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The UN Convention on the Law of the Sea: A governing framework for ocean acidification?

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Ocean acidification is a major emergent threat to the ocean, its wildlife and the goods and services they provide. While the international community has committed to 'minimize and address' ocean acidification as part of the Sustainable Development Goals, it is unclear how this is to be fulfilled, especially as there are no international agreements explicitly designed to tackle this issue. Ocean acidification is of relevance to the work of several global agreements and makes achieving their goals more difficult. Being largely sectoral, these agreements are restricted in their ability to address ocean acidification holistically, often unable to both minimize and address the issue. This has resulted in a very limited response to ocean acidification that is fragmented across a number of regimes. The 1982 United Nations Convention on the Law of the Sea (UNCLOS) has been identified as an agreement that could be used to regulate carbon dioxide emissions and thus mitigate ocean acidification. However, this article argues that a far more pivotal role can be played by UNCLOS, through its creation of a governing framework for ocean acidification. UNCLOS is the one Convention with a mandate broad enough to address ocean acidification in a direct, holistic manner. UNCLOS places a duty on States to both minimize and address ocean acidification through its various provisions that pertain to the protection and preservation of the marine environment and the conservation of marine living resources. The Convention establishes the framework through which ocean governance is to be implemented, which should be understood as extending to ocean acidification. Thus, UNCLOS is uniquely placed to guide a coherent international response.

1 INTRODUCTION

Since the industrial revolution the ocean has absorbed close to 30 percent of all anthropogenic emissions of carbon dioxide (CO_2).[1] While this has had an ameliorative effect on global warming and its subsequent impacts, it is also changing the chemistry of the ocean, making it more acidic. This process is known as ocean acidification and is expected to have wide-ranging

[1] Intergovernmental Panel on Climate Change (IPCC), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC 2019).

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ramifications for marine socio-ecological systems.[2] Impacts are expected to include, but are not limited to, economic losses from declines in fisheries and tourism,[3] impacts on human health due to reduced access to protein changes in nutritional content and rate of bioaccumulation of pollutants in seafood,[4] and decreased coastal protection.[5] Ocean acidification is likely to cause major shifts in marine ecosystems and food webs, including the loss of most coral reefs globally.[6] Declines in species and even extinctions are expected by the end of this century if ocean acidification continues unabated.[7]

Ocean acidification has been described as existing within an 'international legal twilight zone'[8] sitting at the 'rather cracked interface between the climate, biodiversity and oceans regimes'.[9] Given this ambiguity, there is an ongoing conversation around the potential to govern ocean acidification under various multilateral environmental agreements (MEAs), including the United Nations Framework Convention on Climate Change (UNFCCC[10]), the Convention on Biological Diversity (CBD[11]) and the United Nations Convention on the Law of the Sea (UNCLOS[12]).[13] It is evident from this literature that there are substantial gaps in the

[2] JP Gattuso et al, 'Contrasting Futures for Ocean and Society from Different Anthropogenic CO_2 Emissions Scenarios' (2015) 349 Science 45; JM Guinotte and VJ Fabry, 'Ocean Acidification and its Potential Effects on Marine Ecosystems' (2008) 1134 Annals of the New York Academy of Sciences 320; BP Harvey, D Gwynn-Jones and PJ Moore, 'Meta-analysis Reveals Complex Marine Biological Responses to the Interactive Effects of Ocean Acidification and Warming' (2013) 3 Ecology and Evolution 1016; O Hoegh-Guldberg et al, 'Impacts of 1.5ºC Global Warming on Natural and Human Systems' in V Masson-Delmotte et al (eds), Global Warming of 1.5°C (IPCC 2018); KJ Kroeker et al, 'Impacts of Ocean Acidification on Marine Organisms: Quantifying Sensitivities and Interaction with Warming' (2013) 19 Global Change Biology 1884.

[3] Arctic Monitoring and Assessment Programme (AMAP), AMAP Assessment 2018: Arctic Ocean Acidification (AMAP 2018); TA Branch et al, 'Impacts of Ocean Acidification on Marine Seafood''(2013) 28 Trends in Ecology & Evolution 178; LM Brander et al, 'The Economic Impact of Ocean Acidification on Coral Reefs' (2012) 3 Climate Change Economics 1250002; SR Cooley and SC Doney, 'Anticipating Ocean Acidification's Economic Consequences for Commercial Fisheries' (2009) 4 Environmental Research Letters 024007.

[4] SR Cooley et al, 'Nutrition and Income from Molluscs Today Imply Vulnerability to Ocean Acidification Tomorrow' (2011) 13 Fish and Fisheries 182; W Su et al, 'The Health Risk for Seafood Consumers under Future Ocean Acidification (OA) Scenarios: OA Alters Bioaccumulation of Three Pollutants in an Edible Bivalve Species through Affecting the In Vivo Metabolism' (2019) 650 Science of the Total Environment 2987; C Turley and K Boot, UNEP Emerging Issues: Environmental Consequences of Ocean Acidification: A Threat to Food Security (United Nations Enviroment Programme (UNEP) 2010); D Xu et al, 'Ocean Acidification Increases Iodine Accumulation in Kelp-based Coastal Food Webs' (2019) 25 Global Change Biology 629.

[5] JM Hall-Spencer and BP Harvey, 'Ocean Acidification Impacts on Coastal Ecosystem Services Due to Habitat Degradation' (2019) 3 Emerging Topics in Life Sciences 197.

[6] BD Eyre et al, 'Coral Reefs Will Transition to Net Dissolving before End of century' (2018) 359 Science 908; O Hoegh-Guldberg et al, 'Coral Reefs Under Rapid Climate Change and Ocean Acidification' (2007) 318 Science 1737; J Silverman et al, 'Coral Reefs May Start Dissolving when Atmospheric CO_2 Doubles' (2009) 36 Geophysical Research Letters L05606.

[7] Gattuso et al (n 2); IPCC (n 1); Hoegh-Guldberg et al (n 2).

[8] R Baird, M Simons and T Stephens, 'Ocean Acidification: A Litmust Test for International Law' (2009) 4 Carbon and Climate Law Review 459.

[9] RE Kim, 'Is a New Multilateral Environmental Agreement on Ocean Acidification Necessary?' (2012) 21 Review of European Community & International Environmental Law 243, 257.

[10] United Nations Framework Convention on Climate Change (adopted 29 May 1992, entered into force 21 March 1994) 1771 UNTS 107.

[11] Convention on Biological Diversity (adopted 5 June 1992, entered into force 29 December 1993) 1760 UNTS 69.

[12] United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 1 November 1994) 1833 UNTS 397 (UNCLOS).

[13] See, e.g., ER Harrould-Kolieb and D Herr, 'Ocean Acidification and Climate Change: Synergies and Challenges of Addressing both under the UNFCCC' (2012) 12 Climate Policy 378; T Stephens, 'Ocean Acidification' in RG Rayfuse (ed), Research Handbook on International Marine Environmental Law (Edward Elgar 2015) 431; N Oral, 'Ocean Acidification: Falling Between the Legal Cracks of UNCLOS and the UNFCCC?' (2018) 45 Ecology Law Quarterly 9; Y Downing, 'Ocean Acidification and Protection under International Law from Negative

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existing governance of ocean acidification, with a number of regimes partially responding, yet the issue being managed holistically by none.[14] Moreover, ocean acidification is an issue that straddles multiple regimes and needs to be addressed accordingly.

Given that the only long-term solution to addressing ocean acidification is the reduction of CO_2 emissions,[15] most of the legal and policy options discussed have focused on how best to achieve this, with the majority concluding that the UNFCCC needs to be central to the governance of ocean acidification, due to it being the only international regime with the mandate to regulate global emissions of CO_2.[16] Less well discussed in the literature is the potential for measures beyond the reduction of CO_2 to be managed by various MEAs. Indeed, 'mitigation not adaptation' has been proposed as the global mantra with reference to the international regulation of ocean acidification.[17] While it is true that adaptation alone cannot solve the ocean acidification problem, impacts are already evident with negative consequences for marine socio-ecological systems, adaptation is needed.[18] Moreover, as CO_2 emissions continue to rise, and States continue to put forward commitments too weak to avoid the worst impacts of ocean acidification,[19] it is imperative that adaptation and redress measures be put in place to ameliorate the inevitable impacts.[20] Thus, focusing only on addressing ocean acidification through mitigation risks missing multiple other opportunities for a more holistic response to the problem.

Focusing attention on the holistic nature of the problem of ocean acidification, both in terms of response options and its links with other ocean-related issues, including pollution, overexploitation, unsustainable development and the loss of marine biodiversity, situates the issue within the context of ocean governance. For this reason, this article expands upon the existing literature by comprehensively examining the role that UNCLOS can play in governing ocean acidification. The article contends that UNCLOS can be understood as establishing a governing framework for ocean acidification. A governing framework can be described as a decision support structure guiding the actions taken by public and private actors on a particular issue. It is science-based, prescribes overarching policy goals and identifies where collective action is needed.[21] Framework conventions essentially establish legally binding governing frameworks for particular issue areas. This is achieved through the formulation of objectives,

Effects: A Burning Issue amongst a Sea of Regimes' (2013) 2 Cambridge Journal of International and Comparative Law 242; K Fennel and DL VanderZwaag, 'Ocean Acidification: Scientific Surges, Lagging Law and Policy Responses' in R Warner and S Kaye (eds), Routledge Handbook of Maritime Regulation and Enforcement (Routledge 2015) 324; T Potts, 'Climate Change, Ocean Acidification and the Marine Environment: Challenges for the International Legal Regime' in D Hassan and S Karim (eds), International Marine Environmental Law and Policy (Routledge 2019) 87.

[14] D Herr et al, Ocean Acidification: International Policy and Governance Options (IUCN 2014); Downing (n 13); KN Scott, 'Ocean Acidification and Sustainable Development Goal 14: Goal but No Target?' in MH Nordquist, JN Moore and R Long (eds), The Marine Environment and United Nations Sustainable Development Goal 14 (Brill/Nijhoff 2018) 323.

[15] O Hoegh-Guldberg et al, 'The Ocean' in VR Barros et al (eds), Climate Change 2014: Impacts, Adaptation, and Vulnerability Part B: Regional Aspects Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press 2014); K Caldeira and ME Wickett, 'Oceanography: Anthropogenic Carbon and Ocean pH' (2003) 425 Nature 365.

[16] Fennel and VanderZwaag (n 13); ER Harrould-Kolieb, '(Re)Framing Ocean Acidification in the Context of the United Nations Framework Convention on climate change (UNFCCC) and Paris Agreement' (2020 fc) Climate Policy.

[17] Fennel and VanderZwaag (n 13) 356.

[18] A Barton et al, 'Impacts of Coastal Acidification on the Pacific Northwest Shellfish Industry and Adaptation Strategies Implemented in Response' (2015) 28 Oceanography 146.

[19] UNEP, Emissions Gap Report 2019 (UNEP 2019); IPCC (n 2).

[20] ER Harrould-Kolieb and O Hoegh-Guldberg, 'A Governing Framework of International Ocean Acidification Policy' (2019) 102 Marine Policy 10.

[21] ibid.

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the articulation of broad commitments and the outlining of a general governance system.[22] Rather than addressing a complex, multifaceted problem through the regulation of its isolated aspects, the creation of a governing framework (most commonly through the creation of a framework agreement) endeavours to address the issue in a connected and coherent manner.[23] Governance through a framework approach can thus be seen as an attempt to avoid the specialization and fragmentation of international law that can lead to contradictions and conflicts.

The article proceeds by first exploring the potential for describing UNCLOS as a framework agreement with respect to the protection of the marine environment. This is followed by an analysis of the provisions of the treaty and their application with reference to ocean acidification. These provisions are then compared with the proposed governing framework of Harrould-Kolieb and Hoegh-Guldberg,[24] and assessed for their comprehensiveness and ability to address all aspects of the ocean acidification problem. The penultimate section analyses a series of avenues for operationalizing the framework created by UNCLOS, focusing on the creation of implementing agreements and role of external rules and standards. The final section concludes with an overall assessment of the potential for UNCLOS address ocean acidification.

2 UNCLOS AS A FRAMEWORK CONVENTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT

UNCLOS is the principal instrument of international marine environmental governance and provides the legal framework that sets out States' rights and obligations with respect to different zones of the ocean. Significantly, the Convention also establishes the fundamental principles and duties of ocean conservation.[25] UNCLOS as a whole is not generally perceived of as a framework convention,[26] but rather the more comprehensive 'constitution for the oceans'.[27] However, Part XII that addresses the protection and preservation of the marine environment is often referred to as a framework or umbrella agreement for the protection of the marine environment.[28] Therefore, it is possible to consider specific elements of the Convention as fulfilling the role of sectoral framework conventions.

While there is no fixed model for framework agreements, they are most commonly associated with general treaties that establish an overarching system of governance for a particular issue area and the delegation of more detailed obligations to additional instruments.[29] These additional instruments, most commonly manifested as protocols, may already be determined, negotiated simultaneously or subsequently to the framework agreement. An

[22] N Matz-Lück, 'Framework Conventions as a Regulatory Tool' (2009) 1 Goettingen Journal of International Law 439.
[23] ibid.
[24] Harrould-Kolieb and Hoegh-Guldberg (n 20).
[25] P Sands and J Peel, Principles of International Environmental Law (4 edn, Cambridge University Press 2018) 455ff.
[26] J Barrett, 'The UN Convention on the Law of the Sea: A "Living" Treaty?' in J Barrett and R Barnes (eds), Law of the Sea: UNCLOS as a Living Treaty (British Institute of International and Comparative Law 2016) 3; Matz-Lück (n 22).
[27] TTB Koh, 'A Constitution for the Oceans: Remarks by Tommy T.B. Koh, of Singapore' (1982) <http://www.un.org/depts/los/convention_agreements/texts/koh_english.pdf>; SV Scott, 'The LOS Convention as a Constitutional Regime for the Oceans' in AG Oude Elferink (ed), Stability and Change in the Law of the Sea: The Role of the LOS Convention (Martinus Nijhoff 2005) 9, 24.
[28] L Guruswamy, 'The Promise of the United Nations Convention on the Law of the Sea (UNCLOS): Justice in Trade and Environment Disputes' (1998) 25 Ecology Law Quarterly 189; M Wood, 'Reflections on the United Nations Convention on the Law of the Sea: A Living Instrument' in Barrett and Barnes (n 26) lxxvii.
[29] D Bodansky, 'The Framework Convention/Protocol Approach' (WHO Tobacco Free Initiative 1999).

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agreement does not have to be explicitly designated as a framework convention and can be done so retrospectively.[30] Four specific characteristics are common to framework agreements: (i) the formulation of the overarching objectives of the agreement; (ii) the setting out of broad commitments; (iii) the creation of a general system of governance; and (iv) the more detailed rules, obligations and targets delegated to be agreed elsewhere.[31]

These main characteristics of a framework agreement are evident across UNCLOS with regard to the protection and conservation of the marine environment. While UNCLOS is not only an environmental agreement given its broader scope of governance, it does establish a general system of governance for the marine environment and has been described as 'the strongest comprehensive environmental treaty now in existence or likely to emerge for quite some time'.[32] It is the first global agreement to establish a comprehensive legal framework and a system of governance for the protection of the marine environment and the conservation of its living resources.[33] The preamble recognizes the suitability of UNCLOS in playing this role, stating that it is desired that the Convention will establish 'a legal order for the seas and oceans which … will promote … the conservation of their living resources, and the study, protection and preservation of the marine environment'.[34]

In addition to establishing a general system of governance, UNCLOS sets out overarching commitments or objectives to be achieved with regard to the marine environment, stating that that all parties have the 'obligation to protect and preserve the marine environment'.[35] Duties pertaining to this obligation are of a general nature and do not establish control standards or methods for implementation. UNCLOS refers to governance by other international instruments in almost 70 provisions,[36] thereby clearly articulating that more detailed regulation will take place elsewhere. UNCLOS sets out a series of mechanisms for achieving the objectives of the Convention and providing additional detail to its general obligations. These include the adoption of implementing agreements and the creation of or adherence to external rules and standards created by other bodies, such as competent international organizations or general diplomatic conferences. These features of UNCLOS are arguably characteristics of a framework agreement.

3 PROVISIONS APPLICABLE TO OCEAN ACIDIFICATION

UNCLOS is relevant for ocean acidification governance in two ways; (i) via the obligations pertaining to the protection and preservation of the marine environment found in Part XII; and (ii) through the obligations to conserve living resources found in relevant zonal sections of the Convention.[37]

3.1 Protection and preservation of the marine environment

Part XII establishes the obligation on States 'to protect and preserve the marine environment'.[38] The use of both 'protect' and 'preserve' are understood, as elaborated by the Permanent Court of Arbitration in the South China Sea Arbitration, to convey that States are required to take

[30] Matz-Lück (n 22).
[31] ibid.
[32] JR Stevenson and BH Oxman, 'The Future of the United Nations Convention on the Law of the Sea' (1994) 88 American Journal of International Law 488, 496.
[33] Y Tanaka, The International Law of the Sea (Cambridge University Press 2012).
[34] UNCLOS (n 12) preambular para 4.
[35] ibid art 192.
[36] Scott (n 27).
[37] Baird et al (n 8); Fennel and VanderZwaag (n 13).
[38] UNCLOS (n 12) art 192.

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active steps to 'protect' from future damage and to 'preserve' the current state of the marine environment or improve it if necessary.[39] This obligation is considered to have 'transformed discourse about environmental issues in the oceans' and is considered to be a binding norm of customary international law and, therefore, obligatory upon all States, including those that have not ratified the Convention.[40] This obligation is also characterized as a statement of principle that functions to determine the scope of Part XII, which is to cover all forms of harm to the marine environment, not only pollution, which is the focus of many provisions of Part XII.[41] Given this, it has been argued that Part XII should be interpreted broadly, and should include alteration of the marine environment and its components, as well as physical harm and destruction.[42] It follows that a broad interpretation of this provision would include an obligation to address ocean acidification holistically and to do so through efforts that will prevent future damage, preserve the current state of the marine environment and to improve this state if impacted. Thus, it can be argued that Article 192 requires States to put in place measures to mitigate the drivers of ocean acidification, adapt to it impacts and redress any harm it causes.

These provisions can therefore be understood as placing a duty on States to not only work to mitigate ocean acidification, but also to implement adaptation measures. Adaptation efforts to build and maintain resilience can include techniques that have traditionally been used across a variety of ecosystems to meet conservation goals. Such measures should be deployed in a method sensitive to ocean acidification to ensure the greatest benefit.[43] Such measures are within the scope of UNCLOS, as has been found by the tribunal in the Chagos MPA Arbitration, which held that Article 194 is 'not limited to measures aimed strictly at controlling pollution and extends to measures focused primarily on conservation and the preservation of ecosystems'.[44]

The general obligation of Article 192 is elaborated upon in Article 194, which requires, inter alia, that States put in place measures 'to prevent, reduce and control pollution of the marine environment from any source'.[45] Pollution is defined under the Convention as:

> the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.[46]

The definition of pollution under the Convention is flexible enough take into account new and unsuspected pollutants and can be understood as being inclusive of CO_2 entering the ocean.[47] The introduction of CO_2 to the marine environment is known to result in harm to

[39] South China Sea Arbitration (Philippines v China) (Award) (12 July 2016) (PCA Case No 2013-19) ICGJ 495.
[40] JM Van Dyke, 'Giving Teeth to the Environmental Obligations in the LOS Convention' in AG Oude Elferink and DR Rothwell (eds), Oceans Management in the 21st Century: Institutional Frameworks and Responses (Brill 2004) 167.
[41] J Harrison, Saving the Oceans through Law: The International Legal Framework for the Protection of the Marine Environment (Oxford University Press 2017).
[42] ibid.
[43] Harrould-Kolieb and Hoegh-Guldberg (n 20).
[44] Chagos Marine Protected Area Arbitration (Mauritius v United Kingdom) (Award) (18 March 2015) (PCA Case No 2011-03) ICGJ 486 para 538.
[45] UNCLOS (n 12) art 194(1).
[46] ibid art 1(4).
[47] A Boyle, 'Climate Change, Ocean Governance and UNCLOS' in Barrett and Barnes (n 26) 225; Harrison (n 41).

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marine living resources and life due to changes in ocean chemistry and its impacts.[48] Ocean acidification is likely to act as a hazard to human health via alterations in the quality and quantity of protein and nutrient availability and the possible reduction in coastal protection offered by coral reefs.[49] Ocean acidification will also have ramification for fisheries, both capture and aquaculture,[50] impair the quality of sea water, for example, as used by aquaculture facilities[51] and reduce amenity with ramifications for tourism,[52] a legitimate use of the sea. Given the impacts of ocean acidification, it follows that anthropogenic CO_2 in the marine environment meets the threshold established by Article 1 and should be considered a pollutant under the Convention.

Ocean acidification is the result of CO_2 emissions regardless of where they are emitted, including by ships, aircraft, cars, fossil fuel power generators and land-use change. States are required to 'deal with all sources of pollution of the marine environment',[53] including pollution from land-based sources (Article 207), pollution by dumping (Article 210), pollution from vessels (Article 211) and pollution from or through the atmosphere (Article 212). Taken together, these articles collectively cover all sources of CO_2 to the marine environment, the reduction of which is the only method to mitigate ocean acidification globally, as required by Article 192. However, the nature of the obligations for each type of pollution differ and are considerably weaker for land-based and atmospheric pollution – the two main sources of CO_2 to the marine environment. States are required to 'take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other states and their environment'.[54] The International Tribunal for the Law of the Sea (ITLOS) explained that use of the phrase 'to ensure' creates an obligation of due diligence.[55] Its use in this provision can be understood as creating an obligation of due diligence on States to prevent harm from activities under their control and within their jurisdiction to the environment of other states and areas beyond national jurisdiction.[56] According to Boyle these provisions and particularly the obligations under Article 194 are fundamentally an obligation of due diligence and that

> States must take the measures necessary to prevent or minimize harmful pollution, including environmental impact assessment, regulation and use of best available technology, application of the precautionary principle, and enforcement. On that basis States have an obligation to control and reduce CO_2 emissions from any source likely to pollute the marine environment and cause harm to other States.[57]

States are therefore required to take preventative measures to avoid harm to the marine environment, including the control and reduction of CO_2 emissions.

[48] Hoegh-Guldberg et al (n 2).
[49] Hall-Spencer and Harvey (n 5); Su et al (n 4); Xu et al (n 4).
[50] AMAP (n 3); JC Clements and T Chopin, 'Ocean Acidification and Marine Aquaculture in North America: Potential Impacts and Mitigation Strategies' (2017) 9 Reviews in Aquaculture 326; Cooley and Doney (n 3); Cooley et al (n 4); RG Richards et al, 'Effects and Mitigations of Ocean Acidification on Wild and Aquaculture Scallop and Prawn Fisheries in Queensland, Australia' (2015) 161 Fisheries Research 42.
[51] Barton et al (n 18).
[52] Brander et al (n 3).
[53] UNCLOS (n 12) art194(3).
[54] ibid art 194(2).
[55] Responsibilities and Obligations of States Sponsoring Persons and Entities with Respect to Activities in the Area (Advisory Opinion) [2011] ITLOS Rep 10.
[56] HM Dotinga and AG Oude Elferink, 'Acoustic Pollution in the Oceans: The Search for Legal Standards' (2000) 31 Ocean Development and International Law 151.
[57] Boyle (n 47) 219.

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These provisions are also applicable to pollutants that reduce ecological resilience and exacerbate local ocean acidification, including sulphur and nitrogen oxides (SOx and NOx), runoff and nutrient enrichment.[58] While the removal of these pollutants will not mitigate ocean acidification globally, their reduction can contribute to its local abatement, which can delay the likelihood of reaching ecological thresholds, thereby buying time to implement other adaptation measures or to avoid their need altogether as mitigation measures become effective.[59] The reduction of non-CO_2 pollutants can also help to enhance ecological resilience and therefore adaptive capacity,[60] thereby helping species and ecosystems to withstand the pressures of ocean acidification in the short term.

Article 194 also places additional emphasis on the protection and preservation of 'rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life'.[61] While UNCLOS does not refer directly to marine biodiversity, its duty to protect and preserve the marine environment as a whole, along with the duty to conserve living resources and species associated with, dependent upon and found within the same ecosystem can reasonably be understood as including marine biodiversity.[62] Indeed, this provision has been interpreted as requiring protection of marine biodiversity in general, and coral reefs in particular.[63] Ocean acidification is a threat to marine biodiversity and directly impacts corals reefs, which have been projected likely to shift to a state of dissolution by the middle of this century if ocean acidification remains unabated.[64] Given these threats, the emphasis on 'rare and fragile' systems places an even greater onus on States to address ocean acidification.

States are further required to 'take all measures necessary to prevent, reduce and control pollution of the marine environment resulting from the use of technologies under their jurisdiction or control'.[65] This provision can reasonably be applied to the use of marine geoengineering techniques that may be employed to address climate change, some of which are likely to result in the exacerbation of ocean acidification.[66] This would include ocean fertilization, which involves the placement of substances in the marine environment to enhance the biological drawdown of CO_2 from the atmosphere and in the process is likely to transfer ocean acidification from the upper to deep ocean. This application is further strengthened by the duty to not 'transfer, directly or indirectly, damage or hazards from one area to another to transform one type of pollution into another'.[67] This would also apply to the direct injection of CO_2 into the water column, which would assist in limiting rising global temperatures, but

[58] See generally for impact of various pollutants on ocean acidification: IM Hassellöv et al, 'Shipping Contributes to Ocean Acidification' (2013) 40 Geophysical Research Letters 2731; WJ Cai et al, 'Acidification of Subsurface Coastal Waters Enhanced by Eutrophication' (2011) 4 Nature Geoscience 766; X Zeng, X Chen and J Zhuang, 'The Positive Relationship between Ocean Acidification and Pollution' (2015) 91 Marine Pollution Bulletin 14; PY Pascal et al, 'The Toxicological Interactions between Ocean Acidity and Metals in Coastal Meiobenthic Copepods' (2010) 60 Marine Pollution Bulletin 2201.

[59] R Billé et al, 'Taking Action against Ocean Acidification: A Review of Management and Policy Options' (2013) 52 Environmental Management 761; GH Raum EL McLeod and O Hoegh-Guldberg, 'The Need for New Ocean Conservation Strategies in a High-carbon Dioxide World' (2012) 2 Nature Climate Change 720.

[60] F Berkes, J Colding and C Folke, Navigating Social-ecological Systems: Building Resilience for Complexity and Change (Cambridge University Press 2008).

[61] UNCLOS (n 12) art 194(5).

[62] Tanaka (n 33).

[63] A Boyle, 'Marine Pollution under the Law of the Sea Convention' (1985) 79 American Journal of International Law 347.

[64] Eyre et al (n 6); Silverman et al (n 6).

[65] UNCLOS (n 12) art 196.

[66] P Williamson and C Turley, 'Ocean Acidification in a Geoengineering Context' (2012) 370 Philosophical Transactions of the Royal Society A 4317.

[67] UNCLOS (n 12) art 195.

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would exacerbate acidification at the injection site. The requirement to 'prevent, reduce and control pollution of the marine environment by dumping'[68] would also be relevant here. Dumping is defined as meaning 'any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea', which would arguably be inclusive of the deliberate addition of CO_2 to the marine environment to remove it from the atmosphere. Article 208, which requires coastal States to 'adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with seabed activities',[69] may also be relevant here with reference to the placement of CO_2 in geological formations beneath the seabed.

3.2 The conservation of marine living resources

The conservation of marine living resources is further emphasized throughout UNCLOS based upon the jurisdictional area or areas in which they occur.[70] Marine living resources include invertebrates, such as corals, crustaceans and cephalopods, as well as fish, sharks, birds, turtles and marine mammals.[71] Many of these species are either directly impacted by ocean acidification via alterations in biological and physiological processes, or indirectly through changes in habitat and food availability.[72] Thus, it can be understood that provisions relating to the conservation of living resources require a consideration of the impacts of ocean acidification and efforts to address it.

Article 61 addresses the conservation of living resources within States' exclusive economic zones. In these zones States have a duty to determine allowable catch limits for living resources, to conserve and manage living resources under their jurisdiction and to take into account the best available scientific evidence in doing so.[73] Further, the Convention also places a duty on States to enact measures to conserve living resources in areas beyond national jurisdiction,[74] including determining allowable catch limits[75] and cooperating with other States in the conservation and management of these resources.[76] Here States are also required to take the best available scientific evidence into account to maintain or restore populations of harvested species to levels 'qualified by relevant environmental factors'.[77] Given that ocean acidification is an environmental factor likely to result in a lowered maximum sustainable yield in some populations,[78] it is reasonable to assume that UNCLOS requires that ocean acidification be considered in establishing conservation measures and allowable catch limits. Further, States are required to consider not only the target species, but also to consider species 'associated with or dependent upon' the harvested species.[79] It follows that species such as coral reefs or pteropods – species that are highly vulnerable to ocean acidification that may not be the target species but provide vital habitat and food resources to harvested species – should also be considered in conservation planning, especially as habitat preference is a likely

[68] ibid art 210(1).
[69] ibid art 208(1).
[70] Sands et al (n 25) 455.
[71] ibid.
[72] Kroeker et al (n 2); C Cattano et al, 'Living in a High CO_2 World: A Global Meta-analysis Shows Multiple Trait-mediated Fish Responses to Ocean Acidification' (2018) 88 Ecological Monographs 320; Hoegh-Guldberg et al (n 6).
[73] UNCLOS (n 12) art 61.
[74] ibid art 117.
[75] ibid art 119.
[76] ibid art 118.
[77] ibid art 119(1)(a).
[78] Branch et al (n 3).
[79] UNCLOS (n 12) art 119(1)(b).

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predictor of the impacts of ocean acidification on particular fish stocks.[80] UNCLOS also places additional emphasis on 'straddling stocks', i.e. species that occur across multiple jurisdictional zones,[81] highly migratory species such as tuna, swordfish, and sharks,[82] as well as cetaceans.[83] UNCLOS requires that States within whose jurisdictions these species are found or States that exploit these species should agree to measures necessary to coordinate and ensure the conservation and development of such stocks. It follows that such measures should consider the impacts of ocean acidification.

Along with the duty to put in place measures to conserve living resources, States also have an obligation to 'restore populations of harvested species' within their exclusive economic zone (EEZ)[84] and in areas beyond national jurisdiction.[85] These obligations are consistent with Article 192, which has been interpreted as requiring States to improve the existing conditions of the marine environment. Moreover, when taking such measures States are required to restore populations of species associated with or dependent upon harvested species within their EEZ. In areas beyond national jurisdiction States are obligated to consider the impact of fishing on species associated with or dependent upon harvested species 'with the view to maintaining or restoring' their populations. Given that ocean acidification is likely to result in population declines in some harvested species and those connected to them, fishing pressure will likely cause further declines. The need to restore stocks will inevitably be triggered more quickly and frequently than without ocean acidification. While these obligations cannot necessarily be understood as a direct duty to restore all populations and ecosystems impacted by ocean acidification alone, they can be seen as being applicable to harvested species and those associated with or dependent upon them that are impacted by rising acidity. These obligations, coupled with the duty to improve the existing condition of the marine environment in Article 192, can be understood as requiring States to restore ecosystems impacted by ocean acidification. In addition to restoring damaged ecosystems, Article 235 requires that recourse be available for 'compensation or other relief' for damage caused by pollution of the marine environment[86] and to participate in and further develop international law relating to compensation and the settlement of disputes.[87] It has been suggested that these provisions are relevant to ocean acidification and could offer a useful means of bringing a claim under ITLOS.[88] One of the difficulties with bringing such claims will be attributing liability, an area that is receiving increased attention within the research community, with a recent publication attributing 55 percent of global acidification to the 88 largest industrial carbon producers over the 1880–2015 period.[89]

3.3 A governing framework for ocean acidification

The relevant provisions from Part XII and those related to conservation found in other parts of the treaty discussed above can be understood as establishing an obligation on States to address

[80] Branch et al (n 3).
[81] UNCLOS (n 12) art 63.
[82] ibid art 64.
[83] ibid art 65.
[84] ibid art 61(3).
[85] ibid art 119(1)(a).
[86] ibid art 235(2).
[87] ibid art 235(3).
[88] D Bialek and J Ariel, 'Ocean Acidification: International Legal Avenues under the UN Convention on the Law of the Sea' in M Gerrard and G Wannier (eds), Threatened Island Nations: Legal Implications of Rising Seas and a Changing Climate (Cambridge University Press 2013) 473.
[89] R Licker et al, 'Attributing Ocean Acidification to Major Carbon Producers' (2019) 14 Environmental Research Letters 124060.

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harm to the marine environment resulting from ocean acidification. These provisions can be mapped onto the governing framework of Harrould-Kolieb and Hoegh-Guldberg,[90] revealing that UNCLOS has a broad enough mandate to regulate the problem of ocean acidification in a holistic manner (Figure 1).

Taking multiple lines of evidence into account, Harrould-Kolieb and Hoegh-Guldberg[91] set out a conceptual governing framework for international action on ocean acidification, which prescribes overarching policy goals and areas for collective action that are needed to 'minimize and address the impacts of ocean acidification', as called for by Sustainable Development Goal 14.3.[92] This framework establishes three overarching objectives for international action on ocean acidification, namely: (i) to mitigate the cause of ocean acidification, (ii) to adapt to its impacts; and (iii) to redress the harm caused to human and ecological communities. Six areas of collective action are set out to achieve the three objectives: the reduction and removal of carbon dioxide (CO_2) emissions, enhancing adaptive capacity, reducing local acidification, restoring damaged ecosystems and the management of harm.

Each of the provisions highlighted in Figure 1 directs parties to act in a way that can be understood as contributing to the achievement of each of the six areas of collective action that are needed to minimize and address ocean acidification, as called for by Sustainable Development Goal 14.3. Article 192 is situated centrally as it places a duty on States to act directly to respond to ocean acidification through mitigation, adaptation and the redress of harm. Articles above this centre mark are all found in Part XII of UNCLOS and contribute primarily to mitigation and secondarily to adaptation. The provisions situated below the centre mark are found throughout UNCLOS pertaining to conservation and management of species. These provisions contribute primarily to the redress of harm and secondarily, adaptation.

The duty to both protect and preserve the marine environment requires that ocean acidification be mitigated through the reduction of CO_2 emissions, and that if CO_2 removal is required it be done in a way that does not negatively impact or transfer harm to the ocean. Moreover, this duty also requires that the impacts that are not mitigated be addressed through adaptation and redress, either through measures that strengthen marine systems allowing them to withstand the impacts of ocean acidification or restoring systems after impacts have occurred. The existing provisions within UNCLOS can be understood as setting the agenda for international action on ocean acidification by establishing the overarching objectives of mitigation, adaptation and redress, and by setting out the collective actions needed to meet each of these objectives.

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[90] Harrould-Kolieb and Hoegh-Guldberg (n 20).
[91] ibid.
[92] UNGA 'Transforming Our World: The 2030 Agenda for Sustainable Development' UN Doc A/RES/70/1 (21 October 2015) 28.

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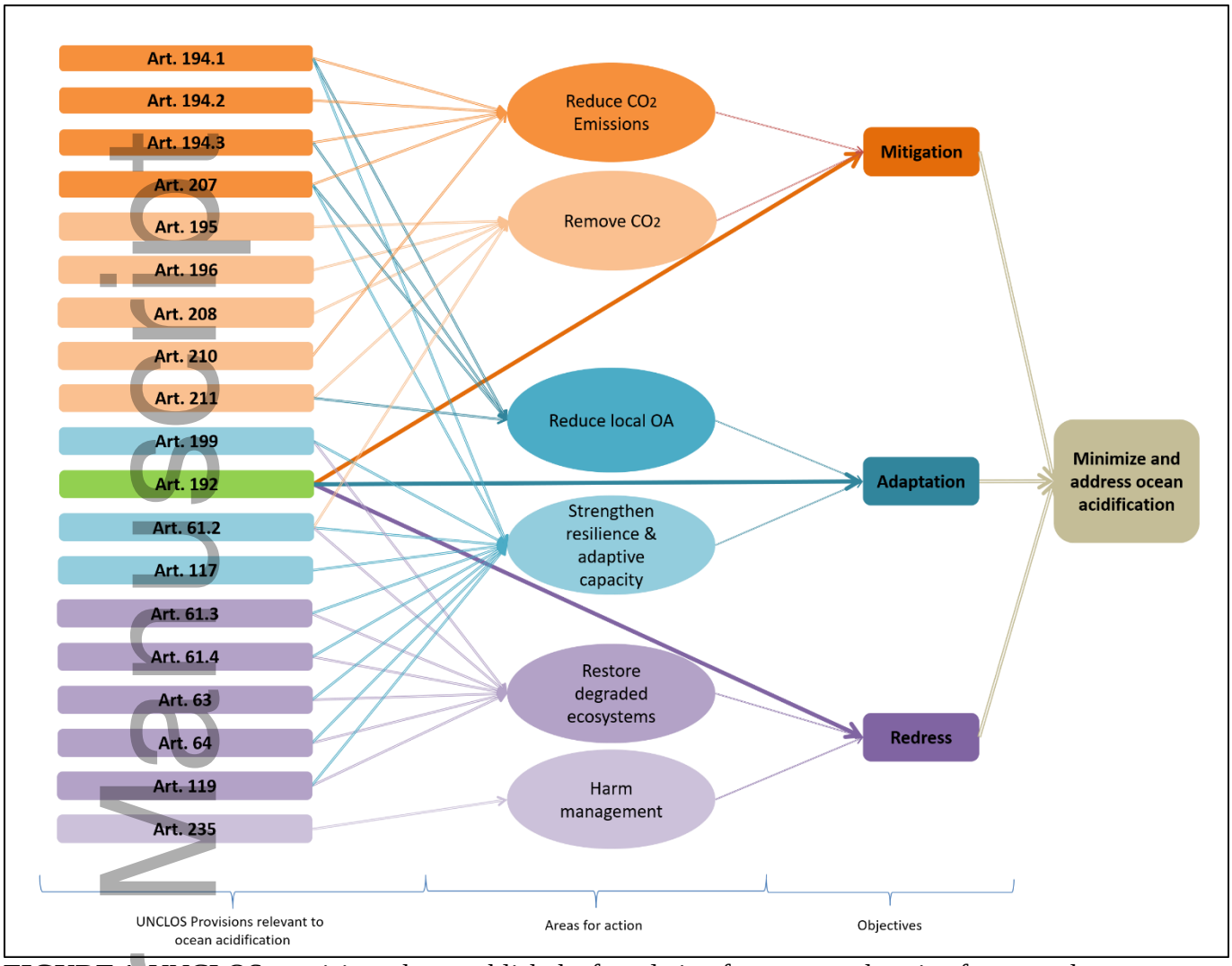

FIGURE 1. UNCLOS provisions that establish the foundation for a comprehensive framework for addressing ocean acidification.[93]

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[93] This figure is an application of governing framework established by Harrould-Kolieb and Hoegh-Guldberg (n 20).

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Article Number	Article Text
Art. 194.1	"States shall take… all measures… that are necessary to prevent, reduce and control pollution of the marine environment from any source"
Art. 194.2	"States shall take all measures necessary to ensure that activities under their jurisdiction or control are so conducted as not to cause damage by pollution to other States and their environment, and that pollution… does not spread beyond the areas where they exercise sovereign rights"
Art. 194.3	"The measures taken pursuant to this Part shall deal with all sources of pollution of the marine environment"
Art. 207	"States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from land-based sources"
Art. 195	"States shall act so as not to transfer… damage or hazards"
Art. 196	"States shall take all measures necessary to prevent, reduce and control pollution… resulting from the use of technologies"
Art. 208	"Coastal States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment arising from or in connection with seabed activities"
Art. 210	"States… shall endeavour to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control [pollution by dumping]"
Art. 211	"States… shall establish international rules and standards to prevent, reduce and control pollution of the marine environment from vessels"
Art. 199	"States… shall cooperate in… preventing or minimizing the damage" of pollution
Art. 192	"States have the obligation to protect and preserve the marine environment"
Art. 61.2	"The coastal State… shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation."
Art. 117	"All States have the duty to take… measures… necessary for the conservation of the living resources of the high seas"
Art. 61.3	Conservation and management "measures shall be designed to maintain or restore populations of harvested species" and "shall take into consideration the effects on species associated with or dependent upon harvested species with a view to… restoring populations"
Art. 61.4	In taking conservation and management measures "the coastal State shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations"
Art. 63	"States shall seek… to agree upon the measures necessary to coordinate and ensure the conservation and development of such stocks [stocks occurring within the EEZs of two or more coastal States or both within the EEZ and in an area beyond and adjacent to it]"
Art. 64	States "shall cooperate… with a view to ensuring conservation and promoting the objective of optimum utilization of such species throughout the region"
Art. 119	"States shall: take measures which are designed… to restore populations of harvested species" and "take into consideration the effects on species associated with or dependent upon harvested species with a view to… restoring populations"
Art. 235	"States shall ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the marine environment. With the objective of assuring prompt and adequate compensation… States shall cooperate in in the implementation of existing international law and the further development of international law"

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4 IMPLEMENTATION

A fundamental characteristic of a framework agreement is its delegation of detailed rules, obligations and targets to additional instruments.[94] This is an integral feature of UNCLOS. The Convention articulates that regulation will occur through subsequent treaties and other already existing agreements,[95] including through the conclusion of implementing agreements and the creation of or adherence to international rules and standards created by other bodies.

4.1 Conclusion of new implementing agreements

Kim suggests that the adoption of an implementing agreement on land-based sources of marine pollution could be an avenue for addressing ocean acidification via the regulation of CO_2.[96] There are currently no global, binding rules regulating land-based pollution of the marine environment, and the global regime to address these pollutants remains weak.[97] As a result, these obligations remain largely aspirational[98] and more specific rules are required at the treaty level.[99] A new agreement would enhance the existing regulatory architecture by strengthening obligations to address land-based pollution. Detailed pollution standards would be established and the threat of ocean acidification and the need to address it through the reduction of pollution could be explicitly articulated.[100] This would situate ocean acidification in a broader ocean pollution context and allow for exacerbating drivers to be addressed alongside that of CO_2. Considering the ongoing efforts within the international climate change regime to tackle CO_2, it is possible that it would not be included within the mandate of an agreement on land-based pollution. Even without the capability to regulate CO_2, such an agreement would still be instrumental in addressing exacerbating pollutants and reducing non-acidifying pollutants that reduce ecosystem resilience and weaken the ability of species to withstand ocean acidification. Perhaps most importantly, an agreement on land-based pollution could identify a threshold of unacceptable pH change,[101] which could establish a standard to be integrated into UNCLOS and other MEAs, including the UNFCCC.

Tanaka suggests that the negotiating process would need to overcome four main impediments with regard to the existing failures to regulate land-based pollution at the global level: (i) a reluctance to restrict economic and industrial activities; (ii) the complexity of sources, substances and actors involved in land-based marine pollution; (iii) the geographical and ecological divergences in the oceans; and (iv) the limited capacity in developing countries.[102] These factors are significant challenges to reaching a binding agreement on land-based pollution in a timely manner and the negotiation process is likely to be long and drawn out, as is occurring with the implementing agreement on biodiversity beyond national

[94] ibid.
[95] Harrison (n 41); IMO, 'Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organization', LEG/MISC.8 (30 January 2014).
[96] Kim (n 9).
[97] Tanaka (n 33).
[98] DL VanderZwaag and A Powers, 'The Protection of the Marine Environment from Land-based Pollution and Activities: Gauging the Tides of Global and Regional Governance' (2008) 23 International Journal of Marine and Coastal Law 423.
[99] Tanaka (n 33).
[100] Kim (n 9).
[101] See generally for the need to establish a threshold or boundary for ocean acidification: J Rockström et al, 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity' (2009) 14 Ecology and Society 32; Harrould-Kolieb (n 16); Scott (n 27).
[102] Tanaka (n 33).

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jurisdiction (BBNJ). Given this, an implementing agreement on land-based pollution, while sorely needed, is likely a long way off, if a reality at all.

The ongoing BBNJ negotiations offer another way to enliven the UNCLOS provisions that require a response to ocean acidification. Ocean acidification has been recognized as one of the greatest emerging threats to marine biodiversity and is likely to impact species found in the open ocean, such as foraminifera, coccolithophres, krill, pteropods and other pelagic molluscs and crustacea. Many of these species are critical components of marine food webs and contribute to biogeochemical processes in areas beyond national jurisdiction. Therefore, any new instrument with the objective of conserving marine biodiversity in these areas should consider the impacts of ocean acidification and can complement agreements that focus on national jurisdictions, such as the CBD. However, ocean acidification has not featured widely across these negotiations.

The new BBNJ agreement is slated to be concluded in 2020, with a focus on four main issue areas: (i) area-based management tools, including marine protected areas (MPAs), (ii) environmental impact assessment (EIA), (iii) marine genetic resources, and (iv) capacity building and technology transfer.[103] MPAs, EIA and capacity building and technology transfer are all activities that can be used to address rising acidity and its impacts.[104] The agreement should acknowledge ocean acidification as a significant threat to marine biodiversity in areas beyond national jurisdiction, and that it is within the scope of the agreement to minimize and address rising acidity and its impacts. The agreement should also make explicit that the tools established for the conservation of BBNJ could be used to address ocean acidification.

Establishing MPAs has been identified as an adaptive measure that can be employed in response to ocean acidification with the aim of enhancing ecosystem resilience, providing greater capacity to withstand and overcome the short-term pressures of ocean acidification.[105] There are no structural limitations to establishing MPAs under UNCLOS. Indeed, their establishment is one way of fulfilling the obligations on parties to implement measures necessary to conserve living resources (fisheries and associated and dependent species and ecosystems) (Articles 61 and 117) and to protect the marine environment (from pollution) (Article 192). Establishing MPAs in areas beyond national jurisdiction can also be seen as joint measures for the protection of the environment in fulfilment of UNCLOS Articles 194 and 197.[106]

Such areas would be governed by the objectives of UNCLOS, including limiting pollution to the marine environment. These MPAs could therefore be established with consideration of ocean acidification and managed with the intent of responding to it. Indeed, a network of high seas MPAs could incorporate the local reduction of acidity into their management as a regular operating procedure.[107] Ill-considered MPAs risk being unable to protect biodiversity faced with higher levels of change in the future.[108] Therefore, consideration of future change will need to be factored into MPA design, including the likely increase in acidity and changes in carbonate chemistry.

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[103] UNGA 'International Legally Binding Instrument under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction' UN Doc A/RES/72/249 (19 January 2018).

[104] Billé et al (n 59); Harrould-Kolieb and Hoegh-Guldberg (n 20).

[105] JP Gattuso et al, 'Ocean Solutions to Address Climate Change and Its Effects on Marine Ecosystems' (2018) 5 Frontiers in Marine Science 337; CM Roberts et al, 'Marine Reserves Can Mitigate and Promote Adaptation to Climate Change' (2017) 114 Proceedings of the National Academy of Sciences 6167.

[106] D Tladi, 'Conservation and Sustainable Use of Marine Biodiversity in Areas beyond National Jurisdiction: Towards an Implementing Agreement' in Rayfuse (n 13) 259.

[107] Billé et al (n 59).

[108] SR Cooley and JT Mathis, 'Addressing Ocean Acidification as Part of Sustainable Ocean Development' (2013) 27 Ocean Yearbook 29.

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EIA is also an important tool for biodiversity conservation and can serve as a measure through which activities likely to exacerbate ocean acidification can be regulated and avoided. UNCLOS imposes a general obligation to assess the potential effects of activities that may 'cause substantial pollution of or significant and harmful changes to the marine environment'.[109] The obligations to assess the potential effects of activities and to prevent pollution from the use of technologies are broad in scope and do not include methodological or procedural standards for conducting EIAs.[110] The inclusion of EIA elements in an BBNJ agreement offer an avenue for capturing activities occurring in marine areas beyond national jurisdiction that may not be subject to existing sectoral processes.[111] Of particular note, it has been proposed that this inclusion could provide a default EIA process for activities such as marine geoengineering.[112] This could provide a mechanism for the consideration of the potential of these activities to exacerbate ocean acidification.

There are a series of stages involved in an EIA process that vary by system but typically include screening, scoping, public notification and consultation, reporting and decision making.[113] There are various ways that ocean acidification could be incorporated into these elements, including in the screening process where the activities that should be subject to the EIA process are determined. It is generally accepted that the potential for significant effects on the environment are the trigger for an EIA process.[114] Here, the potential for the exacerbation of ocean acidification could meet the threshold as any increase in acidity in already vulnerable areas could result in significant effects. Further, it is not uncommon to list particular categories of activities that are required to undergo EIA.[115] Marine geoengineering, for example, could be included.

Ocean acidification considerations could also be incorporated into the scoping portion of the EIA process, where the terms of reference for the EIA are established. It has been proposed that this stage could incorporate examination of impacts on the stability of the global climate.[116] Changes to marine carbonate chemistry could also be identified as an issue for examination. In addition to these suggestions, it is critical that ocean acidification be considered in the decision-making stage, where it is decided whether an activity should be disallowed or allowed with conditions. This stage would include a set of criteria related to the permissible levels of impact and could include a specific level of increased acidity that is deemed safe, if any at all. The inclusion of ocean acidification within the methodological and procedural elements of the EIA included in a new implementing agreement would ensure that activities likely to have a negative impact on species that are sensitive to changes in marine carbonate chemistry are protected.

Another way of addressing ocean acidification within a BBNJ agreement is via the transfer of technology and knowledge to assist in enhancing adaptation. The inclusion of these provisions in the BBNJ negotiations recognize their importance for the conservation and sustainable use of biodiversity, particularly in strengthening capabilities of developing countries to absorb and engage in scientific advances and knowledge production.[117] The 2005

[109] UNCLOS (n 12) art 206.
[110] R Warner, 'Environmental Assessment in Marine Areas beyond National Jurisdiction' in Rayfuse (n 13) 291.
[111] ibid.
[112] ibid.
[113] N Craik, 'International EIA Law and Geoengineering: Do Emerging Technologies Require Special Rules?' (2015) 5 Climate Law 111.
[114] ibid.
[115] Warner (n 110).
[116] ibid.
[117] HR Harden-Davies, 'Research for Regions: Strengthening Marine Technology Transfer for Pacific Island Countries and Biodiversity beyond National Jurisdiction' (2017) 32 International Journal of Marine and Coastal Law 797.

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criteria and guidelines for marine technology transfer developed by the Intergovernmental Oceanographic Commission of UNESCO (IOC Guidelines)[118] were an important development in the implementation of the UNCLOS obligations.[119] These guidelines offer a definition of marine technology, left undefined by UNCLOS, as 'instruments, equipment, vessels, processes and methodologies required to produce and use knowledge to improve the study and understanding of the nature and resources of the ocean and coastal areas'.[120] Under UNCLOS, technology and knowledge transfer is identified as means for protecting the marine environment[121] and social and economic development.[122] Under Article 266, States are required to 'cooperate … to promote actively the development and transfer of marine science and marine technology on fair and reasonable terms and conditions',[123] either directly with each other or through competent international organizations.

Technology transfer is recognized as an important way to increase adaptive capacity in response to climate change.[124] While it is yet to be explored in any meaningful way with reference to ocean acidification, the same rationale for encouraging such transfer in relation to climate change would also hold for ocean acidification. This is particularly important for open-ocean research, which is needed to understand ocean acidification, as this research is resource intensive and costly, and often beyond the capacity of many less-developed and small island States.[125] Capacity building in these countries is important for the creation of monitoring programmes and early-warning systems, which can inform decision making, especially in terms of fisheries management.

Knowledge and technology transfer are also relevant with regard to technologies that may be used to remediate discrete areas of water.[126] This can include electrochemical processes, phytoremediation, enhanced weathering and liming.[127] Knowledge and technology transfer can also assist in the restoration of ecosystems damaged by ocean acidification. This is particularly important for coral reefs, many of which exist in coastal waters of small island developing States and other less developed nations.

4.2 Inclusion in existing implementing agreements

In addition to the inclusion of ocean acidification in future implementing agreements, the United Nations Fish Stocks Agreement (UNFSA)[128] offers an avenue for addressing ocean acidification impacts in reference to straddling and highly migratory fish stocks as required by Articles 63 and 64 of UNCLOS. The UNFSA was concluded with the intention of 'ensur[ing] the long-term conservation and sustainable use of straddling fish stocks and highly migratory

[118] Intergovernmental Oceanographic Commission (IOC), 'IOC criteria and Guidelines on the Transfer of Marine Technology' (2005).
[119] S Minas, 'Marine Technology Transfer under a BBNJ Treaty: A Case for Transnational Network Cooperation' (2018) 112 AJIL Unbound 144.
[120] IOC (n 118) 9.
[121] UNCLOS (n 12) art 202.
[122] ibid art 266.
[123] ibid.
[124] B Biagini et al, 'Technology Transfer for Adaptation' (2014) 4 Nature Climate Change 828.
[125] RJ Morrison et al, 'Developing Human Capital for Successful Implementation of International Marine Scientific Research Projects' (2013) 77 Marine Pollution Bulletin 11.
[126] Cooley and Mathis (n 108).
[127] R Albright and SR Cooley, 'A Solutions-based Approach for Coral Reefs under OA: Adaptation and Mitigation' (International Atomic Energy Agency 2017).
[128] Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (adopted 4 August 1995, entered into forced 11 December 2011) 2167 UNTS 3 (UNFSA).

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fish stocks',[129] and sets forth principles, tools and mechanisms to do so. The UNFSA reiterates many of the obligations of UNCLOS and further expounds upon them in Article 5. Significantly, these include obligations to adopt sustainability measures that are based on the best available scientific advice, apply the precautionary approach, assess the impacts of fishing, other human activities and environmental factors on target stocks and associated and dependent species, to conserve and restore these species as necessary and to protect biodiversity in the marine environment.[130] Given the obligations under UNCLOS to act to address ocean acidification, these UNFSA provisions can reasonably be understood as requiring States to consider how ocean acidification may impact fish stocks and to build this into stock management. Further, the duty to 'assess the impacts of fishing, other human activities and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks'[131] would suggest not only an obligation to consider ocean acidification when establishing measures to protect fish stocks, but also to assess whether exploitation of particular stocks is resulting in a lowered resilience, either in the stock itself or related species and ecosystems, and therefore lowering the potential to adapt naturally to rising acidity.

This appears to be understood by State parties as they have committed under the resumed Review Conference on the Agreement to '[s]trengthen efforts to study and address environmental factors affecting marine ecosystems, including adverse impacts of … ocean acidification, and consider such impacts in establishing conservation and management measures'.[132] They have also committed to assess ways to incorporate consideration of ocean acidification into decision-making processes related to conservation and management measures.[133] However, there is little evidence of these commitments being implemented as yet.

One way that the integration of ocean acidification could occur is through the development of stock-specific 'precautionary reference points', which are required under the Agreement.[134] These are scientifically derived values corresponding to the state of the fishery to be used as a guide for fisheries management.[135] Two reference points are to be designated for each stock, the first a boundary to constrain harvesting within safe biological limits, and the second a target to guide management objectives. In establishing these reference points, fishing pressure, reproductive capacity, resilience, sources of mortality and uncertainty should all be accounted for. Ocean acidification is likely to act as a stress amplifier on stocks via reductions in reproductive capacity and resilience, and as an additional source of mortality. In addition, there remains substantial uncertainty around the precise impacts that ocean acidification will have on stocks, particularly via changes in marine food webs.[136] These reference points offer a robust way for ocean acidification to be factored into the management of straddling and migratory fisheries.

The UNFSA further reaffirms and strengthens the UNCLOS obligation to cooperate in establishing conservation measures by requiring States to become members of or participate in relevant regional fisheries organizations.[137] Regional fisheries management organizations

[129] ibid art 2.
[130] ibid art 5.
[131] ibid art 5(d).
[132] UNGA 'Report of the Resumed Review Conference on the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks' UN Doc A/CONF210/2016/5 (1 August 2016) Annex, para A(4)(a).
[133] ibid Annex, para A(4)(b).
[134] UNFSA (n 128) art 6.
[135] ibid Annex II, art 1.
[136] Branch et al (n 3).
[137] UNFSA (n 128) art 8(3).

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(RFMOs) manage shared, straddling and migratory stocks through decision making and enforcement.[138] Given their jurisdiction in fisheries management, RFMOs can contribute to adaptation and restoration of fisheries in relation to ocean acidification. RFMOs adopt a wide range of conservation and management measures, including establishing total allowable catches, which should be set considering the impacts of ocean acidification on stock levels and resilience. Further, RFMOs have the capacity to close particular areas to fishing, including 'vulnerable marine ecosystems' that may be disrupted by bottom fishing. This could be used to exclude fishing in areas identified as particularly vulnerable to ocean acidification, including cold water reefs or acidification hot spots. These management procedures offer avenues through which the ocean acidification obligations under UNCLOS and the UNFSA can be operationalized. However, to date there is scant evidence that ocean acidification has played a substantial role in the decision-making processes of existing RMFOs.[139] Adaptive capacity can be greatly increased by protecting and enhancing fish stock abundance by reducing non-acidification related stressors, including overfishing.[140] Acting to improve fisheries management via existing RFMOs offers potential to respond to ocean acidification and significantly reduce the risk of impacts to important fisheries.

4.3 Regulation through international rules and standards

UNCLOS requires that States cooperate in the formulation and elaboration of 'international rules, standards and recommended practices and procedures' for the protection and preservation of the marine environment. This obligation is echoed in various forms throughout many provisions of Part XII of the Convention. It is these international rules and standards, to be established primarily through international organizations and diplomatic conference, that can be considered to be an application of the general obligations established by UNCLOS, and in this way they provide instructions for what is required by the general obligation.[141] The incorporation of these external rules and standards into UNCLOS acts to fill the gaps left by the more general agreement and in this way allows for greater detail to be negotiated as needed as well as the development of rules for unforeseen circumstances.[142] UNCLOS provides the overarching legal framework for the protection of the marine environment and conservation of marine living resources for many international agreements, and these agreements in turn provide the detailed rules for achieving UNCLOS obligations. In this way, 'UNCLOS "lives" within all those other treaties',[143] which are expected to 'be carried out in a manner consistent with the general principles and objectives' of UNCLOS.[144] Therefore, external regimes that play a role in the protection and preservation of the marine environment should be implemented

[138] J Swan, 'Decision-Making in Regional Fisheries Bodies or Arrangements: The Evolving Role of RFBs and International Agreement on Decision-Making Processes' (FAO 2004).
[139] With regard to the lack of responsiveness within the RFMOs to climate change generally see: B Pentz and N Klenk, 'The "Responsiveness gap" in RFMOs: The Critical Role of Decision-making Policies in the Fisheries Management Response to climate Change' (2017) 145 Ocean and Coastal Management 44; RG Rayfuse, 'Addressing Climate Change Impacts in Regional Fisheries Management Organizations' in R Caddell and EJ Molenaar (eds), Strengthening International Fisheries Law in an Era of Changing Oceans (Hart 2019) 247.
[140] WWL Cheung et al, 'Opportunities for Climate-Risk Rreduction through Effective Fisheries Management' (2018) 24 Global Change Biology 5149.
[141] International Law Commission, 'Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law' UN Doc A/CN.4/L.682 (13 April 2006); D Rothwell and T Stephens, 'Dispute Resolution and the Law of the Sea: Resolving the Interaction Between the LOS Convention and Other Environmental Instruments' in Oude Elferink and Rothwell (n 40) 209.
[142] C Redgwell, 'The Never Ending Story: The Role of GAIRS in UNCLOS Implementation in the Offshore Energy Sector' in Barrett and Barnes (n 26) 167.
[143] Barrett (n 26) 34.
[144] UNCLOS (n 12) art 237(2).

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in a mutually reinforcing and supportive way of UNCLOS. UNCLOS can thus be perceived as a framework agreement that brings together other relevant agreements that supply the rules, regulations and implementing bodies for operationalization of its obligations. While these external agreements may not necessarily place an explicit obligation on parties to address ocean acidification, compliance with UNCLOS may require that they do so. These external agreements should thus be read in consideration of the UNCLOS obligations to take specific action on ocean acidification.

There is no explicit mention of ocean acidification within the UNFCCC, and little has been done to address with issue within the climate regime.[145] Nevertheless, Harrison postulates that UNCLOS requires States to consider ocean acidification as part of their broader climate change mitigation measures.[146] Specifically, States are required to reduce CO_2 emissions to control ocean acidification. Therefore, efforts to address climate change should be consistent with efforts to address ocean acidification. Bialek and Ariel suggest that bringing ocean acidification to an international court, such as ITLOS, would likely raise its profile within the UNFCCC and move it up on the climate regime's agenda.[147] However, it has also been noted that cases brought under UNCLOS would be unlikely to succeed on claims that parties were not meeting their obligations under the UNFCCC,[148] especially given the non-binding nature of national commitments under the Paris Agreement.[149] Moreover, it is generally accepted that the commitments agreed to under the UNFCCC amount to the international rules and standards to address CO_2 emissions.[150] Thus, it would be difficult to argue that the parties were not meeting their due diligence duty to establish rules.[151] Nevertheless, an effective means of informing action under the UNFCCCC would be for parties to establish a boundary line for ocean acidification that should not be surpassed. This could be done as discussed above under the auspices of the BBNJ negotiations or under the UNFSA. A clearly designated boundary could be taken up in nationally determined contributions, which are to increase in ambition with each new submission. National commitments to maintain an acidification boundary would essentially entail a commitment to avoid perusing emissions reduction pathways that would reduce non-CO_2 emissions in preference to CO_2 and to avoid the use of emission reduction techniques that exacerbate ocean acidification.[152]

Such commitments would be in synergy with commitments under UNCLOS, as any efforts to address climate change that may exacerbate ocean acidification, including the use of some marine geoengineering techniques,[153] solar radiation management[154] and the storage of CO_2 in the deep ocean,[155] would likely be in conflict with UNCLOS provisions to protect and preserve the marine environment (Article 192), not transferring damage from one type of

[145] ER Harrould-Kolieb, 'Ocean Acidification and the UNFCCC: Finding Legal Clarity in the Twilight Zone' (2016) 6 Washington Journal of Environmental Law and Policy 613; D Herr et al, Ocean Acidification: International Policy and Governance Options (IUCN 2014).
[146] Harrison (n 41).
[147] Bialek and Ariel (n 88).
[148] Boyle (n 47).
[149] D Bodansky, 'The Legal Character of the Paris Agreement' (2016) 25 Review of European Comparative and International Environmental Law 142.
[150] Harrison (n 41).
[151] A Boyle, 'Law of the Sea Perspectives on Climate Change' (2012) 27 International Journal of Marine and Coastal Law 831.
[152] Harrould-Kolieb (n 16).
[153] Williamson and Turley (n 66).
[154] L Cao, 'The Effects of Solar Radiation Management on the Carbon Cycle' (2018) 4 Current Climate Change Reports 41.
[155] JP Barry et al, 'Effects of Direct Ocean CO_2 Injection on Deep-sea meiofauna' (2004) 60 Journal of Oceanography 759.

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pollution into another (Article 195) and preventing pollution from the use of technologies (Article 196).

This interpretation would be in line with decisions under the London Protocol (LP) to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter[156] to limit the use of marine geoengineering and prevent the storage of CO_2 in the water column. Under the LP, the dumping of all wastes and other matter is prohibited, barring those listed in Annex 1, thus effectively banning the disposal of CO_2 in the marine environment as well as all geoengineering activities that require the placement of matter in the marine environment, such as ocean fertilization.[157] In 2005, parties expressed their concern about the implications of ocean acidification for the marine environment, acknowledged that the capture and storage of CO_2 is one of a suite of options for addressing both acidification and climate change, and interpreted that the regulation of such activities is within the scope of the London Convention and Protocol.[158] This led to the amendment of the Protocol to allow the placement of CO_2 into sub-seabed geological formations.[159] Annex 1 now provides that '[c]arbon dioxide streams from carbon dioxide capture processes for sequestration' may be considered for dumping, only if 'disposal is into a sub-seabed geological formation'.[160] The qualification of only within geological formations is significant as it is recognized that storage of CO_2 on the seafloor or within the water column is likely to result in acidification, and therefore these techniques remain prohibited under the Protocol. Parties have further acknowledged that CO_2 sequestration within geological formations still risks exacerbating ocean acidification, especially in the case of leakage. In order to minimize these risks, 'Specific Guidelines for the Assessment of Carbon Dioxide Streams for Disposal into Sub-Seabed Geological Formations' were adopted.[161] These guidelines highlight the potential negative effects of CO_2 leakage, particularly in changes to pH of the surrounding water and subsequent biological and ecological effects.

The parties have also acknowledged ocean acidification, or the lowering of the pH of seawater, as a potential risk resulting from ocean fertilization.[162] This has occurred in relation to concerns raised within the dumping regime over the effectiveness of ocean fertilization and its possible negative impacts on the marine environment. In 2008, parties agreed that 'the scope of the London Convention and Protocol includes ocean fertilization activities'.[163] The Resolution further agreed that 'given the present state of knowledge, ocean fertilization activities other than legitimate scientific research should not be allowed'.[164] In 2013, a resolution to amend the Protocol was adopted establishing a platform to regulate marine geoengineering in general and ocean fertilization in particular.[165] Article 6bis places an obligation on parties to 'not allow the placement of matter into the sea from vessels, aircraft,

[156] 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wasted and Other Matter 1972 (as amended in 2006) (adopted 7 November 1996, entered into force 24 March 2006).
[157] RG Rayfuse and R Warner, 'Climate Change Mitigation Activities in the Ocean: Turning up the Regulatory Heat' in R Warner and C Schofield (eds), Climate Change and the Oceans: Gauging the Legal and Policy Currents in the Asia Pacific and Beyond (Edward Elgar 2012) 234.
[158] IMO, 'Report of the 27th Consultative Meeting', LC 27/16 (16 December 2005).
[159] London Convention and Protocol (LC-LP), 'Resolution LP.1(1), On the Amendment to Include CO_2 Sequestration in Sub-Seabed Geological Formations in Annex 1 to the London Protocol' (2 November 2006).
[160] London Protocol (n 156) Annex 1, art 1(8).
[161] LC-LP, '2012 Specific Guidelines for the Assessment of Carbon Dioxide for Disposal into Sub-Seabed Geological Formations', LC 34/15 (2012) Annex 8.
[162] LC-LP, 'Resolution LC-LP.2(2010), On the Assessment Framework for Scientific Research Involving Ocean Fertilization' (14 October 2010) Annex 6, paras 3.4.2.2.4 and 3.5.2.2.1.
[163] LC-LP, 'Resolution LC-LP.1(2008), On the Regulation of Ocean Fertilization' (31 October 2008) para 1.
[164] ibid para 8.
[165] LC-LP, 'Resolution LP.4(8), On the Amendment of the London Protocol to Regulate the Placement of Matter for Ocean Fertilization and Other Marine Geoengineering Activities' (18 October 2013).

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platforms or other man-made structures at sea for marine geoengineering activities listed in annex 4'.[166] This resolution is yet to come into force. Similar concerns have been articulated in resolutions under the Convention on Biological Diversity[167] and all parties have been requested to ensure all geoengineering activities that could impact biodiversity are not used.[168] UNCLOS further requires that States adopt national laws, regulations and measures in relation to dumping and requires that these 'shall be no less effective in preventing, reducing and controlling such pollution than the global rules and standards'.[169] Given that it is generally accepted that the global rules and standards relating to dumping are set out by the London Convention and Protocol,[170] it follows that the placement of CO_2 in the water column or on the sea bed and the deployment of iron fertilization activities be considered as dumping under Article 210 and therefore must be regulated so as to prevent harm to the marine environment.

The 1973 International Convention for the Prevention of Pollution from Ships (MARPOL)[171] offers another example of generally accepted rules and standards that are viewed as fulfilling the obligation to establish such 'international rules and standards to prevent, reduce and control pollution of the marine environment from vessels'.[172] These standards have been expanded to include air pollution from ships under a revised Annex VI, adopted in 2008, which now includes standards for emissions of CO_2 and sulphur and nitrogen oxides (SO_x and NO_x). CO_2 from shipping accounts for approximately 2.2 percent of global emissions, and while its reduction will contribute to mitigating ocean acidification globally, their contribution is relatively small. Perhaps more significantly is the potential to limit the exacerbation of ocean acidification locally through the reduction of SOx and NOx emissions. These emissions within heavily trafficked areas have been estimated to cause an equivalent amount of ocean acidification as global CO_2 emissions.[173] MARPOL allows for the designation of emission control areas with more stringent standards than those accepted globally. These areas could be designated along zones that are vulnerable to increased levels of ocean acidification. However, such efforts have not been initiated in consideration of ocean acidification and should be done so to be in line with UNCLOS provisions to address ocean acidification. Moreover, allowing the emission of these substances in areas highly susceptible to ocean acidification may be deemed as contravening the obligations within UNCLOS of protecting the marine environment from pollution from vessels.

5 CONCLUSION

Matz-Lück states that framework agreements, through the process of establishing general objectives and then specific and detailed regulation are an 'attempt to address an issue of international law in an effective manner' that 'can be contrasted with the so-called "piecemeal approach" to international regulation'.[174] Until now the international community has not taken a direct approach in addressing ocean acidification. There is no unifying agreement or stand-

[166] ibid art 6Bis.
[167]CBD 'Decision IX/16, Biodiversity and Climate Change' UN Doc UNEP/CBD/COP/DEC/IX/16 (9 October 2008).
[168] CBD 'Decision X/33, Biodiversity and Climate Change' UN Doc UNEP/CBD/COP/10/27 (19 December 2010).
[169] UNCLOS (n 12) art 210(6).
[170] Tanaka (n 33) 277; IMO, The London Convention and Protocol: Their Role and Contribution to the Protection of the Marine Environment (IMO 2012) 4.
[171] International Convention for the Prevention of Pollution from Ships as modified by the Protocol of 1978 (adopted 17 February 1978, entered into force 2 October 1983) 1340 UNTS 61 (MARPOL).
[172] UNCLOS (n 12) art 211(1).
[173] Hassellöv et al (n 58).
[174] Matz-Lück (n 22) 446.

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alone mechanism that responds to rising acidity. In the absence of such action, it is possible to interpret UNCLOS as acting as a framework convention for ocean acidification. While UNCLOS was concluded long before any recognition of ocean acidification, this phenomenon arguably falls within the mandate of the Convention, both with respect to its provisions to protect and preserve the marine environment and those pertaining to the conservation of marine living resources. UNCLOS can be understood as requiring States to mitigate the cause, establish adaptation measures and redress the harm of ocean acidification.

UNCLOS offers a series of provisions that establish a framework for action on ocean acidification. However, UNCLOS does not provide methods and standards for implementing this framework. This should rather be achieved through regulation within implementing agreements and other external agreements. Both the UNFSA and the soon to be concluded BBNJ implementing agreements can and should play an important role in operationalizing obligations to protect marine living resources and marine biodiversity from ocean acidification. External rules and standards that can be understood as enlivening UNCLOS provisions should be operationalized in way that is sensitive to ocean acidification, thereby fulfilling UNCLOS obligations. For instance, efforts to reduce CO_2 within the climate regime and SOx and NOx within MARPOL should consider ocean acidification. Further, activities such as geoengineering and storage of CO_2 in the ocean, which are likely to exacerbate ocean acidification, should be understood as being in conflict with UNCLOS obligations.

UNCLOS provides the vocabulary and overarching guiding framework for advancing international action on ocean acidification. UNCLOS offers a framework for identifying the rules and standards within existing regimes that should be operationalised with consideration of ocean acidification. The UNCLOS framework establishes the skeleton for finding coherence and harmonization across the complex of regimes addressing ocean acidification and the obligations to create and adhere to external international rules and standards give flesh to these bones.

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Minimize and address ocean acidification

Art. 210	"States… shall endeavour to establish global and regional rules … procedures to prevent, reduce and control [pollution by dumpi
Art. 211	"States… shall establish international rules and standards to p marine environment from vessels"
Art. 199	"States… shall cooperate in… preventing or minimizing the dan
Art. 192	"States have the obligation to protect and preserve the marine
Art. 61.2	"The coastal State… shall ensure through proper conservation … of the living resources in the exclusive economic zone is not en
Art. 117	"All States have the duty to take… measures… necessary for the seas"
Art. 61.3	Conservation and management "measures shall be designed to species" and "shall take into consideration the effects on speci species with a view to… restoring populations"
Art. 61.4	In taking conservation and management measures "the coasta species associated with or dependent upon harvested species … populations"
Art. 63	"States shall seek… to agree upon the measures necessary to c development of such stocks [stocks occurring within the EEZs o EEZ and in an area beyond and adjacent to it]"
Art. 64	States "shall cooperate… with a view to ensuring conservation … utilization of such species throughout the region"
Art. 119	"States shall: take measures which are designed… to restore po consideration the effects on species associated with or depend restoring populations"

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