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Bridging the maritime domain awareness gap: The role of new technologies in promoting equitable surveillance capabilities to enact environmental obligations under the law of the sea*

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Abstract

In 1982, the Third United Nations Conference on the Law of the Sea expressed concerns about the potential widening technological divide between developed and developing States due to the rapid development in maritime science and technology. Over four decades later, however, the capacity gap in the field of maritime domain awareness is reportedly declining. More accessible advancements in areas such as satellite imagery, low-cost drones, and artificial intelligence contribute to democratising

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states' capabilities to cost-effectively monitor the marine environment. As this monitoring is a due diligence prerequisite of states' obligations to protect and preserve the maritime environment, more equitable capabilities present legal and ethical implications in the broader North-South international maritime and environmental discourse.

Keywords: Maritime domain awareness, Maritime surveillance, Advancements in maritime technology, Marine environmental obligations, North-South disparity

1. Introduction

The natural environment, which includes air, water, soil, flora and fauna, constitutes an essential part of life, the primary source of food, water and other resources indispensable for the existence of living beings. "The environment is not an abstraction but represents the living space, the quality of life, and the very health of human beings, including generations unborn".[1] Within this overarching natural context, the marine environment, as an element of the natural environment, stands as a cornerstone of global ecological health, which provides sustenance, biodiversity, and climatic regulation crucial for the optimal functioning of our planet.[2] In today's increasingly interconnected world, the imperative to protect and preserve the marine environment has attained utmost significance. This

1. *Legality of the Threat or Use of Nuclear Weapons* (Advisory Opinion) [1996] ICJ Rep 226, 242, para 29.

2. Enric Sala et al, 'Protecting the Global Ocean for Biodiversity, Food and Climate' (2021) 592 Nature 397, 397; Christopher C Joyner, 'Biodiversity in the Marine Environment: Resource Implications for the Law of the Sea Symposium: Biodiversity: Opportunities and Obligations' (1995) 28 Vanderbilt Journal of Transnational Law 635, 635-636; 638.

emphasis necessitates a closer examination of the environmental obligations enshrined in the law of the sea framework.

The theme of this volume on the intersection between maritime security, new technologies, and ethics, holding regulatory, legal, and ethical implications, resonates throughout various aspects of the law of the sea, including marine environmental obligations. A classic illustration of this interplay is observed in the historical evolution of maritime territorial sovereignty alongside advancements in cannon technology through the cannon-shot rule. This dynamic was a driving force behind the drafting, negotiation, and adoption of the 1982 United Nations Convention on the Law of the Sea (UNCLOS)[3] as a new constitution for the oceans, which was intended to "take cognizance of the emergence of new technologies [in order to] formulate a new and generally acceptable convention on the law of the sea which would avoid the defects inherent in the four 1958 Geneva Conventions".[4] The relevance of this intersection has recently been underscored in the proceedings before the International Tribunal for the Law of the Sea (ITLOS), where the hearings of the Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Case No. 31) highlighted the law of the sea's inherent adaptability to scientific and technological advancements.[5]

3. United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 396.

4. The United Nations Third Conference on the Law of the Sea, 'Extract from the Official Records of the Third United Nations Conference on the Law of the Sea, Volume XVII (Plenary Meetings, Summary Records and Verbatim Records, as well as Documents of the Conference, Resumed Eleventh Session and Final Part Eleventh Session and Conclusion)' 185th Plenary meeting, A/CONF.62/SR.185, 11, 11.

5. Representative of The Democratic Republic of Congo, *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Verbatim Record)* ITLOS Case No. 31 (21 September 2023, at 10 am) ITLOS/PV.23/C31/2/Rev.1 1.

Focusing on one of the key subject matters of Case No. 31 concerning the obligations of States to protect and preserve the marine environment, this chapter examines how emerging technologies in maritime domain awareness (MDA) can transform the North-South legal and ethical perspectives, another focal point of this volume. It begins with the premise that the duty to protect and preserve the marine environment is contingent upon the due diligence of States, which in turn rests upon States' subjective capability to effectively monitor the maritime domain. Afterwards, this chapter provides an overview of the current technological advancements in areas such as satellite imagery, drone technology, machine learning, and artificial intelligence. It emphasises their cost-effectiveness, open-source nature, and accessibility. This accessibility is increasingly reducing the gap in capabilities for conducting marine environmental monitoring. It suggests that the responsibility to protect and preserve the marine environment may be interpreted more uniformly, treating UNCLOS as a dynamic instrument with evolving ethical expectations. While literature on legal obligations regarding the maritime environment grows with the timely debate surrounding Case No. 31, the 'democratising' impact of new MDA technologies on the North-South perspectives of the obligation to protect and preserve the marine environment remains underemphasised. The recognition that MDA technology trends towards increasing accessibility to the Global South challenges the prevailing notion of an ever-widening technological gap between developing and developed states.

2. Environmental obligations under the law of the sea

For this chapter, environmental obligations are conceptualised as the obligations to protect and preserve the marine environment. These ob-

ligations gained the spotlight with Case No. 31, initiated by the Commission of Small Island States on Climate Change and International Law Commission (COSIS), which represents, as the name may suggest, the States of Antigua and Barbuda and Tuvalu as original members, as well as Niue, Palau, St Lucia, Vanuatu, Saint Vincent and the Grenadines, Saint Kitts and Nevis, and the Bahamas.[6] COSIS had requested clarification on the specific obligations under UNCLOS to prevent, reduce, and control pollution and to protect and preserve the marine environment in relation to the deleterious effects that result or are likely to result from climate change. This case has since prompted input from over 30 States, 8 international organisations, and several relevant non-governmental organisations,[7] reacting to the necessity of ensuring "a stable and predictable 'legal order for the seas and oceans'".[8]

In its Preamble, UNCLOS acknowledges the importance of establish-

6. *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law* (Request for Advisory Opinion submitted to the Tribunal), 12 December 2022, Annual report of the International Tribunal for the Law of the Sea for 2022, 9, paras 42-45.

7. See for example, The Republic of Mauritius, Written Statement Submitted to the International Tribunal for the Law of the Sea (ITLOS Case No. 31, 16 June 2023) 21-27; The International Union for Conservation of Nature and Natural Resources (IUCN) - World Commission on Environmental Law, Ocean Law Specialist Group, Written Statement Submitted to the International Tribunal for the Law of the Sea (ITLOS Case No. 31, 13 June 2023) 20 et seq; The Democratic Republic of Congo (DRC), Observations submitted to the International Tribunal for the Law of the Sea (ITLOS Case No. 31, 13 June 2023) 35-66; Representative of the Democratic Republic of Congo (DRC), *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Verbatim Record)* ITLOS Case No. 31 (21 September 2023, at 10 am) ITLOS/PV.23/C31/16/Rev.1, 1; 19; Representative of the Pacific Community, *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Verbatim Record)* ITLOS Case No 31 (20 September 2023, at 3pm) ITLOS/PV.23/C31/15/Rev.1, 9.

8. Representative of the Commission of Small Island States on Climate Change and International Law, *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Verbatim Record)* ITLOS Case No. 31 (11 September 2023, at 3pm) ITLOS/PV.23/C31/2/Rev.1, 30.

ing a legal framework for the seas and oceans to promote peaceful uses, equitable resource utilisation, conservation of living resources, and environmental protection.[9] Accordingly, Article 192 of the UNCLOS imposes a general obligation on Sates to protect and preserve the marine environment. This obligation encompasses various international duties such as due diligence, prevention of harm, prudence, and precaution,[10] without allowing for any derogations, exceptions, or restrictions.[11] Additionally, Article 194 requires States to take all necessary measures to prevent, reduce, and control pollution of the marine environment from any source, using the best practicable means available and in accordance with their capabilities. Further provisions in UNCLOS, including Articles 196, 204, 207, 210, and 238, also contribute to the protection and preservation of the marine environment.

To understand the scope of the above obligations, it is crucial to analyse the components encompassed by the term 'marine environment' from both geographical and ecological perspectives.

Geographically, the marine environment includes all maritime zones governed by the law of the sea regime, i.e. those within and beyond the national jurisdiction of States. In the *Request for an Advisory Opinion Submitted by the Sub-regional Fisheries Commission (SRFC)*, ITLOS acknowledged that Article 192 of the UNCLOS "applies to all maritime areas, including those encompassed by exclusive economic zones".[12] Similarly, the *South China Sea Arbitration* recognised that "the obligations in Part XII apply to all States concerning the marine environment in

9. UNCLOS (n 3) Preamble.

10. Translated from French text. Didillon Raphaëlle and Philippe Weckel, L'obligation Des États de Protéger et Préserver Le Milieu Marin. Rapport Général' (Monaco Indemer 2023) 28.

11. Ibid., 24.

12. *Request for an Advisory Opinion Submitted by the Sub-Regional Fisheries Commission (SRFC)* (Advisory Opinion, 2 April 2015) ITLOS Reports 2015, 4, para 120.

all maritime areas, both inside the national jurisdiction of States and beyond it."[13]

Ecologically, the marine environment also includes all forms of marine life[14] and all "living resources of the sea",[15] as it encompasses "physical, chemical, geological and biological components".[16] COSIS recently affirmed this understanding,[17] referring to "the entire marine ecosystem of marine organisms and their physical environment".[18] Hence, the obligation to protect and preserve the marine environment encompasses living and non-living marine resources, together with their physical and geographical environment, in all maritime areas within and beyond national jurisdiction.

3. Maritime domain awareness as a prerequisite for fulfilling environmental obligations

In recent decades, the complexity and diversity of incidents in the maritime domain have increased. Coastal states have encountered various threats to their security, including environmental ones such as illegal,

13. *South China Sea Arbitration (Philippines v China)* (2016) ICGJ 495, PCA Case No. 2013-19, para 90.

14. UNCLOS (n 3) Article 194.

15. *Southern Bluefin Tuna Cases (New Zealand* v. *Japan; Australia* v. *Japan)* (Provisional Measures, Order of 27 August 1999) ITLOS Reports 1999, 295, para 70.

16. International Seabed Authority, 'Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area' (22 July 2013) ISBA/19/C/17, art 1, para 3 (c).

17. Commission of Small Island States on Climate Change and International Law (COSIS), Written Statement Submitted to the International Tribunal for the Law of the Sea (ITLOS Case No. 31, 16 June 2023) para 132.

18. Ibid., para 134.

unreported, and unregulated fishing (IUU), unlawful exploitation of marine resources, and water contamination.[19] This section examines MDA in the context of enforcing marine environmental obligations.

MDA is not explicitly defined by the law of the sea; instead, it encompasses a range of practices that foster a comprehensive understanding and awareness of events in the maritime domain. At its core is accurate information, intelligence, surveillance, and reconnaissance of all vessels, cargo, and people.[20] According to Hicks and Metrick, MDA essentially operates as an intelligence tool to develop awareness of a given maritime domain or its subcomponents.[21]

While there is no universally accepted definition of the concept, the International Maritime Organization (IMO) characterizes MDA as "the effective understanding of anything associated with the maritime domain that could impact security, safety, the economy or the marine environment."[22] Consequently, many States view MDA as essential to maritime security, facilitating the early identification of potential threats

19. For detailed information on what activities are primarily sought to be detected by MDA, see Deon Canyon and Jim McMullin, 'Maritime Domain Awareness and Maritime Fusion Centers' (Daniel K Inouye Asia-Pacific Center for Security Studies 2020) 2-3.

20. US Executive Office of the President, 'Securing the Homeland, Strengthening the Nation' (2002), <https://georgewbush-whitehouse.archives.gov/homeland/homeland_security_book.html>; See also Kathleen H Hicks and Andrew Metrick, 'Maritime Domain Awareness: Today and Tomorrow' (Center for Strategic and International Studies (CSIS) 2018) 12-21; Christian Bueger, 'From Dusk to Dawn? Maritime Domain Awareness in Southeast Asia' (2015) 37 Contemporary Southeast Asia 157, 157.

21. Ibid., Hicks and Metrick, 12.

22. IMO, 'Amendments to the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual (24 May 2010) MSC.1/Circ.1367 Annex, page 1.

and enhancing prevention mechanisms.[23] MDA should, therefore, be understood in a broader context that extends beyond the realm of military security. The maritime domain is not limited to the military sector; rather, it encompasses diverse activities such as civilian transport, fishing, recreational activities, violent activities at sea, natural incidents, and incidents directly damaging human health – all of which are subject to surveillance using a similar set of technologies.[24]

Based on the understanding of MDA presented above, it is argued that it aligns with the objectives of Article 204(1) of the UNCLOS in a particular fashion. Paragraph 1 of the Article indicates that "States shall, [...], endeavour, as far as practicable, [...] to observe, measure, evaluate and analyse, by recognised scientific methods, the risks or effects of pollution of the marine environment."

As highlighted by the Democratic Republic of the Congo (DRC) in the ITLOS Case No. 31, this provision firstly requires States to collect primary data through observation and metrology of the marine envi-

23. The White House, 'The National Strategy for Maritime Security' (20 September 2005) <https://georgewbush-whitehouse.archives.gov/homeland/maritime-security.html>; IMO, Maritime Safety Committee, 89th session, 'Use of the Long-Range Identification and Tracking of Ships System Submitted by Canada'; UNSC, Concept note for the Security Council high-level open debate on the theme "Enhancing maritime security: a case for international cooperation", Annex to the letter dated 26 July 2021 from the Permanent Representative of India to the United Nations addressed to the Secretary-General (27 July 2021) UN Doc S/2021/680 2; ITLOS Verbatim Records, *The M/T "San Padre Pio" Case (Switzerland v Nigeria)* (21 June 2019 3 pm) ITLOS/PV.19/C27/2/Rev.1, Representative of Nigeria 9; UNGA, 43rd Plenary meeting, UN General Assembly Official Records 74th session UN Doc A/74/PV.43 (10 December 2019) Representative of Japan 4; IMO, Sub-Committee of Navigation, 89th session, 'Development of an E-navigation Strategy Implementation Plan, Report of the Correspondence Group, Submitted by Norway'. See also Joseph L Nimmich and Dana A Goward, 'Maritime Domain Awareness: The Key to Maritime Security' 83 International Law Studies 57, 65.

24. UNSC, Report of the United Nations assessment mission on piracy in the Gulf of Guinea (7 to 24 November 2011), Letter dated 18 January 2012 from the Secretary-General addressed to the President of the Security Council (19 January 2012) UN Doc S/2012/45, 16-17.

ronment, followed by its evaluation and analysis.[25] The DRC further acknowledges that due to the significance of scientific data in achieving effective protection and preservation of the marine environment, "the obligations established under Article 204 constitute a precondition for the performance [...] of the more general obligations set out in Articles 192 and 194 of UNCLOS."[26]

In light of the ongoing challenges in protecting and preserving the marine environment, MDA can offer comprehensive monitoring and detection capabilities to States through the use of technology. It enables monitoring of vessel movements, detection of IUU fishing activities or unauthorised pollution discharges, identification of oil spills, and monitoring changes in water quality and marine biodiversity.[27] MDA proves highly beneficial in detecting harmful effects or activities that may damage the marine environment. One of its main advantages lies in its capacity to facilitate timely responses to environmental threats, enabling coastal States to fulfil their obligations to protect and preserve the marine environment. For instance, in the case of oil spills or pollution discharges, MDA can play a crucial role by providing real-time information and situational awareness, thereby preventing further harm to the marine environment and mitigating adverse effects.

In summary, MDA serves as the critical link to achieving effective maritime environmental protection and maritime security through per-

25. DRC, Observations submitted to the ITLOS (n 7), para 237.

26. Ibid., para 238.

27. Kamal-Deen Ali, 'Overview of Maritime Security Challenges in the Gulf of Guinea' in *Maritime Security Cooperation in the Gulf of Guinea* (Brill Nijhoff 2015) 88-111; 'Policies for for Maritime Domain Awareness and Space Technology' (The Maureen and Mike Mansfield Foundation, 25 October 2023) <https://mansfieldfdn.org/blog/policy-recommendations-for-maritime-domain-awareness-and-space-technology>; Heidi Vella, 'Drones in the Deep: New Applications for Maritime UAVs' (23 January 2018) Ship Technology <https://www.ship-technology.com/features/drones-deep-new-applications-maritime-uavs/>.

sistent awareness and decision superiority.[28] It is not merely a central component of maritime security, but also a necessary precondition to all other aspects of maritime security, and consequently, to the protection and preservation of the marine environment.[29]

4. The due diligence nature of marine environmental obligations

The effectiveness of the techniques and technologies employed for the MDA lacks a universally defined standard expected from States to fulfil their legal obligations to protect and preserve the marine environment. This is particularly relevant given the due diligence nature of these obligations. The present section delves into the due diligence nature of obligations within the law of the sea, particularly focusing on the practical and ethical dimensions of States' capabilities in fulfilling their environmental obligations and the North-South disparities therein.

The concept of due diligence is applied in various legal domains, including the law of the sea, where it is a well-established concept of international law.[30] In this context, it refers to the obligation to exercise

28. Ruxandra-Laura Bosilca, 'The Use of Satellite Technologies for Maritime Surveillance: An Overview of EU Initiatives' (2016) 8 (1) INCAS Bulletin 153, 155-157; 'National Plan to Achieve Maritime Domain Awareness for the National Strategy for Maritime Security' (October 2005), ii.

29. Ifesinachi Okafor-Yarwood et al, 'Technology and Maritime Security in Africa: Opportunities and Challenges in Gulf of Guinea' (2024) 160 Marine Policy 105976, 2.

30. R Rajesh Babu, 'State Responsibility for Illegal, Unreported and Unrelated Fishing and Sustainable Fisheries in the EEZ: Some Reflections on the ITLOS Advisory Opinion of 2015' (2015) 55 Indian Journal of International Law 239, 258; *See SS Lotus case* (France v Turkey) (1927) PCIJ Ser A No 10, para 269; *Alabama Claims Arbitration* (US v Great Britain) (1872) 29 RIAA 125, 129. In Lotus case for example, it is stated that '[i]t is well settled that a State is bound to use due diligence to prevent the commission within its dominions of criminal acts against another nation or its people.'

reasonable care and precautions to prevent harm or mitigate potential risks in the maritime domain.[31] Important references to the due diligence obligations of States can be found in the ITLOS Advisory Opinion of 2011 and the *Pulp Mills* case before the International Court of Justice (ICJ). Referring to the advisory opinion delivered by ITLOS, the concept, or the so-called definition of the due diligence obligation, could be as follows:

> Obligation "to ensure" […] is an obligation to deploy adequate means, to exercise best possible efforts, to do the utmost, to obtain this result. To utilize the terminology current in international law, this obligation may be characterized as an obligation "of conduct" and not "of result", and as an obligation of "due diligence".[32]

Similarly, the ICJ in *Pulp Mills* defines due diligence as "an obligation that entails not only the adoption of appropriate rules and measures but also a certain level of vigilance in their enforcement and the exercise of administrative control".[33]

While UNCLOS does not use the phrase 'due diligence', the regime it establishes is "mostly based on the due diligence test".[34] From the in-

31. International Law Commission (ILC), 'Draft Articles on the Prevention of Transboundary Harm from Hazardous Activities' (12 December 2001) A/RES/56/82, art 3; Neil McDonald, 'The Role of Due Diligence in International Law' (2019) 68 International & Comparative Law Quarterly 1041, 1042; 1051; Jorge E Viñuales, 'Due Diligence in International Environmental Law: A Fine-Grained Cartography' in Heike Krieger, Anne Peters and Leonhard Kreuzer (eds), *Due Diligence in the International Legal Order* (OUP, 2020) 111, 115.

32. *Responsibilities and obligations of States with respect to activities in the Area* (Advisory Opinion, 1 February 2011) ITLOS Reports 2011, 41, para 110.

33. *Pulp Mills on the River Uruguay (Argentina v Uruguay)* (Merits) [2010] ICJ Rep 14, para 197.

34. Francisco Orrego Vicuña, 'State responsibility, liability, and remedial measures under international law: new criteria for environmental protection' in E Brown Weiss (ed), *Environmental Change and International Law: New Challenges and Dimensions* (United Nations University Press, 1992) 124, 124.

terpretation of international courts and tribunals as mentioned above, it can be understood that due diligence obligations are those in which words such as 'to ensure', 'all necessary, appropriate or effective measures', 'means at their disposal' and 'according to their capabilities' are predominantly used. Considering this, most of the obligations under Part XII of the UNCLOS, i.e. general obligations related to the protection and preservation of the marine environment, are due diligence obligations. For example, the text of Article 194 employs the following wording:

> States shall take, individually or jointly as appropriate, *all measures* consistent with this Convention *that are necessary* to prevent, reduce and control pollution of the marine environment from any source, using for this purpose *the best practicable means at their disposal and in accordance with their capabilities* (emphasis added), and they shall endeavour to harmonise their policies in this connection.

This approach takes into account the limited capabilities of developing States. Afterall, UNCLOS was drafted for the purpose of establishing "a just and equitable international economic order which takes into account [...] the special interests and needs of developing countries".[35]

Article 192, on the other hand, stands out for its unique approach to the due diligence obligations, deviating from conventional formulations observed in other provisions. The former emphasises the general obligation of States to protect and preserve the marine environment without explicitly using terms such as 'to ensure', 'taking all necessary, appropriate or effective measures', or 'in accordance with their capabilities'. Yet, when referring to Article 192, the ITLOS Advisory Opinion of 2015 states that, as it "applies to all maritime areas, including those encompassed by exclusive economic zones, the flag State is under an obligation

35. UNCLOS (n 3) Preamble.

to ensure compliance by vessels flying its flag [...]".[36]

In light of these considerations, the obligations to protect and preserve the marine environment under Part XII are essentially due diligence obligations. COSIS, in Case No. 31, submitted that the provisions of Part XII entail but also go beyond due diligence obligations.[37] This stance was explained by arguing that UNCLOS obligations cannot be neatly categorised as either obligations of conduct or obligations of result, emphasising the importance of interpreting each provision in context to determine its meaning.[38]

Moreover, the concept of due diligence may afford States a flexible opportunity. According to the ITLOS Advisory Opinion of 2011, "due diligence is a variable concept, […] it may change over time as measures considered sufficiently diligent at a certain moment may become not diligent enough in light, for instance, of new scientific or technological knowledge".[39] Due diligence provides flexibility for States in terms of determining which measures are necessary at the time and available within their capacities.[40] This leaves room to justify that the applied measures were necessary, appropriate, and feasible within the available capabilities to deter responsibility.

However, is it that simple to avoid State responsibility by claiming subjective belief in compliance with due diligence obligations? Papanicolopulu emphasises that meeting obligations of result can sometimes be more attainable than those of conduct (i.e., due diligence obligations),

36. ITLOS Advisory Opinion 2015 (n 12) para 120.

37. Commission of Small Island States on Climate Change and International Law (COSIS), Response to Judge Kittichaisaree's Question (ITLOS Case No. 31, 24 September 2023) para 21 et seq.

38. Ibid., paras 23; 25-28.

39. ITLOS Advisory Opinion 2011 (n 32) para 132.

40. Hanqin Xue, 'The Doctrine of Due Diligence and Standard of Conduct' in *Transboundary Damage in International Law* (Cambridge University Press 2003) 162, 164.

as well as that due diligence obligations are not necessarily 'weaker' than the former.[41]

While it may seem straightforward to avoid State responsibility by demonstrating that the State has fulfilled its positive obligation, such as enacting a law in its national legislation, proving that the State has taken "all necessary, appropriate or effective" measures to meet its due diligence obligation can be challenging. For example, consider the obligation to adopt laws and regulations in national legislation to prevent, reduce, and control pollution of the marine environment from land-based sources.[42] While this provision is formulated as an obligation of result, proving compliance with it may be more challenging if it were an obligation of conduct.[43]

In the former scenario, a State might avoid State responsibility by showing it adopted necessary legislation. However, in the latter scenario, questions might arise regarding whether the State has taken all necessary and appropriate measures to prevent, reduce, and control pollution per se.[44]

Due diligence obligations entail not only the adoption of appropriate rules and measures but also a certain level of vigilance in their enforcement and administrative control, as highlighted in cases such as the *Pulp Mills*[45] and the *South China Sea*. In the latter, the Arbitral Tribunal noted that adopting appropriate rules and measures to prohibit a harmful

41. Irini Papanicolopulu, 'Due Diligence in the Law of the Sea' in Heike Krieger, Anne Peters and Leonhard Kreuzer (eds), *Due Diligence in the International Legal Order* (Oxford University Press 2020) 147, 150.

42. UNCLOS (n 3) art 207(1).

43. What is meant by 'obligation of conduct' and not that 'of result' is that the obligation of conduct requires States to take certain actions regardless of the result achieved. *See* ITLOS Advisory Opinion 2011 (n 32).

44. Papanicolopulu (n 41).

45. *Pulp Mills* (n 33).

practice is only one component of the due diligence required by States pursuant to the general obligation of Article 192.[46]

With this assertion, it becomes clear that avoiding these obligations by solely enacting national legislation, without implementing all appropriate measures, under the pretext of limited capabilities, is not a straightforward matter.

In conclusion, with a nuanced understanding of the concept of due diligence, it is evident that States are not inherently obligated to maintain comprehensive awareness of their maritime domains. Moreover, there is no objective threshold for the surveillance expected from States; these obligations are contingent upon their capabilities. This raises ethical concerns regarding the legal and regulatory framework of environmental maritime security, a theme discussed in this volume, particularly highlighting the emergence of a North-South disparity. Moving beyond these ethical considerations, the next section explores advancements in maritime surveillance capabilities enabled by new technologies.

46. *South China Sea Arbitration* (n 13) para 963. Tribunal stated that "there is no evidence in the record that would indicate that China has taken any steps to enforce those rules and measures against fishermen engaged in poaching of endangered species".

5. New technologies bridging the gap in maritime domain awareness

5.1 North-South disparity and maritime technology

Traditionally, developing States lack the capacity for effective surveillance of their maritime domain.[47] The General Assembly recognizes this capacity gap in ocean observation and monitoring.[48] During the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea on 'Ocean observing', several delegations expressed concern about the deficit of developing States in conducting sufficient ocean observation.[49] This was underscored by the report of the Secretary General of the United Nations, emphasising that:

> Many developing countries, in particular the least developed countries and small island developing States, lack capacity to effectively conduct ocean observations, which further impedes the expansion of the ocean observing network. These capacity gaps relate both to in-country human resources and to the financial resources necessary for instrumentation purchase, maintenance, deployment and recovery. [...] Such capacity gaps contribute to an overall gap in observations, particularly surrounding small island developing States and coastal States vulnerable to ocean change.[50]

47. House of Lords, International Relations and Defence Committee, 'UNCLOS: The Law of the Sea in the 21st Century' (2022) 2nd Report of the Session 2021-22, para 94; Steven Haines, 'UNCLOS: Fit for Purpose in the 21st Century?' (2021) Written evidence UNC0037.

48. UNGA Res 76/72 (9 December 2021) UN Doc A/RES/76/72 paras 216-217.

49. '(First Plenary Meeting) 22nd Meeting of the United Nations Open-Ended Informal Consultative Process on Oceans and the Law of the Sea (6 June AM) | UN Web TV' (6 June 2022) The Intervention of the delegation of Chile 1:07:00 – 1:11:00, and the intervention of the delegation of the Philippines 1:13:00 – 1:17:00.

50. UNGA Res 77/68 (28 March 2022) UN Doc A/77/68 para 30.

The Secretary General further notes that "[s]everal delegations, including one group of States, expressed concerns with respect to the limited capacity of many developing countries to effectively conduct and make use of ocean observations".[51]

Nonetheless, new technologies are significantly narrowing the gap in maritime surveillance capabilities. At present, maritime surveillance relies on a combination of coastal radars, satellite observations, vessel patrols, and both manned and unmanned aerial surveillance.[52]

The advent of technological advancements is widely recognised for offering unprecedented opportunities to enhance maritime monitoring and address complex security challenges in maritime domains.[53] There is a generally accepted notion that new technologies "are excellent at monitoring [and] allow a relatively inexpensive real-time view of the ocean and various areas of interest", embodying what has been termed as 'techno-optimism.'[54]

Contemporary technologies such as drones, automatic identification systems (AIS), and satellites excel in monitoring activities, while pro-

51. UNGA 'Report on the work of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea at its twenty-second meeting' UNGA 77th session, UN Doc A/77/119 (24 June 2022) para 12.

52. Ilkka Tikanmäki et al, 'Maritime Surveillance and Information Sharing Systems for Better Situational Awareness on the European Maritime Domain: A Literature Review' in Todor Tagarev et al (eds), *Digital Transformation, Cyber Security and Resilience of Modern Societies* (Springer International Publishing, 2021) 117, 117.

53. *See for example* Narri Yadaiah, Nagireddy Ravi and Garnapalli Shreya, 'Development of IoT Based Underwater Drone for Maritime Security and Surveillance' in VH Saran and Rakesh Kumar Misra (eds), *Advances in Systems Engineering* (Springer, 2021) 667; Rabi Sharma et al, 'Maritime Surveillance Using Instance Segmentation Techniques' in João Manuel RS Tavares et al (eds), *Data Science and Communication* (Springer Nature, 2024) 31; Fitriana Cahyani Ardi, 'Implementation of Integrated Maritime Surveillance System (IMSS) Technology for the Indonesian Navy in Increasing the Security of the Jurisdictional Marine Area' (2023) 4 International Journal of Social and Management Studies 26, 26.

54. Elizabeth Nyman, 'Techno-Optimism and Ocean Governance: New Trends in Maritime Monitoring' (2019) 99 Marine Policy 30, 33.

viding a relatively affordable and real-time overview of the ocean and various strategic areas of interest. The evolution of satellite imagery, coupled with breakthroughs in artificial intelligence, is rapidly advancing, heralding a new era in maritime surveillance.[55] The utility of "high-tech artificial intelligence and space technologies" in environmental monitoring was recently highlighted before ITLOS in Case No. 31.[56]

This revolution is particularly beneficial for States with less developed technological infrastructure, enabling them to establish effective maritime surveillance and bolster maritime security. The report of the United Nations Secretary-General on oceans and the law of the sea underscores the pivotal role of emerging technologies in enhancing the capabilities of developing nations. It emphasises that "the creation of affordable, easy-to-maintain technologies [...] could broaden participation in ocean observation, including among developing countries".[57]

Given that proficient MDA requires the collection and analysis of data, information, and intelligence, with the aim of disseminating it to relevant

55. See for example 'Unmanned Maritime Systems (UMS)' (The European Space Agency) <https://business.esa.int/funding/invitation-to-tender/unmanned-maritime-systems-ums>; Jennifer Raynor, 'We Used AI and Satellite Imagery to Map Ocean Activities That Take Place out of Sight, Including Fishing, Shipping and Energy Development' (*The Conversation*, 3 January 2024); Bosilca (n 28) 153-161; Nadia Proia and Vincent Pagé, 'Maritime Surveillance with the Use of Optical Satellite Images' (Observation des Côtes et des Océans: Senseurs et Systèmes, OCOSS 2010); H Greidanus, 'Satellite Imaging for Maritime Surveillance of the European Seas' in Vittorio Barale and Martin Gade (eds), *Remote Sensing of the European Seas* (Springer, 2008); Yu Wang et al, 'Machine Learning-Based Ship Detection and Tracking Using Satellite Images for Maritime Surveillance' (2021) 13 Journal of Ambient Intelligence and Smart Environments 361; Valerio Fontana et al, 'Artificial Intelligence Technologies for Maritime Surveillance Applications' (21st IEEE International Conference on Mobile Data Management (MDM) 2020); Zaeem Shabbir, Ali Sarosh and Mahhad Nayyer, 'Space Technology Applications for Maritime Intelligence, Surveillance, and Reconnaissance' (2019) 17 Astropolitics 104.

56. *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law (Minutes of Public Sittings)* ITLOS Case No. 31 (11 to 25 September 2023) 195.

57. UNGA Res 77/68 (n 50) paras 64-65.

authorities,[58] the following subsections provide an overview of technological advancements in maritime data collection and analysis. It identifies data collection as the process of capturing inputs from the undersea, surface, and aerial subcomponents of the overarching maritime domain, while data analysis involves the fusion and analysis of collected data. Traditionally, this has been done by trained human operators who possess a deep understanding of specific regional dynamics and patterns of activity. However, there is an increasing use of automated technologies for data analysis.[59]

5.2 Advancements in data collection

The implementation of MDA starts with the collection of maritime data, a process greatly enhanced by technological advancements.[60] Developments in areas such as small satellites, open-source satellite imagery, and the widespread use of low-cost drones are said to have revolutionised maritime surveillance,[61] leading to increased affordability and efficiency.

Satellite technology plays a long-recognised role in environmental monitoring,[62] which also includes maritime environmental monitoring.[63] However, access to such technology has historically been limited to

58. UNSC Doc S/2021/680 (n 23) 2.

59. Hicks and Metrick (n 20) 20-21.

60. Organisation for Economic Co-operation and Development, 'The Ocean Economy in 2030' (OECD, 2016) 41.

61. Giovanni Soldi (et al.), 'Space-Based Global Maritime Surveillance. Part I: Satellite Technologies' (2021) 36 IEEE Aerospace and Electronic Systems Magazine 8.

62. Karen T Litfin, 'The Gendered Eye in the Sky: A Feminist Perspective on Earth Observation Satellites' (1997) 18 Frontiers: A Journal of Women Studies 26, 26; Johan Gärdebo, Agata Marzecova and Scott Gabriel Knowles, 'The Orbital Technosphere: The Provision of Meaning and Matter by Satellites' (2017) 4 The Anthropocene Review 44, 48.

63. UNGA 'Report on the work of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea at its twenty-third meeting' UNGA 78th session, UN Doc A/78/129 (3 July 2023) para 17.

developed States[64] capable of making substantial investments,[65] creating a hegemony that is now being challenged on multiple fronts.

Firstly, the consistent decline in the cost of space technology[66] has enabled developing States to climb the "space technology ladder".[67] The emergence of more affordable "small satellites" offers increased "flexibility, speed of development, resiliency, low cost, and tolerance of risk in cutting edge technology".[68]

Secondly, the rapidly advancing commercial and private space industry[69] presents an opportunity for developing States to benefit from satel-

64. Barry R Posen, 'Command of the Commons: The Military Foundation of US Hegemony' (2003) 28 (1) International Security 5, 19-20; 46. Posen connects US military power with economic and technological dominance. See also, James Clay Moltz, *The Politics of Space Security: Strategic Restraint and the Pursuit of National Interests* (Stanford University Press, 2019) 31-37; Ann Florini and Yahya Dehqanzada, 'Commercial Satellite Imagery Comes of Age' (1999) 16 Issues in Science and Technology 45, 47.

65. *See* Theresa Hitchens, 'Weapons in Space: A Silver Bullet or Russian Roulette? The Policy Implications of US Pursuit of Space-based Weapons' in John Logsdon and Gordon Adams eds, *Space Weapons: Are They Needed?* (Washington, DC: Space Policy Institute, 2003); Michael Krepon and Christopher Clary, *Space Assurance or Space Dominance? The Case against Weaponizing Space* (Henry L Stimson Center, 2003) 58-74; Charles V Peña and Edward L Hudgins, 'Should the United States "Weaponize" Space? Military and Commercial Implications' (18 March 2002) Cato Institute, Policy Analysis No 427, 5-10.

66. Euroconsult for the UK Space Agency, 'Commercial Space Surveillance & Tracking' (2020) Final Report <https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/917912/Euroconsult_-_Commercial_SST_Market_-_for_publication.pdf>; McKinsey & Company, 'McKinsey Technology Trends Outlook 2022 Future of Space Technologies' (August 2022).

67. Danielle Wood and Annalisa Weigel, 'Charting the Evolution of Satellite Programs in Developing Countries – The Space Technology Ladder' (2012) 28 Space Policy 15-24.

68. Joseph R Kopacz, Roman Herschitz and Jason Roney, 'Small Satellites an Overview and Assessment' (2020) 170 Acta Astronautica 93, 93; Simone Battistini, 'Chapter 12 - Small Satellites for Disaster Monitoring' in Adil Denizli et al (eds), *Nanotechnology-Based Smart Remote Sensing Networks for Disaster Prevention* (Elsevier, 2022) 231, 245.

69. USSPACECOM, Leveraging Commercial Space (J8 Memo to Industry, FY26 4th edition, October 2023). UN Office for Outer Space Affairs, 'The proceedings of the Workshop on United Nations treaties on outer space: Actions at the national level' (2004) UN Doc ST/SPACE/22, 4 (Opening statement by Kak-soo Shin).

lite surveillance capabilities without having to invest in national satellite systems.[70]

In this regard, perhaps the most impactful period was the late 1990s and early 2000s, which marked a significant change with the emergence of open-source satellite imagery,[71] 'democratizing' access to what was once a highly exclusive resource.[72] Examples include NASA's Landsat programme,[73] NASA's Land, Atmosphere Near real-time Capability for EO (LANCE) programme,[74] NASA Worldview,[75] NASA Earth Observatory,[76] EU Copernicus/European Space Agency (ESA) Sentinel programme,[77] and Japan's GOSAT project.[78]

Technologically on par, the private sector also offers open-source initiatives like Google Earth Engine,[79] 'Group on Earth Observations' (GEO) and its 'Global Earth Observation System of Systems' (GEO-

70. J Todd Black, 'Commercial Satellites: Future Threats or Allies?' (1999) 52 Naval War College Review 99, 99.

71. Columba Peoples and Tim Stevens, 'At the Outer Limits of the International: Orbital Infrastructures and the Technopolitics of Planetary (In)Security' (2020) 5 (3) European Journal of International Relations 294.

72. Yahya Dehqanzada and Ann M Florini, 'Secrets for Sale: How Commercial Satellite Imagery Will Change the World' (Carnegie Endowment for International Peace 2000).

73. 'Satellites | Landsat Science' (*NASA*, 30 November 2021) <https://landsat.gsfc.nasa.gov/satellites/>.

74. Ibid.

75. 'EOSDIS Worldview' (*Worldview*) <https://worldview.earthdata.nasa.gov/?v=-133.107740991966,-56.656891674339754,42.45673504856204,63.43938758816639&t=2024-03-07-T17%3A10%3A33Z>.

76. 'NASA Earth Observatory - Home' (16 February 2024) <https://earthobservatory.nasa.gov/>.

77. 'Missions - Sentinel Online' (*Sentinel Online*) <https://copernicus.eu/missions>.

78. 'GOSAT Greenhouse Gases Observing Satellite' (*Greenhouse gases observing satellite GOSAT 'IBUKI'*) <https://www.gosat.nies.go.jp/en/>.

79. 'A Planetary-Scale Platform for Earth Science Data & Analysis' (*Google Earth Engine*) <https://earthengine.google.com>.

SS),[80] and DigitalGlobe.[81]

In the field of ocean observation, initiatives such as the OceanOPS, Ocean+, and European Digital Twin of the Ocean (European DTO), European Marine Observation and Data Network (EMODnet), continue to aim at providing open-source and accessible maritime data.[82]

Advancements in satellite technologies as above-mentioned promote different areas of marine environmental protection. For instance, satellite technology can track and map marine pollutants,[83] and other atmospheric pollutants associated with marine transportation.[84] In addition to atmospheric pollution, satellite technology can also aid in the investigation of fishing activities and the monitoring of pollution resulting from oil spills. For example, "publicly available satellite data offered by NASA and the ESA provide an opportunity to actively monitor [IUU fishing]".[85]

Scientists at the U.S. National Oceanic and Atmospheric Administration (NOAA) employ the Visible Infrared Imaging Radiometer Suite (VIIRS), an instrument onboard the NASA/NOAA Suomi National Polar Partnership weather satellite, to identify and pinpoint through satellite images the illumination used by fishermen to lure

80. 'Mission | GEO' (*Group on Earth Observations*) <https://earthobservations.org/>.

81. DigitalGlobe was acquired by Maxar Technologies in 2017: 'Maxar Is a Leading Geospatial Intelligence Company' (*Maxar*) <https://www.maxar.com/maxar-intelligence/about>.

82. UNGA Res 77/68 (n 50) para 64.

83. Sidrah Hafeez et al, 'Detection and Monitoring of Marine Pollution Using Remote Sensing Technologies' in Houma Bachari Fouzia (ed), *Monitoring of Marine Pollution* (IntechOpen, 2018) 1, 2.

84. Saadia M Pekkanen, Setsuko Aoki and John Mittleman, 'Small Satellites, Big Data: Uncovering the Invisible in Maritime Security' (2022) 47 International Security 177, 209.

85. Patrick Beukema et al, 'Satellite Imagery and AI: A New Era in Ocean Conservation, from Research to Deployment and Impact' (2023) 1 <https://openreview.net/forum?id=H-0HdmdXsTp>.

squid and other marine life to the surface during night time.[86] Additionally, the Global Fishing Watch holds an "open-access online platform for visualisation and analysis of vessel-based human activity at sea".[87] This could publicly reveal previously unseen vessel activity around the world.[88]

Oil spill detection has long benefitted from satellite imagery, too.[89] Advancements in technology increasingly allow for the identification of responsible vessels and evaluation of their toxic effects of their activities on the marine ecosystem.[90] For instance, the Second World Ocean Assessment Report names the General National Oceanic and Atmospheric Administration Operational Modelling Environment (GNOME), a system that improves the processing of satellite imagery to predict the trajectory and fate of oil spills.[91] The coding system of GNOME is free,

86. Christopher D Elvidge et al, 'Automatic Boat Identification System for VIIRS Low Light Imaging Data' (2015) 7 Remote Sensing 3020, 3034. Visible Infrared Imaging Radiometer Suite (VIIRS) Boat Detection is described in Christopher D Elvidge et al, 'Rating the Effectiveness of Fishery Closures With Visible Infrared Imaging Radiometer Suite Boat Detection Data' (2018) 5 Frontiers in Marine Science 1, 2.

87. 'Global Fishing Watch Map User Guide' (*Global Fishing Watch*) <https://globalfishingwatch.org/user-guide/>.

88. Dave Poortvliet, 'Emerging Technology Gives First Ever Global View of Hidden Vessels' (*Global Fishing Watch*, 8 June 2022) <https://globalfishingwatch.org/press-release/technology-highlights-hidden-vessels/>.

89. *See* Werner Alpers and Heidi A Espedal, 'Oils and Surfactants' in Christopher R Jackson and John R Apel (eds), *Synthetic Aperture Radar: Marine User's Manual* (Washington, DC: NOAA, September 2004) 263–275. Alpers and Espedal cite operational use of Synthetic Aperture Radar (SAR) imagery as early as 1996 in support of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78); *See* Bingxin Liu et al, 'Tracing Illegal Oil Discharges from Vessels Using SAR and AIS in Bohai Sea of China' (2021) 211 Ocean & Coastal Management 105783.

90. 'Sustainable Ocean Management - Technology' (*Global Fishing Watch*) <https://globalfishingwatch.org/map-and-data/>.

91. UN, '*The Second World Ocean Assessment*' Volume I (New York, 2021) 289.

publicly available, and fully open-source.[92] The Environment & Oil Spill Response is another open-source analytic tool that supports oil spill response planning.[93] The open-coding nature of these tools make them accessible to States of different capabilities.

Another technology to be pinpointed alongside satellite technology is low-cost commercial drones, which have emerged as a cost-effective solution for autonomous maritime surveillance. Initiatives like the MITRE Corporation's partnership with the U.S. Office of Naval Research aim to deploy autonomous drones capable of operating in dynamic ocean environments with low-power sensors and commercial electronics.[94] As MITRE's expeditionary group leader stated, instead of "a crewed asset or an expensive uncrewed asset to maintain cognizance over a wide ocean area, Hopper [drone] can do so at a fraction of the cost".[95]

The US Navy has also invested in a research programme to develop such capabilities, titled Low Cost Unmanned aerial vehicle Swarming Technology, which will allow its operators to control the behaviour of the swarm, while preserving individual drone autonomy.[96] Similar to satellites or other remote technologies, drones provide "large reach over vast areas combined with their low cost make them a cheap solution for the

92. 'GNOME Suite for Oil Spill Modeling' (*Office of Response and Restoration*, 3 January 2023) <https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/gnome-suite-oil-spill-modeling.html>.

93. 'AU Ecoscience - EOS' (Aarhus University, 21 April 2023).

94. Miriam McNabb, 'MITRE's Hopper UAV: Unleashing Unmanned Ingenuity Across Oceans' (DRONELIFE, 30 January 2024).

95. Paul O'Donnell and Denise Schiavone, 'Taking Flight: Hopper Drone Poised to Transform Maritime Missions' (*Mitre*, 26 January 2024).

96. Irving Lachow, 'The Upside and Downside of Swarming Drones' (2017) 73 (2) Bulletin of the Atomic Scientists 96, 98; Tuneer Mukherjee, 'Securing the Maritime Commons: The Role of Artificial Intelligence in Naval Operations' (Observer Research Foundation 2018) ref. 52.

management of large marine spaces".[97]

In sum, the ongoing advancements in data collection technologies within the maritime domain signify a trend towards more inclusive, efficient, and effective surveillance and environmental monitoring practices. This progress not only enhances MDA but also empowers States, especially those with limited resources, to better respond to environmental threats.

5.3 Advancements in data processing

The preceding sections have highlighted the advancements in data collection technologies, showcasing the sheer volume of unclassified imagery and data broadcasts available daily. These terabytes of information from global surveillance operations exceed the processing capacity of human analysts.[98] Even with vast amounts of maritime data collected inexpensively and readily, manual processing would still be impractical, as it would be time-consuming and labor-intensive.[99] This issue ties into another North-South capacity gap identified in the Secretary General's report on ocean observations, which pertains to the availability of human resources for observation activities within each country.

Having said that, advances in computing technology, coupled with statistical approaches for analysing large datasets through machine learn-

97. Kate Bennett et al, 'Managing Large Scale Marine Reserves: Policy Recommendations for the Global Legacy Ocean Campaign' (2015) 52; Trent Lukaczyk et al, 'Unmanned Aircraft as Mobile Components of Ocean Observing Systems for Management of Marine Resources' (IEEE/MTS Oceans 2016) 1-7; Nyman (n 54) 32; *See also* Quentin Laporte-Fauret et al, 'Low-Cost UAV for High-Resolution and Large-Scale Coastal Dune Change Monitoring Using Photogrammetry' (2019) 7 Journal of Marine Science and Engineering 63.

98. Robert Cardillo, 'Small Satellites - Big Data | National Geospatial-Intelligence Agency' (Utah State University, Logan, Utah, 7 August 2017) <https://www.nga.mil/news/Small_Satellites_-_Big_Data.html>; Pekkanen et al (n 84) 177.

99. Nyman (n 54) 32.

ing and artificial intelligence, have improved the utility of ocean datasets.[100] Automated technologies now provide substantial support to human operators in analysing data collected from maritime domains,[101] enabling the examination of vast quantities of surveillance footage[102] with profound implications for environmental protection.[103]

It is notable that these automated algorithms offer a more cost-effective solution than traditional human analysis.[104] While it is not indicated that they would completely replace human capacity, this progression continues to bridge the gap in human resources between developed and developing States, as highlighted by the Secretary-General's report on ocean observation.[105]

In fact, research on intelligent vision-based technology at sea is ongoing to offer cost-effective enhancements over conventional, human-centric object detection, even in areas where human capabilities would still be employed.[106]

In the context of fishing, for instance, ongoing research is examining how machine-learning algorithms can discern patterns amidst various factors such as vessel movements, islands, waves, and other noise. The aim is to detect vessels going 'dark' (e.g., turning off their tracking sys-

100. Hilde M Toonen and Simon R Bush, 'The Digital Frontiers of Fisheries Governance: Fish Attraction Devices, Drones and Satellites' (2020) 22 Journal of Environmental Policy & Planning 125, 125; Yu Wang et al (n 55).

101. Hicks and Metrick (n 20) 20-21.

102. Vijay Sakhuja, 'Artificial Intelligence and Maritime Domain Awareness | Society for the Study of Peace and Conflict' (11 June 2018) <https://sspconline.org/index.php/opinion/artificial-intelligence-maritime-domain-awareness-vijay-sakhuja-110618>.

103. Alexandru Pohontu, 'A Review over AI Methods Developed for Maritime Awareness Systems' (2020) XXIII Scientific Bulletin of Naval Academy 287, 287.

104. National Plan to Achieve Maritime Domain Awareness (n 28) page ii, 8.

105. UNGA Res 77/68 (n 50) para 30.

106. Rabi Sharma et al (n 53) 37.

tems) and predict which of those vessels are engaged in fishing.[107] The Second World Ocean Assessment reports how the use of artificial intelligence and machine learning approaches can complement other advancements in remote sensing and camera technologies, contributing to better monitoring of IUU catches. This can also improve the reporting of catches, allow for the traceability of products, reduce wastage along supply chains, and assist in improved monitoring of the movements of fishing fleets. Ultimately, this ensures more effective management of protected areas.[108]

These developments in the field of maritime surveillance are evolving rapidly,[109] with the potential to "revolutionize maritime operations" by enhancing efficiency and effectiveness in data processing and interpretation.[110] Yet, what is notable in the context of the North-South capacity

107. The xView3 data challenge is described in Sarah Bladen, 'US Government and Nonprofit Organization Host Prize Competition to Leverage the Latest Technology to Detect and Defeat Illegal Fishing' (*Global Fishing Watch*, 22 July 2021) <https://globalfishingwatch.org/press-release/usgovt-gfw-xview3/>. *See also*, Pekkanen et al (n 84) 211.

108. UN, '*The Second World Ocean Assessment*' Volume I (New York, 2021) 70-71; *See also* Emmanouil Detsis et al, 'Project Catch: A Space Based Solution to Combat Illegal, Unreported and Unregulated Fishing: Part I: Vessel Monitoring System' (2012) 80 Acta Astronautica 114; J Ruiz et al, 'Electronic Monitoring Trials on in the Tropical Tuna Purse-Seine Fishery' (2015) 72 ICES Journal of Marine Science 1201; Sara G Lewis and Mariah Boyle, 'The Expanding Role of Traceability in Seafood: Tools and Key Initiatives' (2017) 82 Journal of Food Science A13; Tomas Hafliðason et al, 'Criteria for Temperature Alerts in Cod Supply Chains' (2012) 42 International Journal of Physical Distribution & Logistics Management 355; Gwilym Rowlands et al, 'Satellite Surveillance of Fishing Vessel Activity in the Ascension Island Exclusive Economic Zone and Marine Protected Area' (2019) 101 Marine Policy 39.

109. Debra Werner, 'Forecasts Call for Rapid Growth in Earth Observation Market' [2018] *SpaceNews Magazine*; Valery Komissarov, 'How Will the Earth-Observation Market Evolve with the Rise of AI?' [2018] *SpaceNews Magazine.*

110. TechSur Solutions, 'Leveraging AI/ML for Enhanced Maritime Domain Awareness With a Focus on AMVER Modernization' (*TechSur Solutions*, 2 October 2023)) <https://techsur.solutions/leveraging-ai-ml-for-enhanced-maritime-domain-awareness-with-a-focus-on-amver-modernization/>.

gap is that automated analytical tools and processing systems are significantly more accessible than human capacities. For instance, the Allen Institute for Artificial Intelligence (AI2), a non-profit organisation in Seattle, USA, has developed 'SkyLight', an initiative aimed at delivering top-quality data and analytics to support enforcement and compliance actions in reducing IUU fishing and other maritime crimes.[111] Advanced artificial intelligence technology provides developing countries with access to free monitoring and analysis software designed to process publicly available ocean monitoring data. Currently, the initiative supports the real-time monitoring efforts of over 60 countries and 308 organisations for free.[112]

Therefore, "with the growing accessibility of analytic tools [...] prospects for a more effective understanding of maritime activities" can be achieved more cost-effectively.[113] Together with open-source data, automated algorithms processing systems can enhance the analytical capabilities of humans in the maritime domain.[114] This presents a cost-effective approach for developing States to achieve more effective MDA.

As research continues leveraging machine learning and artificial intelligence for efficient maritime data processing, these new technologies serve as a powerful equalizer between the capabilities of developing and developed States, leading to the questions of legal and ethical implications.

111. 'Skylight A Product of AI2: AI for Maritime Domain Awareness' (6th High-Level Meeting on the Implementation of the Jeddah Amendment to the Djibouti Code of Conduct, 24 October 2023).

112. 'Skylight | Home' (*SKYLIGHT A product of AI2*) <https://www.skylight.global/>.

113. Pekkanen et al (n 84) 190.

114. National Plan to Achieve Maritime Domain Awareness (n 28) page ii.

6. Legal and ethical implications of technological advancements

The previous sections highlight how new and emerging technologies provide affordable and accessible capacities to States to effectively monitor the maritime domain. This would be particularly helpful for developing States to protect the marine environment within their domain from pollution, IUU fishing, and other activities causing environmental damage.

At the same time, the technological developments in capabilities could prompt ethical and potentially legal considerations towards more established objective obligations on developing States to exercise the necessary level of domain awareness by their further accessible capabilities. By understanding UNCLOS as a living instrument,[115] it could be argued that while the drafting Parties may not have anticipated such widespread and affordable environmental obligations, rapid technological advancements could lead to a stricter interpretation of due diligence obligations.

As new capabilities such as open access satellite data and affordable processing software become increasingly accessible to all States, including developing ones, provisions like Article 194 of the UNCLOS place individual and collective obligations on States to use "the best practicable means at their disposal and in accordance with their capabilities" to reduce and control pollution of the marine environment from any source. These provisions can be broadly understood to include the use of new technologies for this purpose.

While it is understandable that developing states may be unable to invest in the massive capabilities required to conduct MDA, the increasing accessibility of affordable means of maritime surveillance could create an ethical expectation for states to take the necessary measures.

115. Jill Barrett, *Law of the Sea - UNCLOS as a Living Treaty* ((E-Publication) 2016).

It would therefore not be surprising if concrete obligations regarding maritime surveillance were recognised by ITLOS in the upcoming Advisory Opinion in Case No. Similarly, emphasis on the integration of new technologies might be requested to highlight a minimum threshold expected from states to monitor their marine environment in the upcoming United Nations Ocean Conference 2025, or in the upcoming United Nations Climate Change Conference of Parties to the Paris Agreement.

It could also be possible that the need to rely on new technologies in maritime surveillance reaches legal proceedings. In the momentum of climate litigation,[116] currently embodied through Requests for advisory opinions have been filed before the ITLOS,[117] ICJ,[118] the Inter-American Court of Human Rights,[119] a State might be held in violation of its environmental obligations. In such a case, the allegedly violating State might naturally cite its limited capabilities of monitoring the marine environment to preclude its international responsibility. In such a scenario, it would not be surprising if the analysis regarding a State's capacity to conduct MDA included how new and emerging technologies are increasingly presenting all States with the capability to conduct environmental monitoring.

In fact, it would not be surprising if the Court or Tribunal itself referred to publicly accessible data to assess the scope of the alleged violation, as such technologies have indeed made their way into legal

116. *See* Joana Setzer and Catherine Higham, 'Global Trends in Climate Change Litigation: 2023 Snapshot' (Grantham Research Institute on Climate Change and the Environment and the Centre for Climate Change Economics and Policy 2023).

117. *See* (n 7).

118. *For case progress and updates, see* 'Obligations of States in Respect of Climate Change; (*International Court of Justice*) <https://www.icj-cij.org/case/187>.

119. *See Request for an advisory opinion on the Climate Emergency and Human Rights (Request for an advisory opinion submitted to the Inter-American Court of Human Rights by the Republic of Colombia and the Republic of Chile)* 9 January 2023.

proceedings.[120] The arbitral tribunal used publicly available geospatial intelligence as evidence, ruling that China had breached its obligations under the respective Articles of UNCLOS concerning the protection and preservation of the marine environment. This breach was due to China's failure to prevent Chinese fishing vessels from engaging in harmful harvesting activities of endangered species.[121] Additionally, China's island-building activities were found to be in violation.[122] All of these violations were detected and proven through the use of publicly available geospatial intelligence.[123]

To conclude, the evolving landscape of maritime surveillance and environmental protection underscores the significant legal and ethical implications of technological advancements. As new technologies become increasingly accessible, there is a growing expectation for states to fulfil their obligations under international law, particularly regarding the protection and preservation of the marine environment.

7. Conclusion

In 1982, the Third United Nations Conference on the Law of the Sea adopted the Resolution on the development of national marine science,

120. Pekkanen et al (n 84) 211; *See also* Jean Kay et al eds, 'Evidence from Space: Use of Space-Derived Earth Observation Information as Evidence in Judicial and Administrative Proceedings' (London Institute of Space Policy and Law, 2012) Document ESA-ISPL/EO 76/final, 32–34, 86–95, 158–166.

121. *South China Sea Arbitration* (n 13) para 992.

122. Ibid., para 993.

123. Steven G Keating, 'Rock or Island? It Was an UNCLOS Call: The Legal Consequence of Geospatial Intelligence to the 2016 South China Sea Arbitration and the Law of the Sea' (2018) 35 American Intelligence Journal 101, 114.

technology, and ocean service infrastructures.[124] The Resolution raises "[awareness] of the rapid advances being made in the field of marine science and technology".[125] Unless urgent measures are taken, "the marine scientific and technological gap between the developed and the developing countries will widen further and thus endanger the very foundations of the new regime".[126] The Resolution, initially submitted by Peru on behalf of the Group of 77 representing the concerns of developing States,[127] made its way to UNCLOS,[128] highlighting this concern. Given the vast scope of developments in maritime science and technology over the past four decades, it is impractical for a single chapter to comprehensively evaluate the current status of this disparity. However, a focused examination, particularly in the realm of maritime surveillance, reveals that contrary to initial warnings, there has been significant progress in narrowing the technological gap among States. This suggests an evolving landscape where the capabilities of different nations in certain areas of marine science and technology are increasingly converging.

The current chapter argues that advancements in satellite technology, low-cost drones, artificial intelligence, and machine learning have significantly narrowed the technological divide between developed and developing States. With the continuous evolution of existing technologies, exemplified by the increasing availability of satellite imagery as open-

124. The United Nations Third Conference on the Law of the Sea, 'Resolution on development of national marine science, technology and ocean service infrastructures adopted by the Conference at the 181st meeting on 30 April 1982' (7 May 1982) UN Doc A/CONF.62/120, 176.

125. Ibid.

126. Ibid.

127. The United Nations Third Conference on the Law of the Sea, 'Draft Resolution on Development of National Marine Science, Technology and Ocean Service Infrastructures Submitted by Peru on Behalf of the Group of 77' (8 March-30 April 1982) UN Doc A/OONP.62/L.127, Annex I, 2.

128. UNCLOS (n 3) Annex VI.

source data, and the emergence of cost-effective commercial drones alongside sophisticated artificial intelligence and machine learning applications, the ability to conduct comprehensive maritime surveillance is no longer limited to nations with substantial technological prowess. Such advancements provide States with unprecedented opportunities to bolster their maritime surveillance and environmental monitoring capabilities, enabling all States to efficiently monitor and safeguard their maritime environments.

The legal and ethical ramifications of these technological advancements are profound. With MDA emerging as a crucial tool in fulfilling environmental obligations, new technologies not only enhance States' abilities to meet their commitments under UNCLOS but also have the potential to redefine the scope of these obligations. The full implications of continuous technological advancements in the field of maritime surveillance are yet to be uncovered as the global community strives to utilize all legal and ethical mechanisms to protect the marine environment, which forms the very foundation of our planet's health and sustainability.