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WHITE BLACK LEGAL is an open access, peer-reviewed and refereed journal provide dedicated to express views on topical legal issues, thereby generating a cross current of ideas on emerging matters. This platform shall also ignite the initiative and desire of young law students to contribute in the field of law. The erudite response of legal luminaries shall be solicited to enable readers to explore challenges that lie before law makers, lawyers and the society at large, in the event of the ever changing social, economic and technological scenario.

With this thought, we hereby present to you

FROM AUTOMATION TO OCEAN STEWARDSHIP: THE ROLE OF ARTIFICIAL INTELLIGENCE IN SHAPING MARITIME LAW FOR THE SDGS

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Abstract:

The fast adoption of Artificial Intelligence (AI) within the shipping industry is a major turning point, not only from a perspective of enrichment but also from that of the earth. Besides being a technical advancement, it has also impacted the legal and moral aspects of global ocean governance. The author considers how AI technology: like automated ships, predictive data analytics and eco-friendly monitoring systems; could one day unlock the Sustainable Development Goals (SDGs) if proper legal and ethical frameworks are put in place to control them. The author intends to convey the message of sustainable and ethical AI governance, wherein transparency, environmental responsibility, and participation in maritime innovation will play the most important roles. Besides, this paper will illustrate the law's part in making AI accountability standards, and specifically, the international legal agreements, for instance, the United Nations Convention on the Law of the Sea (UNCLOS), and the newly created soft-law mechanisms, which need to change so they can deal with issues of liability, data protection, and safety in the digital maritime world. The author wraps up her paper with some proposals for policy measures that, among others, would lead to the setting up of international cooperation mechanisms, the incorporation of sustainability audits in AI applications, and the promotion of interdisciplinary governance between nations, industries, and institutions. In doing so, the author makes it clear that a proper technology-law-ethics tripartite relationship is indispensable for the AI to act as a powerful tool for the sustainability of the maritime sector rather than an obstacle due to the regulatory farce it might create.

Keywords: Artificial Intelligence, Maritime Law, Ocean Governance, Sustainable Development Goals, Ethical Regulation.

1. INTRODUCTION

Just ten years back, the maritime sector would have never imagined things like Artificial Intelligence (AI) enabling its navigation systems, predictive maintenance, and even automated compliance with laws. The scenario, however, is entirely different now, with AI being the major player in the industry transition that affects technology, law, and sustainable development positively. Overexploitation, pollution, climate change, and unregulated industrial activities have made the oceans increasingly threatened and AI is coming up as the not only an automation tool but also a promoter of ocean stewardship with a great impact in this respect. The maritime law, which was historically slow to change, is now under pressure to evolve along with the rapid technological shift. The author of this paper discusses the role of AI in governance on the ocean, the legal framework that must change in order to regulate AI-based maritime operations in an environmentally friendly manner, and finally the UN Goals for Sustainable Development influenced by AI.¹

The management of the oceans has for a long time been in the hands of humans who made the decisions, enforced the compliance manually, and followed a state centered regulatory system. In contrast, the AI technology is now found in different systems that the shipping industry uses, such as, vessel traffic, ships control, environmental monitoring devices, and digital registries, thus, a completely new non-human decision-making layer has emerged which the maritime law was not prepared for. Each of these changes brings along the need for new legal norms to be established in order for the safety measures, liability, and environmental accountability to be made clear. Meanwhile, the AI-enabled systems deliver power to the states and institutions to fulfill their international obligations under the SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 16 (Strong Institutions), without any hassle. Thus, the twofold function-being efficient and taking care of the environment-makes AI a major player in determining the course of maritime governance for the future.²

In this regard, scholars and international organizations are gradually and increasingly asserting that the regulation of AI requires to be done through ethical and human-centered frameworks first so that the latter could be conformed with the international law. The main arguments come

¹ United Nations, The Future of Our Ocean: Emerging Issues in Ocean Governance, U.N. Doc. A/75/70 (2020).

² International Maritime Organization, Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS), IMO Doc. MSC 102/INF.3 (2020).

from the maritime area where the imperatives of such regulations take on a different dimension owing to the nature of oceans as shared resources, the fact of marine ecosystems being highly susceptible to any disruption, and the concurrent development of maritime autonomy that leads to the questioning of long-standing legal concepts such as the duty to assist at sea and fault-based liability. The International Maritime Organization (IMO), the International Seabed Authority (ISA), and national maritime regulators are now sourcing the principles for the automation and digitalization technologies, but a holistic framework that considers humanitarian, environmental, and legal aspects still doesn't exist.³

This paper discusses AI, as not merely a technological development, but rather as a governance tool that would eventually serve global ocean sustainability. It calls for "AI-assisted ocean stewardship" as a framework that blends technology with environmental concern through a mixed method that consists of doctrinal legal analysis, technology assessment, and policy evaluation. It investigates the doctrinal gaps in current maritime law, the risks that AI-enabled systems can bring about, and the advantages that AI may offer to the states and institutions in terms of reinforcing maritime governance that is in line with the Sustainable Development Goals.⁴

2. ARTIFICIAL INTELLIGENCE IN THE MARITIME DOMAIN: CONCEPTUAL AND TECHNOLOGICAL FOUNDATIONS

AI or artificial intelligence is a term that covers all the computational systems that can carry out human-like intellectual tasks, such as perceiving, making decisions, forecasting, and recognizing patterns. AI in the maritime business includes technology such as machine learning, neural networks, autonomous navigation algorithms, environmental sensing systems, and digital twins for vessel operations. These high-tech tools provide support for various maritime activities such as navigation, search and rescue, logistics, environmental monitoring, and regulatory compliance. While maritime industries are digitalizing, AI becomes a major player that transforms safety, efficiency, and sustainability throughout shipping, ports, offshore energy, fisheries, and deep-sea exploration areas.⁵

³ International Seabed Authority, ISA Draft Regulations for Exploitation of Mineral Resources in the Area, ISBA/25/C/WP.1 (2019).

⁴ David J. Attard et al., eds., *The IMLI Treatise on Global Ocean Governance*, Vol. 2 (Oxford Univ. Press 2018).

⁵ OECD, *Artificial Intelligence in Society* 108-15 (OECD Publishing 2019).

The AI systems in the maritime industry can be divided into three major types: (1) Decision-support AI that improves the quality of human decisions by analyzing big data like the weather, sea, and ship performance; (2) Operational/Control AI that carries out active functions such as preventing a collision or driving a ship on its own; and (3) Predictive AI that is responsible for predicting catastrophes, e.g. equipment fails, pollution increases, or environmental degradation. In reality, such categories tend to blur and lead to the development of complex interrelated systems that need a strong governance framework. The transformation of vessels from "smart ships" to completely self-operating Maritime Autonomous Surface Ships (MASS) also contributes to the widening of AI's role and influence in maritime governance.⁶

The harbor's adoption of AI technology has been another major step taken towards modernization. Technically, ports are equipped with various AI-powered devices like intelligent sensors, automated cranes, and sophisticated logistics systems that work together to speed up the loading and unloading of goods, cut the total emissions produced by port operations to the atmosphere, and shrink the share of human error. Furthermore, AI-driven systems in port communities enable safe data transfer, customs processes automation, and make predictions regarding bottleneck and vessel turnaround time. The use of such technologies is in line with global sustainability aims per SDG 9 and SDG 14, while decreasing the carbon footprint of maritime logistics.⁷

The use of AI is affecting the marine environment monitoring in a big way. To overcome illegal fishing and polluting water with chemicals, AI applications like satellite imaging, machine learning, and sensor technology are continuously observing the ocean and controlling corals. These tools give an extra edge to the states in fulfilling their roles as per the United Nations Convention on the Law of the Sea (UNCLOS), which mandates the member countries, among other things, to take necessary actions for the conservation and protection of the marine environment and conducting environmental impact assessments. AI not only enhances the surveillance capabilities but also makes it harder for the violators to hide their activities and thus, it becomes easier to enforce rules and regulations in the maritime domain.⁸

AI plays a major role in maritime security as it provides automated threat identification,

⁶ IMO, Interim Guidelines for MASS Trials, MSC.1/Circ.1604 (2019).

⁷ World Bank, Building Smart Ports in the Era of Digitalization 45-50 (2022).

⁸ United Nations Convention on the Law of the Sea arts. 192, 194, Dec. 10, 1982, 1833 U.N.T.S. 3.

predictive piracy analysis, and anomaly detection for vessel behavior. To detect abnormal behavior, machine learning algorithms scrutinize AIS (Automatic Identification System) data for suspicious actions like ships waiting unreasonably, turning off their transponders, or not following designated shipping lanes. Navies, coast guards, and law enforcement agencies that operate in the maritime sector get support through such technologies in their fight against piracy, armed robbery, smuggling, and IUU (illegal, unreported, and unregulated) fishing. The use of AI in maritime security still remains within the purview of SDG 16 which aims at ensuring peace, justice, and strong institutions.⁹

3. LEGAL FRAMEWORK GOVERNING ARTIFICIAL INTELLIGENCE IN MARITIME OPERATIONS

International maritime law has been taking a long time to adapt to technology changes, and when it comes to AI-powered maritime systems, the challenge is even more difficult to cope with. The main legal framework around UNCLOS was built in a period when ships were totally manned. Terms like "master," "crew," "flag State control," and "due diligence" were written without forecasting the existence of robots in the marine industry and AI-assisted decision-making systems. Therefore, the existing maritime rules on the technology-enhanced operations have to deal with interpretation, and in some cases, the creation of entirely new regulations.¹⁰

A. UNCLOS and the Challenges of AI Integration

UNCLOS provides the legal rules for the world oceans, which include rights of navigation, responsibilities for protecting marine environments, and obligations of the states. But, at the same time, it does not specify what a "ship," "master," or "seafarer" means in technological terms, thus causing difficulties in interpreting the law as to the use of autonomous vessels or AI used for operating ships. The flag States, according to Article 94, are required to exercise their jurisdiction and control over ships that fly their flag effectively. However, such a requirement becomes a complex challenge when ships with no crews and/or AI are doing the main functions of the master or officers. The lack of a human controller brings up issues about who is responsible, who is accountable, and who is going to comply with the law in case there is a collision, an oil spill, or a malfunction of the ship.¹¹

⁹ European Maritime Safety Agency, AI-Based Maritime Surveillance Systems, EMSA Technical Report (2021).

¹⁰ Robin Churchill & Vaughan Lowe, *The Law of the Sea* 8-12 (4th ed., Manchester Univ. Press 2022).

¹¹ UNCLOS arts. 94, 97, Dec. 10, 1982, 1833 U.N.T.S. 3.

B. IMO's Regulatory Scoping Exercise for Maritime Autonomous Surface Ships (MASS)

The IMO, recognizing the need to address this issue, started the Regulatory Scoping Exercise (RSE) to see if the existing instruments of the Maritime Safety Committee (MSC) and Legal Committee (LEG) could be adapted to cover the issue of autonomous ships. The RSE identified that, despite their apparent relevance, many IMO conventions like SOLAS, COLREGs, STCW, and MARPOL would still require human presence and human accountability either explicitly or implicitly. One of the main contenders for the RSE's assessment, the COLREGs, state that there should be "proper lookout by sight and hearing" on board, which in the context of AI sensors and automated perception technologies, the requirement becomes less clear. The work of the IMO is an ongoing process of deciding which rules can be adapted, which require amendments, and which need entirely new frameworks to regulate MASS operations safely and lawfully.¹²

C. Environmental Obligations and AI-Enhanced Compliance Under MARPOL

MARPOL stipulates very high levels of pollution prevention from ships, on the one hand, and puts AI into the same area as a legal bottleneck and opportunity, on the other hand. AI could be used for automatic monitoring and control of the engine which would prevent, among others, the discharge of gas mixtures that would breach the discharge limits set by MARPOL and thus, the companies would not face any environmental fines. Also, the processing of some machine-related issues can be forecasted with the help of AI, and the company will be informed of the issue before it takes place, thus preventing any emissions-related environmental obligations and the courts through the legal mechanisms. Such measures as monitoring or control of pollution by AI inevitably raise questions of who will be held liable in cases of automated systems cease to function, or when decisions taken by algorithms result in violations. The legal discussion of whether liability is on the shipowner, manufacturer, software creator, or operator remains unresolved and serves as a pointer to the lack of explicit legislative support for AI-assisted pollution control.¹³

¹² IMO, Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS), MSC 103/INF.2 (2021).

¹³ MARPOL Annex I-VI, Int'l Maritime Org. (1983).

D. STCW Convention and the Future of Human Elements in AI-Operated Vessels

The STCW Convention regulates the qualification, training, and watchkeeping for maritime personnel. It indicates that sailors are still needed to perform physical duties related to the running of the ship, such as navigation, operation, and engineering. The concepts of watchkeeping, situational awareness, and competence are to be redefined in the context of AI. At present, it is a matter of discussion whether the remote operators qualify as "seafarers" and if new competency standards should be set for roles like "remote vessel operator" or "AI systems supervisor." The prevailing conflicts portray larger issues regarding the acceptance of AI in convention-based maritime labor and safety standards.¹⁴

E. National Legislation and Emerging Domestic Frameworks

Many coastal and flag countries have already considered the necessity of setting up domestic rules that would support the conduct of trials and the operations of AI-assisted, autocruising vessels. For instance, Singapore, Norway, Japan, and Finland have already introduced rules for technology-based shipping operations—these include test sites for MASS, digital registries, and remote-control operations. Although these nations' efforts do establish valuable governance models, they also run the risk of generating fragmented regulatory landscapes unless international harmonization is developed along with them. The differences among various countries' regulatory regimes could erode the 'one world, one law' principle that has been one of the chief attractions of international maritime law in the past. Thus, the need for a fast and coordinated multilateral legal framework for AI governance is reiterated.¹⁵

4. AI AND THE SUSTAINABLE DEVELOPMENT GOALS: TOWARDS OCEAN STEWARDSHIP

The use of artificial intelligence has been and will continue to be a significant factor in the achievement of the United Nations Sustainable Development Goals (SDGs), especially those concerning the ocean. One of the key points of SDG 14 ("Life Below Water") is the demand for an immediate action plan to clean up the sea, control fishing and other activities, protect habitats, and so on. AI facilitates the Monterey Bay and Pacific States monitoring capacity because it can determine the conditions of the oceans in real time via data on pollution,

¹⁴ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended.

¹⁵ Singapore Maritime and Port Authority, MASS Trial Guidelines (2021).

fisheries, and climate impact. This technology allows decision-makers to act wisely and simultaneously strengthens the international commitment to ocean sustainability governance.¹⁶

A. AI for Marine Environmental Protection (SDG 14)

AI is a key player in the process of detection, prediction, and prevention of marine pollution. Machine-learning algorithms are used in the analysis of satellite data to spot oil spills, marine debris, and harmful algal blooms at the earliest stages. AI-equipped autonomous underwater vehicles (AUVs) can perform tasks such as mapping coral reef damage, tracking plastic pollution, and biodiversity monitoring. The results of their efforts allow the states to comply with the provisions of UNCLOS Articles 192 and 194, which precondition the protection and preservation of the marine environment, among others. AI, thus, not only facilitates the environmental governance that is based on data but also gives direct support to the objectives of SDG 14.1 on marine pollution reduction and 14.2 on marine ecosystems sustainable management.¹⁷

B. AI for Climate Resilience and Ocean Science (SDG 13)

Climate change is one of the main factors that contribute to the decline of oceans' health worldwide, not to mention the most important one. It changes marine habitats and causes extinction of some species through rising water temperatures and ocean acidification, among other things. One major impact of these changes is the increase in the occurrences of extreme weather. One way that AI does this is through its ability to predict the future by forecasting sea-level rise, modeling storm surges, and determining climate-related risks to coastal areas. The deep learning algorithms perform huge climate data analysis and come up with long-term environmental changes forecasts that are significantly precise. It is not only the case that these instruments are of utmost importance in meeting the SDG 13 goals, but climate change adaptation and enhancing scientific research are also at the forefront of the battle. Governments are making use of AI-powered models for disaster readiness, coastal management, and environmental impact assessments that come along their legal obligations under international environmental law.¹⁸

¹⁶ United Nations, The Sustainable Development Goals Report 2023.

¹⁷ UNCLOS arts. 192, 194, Dec. 10, 1982, 1833 U.N.T.S. 3.

¹⁸ IPCC, Climate Change 2022: Impacts, Adaptation and Vulnerability, Working Group II Report (2022).

C. AI in Combating Illegal, Unreported, and Unregulated (IUU) Fishing

Illegal, unreported, and unregulated (IUU) fishing has a negative effect on ocean life balance, and it is also very harmful to the food supply and to the poor coastal dwellers. Different AI-based techniques such as electronic monitoring (VMS), algorithms for anomaly detection, and satellite imaging have made it fairly easy to catch and even keep track of the vessels that are doing illegal fishing and are using false AIS data. By looking at the locations of the ships, their speeds, and their habits, AI can tell the difference between legal fishing and illegal fishing that is just disguised by slow and less-frequent movements. All these tools are helping SDG 14.4, which deals with the end goal of IUU fishing and the regulation of fish stocks (the issue of overfishing has even been highlighted). The fact that AI surveillance is being used has further strengthened the capabilities of regional fisheries management organizations (RFMOs) and has simultaneously met the commitments under the FAO Port State Measures Agreement.¹⁹

D. AI for Safer and More Sustainable Shipping (SDG 9 and SDG 13)

AI is a big help to sustainable industrialization and innovation under SDG 9 as it improves the ships' efficiency, cuts the operational costs, and brings down the energy consumption to the least. The use of machine learning algorithms leads the way to less fuel consumption, better travel planning, and lower carbon dioxide emissions. The systems of predictive maintenance can detect mechanical defects before they happen, thus eliminating the risks of accidents and spills that might negatively impact the marine ecosystem, among other things. These tech solutions are on the front line of the maritime industry's decarbonization efforts, speaking to SDG 13.2 about climate measures being integrated into national policies and to SDG 9.4 regarding the upgrading of infrastructure to be both sustainable and resource-efficient.²⁰

E. AI and Ocean Data for Global Governance (SDG 17)

While SDG 17 calls for global partnerships for sustainable development, AI's contribution is really important. It is through AI that the sharing of ocean data becomes an aspect of international cooperation strengthened. The platforms that are AI-supported bring together the information regarding sea temperatures, biodiversity, pollution, maritime traffic, and climate hazards. The Global Ocean Observing System (GOOS) and the Deep-Ocean Observing

¹⁹ Food and Agriculture Organization, The State of World Fisheries and Aquaculture 2022.=

²⁰ International Chamber of Shipping, Decarbonization in Shipping: Pathways and Challenges (2021).

Strategy (DOOS) are some of the initiatives that depend on AI to deal with the complex data sets and so to enhance the scientific comprehension of the marine environment. The establishment of these systems empowers countries to work together in the area of conservation, to align the environmental standards, and to fulfil the reporting obligations according to UNCLOS and other agreements. The AI-led data amalgamation is a driver of transparency, accountability, and evidence-based decision-making throughout the world.²¹

5. REGULATORY AND ETHICAL CHALLENGES OF ARTIFICIAL INTELLIGENCE IN MARITIME LAW

The fast-paced incorporation of AI technology into shipping operations has posed intricate regulatory issues that global and local laws are not able to fully tackle. The old maritime laws are based on the idea that there will be human control, accountability, and decision-making on the ships. In this respect, the use of AI, especially in the case of autonomous ships, overturns this assumption by creating non-human decision-making agents that complicate the setting of responsibility and legal liability. The legal rules that have served for years need replacement with new standards that embrace the technological realities and at the same time consider established legal principles of safety, environmental protection, and state responsibility.²²

A. Liability and Accountability in AI-Driven Maritime Systems

Establishing who is liable in accidents with AI-controlled vessels is the most urgent legal issue to confront. The existing maritime liability regimes-which are grounded in fault, negligence, or strict liability-have always been centered around human error or mechanical failure. However, when AI systems autonomously take navigational decisions or make operational choices, it becomes a challenge to identify the responsible party-be it the owner, programmer, manufacturer, or operator. This uncertainty is exacerbated in the case of machine-learning systems that change their behavior over time, maybe even becoming unpredictable. The fact that there is no universal agreement about the accountability of AI complicates the creation of insurance and compensation schemes for accidents with autonomous ships.²³

²¹ IOC-UNESCO, Global Ocean Observing System (GOOS) Implementation Plan (2019).

²² Henrik Ringbom, Regulating Autonomous Ships-Concepts, Challenges and Precedents, 50 Ocean Dev. & Int'l L. 134 (2019).

²³ Andrew Norris, Liability Issues for Autonomous Ships, 103 Mar. L. Ass'n Dig. 17 (2018).

B. Data Protection, Cybersecurity, and Digital Integrity

AI applications in the maritime sector are mostly dependent on the real-time exchange of data, remote access and the use of cloud analytics. This is a double-edged sword since the maritime sector's operations are quite susceptible to cyber security threats such as piracy, hacking, data manipulation, and interference with systems. The cyberattacks on autonomous ships or smart ports might result in an operational blackout, an environmental catastrophe, or getting the company exposed to piracy. The IMO's 2021 cybersecurity changes to the ISM Code require ship operators to evaluate cyber risks, but the rules are still not obligatory and are technologically obsolete. To improve the security of the maritime cyber network, there is a need for stronger encryption standards, user authentication measures, and system audits.²⁴

C. Ethical Concerns: Human Dignity, Safety, and Fair Labor

The application of AI in the shipping industry poses ethical issues which are not merely of the legal liability kind. Automation leading to a decrease in the number of seafarers raises worries about the future of the shipping industry's labor force, particularly in developing nations like India and the Philippines, which have a large maritime workforce. Questions regarding the overall safety of relying on completely automated systems during emergencies also bring up ethical issues. The norm of human dignity imposes that AI-based systems must not ever compromise human safety or the basic rights of seafarers. It might be necessary to amend international conventions like the Maritime Labour Convention (MLC 2006) to extend labor protection in the digitalized era of shipping.²⁵

D. Environmental Risks and Algorithmic Bias

AI has a very powerful environmentally-friendly side but, on the other hand, it also has a dark side. One case is the misclassification of marine species, accidentally low pollution levels, and wrong environmental predictions, which can be the result of AI algorithms using incomplete or biased data. Such mistakes can result in wrong policy decisions or not enough protection given to marine ecosystems. On top of that, the large AI models' carbon footprint is an issue and the concern is raised even more when it comes to the energy-consuming oceanographic data processing. Legal systems have to make sure that there will be no more breakthroughs in transparency, audit capability, and environmental safeguards in the area of AI-powered marine

²⁴ IMO, Guidelines on Maritime Cyber Risk Management, MSC-FAL.1/Circ.3 (2021).

²⁵ Maritime Labour Convention, 2006 (adopted by ILO).

scientific research.²⁶

6. TOWARDS A FRAMEWORK OF "AI-ASSISTED OCEAN STEWARDSHIP"

Maritime governance is significantly going to be supported by AI. The first question that comes to mind is, what is going to be the most important legal and policy framework for this new development? It could be one that recognizes the importance of technological innovation, alongside the environment and ethics, and brings them together. The "AI-assisted ocean stewardship" model suggests a comprehensive plan that connects the use of AI with the objectives of safe shipping, protecting marine life, and the climate through resilience, using resources sustainably, and making the law accessible for all. This means that the partnership of AI is not only for efficiency but also for maintaining ocean sustainability together with the SDGs.²⁷

A. Principles of AI-Assisted Ocean Stewardship

The model is based on four main tenets: (1) Precaution, which obliges states and businesses to carry out an assessment of any possible dangers from an AI system that is to be implemented; (2) Transparency, which makes it possible for AI used in shipping to be both understandable and worthy of examination; (3) Accountability, which means that it will be made very clear who is responsible for any AI-related actions or decisions; and (4) Sustainability, which represents the joining of environmental protection and the setting of climate goals through AI system design and operation. The above principles combine both the longtime accepted norms of international environmental law and the moral standards that are being developed through the debates on AI governance worldwide.²⁸

B. Regulatory Innovations for Autonomous and AI-Driven Vessels

For the successful implementation of AI-assisted ocean stewardship it is crucial that maritime regulators create new legal instruments and change existing treaties. Among these would be giving a legal position to automatic ships, setting common rules for remote operators, and mandating safety protocols for AI-assisted navigation. The International Maritime

²⁶ European Commission, Ethics Guidelines for Trustworthy AI (2019).

²⁷ David J. Attard et al., eds., *The IMLI Treatise on Global Ocean Governance*, Vol. 2 (Oxford Univ. Press 2018).

²⁸ OECD, *AI Principles: Responsible Stewardship of Trustworthy AI* (2019).

Organization (IMO) might go so far as to propose a new treaty for autonomous ships that would govern worldwide their safety and environmental concerns along with liability issues. Furthermore the domestic systems have to incorporate measures such as AI certification, algorithmic auditing and cybersecurity in order to allow responsible and safe use of AI in oceanic locations.²⁹

C. Environmental Governance and AI-Enhanced Monitoring

AI-assisted stewardship also provides for the application of high-tech monitoring devices in the environmental governance. The use of such technologies could be automated spill detection, digital EIA platforms and AI-based habitat mapping which would all be contributing to the strengthening of compliance with the environmental regulations of the UNCLOS. The States can utilize AI-equipped marine monitoring networks as a zealous sky for marine observation in MPAs (Marine Protected Areas), deep-seabed mining under ISA's supervision, and total impact on oceanic ecosystems assessment. These innovations work as environmental law practice assistants, closing the gap between law and actual environmental protection which has been a barrier to global ocean governance.³⁰

D. Capacity Building and Equitable Access to Maritime AI

One of the main supports for AI-assisted ocean management is the access to maritime AI technologies for the developing countries. If the access is not equitable, the digital divide will be created, thus working against SDG 17 on global partnerships. Capacity-building programs must consist of AI training for maritime authorities, digital infrastructure support, and technology transfer. Regional cooperation through organizations like IORA, BIMSTEC, or the African Union can aid in the development of AI-driven maritime data systems, thereby improving regional ocean governance and creating a united resilient force.³¹

E. Human-Centric AI in the Maritime Sector

Humans are still the main source of knowledge, even though there is more and more automation. The AI-assisted stewardship brings to light the human role, provides ethical safeguards and supports the maritime industry. The education system has to be reformed in such a way that one day all maritime professionals would be AI-literate, the future officers

²⁹ IMO, Future Maritime Regulatory Framework for Autonomous Ships, LEG 108/5 (2021).

³⁰ ISA, Draft Environmental Management Plan for the Clarion-Clipperton Zone (2022).

³¹ UNCTAD, Technology and Innovation Report 2021.

would be aware of algorithmic decision-making, cybersecurity, and digital navigation tools. This idea secures the function of the crew alongside the safe coexistence of human operators and AI-enabled systems.³²

7. Conclusion: Toward a Responsible, AI-Driven Maritime Future

The maritime industry is being profoundly impacted by artificial intelligence and is likely to be the main beneficiary of it. Vessels will be able to navigate by safer and more eco-friendly means, ocean resources will be exploited and managed more efficiently, and States will be able to meet their international legal obligations more smoothly. The basic idea is that these systems need to be in sync with the ethical, legal, and environmental commitments to the SDGs that the world has agreed upon, which are not only technological sophistication but also the system's capability to be in sync with these commitments. AI has the potential to tackle the world's toughest maritime governance problems by allowing the existing governance frameworks—which are usually slow, reactive, and fragmented—to be overlapped by the rapidly changing, data-driven demands of the ocean environment. The changing legal milieu must then be prepared to accept AI not simply as a source of improved efficiency but as an initiator of fair, open, and green maritime governance.³³

Maritime law will be increasingly reliant upon AI being a part of risk assessment, navigation rules, environmental monitoring, and maritime security measures. The already existing international instruments—including UNCLOS, the IMO conventions, and regional fisheries agreements—need to be strengthened so that they can easily embrace automation, autonomous vessels, and algorithmic decision-making. The need for States and international organizations to come up with binding rules on liability, cyber resilience, data governance, and ethical AI deployment in the maritime sector will surely arise. The AI-assisted monitoring and verification systems can also be instrumental in the compliance with the environmental standards set under MARPOL, the Biodiversity Beyond National Jurisdiction (BBNJ) Agreement, and deep seabed mining regulations governed by the International Seabed Authority.³⁴

³² World Maritime University, *Transport 2040: Automation, Technology, and the Future of Work*, WMU Report (2019).

³³ UNITED NATIONS, *Transforming Our World: The 2030 Agenda for Sustainable Development* (2015).

³⁴ United Nations Convention on the Law of the Sea, Dec. 10, 1982, 1833 U.N.T.S. 3; International Maritime Organization, *Revised MARPOL Annex VI* (2021); Agreement Under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ), June 19, 2023.

Nonetheless, the progress of technology development has the downside of new vulnerabilities as well: the usage of biased datasets that bring about unequal results, cyberattacks against unmanned ships, black-box algorithms that prevent safe navigation among others, and the unequal distribution of AI resources among the coastal countries which create a situation called "technological apartheid". All these above-mentioned risks point out the necessity of a cautious, people-oriented method in the Maritime governance that is reliant on artificial intelligence.³⁵

In order to prevent the global technology gap from widening, it is vital to ensure transparency, interoperability, capacity-building and equitable data-sharing. A progressive maritime legal framework should consider AI as a worldwide public good—a tool that can help to promote ocean governance and climate-smart development. Only through multilateral cooperation, inclusive policymaking, and ongoing conversations among the technologists, legal experts, environmental scientists, and maritime stakeholders, the realization of this vision is possible. The international community's role is not just to control AI, but rather to lead the way to a future where such innovations will be in favour of shared security, environmental care and equitable use of the oceans.³⁶

Essentially, the trip "from automation to ocean stewardship" symbolizes a transferring of viewpoints; shipping is no longer considered as just a sector where AI works for its optimization, but it is regarded as part of a more extensive and ethical mission to protect the sea from further degradation and pollution. The legislation governing maritime matters must change along with the technology used for the enforcement of these laws, so that new developments can uphold the principles of being fair, responsible and environment-friendly. Only in this way, can AI be an effective ally in creating a maritime world that is both resilient and equitable, keeps the SDGs declarations alive and reinforces mankind's vow to the oceans which are the source of life's support on Earth.³⁷

³⁵ International Maritime Organization, Interim Guidelines for Autonomous Ships (MAS), MSC.1/Circ.1640 (2023).

³⁶ International Seabed Authority, Draft Exploitation Regulations for Deep Seabed Mining (2024).

³⁷ Id.; UNITED NATIONS, UN Ocean Decade Implementation Plan (2021).