Science, technology and the law of the sea: Reflections on a relationship of dependency and construction

*Reece Lewis**

1. Introduction

An understanding of the interaction between the law of the sea and emerging technology and science is more important than ever.[1] In practice, these new technologies are becoming increasingly employed, and little wonder too: if there is a more effective and efficient way of doing something and if the technology permits this then why labour under traditional methods? We would be remiss if we answer with: "but the law

* Reece Lewis, LLB, LLM, PhD, is a lecturer in law at Cardiff University. He has published in the areas of international legal theory and the law of the sea, the principal publications of which include *Legal Fictions in International Law* (2021 Edward Elgar) and *Islands, Law and Context: The Treatment of Islands in International Law* (2023 Edward Elgar). He served as the Specialist Adviser to the UK House of Lords' International Relations & Defence Committee in its inquiry into the law of the sea in 2021–22.

1. See further, e.g., James Kraska and Young-Kil Park (eds), *Emerging Technology and the Law of the Sea* (CUP, 2022); Donald R, Rothwell, Alex G. Oude Elferink, Karen N. Scott and Tim Stephens, 'Charting the Future for the Law of the Sea', in Donald R, Rothwell, Alex G. Oude Elferink, Karen N. Scott and Tim Stephens (eds), *The Oxford Handbook of the Law of the Sea* (OUP, 2015) 888; Keyuan Zou and Anastasia Telesetsky, *Marine Scientific Research, New Marine Technologies and the Law of the Sea* (Brill, 2021); and Hilde Woker, Rozemarijn J. Roland Holst and Harriet Harden-Davies, 'New Technology and the Protection of the Marine Environment', in Rosemary Rayfuse, Aline Jaeckel, and Natalie Klein (eds), *Research Handbook on International Marine Environmental Law* (Edward Elgar, 2023).

insists so". Why? Firstly, because the law (like science and technology) is not to be more or less revered than any other aspect of human endeavour and it ultimately ought to be employed to make our lives better, easier and more fruitful than frustrate the same. Secondly, because it is doubtful that the law insists upon frustrating technological evolution and its employment in the maritime domain, in any event.

It is commonly thought that the relationship between law and science resembles something of an unhappy marriage in which the partners are forced to collaborate with each other because whatever happens one of them, impacts upon the other – possibly, albeit begrudgingly. In other words, it is supposedly not a constructive relationship which would, in contrast, involve some element of alignment and realignment whenever divergence occurs. There seems to be the view that "the law needs to keep up with the latest science. And science can only go so far as the dusty old law permits."[2] This view seems to somewhat flavour considerations of the impact that emerging maritime technology has on the law of the sea: a view, essentially, that "[t]he 1982 UN Convention on the Law of the Sea (hereinafter UNCLOS) is having to go along kicking and screaming with the new technology on the block". However, in reality, the relationship is much more nuanced: this has been the case in the past, and there is no reason why it will not be in the future.

There are many examples of new technology challenging the traditional approaches to the law of the sea and of seemingly being difficult to shoehorn into the regulatory framework provided for by the UNCLOS.[3]

2. It is, in truth, an entirely fair view to hold and somewhat flavours the tone of the evidence considered by the UK House of Lords International Relations and Defence Committee's inquiry, *UNCLOS: the law of the sea in the 21st century* (2022).

3. E.g., in relation to autonomous vessels, Alexandros Ntovas 'Functional and Maritime Autonomous Surface Ships' and Raul (Pete) Pedrozo, 'Unmanned and Autonomous Warships and Military Aircraft' in Kraska and Park (n 1); Natalie Klein, Douglas Guilfoyle, Md Saiful Karim and Rob McLaughlin, 'Maritime Autonomous Vehicles: New Frontiers in the Law of the Sea' (2020) 69(3) ICLQ 719; and Natalie Klein, Douglas Guilfoyle, Md Saiful Karim and Rob McLaughlin, 'Written evidence (UNC0003) to the House of Lords UNCLOS Inquiry', (2022).

An examination of how these innovations can be understood within the UNCLOS in the light of the definitional complexities of many of the terms used in the Convention is relatively well rehearsed in the scholarship of the law of the sea. Furthermore, a paper of this length cannot hope to address the entire suite of examples in which it is said a cleavage has arisen between the law of the sea on the one hand and new technologies, science and capabilities on the other.

As a result, this paper is concerned with the more general reflection on the relationship between the law and emerging technologies. It is concerned with examining the broader themes which underpin this relationship, and which characterise the way that the law of the sea continues to be challenged and ultimately shaped by new technology and science. To do so, Section 2 examines the way that what was once regarded as 'emerging technologies' considerably shaped the modern law of the sea. Having demonstrated that the law of the sea developed alongside new science and technological capabilities, Section 3 considers how this will continue to be the case in the future. In light of the lessons to be learned from past (Section 2), and from current and future (Section 3) interactions between the law of the sea and emerging science and technology, Section 4 concludes the paper with a reflection on the future prospects for the relationship: ultimately arguing not only that we can be optimistic that specific legal solutions will be found to specific challenges when new technologies enable the law of the sea to achieve its objectives more easily, but also that new technology is creating the conditions in which more innovative approaches to the law of the sea, in general, might now be considered to be more feasible than ever before.

2. The law of the sea and 'emerging' science and technology

The law of the sea has long been developed in tandem with advances in maritime technology. Developments in scientific knowledge about our ocean spaces and their resources have long influenced the law of the sea and even the UNCLOS itself is replete with references to (various iterations of) 'the best available scientific evidence'.[4]

There are many examples of the inherent connection between science and technology and the law of the sea, but two are perhaps the most prominent and illustrative of the point. First, is the way that the law regulating the continental shelf evolved.[5] Of course, the idea of being able to drill for natural resources (oil and gas) in the continental shelf of coastal states was once an 'emerging technology' and as soon as the riches of the continental shelf became technologically and economically available to states, this motivated them to make such riches exclusively enjoyable for them – President Truman, in his now famous Proclamation of 1945, declared that "the natural resources of the subsoil and seabed of the continental shelf beneath the high seas but contiguous to the coasts of the US as appertaining to the US, subject to its jurisdiction and control".[6]

However, doing so involved a not insignificant recasting of what was then a 'rigid' approach taken to jurisdiction in the law of the

4. Hilde Woker, 'The Concept of the "Best Available Science" in the UNCLOS' presentation delivered at the 10th Biennial Advisory Board on the Law of the Sea (October 2023).

5. See further, Malcolm D. Evans and Reece Lewis, 'Law of the Sea', in Malcolm D. Evans (ed), *International Law* (OUP, 2024, forthcoming) Section V.A.; David A. Colson, 'The Delimitation of the Outer Continental Shelf between Neighbouring States' (2003) 97 AJIL 91; Bjarni M. Magnusson, *The Continental Shelf Beyond 200 Nautical Miles: Delineation, Delimitation and Dispute Settlement* (Brill, 2015); and Joanna Mossop, *The Continental Shelf beyond 200 Miles: Rights and Responsibilities* (OUP, 2016).

6. The Truman Proclamation (1945) available in: 1 New Directions in the Law of the Sea 106.

sea.[7] A new functional zone focussed on resources – with its associated suite of coastal state rights and duties alongside the reciprocal rights and duties for other states – needed to be carved out from the traditional territorial seas/high seas dichotomy which had long characterised the law of the sea for centuries before.[8]

The question *then* was: to what extent? How far does the coastal state's exclusive enjoyment of a continental shelf extend beyond the baselines? Again 'emerging technology' would inform the law and, even more than that, the law tied itself to technological developments: even if the technical scientific language is absent from the legal provisions. Initially, the limit of the continental shelf was defined in Article 1 of the 1958 Continental Shelf Convention (1958 CSC) as being "the seabed and subsoil of the submarine areas adjacent to the coast but outside the area of the territorial sea, to a depth of 200 metres or, beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas." In other words, as technology developed and enabled the resources of the continental shelf to be extracted further and further from the coast and deeper and deeper in the ocean, the coastal state would be entitled to exclusive enjoyment of the resources it found there.

It was little surprise then that this idea soon became unsatisfactory for a host of states, not only those concerned about the extension of coastal state jurisdiction into high seas areas, but also for those who themselves wanted to extend their continental shelf claims but could not satisfy

---

7. See further Robin R. Churchill, Vaughan Lowe and Amy Sander, *Law of the Sea* (Manchester University Press, 2023), Chapter 7.

8. For historical context, see Ram Prakash Anand, *Origin and Development of the Law of the Sea: History of International Law Revisited* (Martinus Nijhoff, 1983); Daniel Patrick O'Connell, *The International Law of the Sea, vol I* (Clarendon Press, 1982), Chapters 1 and 2; Tullio Treves, 'Historical Development of the Law of the Sea'; and Douglas Guilfoyle, 'The High Seas', in Rothwell, Oude Elferink, Scott and Stephens (n 1).

the so-called exploitability test in Article 1 of the 1958 CSC. The International Court of Justice (ICJ) in the *North Sea continental shelf cases* intimated that there *was* some objective limit to the continental shelf that was *not* based on exploitability and thus placing some restrictions to the extent of state claims, even if the technology permitted resource extraction.[9] This is the now much debated idea that the continental shelf somehow represents the "natural prolongation" of the coastal state's land mass into the sea. But again, for those states who (thanks to better – and emerging – sea-floor data retrieval technology) could not demonstrate "a natural prolongation" of their landmass into areas they wanted to claim as their continental shelf because it simply plummeted to the deep ocean floor, this was unsatisfactory.

Another test was needed and was finally adopted in the 1982 UNCLOS. This time, reference *was* made to a scientific understanding of the continental shelf. Article 76(1) provides that the continental shelf extends beyond the "territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles (nm) from the baselines from which the breadth of the territorial sea is measured". Article 76(2)-(6) then sets out the rather complicated formula for establishing the "outer edge of the continental margin" beyond 200 nm. In sum, states may claim either (i) up to the point at which the depth of the sedimentary rock of the shelf is greater than 1 percent of the distance to the foot of the continental slope; or (ii) an additional 60 nm from the foot of the continental slope drawn by straight lines. But neither of these methods entitle states to claim beyond 350 nm or more than 100 nm from the depth of a 2,500-metre isobath.

For our purposes we need not get into the detail here: but what *is* important is that none of these *legal* tests would be possible without

9. *North Sea Continental Shelf, Judgment* [1969] ICJ Reports, p 3, [18].

a scientific understanding of the continental shelf and nor would the legal tests be satisfied without the availability of technology sufficient to calculate and test the depth, breadth and nature of the seabed and subsoil.

The second core example illustrating the interwoven relationship that scientific advances have had on developments in the law of the sea is the legal treatment of the deep seabed — the so-called 'Area' addressed in Part XI of the UNCLOS.[10] This Area is defined in Article 1(1) UNCLOS as the "seabed and ocean floor and subsoil thereof beyond national jurisdiction". Concerns regarding the extraction of the resources of the deep seabed are experiencing somewhat of a renaissance — again, because the latest scientific evidence is showing how diverse and rich life can be in the greatest depths of our ocean spaces (a space previously thought to be barren and largely lifeless).

But advances in technology have always been key to the creation of the legal regime of the Area. As Tanaka makes clear, "the exploration and exploitation of natural resources in the Area are a relatively new subject of the law of the sea which was prompted by scientific discovery of polymetallic nodules."[11] States soon became keen to develop another *sui generis* legal regime that enabled the realisation of the economic benefits of what were fantastical estimates at the time of the wealth that was said to be at the bottom of the high seas. At the time of their discovery, much of this was hypothetical: the technology was not available to begin extracting these resources.[12] This did not, however, prevent developing states from being concerned that only the already wealthy states would

10. See further, e.g., Churchill, Lowe and Sander (n 7), chapter 12, generally; Michael Lodge, 'The Deep Seabed', in Rothwell, Oude Elferink, Scott and Stephens (n 1); Catherine Banet, *The Deep Seabed* (Brill, 2020) and David Kenneth Leary, *International Law and the Genetic Resources of the Deep Sea* (Martinus Nijhoff, 2006).

11. Yoshifumi Tanaka, *The International Law of the Sea* (CUP, 2023) 234.

12. See Churchill, Lowe and Sander (n 7) 414–415.

be able to extract and enjoy the benefits of these resources.[13] A novel solution was proposed during the negotiations of the UNCLOS: regard the Area's resources as the 'common heritage of mankind'.[14]

The introduction of this concept resulted in further tortuous negotiations at UNCLOS III with the mainly developed states ultimately being unsatisfied with the original Part XI of the convention which envisaged a stronger role for an international agency to regulate activities and itself conduct activities on its own within the Area and to (re) distribute the proceeds to developing states. The result was that Part XI would need to be re-written before the UNCLOS would be ratified by the major developed nations. This was the effect of the (arguably misleadingly called) 1994 Implementation Agreement concerning Part XI of the UNCLOS. This essentially re-wrote Part XI of the UNCLOS, watered down the role of the International Seabed Authority (ISA) and constituted a 'rebalance' towards the interests of developing states.[15] While other factors contributed to reaching this compromise, crucially it became increasingly thought (thanks to the then latest scientific evidence) that the early estimates of the wealth of the Area were very much overestimated.

Today, however, two fundamental changes threaten to upset this balance. Firstly, the technology is getting better and better, and the prospect of deep-sea mining is increasingly closer to reality. Secondly, the latest scientific estimates suggest that the Area *is* actually resource rich and now

13. See e.g., James Harrison, 'Resources of the International Seabed Area' in Elisa Morgera and Kati Kulovesi (eds), *Research Handbook on International Law and Natural Resources* (Edward Elgar, 2016) and the contributions in Erik J. Molenaar and Alex Oude Elferink (eds), *The International Legal Regime of Areas beyond National Jurisdiction: Current and Future Developments* (Brill, 2010).

14. Arvid Pardo, *The Common Heritage: Selected Papers on Oceans and World Order 1967–1974* (Malta University Press, 1975); and Rudiger Wolfrum 'The Principle of the Common Heritage of Mankind' (1983) 43 ZaöRV 312.

15. Churchill, Lowe and Sander (n 7) 451–455.

the global economy (with its emphasis on battery technology) demands and values the extraction of these polymetallic nodules.

It is little wonder, then, that on 9 July 2021, Nauru submitted a request to the ISA Council to develop regulations concerning the exploitation of the non-living resources of the deep seabed.[16] It did so because Section 1(15) of the Annex to the 1994 Implementation Agreement concerning Part XI of the UNCLOS provides that the Council "shall elaborate and adopt … rules, regulations and procedures based on the principles contained in sections 2, 5, 6, 7 and 8 of this Annex, as well as any additional rules, regulations and procedures necessary to facilitate the approval of plans of work for exploration or exploitation" and shall "complete the adoption of such rules, regulations and procedures within two years of the request". And while the Council *has* developed three sets of rules, regulations, and procedures relating to the exploration of the Area, it still has not done so in relation to its exploitation, even after two years have passed since a formal request to do so was made. Even though the Council has recently proclaimed that it does *not* interpret Section 1(15) of the Annex to mean that it must simply approve a submitted plan of work for exploitation in the absence of regulation, this is not the only potential interpretation of that provision and there are, of course, those with an interest in challenging the Council's approach.[17]

---

16. See Evans and Lewis (n 5) Section V.D., and House of Lords Inquiry Report (n 2) [278]–[290].

17. Council of the International Seabed Authority, 'Decision of the Council of the International Seabed Authority relating to the understanding and application of section 1, paragraph 15, of the Annex to the Agreement relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea' (21 July 2023) ISBA/28/C/25, available at <https://www.isa.org.jm/wp-content/uploads/2023/07/ISBA_28_C_25.pdf>. See further, A Sander and S Aughey, 'Deep seabed mining: The critical juncture that we should all be talking about' (2023) Essex Court Chambers, Climate Change Law, Current Perspectives series, available at <https://essexcourt.com/publication/deep-seabed-mining-the-critical-juncture-that-we-should-all-be-talking-about-week-7-series-2/>.

Again, the details of the regime of the Area are not important for present purposes but what *is*, is the extent to which the science, the best available data, and emerging technology have considerably shaped the law – albeit in a somewhat toing and froing manner.

This Section began with the claim that the relationship between the law of the sea and science and emerging technologies is, in reality, much more nuanced than the simple belief that these are two separate worlds which minimally interact and only do so to the extent that the one presents new challenges for the other. The above demonstrated that science had a major role in shaping several new functional zones of resource jurisdiction in the law of the sea and which are set out within the UNCLOS. The Section below now addresses the *future*.

3. Future Development of the Law of the Sea

Just as science and (what was then) "emerging technology" greatly influenced the development of the law of the sea, so too will it in the future – and, indeed, this is already happening. The question is: *how*?

A. Opportunities for incorporation by interpretation

Treaties can – and arguably should – be interpreted in ways that apply their concepts to new circumstances, and UNCLOS is no different.[18] What matters is convergence. When there is convergence between the

18. See Jill Barrett and Richard Barnes (eds), *Law of the Sea: UNCLOS as a Living Treaty* (British Institute of International and Comparative Law, 2016) and Alan Boyle, 'Further Development of the 1982 Convention on the Law of the Sea: Mechanisms for Change', in Richard Barnes, David Freestone and David Ong, *The Law of the Sea: Progress and Prospects* (OUP, 2006).

law and emerging technology, we have seen the courts and states essentially 'update' the UNCLOS without needing to redraft the provisions themselves. Often, the objectives of the law of the sea can be more effectively achieved through emerging technologies. Emerging technologies can help facilitate the application of the existing law of the sea and help states to more efficiently fulfil their obligations under the UNCLOS.

For example, the 'hot pursuit' of a vessel that has committed an illegal act within the jurisdiction of the coastal state can *only* be pursued once a visual or auditory signal to stop has been given and then ignored.[19] Although this once meant the pursuing vessel had to get physically close enough to the pursued vessel to either visually display a signal (such as through raising a nautical flag) or auditorily signal (such as through a megaphone) to stop, the Arbitral Tribunal in the *Arctic Sunrise Award* (2015) considered a message to stop over VHF radio (commonly and widely used by vessels nowadays) satisfied this requirement.[20] And so, it is possible for common sense interpretations (beyond a literal reading of the text of the UNCLOS) to be utilised and to incrementally align the Convention with modern practices. What mattered in this case was that the "new" technology was consistent with the objectives behind the law. Regarding a VHF radio message as an auditory signal to stop did not expand the 'right of hot pursuit' beyond its carefully crafted confines

19. See further, Reece Lewis, 'The Doctrine of Constructive Presence and the Arctic Sunrise Award (2015): The Emergence of the "Scheme Theory"' (2020) 51 ODIL 19; Craig H. Allen, 'Doctrine of hot pursuit: A functional interpretation adaptable to emerging maritime law enforcement technologies and practices' (1989) 20 ODIL 309; Bill Gilmore, 'Hot Pursuit' in Marc Weller (ed), *The Oxford Handbook of the Use of Force in International Law* (OUP, 2015) 897; Nicholas M. Poulantzas, *The Right of Hot Pursuit in International Law* (A. W. Stijhoff, 1969).

20. *The Arctic Sunrise Case (The Kingdom of the Netherlands v The Russian Federation)* (14 August 2015) Award on the Merits, PCA Case No 2014-02, [259]. See James Harrison, 'Current Legal Developments, The Arctic Sunrise Arbitration (Netherlands v. Russia)' (2016) 31 IJMCL 151.

within the UNCLOS, nor did it undermine the careful balance of the interests in the freedom of navigation on the one hand and coastal states security concerns on the other.

As we turn to the future, new technology can similarly provide opportunities for further compliance with the UNCLOS. This is particularly the case in controlling activities within coastal state's exclusive economic zones (EEZs). New technologies, including drones and maritime autonomous vessels can be employed by coastal states' maritime enforcement agencies and coast guards to monitor and review the activities of vessels in a potentially more expedient and efficient manner than crewed vessels. Of course, when it comes to inspection, boarding and interdiction, the need for a crew increases,[21] but remote-controlled technology can provide expedient initial reconnaissance opportunities without the need for scrambling a crew and potentially putting them in danger unnecessarily.

Such remote technologies can also be used in the pursuit and arrest of vessels engaged in illicit activity. But the legal situation is slightly more complicated. However, to return to the example of the right of hot pursuit, just as new technology has been incorporated into the meaning of the 'signal to stop' in Article 111(4) of the UNCLOS, there seems to be no reason why it cannot similarly be incorporated into the criteria for the pursuit itself in Article 111(1). The pursuit of a vessel must be 'hot' and so any pauses by the pursuing authorities will no longer be regarded as a 'hot pursuit'. Remotely operated technology can clearly facilitate the hot pursuit of a vessel and be launched by the pursuing state's vessels to ensure that the pursuit remains 'hot'.

21. Vaughan Lowe and Antonios Tzanakopoulos, 'Ships, Visit and Search' Max Planck Encyclopedia of Public International Law [MPEPIL]; and see generally, Natalie Klein, *Maritime Security and the Law of the Sea* (OUP, 2011); Douglas Guilfoyle, *Shipping Interdiction and the Law of the Sea* (CUP, 2009); and Efthymios Papastavridis, *The Interception of Vessels on the High Seas, Contemporary Challenges to the Legal Order of the Oceans* (Hart, 2014).

However, Article 111(5) says that "[t]he right of hot pursuit may only be exercised by warships or military aircraft, or other ships or aircraft clearly marked and identifiable as being on government service and authorized to that effect". As a result, the question, again, becomes whether the terms used in the UNCLOS can be updated to reflect modern technology. In this case it concerns the more complicated question whether drones and maritime autonomous vessels can be considered as 'aircraft' and 'ships'.[22] This question has come to dominate considerations of the use of maritime autonomous vessels, not only in the literature, but also in practice – such as the work of the International Maritime Organization (IMO) in developing a regulatory framework for Maritime Autonomous Surface Ships (MASS), with a Code being developed currently with an anticipated date of entry into force in 2028.[23]

Nevertheless, in the absence of a reimagining of the definition of the terms 'ship' and 'aircraft' in the UNCLOS in general, a more contextual approach can be taken to these terms rather than a one size fits all meaning – and thereby efforts could avoid becoming laboured under considerations other than those pertinent to the present issue. In the context of hot pursuit, for example, so long as the autonomous vessel or drone is clearly marked and identifiable as being employed by a military vessel or by the coastguard, why shouldn't these be used to pursue vessels? Put yourself in the position of the pursued vessel: it engages in illegal behaviour inside the coastal state's jurisdiction; the coastal state orders it to stop (even via VHF Radio) and it continues to flee beyond the state's jurisdiction; it is then pursued by the coastal state's remote-control technology (whether that be by drone or autonomous vessel technology): who else would the crew reasonably think the vessel

22. Klein, Guilfoyle, Md Saiful Karim and McLaughlin (n 3).

23. House of Lords Inquiry Report (n 2) chapter 6; See, International Maritime Organization, 'Autonomous shipping' (IMO.org).

is being pursued by other than the coastal state's coast guard or military? Again, if what matters is convergence – that the new technology can help facilitate the application of the existing law and does not upset the balance of trade-offs behind it – then why shouldn't remote controlled technology be understood as ships and aircraft for the purposes of hot pursuit?

Space precludes a full exposition of the many examples in which the UNCLOS could through interpretation be 'updated' so as to incorporate advances in technology and science. But what the above has shown, nonetheless, is that innovative interpretation can incorporate new technologies and science when they can be used to assist the implementation of the UNCLOS without undermining the delicate balance of rights, duties, and interests that it represents.

As we look to the future, again it is possible to form the optimistic view that new technology can provide the means for further compliance with the UNCLOS. Coastal states now have available to them more effective and efficient tools to survey activities within their jurisdiction. For similar reasons, flag states equally have the means to improve monitoring and the review of activities on board vessels that fly their flag.[24] Technology is breaking down barriers put in place by traditional considerations such as distance. Environmental monitoring and knowledge of the impact of human activity at sea continue to develop and improve apace: it is little wonder that the new Biodiversity Beyond National Jurisdiction (BBNJ) Agreement incorporates environmental impact assessments into its regulatory regime, as do many regional fisheries management organisations (RFMOs). Again, the point being made here is that advances in technology can be increasingly incorporated into the existing UNCLOS

24. This relates to one of the more interesting and important conclusions of the Wilton Park Report on 'Human Rights Law at Sea' (2022), available at <https://www.wiltonpark.org.uk/event/human-rights-law-at-sea/>, concerning enhanced flag-state monitoring and enforcement of labour standards and human rights compliance.

framework and can be used by states to comply with their obligations more effectively and efficiently.

B. Needs must: practise

In truth, not all situations present such a harmonious picture. But that is not to say that these do not provide opportunities for the law of the sea to develop in ways that are increasingly responsive to changing behaviours that have been facilitated by emerging technologies. Much like science and advances in technology informed the formation of the UNCLOS (in a toing and froing fashion as outlined above), it can continue to do the same today. Quite simply, whenever the legal framework fails to keep pace with such developments, we have thus far seen a response whether that be through ingenious legal interpretation in the way described immediately above or through the development of new instruments, such as the new BBNJ Agreement or those adopted between states (such as those generated under the auspices of the IMO). In other words, practise 'nudges' the law to develop.

However, a more complicated situation arises if the emerging practice seems to conflict with a fundamental element of the UNCLOS framework. For instance, the zonal approach to jurisdiction at sea is one of the key aspects of the UNCLOS. This was one of the ways in which coastal states ensured that their interests in the security and defence of their waters and territory were incorporated into the legal framework.

Included in this are the coastal state's concerns regarding survey activities and marine scientific research within its jurisdiction. Such activities are essentially reserved for the national authorities of the coastal state. Article 19 of the UNCLOS provides that a vessel undertaking survey and research activities within the territorial sea is not entitled to innocent passage, and the authorities of the state prevent such passage and interdict vessels engaged in illicit activity. Similarly, vessels undertaking

survey and research activities within straits will not be entitled to the right of innocent passage, nor will they be entitled to transit passage[25] in straits where this would otherwise be available. Likewise, within the EEZ, the coastal state has the exclusive right to undertake marine scientific research activities.[26]

However, there is a real need for up-to-date bathymetric data to identify hazards to the safe navigation of vessels and for this information to be shared with others so that they too can avoid any dangers. National hydrographic offices provide this information (reflecting the exclusive rights to such activities in national waters), but there remain considerable areas of the seas including coastal waters, which remain unmapped. And even in areas of the sea that *have* been surveyed, this may have been conducted many years ago and not using the more accurate tools available today, geomorphological changes to the seabed can also occur, and new hazards can emerge or simply be missed in previous surveys.[27]

From the perspective of the mariner, there is a real need to address this situation. The technology exists which permits the instantaneous and accurate collection of bathymetric data and for this to be shared with other seafarers. Crowdsourced bathymetry has been defined by the International Hydrographic Organization (IHO) as

> the collection of depth measurements from vessels, using standard navigation instruments, while engaged in routine maritime operations. The information, adequately categorized with respect to quality, would be used to supplement the more rigorous and scientific bathymetric

25. UNCLOS, Article 40.

26. UNCLOS, Article 56(1)(b)(ii).

27. See further, Steven Geoffrey Keating, 'Artificial Intelligence to Facilitate Safe Navigation of Ships', in Kraska and Park (n 1).

> coverage undertaken by hydrographic offices, industry, and researchers around the world.[28]

Crowdsourced bathymetry can, therefore, make a considerable contribution to the safety of navigation. It is little surprise, then, that seafarers are taking matters into their own hands and, what's more, they may even be required to do so.[29] In two recent grounding instances concerning the *MV Costa Concordia* and the *Motor Tanker Pazifik*, the 'finders of fact' cite Article 5 of the 1972 Collision Regulations (COLREGS) to conclude that the master is under a duty to ensure the safe passage of the vessel and that this includes making use of *all* available means to avoid a collision.[30] One (entirely feasible) interpretation of this is that this includes making use of crowdsourced bathymetric data, when this is the best available data.[31]

Whether the 'citizen' collection and sharing of bathymetric data legally violates any provision of the UNCLOS is a penetrating but increasingly redundant question. States are seemingly waking up and recognising the need and benefits of such technology – the safety of navigation is in all coastal states and seafarers' interests, including economic and political interests. The result is that an increasing number of states now accept the collection and sharing of crowdsourced bathymetric data even in areas inside national jurisdiction. The United States, for example, permits this

---

28. Jennifer Jencks (et al.), 'A Commitment to Crowdsourced Bathymetry Citizen Sourced Data – help reveal the deep and share your data' (2021) IHO, available at <https://ihr.iho.int/articles/a-commitment-to-crowdsourced-bathymetry-citizen-sourced-data-help-reveal-the-deep-and-share-your-data/>.

29. Steven Geoffrey Keating, 'Crowdsourced Bathymetry' presentation delivered at the 10th Biennial Advisory Board on the Law of the Sea (October 2023).

30. See Investigation Report 241/18, Serious Marine Casualty: Grounding of the motor tanker Pazifik off Indonesia on 9 July 2018 (23 January 2020) German Federal Bureau of Maritime Casualty Investigation; and Costa Concordia, Marine casualty on January 13, 2012 Report on the safety technical investigation (2012) Italian Ministry of Infrastructure and Transport.

31. Keating (n 27).

in all of its waters, other states permit it in their waters but with the caveat that it be reviewed by their national Hydrographic Offices or by the IHO itself, and other states require prior approval.[32]

Just like the situation concerning the autonomous vessels (with the IMO developing its 'MASS Code'), practice is encouraging the development of novel practical and legal solutions to meet evolving requirements – needs must.

4. Conclusion: Future prospects for the relationship between the law of the sea and emerging science and technology

4.1 Themes of construction and evolution

Much of the discussion regarding the impact that new technology and science have on the law of the sea, comes to focus on specific issues, specific gaps and specific solutions to these: i.e., on the technical and interpretive ways to update the law of the sea in order to bridge the gap between emerging practices and the law. What this paper has sought to do is reflect more generally on the relationship between the law of the sea and emerging technology and advances in science. It has considered key themes in this relationship which have demonstrated how advances in technology have helped construct the law of the sea as it exists today.

These themes include: firstly, the idea that new technological capabilities of states and private actors combined with new information and emerging science concerning our ocean spaces, instigated the creation of

32. See 'Acceptance of Crowdsourced Bathymetry Activities and Provision of Resultant Datasets in National Waters of Jurisdiction' (2023) IHO, available at <https://iho.int/uploads/user/Inter-Regional%20Coordination/CSBWG/MISC/B-12_2023_EN_Acceptance_of_CSB_Data_in_NWJ_v7.0.pdf>.

(at the time) considerably novel legal approaches – even impacting foundational legal aspects such as jurisdiction at sea. Secondly, following the coming into force of the 1982 UNCLOS, emerging technology continues to change behaviour and practice at sea at an even more rapid pace. This is opening up new opportunities for the use and enjoyment of the sea and its resources. But this also presents new maritime security risks, such as new maritime technology which can be harnessed for illicit activity.

Thirdly, emerging technologies also seem to create regulatory challenges when it appears that the 1982 Convention cannot keep pace with change. Here, much depends on whether these changes can be retrofitted into the UNCLOS framework: through innovative and common-sense interpretation of the provisions of the Convention and the concepts contained within it, and also through new treaties, codes and other soft law innovations. As the above has shown, what matters is whether the innovation assists the implementation of the UNCLOS, such as providing new (more efficient and effective) means for states to fulfil their obligations under the Convention.

However, there are going to be innovations that simply cannot be retrofitted into the Convention's framework – even through ingenious interpretation – especially if that changing behaviour contrasts with an essential aspect of the Convention. Here, what seems to matter most is whether the new practice is, quite simply, much better than the old ones (such as providing for more efficient and safe passage) such that novel legal approaches are adopted because they are better than languishing behind with our current approaches. It remains within the gift of states to construct these new approaches when presented with opportunities to do so.

4.2 A sea-change of approach to the law

This section now turns to a further theme: how technology can and is beginning to enable a fundamental shift in approach to the law of the

sea. This is the idea that the law of the sea is beginning to embrace a more digital – in contrast to the more traditional analogue – approach to the governance of our ocean spaces: that there are now different emphases which no longer depend on concepts such as the physical or actual domination of the state over the sea or that the geographic peculiarities of the state dictate its maritime entitlement. After all, if the coastal state's entitlements over the sea can now be digitally or virtually rendered and thereby digitally frozen, then is it necessary for this to remain physically true? Much like how many international legal rules once relied upon physical approximations to emerge (e.g., that the premises of the diplomatic mission represented the land territory of the sending state, or ships as floating portions of the state's territory),[33] will many rules of the law of the sea similarly move away from physical to a virtual reality – something which may now be more technologically feasible?

The physical or actual control of the sea underpins the traditional approach to jurisdiction in the law of the sea. This is represented in the old adage that the 'land dominates the sea'. The territorial sea, for example, was traditionally based on the physical domination of the coastal state over the maritime belt of water immediate to its land territory. Hence, the extent of the coastal state over which the coastal state claimed territorial sovereignty was said to be based on the so-called cannon-shot rule (i.e., on how far the state's land-based domination might practically apply at sea): this was traditionally something approximate to 3 nautical miles out to sea, and this distance became the predominant approach among a number of states to the extent of the territorial sea until the codification attempts occurred in the Twentieth Century culminating in a fixed distance of 12 nautical miles from the coastal state's baselines in the 1982 UNCLOS.

Similarly, the underlying premise of entitlement to the continental shelf was the idea that it represented the physical extension of the coastal

33. See further Reece Lewis, *Legal Fictions in International Law* (Edward Elgar, 2021) 45–48.

state's land mass into and under the sea. Hence, in Article 76(1) of the UNCLOS, the continental shelf is described as representing the "natural prolongation of [the coastal state's] land territory". It is on this basis that the coastal state's entitlement to its continental shelf is considered to be inherent and, thus, need not be positively claimed — in contrast to the EEZ.[34] As explained above, over time, the extent of the continental shelf has come to rely on distance, and the idea that the continental shelf represents the "natural prolongation of the state's landmass" has now been somewhat rendered outdated.

This has recently been demonstrated in the *Nicaragua v Colombia case* (2023) before the ICJ, in which the predominance of considerations of distance over natural prolongation was at stake. Nicaragua claimed that it was entitled to extend its continental shelf beyond 200 nautical miles from its baselines but within a distance *less than* 200 nautical miles from the coast of Colombia. The ICJ disagreed, holding that "under customary international law, a state's entitlement to a continental shelf beyond 200 nautical miles from the baselines from which the breadth of its territorial sea is measured may *not* extend within 200 nautical miles from the baselines of another state".[35] In doing so, the ICJ has essentially clarified that the continental shelf is now predominantly based on distance – it is a 200 nautical mile zone of resource jurisdiction – and that states may *only* claim a continental shelf beyond 200 nautical miles where this does not extend into another state's distance-based entitlement.[36]

Just as distance has come to be the predominant basis upon which the extent of maritime entitlements in the law of the sea is based (and

34. *North Sea Continental Shelf, Judgment,* [1969] ICJ Reports, p 3, [19], [39], and [43].

35. *Question of the Delimitation of the Continental Shelf between Nicaragua and Colombia beyond 200 Nautical Miles from the Nicaraguan Coast (Nicaragua v Colombia), Judgment of 13 July 2023,* ICJ Reports, [79].

36. See further, Malcolm D. Evans and Nicholas A. Ioannides, 'A Commentary on the 2023 Nicaragua v Colombia case' (2023) EJIL:Talk!; and Evans and Lewis (n 5) Section V.A.

represents a significant shift from being based upon its physical/actual existence), it becomes easier to envision moving to a world in which entitlements can exist without attachment to physical reality. This is increasingly called for by states whose maritime entitlements are threatened by sea-level rise.[37] For example, the Pacific Island Forum (comprising 18 member states including Australia, New Zealand and many developing Pacific island-states such as Kiribati, Samoa and Vanuatu) issued its Declaration on Preserving Maritime Zones in the Face of Climate Change-related Sea-Level Rise in 2021. This declared "that that once having, in accordance with the Convention, established and notified our maritime zones to the Secretary-General of the United Nations, we intend to maintain these zones without reduction, notwithstanding climate change-related sea-level rise" and "that we do not intend to review and update the baselines and outer limits of our maritime zones as a consequence of climate change-related sea-level rise".[38]

There is growing support for the Pacific Island Forum's interpretation of the UNCLOS and to fix baselines and maritime zones as they currently exist despite the regression of the physical geographical coastline of the state.[39] It remains to be seen whether the Pacific Island Forum's interpretation will be more broadly adopted. However, the need to provide stability concerning the extent of state's maritime entitlements is increasingly being recognised and increasingly being regarded as consist-

37. House of Lords Inquiry Report (n 2) chapter 4.

38. Pacific Islands Forum, 'Declaration on Preserving Maritime Zones in the Face of Climate Change related Sea-Level Rise', (6 August 2021), available at <https://www.forumsec.org/2021/08/11/declaration-on-preserving-maritime-zones-in-the-face-of-climate-change-related-sea-level-rise/>.

39. E.g., Ministry of Foreign Affairs of Japan, 'Foreign Minister Hayashi's Meeting with the Delegation of the Pacific Islands Forum' (MOFA, 6 February 2023), available at <https://www.mofa.go.jp/press/release/press1e_000369.html>.

ent with the UNCLOS.[40] This very subject is under examination by the International Law Commission.[41]

The future will tell whether we will ultimately move to a world where technology rather than the land dominates the sea, whether geography can be essentially converted into points on a digital map and still generate maritime entitlement. Nonetheless, the calls for an essentially virtual maritime entitlement grow and one cannot help but observe that modern and emerging technology have created the conditions in which such calls can appear more feasible and realistic.

This, in a sense, typifies the way that emerging technology impacts the development of the law of the sea: it opens up new possibilities, challenges orthodoxies and (sometimes slowly, but surely) creates the conditions permissive for the adoption of novel legal approaches.

40. E.g., Frances Anggadi, 'What States Say and Do About Legal Stability and Maritime Zones, and Why it Matters' (2022) 71 ICLQ 767.

41. See further, International Law Commission, 'Sea-level rise in relation to international law', available at <https://legal.un.org/ilc/guide/8_9.shtml>.