1

Introduction: Climate Change and Resilient Fisheries Management

Olav Schram Stokke, Andreas Østhagen, Andreas Raspotnik and Jan Erik Stiansen

The world's oceans are already feeling the impacts of global warming. How may this affect the international management of marine living resources? In this book we examine the challenges that warming oceans pose to institutions for managing fish stocks that are shared by several states or straddle the high seas beyond national jurisdiction. Special attention is paid to institutional resilience – the capacity of management regimes to adapt to such challenges.

In recent decades, changes in climate have affected natural and human systems on all continents and across the oceans. Scientific projections of climate changes expected by the mid-twenty-first century and beyond show that global marine-species redistribution and marine-biodiversity reduction in sensitive regions will challenge the sustained provision of fisheries productivity and other ecosystem services (IPCC 2015). Spatial shifts of marine species due to projected warming will bring invasions to high-latitude seas, and greater local-extinction rates in the tropics and in semi-enclosed seas. Species richness and fisheries catch-potential are projected to increase at mid- and high latitudes and decrease at tropical latitudes.

Much of the evidence of recent climate change has been obtained through remote sensing and outputs from coupled atmosphere-ocean models. However, to detect the effects of these changes on marine living resources in each region it is necessary to link global trends with observations at the regional level. Combining oceanographic and biodiversity data offers a major source of regional data for uncovering climate-change effects on living marine resources in high latitudes over the past fifty years, as described in Chapters 6 and 11.

Climate change affects marine living resources by inducing greater variability in ocean conditions such as temperature, sea-ice extent, salinity and stratification. Such variability may affect the metabolic and reproductive processes of marine organisms directly; or indirectly, by altering their biological and abiotic environment – including spatial overlaps with predators and prey and the type and structure of their habitat. Among the possible consequences of such changes are shifts in the abundance, geographical distribution and migratory patterns of commercially and ecologically important fish stocks.

Narrowing in on selected cases of international marine living resources management, the contributions to this book bring out how these impacts of climate change impinge on the core tasks of resource management – scientific advice, regulation and compliance control – and how institutional features interact with political factors in efforts to adapt management regimes in order to retain or improve their performance. The cases of resource management studied here (cod, mackerel and crustaceans) are among the largest harvested stocks in the world. As this introductory chapter brings out, findings from these cases are relevant also for many other unilateral, bilateral and multilateral efforts worldwide to cope with resource-management challenges that are becoming amplified by the impacts of climate change.

Climate change and the abundance and distribution of marine stocks

Annual-to-decadal variations in ocean temperature tend to have greater amplitude than multi-decadal variations, and the variability at these two timescales differs in the impacts on marine ecosystems.[1] In general, ecological changes due to physical forcing move from local effects on individuals on shorter timescales (hours/days/months), to regional effects on population dynamics on medium timescales (seasonal/annual/decadal), to broader basin-scale effects on ecosystem dynamics on longer timescales (decadal/multidecadal). For example, annual-to-decadal temperature variations might affect production on lower trophic levels as well as fish recruitment and year-class strength, whereas multi-decadal variations may induce habitat expansion of populations as well as altering production, especially on higher trophic levels. These different timescales must be taken into consideration when discussing how climate change affects marine ecosystems.

The cold-temperate regions of the oceans, from about 40°N latitude to the Arctic Front and southward from the Antarctic Polar Front, support large and productive fisheries. Not all species have responded in the same way to ocean warming (Hollowed and Sundby 2014). Response patterns appear to be linked to a complex suite of climatic and oceanic processes that may portend future responses to warming ocean conditions. For example, the year-class strength of Northeast Arctic cod, the world's largest cod stock, is governed by a complex suite of processes during the first year of life. Temperature serves as a proxy for several of these processes.

Climate variability and change are known to have many and diverse biological effects – directly on an organism, such as through inducing physiological changes, or indirectly, for example through their effect on predators and prey. Inter-annual temperature variations influence recruitment from year to year, but longer-term variations also influence stock structure and distribution. During warming phases, the spawning-stock biomass may gradually build up, whereas in cooling phases, spawning-stock biomass may decrease. It is becoming increasingly important to identify the mechanisms by which climate change can affect fish population dynamics; to improve our understanding of how climate change will impact shifts in the distributions of

fish species; and to develop models to predict the effects of climate change on future distributions of fish and fisheries (Hollowed et al. 2013).

By developing and linking models of physical, biological and human responses to climate change, we can predict impacts on fish yields and dependent societies. The adoption of highly resolved shelf-sea physical-biological models rather than global climate models gives greater confidence in predicting the consequences at national scales, although there are significant trade-offs (Barange et al. 2014).

In a global perspective, climate change will generally increase the water temperature at every location. The temperature gradient polewards from the Equator will remain, but the species-temperature habitat will move polewards, leading to pressure on Arctic and Antarctic species. As biodiversity is highest at low latitudes and decreases nearer the poles, it is likely to increase locally in areas of polar water retreat. However, the lower biodiversity found in the open oceans has also allowed a few specialist species to proliferate, as is the case in the Nordic and Barents Sea ecosystems as well as in the Southern Ocean. These abundant species will tend to shift polewards, albeit limited by factors such as food availability, competition and good spawning grounds. Kjesbu et al. (2021) investigated thirty-nine commercial species in the Northeast Atlantic: they found that in the next fifty years the boreal species of the Norwegian Sea are highly likely to benefit from climate change, whereas the Arctic-water species in the Barents Sea will decline. Bryndum-Buchholz et al. (2020) report similar results for the Northwest Atlantic, noting that projected declines in harvestable biomass have been especially marked in historically important fishing grounds such as the Grand Banks of Newfoundland and the Scotian Shelf. As elaborated by McBride in Chapter 11, modelling studies of krill in the Southern Ocean under different warming scenarios generally predict a reduction and a poleward shift (e.g. Cuzin-Roudy et al. 2014; Piñones and Fedorov 2016). Arctic ecosystems, and probably also the Antarctic ones, will be losers in the long run, with shrinking areas of productivity.

Management tasks, stock-shifts and institutional resilience

Changes in the abundance and spatial distribution of marine stocks will pose additional challenges to the institutions that have been set up to manage transboundary stocks (see Pinsky and Mantua 2014; Cheung et al. 2017; Cheung 2018; Pinsky et al. 2018; Sumaila et al. 2020). Managing marine living resources involves making and implementing authoritative decisions on use and conservation: 'use' here refers to resource exploitation and allocation of benefits, whereas 'conservation' is about ensuring future availability. The problem of balancing those objectives can be subdivided into three management tasks: cognitional, regulatory and behavioural (Stokke 2015).

The *cognitional* management task involves providing scientific advice based on a shared, well-founded understanding of how various levels of harvesting pressure will affect the state of the fish stocks, as well as their long-term ability to provide employment, fishery yield, food security and food-web stability. The *regulatory* task entails moving from such a shared understanding of means–end relationships into joint

commitments among states to a set of common or compatible rules. The behavioural or *compliance* task is to ensure that those rules actually shape the performance of target groups. In conjunction with other factors that affect the spatial distribution of marine stocks – notably, bottom topography, stock size and food availability – climate change can impinge on each of these management tasks and therefore on the performance and effectiveness of various institutions established to support them.

For instance, a stock that expands its area of distribution may become available to fishers from additional states, complicating the cognitional task by requiring not only wider spatial coverage in the scientific survey activities often underlying the advice but also broader involvement in data analysis and generation of policy advice (Cheung 2018: 800). Studies of scientific assessments (Cash et al. 2003; Mitchell et al. 2006) indicate that, without such involvement, scientific advice is less likely to be perceived as credible and legitimate by those who are involved in the fishery and its regulation – which may in turn impinge on the collective ability of the states involved to reach agreement on the conservation measures advised by scientists.

Also the *regulatory* side of management can be directly affected by a spatial stock shift. For instance, it may put pressure on agreed quota-allocation arrangements among user-states (Pinsky et al. 2018: 1189), especially if the shift involves a significant and long-term change in the stock's 'zonal attachment': its occurrence in the various exclusive economic zones (EEZs) that states have established along their coasts and in waters beyond national jurisdiction.

With respect to *compliance* activities, a stock that moves into high-seas areas will narrow the jurisdictional basis for at-sea inspection and other modes of verification necessary for review of compliance and response to rule violation. That is because, under international law, the flag state enjoys a near-monopoly on rule enforcement beyond the maritime zones of coastal states (Stokke 2019).

In such cases, climate change will amplify generic challenges to the cognitional, regulatory and compliance tasks of fisheries management, thereby giving rise to questions about institutional resilience. In ecosystems analysis, resilience denotes 'the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist' (Holling 1973: 17). In the study of governance systems, 'institutional resilience' concerns the ability to deal with new challenges by adapting institutions, or relationships among them, to an extent sufficient for maintaining or improving institutional performance (see Young 2010: 379; Herrfahrdt-Pähle and Pahl-Wostl 2012: 2).[2] Possible adaptations include creating new management regimes in areas where no such bodies have existed; within-regime changes such as broader membership or geographic scope, or modified quota-allocation keys; and efforts to improve the interplay among institutions relevant to management, including their spatial or functional division of labour.

The chapters in this book disentangle these relationships between climate change and international management of shared and straddling fish stocks, drawing on findings from in-depth case studies to shed light on general requirements for institutional resilience.

Research questions and case diversity

The overarching questions examined in this book concern institutional performance in the face of rapidly changing circumstances; and answering them has involved close collaboration between natural and social scientists:

1. How do global warming and other environmental changes generate shifts in the abundance, distribution and migratory patterns of commercially and ecologically important marine stocks?
2. To what extent and how do stock-shifts pose challenges to the national, international and transnational management regimes established for the management of commercially and ecologically important fisheries?
3. To what extent and how have the actors operating these regimes adapted them to the changing circumstances and succeeded in maintaining or improving levels of performance – i.e. achieved institutional resilience?

We examine those three questions empirically by narrowing in on selected marine stocks in the Barents Sea, the Nordic Seas and the Southern Ocean – of cod, snow crab, mackerel and krill. Jointly, the processes of managing these stocks provide analytically helpful diversity with respect to three factors likely to weigh heavily on the capacity of resource management regimes to cope with the challenges posed by climate-related stock-shifts: the *extent* of the spatial shift, especially in terms of changes in zonal attachment; the *number of actors* who are engaged in the fishery and who must agree to any change in the management system in response to a stock shift; and the procedural *strength* of the management institution in place: its ability to adopt binding decisions also on substantive matters that are controversial among members.

Here we elaborate on this case diversity and on how it affects the implications to be drawn from this study to efforts in other parts of the world aimed at adapting fisheries management regimes to the impacts of climate change.

Extent of the spatial shift

The extent of change in the spatial distribution of a marine stock matters, because a minor change in zonal attachment from one year to another is unlikely to complicate the provision of scientific advice or to generate politically demanding requests for renegotiation of existing allocation arrangements. Among the cases studied here, the spatial distribution of Northeast Atlantic mackerel has shifted widely in the period under study; that for Northeast Arctic cod has shifted only slightly; whereas scientific uncertainty and dissensus remain concerning the strength of the evidence of a poleward shift of Antarctic krill associated with a warming Southern Ocean.

The 'Nordic Seas' is a collective term denoting the Norwegian Sea, the Greenland Sea and the Iceland Sea, three ocean areas separated from the remaining North Atlantic by the Greenland–Scotland Ridge (ICES 2018). These waters are home to the world's largest stocks of mackerel and herring, as well as holding many other species

such as blue whiting, saithe, redfish, salmon and tuna. The chapters in this book pay particular attention to the regional mackerel stock (*Scomber scombrus*), which has posed especially difficult management challenges in recent years. From around 2007, the increased abundance and considerable geographic expansion of this stock, involving greater availability in Faroese, Icelandic, Greenlandic and high-seas waters (Astthorsson et al. 2012; Utne et al. 2012; Nøttestad et al. 2016), have given risen to international negotiations, deadlocks and sanctions of various kinds between new entrants and those with a long track record of harvesting this stock – the EU and Norway (see Ch. 7). Further confounding this management challenge was the UK decision in 2016 to leave the EU, implying that it would again become an independent actor in international fisheries regulation – and linking efforts to cope with the mackerel dispute to the protracted and complex negotiations over the fisheries part of Brexit.

A more modest, yet significant, spatial shift has been recorded for the main commercial stock in the Barents Sea, Northeast Arctic cod (*Gadus morhua*). This stock occurs mostly in the EEZs of the two coastal states, Norway and Russia, but in some years it is also available in economically lucrative amounts in the high-seas 'Loophole' area of the Barents Sea (see Ch. 9). Since around 2010, a combination of relatively high ocean temperatures and a large stock size has induced a north- and eastward expansion, with somewhat higher zonal attachment in the Russian EEZ than previously (see Chs. 6 and 8).

In the Barents Sea we also examine a regional stock of snow crab (*Chionoecetes opilio*), believed to have entered the region either through migration from the Beaufort Sea through Russian waters or in shipborne ballast water (McBride et al. 2016: 80). Snow crab is a sedentary species that was first observed in the Barents Sea in the mid-1990s, around Novaya Zemlya; it has since expanded westwards and is now found also in western parts of the Barents Sea, including the waters around Norway's Svalbard archipelago. This has led to an international management dispute between Norway and the EU: the EU holds that certain provisions in the 1920 international treaty that granted Norway sovereignty over Svalbard imply that nationals of other signatories have equal access to natural resources in these waters as do Norwegians (see Chs. 8–10 and 14).

The extent of the spatial shift in distribution is uncertain for the final case of international resource management studied here, revolving around the world's largest crustacean fishery, that for Antarctic krill (*Euphausia superba*) – the hub of the Antarctic marine ecosystem with a circumpolar biomass of several hundred million tonnes (Atkinson et al. 2017). Whereas modelling studies concur that a contraction and a poleward shift of this stock is an expected result of global warming, a hefty scholarly debate has arisen over studies reporting that such changes are already underway (Cox et al. 2019; Hill et al. 2019; see Ch. 11).

Number of actors

The number of states or other entities with access to the fishery matters, because the fewer the actors who must agree on regulatory constraints, the lower the danger that

one or more will exploit the free-rider option of avoiding commitments or compliance, or both (Olson 1971; see also Chs. 2–3).

Snow crab is managed unilaterally by Norway and Russia on their respective continental shelves, although the EU challenge complicates the matter with respect to the continental shelf around Svalbard. Cod is a shared stock occurring primarily in waters under Norwegian or Russian jurisdiction and is subject to bilateral management by those coastal states. Like herring, Northeast Atlantic mackerel is now taken by seven states or other entities with exclusive fisheries jurisdiction in the Northeast Atlantic: the EU, the Faroe Islands, Greenland, Iceland, Norway, Russia and, following Brexit, the UK. The number of states involved in the fisheries for Antarctic krill in the Southern Ocean is comparable to the case of mackerel, but management of this stock is placed within the much broader Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), with its twenty-six members, including the EU.

As with the extent of the spatial shift, therefore, our cases display considerable variance also on the actor dimension.

Procedural strength

The procedural strength of an institution denotes its capacity to adopt prescriptive outputs that are deep – i.e. that request more than the prescriptive target (here, states engaging in resource management) would otherwise do – despite resistance from one or a minority of those targeted (Underdal 2004). Although in practice the procedural rule of consensus predominates in all the management regimes examined here, as it does in most environmental management regimes, there is considerable diversity regarding institutional means that facilitate consensus.

On a continuum of procedural strength, the Joint Norwegian–Russian Fisheries Commission (JNRFC) is located on the 'strong' side. This bilateral management body, established in 1976, forms the core of a well-established management institution that annually sets legally binding national catch quotas and a range of technical regulations applicable throughout the area of distribution of the shared stocks: cod, haddock, capelin, Greenland halibut and, since 2017, redfish (see Ch. 8). Scientific advice is provided by the International Council for the Exploration of the Sea (ICES), with its solid reputation for impartiality (Gullestad 1998) and advanced peer-review procedures for insulating the advisory process from political pressure (Lassen, Kelly and Sissenwine 2014). Underlying the ICES advice, moreover, are longstanding and cooperative surveys and data analyses conducted by scientists from both coastal states. Regulations adopted under the JNRFC bind also other user-states in the region by means of a string of reciprocal and other access and quota agreements negotiated annually with the EU, Iceland, the Faroe Islands, Greenland and following Brexit, also the UK.

On the opposite side of the procedural-strength continuum we find the fragmented institutional complex responsible for managing pelagic fisheries in the Nordic Seas. As with the JNRFC, scientific advice from ICES forms the basis for annual negotiations among the user-states, but the *regulatory* task is far more decentralized. In the JNRFC, annual negotiations start out from agreed

interpretations of basic conservation principles, like the precautionary approach, and clearly defined harvest-control and allocation rules – whereas management of the pelagic complex proceeds on a stock-by-stock basis, involving two multilateral venues and numerous bilateral ones. The regulatory core is an annual multilateral fisheries consultation process among those with acknowledged coastal-state rights, groupings that may vary from one stock to another. Such consultations sometimes produce an inclusive agreement on the TAC and its allocation, but more often the result is an agreement limited to a subset of those capable of harvesting the stock within their own EEZ.

The outcomes of those stock-specific multilateral consultations on pelagic stocks in the Nordic Seas form the basis for subsequent bilateral negotiations among the relevant coastal states concerning quota exchange and mutual access to each other's zones. Here, the additional complications deriving from Brexit are evident in the fact that, although the UK has negotiated a string of framework instruments with other user-states and entities to enable annual consultations on fisheries, by the end of 2021 only that with the EU had generated a tangible accord on quota sharing and mutual access to each other's zones. The outcomes of the multilateral consultations also set the parameters for decisions within the North-East Atlantic Fisheries Commission (NEAFC), whose competence relates mainly to the high seas, including a segment of the high-seas portion of the Central Arctic Ocean.

Somewhere in-between the cohesive strength of the JNRFC and the fragmented weakness of the institutional complex for managing pelagic species in the Nordic Seas we find CCAMLR. For reasons associated with the disputed sovereignty claims to the Antarctic continent, this institution is not authorized to allocate the agreed total allowable catch among its members by means of catch or effort quotas – but CCAMLR's contribution to the practical suspension of the sovereignty claims and its placement in the larger cooperative framework of the Antarctic Treaty System has nurtured the development of a general consensus-seeking approach (Stokke 1996; see also Ch. 12). That approach, in which problematic issues are typically aired already in the preparatory stages, allowing adaptation of proposals before they reach the decision stage, enabled CCAMLR to take an early lead among regional fisheries management organizations with respect to precautionary management and measures for combating illegal, unreported and unregulated (IUU) fishing (Szigeti and Lugten 2015: 8–9). Since every member is a de facto veto-holder, regulatory advance under CCAMLR is vulnerable to substantive political disagreement, which has been on the rise during the past decade – especially concerning the designation and implementation of marine protected areas (MPAs) in the Southern Ocean (see Chs. 12–13). An unusual feature of CCAMLR, and one that may contribute to disagreement over how to balance between use and protection, is that only a subset of its members engage in fisheries in the Southern Ocean.

In short, the cases examined in this book display considerable diversity with respect to three conditions likely to influence institutional resilience to the challenges that climate change may pose to sustainable resource management: the extent of a stock shift, the number of states and entities involved in the harvesting and the procedural strength of the management institution.

Case diversity and broader relevance

Northeast Arctic cod, Barents Sea snow crab, Northeast Atlantic mackerel and Antarctic krill are all commercially and ecologically important transboundary stocks that have experienced substantial variations in abundance and geographic distribution over the past decade. The management cases studied in this book are highly interesting in themselves for anyone interested in whether and how climate- or otherwise-induced spatial stock-shifts can impinge on the performance of international management systems.

The relevance of our case studies is further broadened by the diversity concerning the extent of the spatial stock shift experienced, the number of participants engaged in the fisheries and the procedural strength of the management regimes involved. That is because the cross-case variation in conditions believed to influence institutional resilience means that the processes and outcomes studied in this book may shed light on more generic propositions on circumstances that promote or impede institutional adaptation to external perturbations – within as well as beyond the empirical context of climate change and fisheries management.

Such case diversity also improves the potential for generalizing our findings to other regional fisheries-management efforts aimed at dealing with distributive impacts of climate change. Although caution should always be exercised in drawing broader implications from a small number of cases, as the dynamics observed may derive from case-specific combinations of conditions not found elsewhere (Ragin 1994; Levy 2008), the basis for generalization is nevertheless improved if major categories of the phenomena under study are represented among the cases.

Thus, the broader category of resource management institutions represented by the Barents Sea snow-crab case comprises regulatory measures set up unilaterally by a coastal state and challenged by one or more other states or entities over issues of jurisdiction. Such jurisdictional disputes with fisheries implications abound worldwide, including in the South China Sea (e.g. Zhang 2018) and the dispute involving Japan and Russia concerning islands north of Hokkaido that were occupied by the Soviet Union towards the end of the Second World War.[3]

Among the bilateral fisheries management institutions, in this book represented by the JNRFC, we also find other longstanding bodies set up by two coastal states for managing transboundary stocks, such as the International Pacific Halibut Commission established by Canada and the USA nearly a century ago (see Sumaila et al. 2020). Also in this category are institutionally thinner frameworks for annual negotiations over quota sharing and reciprocal access, like those established in almost all dyads of states littoral to the Northeast Atlantic – and many other places worldwide.

Similar comments apply to multilateral regional fisheries management organizations or arrangements (RFMO/As) (see Ch. 2).[4] Both variants have a distinctive decision-making body, but arrangements (RFMAs) lack the defining features of an international organization – legal personality, a (usually small) staff and physical location. Represented in this book is the subcategory with regulatory competence mainly limited to the high-seas waters (NEAFC, one part of the complex for managing mackerel) as well as that with institutions also authorized to make binding decisions concerning EEZs (CCAMLR).

In the former subcategory we also find, for instance, the Northwest Atlantic Fisheries Organization (see Joyner 2001) and the arrangement based on the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea (see Balton 2001). As in the mackerel case, those two institutions have a medium-sized membership of wealthy states and entities – whereas another RFMO/A with a high-seas mandate only, the South East Atlantic Fisheries Organization, also involves coastal states belonging to the Global South (see Henriksen et al. 2006).

In the second subcategory – fisheries regimes with regulatory competence in high seas as well as waters under national jurisdiction – we find several tuna RFMOs, typically with relatively large numbers of members, as is also the case of CCAMLR.

In summary, the cases of institutional resilience to changing spatial distribution of marine stocks studied in this book are highly interesting in their own right – because the stocks are so important and their spatial shifts so significant – but they also have far broader relevance. With their diversity in terms of conditions likely to influence resilience and the fact that they represent major categories of fisheries management institutions, the cases examined here can shed light on a wide range of other efforts to adapt management institutions to the impacts of climate change. However, the caution always warranted when generalizing findings from one empirical context to another includes taking into consideration the similarities and differences among the international fisheries institutions noted in this section.

Structure of the book

After the introductory Part I, the chapters in Part II elaborate on legal and political aspects of international fisheries management institutions and examine the roles of two important non-state actors involved in all the management cases studied here – the partly supranational EU, a member of both NEAFC and CCAMLR, and the leading private governance organization in world fisheries, the Marine Stewardship Council.

Parts III and IV deal with the two regions in focus here: the eastern Atlantic segment of the Northern Seas (the Barents and Nordic Seas) and the Southern Ocean. Each part begins by presenting the state of knowledge regarding observed and modelled impacts of climate change on the abundance and spatial distribution of major stocks, followed by analyses of how the actors and institutions examined in Part II interact and adapt to those impacts in order to retain or improve performance. The concluding chapter in Part V summarizes the answers derivable from Parts II to IV to the three overarching research questions formulated above, including a comparative analysis of the cases studied.

Part II: Institutions and actors

Chapter 2 by Erik Molenaar examines legal aspects of cooperation through RFMO/As. The focus is on the meaning and scope of the duty that states have under international law to cooperate through such regional regimes which, as Molenaar notes, have become the pre-eminent institutions in international fisheries law. He links that duty to various practical challenges to effective fisheries management that are exacerbated by climate

change – such as new entrants in the fishery, or free riders that either refuse to accept regulations or fail to comply with them – as well as rules and practices concerning participation in management regimes and allocation of fishing opportunities. Also examined is how the Fish Stocks Agreement's approach to strengthening the duty to cooperate has served as inspiration in the ongoing negotiation of a legally binding instrument on marine biodiversity of areas beyond national jurisdiction (BBNJ).

Chapter 3 by Oran Young and Olav Schram Stokke starts out from the observation that responding to challenges arising from climate- or otherwise-derived stock-shifts is a variant of the more generic problem of finding ways to avoid institutional failure. Avoiding such failure when creating, adapting or operating institutions, they argue, often entails navigating between two opposite perils that threaten to derail management efforts – *reductionism* and *overload*. Institutional reductionism is evident when those responsible for creating and implementing environmental regimes have failed to take account of substantively important parts of the activity system, or fail to adapt the institution when the activity system has changed – for instance, due to stock-shifts that bring new entrants in a fishery, or increased user conflicts across sectors of industry. Institutional overload denotes the opposite pitfall: it occurs when those responsible for designing or adapting regimes strive to incorporate all relevant factors in an effort to respond to the complexities of real-world situations. This may result in unwieldy or excessively ambitious arrangements, frequently yielding gridlock rather than problem-solving. Central to the discussion by Young and Stokke is the presentation of a set of risk factors likely to propel governance systems toward reductionism or overload, and a set of response strategies that can help those negotiating or operating management regimes to avoid both perils.

Chapter 4 by Andreas Raspotnik and Andreas Østhagen concerns the EU and its actorness in international fisheries governance – that is, its externally recognized capacity to act coherently and influentially (Bretherton and Vogler 2008). Because its member-states have granted the EU the competence to represent them in international fisheries regulation, the EU has obtained membership in many international fisheries regimes. Raspotnik and Østhagen note certain tensions discernible between the internal and the external dimensions of the EU Common Fisheries Policy. Notably, the internal emphasis on the sustainability and precautionary principles contrasts with the emphasis assigned to fishing-industry interests in external negotiations, such as those on EEZ access in the Global South and quota allocation in the Northern Seas. The authors relate those tensions to the contrast between the complexity and convolution that marks EU decision-making on fisheries issues, and external perceptions of the EU as a relatively cohesive actor.

In Chapter 5, Geir Hønneland assesses the role of another non-state, yet increasingly influential, actor in international fisheries management – the Marine Stewardship Council (MSC), which currently certifies more than 10 per cent of the world's marine capture fisheries, including those for major stocks in all the seas examined in this book. Hønneland explains the procedural and substantive requirements for MSC certification and uses several Northeast Atlantic mackerel cases to evaluate the effects of this private governance arrangement on the mackerel fisheries as well as its international regulation.

Part III: Northern Seas

The term 'Northern Seas' refers to the northern North Atlantic, the Nordic Seas, the Barents Sea and the Central Arctic Ocean (Dickson et al. 2008; Eldevik et al. 2014: 225). As noted, the cases in this part of the book concern the management of demersal, benthic as well as pelagic species in the Barents Sea and the Nordic Seas.

Chapter 6 by Jan Erik Stiansen, Geir Odd Johansen, Anne Britt Sandø and Harald Loeng provides an update on the state of knowledge regarding how climate change affects physical and biotic conditions as well as the harvesting patterns for major marine stocks in the Nordic and Barents Seas, including mackerel, herring, cod and snow crab. These authors bring out the close link between the Norwegian and Barents Seas, in terms of physical oceanography and their ecosystems. Both regions exhibit high inter-annual as well as multi-decadal hydrographic variability; multi-decadal variations in temperature both amplify and counteract the slower increase in temperature due to climate change in the Barents Sea as well as in the Norwegian Sea. In general, northwards shifts in temperature habitats are opening new potential feeding areas for fish stocks farther north and east; but the effects on spatial distribution will differ with factors such as bottom topography, stock size and food availability.

Chapter 7 by Andreas Østhagen, Jessica Spijkers and Olav Anders Totland focuses on the mackerel dispute between the EU and Norway on the one hand and the three new entrants to this fishery – Iceland, the Faroe Islands and Greenland – on the other. Seeking to draw lessons for other transboundary quota disputes, the authors examine whether the failure to reach an inclusive allocation agreement is best explained by scientific uncertainty, weak international institutions or excessively rigid positions due to heavy fishing-industry influence on the negotiators.

In Chapter 8, Anne-Kristin Jørgensen enquires into why the spatial shift of the Northeast Arctic cod stock, entailing higher availability in parts of the Barents Sea that fall within the coastal-state maritime zones of the Russian Federation, has *not* given rise to allocation disputes similar to those over the pelagic stocks in the Norwegian Sea. Although the JNRFC has not been completely spared from challenges to existing allocation rules, those challenges have concerned stocks of lesser commercial value than cod, and have been handled cooperatively within the regime. Certain characteristics of that institution – notably the increasing involvement of scientific and technical expertise in the preparation of allocation decisions and its longstanding history of facilitating compromises on difficult issues – are among the drivers of resilience pinpointed by Jørgensen.

Whereas Chapters 7 and 8 focus on the regulatory side of management, and quota allocation in particular, Chapter 9 by Olav Schram Stokke concerns challenges to the compliance systems of international institutions. Like Jørgensen, Stokke examines management of cod in the Barents Sea; he too identifies institutional differentiation within the JNRFC, notably the creation of an expert body on compliance and control, as an important mechanism for adapting the regime to a climate-related compliance deficit. An even more important adaptation, according to Stokke, is the gradual expansion of the institutional complex drawn upon to ensure compliance

with international quota agreements, bringing in also a string of bilateral coastal-state agreements, the NEAFC and international trade rules.

In closing the Northern Seas part of the book, Andreas Østhagen and Andreas Raspotnik (Ch. 10) focus on the dispute between Norway and the EU over snow crab, a relatively new species in the Barents Sea. That dispute gives rise to issues extending beyond the management of living resources – partly because harvesting has occurred in waters near Svalbard, where the parties hold differing positions regarding the legal basis for their right to quotas, linked to disagreement on the spatial scope of the 1920 Svalbard Treaty.[5] Moreover, harvesting of this sedentary species is governed by the continental shelf regime, so any solution to the dispute might have implications for the regulation of oil and gas activities as well. As Østhagen and Raspotnik point out, the various participants in EU decision-making differ in the relative emphasis they place on fisheries and broader foreign-policy concerns.

Part IV: Southern Ocean

Part IV shifts the focus to the Southern Ocean. In Chapter 11, Margaret Mary McBride presents the physical and biological characteristics of this large marine ecosystem, including its relatively low species diversity and the central food-web position held by Antarctic krill. Rapid upper-ocean warming has occurred in the Atlantic sector where practically all krill harvesting occurs, so this chapter pays special attention to the implications of that development for krill abundance and the spatial distribution of this stock, which supports the world's largest crustacean fishery.

Krill fisheries are also central in Chapter 12, where Stokke assesses the capacity of CCAMLR to detect climate-induced or other changes in the distribution and abundance of this stock and its predators, and to adjust regulations accordingly. In focus are the prospects for overcoming political and other impediments to an improved risk-assessment procedure that includes regular monitoring of ecosystem components potentially affected by krill fisheries, and a feedback management system that employs the data from such monitoring to adjust the agreed conservation measures.

Chapter 13 returns to the issue of EU actorness. As in the Northern Seas, the EU is a major actor in Antarctic fisheries management. But as Raspotnik and Østhagen show, the EU's economic interest in krill harvesting has been miniscule. They relate this observation, and EU commitments to global targets on marine protection, to a series of initiatives within CCAMLR focused on the creation of new MPAs in the Antarctic. As they showcase, much of the EU's stance on this issue can be attributed to special interests in the EU system relating to actions – more or less symbolic – to accommodate demands for conservation efforts at sea.

Part V: Comparisons and conclusions

Stokke's concluding Chapter 14 summarizes the main answers offered by the individual chapter authors to the three questions specified above: 1) the effects of climate change and other environmental changes on the abundance and distribution of major stocks in two large polar marine ecosystems; 2) the challenges that such shifts imply for the

complexes of institutions that co-govern fisheries for major commercial species; and 3) how to explain variation in the resilience of these management regimes – their ability to adapt, if necessary, to such changing circumstances in order to retain or even raise levels of performance. The author compares the regional management regimes examined here in terms of resilience to the additional cognitional, regulatory and compliance challenges posed by climate- or otherwise-induced stock-shifts, seeks to explain variation in institutional resilience by means of the risk factors identified in Chapter 3 and examines the applicability of the book's findings to broader sets of efforts to adapt fisheries management to the impacts of climate change in other parts of the world.

Notes

1 We would like to thank Harald Loeng for valuable inputs to this section.
2 Specific performance indicators derive from the social problem the institution was set up to address (Young 1999; Stokke 2012).
3 For reports on recent fisheries incidents, see 'Fight over Fish Fans a New Stage of Conflict in South China Sea', *Bloomberg*, 1 September 2020, https://www.bloomberg.com/graphics/2020-dangerous-conditions-in-depleted-south-china-sea/; and 'Russia Seizes Japanese Fishing Boat Near Disputed Islands', *Moscow Times*, 15 January 2020, https://www.themoscowtimes.com/2020/01/15/russia-seizes-japanese-fishing-boat-near-disputed-islands-a68917.
4 Note that the category RFMO/As include also bilateral institutions; Chapter 2 by Molenaar gives an overview of the general phenomenon and a list of those with high-seas coverage, including the JNRFC.
5 Treaty concerning the Archipelago of Spitsbergen, 9 February 1920; in force 14 August 1925, here: Svalbard Treaty.

References

Astthorsson, O. S., H. Valdimarsson, A. Gudmundsdottir and G. J. Óskarsson (2012), 'Climate-Related Variations in the Occurrence and Distribution of Mackerel *(Scomber scombrus)* in Icelandic Waters', *ICES Journal of Marine Science*, 69 (7): 1289–97.

Atkinson, A., S. L. Hill, E. A. Pakhomov, V. Siegel, R. Anadon, S. Chiba, K. L. Daly, R. Downie, S. Fielding, P. Fretwell, L. Gerrish, G. W. Hosie, M. J. Jessopp, S. Kawaguchi, B. A. Krafft, V. Loeb, J. Nishikawa, H. J. Peat, C. S. Reiss, R. M. Ross, L. B. Quetin, K. Schmidt, D. K. Steinberg, R. C. Subramaniam, G. A. Tarling and P. Ward (2017), 'KRILLBASE: A Circumpolar Database of Antarctic Krill and Salp Numerical Densities, 1926–2016', *Earth System Science Data*, 9: 193–210.

Balton, D. A. (2001), 'The Bering Sea Doughnut Hole Convention: Regional Solution, Global Implications', in O. S. Stokke (ed.), *Governing High Seas Fisheries: The Interplay of Global and Regional Regimes*, 143–77, Oxford: Oxford University Press.

Barange, M., G. Merino, J. L. Blanchard, J. Scholtens, J. Harle, E. H. Allison, J. I. Allen, J. Holt and S. Jennings (2014), 'Impacts of Climate Change on Marine Ecosystem Production in Societies Dependent on Fisheries', *Nature Climate Change*, 4: 211–16. doi: 10.1038/nclimate2119.

Bennett, J. R., J. D. Shaw, A. Terauds, J. P. Smol, R. Aerts, D. M. Bergstrom, J. M. Blais, W. W. L. Cheung, S. L. Chown, M. A. Lea, U. N. Nielsen, D. Pauly, K. J. Reimer, M. J. Riddle, I. Snape, J. S. Stark, V. J. Tulloch and H. P. Possingham (2015), 'Polar Lessons Learned: Long-Term Management Based on Shared Threats in Arctic and Antarctic Environments', *Frontiers in Ecology and the Environment*, 13: 316–24.

Bretherton, C. and J. Vogler (2008), 'The European Union as a Sustainable Development Actor: The Case of External Fisheries Policy', *Journal of European Integration: Policy Coherence and EU Development Policy*, 30: 401–17. doi: 10.1080/07036330802142012.

Bryndum-Buchholz, A., D. G. Boyce, D. P. Tittensor, V. Christensen, D. Bianchi, and H. K. Lotze (2020), 'Climate-Change Impacts and Fisheries Management Challenges in the North Atlantic Ocean', *Marine Ecology Progress Series*, 648: 1–17.

Cash, D. W., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jäger and R. B. Mitchell (2003), 'Knowledge Systems for Sustainable Development', *Proceedings of the National Academy of Sciences of the United States of America*, 100 (14): 8086–91. doi: 10.1073/pnas.1231332100.

Cheung, W. W. L. (2018), 'The Future of Fishes and Fisheries in the Changing Oceans', *Journal of Fisheries Biology*, 92: 790–803.

Cheung, W. W. L., M. C. Jones, V. W. Y. Lam, D. D. Miller, Y. Ota, L. Teh, and U. R. Sumaila (2017), 'Transform High Seas Management to Build Climate Resilience in Marine Seafood Supply', *Fish and Fisheries*, 18: 254–63.

Cox, M. J., S. Candy, W. K. de la Mare, S. Nicol, S. Kawaguchi and N. Gales (2019), 'Clarifying Trends in the Density of Antarctic krill *Euphausia superba* Dana, 1850, in the South Atlantic: A Response to Hill et al.', *Journal of Crustacean Biology*, 39 (3): 323–27. doi: 10.1093/jcbiol/ruz010.

Cuzin-Roudy, J., J.-O. Irisson, F. Penot, S. Kawaguchi and C. Vallet (2014), 'Southern Ocean Euphausiids', in C. De Broyer, P. Koubbi, H. J. Griffiths, B. Raymond, B. C. d'Udekem d'Acoz, A. P.Van de Putte, B. Danis, B. David, S. Grant, J. Gutt, C. Held, G. Hosie, F. Huettmann, A. Post and Y. Ropert-Coudert (eds), *Biogeographic Atlas of the Southern* Ocean, 309–20, Cambridge: Scientific Committee on Antarctic Research.

Dickson, R. R., J. Meincke and P. Rhines (2008), *Arctic–Subarctic Ocean Fluxes: Defining the Role of the Northern Seas in Climate*, Dordrecht: Springer Netherlands.

Eldevik, T., B. Risebrobakken, A. E. Bjune, C.Andersson, H. J. B. Birks, T. M. Dokken, H. Drange, M. S. Glessmer, C. Li, J. E. Ø. Nilsen, O. H. Otterå, K. Richter and Ø. Skagseth (2014), 'A Brief History of Climate – The Northern Seas from the Last Glacial Maximum to Global Warming', *Quaternary Science Reviews*, 106: 225–46. doi: 10.1016/j.quascirev.2014.06.028.

Gullestad, P. (1998), 'The Scope for Research in Practical Fishery Management', *Fisheries Research*, 37: 251–8.

Henriksen, T., G. Hønneland and A. Sydnes (2006), *Law and Politics in Ocean Governance: The UN Fish Stocks Agreement and Regional Fisheries Management Regimes*, Leiden: Brill Nijhoff.

Herrfahrdt-Pähle, E. and C. Pahl-Wostl (2012), 'Continuity and Change in Social-ecological Systems: The Role of Institutional Resilience', *Ecology and Society*, 17. doi: 10.5751/ES-04565-170208.

Hill, S. L., A. Atkinson, E. A. Pakhomov and V. Siegel (2019), 'Evidence for a Decline in the Population Density of Antarctic Krill *Euphausia superba* Dana, 1850 Still Stands: A Comment on Cox et al.', *Journal of Crustacean Biology*, 39: 316–22. doi: 10.1093/jcbiol/ruz004.

Holling, C. S. (1973), 'Resilience and Stability of Ecological Systems', *Annual Review of Ecology and Systematics*, 4: 1–23.

Hollowed, A. B. and S. Sundby (2014), 'Change is Coming to the Northern Oceans', *Science*, 344: 1084. doi: 10.1126/science.1251166.

Hollowed, A. B., B. Planque and H. Loeng (2013), 'Potential Movement of Fish and Shellfish Stocks from the Sub-Arctic to the Arctic Ocean', *Fisheries Oceanography*, 22 (5): 355–70.

ICES (2018), 'Norwegian Sea Ecoregion: Ecosystem Overview', *ICES Advice*. https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/NorwegianSea_EcosystemOverview.pdf.

IPCC (2015), *Climate Change 2014: Synthesis Report*, Geneva: Intergovernmental Panel on Climate Change (IPCC)

Johannesen, E., L. L. Jørgensen, M. Fossheim, R. Primicerio, M. Greenacre, P. A. Ljubin, A. V. Dolgov, R. B. Ingvaldsen, N. A. Anisimova and I. E. Manushin (2017), 'Large-scale Patterns in Community Structure of Benthos and Fsh in the Barents Sea', *Polar Biology*, 40: 237–46. doi: 10.1007/s00300-016-1946-6.

Joyner, C. C. (2001), 'On the Borderline? Canadian Activism in the Grand Banks', in O. S. Stokke (ed.), *Governing High Seas Fisheries: The Interplay of Global and Regional Regimes*, 207–33, Oxford: Oxford University Press.

Kjesbu, O. S., S. Sundby, A. B. Sandø, M. Alix, S. S. Hjøllo, M. Tiedemann, M. Skern-Mauritzen, C. Junge, M. Fossheim, C. T. Broms, G. Søvik, F. Zimmermann, K. Nedreaas, E. Eriksen, H. Höffle, A. M. Hjelset, C. Kvamme, Y. Reecht, H. Knutsen, A. Aglen, O. T. Albert, E. Berg, B. Bogstad, C. Durif, K. T. Halvorsen, Å. Høines, C. Hvingel, E. Johannesen, E. Johnsen, E. Moland, M. S. Myksvoll, L. Nøttestad, E. Olsen, G. Skaret, J. E. Skjæraasen, A. Slotte, A. Staby, E. K. Stenevik, J. E. Stiansen, M. Stiasny, J. H. Sundet, F. Vikebø and G. Huse (2021), 'Highly Mixed Impacts of Near-Future Climate Change on Stock Productivity Proxies in the North East Atlantic', *Fish and Fisheries*. doi: 10.1111/faf.12635.

Lassen, H., C. Kelly and M. Sissenwine (2014), 'ICES Advisory Framework 1977–2012: From Fmax to Precautionary Approach and Beyond', *ICES Journal of Marine Science*, 71 (2): 166–72.

Levy, J. S. (2008), 'Case Studies: Types, Designs, and Logics of Inference', *Conflict Management and Peace Science*, 25: 1–18.

McBride, M. M., J. R. Hansen, O. Korneev, O. Titov, J. E. Stiansen, J. Tchernova, A. Filin and A. Ovsyannikov (2016), *Joint Norwegian-Russian Environmental Status 2013 Report on the Barents Sea Ecosystem*. Bergen: Marine Research Institute.

Mitchell, R. B., W. C. Clark, D. W. Cash and N. M. Dickson (2006), *Global Environmental Assessments: Information and Influence*, Cambridge, MA: MIT Press.

Molenaar, E. J. (2019), 'Participation in Regional Fisheries Management Organization', in J. R. Caddell and E. J. Molenaar (eds), *Strengthening International Fisheries Law in an Era of Changing Oceans*, 103–29, London: Hart.

Nøttestad, L., K. R. Utne, G. J. Óskarsson, S. Þ. Jónsson, J. A. Jacobsen, Ø. Tangen, V. Anthonypillai, S. Aanes, J. H. Vølstad, M. Bernasconi, H. Debes, L. Smith, S. Sveinbjörnsson, J. C. Holst, T. Jansen and A. Slotte (2016), 'Quantifying Changes in Abundance, Biomass, and Spatial Distribution of Northeast Atlantic Mackerel (Scomber scombrus) in the Nordic Seas from 2007 to 2014', *ICES Journal of Marine Science*, 73 (2): 359–73.

Olson, M. (1971), *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA: Harvard University Press.

Palacios-Abrantes, J., U. R. Sumaila, and W. W. L. Cheung (2020), 'Challenges to Transboundary Fisheries Management in North America under Climate Change', *Ecology and Society*, 25: 41.

Piñones, A. and A. V. Fedorov (2016), 'Projected Changes of Antarctic Krill Habitat by the End of the 21st Century', *Geophysical Research Letters*, 43: 8580–9.
Pinsky, M. L. and N. J. Mantua (2014), 'Emerging Adaptation Approaches for Climate-Ready Fisheries Management', *Oceanography*, 27: 146–59.
Pinsky, M. L., G. Reygondeau, R. Caddell, J. Palacios-Abrantes, J. Spijkers and W. Cheung (2018), 'Preparing Ocean Governance for Species on the Move', *Science*, 360.
Ragin, C. C. (1994), *Redesigning Social Inquiry: Set Relations in Social Research*, Chicago, IL: University of Chicago Press.
Stokke, O. S. (1996), 'The Effectiveness of CCAMLR', in O. S. Stokke and D. Vidas (eds), *Governing the Antarctic: The Effectiveness and Legitimacy of the Antarctic Treaty System*, 120–51, Cambridge: Cambridge University Press.
Stokke, O. S. (2012), *Disaggregating International Regimes: A New Approach to Evaluation and Comparison*, Cambridge, MA: MIT Press.
Stokke, O. S. (2015), 'Fisheries and Whaling', in *Encyclopedia of Global Environmental Governance and Politics*, 364–73, Cheltenham: Edward Elgar.
Stokke, O. S. (2019), 'Management Options for High Seas Fisheries: Making Regime Complexes More Effective', in J. R. Caddell and E. J. Molenaar (eds), *Strengthening International Fisheries Law in an Era of Changing Oceans*, 51–78, London: Hart.
Sumaila, U. R., J. Palacios-Abrantes and W. W. L. Cheung (2020), 'Climate Change, Shifting Threat Points, and the Management of Transboundary Fish Stocks', *Ecology and Society*, 25: 40.
Szigeti, P. D. and G. Lugten (2015), The Implementation of Performance Review Reports by Regional Fishery Bodies 2004–2014, *FAO Fisheries and Aquaculture Circular*, C1108.
Underdal, A. (2004), 'Methodological Challenges in the Study of Regime Effectiveness', in A. Underdal and O. R. Young (eds), *Regime Consequences: Methodological Challenges and Research Strategies*, 27–48, Dordrecht: Kluwer Academic.
Utne, K. R., G. Huse, G. Ottersen, J. C. Holst, V. Zabavnikov, J. A. Jacobsen, G. J. Óskarsson and L. Nøttestad (2012), 'Horizontal Distribution and Overlap of Planktivorous Fish Stocks in the Norwegian Sea During Summers 1995–2006', *Marine Biology Research*, 8 (5–6): 420–41.
Young, O. R. (1999), *The Effectiveness of International Environmental Regimes: Causal Connections and Behavioral Mechanisms*, Cambridge, MA: MIT Press.
Young, O. R. (2010), 'Institutional Dynamics: Resilience, Vulnerability and Adaptation in Environmental and Resource Regimes', *Global Environmental Change*, 20 (3): 378–85. http://dx.doi.org/10.1016/j.gloenvcha.2009.10.001.
Zhang, H. (2018), 'Fisheries Cooperation in the South China Sea: Evaluating the Options', *Marine Policy* 89: 67–76.