrants, as indicated in Part 2, section G, a significance increase in global migration is expected by 2050.

The maritime route is often preferred by migrants especially by those who are travelling clandestinely with the assistance of smugglers and/or traffickers. Those migrants often find themselves in distress situations in particular if their mode of transportation is unseaworthy. Although firmly established in international law, the obligation to rescue persons at sea is not always complied with. When it is, shipmasters often face difficulties disembarking people rescued at sea, although coastal States are obliged to coordinate and cooperate so that the rescued persons are disembarked from the assisting ship and delivered to a place of safety. Questions related to the impact of MASS on the fulfillment of the duty to rescue at sea are raised above. Another crucial concern is the push-back and refoulement of migrants.

What further measures are required to strengthen the legal regime to ensure that persons in distress are rescued and delivered to a place of safety? What does the obligation to deliver those rescued to a place of safety imply? Does the principle of non-refoulement apply to all ships equally? How to ensure accountability for violations of refugee and human rights law at sea?

(iii) When it comes to the rights of seafarers there is a need for universal participation in the Maritime Labour Convention (MLC) and effective implementation of its provisions by flag States. Port State control to verify compliance by foreign ships with the requirements of the MLC is also critical and should be strengthened. Detention and the imposition of sanctions against ships that do not comply with the MLC should be promoted and harmonized on a regional or global basis along with Port State Control procedures (For example, measures taken by Australia against ships for serious breaches of the MLC, included detention of the ship, directing the operator of the ship to pay outstanding wages and change the crew and banning a ship from its ports for six months, see https://www.offshore-energy.biz/australia-bans-bulker-for-underpaying-crew/).

Protecting the vulnerable and delivering welfare services will also require new approaches, for example, investing in digital outreach for those who are on board and the creation of seafarer support centers for those who are ashore, and conducting a strategic review of local seafarer services around the world. The establishment of a global seafarer advocacy organization to lobby for funding and better standards as well as to support individual seafarers has also been recommended (N. Gardner & N. Chubb, 'A fair future for Seafarers?' Thetius Inmarsat). Incidences of abandonment of seafarers and crimes against seafarers must be prevented.

How can the safety and rights of seafarers be further protected?

(iv) Concerning fishers, as indicated in Part 2, section G, unless their human rights and labour rights, are better protected in the future, the current widespread practice of exploitation, especially of migrant workers, will continue and may increase. Broad participation is required in the Work in Fishing Convention (C188) and the Cape Town Agreement needs to enter into force. But other measures may also be required since for example, the Work in Fishing Convention (C188) does not apply to small fishing vessels. Also, while port State control is critical, some vessels may not dock to restock, instead transferring their catch to another boat while still at sea. Furthermore, some fishing vessel operators simply switch the flags on their vessel, linking it with countries that have less strict or non-existent standards.

Linking employment conditions for fishers to fishing licences (as in the case of the Pacific Islands Forum Fisheries Agency, see Joint Media Release: Ending Slavery at Sea headlines key Regional Fisheries Meeting (10 May 2019)) or to the use of yellow or red cards in the context of combating IUU fishing (used by the European Union) could be effective tools towards an improvement of labour conditions.

How can the human and labour rights of fishers at sea be effectively protected? What role could regional fisheries management organizations play? Should licensing provisions that include crew employment conditions be widely recommended? Should trade arrangements relating to fisheries incorporate a requirement regarding decent labour conditions in the fishing industry?

B. Addressing ocean governance and management challenges

The synergies and interactions between all the sectors examined in this White Paper, and the management of the different challenges highlighted in Part 2 call for an integrated approach, encompassing science, policies and laws, economics, ocean literacy, education, participation of stakeholders and international cooperation on capacity-building, and transfer of technology, as well as technical and financial support at multiple levels (WOA II, vol. II, p. 168).

1. General issues

Effective ocean governance requires a coherent cross-sectoral, integrated approach to ocean management based on agreed legal frameworks and principles, such as the precautionary approach/principle and ecosystem approach, best available science, the traditional knowledge of Indigenous Peoples and local communities, and participatory and inclusive decision-making. It will necessitate the integration and mainstreaming of the three pillars of sustainable development at all levels, in particular environmental protection and social development, but also international human rights, including a gender perspective; the development of a supportive policy framework and legal measures that enhance integrated, ecosystem-based approaches; and the establishment of the supporting institutional frameworks to achieve cross-sectoral cooperation and coordination at all levels.

How can the international community advance the adoption of policy, legal and institutional frameworks that lead to integrated, ecosystem-based approaches?

The increasing number of activities that are expected to take place in the ocean in the future and the current fragmented governance system also raise a number of more specific questions.

How can competing interests be reconciled? Can the 'due regard' obligation in UNCLOS effectively balance the various interests of States? Is guidance needed on how to implement the 'due regard' obligation? How can governance policies effectively address multisectoral cumulative impacts? Since emerging industries might require the same infrastructure, how could synergies be explored?

The need for cooperation at all levels, including between and among States and international organizations cannot be underestimated. Such cooperation also needs to include effective collaboration with all relevant stakeholders, including the private sector and industry, in particular in order to promote a shift towards more sustainable solutions (WOA, II, vol. II, p. 169). Participation of relevant stakeholders in the development of policy and decision-making is critical. Another key aspect of participatory approaches is the sharing of benefits derived from the ocean and their resources.

How can inclusive participatory approaches be ensured?

2. Enablers and tools

Effective ocean governance and management must be supported by enablers and tools, such as scientific knowledge and data, the application of an ecosystem-based and precautionary approach/principle, EIAs, strategic environmental assessments, area-based management tools, such as marine protected areas and marine spatial planning. It has been suggested that a structure and process is needed to engage the range of stakeholders including ocean industries in the development of common global standards and best practices for these tools and approaches (World Ocean Council, 'Ocean Governance and the Private Sector', White Paper, June 2018.)

(a) Information, data and knowledge-sharing

Strengthening the science-policy interface to increase knowledge and information and to inform decision-making and monitoring is critical. To that end, coordination between social and natural

sciences, between scientists, policymakers, civil society, and industry, as well as the inclusion of traditional knowledge of Indigenous Peoples and local communities, culture and social history in management, is necessary. Such cross-sectoral understanding is important for management that is truly holistic (WOA II, vol. II, p. 463).

How can the science-policy interface be strengthened?

The best available science is needed on many aspects. For example, there is a need to harmonize the vision for how to measure the health of ecosystems, a well-used term for which there is still no agreed measurement methodology (UN, 'Interactive dialogue 2' UN document A/CONF.230/2022/10 (2022); and UN, 'Interactive dialogue 1' UN document A/CONF.230/2022/9 (2022)). But it has also been noted that universally accepted answers to questions such as what 'sustainable use' and 'precaution' really mean would foster more collaboration between conservationists and the development community.

Should there be universally accepted definitions of 'sustainable use' and 'precaution'? What are the best ways to create baselines and measure progress towards sustainable development of the ocean and its resources? What might be the role of collaborative research partnerships to assess and build knowledge on environmental and socio-economic stressors, drivers and trends, including the effects of climate change?

Scientists have repeatedly argued that transformative, multiscale global scenarios are needed as tools in the quest to halt the decline of biodiversity and achieve sustainability goals and several different scenarios have been developed which also take into account the impacts of climate change on the ocean. While it is complex to develop various scenarios, they are useful for steering the future trajectory towards one that is socially and ecologically desirable.

Should global multiscale scenarios be developed within the framework of the Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including Socioeconomic Aspects for the consideration of the United Nations General Assembly and its Ad Hoc Working Group of the Whole on the Regular Process?

(b) Equity, capacity-building, transfer of marine technology and financial resources

Legal frameworks partially exist to support equity, but they have proven to be insufficient: in practice, ocean policies are largely equity-blind, poorly implemented and fail to address inequity. Thus, although UNCLOS sought to make all States benefit from the resources of the ocean, in effect it has favoured developed States (Ph. Kastner, 'Written evidence-UNCLOS fit for purpose in the 21st century? (UNC0029)'); moreover technological advances may increase disparities between States (A. Jaeckel and H. Harden-Davies, 'New technology, equity and the law of the sea' on ILA Reporter (10 September 2021)). According to the IPCC 2019 Special Report, prioritising measures to address social vulnerability and equity underpins efforts to promote fair and just climate resilience and sustainable development and can be helped by creating safe community settings for meaningful public participation, deliberation and conflict resolution. Critical elements to achieving equity include access to information, promotion of ocean literacy, and engagement across diverse actors with different skills, capacities and powers to address inequities.

How can the goals in UNCLOS in support of equity be achieved? What measures are required? In an ocean context, how can the core promise of the 2030 Agenda for Sustainable Development – to leave no one behind – be achieved?

Capacity-building, the transfer of marine technology and financial resources will be essential in all concerned sectors. Significant challenges remain when it comes to integrated approaches to the building of capacity, the transfer of marine technology in accordance with UNCLOS, and the availability of sustained funding for capacity-building.

When it comes to financial resources, UNCLOS did not provide for a funding mechanism. A series of voluntary trust funds were established by the Secretary-General of the United Nations pursuant to decisions of the General Assembly, but they proved

to be insufficient for the most part. Apart from the need for effective partnerships, including public-private, the possibility to establish a dedicated financial mechanism, or other innovative schemes to stimulate private sector support has been raised (UN document A/74/630 2019, *op. cit.*), as well as the need to support investment in SIDS and least developed countries through the development of innovative financial tools and options (UN, 'Interactive dialogue 5' UN document A/CONF.230/2022/5 (2022)).

How can the need for sustained funding to support States in the implementation of UNCLOS and its implementing agreements and to drive the transformation to sustainable ocean-based economies, and the scaling up of nature-based solutions and ecosystem-based approaches be addressed? What are the sectors where targeted investments can have the greatest impact in building sustainable ocean-based economies of developing countries, in particular in SIDS and least developed countries? What innovative financial tools and options can be developed and deployed to support investment in SIDS and least developed countries? How could investment into coastal and marine natural capital to mitigate risk and build resilience be advanced?

(c) Area-based management tools and environmental impact assessments

Area-based management tools (ABMTs) including marine protected areas (MPAs) in areas beyond national jurisdiction are currently under consideration within the framework of the negotiations on the future BBNJ agreement. With regard to MPAs that have been established within areas under national jurisdiction, little information is available regarding their level of effectiveness. Monitoring the effectiveness of management outcomes can be difficult and determining effectiveness is

further complicated by the impacts of climate change and by weak cross-institutional cooperation, in particular across jurisdictional boundaries (UN, 'Interactive dialogue 2', *op. cit.*). Moreover, the power to affect ocean health is not uniformly or equitably distributed. Nonetheless, there is an increasing need for a global evaluation of the effectiveness and equitable outcomes of spatial management approaches (L. H. Pendleton & al, 'Debating the effectiveness of marine protected areas', ICES Journal of Marine Science, vol. 75, No. 3, (2018)). To date there has been little discussion of how the conservation or protection of 30% of the global ocean through the establishment of marine protected areas will impact the remaining 70% of the ocean that will not be protected and where ocean activities and uses will be concentrated. The potential role of coupled environmental and socio-economic assessments leading to marine spatial planning[10] as a tool for achieving integrated, ecosystem-based management and in reducing conflicts among users can be noted in that regard.

Note 10 IOC/UNESCO defines marine spatial planning as a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that have been specified through a political process.

Should an evaluation be carried out at the global level of how MPAs and other ABMTs have achieved their objectives? How can the international community ensure that the remaining ocean areas where no ABMTs exist will be used in a sustainable and equitable manner? How can the use of marine spatial planning be promoted? Should there be a legal requirement to implement marine spatial planning in ocean areas where a number of ocean activities already take place or will take place?

Other important management tools are EIAs, as well as strategic environmental assessments (SEAs). It is expected that these tools will also be addressed in the future BBNJ agreement. International cooperation in the conduct of such assessments in areas within national jurisdiction is also critical especially where activities are likely to have significant adverse transboundary impacts. EIAs also need to be expanded from the consideration of the multiple effects of single development activities (or the accumulation of effects of multiple similar activities within a single industrial sector) to the combined effects of all pressures on marine ecosystems. Standardization of EIA requirements can also foster investment. For example, IRENA has pointed out that a lack of consistency in EIA requirements with respect to mitigation measures in the design, operation and maintenance of offshore energy installations can create considerable diffi-

culties for project developers and result in added risks for investors and significant delays (IRENA (2021), 'Offshore Renewables...', *op. cit.*, p. 74).

(d) Institutional framework at the global level

In conclusion, the question arises whether the intergovernmental organizations that have been established by UNCLOS and other treaties, and the institutions that are likely to be established under the future BBNJ agreement are in a position to promote effective ocean governance and integrated, ecosystem-based management at the global level. Currently, only the General Assembly undertakes a comprehensive and integrated review of ocean affairs and the law of the sea which is reflected in its annual resolutions on oceans and the law of the sea and on sustainable fisheries. However, during its consultations on the draft resolutions, the Assembly does not have the time to systematically review progress achieved pursuant to its calls for action nor does it have a specific mandate to review implementation of UNCLOS. Other UNCLOS related fora also do not have such mandate. There are divergent views regarding the scope of the mandate of the Meeting of States Parties to UNCLOS and the mandate of the future institutions under the BBNJ agreement will not cover all ocean issues.

How and where can the wide-range of challenges that have been identified in this White Paper be addressed in an integrated and cross-sectoral manner? Can the aforementioned institutional arrangements provide the required effective, integrated, cross-sectoral ecosystem-based governance framework at the global level?

annex 01

persons interviewed

- Paul Holthus - Founding President & CEO World Ocean Council
- Ioannis Lyras - Member of the Board of Directors of the Union of Greek Shipowners, Chairperson of the Foreign Affairs Committee
- Jake Rice - Chief Scientist-Emeritus, Department of Fisheries and Oceans Canada (DFO)
- Jyotika Virmani - Executive Director, Schmidt Ocean Institute
- Simon Young - Senior Director in the Climate and Resilience Hubat, Willis Towers Watson

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adi.ila2023.ocean@gmail.com