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Climate Change at Sea

Interactions, Impacts, and Governance

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Introduction

Climate change is the greatest challenge facing humanity. But the challenge would be far greater where it is not for the role played by oceans and seas. This is because the oceans have restrained global warming. They have absorbed the vast majority of the heat in global warming and are the largest environmental storehouse or "sink" for the most consequential greenhouse gas (GHG) – humanity's carbon dioxide (CO_2) pollution. Without these buffering services provided by the oceans, global warming, and other manifestations of climate change would be vastly worse – for the atmosphere, for terrestrial ecosystems, and for societies. However, in performing these services, ocean ecosystems themselves are being severely undermined. Indeed, some of the most profound effects of climate change will occur beneath oceans, across seas, and along coastlines. These effects are already being manifested in rising ocean temperatures. As ocean waters warm and land ice melts, sea levels are rising and vast areas are being transformed. What is more, as CO_2 pollution is absorbed by the oceans, seawater is becoming more acidic. Marine biodiversity and ecosystems are suffering the effects. These and many other changes create enormous difficulties for communities that depend upon marine and coastal ecosystems for sustenance, economic wellbeing, and ways of life.

The environmental, social, and economic consequences of *oceanic change* – the changes to seas and oceans arising from broader climate change – present tremendous challenges for governments and other actors. Existing national and international institutions for marine governance, which were created when oceanic conditions were relatively stable and humanity's exploitation of the oceans were much less than they are today, may not be adequate for a future characterized by continuous oceanic change. The impacts of climate change on oceans and seas will have political implications at all levels – local, national, international, and global. Responses to oceanic change will result in winners and losers. This will require politically difficult choices. New and innovative policies for governing oceans and seas, and for managing vital marine resources, have never been more important.

The objective of this book is to explore and understand possibilities for *ocean governance amidst climate change*. We conceive of governance broadly as "a social function centered on efforts to steer societies or human groups away from

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collectively undesirable outcomes (e.g., the tragedy of the commons) and toward socially desirable outcomes (e.g., the maintenance of a benign climate system)" (Delmas and Young, 2009: 6). Governance is often performed by governments alone, but increasingly involves other actors ranging from international organizations to nongovernmental organizations (NGOs) and businesses. Sometimes those actors work completely independently of governments (Rosenau and Czempiel, 1992). To introduce the topic of climate change and ocean governance, some of the major connections between climate change and oceans (and seas) are briefly described in this chapter. The chapter then highlights some of the international responses to climate change, especially key agreements for climate governance. Finally the case studies presented in subsequent chapters are introduced and summarized.

Climate Change and Oceans: Interactions and Impacts

Science is central to understanding and responding to climate change. This volume is not about the science of climate change per se, so we leave a detailed examination of that to others (see, e.g., IPCC, 2013). However, each of the chapters that follows is necessarily informed by climate science. Similarly, while this volume is not about the science of oceanic change per se, nearly everything that is examined here is intimately connected to that science (see, e.g., IPCC, 2013: 361–484). Governance of the environment without science is impossible. This is not to say that other factors, such as values, preferences, capabilities, and political bargaining are not central to climate governance; rightly or wrongly, they can be more important than science. But to discount science in the governance process virtually assures that governance will fail. To be sure, there are still persons, including those in high office, who wish to deny the realities of climate science, presumably including what it tells us about the oceans. This denial of reality can have real-world consequences, as manifested in the policy decisions of the Trump Administration in the United States. At the time of this writing in 2018, it is working diligently to undermine American and global efforts to address climate change effectively, and indeed it is working equally diligently to shrink dramatically existing marine protected areas and to open up coastal and offshore areas for fossil fuel extraction (Friedman, 2018). These efforts will undermine, or at least delay, effective governance of climate change generally, and governance of oceanic change particularly. Ironically, such actions will make the actual science of climate change, and what it tells us about the future, all that more important.

Climate Change Science and Ocean Interactions

The science of climate change is not new. The idea that carbon emissions from human activities could warm Earth's atmosphere and lead to unnatural global warming was first hypothesized in the nineteenth century. However, it was only in the 1970s that the problem started to become prominent on an international agenda,

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and it took another decade before governments agreed to create a global organization to study it – the Intergovernmental Panel on Climate Change (IPCC). Since 1990, the IPCC has produced a number of reports examining the science of climate change and describing its causes, environmental impacts, and socioeconomic consequences (see, most recently, IPCC, 2013, 2014). As time has passed, the scientific understanding of climate change has increased markedly, as have the predictions of dire consequences. Indeed, the harmful consequences that were seen as relatively unlikely possibilities a quarter century ago are now viewed as virtual certainties. What is more, climate change has gone from being perceived as mostly a future problem to be avoided, to a problem that is being experienced today. As highlighted in a number of the chapters in this volume, the world is now getting a taste of things to come.

The primary causes and major consequences of climate change will be familiar to most readers of this volume. To recap, in simple terms, climate change involves long-term and large-scale anthropogenic change to Earth's climate system, including global warming – the "Greenhouse Effect" – and follow-on changes to other Earth systems. For our purposes, this includes unnatural changes in Earth's oceanic systems. Global warming and other manifestations of climate change are by-products of global CO_2 emissions produced during humanity's burning of fossil fuels – coal, oil, and natural gas – since the start of the Industrial Revolution more than two centuries ago, as well as emissions of other climate-effecting pollutants, often referred to as "greenhouse gases." These pollutants have a number of effects, among the most prominent for the oceans being ocean warming – a major aspect of *global* warming – and chemical reactions between CO_2 and seawater that lead to ocean acidification. These and other changes in oceans and seas associated with climate change are referred to here as oceanic change.

One cannot understate the importance of the oceans in the wider global *problematique* of climate change. Perhaps the most profound example of this is the role that the oceans play both as sinks for CO_2 pollution and for the global heat that results from that pollution. The oceans have absorbed at least one-third of the CO_2 emitted into the atmosphere since the Industrial Revolution (Khatiwala et al., 2013) and more than 90 percent of the heat resulting from humanity's CO_2 emissions (Wijjfels et al., 2016). However, the capacity of the oceans to absorb CO_2 pollution may decline and their ability to absorb the extra heat of global warming will have its limits. Indeed, it is possible that the oceans may switch from absorbing the heat of global warming to releasing that heat back into the atmosphere. This could happen on timescales that will have very real consequences for humanity (Tollefson, 2016).

In essence, the oceans have been a planetary dump for the much of the negative environmental externalities of global industrialization and modernization. If a stable global climate is what we value, then we owe an enormous debt of gratitude to the oceans. Without their role in mitigating climate change, and global warming in particular, environmental changes would be far greater and more rapid than they have been and will be in the future. However, much as every other environmental sink has its limits, the oceans will not be able to continue to buffer climate change

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forever. The impacts of climate change on the oceans themselves are profound. The consequences for societies will be – are already, in many places – equally profound.

Impacts of Oceanic Change

The effects of climate change at sea are probably as varied as the oceans themselves. Among the biggest effects are ocean warming, sea-level rise, and acidification. These effects have associated direct and indirect impacts that are of consequence to human societies. Ocean warming arises when oceans absorb the heat of global warming. Ocean warming is largely a function of ocean circulation among the sea surface and deep oceans, and among different regions via major currents. Worryingly, the ocean circulation that enables the transfer of heat from the atmosphere into the deep oceans may result in changes to those very circulation systems, with potentially paradoxical consequences, such as substantial cooling of Europe's climate (Struzik, 2017). Among the major consequences of ocean warming are mortality of coral reefs, typified by coral "bleaching" events (see Chapters 17 and 22). In combination with acidification and other environmental stressors such as river runoff containing agricultural pollution, warming seas have resulted in dramatic declines in corals in most areas where they traditionally thrive (Langlais et al., 2017). Just as dramatic are the consequences of ocean warming for the Arctic Ocean (see Chapters 12, 14, and 15). Warming there has resulted in radical reductions in the thickness and total area of ice coverage, with consequential major effects for Arctic marine ecosystems. What is more, reduced ice coverage is opening new areas of the Arctic to exploitation of oil, gas, and minerals, potentially exacerbating climate change still further. Frighteningly, warming in the Arctic could result in the release of seabed methane, substantially contributing to total global GHG emissions and creating a "positive feedback loop" to drive additional global warming (Wadhams, 2016).

A manifestation of oceanic change that is particularly evident to many people is that of sea-level rise (see especially Chapters 5, 8, and 18). As the oceans warm, they expand, resulting in some of the rise in sea levels that has already been experienced and will be much more so in the future. Furthermore, as oceans warm, they contribute to the melting of glaciers on land at the edge of the sea, thereby adding to sea-level rise. Rising seas are also a consequence of the melting of inland and mountain glaciers due to atmospheric warming. Estimates of sea-level rise are on the order of one meter or more by the end of this century, and potentially multiples of that in later centuries, with actual rises depending on location (see, for example, IPCC, 2013: 285–91; DeConto & Pollard, 2016). Roughly one-third of sea level rise is attributed to thermal expansion, with the remainder mostly the consequence of melting of glaciers and ice sheets on land (National Research Council, 2012: 33–53). Rising seas have myriad adverse consequences for coastlines and shallow seas (see the chapters in Part II). They inundate estuaries, which are vital nurseries for many fish and other marine species, and they can rise too quickly for coral reefs to adapt, in turn harming entire reef ecosystems.

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Even if global warming were, by some cosmic intervention, to stop suddenly, the oceans and countless species that live within them would be threatened. That is because ocean acidification – the decrease in the pH of seawater resulting from absorption of CO_2 – is affecting seawater itself: the very chemistry of the oceans is undergoing quite a rapid change. Ocean acidification is contributing to coral bleaching and making survival difficult for other marine species dependent on calcification, such as many species of plankton and shellfish (Tynan, 2016). Ocean waters are changing in other ways as a consequence of climate change. For example, due to glacial runoff and intensified rain, salinity is undergoing significant change, affecting ocean ecosystems and circulation, thereby impacting the distribution of marine life and even weather phenomena (Balaguru et al., 2016; Lange and Marshall, 2017).

Taken together, oceanic change is already resulting in substantial deviations in marine species and habitats from longstanding historical norms. The impacts will be felt by people who live, often precariously, along coastlines, and by those who rely on vital resources from the sea. Rising seas are already major threats to some of the world's poorest countries, most obviously many vulnerable small-island states (see Chapters 8 and 18). Fish species are disappearing from their normal habitats, sometimes being lost altogether or migrating to new areas where regulatory protections are weaker (see the chapters in Part III). Other impacts include loss of inhabited areas along and near coasts, damage to infrastructure and loss of agricultural land to the sea, impacts from more powerful storms, and threats to coastal and high-seas fisheries (see the chapters in Parts II and III). Some island communities and entire nation-states face the existential threat of becoming uninhabitable within decades (Storlazzi, Elias, and Berkowitz, 2015). The chapters that follow explore these impacts in detail, in the process demonstrating the importance of climate change for the oceans and, in turn, the importance of oceanic change – and the importance of effective governance of it – for people and societies.

Climate Governance: Key Objectives and Agreements

Climate change has been on the global policy agenda for the better part of half a century. The climate change regime complex consists of formal international treaties, notably a framework convention and a protocol, associated nonbinding agreements, ongoing conference negotiations, and a variety of implementation mechanisms at regional, national, and local levels. Furthermore, the climate regime is intimately connected to, and arguably not complete without, agreements associated with other issues. For example, one major tool for reducing GHG pollution has been to use the Montreal Protocol on Substances that Deplete the Ozone Layer. The pollutants controlled by that agreement are powerful GHGs, so action in the context of the Montreal Protocol is effectively action on climate change. The climate regime also comprises commonly accepted overarching goals and standards. For example, it is now widely accepted by governments and most major industries that

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climate change demands action. Acceptance does not automatically translate into action, but it helps. This section briefly highlight some of the steps that have been taken internationally to craft the international regime for climate governance (see Harris, 2018, from which this section is adapted, for a more detailed description).

In response to concerns among scientists about the global implications of climate change, the United Nations Framework Convention on Climate Change (UNFCCC) was signed at the 1992 UN Conference on Environment and Development. The objective of the framework convention was the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992: art. 2). The UNFCCC called on the world's developed states to reduce their emissions of GHGs to 1990 levels by 2000. That "soft" objective – there were no real penalties for noncompliance – was not achieved. However, the agreement of the UNFCCC was the start of a decades-long series of negotiations to find ways to formulate international objectives and rules for addressing climate change. The first UNFCCC "Conference of The Parties" (COP) was held in 1995, with COPs soon becoming annual (or nearly so) international meetings of diplomats and others to debate and negotiate implementation of the framework convention.

At the first COP, held in Berlin, diplomats agreed that the principle of "common but differentiated responsibilities" ought to guide responses to climate change. According to this principle, all of the world's states have common responsibility for climate change, but the developed states have more responsibility to do so. At the 1996 second COP, diplomats called for a legally binding protocol to the UNFCCC that would have specific targets and timetables for limiting GHG pollution coming from developed states. Toward that end, the Kyoto Protocol was agreed at the third COP in 1997. The protocol required developed states to reduce their collective GHG emissions by 5.2 percent below 1990 levels by 2012. The Kyoto Protocol was designed to provide flexibility in implementing its objectives. However, much as they failed to do what they promised in the UNFCCC, many developed states did not do what the Kyoto Protocol demanded. One contentious issue among all states was whether the use of carbon sinks, such as planting forests and making other land-use changes to remove GHGs from the atmosphere, should be counted alongside concrete reductions in greenhouse emissions (see Chapter 22). The effectiveness of such an approach is still subject to debate.

Subsequent international climate negotiations have been tortuous. They have resulted in incremental steps toward action on climate change, but in the process they have highlighted recurring differences among states about how best to achieve the fundamental objective of the UNFCCC to "prevent dangerous anthropogenic interference with the climate system." Many states have been unwilling to accept internationally mandated cuts in their GHG pollution. As with most other international collective action problems (not least those associated with governing the oceans), states that are required to take action frequently try to avoid doing so if there are significant financial or political costs involved (see Harris, 2013). At the seventeenth COP in 2011, diplomats affirmed an informal objective of limiting

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global warming to less than 2°C above the pre-industrial norm. At the same time, however, they admitted that twice that much global warming was likely without new national commitments to cut global emissions of GHGs far more aggressively. By the time of the twentieth COP in 2014, the UN Environment Program was making it clear that *urgent* action was necessary to limit GHG emissions, specifically *halving* them almost immediately and eliminating them completely later this century (UNEP, 2014). The "top-down" approach of dealing with climate change, whereby GHG limitations were decided internationally, was not working.

A shift in the approach to climate governance was agreed at the 2015 Paris COP. In the Paris Agreement on climate change, governments accepted that overall climate objectives could be agreed internationally, but that the commitments of each state – how much each country should be required to cut or otherwise limit its GHG emissions – would be determined nationally – by individual states themselves (United Nations, 2016). Perhaps as a consequence, unlike in previous international agreements on climate change, in the Paris Agreement developing states agreed to join developed ones in limiting their GHG emissions. As part of the Paris Agreement, all states accepted the common objective of limiting global warming to less than 2°C, and they acknowledged that it would be preferable to go further and aim for a target of 1.5°C. As part of the agreement, each state pledged to limit its national emissions in some way, although not necessarily to *reduce* them. The idea was that these pledges – formally known as "nationally determined contributions" – would become baselines for more action in the future (see Chapter 16). This approach garnered nearly universal participation. That said, this new "bottom-up" approach has so far resulted in pledges that will *not* achieve the objective of the UNFCCC to prevent "dangerous anthropogenic interference" in Earth's climate. Even if all of the Paris pledges were to be fully implemented, global warming would surpass 3°C (UNEP, 2016).

Because the international climate change agreements have been informed by science, the role of the oceans in governing climate change has been implicit from the start of negotiations. That said, for the most part the oceans have seldom played a major role in international policy making on climate change. After all, getting governments to agree to take climate change seriously, and specifically to actually limit and then cut their use of fossil fuels – to "decarbonize" their economies – is difficult enough. For most of them to also focus on the role of oceans is quite a lot to ask. However, recently this has started to change, as a number of the chapters in this volume point out. The oceans are now increasingly part of the official climate regime and a central feature of related governance initiatives, whether those be about the oceans per se – for example, fisheries agreements (see chapters in Part III) – or about other issues – for example, the UN's Sustainable Development Goals (see Chapters 16 and 19).

Governance of Threatened Seas: Case Studies

Scientific literature on the role of oceans and seas in climate change is now substantial. In contrast, the body of literature looking at the *governance* of oceanic change

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is relatively small. Through the chapters that follow, this volume aims to help address this shortfall in the literature. It brings together research findings from political science and cognate disciplines to examine the political and policy dimensions of climate change for the oceans. Collectively, the chapters give a snapshot of the current state of knowledge and portray a cross-section of research and analyses being conducted in this nascent and vital area of climate-related scholarship. All of the chapters make explicit connections between climate change, oceans (or seas), and questions of governance, particularly politics, policy formulation, and policy implementation at all levels, from the global to the local. Taken together, the chapters in this volume provide a comprehensive look at the state of climate change and ocean governance in its relative infancy.

Before the case studies begin, Part I of this volume continues with a chapter by Elizabeth Mendenhall. In Chapter 2, Mendenhall constructs some scaffolding that is useful for understanding subsequent chapters. She does this by surveying the most important international conventions and institutions for ocean governance. Mendenhall notes that the basic principles of ocean governance have evolved over many centuries. By the middle of the last century, increasing exploitation of the oceans had prompted unilateral claims by coastal states for control of resources well offshore. This increased the need for more effective rules for ocean governance. Toward that end, under the auspices of the United Nations, starting in the 1970s, the international community negotiated a framework for ocean governance: the UN Convention on the Law of the Sea (UNCLOS). The convention simultaneously nationalized, regionalized, and internationalized ocean governance (see the chapters in Part V). National zones of ownership and jurisdiction, and particularly exclusive economic zones, gave coastal states rights to the fish and other resources that could be found in a large proportion of the oceans (see Chapter 18). The Law of the Sea convention created new instruments for the resolution of maritime disputes, particularly those related to delimitation of national jurisdictions. The convention also contained several provisions to facilitate international cooperation, with one result being the emergence of regional bodies to manage fisheries and pollution (see the chapters in Part III). The UNCLOS reaffirmed the status of the high seas as a global commons area and designated the deep seabed as "common heritage" of humanity. As examined in subsequent chapters, especially those in Part V, while UNCLOS has established institutional mechanisms for governing the oceans in many ways, not all of these mechanisms have been successful. It is therefore of great importance to ask whether and how the current oceans regime can be deployed to govern the world's oceans as they grow warmer, higher, and more acidic (see, especially, Chapter 20).

Vulnerable Islands and Coasts

Our analyses begin with several chapters on the vulnerabilities of islands and coasts. The first case study, by Lisa Benjamin and Adelle Thomas, examines climate-related challenges for island states of the Caribbean. Small island developing states (SIDS)

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are among the areas most vulnerable to the impacts of climate change (see also Chapters 3, 6, 7, and 18). Rising sea levels, ocean acidification, coastal erosion, and loss of coral reefs are all highly likely to have significant ecological, economic, and societal impacts in SIDS. Climate change may ultimately threaten the territorial existence of some of them. In the Caribbean, coastlines and beaches are vital economic resources for national economies due to their close association with tourism. Coastal tourism contributes disproportionately to the economic development of countries in this region, often providing jobs for a high percentage of the working population. But the coasts of the Caribbean are particularly vulnerable to climate change. Reducing vulnerability through adaptation actions, such as through setting back coastal property development, would make some of the most valuable real estate unavailable to local economies. Benjamin and Thomas argue that such actions will restrict already-limited development options and thereby undermine economic development in Caribbean countries. Their chapter focuses especially on the contributions that coastlines make to the economies of Commonwealth Caribbean states and the detrimental impacts that sea-level rise may have on their political economy. An examination of the laws and policies on coastal development in The Bahamas is a case in point. Difficult political choices between economic survival and climate change adaptation will arise. The Bahamas case shows that policymakers in the Caribbean are often reluctant to implement adaptation measures that severely hamper options for near-term economic development along coastlines. This could have significant implications for long-term governance of climate change in the region, with governance implications for vulnerable SIDS in other parts of the world.

In Chapter 4, Mohammad Al-Saidi describes the many challenges that climate change presents to countries of the Persian/Arabian Gulf. Using the case of Qatar, Al-Saidi highlights the implications and policy responses among countries of the Gulf Cooperation Council (GCC). Not surprisingly, climate change will have significant impacts along the shorelines of GCC member states. Vital infrastructure, such as refineries, power plants, agricultural schemes, and desalination systems, will be negatively affected. Reduced rainfall, greater seasonal temperature variability, sea-level rise, and loss of agricultural production are some expected consequences of climate change in area, as are increased migration pressures. Vulnerable marine ecosystems of the Gulf are vital for food security, recreation, and cultural identity. Al-Saidi's chapter analyses climate-related challenges for developmental initiatives, coastal areas, and marine ecosystems. He identifies marine ecosystem vulnerabilities in the region and explores key drivers of that vulnerability, including coastal development ratios; dependency on vital services, such as those for water, energy, and food supplies; and the sensitivity of the ecosystems to climate change and their ability to recover from external shocks. Al-Saidi maps out the official stakeholders and marine policies related to climate change, identifies policy choices related to mitigation and adaptation, and highlights future policy-related risks. Using the case of coastal development and maritime policies of Qatar, his chapter presents examples from specific coastal industries in energy, desalination, real estate, and tourism.

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His chapter identifies some of the internal societal pressures and external factors that influence policy, notes complexities arising from rivalries among states and the demand for economic development, and explores the potential for cooperation and joint action on coastal development amidst climate change.

Vulnerable islands and coasts must bear the brunt of some of the harshest impacts of climate change. More storms – or more intense storms – are bad enough, but when combined with other consequences of climate change, such as sea-level rise, the impacts on these areas can be devastating. Sometimes the impacts are acute, as when storms hit degraded shorelines; at other times they are chronic, as when shorelines erode, even in the best of times. This juxtaposition of acute and chronic impacts is highlighted in Chapter 5, by Arne Harms, which focuses on South Asia. As Harms makes abundantly clear, climate change will result in shifting weather patterns, groundwater depletion, and coastal erosion in South Asia. Along many of the region's low-lying and heavily populated shorelines, these impacts will add to an already long list of threats. The region's coastal populations have demonstrated a high degree of adaptation to recurring, but relatively infrequent, storms, and surges. However, they are facing greater difficulties in coping with normalized, climate change-related degradations. This is particularly the case with amplified coastal erosion due to sea-level rise, which has already displaced entire communities. This type of challenge is mirrored in humanitarian institutions, which are reasonably well-equipped to deal with traditional disasters, but not well-prepared to provide adequate assistance in situations of normalized degradation that are increasingly the consequence of climate change. Based on long-term fieldwork in coastal India, Harms argues that relatively effective measures taken by governments to safeguard populations from cyclones and storm surges have not been effective in accounting for chronic tidal incursions and coastal erosion. To explain this failure, Harms highlights the relative novelty of the massive scale of climate-caused coastal incursions and erosion. He looks at the framing of what counts as a disaster, and therefore, what mobilizes funds, technology, and labor toward needy populations. Harms' chapter shows that, because coastal degradation is becoming normalized, small-scale and only rarely deadly, it is not a priority for governmental and nongovernmental humanitarian institutions. To counter coastal erosion effectively would require considerably more funding, and indeed more political will. However, because development priorities across much of South Asia are not focused on rural coasts, neither adequate funds nor sufficient political will seem to be available.

In Chapter 6, Noralene Uy and Joe-Mar Perez also look at the implications of acute-but-recurring coastal impacts of climate change, specifically those associated with severe storms along coastal areas of the Philippines. The Philippines are composed of many islands, and thus, have long coastlines that are at risk to many ocean-related threats. Among the greatest acute threats are typhoons, which invariably strike the country several times each year due to its geographic location in the western Pacific, not far from where the majority of typhoons form over warm ocean waters. Increases in the frequency and severity of destructive typhoons, likely

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associated with climate change, have exacerbated other vulnerabilities of coastal areas in the Philippines. Uy and Perez's chapter examines many of the policy and institutional ramifications of strong typhoons. They review the institutional landscape on disaster risk reduction and management in the Philippines, as well as some of the country's policies for adaptation to climate change. They draw on the experience of Typhoon Haiyan, which struck the country in late 2013. They look at how plans for disaster risk reduction and management are translated (or not) from the level of the national government down to local governance in coastal areas. As they show, despite anticipating growing dangers from the sea that climate change is bringing, having plans in place does not guarantee effective responses when those dangers become real. The experience of the Philippines in preparing for the "new normal" of typhoons made worse by climate change highlights the need for careful adaptation governance in coastal areas. Uy and Perez's chapter describes some of the things that countries with vulnerable coastlines can learn from the case of the Philippines' response to typhoons. International governmental and NGOs concerned with humanitarian assistance can likewise draw lessons for delivering more effective support to coastal communities in developing countries.

Possibly no developing country is more vulnerable to the coastal impacts of climate change than is Indonesia. In Chapter 7, Achmad Poernomo and Anastasia Kuswardani describe Indonesia's vulnerabilities and related policy institutions and responses. As they point out, due to its geography, Indonesia is extremely reliant on ocean and coastal ecosystems. Threats from climate change faced by Indonesia include coastal erosion, coastal ecosystem degradation, sinking islands and cities, coral bleaching, potential loss of homes for coastal inhabitants, and loss of income from marine resources. Indonesia holds a significant share of the world's sea grass meadows and mangrove forests. These ecosystems are important for the mitigation of climate change due to their roles as natural sinks for atmospheric carbon (see also Chapter 22). Although many policies on climate change have been promulgated in Indonesia since the 1990s, those addressing ocean and coastal areas are surprisingly limited given the archipelagic nature of the country. What is more, there are quite extensive problems of related policy coordination between national and local governments, among ministries and agencies, and between presidential administrations. Poernomo and Kuswardani's chapter reviews the approaches of the Indonesian government to mitigate and adapt to the coastal and oceanic impacts. They give some suggestions for how policy might be improved in the future. Especially when combined with other chapters in Part II of this volume, their observations help us to better understand the challenges and opportunities for responding to climate change on vulnerable islands and coasts in other regions.

Our focus on vulnerable coasts and islands concludes with an analysis of narratives about rising sea levels among small island developing states. In Chapter 8, Ian McGregor and Hilary Yerbury look at such narratives at local, national, and international levels. The politics of climate change and rising tides include processes in which international NGOs, such as the Pacific Calling Partnership and the

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Climate Action Network, collaborate with local NGOs. The most urgent climate-related concerns of local NGOs involve adaptation, vulnerability, and resilience. The politics of vulnerability is particularly clear in narratives around climate mitigation, especially when the intended audiences are foreign governments and citizens. Greenhouse gas emissions of SIDS are minimal, so the message coming from their governments and local NGOs is that developed countries should implement large and urgent emissions reductions to lessen sea-level rise and other adverse changes to oceans. Within the politics of resilience, however, the key audiences are primarily the populations of the island states themselves. These populations face a number of existential questions, such as whether they will be able to adapt to rising sea levels and increasing storm surges. In this respect, questions are about adaptation strategies that SIDS might implement to sustain their societies, and whether they can access the financial, technical, and other resources necessary to implement these strategies. Many local NGOs aim to educate climate change activists, supporters, and the global public about the risks faced by SIDS. McGregor and Yerbury's chapter shows how small-scale local actions to increase resilience, some of which are supported through NGOs, can present a perspective on climate change governance that contrasts with the dominant messages about vulnerability in international ocean politics.

Marine Fisheries and Pelagic Seas

Climate change will have direct and enormous impacts on fish in the sea. Rising ocean temperatures and increasing acidification of ocean waters are profoundly impacting the populations and ranges of commercially valuable fish species. These repercussions of climate change are creating both winners and losers in the short-term, but in the long-term the consequences are dire for the fishing industry as a whole. In Part III, we turn our attention to the difficult question of how to respond to these impacts, and specifically how to govern fisheries and protect their viability into the future. We begin in Chapter 9 by looking at what fishers themselves – especially small-scale fishers – say about climate change and official policies to manage impacted fisheries. In Chapter 9, Andrew Tirrell recounts what he learned by talking to fishers in the United States, New Zealand, and Norway. Tirrell considers the impacts of climate change in the context of the national fisheries management systems of these countries. He explores fishers' perceptions of the consequences of changing oceans for their industries. For each country case, Tirrell looks at the current political structures of fisheries management and considers how governance responses to climate change challenge local fishing economies. He shows that general levels of trust in government are closely related to whether, and how much, fishers trust their governments' efforts to respond to the fisheries-related consequences of climate change. Where historical trust in fisheries science and policies is relatively high, there is relatively high trust in related policies associated with climate change. Where that trust is low, fishers are highly skeptical of fisheries policies aimed at

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responding to climate change impacts at sea. Tirrell's chapter suggests some context-specific recommendations that have implications in other national or regional fisheries affected by climate change.

How might fisheries policies actually help fishers adapt to climate change? This question receives multiple answers from Wendy E. Morrison and Valerie Termini in Chapter 10. As Morrison and Termini point out, climate change will affect marine fisheries by altering ecosystem functions, fish abundance and productivity, distributions of fish populations, fish phenology, interactions of fisheries with nontarget species, bycatch rates and levels, and habitat use and availability. How should fisheries managers prepare for and respond to these changes? Morrison and Termini present a range of options currently being discussed in the scientific literature. In general, management approaches can be either proactive, thereby planning for future climate change at sea, or they can be reactive and respond to change after it has occurred. Proactive management alternatives can be implemented to increase resilience of fish stocks, species, and ecosystems, as well as local communities and businesses. Given the large uncertainties surrounding the effects of climate change, two potential governance approaches involve efforts to reduce uncertainty through research, and to devise management options that will be robust despite uncertainty. Morrison and Termini argue that policies seeking to increase management flexibility and provide incentives to the fishing industry to attempt new approaches, while simultaneously preserving genetic diversity of fished populations, should prove to be beneficial. Ideally, the advantages, disadvantages, and trade-offs associated with various management options should be evaluated to determine the best approach, or mix of approaches, given an understanding of likely environmental changes in the future. New approaches will have to emerge as fisheries management across the globe grapples with climate change.

Growing awareness about the effects of ocean warming and acidification has resulted in governments and environmental groups pursuing increasingly large marine protected areas (MPAs). These areas are the subject of Chapter 11, by Justin Alger. As Alger points out, eighteen of the world's nineteen largest MPAs have been established since 2006. Each of these areas exceeds 200,000 square kilometers. This increase in the scale of protected ocean spaces has mostly occurred in very remote regions. The diffuse risks of climate change are as salient in these regions as they are in coastal areas, but the remoteness of these risks makes them much less visible. Scientific studies have shown that large no-take MPAs increase the resilience of marine ecosystems to ocean warming and acidification. Consequently, creating MPAs in remote locations is a policy option for governments that are looking for ways to increase the resilience of their own seas and the living resources within them. However, protections for these remote areas has led to a disconnect between the greatest threat in them, namely climate change, and the targets of the regulations imposed on them, which is typically the fishing industry. Domestic fishing industries have tended to strongly resist the creation of MPAs. According to Alger, these industries perceive themselves to be under siege as governments prohibit fishing in

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remote areas that industry claims are already being sustainably managed. Drawing upon his own fieldwork and interviews with scores of stakeholders across five large MPAs, Alger argues that the opposition of fishing industries is disproportionate to the impact that MPAs have on their industries. The source of this disproportionality is a change in marine conservation priorities. Governments target MPAs, despite fishing industry opposition, because doing so represents a path of least resistance to addressing some of the impacts of climate change on the oceans.

As climate change brings on warming seas, marine species will migrate into new areas. This presents challenges to existing institutions for the governance of fisheries. A case in point is the unique fisheries management area around the Arctic Ocean archipelago of Svalbard, the subject of Chapter 12. In this chapter, Rachel Tiller and Dorothy Dankel ask whether the Svalbard Fisheries Protection Zone will be able to cope with the perturbations that arise when new species move into the zone due to oceanic change. Projections suggest that a warming climate will increase overall marine species richness and abundance in the Arctic, resulting in increased catch potential around Svalbard, while also pushing fishers out of customary fishing grounds farther to the south. Tiller and Dankel describe the Svalbard Fisheries Protection Zone around the archipelago as a "contested management area." It has been managed by Norway for nearly a century. Other states have acquiesced to this management in practice because Norway has recognized their historical access to fishing grounds. However, as new species arrive, history may no longer be a reliable guide for determining which states should have full access to the zone's marine resources. Chapter 12 explores the implications that climate change may have for this fisheries' zone specifically, and on cooperation in the changing Arctic Ocean more generally (on the Arctic, see also Chapters 14 and 15.) To do this, Tiller and Dankel draw on the experiences of other international environmental regimes. They conclude that the adaptation of other regimes to environmental perturbations may not come as easily in the Svalbard case. As new species of fish move northward due to ocean warming, conflict over them is likely to increase.

Changing Polar Seas

In Part IV, our focus turns from the governance of fisheries amidst climate change to governance of the polar oceans, which both influence global climate and are being profoundly affected by it. In Chapter 13, Marcus Haward describes what he calls the "regime complex" for governing seas surrounding Antarctica. Haward highlights the significance of the Southern Ocean for Earth's climate system generally, and global ocean circulation (currents) more specifically. He notes some of the challenges that climate change presents for this ocean region, including biophysical change and shifts in the ranges of marine species. Haward's chapter outlines the key institutions for governance of the Southern Ocean under the Antarctic Treaty System, particularly the Convention on the Conservation of Antarctic Marine Living Resources and its decision-making body, the Commission for the

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Conservation of Antarctic Marine Living Resources. He looks at instruments relevant to addressing the impacts of climate change, and which of them are contributing to an evolving Southern Ocean regime complex. Haward reveals how climate change heightens the salience of ongoing research into the resilience of Antarctic regimes. In particular, he shows that there is growing cooperation between institutions created decades ago to manage the Southern Ocean and institutions that have been created to address climate change in particular. The regime complex for the Antarctic region is starting to overlap and interact with the regime complex for climate change.

In Chapter 14, we shift our attention from the polar seas of the South to those of the North. In this chapter, Benjamin Hofmann analyses international regulatory responses to growing environmental threats from increasing maritime industrial activities in a warming Arctic Ocean. Climate change accelerates the melting of Arctic Ocean sea ice, thereby making the area much more accessible to shipping and facilities for offshore oil and gas production. These industrial activities can have negative external effects on this ecologically vulnerable region. Hofmann investigates how states have responded to such threats, assessing and comparing the stringency of international environmental regulation of maritime industries in the Arctic. Stringency is a product of a regulation's formal "tightness" and its "ambition." "Tightness" refers to legality, precision, monitoring, and enforcement. "Ambition" includes changes in the scope and level of requirements imposed by regulations, as measured temporally and globally. Hofmann's chapter introduces a stringency database that encompasses regulations that partly or wholly covered the Arctic from 1950 to 2016. His chapter compares regulatory stringency across the shipping, oil, and gas industries; across regulators, such as the International Maritime Organization (IMO) and the Arctic Council; and across external effects and time periods. Hofmann shows that Arctic warming has been accompanied by increased regulatory activity to address the environmental impacts of maritime industries. However, the stringency of these regulations is found to vary considerably across regulatory bodies. Hofmann's findings can be used by policymakers to identify regulatory gaps and to create blueprints for more stringent regulations in a warming and threatened Arctic Ocean. His findings have important implications for governance in other ocean regions.

The profound environmental changes that are underway in the Arctic Ocean are manifested most dramatically by the melting of sea ice. In Chapter 15, Thomas Brewer reaffirms what is evident from the preceding chapter: the extent and speed of sea ice melt in the Arctic Ocean will soon result in increasing international maritime shipping across the region. With this increased presence of shipping in the Arctic will come an increase in the emissions of "black carbon," which is a highly potent climate change pollutant. Reports of the Arctic Council have focused attention on the problem of black carbon deposition in the region, but they have also noted that black carbon reaches the Arctic from other regions. Black carbon pollution also comes from aircraft flying over or near the Arctic. Existing institutions for Arctic

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governance are not able to impose regulatory measures to address this pollution. The IMO (see Chapter 2) has taken an interest in the problem of black carbon emissions from the diesel engines that power nearly all vessels, but it has yet to take action to address black carbon pollution. Similarly, in the case of aircraft, the International Civil Aviation Organization has not given the problem of black carbon any sustained attention, nor has it included black carbon in its plan for a carbon emissions offset program. Bearing in mind these weaknesses of existing forms of governance, in his chapter Brewer proposes that an Arctic Black Carbon Agreement be negotiated as a starting point for the development of a new regulatory framework. Such an approach, he predicts, could begin the process of more effectively responding to the impacts of black carbon pollution on the Arctic Ocean.

Institutions and Law for Ocean Governance

Building on analyses in earlier chapters, in Part V we focus on institutions and law for ocean governance amidst climate change. We begin in Chapter 16 with an analysis of "contested multilateralism" by Reuben Makomere and Kennedy Liti Mbeva. Makomere and Mbeva explore the process of "alignment" between the international regime for climate governance, exemplified in the UNFCCC and related international agreements, and the international regime for ocean governance, specifically the agreements and practices associated with the United Nations Convention on the Law of the Sea (see Chapter 2). Makomere and Mbeva argue that contemporary regimes for ocean and climate governance have not kept up with the growing complexity of changes underway in Earth's climate and ocean systems. This is not particularly surprising to students of international relations; it is emblematic of the broader challenge of gridlock and complex interdependence in other areas of global governance, including those related to the global environment. That said, Makomere and Mbeva see evidence of modest changes with respect to climate change and ocean governance. Their chapter examines pathways of alignment between the ocean and climate governance regimes. It analyses linkage politics as a catalyst for more coordinated climate-and-oceans governance, in the process examining how and why states have used mechanisms, such as the Paris Agreement's nationally determined contributions and the United Nations' Sustainable Development Goals, to push for greater alignment between the regimes for oceans and climate. Chapter 16 shows that coalitions of poor and small island states have worked together to highlight and promote key ocean-related issues. They have leveraged provisions of the climate regime in an effort to make the ocean regime more attuned to their needs.

In Chapter 17, Pedro Fidelman looks in detail at institutions for ocean governance amidst climate change, specifically an initiative that has the potential to enhance adaptive capacity. Fidelman identifies the role of power relationships among states in shaping institutions for climate change and ocean governance. The subject of his analysis is the Coral Triangle, a region of extraordinary ecological

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diversity encompassing seas around Malaysia, the Philippines, Indonesia, Timor Leste, Papua New Guinea, and the Solomon Islands. More than 120 million people in the region depend directly on coastal and marine resources for income, livelihood, and food security. As part of their efforts to address degradation of coastal and marine environments threated by climate change, and to use ocean natural resources more sustainably, governments of the region negotiated the Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI). The CTI is an example of a large-scale intervention to implement ecosystem-based management in the changing marine environment (see Chapter 11 for other examples). Governance institutions associated with those types of interventions can both facilitate and constrain the capacity of actors to adapt to climate change. Drawing upon empirical research, Fidelman examines how the CTI may enable such adaptive capacity. His chapter assesses the CTI in terms of its ability to encourage the involvement of a variety of actors, perspectives, and solutions; to enable actors to learn and improve governance institutions; to motivate stakeholders to self-organize, design, and reform their institutions; to mobilize leadership and resources for decision-making and implementation; and to support principles of fair governance. Fidelman concludes that the CTI has fostered collaboration among some stakeholders. However, broadening network relations and achieving effective collaboration remain a challenge. As the ocean impacts of climate change increase, it is increasingly important to cope with the relative power of the states (and other actors) involved in formulating and implementing institutional governance.

Shifting from international agreements and organizations for ocean governance amidst climate change, in Chapters 18–20 the focus turns to the institution of international law (see Chapter 2). In Chapter 18, Ori Sharon examines the vexing question of the future rights of small island states if – or, more likely, when – their territories encounter the existential threat of sea-level rise. Faced with the unthinkable reality of losing their territory and sovereignty to rising seas, governments of SIDS have been working to secure alternative territories for the resettlement of their populations. However, as developing states with marine-oriented economies, these countries have little to offer in exchange for territory. According to conventional interpretations, SIDS' most valuable national asset – sovereignty over resource-rich marine exclusive economic zones (EEZs) – will vanish, or at least be reduced, if these countries' territories are submerged. Territory is currently a prerequisite for enjoying the full rights of statehood, and it is also a prerequisite for an EEZ. However, Sharon questions this assumption. He argues that a disappearing EEZ does not necessarily entail the loss of associated rights. To identify whether a right is extinguished, one must first answer a series of questions pertaining to the nature of the right, the character of the right holder, the relationship that established the right, and the circumstances that might lead to the disappearance of that right. Sharon applies three ethical and political frameworks to address such questions: a rights-based approach that focuses on the origins of the basic human right to subsistence; a communitarian property theory of national resources; and a contractarian theory of

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international treaties. He shows how it may be possible to avoid the unjust outcome that a pre-climate change interpretation of territorial seas might otherwise prescribe. A key to such an outcome will be the equitable treatment of the peoples most affected.

The significance of equity is apparent again in Chapter 19, by Freedom-Kai Phillips and Konstantia Koutouki. Phillips and Koutouki argue that a number of apparently unrelated international treaties for governing water resources are highly germane to the governance of climate change. Their chapter introduces various measures under these treaties for managing and conserving international watercourses. It identifies potential synergies for adaptation to, and mitigation of, climate change. After highlighting significant legal provisions of climate change agreements, Phillips and Koutouki outline international legal norms relating to marine governance. Particular attention is given to related measures established under the Convention on the Law of the Non-Navigational Uses of International Watercourses (the New York Convention), the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (the Helsinki Convention), the Convention on Wetlands of International Importance, especially as Waterfowl Habitat (the Ramsar Convention), and the Convention on Biological Diversity. Phillips and Koutouki point to mutually supportive mechanisms at the nexus of marine ecosystem governance and climate governance, including the interconnection of obligations under international law, the evolving application of the due diligence standard, and the broad intersections of the UN's Sustainable Development Goals. Use of "source-to-sea" governance, positive incentives for conservation and sustainability, equitable use of traditional knowledge, and effective governance of areas beyond national jurisdiction, are identified as a means by which marine ecosystem governance can be strengthened, in the process supporting climate change adaptation and mitigation. Phillips and Koutouki show that effective governance of marine ecosystems can help the world respond to the growing pressures of climate change.

The final chapter in Part V, Chapter 20, asks whether the legal framework of the UN Convention on the Law of the Sea (see Chapter 2) is sufficient to address the biological, chemical, and geographic impacts of climate change. To answer this question, Anastasia Telesetsky reviews UNCLOS obligations that are impacted by climate change. She starts by arguing that human-generated atmospheric GHGs are, in the lexicon of UNCLOS, "pollution of the marine environment." As such, GHG emissions violate UNCLOS-derived obligations of states to prevent, reduce, and control ocean pollution. Telesetsky then looks at fisheries management under UNCLOS and the need for that management to adapt to existing and anticipated changes in fishery migrations and habitat losses (see also chapters in Part III). Finally, Telesetsky's chapter examines UNCLOS precedents on establishing basepoints for measuring maritime jurisdictions. It evaluates the evidence for the formation of customary international law regarding the fixing of basepoints (see also Chapter 18). With these UNCLOS-derived obligations as the context, Telesetsky reflects on whether the right of coastal states to exploit fossil fuels on their continental shelves (see Chapter 24), which is a core part of the UNCLOS regime, will

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undermine efforts to mitigate ocean pollution, adapt fisheries management plans, and fix basepoints for states vulnerable to sea level rise. A question is whether the traditional provisions of UNCLOS – and indeed provisions of other extant regimes for governing seas and oceans – will be effective foundations for ocean governance amidst climate change.

Policies for Ocean Governance

In Part VI, we look in greater detail at particular areas of policymaking and policy implementation. This begins with an exploration in Chapter 21 of the links between the science, policy, and justice of plastic pollution of the oceans. Plastic pollution in the oceans is now an enormous problem. Perhaps surprisingly, this phenomenon has potentially important implications for climate governance. In Chapter 21, Peter Stoett and Joanna Vince ask whether there is a "plastic-climate nexus" that might assist us in better understanding the means for realizing ocean governance amidst climate change. The advent of massive amounts of plastic pollution in the oceans will both exacerbate climate change-related impacts at sea and further complicate political and policy responses to climate change. There is mounting concern that the density of marine plastic waste and associated toxicity will permanently damage the marine food web and reduce the ability of the oceans to absorb CO_2. Plastic debris can be a transport vector for pathogenic microbes and invasive species, thereby exacerbating climate-induced threats to marine life. From a wider governance perspective, the political similarity between the climate-related oceanic change and micro-plastic pollution may be very significant. Both of these environmental problems are, to a large extent, a consequence of the fossil-fuel industry, and in both cases small island states and other relatively disadvantaged coastal communities tend to suffer the most from them (see the chapters in Part II). Both problems will need significant industrial collaboration and normative development if solutions to them are to be found. Stoett and Vince reveal what those interested in ocean-and-climate change governance can learn from the micro-plastics issue. In particular, they show how the experience with plastic offers lessons for more effective and environmentally just ocean governance in the future.

In Chapter 22, we turn to questions of how biological systems can be protected for the benefit of both climate and oceans. Kamleshan Pillay, Yanasivan Kisten, Albertus Smit, and David Glassom explore whether lessons learned from efforts to protect global forests as carbon sinks can be applied to future efforts to protect coral reefs. As they point out, there is a growing need for innovative and well-structured climate policies that can contribute to mitigation of GHG pollution. Forest protection is already considered to be a vital policy for carbon sequestration in particular. Other biological systems have the potential to assist in these efforts. Coral reefs, which Pillay *et al.* refer to as the "forests of the sea," possess the highest biodiversity per unit area of any biome. Consequently, reefs hold the substantial potential to sequester carbon. Pillay *et al.* argue in favor of coral reefs being considered

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collectively as a "payment for ecosystem scheme" as part of efforts to realize the objectives of the Paris Agreement on climate change. Using forest-protection schemes as their reference point, they describe important attributes of a future coral reef protection mechanism (CRPM). Key to such a mechanism will be finance. Pillay *et al.* argue that developing a market-based mechanism might allow for a CRPM to generate finance that would make the mechanism more robust. Importantly, a successful CRPM would provide "co-benefits" to local communities, for example in the form of additional marine resources and jobs. Such benefits would encourage greater participation and "buy in," a lesson that arguably ought to be applied to other mechanisms for ocean governance in a future characterized by climate change.

Ships and shipping are synonymous with the oceans. But ships and shipping contribute to pollution, including pollution-causing climate change. In Chapter 23, Judith van Leeuwen points out that commercial shipping runs on highly polluting heavy fuel oil. In addition to contributing to climate change through CO_2 emissions, shipping emits sulfur, nitrogen oxide, particulates, and black carbon (the latter examined in Chapter 15). While most of these marine pollutants are regulated by international convention, CO_2 emissions from shipping have not been included in international climate change agreements. Instead, the IMO has in recent years developed related regulations for ships (see also Chapter 2). It has considered measures to make ships less polluting, for example by levying fees on fuel oil, using emissions cap-and-trade markets, and disseminating requirements for energy efficiency. In her chapter, van Leeuwen gives an overview of the way in which the climate change impact of shipping is regulated and reflects on the major bottlenecks that exist in moving forward internationally in this policy domain. She argues that there is a conflict of interest between developing maritime nations and European countries. There are few incentives worldwide for technical innovation to support a switch to more sustainable forms of energy in shipping. What is more, pressure from society is quite limited when it comes to shipping's climate change impact. To overcome these obstacles, new forms of governance are probably needed. These might include the use of market- or information-based measures that more effectively target ships' GHG emissions. Van Leeuwen shows how such new forms of governance might compensate for IMO's regulatory gaps, thereby helping to move toward decarbonizing a mode of transport that is vital to the global economy.

In Chapter 24, Christina Reichert and John Virdin look at technologies and related policies for extracting renewal energy from the oceans. They consider some of the implications of climate change for ocean-derived sources of energy. The offshore oil-and-gas sector has traditionally been virtually the only source of ocean energy for those living on land. Fossil fuels from the seabed remain very significant even as new sources of energy are developed. However, with growing emphasis on decarbonizing the world economy, as well as recognition of the adverse environmental effects of pollution from offshore oil and gas drilling, there is growing demand for a generation of renewable energy. The historical focus on offshore oil and gas extraction has shifted. Far more attention is being given to the development of technologies for

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extracting renewable energy from the sea, the worldwide potential of which is enormous. This potential has already resulted in the development of a number of prototype technologies, many of which are introduced in this chapter. However, as Reichert and Virdin point out, significant challenges to widespread commercialization of these technologies exist. These challenges include high investment costs, operational costs that sometimes compare unfavorably to traditional energy sources, and public opposition. Consequently, government assistance, for example in the form of support for research and development and guaranteed feed-in tariffs, will likely be needed if renewable ocean energy sources are to be fully exploited. Reichert and Virdin make a case for innovative governance that can overcoming some of the barriers to more widespread commercialization of renewable energy from the oceans.

While commercial ships are nearly always invisible to most of the world, being out of sight and seldom in the news, the same cannot be said of naval ships. Indeed, navies of the world will increasingly find themselves involved in operations that are affected by, or instigated by, the impacts of climate change. In Chapter 25, Kapil Narula tells us how navies are bracing for these impacts. He analyses the changing role of navies in response to the uncertainties that arise due to climate change. As Narula shows, as seen through the lens of national security, climate change will have both direct and indirect consequences for naval readiness. He examines these consequences and reveals how they have grown in salience within governments of many maritime countries. New threats from climate change range from damage to critical infrastructure, which could undermine operational capabilities of navies, to the reduced ability of navies to provide civilian aid during climate change-induced disasters. This contrasts with the likelihood – arguably the certainty – that climate change will increase the need for navies to undertake international humanitarian missions and provide disaster relief. This is expected to change the way in which ships are utilized and how military personnel are trained. In the long run, climate change could also lead to changing military strategies and force structures. One example of such a shift is the decrease in sea ice in the Arctic (see Chapters 14 and 15), which has already led the navies of China, the United States, and other countries to adopt new Arctic strategies. Using case studies from different countries, Narula proposes several policy responses to the impacts of climate change on navies. He argues that the world's navies can better brace themselves for climate change by taking timely action.

Increasingly, it will be the work of navies to respond to climate change at sea. But what might be done at sea to mitigate climate change proactively? One answer – an answer that some would say is radical – might be to "geoengineer" the oceans to bolster their ability to absorb the carbon pollution that is causing climate change. In Chapter 26, John T. Oliver and Steven M. Tucker describe one potential means for doing this: "fertilization" of large areas of the oceans. They propose that this could be done in areas where biological productivity is currently limited by consistently low nutrient levels. If the promise of ocean fertilization could be safely and efficiently realized, Oliver and Tucker argue, it might remove billions of tons of excess CO_2 from the atmosphere and from ocean waters. At the same time, they observe, it

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might increase the amount of biomass available to the marine food chain, ultimately reducing ocean acidification and increasing the amount of fish that are available for exploitation by humans. As Oliver and Tucker acknowledge, while any geoengineering proposal would have to be approached with extreme caution, it may be important to thoughtfully consider ocean fertilization as one of the responses to climate change. So far, discussion of ocean fertilization has been restrained, but Oliver and Tucker believe that policymakers and research scientists should do more to determine whether it is an environmentally safe and cost-effective policy response to climate change. Assuming that long-term safety and efficacy of this type of geoengineering can be clearly established, it might then be time to lay the groundwork for implementing the concept. If Oliver and Tucker are right, ocean governance amidst climate change may involve super-human attempts to bolster the role that the oceans have played already: to absorb human-generated pollution and heat.

Conclusion

The chapters that follow portray many of the problems of, and prospects for, climate change and ocean governance. One cannot overstate the importance of the oceans for climate change. Without the oceans, climate change would be far worse. Effective governance of the oceans may help the global community to both mitigate climate change and adapt to it. It is vital that the oceans become an integral part of the wider climate change regime, ranging from international agreements and principles to local policies and actions. In the real world, climate change and oceanic change are inseperable; they will have to be similarly inseperable in climate governance.

The case studies in this volume highlight the challenges, explore the policy responses, and provide suggestions for how to govern the oceans in what will be a very challenging future. To be sure, no single volume – nor dozens of them – can capture the full range of issues that are, and should be, considered in efforts to formulate and implement policies for effective governance of oceanic change. Nevertheless, the chapters that follow offer valuable information and insights that will have to be part of those efforts. They point to many lessons for the future. It is to those lessons that the final chapter turns. Therein, some of the common themes and conclusions of the preceding chapters are distilled. Some actual and potential strengths and weaknesses of ocean governance in the context of climate change are pinpointed. Likely and alternative future directions for ocean governance as the impacts of climate change inevitably become more pronounced are also discussed.

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