1. Introduction to the *Research Handbook on Ocean Acidification Law and Policy*

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Ocean acidification has been aptly described as the ‘evil twin’ of climate change.¹ Rising carbon dioxide (CO₂) emissions have fueled warmer atmospheric and ocean water temperatures, with associated climate change impacts on marine and coastal ecosystems, such as sea-level rise, deoxygenation, coral bleaching, loss of sea ice, and shifts in abundance and distributions of species.² Those emissions have also contributed to ocean acidification. The ocean is estimated to absorb about a quarter of total anthropogenic CO₂ emissions³ with some 525 billion tons of CO₂ absorbed since the beginning of the industrial era and about 22 million tons sequestered each day.⁴ CO₂ mixing with sea water forms carbonic acid and the related chemical changes have lowered pH conditions and lowered saturation states of carbonate minerals, like aragonite and calcite, used by many marine organisms in forming shells and skeletons.⁵ Ocean surface waters on average have become about 30 percent more acidic over the last 200 years. If CO₂ continues to be emitted at current rates, the pH has been projected to drop by another 120 per cent by the end of this century.⁶ The current rate of ocean acidification is thought to be higher than anytime in at least the last 300 million years.⁷

While numerous scientific uncertainties surround the effects of ocean acidification, partly due to the difficulties of understanding the roles of multiple stressors and the acclimation

¹ See, e.g., Eric V Hull, ‘Ocean Acidification: Legal and Policy Responses to Address Climate Change’s Evil Twin’ (2014) 20 *New York University Environmental Law Journal*, 507.

² Intergovernmental Panel on Climate Change (IPCC), *The Ocean and Cryosphere in a Changing Climate: Summary for Policymakers* [H-O Pörtner, D C Roberts, V Masson-Delmotte et al. (eds)] (IPCC 2019); D Laffoley and J M Baxter (eds), *Explaining Ocean Warming: Causes, Scale, Effects and Consequences* (IUCN 2016).

³ Scott C Doney, D Shallin Busch, S R Cooley, and Kristy J Kroeker, ‘The Impact of Ocean Acidification on Marine and Reliant Human Communities’ (2020) 30 *Annual Review of Environment and Resources*, 11.1, 11.2.

⁴ Ocean Portal Team, ‘Ocean Acidification’ <https://ocean.si.edu/ocean-life/invertebrates/ocean-acidification> accessed January 9, 2021.

⁵ Ove Hoegh-Guldberg, Linwood Pendleton, and Anne Kaup, ‘People and the Changing Nature of Coral Reefs’ (2019) 45 *Regional Studies in Marine Science*, 100699.

⁶ Ocean Portal Team (n 4).

⁷ B Hönlisch, A Ridgwell, and D N Schmidt et al., ‘The Geological Record of Ocean Acidification’ (2012) 335:6072 *Science*, 1058; Kunshan Gao, John Beardall, and Donat-P Häder et al., ‘Effects of Ocean Acidification on Marine Photosynthetic Organisms under the Concurrent Influences of Warming, UV Radiation, and Deoxygenation’ (2019) 6 *Frontiers in Marine Science*, Article 322.

potential of various marine species,⁸ a long list of impacts have been identified.⁹ They include, among others: difficulty for shelled marine species, such as oysters, mussels, clams, urchins, and starfish, to build their shells; possible reduction of calcifying zooplankton and phytoplankton species with associated food web disruptions; limitation of coral growth; increased toxicity and abundance of harmful algae blooms; alteration of sensory systems and avoidance of predator behavior in some fish; and a decline in some fish populations.¹⁰

Ocean acidification might also be characterized as the ‘neglected twin’ of climate change. Public and political attention has focused on climate change and other environmental challenges such as plastic pollution in the ocean with ocean acidification not receiving high priority.¹¹ The Paris Agreement,¹² addressing climate change mitigation, adaptation, and loss and damage,¹³ is highly focused on keeping the global atmospheric temperature under control with a target of holding the global average temperature increase to well below the 2°C pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels.¹⁴ Although many organizations and initiatives have attempted to raise the profile of ocean acidification within the climate change regime,¹⁵ ocean acidification has received scant attention.¹⁶

Getting a grip on the law and policy dimensions of addressing ocean acidification is not easy. No comprehensive and integrative global agreement has been adopted to address ocean acidification, although a specific ocean acidification agreement has been suggested.¹⁷

⁸ Doney et al. (n 3); Jean-Pierre Gattuso, ‘A Short Summary of Current Knowledge on Ocean Acidification’ in N Hilmi, D Allemand, and C Kavanagh (eds), *Bridging the Gap between Ocean Acidification Impacts and Economic Valuation: Regional Impacts of Ocean Acidification on Fisheries and Aquaculture* (IUCN 2015) 19, 20; C Turley and J-P Gattuso, ‘Future Biological and Ecosystem Impacts of Ocean Acidification and Their Socioeconomic–Policy Implications’ (2012) 4 *Current Opinion in Environmental Sustainability*, 278.

⁹ Doney et al. (n 3).

¹⁰ IPCC, *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H-O Pörtner, D C Roberts, V Masson-Delmotte et al. (eds)] (IPCC 2019) ch 5; Secretariat of the Convention on Biological Diversity, *An Updated Synthesis of the Impacts of Ocean Acidification on Marine Biodiversity*, Technical Series No. 75 (2014).

¹¹ Rachel Tiller, Francisco Arenas, and Charles Galdies et al., ‘Who Cares about Ocean Acidification in the Plasticene?’ (2019) 174 *Ocean and Coastal Management*, 170.

¹² Paris Agreement, adopted December 12, 2015, [2016] ATS 24, entered into force November 4, 2016.

¹³ Daniel Klein, Maria Pia Carazo, and Meinhard Doelle et al. (eds), *The Paris Agreement on Climate Change: Analysis and Commentary* (Oxford University Press 2017).

¹⁴ Paris Agreement (n 12) art 2(1)(a).

¹⁵ See, e.g., the Because the Ocean Initiative www.becausetheocean.org accessed January 9, 2021; the Blue Carbon Initiative <http://thebluecarboninitiative.org> accessed January 9, 2021; and the International Alliance to Combat Ocean Acidification www.oaalliance.org accessed January 9, 2021.

¹⁶ See Cecilia Engler, David L VanderZwaag, and Katja Fennel, ‘Ocean Acidification Post-Paris: Gauging Law and Policy Responses in Light of Evolving Scientific Knowledge’ (2019) 33 *Ocean Yearbook*, 207.

¹⁷ See Rakhuan E Kim, ‘Is a New Multilateral Environmental Agreement on Ocean Acidification Necessary?’ (2012) 21 *Review of European Community and International Environmental Law*, 243; V González, ‘An Alternative Approach for Addressing CO₂-driven Ocean Acidification’ (2012) 12 *Sustainable Development Law and Policy*, 45.

Instead, a fragmented array of international agreements and initiatives has emerged,¹⁸ with climate change agreements being central to mitigation and adaptation to ocean acidification.¹⁹ Regional sea programs and regional fisheries management organizations (RFMOs) are at various stages in responding to climate change and ocean acidification.²⁰ At the national level, countries vary considerably in how they are addressing ocean acidification with legal fragmentation again a key reality, especially in federated states.²¹

One thing is clear about international and national law and policy responses to date. They have not been up to the task of countering the growing threats of ocean acidification²² with various terms describing the reality including ‘lagging law and policy responses’²³ and ‘falling through the cracks of [the United Nations Convention on the Law of the Sea] and the [United Nations Framework Convention on Climate Change]’.²⁴ Parties to the Paris Agreement have not committed to sufficient mitigation action to date, with their nationally determined contributions (NDCs) to mitigate emissions determined to be inadequate and suggesting a temperature increase of at least 3 °C by the end of the century.²⁵ The pace at which countries will move to low-carbon economies, and the shift of the world’s population to low-carbon lifestyles, also remains uncertain even in the wake of the COVID-19 crisis.²⁶

Whether the Paris Agreement and even its most ambitious target of keeping global temperature rise to 1.5 °C will be able to save coral reefs from the combined stressors of climate change and ocean acidification is particularly in doubt.²⁷ The Intergovernmental Panel on Climate Change in its 2018 *Special Report on Global Warming of 1.5 °C* concluded that coral reefs are projected to decline by a further 70–90 percent at 1.5 °C (high confidence) with larger losses (>99.6) at 2 °C.²⁸ Recent projections of future coral bleaching also point to a rather bleak picture.²⁹

¹⁸ See Engler et al. (n 16); Tim Stephens, ‘Warming Waters and Souring Seas: Climate Change and Ocean Acidification’ in Donald R Rothwell, Alex G Oude Elferink, Karen N Scott, and Tim Stephens (eds), *The Oxford Handbook of the Law of the Sea* (Oxford University Press 2015) ch 34; Yangmay Downing, ‘Ocean Acidification and Protection under International Law from Negative Effects: A Burning Issue amongst a Sea of Regimes?’ (2013) 2 *Cambridge Journal of International and Comparative Law*, 242.

¹⁹ Ellycia R Harrould-Kolieb, ‘Ocean Acidification and the UNFCCC: Finding Legal Clarity in the Twilight Zone’ (2016) 6 *Washington Journal of Environmental Law & Policy*, 612.

²⁰ See Chapters 8 and 9 in this book respectively.

²¹ For a description of the legal fragmentation in the United States, see Kimberly N Smith, ‘Ocean Acidification: Dealing with Uncharted Waters’ (2019) 30 *Villanova Environmental Law Journal*, 199.

²² Engler et al. (n 16).

²³ Katja Fennel and David L VanderZwaag, ‘Ocean Acidification: Scientific Surges, Lagging Law and Policy Responses’ in Robin Warner and Stuart Kaye (eds), *Routledge Handbook of Maritime Regulation and Enforcement* (Routledge 2016) ch 20.

²⁴ Nilüfer Oral, ‘Ocean Acidification: Falling between the Legal Cracks of UNCLOS and the UNFCCC?’ (2018) 45 *Ecology Law Quarterly*, 9.

²⁵ United Nations Environment Programme (UNEP), *Emissions Gap Report 2020* (UNEP 2020) xi.

²⁶ *ibid* chs 4 and 6.

²⁷ For a general questioning of the Paris Agreement’s ‘bottom up’ approach, see Jennifer Devlin Calkins, ‘Paris When It Sizzles: What Agenda 21 Can Tell Us About the Likely Success of the Paris Agreement’ (2018) 27 *Washington International Law Journal*, 523.

²⁸ IPCC, *Special Report on the Impacts of Global Warming of 1.5 °C: Summary for Policymakers* [V Masson-Delmotte, P Zhai, H-O Pörtner et al. (eds)] (IPCC 2018) 10.

²⁹ UNEP, *Projections of Future Coral Bleaching Conditions Using IPCC CMCP6 Models: Climate Policy Implications, Management Applications, and Regional Seas Summaries* (UNEP 2020).

This Research Handbook, divided into four parts, aims to provide a navigational guide to the tangled currents of international, regional and national laws and policies relevant to ocean acidification. Part I, consisting of Chapter 2 by Dan Laffoley, John M Baxter, Elizabeth B Jewett, Maureen Brooks and Nelson A Lagos, sets the scientific context for the ocean acidification law and policy discussions to follow. The authors first describe the major scientific understandings and concerns. While the long-term ecosystem consequences of ocean acidification remain uncertain, many concerns exist, including the vulnerability of animals and plants with calcium carbonate-based shells or skeletons; the loss of species and key links within food webs; the degradation of coral reefs adversely affecting food security, tourism, shoreline protections, and biodiversity; and a reduced marketability of seafood due to acidification impacts on taste and looks of products. Following the scientific overview, the authors proceed to highlight key scientific research challenges. They include shifting research from individual species to ecosystems; devising long-term studies to understand adaptation and acclimation potential of marine organisms; understanding the roles of multiple stressors and natural variabilities; identifying regions of the ocean most resilient to acidification so as to support establishment of coastal refugia; supporting scientific training in vulnerable regions lacking scientific capabilities; and mapping and projecting economic impacts of ocean acidification at local and regional levels.

The five chapters in Part II of this Handbook address global law and policy frameworks and developments relevant to ocean acidification. Chapter 3 by Ellycia R Harrould-Kolieb, reviews the limited regulation of ocean acidification under the climate change regime but highlights promising avenues opened through the Paris Agreement to catalyze future actions to address ocean acidification. Three main ways forward are proposed: including an ocean acidification boundary in nationally determined contributions along with a commitment to maintain the boundary; directly addressing ocean acidification through adaptation strategies included in national adaptation communications and plans; and bolstering research on loss and damage due to ocean acidification and attribution of the impacts to those most responsible.

Chapter 4, by Naporn Popattanachai and Elizabeth A Kirk, explores the role of multilateral environmental agreements in addressing ocean acidification with a focus on the United Nations Convention on the Law of the Sea (UNCLOS)³⁰ and the Convention on Biological Diversity (CBD)³¹ and their relationship with the climate change regime. The many pollution prevention and control obligations set out in UNCLOS are reviewed along with their limitations. Actions under the CBD are also highlighted, including the publication of two scientific synthesis reports on ocean acidification and a specific Aichi Biodiversity Target 10 calling for the minimization of multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification. After noting the lack of coordination in addressing ocean acidification among the law of the sea, biodiversity, and climate change regimes, the authors conclude by suggesting ways to enhance future cooperation including using the United Nations as a forum to encourage cooperation; holding joint or consecutive conferences of the parties; and bolstering cooperation among the secretariats and subsidiary bodies.

³⁰ United Nations Convention on the Law of the Sea, adopted December 10, 1982, 1833 UNTS 3, *entered into force* November 16, 1994.

³¹ Adopted June 5, 1992, 1760 UNTS 79 *entered into force* December 29, 1993.

Chapter 5, by Beatrice Martinez Romera, documents the efforts of the International Maritime Organization (IMO) to control CO₂ emissions from ships and other vessel-source pollution discharges that may add to ocean acidification stresses on the marine environment. Key developments under the IMO include adoption of mandatory energy efficiency requirements and an Initial Strategy on Reduction of Greenhouse Gas (GHG) Emissions from Ships. The Initial Strategy pledges the peaking of GHG emissions from international shipping as soon as possible and achieving GHG emission reductions by at least 50 percent by 2050 from 2008 levels.

In Chapter 6, Joanna Mossop discusses the history of negotiations for a new treaty on the conservation and sustainable use of marine biological diversity (BBNJ) in areas beyond national jurisdiction and the implications of such an instrument in addressing ocean acidification. She tracks how climate change and ocean acidification received passing attention in the processes leading up to negotiations and in the negotiations themselves. Although negotiations have yet to be concluded, she postulates that a new treaty is likely to make at least two major contributions to addressing ocean acidification. Requiring environmental impact assessments for new activities that may have harmful impacts on marine biodiversity provides an opportunity for cumulative impacts, including those of climate change and ocean acidification, to be factored into decision-making. Establishing a framework for the designation and management of marine protected areas (MPAs) in areas beyond national jurisdiction is expected to contribute to the resiliency of ecosystems in the face of climate change and ocean acidification.

A human rights based approach to addressing climate change and ocean acidification impacts on the livelihoods of many people living in coastal zones is advocated by Hilal Elver and Nilüfer Oral in Chapter 7. They emphasize how the displacement and marginalization of the world's small-scale fisheries and the food insecurity of coastal communities are often overlooked and undervalued. They review international law instruments relating to the ocean and food security and provide a detailed listing of human rights instruments recognizing a right to food and food security. The authors highlight the need to consider the right to food in making future mitigation and adaptation policy decisions relating to climate change and ocean acidification.

Part III of the Research Handbook explores how ocean acidification is being addressed at the regional level. Chapter 8, by Kerry Tetzlaff, examines the extent to which regional seas programs have responded to climate change and ocean acidification. After noting that the United Nations Environment Programme's (UNEP) Regional Seas Programme has identified climate change and ocean acidification as one of four strategic themes to be addressed as part of the Regional Seas Strategic Directions (2017–2020), she proceeds to analyze how 16 individual regional sea programs have addressed ocean acidification. Those programs include seven regional seas programs being administered directly by UNEP (Caspian Sea, East Africa, East Asia, Mediterranean, Northwest Pacific, West and Central Africa, and the Wider Caribbean); seven forming part of UNEP's Regional Seas Programme while being administered by a regional organization (Black Sea, North Pacific, Pacific, Red Sea and Gulf of Aden, ROPME, South Asia, and South-East Pacific); and two independent regional sea programs that partner with UNEP's Regional Seas Programme (Baltic and North-East Atlantic). She documents the wide variation in regional responses and highlights how most regional sea programs have not responded with a comprehensive strategy for research and monitoring, awareness building, and mitigation and adaptation measures. She also describes positive advances in some regions by introducing monitoring programs; convening ocean acidification

related workshops or conferences; encouraging restoration of mangroves, seagrasses, salt marshes, and coral reefs; and in the case of the North-East Atlantic, addressing carbon capture and storage in geological formations.

In Chapter 9, Rosemary Rayfuse provides a tour of how RFMOs have assessed and addressed the risks and impacts of ocean acidification. She first reviews what is known about the effects of ocean acidification on fish stocks, including the substantial scientific uncertainties but also numerous concerns, such as reduced growth and abundance in some species and indirect alterations of food webs and predator-prey relationships. She then proceeds to examine how selected RFMOs, five ‘tuna’ RFMOs, seven ‘non-tuna’ RFMOs and two anadromous fisheries organizations, have fared in following the three main pathways towards adaptive management in the face of climate change and ocean acidification. Regarding the first pathway of supporting ocean acidification and climate change science within RFMOs, Rayfuse concludes that overall there has been a paucity of focus on ocean acidification with climate change being recognized in a general way, but without explicit engagement with relevant science or specific ocean acidification research suggestions or support. For the second pathway of absorbing ocean acidification through incorporation of precautionary and ecosystem approaches in decision-making, Rayfuse finds RFMOs have inadequately operationalized the precautionary approach by not accounting for environmental factors such as climate change and ocean acidification in stock assessments. Implementation of the ecosystem approach has lagged due to the tendency of RFMOs to focus on the impacts of a fishery on non-target species or on the broader marine ecosystem, but not the impacts of ocean acidification and climate change on the harvested and dependent and associated species. For the third pathway of addressing ocean acidification in management regimes, Rayfuse highlights the advances in many RFMOs to protect vulnerable marine ecosystems (VMEs) but without any explicit consideration of ocean acidification. She goes on to identify key institutional constraints on the ability of RFMOs to effectively engage in adaptive management, including a requirement for decisions to be adopted either by consensus or unanimous vote; presence of an objection procedure; and the common practice of ignoring scientific advice regarding sustainable catch levels in favor of socioeconomic and political factors. The chapter concludes that although it may be premature to make judgments on the extent RFMOs are addressing the risks and impacts of ocean acidification on fish stocks in light of the nascent state of ocean acidification science, RFMOs will need to promote and explicitly utilize ocean acidification science in the future and adjust stock assessments, catch limits and quota allocations accordingly.

The next two chapters in Part III address how ocean acidification has been addressed in the two polar regions. The status of scientific and governance responses to ocean acidification in the Arctic is reviewed by Nadja Steiner and David L VanderZwaag in Chapter 10. Scientific studies relevant to ocean acidification in the region are first summarized with a focus on the two ocean acidification assessments completed in 2013 and 2018 through the Arctic Monitoring and Assessment Programme (AMAP) Working Group of the Arctic Council. The limited efforts to address mitigation and adaptation of ocean acidification by the Arctic Council are reviewed with differing national perspectives regarding the threats of climate change thwarting the articulation of specific policy recommendations through ministerial meetings. Adaptation initiatives to reduce various stresses on the marine environment by Arctic Council working groups, task forces, and expert groups are summarized in relation to pollution prevention and control and the commitment to develop a regional network of marine protected areas.

The importance of the new Central Arctic Ocean Fisheries Agreement,³² signed in October 2018, is also highlighted with its call for a precautionary and adaptive approach to potential future commercial fisheries in the high seas areas of the central Arctic Ocean. The chapter concludes with suggested future directions for enhancing Arctic Ocean acidification research and monitoring and for strengthening governance responses. Adaptation responses include, among others, updating the Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-Based Activities³³ and following through with the actual establishment of a network of MPAs in the Arctic.

How states parties to the Antarctic Treaty System instruments have addressed ocean acidification is explored by Karen N Scott in Chapter 11. She notes the reluctance by Antarctic Treaty Consultative Meetings to engage with climate change and ocean acidification at the policy level as some parties regard these threats as being more appropriately addressed within the United Nations Framework Convention on Climate Change (UNFCCC) regime, although a considerable number of scientific reports have been produced on climate change and the Antarctic environment. She reviews the struggles within the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) to develop a strategic and comprehensive approach to climate change and ocean acidification with climate change being somewhat incorporated into area-based management measures but not generally into fisheries management. The relevance of the 1991 Environmental Protocol³⁴ to addressing ocean acidification is also discussed. The author concludes by arguing that Article 2 of the 1991 Protocol can be interpreted to impose a due diligence obligation on parties to take action to address the causes of ocean acidification in regard to activities outside the Antarctic Treaty area.

The final chapter in Part III, Chapter 12 by Clement Yow Mulalap, highlights the special vulnerabilities of Pacific Island Countries and Territories (PICTS) to ocean acidification and provides a survey of how the Pacific Small Island Developing States (PSIDS) in particular have been pushing the international community to undertake progressively ambitious actions to curb greenhouse gas emissions. He describes efforts by PSIDS to raise the profile of climate change and ocean acidification in various intergovernmental processes including under the UNFCCC with its launch of the Ocean Pathway Initiative in 2017; through the International Civil Aviation Organization and the IMO and their CO₂ emission reduction efforts; in negotiations for a new BBNJ instrument; and through supporting resolutions and actions by the Human Rights Council linking human rights and climate change. He summarizes the efforts of some Pacific Small Island states to pursue an advisory opinion from the International Court of Justice on questions relating to the responsibilities of states to ensure their other emissions do not harm other states. He also discusses the possible alternative of seeking an advisory opinion on climate change from the International Tribunal for the Law of the Sea.

Part IV of the Research Handbook includes four chapters examining selected national law and policy approaches and challenges in addressing ocean acidification. In Chapter 13, Ellycia

³² Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean, adopted October 3, 2018, www.dfo-mpo.gc.ca/international/agreement-accord-eng.htm accessed July 1, 2020, not yet in force.

³³ Protection of the Arctic Marine Environment (PAME) Working Group, *Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-based Activities* (Arctic Council 2009).

³⁴ Protocol on Environmental Protection to the Antarctic Treaty, adopted October 4, 1991, 30 ILM 1461, *entered into force* January 14, 1998.

R Harrould-Kolieb and Tim Stephens highlight the limited attention given to ocean acidification under Australian law and policy. This is shown by the lack of a dedicated ocean acidification research program; a failure to consider ocean acidification in formulating national greenhouse gas emission reduction targets; and the lack of law and policy measures to meet adaptation challenges. The authors recommend that producing a comprehensive Australian ocean acidification assessment should be an urgent national priority. They suggest various measures to better address climate change and ocean acidification including adopting a ‘safe’ or acceptable ocean acidification target for Australian marine bioregions; legislating binding emission reduction commitments; developing a national ocean acidification adaptation plan; and incorporating ocean acidification into marine bioregional planning processes.

Chapter 14 reviews how Brazil has addressed climate change and ocean acidification. The authors, Maria Helena Fonseca de Souza Rolim and Victor Alencar Mayer Feitosa Ventura, highlight relevant ocean acidification assessment efforts in Brazil, such as the Brazilian Ocean Acidification Network, which has published two main reports on the status of ocean acidification in Brazilian waters. However, Rolim and Ventura note the overall lack of funding and policy support for ocean acidification scientific research projects. They emphasize the particular difficulties in the Brazilian legal system of responding to ocean acidification due to the fragmented federal, state, and municipal laws and policies addressing environmental protection issues. The Brazilian framework for addressing climate change policy is reviewed, including Brazil’s National Policy on Climate Change and National Fund for Climate Change, both adopted in 2009. While Brazil is a party to all the key ocean and marine environment-related treaties, the authors observe that Brazil has yet to develop a solid legal framework in regard to ocean acidification. They conclude with an expression of hope that Brazil will proceed to adopt the draft National Policy for the Conservation and Sustainable Use of the Marine Environment, still under discussion in the Brazilian Lower House, which promises to set new directives for mitigating and adapting to climate change and ocean acidification.

China’s law and policy responses to ocean acidification are reviewed in Chapter 15 by Jiaya Bai and Jiaxin Sui. The authors highlight the varying status of ocean acidification in China’s adjacent marginal seas, namely, the Bohai Sea, Yellow Sea, East China Sea, and South China Sea, and summarize environmental and marine environmental cooperative arrangements of China with maritime neighbors. The chapter notes the lack of explicit provisions on ocean acidification under China’s Constitution and domestic laws but summarizes the many laws that may indirectly address ocean acidification, particularly China’s Marine Environment Protection Law and its revised Environmental Protection Law. China’s key policies addressing climate change are also described, including China’s National Plan on Climate Change (2014–2020) and China’s Work Plan on Controlling Greenhouse Gas Emissions, issued in 2016 as part of its 13th Five-Year Plan, which aims to reduce CO₂ emissions per unit of GDP by 18 percent by 2020 compared to 2015 and encourages the development of low-carbon energy sources and low-carbon industrial systems.

The battle against ocean acidification in the United States is described in the final chapter of this book. In Chapter 16, Sherry P Broder reviews the difficulties of addressing climate change and ocean acidification under the Trump Administration and the numerous actions to roll-back carbon emission controls. She discusses the challenges of addressing ocean acidification under the Clean Water Act with the Act’s permitting processes offering some promise to reduce storm water runoff and nutrient pollution. A number of key legal innovations in the United States to address ocean acidification are highlighted, including the enactment in 2009 of the

Federal Ocean Acidification Research and Monitoring (FOARAM) Act, which mandates an active monitoring and research program, and the passage of legislation in some states establishing task forces or councils to work on ocean acidification issues.

One chapter and regional topic, originally planned for inclusion in this Handbook, had to be omitted. The author of a chapter on how the European Union and its member states have addressed ocean acidification had to withdraw due to COVID-19 issues. However, European policies and legislation targeting ocean acidification have been reviewed elsewhere.³⁵

It is clear from the contributions to this Handbook that ocean acidification has not attracted the attention it merits from policy-makers, despite the sharpening scientific consensus about the significant impacts that it is having on marine ecosystems globally. As the ‘evil twin’ to climate change, the success or failure of efforts to address ocean acidification will also depend in large part on global initiatives to curb carbon emissions. However, as is made clear in several chapters in the Handbook, there are also opportunities for regional, national, and sub-national responses, particularly in building the resilience of especially vulnerable marine environments. There is also much that can be learned from the ways in which different jurisdictions and institutions are approaching the ocean acidification policy challenge, and this Handbook seeks to make some contribution to this process in the hope that governments will rise to this major challenge.

³⁵ See Charles Galdies, Richard Bellerby, and Donata Canu et al., ‘European Policies and Legislation Targeting Ocean Acidification in European Waters: Current State’ (2020) 118 *Marine Policy*, 103947.