Climate Change and Antarctic Fisheries: Ecosystem Management in CCAMLR

*Rosemary Rayfuse**

Climate change and associated ocean acidification present varied and complex threats to Antarctic fisheries, making conservation and sustainable management of these fisheries more challenging than ever. The ecosystem approach is generally considered to be the most effective way of enhancing the climate resilience of fisheries, and the Commission on the Conservation and Management of Antarctic Marine Living Resources is expressly charged with implementing that approach in achieving its conservation objective. Implementation of the ecosystem approach is, however, a complex and challenging matter, and the emerging need to graft climate change impacts onto the range of factors already to be considered exacerbates these difficulties. This Article examines the implications of climate change for Antarctic fisheries, focusing on issues of both ecosystem resilience and the institutional resilience of the Commission on the Conservation and Management of Antarctic Marine Living Resources. While the potential implications of climate change on the Antarctic marine ecosystem have been under general discussion in the Commission since 2002, the Commission still has a long way to go in moving to actively anticipate climate stressors, in absorbing their importance into its decision-making processes, and in reshaping its management measures to address climate-driven changes in the Antarctic marine ecosystem.

DOI: https://doi.org/10.15779/Z381834271

* Scientia Professor in Law, UNSW Sydney; Conjoint Professor and Kerstin Hesselgren Visiting Professor, Faculty of Law, Lund University.

INTRODUCTION

Fish represent a major portion of marine biodiversity. Fish also provide a vital contribution to global food security, providing about 20 percent of global animal intake.[1] However, the Intergovernmental Panel on Climate Change warns that by 2050, global redistribution of fish yields, coupled with decreases in open-ocean net primary production and fish habitat caused by ocean warming, anoxia, and acidification, will have profound implications for fish stocks, and thus, for global food security.[2] At the international level, these changes will also have profound implications for the Regional Fisheries Management Organizations (RFMOs) and other arrangements established to conserve and manage international fisheries.[3] In other words, the challenges relate not only to ecosystem and stock resilience but to institutional resilience as well.

Although initially designed for managing under more biologically stable conditions, in a climate-changed world RFMOs must ensure that their conservation and management measures are aimed at enhancing the climate resilience of the fisheries they are managing. The ecosystem-based approach to management is generally considered to be the most effective means of preserving ecological, and thus climate, resilience.[4] As Ogier et al. put it, the ecosystem

---

1. WORKING GROUP II, INT'L PANEL ON CLIMATE CHANGE [IPCC], CLIMATE CHANGE 2014: IMPACTS, ADAPTATION AND VULNERABILITY: PART A: GLOBAL AND SECTORAL ASPECTS: CONTRIBUTION OF WORKING GROUP II TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 452 (2014) [hereinafter IPCC, CONTRIBUTION OF WORKING GROUP II].

2. *Id.* at 459.

3. *See* Rosemary Rayfuse, *Climate Change and the Law of the Sea*, *in* INTERNATIONAL LAW IN THE ERA OF CLIMATE CHANGE 147, 158–162 (Rosemary Rayfuse & Shirley V. Scott eds., 2012).

4. *See* Tim Daw et al., *Climate Change and Capture Fisheries: Potential Impacts, Adaptation and Mitigation*, *in* Food & Agric. Org. of the United Nations [FAO], *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge*, FAO FISHERIES & AQUACULTURE TECHNICAL PAPER NO. 530, at 107, 141–43 (Kevern Cochrane et al. eds., 2009).

approach "can help increase the adaptability and resilience of fisheries resources, associated ecosystems, and dependent communities and industries; consider multiple sectors and policies; address cumulative impacts; consider scientific and technical information; and embrace ecosystem services."[5] In other words, the ecosystem approach provides a framework through which RFMOs can anticipate climate stressors, absorb the importance of these stressors into their decision-making processes, and reshape their management measures to best address climate-driven changes.[6]

The first RFMO charged with applying the ecosystem approach to the conservation and management of international fisheries was the Commission on the Conservation of Antarctic Marine Living Resources (CCAMLR).[7] In truth, CCAMLR is not really an RFMO. More than a mere fisheries management organization, CCAMLR is charged with a broader conservation mandate relating to all living marine resources in the Antarctic.[8] Nevertheless, to the extent this mandate involves managing fisheries, CCAMLR does exhibit many of the characteristics of an RFMO. Its experience is thus germane to any study of the challenges of international fisheries management under conditions of climate change.

This Article examines the implications of climate change for Antarctic fisheries, focusing on issues of both ecosystem resilience and the institutional resilience of CCAMLR. The Article starts with a description of the impacts of climate change on Antarctic fisheries, followed by a discussion of CCAMLR's ecosystem approach to management under conditions of uncertainty. It then examines the measures and other actions CCAMLR is taking to address the threats posed by climate change and associated ocean acidification to the ecosystems under its management. This discussion reveals that while CCAMLR is taking positive steps to anticipate the effects of climate stressors on Antarctic marine ecosystems and the fisheries under its management, the extent to which CCAMLR has absorbed climate change into its decision-making processes and addressed its effects through the adoption of relevant conservation measures remains limited. In other words, CCAMLR still has a long way to go in integrating both the ecosystem approach and climate-change impacts into its management decisions.

---

5. Emily M. Ogier et al., *Fisheries Management Approaches as Platforms for Climate Change Adaptation: Comparing Theory and Practice in Australian Fisheries*, 71 MARINE POL'Y 82, 90 (2016).

6. *See* Tim Daw et al., *supra* note 4, at 137–41.

7. Erik Jaap Molenaar, *CCAMLR and Southern Ocean Fisheries*, 16 INT'L J. MARINE & COASTAL L. 465, 467–68 (2001). For a history of the negotiations, see SIMON LYSTER, INTERNATIONAL WILDLIFE LAW 156–60 (1st ed. 1985), *and History of the Convention*, CCAMLR, https://www.ccamlr.org/en/organisation/history-convention (last modified Sept. 4, 2013).

8. Convention on the Conservation of Antarctic Marine Living Resources art. II, *opened for signature* Aug. 1, 1980, 1329 U.N.T.S. 48 (entered into force Apr. 7, 1982) [hereinafter CAMLR Convention].

I. ANTARCTIC FISHERIES AND CLIMATE CHANGE

It is undisputed that a warming and changing ocean has implications for international fisheries. Admittedly, fish and their surrounding ecosystems are naturally subject to climate-related variability, which drives fluctuations in abundance.[9] However, climate change-related shifts in water temperature, oxygenation, ocean acidity, and ocean currents are predicted to amplify these natural variations, leading to greater changes in abundance levels and to changes in species distribution.[10]

With respect to ocean warming (and associated deoxygenation), evidence exists that species are already being displaced towards the poles and are experiencing changes in their size and abundance.[11] Not all of these changes are necessarily negative, as anticipated reductions in abundance in tropical and sub-tropical oceans may be compensated for by increases in abundance in the higher latitudes.[12] However, much will depend on the degree and rapidity of warming. For example, while models suggest that fisheries in the tropical Pacific Ocean will only shrink by 12 percent if global warming is kept within the 1.5°C limit set by the Paris Agreement, a rise of 3.5°C will see a reduction in catch of 47 percent.[13] Although this reduction may initially be offset by an estimated 30 to 55 percent increase in catch in the Arctic, at about 3.5°C of warming a tipping point will be reached after which the increase in temperature will have negative consequences for these fisheries as well.[14]

Moreover, ocean warming is not the only climate change-related problem for fisheries. Increasing concentrations of atmospheric CO_2 have led to increasing ocean uptake of CO_2, resulting in decreased ocean pH, which is fundamentally changing ocean carbonate chemistry.[15] This process, known as ocean acidification, has been observed in all ocean areas but is particularly noted at high latitudes, where its effects might be expected to partially counteract any increase in abundance due to ocean warming.[16] Admittedly, ocean acidification is not caused by climate change or global warming. Rather, it is a parallel impact resulting from higher atmospheric CO_2 concentrations.[17] Nevertheless, while evidence of the biological effects of ocean acidification is still largely limited to historical observations of the geological record, it is worth noting that during the

9. IPCC, CONTRIBUTION OF WORKING GROUP II, *supra* note 1, at 414.
10. *Id.*
11. *See* William W. L. Cheung et al., *Shrinking of Fishes Exacerbates Impacts of Global Ocean Changes on Marine Ecosystems*, 3 NATURE CLIMATE CHANGE 254, 254–58 (2013).
12. *See* IPCC, CONTRIBUTION OF WORKING GROUP II, *supra* note 1, at 414.
13. William W. L. Cheung et al., *Large Benefits to Marine Fisheries of Meeting the 1.5°C Global Warming Target*, 354 SCIENCE 1591, 1593 (2016).
14. *Id.*
15. *See* IPCC, CONTRIBUTION OF WORKING GROUP II, *supra* note 1, at 1673.
16. *See id.* at 17, 1658, 1673 fig.30-7.
17. *See id.* at 426.

last period in which ocean acidification reached the levels predicted for the year 2100, a mass extinction of marine organisms occurred.[18]

Ocean acidification poses substantial risks to both organism physiology and behavior, as well as to population dynamics in everything from phytoplankton to animals.[19] It may lead to more frequent harmful algal blooms, and, by decreasing the rate of calcification, it is predicted to have potentially catastrophic consequences for corals and shelled marine life such as mollusks and echinoderms.[20] While its *direct* effects on fish are currently considered to be minimal, its *indirect* effects, through destruction of prey and habitat, are predicted to have profoundly detrimental impacts on fisheries, broader ecosystem services, and livelihoods.[21] When combined with ocean warming, the effects of ocean acidification will be amplified.[22] When combined with other existing stressors such as overfishing and pollution, the accumulated negative effects of rapid climatic shifts will not only further complicate the sustainable management of fish stocks, but may well threaten the continued viability of many species.[23]

The impacts associated with climate change are particularly acute in the polar regions.[24] In the Antarctic in particular, studies reveal that, in recent decades, Southern Ocean temperatures have been increasing more rapidly and to greater depth than the global average.[25] In addition, the water chemistry of the Southern Ocean appears to be changing faster than previously estimated, particularly in the deep ocean layers.[26] In other words, the Southern Ocean is both warming and acidifying more rapidly than expected.

While responses to climate-related changes will be highly species specific,[27] of critical importance in the Antarctic context will be the response of

---

18. *See* Quirin Schiermeier, *Earth's Acid Test*, 471 NATURE 154, 155–56 (2011).

19. IPCC, CONTRIBUTION OF WORKING GROUP II, *supra* note 1, at 439–41.

20. *See id.* at 436, 439.

21. *See id.* at 415, 436, 440–42, 1658.

22. *See* Nathalie Hilmi et al., *Towards Improved Socio-Economic Assessments of Ocean Acidification's Impacts*, 160 MARINE BIOLOGY 1773, 1781 (2013); Carol Turley & Kelvin Boot, *The Ocean Acidification Challenges Facing Science and Society*, *in* OCEAN ACIDIFICATION 249, 250–56 (Jean-Pierre Gattuso & Lina Hanson eds., 2011); *see also* U.N. Secretary-General, *Oceans and Law of the Sea*, ¶¶ 8–39, U.N. Doc. A/68/71 (Apr. 8, 2013).

23. *See* IPCC, CONTRIBUTION OF WORKING GROUP II, *supra* note 1, at 17.

24. *See* WORKING GROUP II, INT'L PANEL ON CLIMATE CHANGE [IPCC], CLIMATE CHANGE 2001: IMPACTS, ADAPTATION, AND VULNERABILITY: CONTRIBUTION OF WORKING GROUP II TO THE THIRD ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 803–05 (2001).

25. *See, e.g.*, Peter Convey et al., *Review: Antarctic Climate Change and the Environment*, 21 ANTARCTIC SCI. 541, 548–59 (2009); Dean Roemmich et al., *Unabated Planetary Warming and Its Ocean Structure Since 2006*, 5 NATURE CLIMATE CHANGE 240, 241–42 (2015).

26. *See* Claudine Hauri et al., *Abrupt Onset and Prolongation of Aragonite Undersaturation Events in the Southern Ocean*, 6 NATURE CLIMATE CHANGE 172, 174 (2016).

27. Sci. Comm. on Antarctic Research [SCAR], *Antarctic Climate Change and the Environment – 2017 Update*, at 6, Doc. IP 80 rev.1 (Mar. 21, 2017), https://www.scar.org/antarctic-treaty/actm-papers/atcm-xl-and-cep-xx-2017-beijing-china/2966-atcm40-ip080/file/; *see also* Melody S. Clark et al., *Biodiversity in Marine Invertebrate Responses to Acute Warming Revealed by a Comparative Multi-omics Approach*, 23 GLOBAL CHANGE BIOLOGY 318, 323 (2017); W. James Grecian et al., *Contrasting*

krill, a crustacean which forms the major link in the Antarctic food web between phytoplankton and higher trophic levels, including fish, whales, seals, penguins, albatrosses, petrels, and squid.[28] The dependence of so many upper-level vertebrate predators on a single species—krill—means that any perturbation in the krill population may have ramifications throughout the Southern Ocean system.[29]

According to scientists, significant changes in air temperatures, sea ice, and ocean temperatures in the Antarctic have already impacted krill abundance in some regions.[30] "Future reductions in sea ice may therefore lead to further changes in distribution and abundance across the [entire Southern Ocean], with consequent impacts on foodwebs where krill are currently key prey items for many predator species,"[31] including whales, whose recovery from historical overexploitation will be negatively impacted by changes in krill abundance and distribution.[32] In particular, as a specially adapted low-temperature creature, krill are considered unlikely to be able to adapt to large oscillations in temperature outside the main range of their habitat.[33] Predicted poleward shifts in distribution towards the cold waters that Antarctic krill need to survive will thus only result in their reduced overall production and abundance and in the concentration of demand by predators, including penguins, seals, and whales, into reduced areas.[34] This reduction in abundance and concentration of demand may lead to

---

Migratory Responses of Two Closely Related Seabirds to Long-Term Climate Change, 559 MARINE ECOLOGY PROGRESS SERIES 231, 232 (2016); Tina Sandersfeld et al., *Temperature-Dependent Metabolism in Antarctic Fish: Do Habitat Temperature Conditions Affect Thermal Tolerance Ranges?*, 40 POLAR BIOLOGY 141, 145 (2017); Julie B. Schram et al., *Seawater Acidification More Than Warming Presents a Challenge for Two Antarctic Macroalgal-Associated Amphipods*, 554 MARINE ECOLOGY PROGRESS SERIES 81, 92–94 (2016); Philip N. Trathan & David J. Agnew, *Climate Change and the Antarctic Marine Ecosystem: An Essay on Management Implications*, 22 ANTARCTIC SCI. 387, 388–92 (2010); Jane L. Younger et al., *The Influence of Historical Climate Changes on Southern Ocean Marine Predator Populations: A Comparative Analysis*, 22 GLOBAL CHANGE BIOLOGY 474, 489 (2016).

28. SCI. COMM. ON ANTARCTIC RESEARCH [SCAR], THE SOUTHERN OCEAN OBSERVING SYSTEM: INITIAL SCIENCE AND IMPLEMENTATION STRATEGY 16 (2012), https://www.scar.org/scar_ media/documents/publications/SOOS_Strategy-lowres.pdf.

29. *See* Susie M. Grant et al., *Conservation and Management of Antarctic Ecosystems*, *in* ANTARCTIC ECOSYSTEMS: AN EXTREME ENVIRONMENT IN A CHANGING WORLD 492, 498 (Alex D. Rogers et al. eds., 2012).

30. *See* Hauke Flores et al., *Impact of Climate Change on Antarctic Krill*, 458 MARINE ECOLOGY PROGRESS SERIES 1, 11 (2012).

31. Margaret M. McBride et al., *Krill, Climate, and Contrasting Future Scenarios for Arctic and Antarctic Fisheries*, 71 ICES J. MARINE SCI. 1934, 1949 (2014).

32. Elisa Seyboth et al., *Southern Right Whale (*Eubalaena australis*) Reproductive Success is Influenced by Krill (*Euphausia superba*) Density and Climate*, SCI. REP., June 16, 2016, at 1, 6.

33. *See* Flores et al., *supra* note 30, at 13; Andrew P. Mackey et al., *Antarctic Macrozooplankton of the Southwest Atlantic Sector and Bellinghausen Sea: Baseline Historical Distributions (*Discovery Investigations*, 1928–1935) Related to Temperature and Food, with Projections for Subsequent Ocean Warming*, 59–60 DEEP-SEA RES. II 130, 143 (2012) (observing a poleward shift and retreat to greater depths by zooplankton from the South Georgia ecosystem due to warm temperatures).

34. *See* Trathan & Agnew, *supra* note 27, at 390–91.

competition for krill not only between predators, but between predators and humans engaged in krill fisheries as well.[35]

Moreover, since CO_2 is being absorbed at a higher rate in the cold Southern Ocean than in subtropical waters, a poleward shift will take krill further into more strongly acidified waters, the effects of which will have further adverse impacts on production and lead to further degradation of food-web structure and balance.[36] While there is some evidence that populations of salps (a gelatinous planktonic invertebrate that is 95 percent water and resembles a jellyfish) may be increasing in the Southern Ocean, salps are "not considered to be a major link to higher trophic levels, i.e. pelagic fish, seabirds, [and] whales," and are therefore not likely to replace krill in the food web.[37] Thus, climate change-induced reductions in krill productivity and abundance represent a major threat to the Antarctic ecosystem.[38]

Predicted prospects for expanded fin-fishery production in the Antarctic are similarly less than inspiring. While a reduction in winter sea ice and ice shelves may open up new areas of potential production and enhance demersal and semi-demersal[39] fish production, these areas will remain highly seasonal at best, and thus large increases in fish production are considered unlikely.[40] Mismatches between timing of reproductive effort and availability of prey will affect recruitment[41] in fish and other higher trophic-level species, as will changes in distribution.[42] Indeed, the high level of endemism among the five major groups of fish species present in the Antarctic, together with their particular life-history characteristics, including delayed maturity, reduced growth rates, low mortality rates, larger body size, and longer lifespans, makes them particularly vulnerable to fishing pressure and other ecosystem perturbations such as ocean warming and acidification.[43]

Furthermore, poleward shifts in non-Antarctic pelagic species are unlikely given the circulatory and thermal barriers created by the Sub-Antarctic, Polar,

---

35. *See* McBride et al., *supra* note 31, at 1939, 1944.

36. Hauri et al., *supra* note 26, at 172.

37. McBride et al., *supra* note 31, at 1944–45.

38. *Id.* at 1939.

39. Demersal fish live and feed on or near the bottom of the ocean. Pelagic fish live and feed away from the bottom in the open water column.

40. *See* Lloyd S. Peck et al., *Negative Feedback in the Cold: Ice Retreat Produces New Carbon Sinks in Antarctica*, 16 GLOBAL CHANGE BIOLOGY 2614, 2616–19 (2010) (describing the "interannual variability" of phytoplankton blooms, which would impact higher trophic species).

41. 'Recruitment' refers to "the number of fish surviving to enter the fishery." *Fish Recruitment,* SCOT. GOV'T, http://www.gov.scot/Topics/marine/marine-environment/ecosystems/population/recruitment (last updated July 14, 2014).

42. *See* Trathan & Agnew, *supra* note 27, at 390–91.

43. *See* Erin E. Flynn et al., *Ocean Acidification Exerts Negative Effects During Warming Conditions in a Developing Antarctic Fish*, CONSERVATION PHYSIOLOGY, July 27, 2015, at 1, 2–3; McBride et al., *supra* note 31, at 1940–41; Eugene J. Murphy et al., *Climatically Driven Fluctuations in Southern Ocean Ecosystems*, 274 PROC. ROYAL SOC'Y B 3057, 3057 (2007); *see also* Mark Belchier & Martin A. Collins, *Recruitment and Body Size in Relation to Temperature in Juvenile Patagonian Toothfish (*Dissostichus eleginoides*) at South Georgia*, 155 MARINE BIOLOGY 493, 501 (2008).

and Southern Antarctic Circumpolar Current Fronts (collectively the Polar Front). The Polar Front is the natural boundary where cold, northward-flowing Antarctic waters meet and sink below the relatively warmer waters of the subantarctic. It effectively separates polar waters from the waters to the north and serves as a biogeographic barrier to species dispersal between the Southern Ocean and lower latitudes.[44] Species such as Southern Bluefin Tuna (*Thunnus maccoyii*), which occur in the areas to the north of the Polar Front, are unable to survive in the lower temperature systems to its south.[45] Although there is evidence to suggest there has been a southward shift in the position of the Polar Front in some regions that will allow southward movement of Sub-Antarctic species, "[t]he potential for invasion into the Southern Ocean of large and highly productive pelagic finfish therefore appears low."[46] In other words, Southern Ocean fisheries will remain largely dependent on the species that currently exist there—even as those species are pushed southwards into an ever-decreasing area of cold and increasingly acidified polar water.

It is clear that climate change and associated ocean acidification present varied and complex threats to Antarctic fisheries. In the face of both historic stressors such as whaling, sealing, and ozone depletion, and existing and new stressors such as climate change and ocean acidification, their conservation and sustainable management is thus more important—and more challenging—than ever. The following Part examines the current regime for the conservation and management of Antarctic fisheries as a backdrop to assessing its adequacy for a climate-changed future.

II. CCAMLR AND THE ECOSYSTEM APPROACH TO MANAGING ANTARCTIC FISHERIES

As noted at the outset, conservation and management of Antarctic fisheries is the responsibility of CCAMLR, which was established in 1982 pursuant to the 1980 Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention).[47] The CAMLR Convention establishes CCAMLR as the decision-making body, which makes decisions on the basis of consensus,[48] and the CAMLR Scientific Committee (SC-CAMLR), which is charged with advising CCAMLR on using the best available science.[49]

44. Matthew P. Galaska et al., *Crossing the Divide: Admixture Across the Antarctic Polar Front Revealed by the Brittle Star* Astrotoma agassizii, 232 BIOLOGICAL BULL. 198, 198 (2017).

45. McBride et al., *supra* note 31, at 1949.

46. *Id.*

47. CAMLR Convention, *supra* note 8, at art. VII.

48. *Id.* at art. XII. There are currently thirty-six Contracting Parties, twenty-five Members (including the European Union (EU)), and eleven Acceding States. For information on the Commission and its membership, see *About CCAMLR*, CCALMR, https://www.ccamlr.org/en/organisation/about-ccamlr (last modified Apr. 23, 2015).

49. CAMLR Convention, *supra* note 8, at arts. XIV–XV.

The CAMLR Convention applies to all marine living resources found south of the Antarctic Convergence (as the Polar Front is referred to in the CAMLR Convention), including "fin fish, molluscs, crustaceans and all other species of living organisms, including birds."[50] Although the precise location of the Convergence changes seasonally, the CAMLR Convention deems its location to be determined by a line joining precise geographical points,[51] the importance of which is that this line extends the CAMLR Convention's application well beyond the boundary of the Antarctic Treaty area at 60° South.[52]

At the time CCAMLR was established, several finfish stocks in the Southern Ocean had already been decimated by industrial fishing.[53] Krill stocks were also being heavily targeted, and there were fears of potential consequential effects of increasing catches on krill-dependent species in the Antarctic.[54] It was in this context that CCAMLR became the first international organization charged with an ecosystem mandate.[55]

CCAMLR's task is "to give effect to the objective and principles set out in Article II of [the CAMLR] Convention."[56] The objective of the CAMLR Convention is "the conservation of Antarctic marine living resources," where the term "'conservation' includes rational use."[57] Any harvesting and associated activities are to be carried out in accordance with the following "principles of conservation":

> (a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;
>
> (b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in sub-paragraph (a) above; and
>
> (c) prevention of changes or minimisation of the risk of changes in the marine ecosystem which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the

50. *Id.* at art. I.
51. *Id.*
52. The Antarctic Treaty art. VI, Dec. 1, 1959, 402 U.N.T.S. 71 (entered into force June 23, 1961).
53. *See* KARL-HERMANN KOCK, ANTARCTIC FISH AND FISHERIES 212–13 (1992); David G. Ainley & Louise K. Blight, *Ecological Repercussions of Historical Fish Extraction from the Southern Ocean*, 9 FISH & FISHERIES 1, 1 (2008).
54. *See* Stephen Nicol & Jacqueline Foster, *Recent Trends in the Fishery for Antarctic Krill*, 16 AQUATIC LIVING RESOURCES 42, 42–45 (2003).
55. *See* LYSTER, *supra* note 7, at 157–58.
56. CAMLR Convention, *supra* note 8, at art. IX.
57. *Id.* at art. II, ¶¶ 1–2.

> direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem, and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.[58]

These principles are designed to take into account the delicate and complex relationships between organisms and physical processes that constitute the Antarctic marine ecosystem, and they constitute the embodiment of the ecosystem and precautionary approaches that CCAMLR is tasked with applying to the conservation and management of Antarctic marine living resources.[59] To achieve its purpose, CCAMLR is charged with wide-ranging responsibilities including the power to adopt conservation measures for the designation of catch quotas, protected species, and special areas for protection and scientific study, as well as to adopt any other measures necessary to address the impacts of fishing on the wider ecosystem.[60]

Since climate impacts can be moderated by reducing stresses from other human activities, it is useful to examine the manner in which CCAMLR implements the ecosystem approach in general before turning to its specific response to climate change. This discussion is particularly valuable given that CCAMLR is generally considered to be at the forefront of effective precautionary, ecosystem-based management.[61]

CCAMLR's current approach to achieving conservation of Antarctic marine living resources effectively separates their management into three broad areas: finfish fisheries, krill fisheries, and spatial management. A brief review of these approaches reveals the need for better integration, both across these approaches and of broader ecosystem concerns, if the ecosystem-based conservation objective of the CAMLR Convention is to be fully achieved. As will be seen, this integration is even more essential in the context of climate change.

A. Finfish Fisheries

While a number of finfish fisheries have operated in the Southern Ocean since the 1960s, many have now ceased due to lack of interest or heavy

58. *Id.* at art. II, ¶ 3.

59. Andrew J. Constable et al., *Managing Fisheries to Conserve the Antarctic Marine Ecosystem: Practical Implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR)*, 57 ICES J. MARINE SCI. 778, 779 (2000).

60. CAMLR Convention, *supra* note 8, at art. IX, ¶¶ 1–2.

61. Denzil Miller & Natasha M. Slicer, *CCAMLR and Antarctic Conservation: The Leader to Follow?*, *in* GOVERNANCE OF MARINE FISHERIES AND BIODIVERSITY CONSERVATION: INTERACTION AND COEVOLUTION 253, 253 (Serge M. Garcia et al. eds., 2014); Adriana Fabra & Virginia Gascón, *The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Ecosystem Approach*, 23 INT'L J. MARINE & COASTAL L. 567, 575–76 (2008).

overexploitation in the years before CCAMLR was established.[62] Currently, the only targeted species are Patagonian toothfish (*Dissostichus eleginoides*), Antarctic toothfish (*Dissostichus mawsoni*), and mackerel icefish (*Champsocephalus gunnari*).[63] CCAMLR'S management of these fisheries is based on stochastic projection methods that account for uncertainty in key biological parameters and allow for random recruitment fluctuations.[64] In theory, this allows for the setting of ecosystem-based precautionary catch limits designed to ensure the long-term sustainability of the fishery.[65] In addition to determining catch limits, conservation measures also determine other operational aspects of fisheries such as where, when, and in what manner fishing can be carried out.[66] The objective of these measures is to manage potential impacts on targeted species as well as on associated and dependent species. Broader ecosystem concerns are also accommodated in measures aimed at restricting the use of certain gear types, reducing by-catch of non-target fish species, reducing incidental mortality of seabirds, and prohibiting fishing for sharks.[67]

To ensure that new fisheries are not overexploited before essential management information and baseline data is acquired and management measures are put in place, CCAMLR has, since 1991, required prior notification of any plans to undertake a new fishery and the implementation of various conditions, including the requirement of a Data Collection Plan.[68] "Exploratory fisheries," defined as fisheries that are no longer new but for which critical information remains unavailable, are similarly subject to a range of measures designed to ensure acquisition and submission of relevant data and to preempt overexploitation.[69]

Nevertheless, despite general positive assessments of CCAMLR's finfish management as precautionary,[70] its management is essentially based on single species rather than ecosystem considerations. While scientists involved in

---

62. Ainley & Blight, *supra* note 53, at 5–8.

63. *Fisheries*, CCAMLR, https://www.ccamlr.org/en/fisheries/fisheries (last modified May 31, 2017).

64. Constable et al., *supra* note 59, at 783–84.

65. *Id.* at 783, 786.

66. *See* Rosemary Rayfuse, *Regional Fisheries Management Organisations*, *in* THE OXFORD HANDBOOK OF THE LAW OF THE SEA 439, 449–50 (Donald R. Rothwell et al. eds., 2015). For CCAMLR Conservation Measures, see *Browse Conservation Measures*, CCAMLR, https://www.ccamlr.org/en/conservation-and-management/browse-conservation-measures (last modified Oct. 20, 2014).

67. Rayfuse, *supra* note 66, at 457.

68. CCAMLR, *Conservation Measure 21-01: Notification that Members Are Considering Initiating a New Fishery*, ¶¶ 3, 8, (2016), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//21-01_18.pdf.

69. CCAMLR, *Conservation Measure 21-02: Exploratory Fisheries*, ¶¶ 1, 6 (2016), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//21-02_39.pdf.

70. *See* SC-CAMLR, *Report of the Thirty-Fourth Meeting of the Scientific Committee*, at 22–33, SC-CAMLR-XXXIV (Nov. 2015); Peter A. Abrams et al., *Necessary Elements of Precautionary Management: Implications for the Antarctic Toothfish*, 17 FISH & FISHERIES 1152, 1169 (2016); Andrew J. Constable, *Lessons from CCAMLR on the Implementation of the Ecosystem Approach to Managing Fisheries*, 12 FISH & FISHERIES 138, 139–40, 143 (2011).

CCAMLR are developing integrated ecosystem models, it is unclear whether, and if so, to what extent, these models are influencing CCAMLR's decision making.[71] In addition, while SC-CAMLR takes estimates of illegal, unreported, and unregulated fishing for toothfish into account when developing its management advice, these estimates are inherently uncertain, and thus further undermine the precautionary effect of CCAMLR catch limits.[72] CCAMLR's consensus decision-making procedures also produce catch limits and other measures that are often set on the basis of political, rather than purely scientific considerations.[73] Indeed, recent research suggests that as a result of various knowledge gaps and associated uncertainties, the total allowable catch for the toothfish fishery in the Ross Sea is not set at a sufficiently precautionary level.[74]

Moreover, while assessments of some stocks are well established, as recognized in the Report of the Second CCAMLR Performance Review submitted to the 2017 meeting of the Commission,[75] no consolidated assessments exist of the status of depleted species and their likely trajectories. In other words, little is known about the recovery of historically depleted stocks beyond the fact that, contrary to the implicit expectations of Article II of the Convention that recovery might be potentially reversible in two or three decades, these stocks have still not recovered.[76] Consolidated assessments of the potential for current fisheries to impede recovery of depleted species either directly or indirectly and of the changes to the ecosystem that may arise as a result of the recovery of depleted species are also lacking.[77] In addition, critical factors such as environmental and recruitment relationships are not taken into account in stock assessments.[78] This has led some to suggest that CCAMLR stock assessment work, and thus its fisheries management, may not be as robustly precautionary as is needed to ensure effective ecosystem management into the future.[79]

---

71. *See* Peter A. Abrams, *How Precautionary Is the Policy Governing the Ross Sea Antarctic Toothfish (*Dissostichus mawsoni*) Fishery?*, 26 ANTARCTIC SCI. 3, 6–8 (2014).

72. Fabra & Gascón, *supra* note 61, at 577.

73. *See* Jessica A. Nilsson et al., *Consensus Management in Antarctica's High Seas – Past Success and Current Challenges*, 73 MARINE POL'Y 172, 175–76 (2016) (discussing how international politics play a role in Southern Ocean management).

74. Abrams, *supra* note 71.

75. CCAMLR, *Report of the Second CCAMLR Performance Review Panel, presented to the Thirty-Sixth Meeting of the Commission*, ¶ 31 (Aug. 23, 2017), https://www.ccamlr.org/en/organisation/ second-ccamlr-performance-review-0 [hereinafter CCAMLR PR2 Report].

76. Ainley & Blight, *supra* note 53, at 15; Constable, *supra* note 70, at 139, 142; McBride et al., *supra* note 31, at 1948.

77. CCAMLR PR2 Report, *supra* note 75.

78. *Id.*; Trathan & Agnew, *supra* note 27, at 394.

79. *See* Trathan & Agnew, *supra* note 27, at 394–96.

B. Krill Fisheries

CCAMLR's management of toothfish fisheries has received considerable attention over the years due to its efforts to combat illegal, unreported, and unregulated (IUU) fishing.[80] However, the real core of CCAMLR's development of precautionary ecosystem-based management has centered on the fishery for Antarctic krill, *Euphausia superba*.[81] Importantly, CCAMLR has been able to develop its krill management in advance of heavy commercial exploitation.[82] Although a large krill fishery existed in the 1960s and 1970s, conducted primarily by Soviet vessels, problems with end-product processing as well as the breakup of the Soviet Union in 1991 saw the fishery decline markedly.[83] Only in the past decade has interest in the fishery taken off again, following the introduction of new catching and processing technologies.[84]

Management of the krill fishery is based on "decision rules" derived from three management principles intended to ensure sufficient krill supplies remain available for both marine and land-based predators.[85] These principles require maintaining krill biomass at levels higher than what might be the case if only single-species considerations are taken into account.[86] As the Commission puts it, "CCAMLR's approach to managing the krill fishery is to minimise the impact on the ecosystem rather than trying to maximise the size of the fishery."[87] Total krill biomass in the CCAMLR Area is currently estimated to be around 379 million tonnes spread across various management areas and subareas.[88] In 1991, CCAMLR adopted a "unique and precedent-setting"[89] precautionary krill catch limit of 1.5 million tonnes for Area 48, where total biomass was then estimated at 15 million tonnes, with a 'catch trigger' of 620,000 tonnes, above which catches could not exceed, in each of three specific subareas.[90] The purpose of the

---

80. *See, e.g.*, Denzil G.M. Miller et al., *IUU Fishing in Antarctic Waters: CCAMLR Actions and Regulations*, *in* LAW, TECHNOLOGY AND SCIENCE FOR OCEANS IN GLOBALISATION: IUU FISHING, OIL POLLUTION, BIOPROSPECTING, OUTER CONTINENTAL SHELF 175, 184–96 (Davor Vidas ed., 2010).

81. Constable, *supra* note 70, at 139, 141–42; Stephen Nicol et al., *The Fishery for Antarctic Krill – Recent Developments*, 13 FISH & FISHERIES 30, 30–31 (2012).

82. Stephen Nicol & Yoshinari Endo, *Krill Fisheries: Development, Management and Ecosystem Implications*, 12 AQUATIC LIVING RESOURCES 105, 115 (1999).

83. Karl-Hermann Kock, *Fishing and Conservation in Southern Waters*, 30 POLAR REC. 3, 5 (1994).

84. McBride et al., *supra* note 31, at 1941; Nicol et al., *supra* note 81, at 31–32.

85. SC-CAMLR, *Report of the Thirteenth Meeting of the Scientific Committee*, ¶¶ 5.18–5.26, SC-CAMLR-XIII (Nov. 1994); Denzil G.M. Miller, CCAMLR Management and Conservation of Antarctic Marine Living Resources 37–40 (May 27, 2014) (unpublished manuscript) (copy on file with author).

86. Miller, *supra* note 85; Trathan & Agnew, *supra* note 27, at 394.

87. *Krill Fisheries and Sustainability*, CCAMLR, https://www.ccamlr.org/en/fisheries/krill-fisheries-and-sustainability (last modified Feb. 16, 2018).

88. *Id.*

89. Denzil G.M. Miller et al., *Managing Antarctic Marine Living Resources: The CCAMLR Approach*, 19 INT'L J. MARINE & COASTAL L. 317, 323–24 (2004).

90. CCAMLR, *Conservation Measure 51-01: Precautionary Catch Limitations on* Euphasia superba *in Statistical Area 48* (2002), originally adopted as *Conservation Measure 32/X (1991)*

catch trigger was to avoid unacceptable concentration of large catches within vulnerable predator foraging areas.[91] The precautionary catch limit has since been revised upwards to 5.6 million tonnes while the trigger level remains 620,000 tonnes.[92] Precautionary limits and catch triggers have also been adopted in other management areas where catches cannot exceed the trigger level until CCAMLR has agreed upon a mechanism—which it has yet to do—to spread allocation of the total catch limit between smaller management units.[93] The intention is to avoid concentrating fishing effort in a few areas where locally high catches could potentially adversely impact the local ecosystem.[94] The approach is thus designed to allay concerns relating to the effects of what appears to be a rapidly expanding krill fishery on associated and dependent species such as penguins, seals, and whales.[95]

In recognition of the krill fishery's potential to cause adverse impacts on the broader marine ecosystem, the CCAMLR Ecosystem Monitoring Program (CEMP) was established in 1989 to monitor the impacts of commercial krill fishing on dependent and associated species.[96] CEMP aims to produce monitoring information that can be used to predict the ecosystem impacts of various harvesting strategies, thereby providing the opportunity to avoid serious deterioration of Antarctic marine ecosystem health.[97] To that end, CEMP is charged with detecting and recording significant changes in certain critical components of the marine ecosystem in order to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological.[98] The utility of CEMP is limited, however, by its restriction to only a few sites with limited Member State participation.[99]

---

https://www.ccamlr.org/sites/drupal.ccamlr.org/files//51-01_3.pdf; CCAMLR, *Report of the Tenth Meeting of the Commission,* ¶¶ 6.17, 10.4 (Nov. 1991).

91. Miller, *supra* note 85, at 23.

92. CCAMLR, *Conservation Measure 51-01: Precautionary Catch Limitations on* Euphausia superba *in Statistical Subareas 48.1, 48.2, 48.3 and 48.4* (2010), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//51-01.pdf.

93. *See* CCAMLR, *Conservation Measure 51-02: Precautionary Catch Limitation on* Euphausia superba *in Statistical Division 58.4.1* (2008), http://archive.ccamlr.org/pu/e/e_pubs/cm/11-12/51-02.pdf; CCAMLR, *Conservation Measure 51-03: Precautionary Catch Limitation on* Euphausia superba *in Statistical Division 58.4.2* (2008), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//51-03_2.pdf.

94. CCAMLR, *Report of the Twenty-Ninth Meeting of the Commission*, ¶ 14.2, CCAMLR-XXIX (Nov. 2010).

95. Miller, *supra* note 85, at 23.

96. *CCAMLR Ecosystem Monitoring Program (CEMP)*, CCAMLR, https://www.ccamlr.org/en/science/ccamlr-ecosystem-monitoring-program-cemp (last modified Oct. 23, 2013).

97. *See* Inigo Everson, *Consideration of Major Issues in Ecosystem Monitoring and Management*, 9 CCAMLR SCI. 213, 216–17 (2002).

98. David J. Agnew, *The CCAMLR Ecosystem Monitoring Programme*, 9 ANTARCTIC SCI. 235, 236 (1997); Keith Reid et al., *Antarctic Ecosystem Monitoring: Quantifying the Response of Ecosystem Indicators to Variability in Antarctic Krill*, 62 ICES J. MARINE SCI. 366, 367 (2005).

99. *See* Trathan & Agnew, *supra* note 27, at 395.

Nevertheless, since 2011, CCAMLR has been committed to adopting a feedback-management approach to the krill fishery as a more effective way of achieving the multiple objectives required of an ecosystem approach than the fixed-catch-limit approach permits.[100] However, this goal has presented profound challenges relating especially to the need to meet multiple management objectives for krill, its predators, and the fishery, and the need to factor in ongoing ecosystem changes with multiple putative drivers, including current and past harvesting, and climate change.[101] The effort has also been undermined by high levels of uncertainty in the current understanding of ecosystem structure and functions.[102] These challenges have yet to be overcome. In addition, while CEMP data may be used to feed into the krill feedback management approach, CCAMLR has yet to work out how to use CEMP data in an ecosystem-management strategy that goes beyond the narrow scope of understanding the impacts of the krill fishery.[103] This ongoing failure to adopt a workable krill feedback management strategy rather begs the question as to just how effective CCAMLR's krill management is in a broader ecosystem sense.

C. Spatial Management and Area-Based Measures

The third ecosystem-based management approach adopted to date is spatial management. Here, two primary strategies are evident: the protection of vulnerable marine ecosystems (VMEs), including seamounts, hydrothermal vents, cold water corals, and sponge fields,[104] and the establishment of marine protected areas (MPAs).[105] While relatively little is known about the benthic marine ecosystems in the Antarctic,[106] they are understood to be slow growing, and therefore the impacts of fishing on vulnerable taxa may be magnified because of longer recovery times.[107] Like other RFMOs, CCAMLR has responded to UN General Assembly Resolution 61/105[108] by prohibiting the use

100. *See* SC-CAMLR, *Report of the Thirtieth Meeting of the Scientific Committee*, ¶¶ 3.33–3.35, SC-CAMLR-XXX (Nov. 2011).

101. McBride et al., *supra* note 31, at 1947–48; Miller, *supra* note 85; Trathan & Agnew, *supra* note 27, at 394.

102. Miller, *supra* note 85, at 40.

103. Trathan & Agnew, *supra* note 27, at 395.

104. VMEs constitute areas that may be vulnerable to impacts from fishing activities. Food & Agric. Org. of the United Nations [FAO], *International Guidelines for the Management of Deep-Sea Fisheries in the High Seas* ¶¶ 14–16 (2009), http://www.fao.org/docrep/011/i0816t/i0816t00.htm.

105. MPAs are ocean areas in which human activities are restricted for conservation purposes. WORLD COMM. ON PROTECTED AREAS, GUIDELINES FOR MARINE PROTECTED AREAS, at xi (Graeme Kellher ed., 1999) (discussing the categories and goals of MPAs).

106. Huw J. Griffiths, *Antarctic Marine Biodiversity – What Do We Know About the Distribution of Life in the Southern Ocean?*, PLOS ONE, Aug. 2010, at 1, 6–9 (2010). *But see* Andrew Clarke, *Antarctic Marine Benthic Diversity: Patterns and Processes*, 366 J. EXPERIMENTAL MARINE BIOLOGY & ECOLOGY 48, 53 (2008) (describing new research into the Antarctic benthic ecology over the past two decades and how this research has revolutionized scientists' understanding of the Southern Ocean).

107. *Vulnerable Marine Ecosystems (VMEs)*, CCAMLR, https://www.ccamlr.org/en/science/vulnerable-marine-ecosystems-vmes (last modified Feb. 16, 2018).

108. G.A. Res. 61/105 (Dec. 8, 2006).

of bottom trawling and deep-water gillnets and by otherwise regulating bottom-fishing activities in order to prevent significant impacts on VMEs.[109] Rules have been established to assist fishing vessels in identifying VMEs and setting out the action to be taken in the event of a VME encounter, including immediate cessation of the actual fishing activities and the eventual development by CCAMLR of other management measures.[110] The clear intent of these measures is to avoid or mitigate significant adverse impacts on VMEs during bottom-fishing activities. The procedures are not, however, entirely uncontroversial,[111] and they have given rise to complex discussions relating to the influence of different gear types on VME bycatch, the use of bottom trawls, and the need to extend VME cumulative adverse impact assessments to gear other than longlines.[112]

By far the most controversial area-based approach in recent years has been the adoption of MPAs. In 2002, CCAMLR committed to creating a network of MPAs by 2012, consistent with the targets set by the 2002 World Summit on Sustainable Development.[113] However, it has yet to live up to this commitment. Conservation objectives for MPAs were identified in 2005[114] and a series of benthic and pelagic bioregions were identified in 2007[115] for use as an outline of a possible representative network of CCAMLR MPAs. In 2008, CCAMLR recognized the value of MPAs as a spatial management tool for facilitating the conservation of marine biodiversity,[116] and divided the CCAMLR Area into nine MPA Planning Domains, committing to establishing MPAs in each of them. In

---

109. CCAMLR, *Conservation Measure 22-06: Bottom Fishing in the Convention Area* (2017), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//22-06_20.pdf; CCAMLR, *Conservation Measure 22-07: Interim Measure for Bottom Fishing Activities Subject to Conservation Measure 22-06 Encountering Potential Vulnerable Marine Ecosystems in the Convention Area* (2013), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//22-07_2.pdf; CCAMLR, *Conservation Measure 22-05: Restrictions on the Use of Bottom Trawling Gear in High-Seas Areas of the Convention Area* (2008), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//22-05.pdf. For discussion, see Keith Martin-Smith, *A Risk-Management Framework for Avoiding Significant Adverse Impacts of Bottom Fishing Gear on Vulnerable Marine Ecosystems*, 16 CCAMLR SCI. 177, 184 (2009) ("[A] default consequence of major disturbance is consistent with the precautionary approach used by CCAMLR.").

110. CCAMLR, *Conservation Measure 22-06*, *supra* note 109.

111. Rayfuse, *supra* note 66, at 458.

112. *See* CCAMLR, *Report of the Thirty-Fourth Meeting of the Commission*, ¶ 5.70, CCAMLR-XXXIV (Nov. 2015) (bottom fishing and vulnerable marine ecosystems); CCAMLR, *Report of the Thirty-Third Meeting of the Commission*, ¶ 5.70, CCAMLR-XXXIII, (Nov. 2014) (bottom fishing and vulnerable marine ecosystems); CCAMLR, *Report of the Thirty-Second Meeting of the Commission*, ¶¶ 5.68–5.69, CCAMLR-XXXII, (Nov. 2013) (bottom fishing and vulnerable marine ecosystems).

113. CCAMLR, *Report of the Twenty-First Meeting of the Commission*, ¶¶ 4.19–4.20, CCAMLR-XXI (Nov. 2002).

114. CCAMLR, *Report of the Twenty-Fourth Meeting of the Commission*, ¶¶ 4.12–4.18, CCAMLR-XXIV (Nov. 2005).

115. CCAMLR, *Report of the Twenty-Sixth Meeting of the Commission*, ¶¶ 7.3–7.19, CCAMLR-XXVI (Nov. 2007).

116. CCAMLR, *Report of the Twenty-Seventh Meeting of the Commission*, ¶¶ 7.1–7.2, CCAMLR-XXVII (Nov. 2008); *see also* SC-CAMLR, *Report of the Twenty-Seventh Meeting of the Scientific Committee*, ¶ 3.55 SC-CAMLR-XXVII (2008).

2009, CCAMLR established its first MPA, and one of the first high seas MPAs in the world, covering 94,000 square kilometers on the South Orkney Islands Southern Shelf MPA.[117] However, this MPA applies only to the shelf, not the water column, and thus, in deference to the interests of fishing states, does not affect any fishing activities in the area.[118] Indeed, the originally proposed area was reduced specifically to avoid inclusion of potential crab fishing grounds.[119]

Such compromises continue to haunt the CCAMLR MPA experience and call into question the very efficacy and appropriateness of CCAMLR MPAs as ecosystem management tools. In 2011, CCAMLR adopted a framework to establish MPAs on the basis of the best available scientific evidence and to contribute to the achievement of Convention objectives.[120] Separate proposals were submitted by New Zealand and the United States relating to the Ross Sea, and Australia and France presented proposals for an East Antarctic Region network of MPAs.[121] Germany agreed to take the lead on developing a proposal for an MPA in the Weddell Sea, and the United Kingdom (UK) and the EU proposed a measure on interim protection of areas newly exposed following ice shelf collapse.[122] However, in 2012, both the UK/EU and the German proposals were withdrawn and their preparation suspended pending a demonstration by CCAMLR of "the clear political will to promote MPAs."[123] The proposed East Antarctic MPA was rejected, and despite extensive revision and ongoing negotiations in the intervening years, its future remains uncertain.[124] To date, only the Ross Sea MPA proposal has come to fruition,[125] and then only after years of difficult and often acrimonious debate between proponents and opponents of the proposal, including during the second-ever extraordinary meeting of CCAMLR, held in 2013,[126] and the proposal's extensive

117. CCAMLR, *Conservation Measure 91-03: Protection of the South Orkney Islands Southern Shelf* (2009), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//91-03.pdf.

118. CCAMLR, *Report of the Twenty-Eighth Meeting of the Commission*, ¶¶ 7.4, 7.14, 7.17, CCAMLR-XXVIII (Nov. 2009).

119. *Id.* ¶ 5.4.

120. CCAMLR, *Conservation Measure 91-04: General Framework for the Establishment of CCAMLR Marine Protected Areas* (2011), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//91-04.pdf.

121. CCAMLR, *Report of the Thirtieth Meeting of the Commission*, ¶¶ 7.10–7.30, CCAMLR-XXX (Nov. 2011).

122. *Id.* ¶¶ 7.31–7.36.

123. CCAMLR, *Report of the Thirty-First Meeting of the Commission*, ¶ 7.91, CCAMLR-XXXI (2012).

124. CCAMLR, *Report of the Thirty-Sixth Meeting of the Commission*, ¶¶ 8.29–8.51, CCAMLR-XXXVI (Nov. 2017); CCAMLR, *Report of the Thirty-Fifth Meeting of the Commission*, ¶¶ 8.74–8.84, CCAMLR-XXXV (Nov. 2016).

125. CCAMLR, *Conservation Measure 91-05: Ross Sea Region Marine Protected Area* (2016), https://www.ccamlr.org/sites/drupal.ccamlr.org/files//91-05_2.pdf.

126. CCAMLR, *Report of the Second Special Meeting of the Commission*, ¶¶ 3.57–3.81, CCAMLR-SM-II (July 2013).

consolidation and revision,[127] and what may be euphemistically referred to as its "refinement."

As the Commission's website itself notes, the extensive discussions in the SC-CAMLR and CCAMLR about the establishment of MPAs "are very difficult to summarise."[128] Suffice it to say that despite scientific near-consensus that the dual pressures of climate change and human activity (mostly fishing) justified the establishment of MPAs, achieving political consensus on their establishment ran headlong into perceived economic and political costs. Proponents of the MPAs have argued that they are necessary to safeguard sustainable fisheries while the opponents sought to safeguard unfettered fishing and other interests.[129] Arguments raised by the opponents of the MPAs, in particular China, Japan, Russia, and Ukraine, have included that CCAMLR lacks the legal authority to create MPAs (despite the fact that they had been part of the consensus decision to designate MPAs in 2008[130]), that it lacks any accepted definition of what constitutes an MPA, that the areas to be preserved are not "pristine" and therefore do not warrant protection, that the proposed boundaries are arbitrary, that the proposed areas are excessively large, that the proposals do not specify the specific vulnerabilities to be protected, and that MPAs are unnecessary since CCAMLR already has a system of closures in place and adding more will only complicate research and encourage IUU fishing.[131] It has also been argued that the scientific information and data on which the proposals are based is out of date and therefore does not constitute the best available science, and that the proposals must be time-limited and include provisions for termination of MPA designation, despite the prevailing international practice that MPAs are not time-limited.[132] More fundamentally, opponents have argued that the MPA proposals violate the obligation to permit exploitation of Antarctic marine living resources as provided for in Article II of the CAMLR Convention and that the proposed MPAs are nothing more than thinly veiled attempts by the Antarctic coastal claimant states to assert sovereignty in contravention of the Antarctic Treaty.[133] These latter

127. Cassandra M. Brooks & David G. Ainley, *Fishing the Bottom of the Earth: The Political Challenges of Ecosystem-based Management*, *in* HANDBOOK ON THE POLITICS OF ANTARCTICA 422, 430–32 (Klaus Dodds et al. eds, 2017); *see also* Klaus Dodds et al., *The Politics of Antarctica*, ELGAR BLOG (Feb. 8, 2017), https://elgar.blog/2017/02/08/the-politics-of-antarctica/#more-7049.

128. *Marine Protected Areas (MPAs)*, CCAMLR, https://www.ccamlr.org/en/science/marine-protected-areas-mpas (last modified Jan. 2, 2018).

129. Cassandra M. Brooks et al., *Science-Based Management in Decline in the Southern Ocean*, 354 SCIENCE 185, 185–187 (2016).

130. CCAMLR, *Report of the Twenty-Seventh Meeting of the Commission*, *supra* note 116, ¶¶ 7.8–7.16.

131. CCAMLR, *Report of the Thirty-First Meeting of the Commission*, *supra* note 123, ¶¶ 7.60–7.104, See also CCAMLR, *Report of the Second Special Meeting of the Commission*, *supra* note 126.

132. CCAMLR, *Report of the Thirty-First Meeting of the Commission*, *supra* note 123, ¶ 7.89.

133. *Id.* ¶ 7.97. Article IV of the Antarctic Treaty suspends all territorial claims in Antarctica including those of the seven claimant states: Argentina, Australia, Chile, France, New Zealand, Norway, and the UK. The Antarctic Treaty, *supra* note 52, at art. IV; *see also* CAMLR Convention, *supra* note 8, at art. IV.

objections, in particular, strike at the very heart of the CAMLR Convention objective of conservation, which is defined in Article II as including "*rational* use,"[134] and at the heart of the suspension of territorial claims, which is central to the wider Antarctic Treaty system.[135]

In any event, the Ross Sea Region MPA was finally adopted in 2016. It is the first full purpose high seas MPA in the CCAMLR Area, meaning that it applies to both the water column and the sea floor. The MPA covers 1.55 million square kilometers in the Ross Sea Region in which certain activities are either limited or entirely prohibited in order to meet specific conservation, habitat protection, ecosystem monitoring, and fisheries management objectives.[136] Approximately 72 percent of the MPA is a "no-take" zone in which commercial fishing is forbidden, while in other sections, some harvesting of fish and krill is permitted for scientific research.[137] Unfortunately, commercial fishing effort displaced from the no-take zone has simply been allowed to relocate to formerly closed areas outside the MPA.[138] Moreover, the boundaries of the MPA were significantly reduced from those originally proposed, placing further previously untouched ecosystems at risk.[139] In addition, in order to achieve consensus, proponents of the MPA were forced to agree that the designation will expire after only thirty-five years.[140] It is hardly surprising, then, that CCAMLR has come under considerable criticism for both the rate at which it completed its work on the Ross Sea Region MPA designation and the extent to which that designation is sufficiently enduring and conservation-focused.[141] As the report of the Second CCAMLR Performance Review Panel notes,

> Set against a broad range of studies, which show that for MPAs to be effective, they need to be of long duration and have significant no-take zones, the fact that the Ross Sea MPA expires after [thirty-five] years (which is shorter than the life histories of many birds, mammals and fish that the MPA sets out to protect) raises questions as to the extent to which CCAMLR is in line with MPA best practices.[142]

---

134. *See* CCAMLR, *Conservation at CCAMLR: Understanding Article II of the Convention of the Conservation of Antarctic Marine Living Resources*, Doc. CCAMLR-XXXV/BG/28 (Sept. 17, 2016) (submitted by the Delegations of Australia and the United States) (copy on file with author); CCAMLR, *Implementing Article II of the CAMLR Convention*, Doc. CCAMLR-XXXIV/BG/25 (Sept. 19, 2015) (submitted by Antarctic and Southern Ocean Coalition [ASOC]) (copy on file with author).

135. *See* Alan D. Hemmings et al., *Introduction: The Politics of Antarctica*, *in* HANDBOOK ON THE POLITICS OF ANTARCTICA, *supra* note 127, at 1, 8, 13.

136. CCAMLR, *Conservation Measure 91-05*, *supra* note 125, ¶¶ 1, 3, 7–11. The MPA came into force on December 1, 2017.

137. *Id.*; Press Release, CCAMLR, CCAMLR to Create World's Largest Marine Protected Area (Oct. 28, 2016), https://www.ccamlr.org/en/organisation/ccamlr-create-worlds-largest-marine-protected-area.

138. CCAMLR, *Report of the Thirty-Fifth Meeting of the Commission*, *supra* note 124, ¶ 8.39.

139. *Id.* ¶¶ 8.37–8.49.

140. *Id.* ¶ 8.39; CCAMLR, *Conservation Measure 91-05*, *supra* note 125, ¶ 20.

141. Brooks et al., *supra* note 129.

142. CCAMLR PR2 Report, *supra* note 75, ¶ 33.

The fact that CCAMLR was unable to agree to a further proposal for an East Antarctic MPA in 2017, similarly after many years of acrimonious debates and many environmental and political concessions, reinforces the concern.[143]

The MPA discussions in CCAMLR have laid bare a host of critical tensions between harvesting and non-harvesting member states and between the coastal claimant states and other member states over the meaning of the conservation objective of CCAMLR,[144] and over perceptions of veiled territorial assertions,[145] both of which threaten to fundamentally undermine CCAMLR. Even rejecting such a pessimistic outlook, however, it is clear from CCAMLR's experience in managing krill and finfish fisheries that implementing an ecosystem approach is a complex and challenging task. Grafting climate change impacts onto the range of factors that must already be considered can only complicate the matter. Nevertheless, as climate- and human-induced effects on ecosystem-resource management are unlikely to be reversed, it is necessary to adapt ecosystem management to new ecological regimes. In other words, ecosystem and fisheries management in the Antarctic need to be fully integrated with an understanding of the ecological consequences of climate change. The next Part examines CCAMLR's progress in this regard.

III. CCAMLR AND CLIMATE CHANGE

At its heart, the challenge posed by climate change for any RFMO relates to the organization's ability to manage its fisheries under conditions of uncertainty relating to both the managed fish populations and the broader marine ecosystem. As we have seen, CCAMLR has considerable experience in this regard. However, the uncertainties it has encountered to date have largely been "uncertainties associated with '*status quo*' environmental effects,"[146] and not with climate change effects, which, in addition to changes in species composition, abundance, and location, may push the Antarctic ecosystem beyond certain tipping points and cause fundamental changes in ecosystem structure and function.[147] This begs the question as to whether, and if so to what extent, CCAMLR is moving to actively anticipate *climate* stressors, to absorb their

143. *See* April Reese, *Plans Rejected for East Antarctic Marine Park*, NATURE NEWS (Oct. 27, 2017), https://www.nature.com/news/plans-rejected-for-east-antarctic-marine-park-1.22913.

144. Laurence Cordonnery et al., *Nexus and Imbroglio: CCAMLR, the Madrid Protocol and Designating Antarctic Marine Protected Areas in the Southern Ocean*, 30 INT'L J. MARINE & COASTAL L. 727, 733–35 (2015); Jennifer Jacquet et al., *'Rational Use' in Antarctic Waters*, 63 MARINE POL'Y 28, 29–31 (2016). *See generally* Nilsson et al., *supra* note 73.

145. *See* V.V. Lukin, *Russia's Current Antarctic Policy*, 4 POLAR J. 199, 201–05 (2014); *see also* Kevin A. Hughes & Susie M. Grant, *The Spatial Distribution of Antarctica's Protected Areas: A Product of Pragmatism, Geopolitics or Conservation Need?*, 72 ENVTL. SCI. & POL'Y 41, 42 (2017).

146. Trathan & Agnew, *supra* note 27, at 393.

147. *See* Andrew J. Constable et al., *Climate Change and Southern Ocean Ecosystems: How Changes in Physical Habitats Directly Affect Marine Biota*, 20 GLOBAL CHANGE BIOLOGY 3004, 3005–07, 3018 (2014); Miller, *supra* note 85, at 96.

importance into its decision-making processes, and to reshape its management regimes to address climate-driven changes in the Antarctic marine ecosystem.

A review by the author of RFMO annual reports indicates that most RFMOs treat climate change as a subcategory of general climate fluctuations and not as its own distinct environmental challenge. While multiple references to the importance of ecosystems are common, these references are not necessarily made in the context of considering climate change but rather in the context of considering the interactions between various species. In general, there appears to be considerable commonality between the annual reports of RFMOs, which generally contain a blanket statement that climate change is recognized as possibly affecting the oceans but very little in the way of substantive analysis aimed at determining specific measures to be taken to address its effects. CCAMLR, however, stands out as one RFMO that has specifically placed climate change on its meeting agenda, and has taken positive steps to anticipate the effects of climate stressors on Antarctic marine ecosystems and the fisheries under its management. However, as discussed below, the extent to which CCAMLR has absorbed climate change into its decision-making processes and addressed its effects through the adoption of relevant conservation measures remains limited.

A. Anticipating Climate Stressors

The potential implications of climate change on the Antarctic marine ecosystem have been under general discussion in the SC-CAMLR since 2002.[148] In 2006, CCAMLR itself acknowledged "the need to address climate change effects and to monitor such effects in relation to future potential changes in, and influences on, the species and area for which CCAMLR is responsible."[149] In 2008, the topic of climate change became a regular reporting item on the agendas of both CCAMLR and the SC-CAMLR,[150] indicating recognition of climate change as a problem in its own right and not just another aspect of environmental variability.

The SC-CAMLR has identified a broad range of consequences of climate change that could carry significant risks to Antarctic marine ecosystems, including increasing sea temperature, increasing sea height, changes to global ocean thermohaline circulation, increasing ocean acidification, the introduction of alien species, and increasing accessibility in areas previously restricted by sea

148. *See* SC-CAMLR, *Report of the Twenty-First Meeting of the Scientific Committee*, ¶ 3.11, Annex IV, ¶ 3.88, SC-CAMLR-XXI (2002).

149. CCAMLR, *Report of the Twenty-Fifth Meeting of the Commission*, ¶ 17.3, CCAMLR-XXV (2006).

150. SC-CAMLR, *Report of the Twenty-Seventh Meeting of the Scientific Committee*, *supra* note 116, ¶¶ 7.10–7.16; CCAMLR, *Report of the Twenty-Seventh Meeting of the Commission*, *supra* note 116, ¶¶ 4.61–4.63.

ice to fishing, tourism, and commercial transport.[151] Four major areas of impact have been particularly singled out for consideration by the SC-CAMLR: potential effects on invertebrates, potential effects on higher-trophic levels, potential effects on CCAMLR managed fisheries, and the special effects of increased accessibility associated with the increase in ice-free areas.[152] In furthering CCAMLR's internal capacity to respond to these climate impacts, the SC-CAMLR has focused on three key areas: the robustness of SC-CAMLR advice and stock assessments in light of increasing uncertainty accompanying climate change, the need to improve monitoring programs to provide robust and timely indicators of climate change impacts, and the determination of whether management objectives and performance indicators require modification in the face of climate change uncertainty.[153]

With respect to robustness of stock assessments, CCAMLR's work to date has focused predominantly on the negative effects of climate change and ocean acidification on krill.[154] Indeed, the effects of climate change and ocean acidification on krill have been identified as matters of critical importance to CCAMLR. The SC-CAMLR has identified the anticipated impacts, and both the SC-CAMLR and CCAMLR have acknowledged that the development of a feedback management strategy for the krill fishery would help with adaptation to these impacts.[155] However, no such strategy has yet been adopted. Rather, work is ongoing on building long-term data series that enable disentangling of trends arising from climate change from change due to natural variability, on designing scientific studies capable of predicting or uncovering ecosystem changes at an early stage, and on developing management approaches that work well in a changing climate.[156] The SC-CAMLR has also highlighted the need to develop a risk assessment framework for identifying when climate change and ocean acidification impacts may need attention from CCAMLR.[157] In the meantime, however, the krill stock assessment is still based on a synoptic survey conducted in 2000, and the current decision rules make no provision for how variability in recruitment, growth, and mortality might be affected by climate change.[158]

151. SC-CAMLR, *Report of the Twenty-Seventh Meeting of the Scientific Committee*, *supra* note 116, ¶¶ 7.10–7.14.

152. *Id.* ¶ 7.13.

153. *Id.* ¶ 7.14.

154. *See* SC-CAMLR, *Report of the Thirty-Third Meeting of the Scientific Committee*, ¶¶ 8.4–8.6, SC-CAMLR-XXXIII (2014) (ocean acidification); CCAMLR, *Report of the Thirty-Third Meeting of the Commission*, *supra* note 112, ¶¶ 5.89–5.91 (climate change).

155. SC-CAMLR, *Report of the Thirty-Third Meeting of the Scientific Committee*, *supra* note 154, ¶¶ 5.6–5.11, 8.4 (2014); CCAMLR, *Report of the Thirty-Third Meeting of the Commission*, *supra* note 112, ¶¶ 5.89–5.91 (climate change).

156. *See, e.g.*, *Report of the Thirty-Fourth Meeting of the Scientific Committee*, *supra* note 70, ¶ 8.2.

157. *Id.* ¶¶ 8.5–8.6.

158. *See* Nilsson et al., *supra* note 73, at 176.

With respect to monitoring programs, the SC-CAMLR has recognized the need for sufficiently frequent biodiversity surveys and adequate monitoring programs capable of providing an understanding of climate change-induced responses in species distribution and abundance.[159] In particular, SC-CAMLR has highlighted the limitations of CEMP monitoring, including the need to expand and improve CEMP data collection to enable detection, attribution, and differentiation between changes related to natural variability and those related to climate change.[160] The need to ensure the existence of reference, or control, sites has also been identified as necessary for monitoring changes and attributing them to climate or other impacts.[161] The SC-CAMLR has also recognized that climate change may impact the manner in which the monitoring information generated by CEMP might be used to detect fisheries impacts on associated and dependent species.[162] In other words, climate change may undermine the usefulness of CEMP data in predicting ecosystem impacts of various harvesting strategies. Nevertheless, no strategy currently exists for the coordinated collection of information on predator-prey interactions, habitat variables, and population biology,[163] and debate persists as to what constitutes relevant scientific data for the purpose of observing and monitoring the effects of climate change.[164] Work is ongoing to consider whether existing data is sufficient to assess climate change impacts or whether new approaches or mechanisms for the acquisition and sharing of data are needed.[165]

With respect to possible modification of management objectives and performance indicators, in 2017 Australia and Norway proposed the adoption of Climate Change Response Work Programs by both the SC-CAMLR and CCAMLR. The objective of such work programs would be:

> to provide a mechanism for identifying and revising goals and specific actions by the Commission and SC-CAMLR to support efforts within the Antarctic Treaty system to prepare for, and build resilience to, the environmental impacts of a changing climate and the associated implications for the governance and management of the Southern Ocean and the conservation of Antarctic marine living resources.[166]

Although the proposal was widely supported, Russia and China in particular refused to join the consensus and the proposal was not adopted.[167] Other

---

159. SC-CAMLR, *Report of the Twenty-Ninth Meeting of the Scientific Committee*, ¶ 8.4, SC-CAMLR-XXIX (2010).

160. SC-CAMLR, *Report of the Twenty-Eighth Meeting of the Scientific Committee*, ¶¶ 7.11–7.15, SC-CAMLR-XXVIII (2009).

161. *Id.* ¶¶ 7.12–7.13.

162. *Id.* ¶¶ 3.8–3.13, 3.101–3.104.

163. CCAMLR PR2 Report, *supra* note 75, at 18.

164. *See, e.g.*, SC-CAMLR, *Report of the Thirty-Fifth Meeting of the Scientific Committee*, ¶¶ 8.1–8.24, SC-CAMLR-XXXV (2016) (debating over the "risk assessment" model).

165. *See id.*

166. CCAMLR, *Proposal for a Climate Change Response Work Program for CCAMLR*, Doc. CCAMLR-XXXVI/20, https://www.ccamlr.org/en/ccamlr-xxxvi/20.

167. CCAMLR, *Report of the Thirty-Sixth Meeting of the Commission*, *supra* note 124, ¶ 7.7.

members of CCAMLR expressed considerable disappointment at this failure to move forward on the issue of incorporating considerations of climate change into the deliberations of CCAMLR in a more structured fashion.[168]

B. Absorbing Climate Change into Decision-Making Processes

There is no doubt that CCAMLR recognizes the critical importance of climate change to its work. Resolution 30/XXVIII, adopted in 2009, recognizes climate change as one of the greatest challenges facing the Southern Ocean and urges increased consideration of climate change impacts in the Southern Ocean to better inform CCAMLR's management decisions.[169] Clearly, appropriate management decisions can mitigate some of the negative impacts of climate change on the Southern Ocean. However, application of the ecosystem and precautionary approaches at the heart of the CAMLR Convention requires more than just encouragement of consideration of climate impacts. It also requires the actual integration of these considerations into CCAMLR's decision-making. Verifiable progress in this respect has been slow.

A 2014 proposal aimed at formalizing this integration through a requirement to include a climate change implication statement in all CCAMLR and SC-CAMLR working papers and fisheries reports was met with objection.[170] Instead, in 2015, the Commission agreed to the establishment of an Intersessional Correspondence Group (ICG) to provide the SC-CAMLR and CCAMLR with information, advice, and recommendations as to how they might more appropriately integrate climate change impacts into their work.[171] The ICG again suggested the idea of climate change implications statements and also proposed that work proceed on assessing the status and trends of habitats, key species, and ecosystems for the purpose of assessing the effects of climate change, and that climate change response work programs be developed for both the SC-CAMLR and CCAMLR.[172] The ICG also endorsed the recommendations from the second Joint CEP-SC-CAMLR Workshop on Climate Change and Monitoring,[173] particularly those relating to interactions with the Scientific Committee on

168. *Id.* ¶¶ 7.7–7.20.

169. CCAMLR Res. 30/XXVIII, *Climate Change* (2009).

170. CCAMLR, *Report of the Thirty-Third Meeting of the Commission*, *supra* note 112, ¶¶ 5.93–5.97; *see also* CCAMLR, *Incorporating Climate Change into CCAMLR's Decisionmaking Processes*, Doc. CCAMLR-XXXIII/BG/21 (Sept. 20, 2014) (submitted by the Antarctic and Southern Oceans Coalition [ASOC]) (copy on file with author).

171. CCAMLR, *Report of the Thirty-Fourth Meeting of the Commission*, *supra* note 112, ¶ 7.12; *see also* CCAMLR, *Establishing an Intersessional Correspondence Group (ICG) to Consider Approaches for Appropriately Integrating Climate Change into the Work of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)*, Doc. CCAMLR-XXXIV/31 (Sept. 4, 2015) (submitted by the Delegations of Australia and Norway) (copy on file with author).

172. CCAMLR, *Report of the Thirty-Fifth Meeting of the Commission*, *supra* note 124, ¶¶ 7.1–7.14.

173. *Id.* ¶ 8.38; *see also* CCAMLR, *Co-conveners' Report of the Joint CEP–SC-CAMLR Workshop on Climate Change and Monitoring – Introduction for WG-EMM-16*, Doc. WG-EMM-16/30 (June 16, 2016).

Antarctic Research, mechanisms for enhancing cooperation, and data access and data sharing between the Committee on Environmental Protection for Antarctica and the SC-CAMLR.[174]

Despite extensive discussion about the need for processes for the better integration of climate change considerations into decision making, no existing conservation measures have yet been amended with the obvious intent of incorporating climate change and ocean acidification effects. However, as discussed in the following subpart, CCAMLR has adopted two new conservation measures with direct relevance to climate change.

C. Addressing Climate-Driven Changes in Antarctica

The challenge for CCAMLR in addressing climate-driven changes in Antarctic marine ecosystems has both internal and external aspects. The internal challenge relates to its willingness and ability to adopt conservation measures either expressly or implicitly aimed at addressing the impacts of climate change and ocean acidification. Externally, the challenge for CCAMLR arises as a result of climate-induced species migration.

CCAMLR adopted its first specifically climate change-related conservation measures in 2016. Conservation Measure 24-04 establishes time-limited Special Areas for Scientific Study in newly exposed marine areas following ice-shelf retreat or collapse.[175] The origins of this measure lay in discussions in the SC-CAMLR in 2009 and 2010 and the EU/UK proposal for interim MPA protection of newly ice-free areas that was withdrawn in 2012.[176] At the time of its withdrawal, CCAMLR noted that the establishment of interim special areas for scientific research in marine habitats and communities exposed following ice-shelf collapse was inherently different in nature from the long-term closure of areas as envisaged by an MPA.[177] This did not necessarily make the idea any more palatable to harvesting member states looking forward to ready access to new fishing areas and the proposal was rejected.[178] Nevertheless, the proposal for interim protection of such areas was reintroduced in 2015,[179] and after extensive revision, finally adopted in 2016.[180]

CM 24-04 establishes a two-phase process for the protection of areas newly exposed by ice-shelf retreat or collapse.[181] Retreat is defined as the "landward

174. CCAMLR, *Report of the Thirty-Fifth Meeting of the Commission supra* note 124, ¶¶ 7.1–7.11.

175. CCAMLR, *Conservation Measure 24-04: Establishing Time-Limited Special Areas for Scientific Study in Newly Exposed Marine Areas Following Ice-Shelf Retreat or Collapse in Statistical Subareas 48.1, 48.5 and 88.3* (2016).

176. *See* discussion *supra* Part II.C.

177. CCAMLR, *Report of the Thirty-First Meeting of the Commission*, *supra* note 123, ¶ 5.63.

178. *Id.* ¶ 7.88.

179. CCAMLR, *Report of the Thirty-Fourth Meeting of the Commission*, *supra* note 112, ¶¶ 7.1–7.9.

180. CCAMLR, *Report of the Thirty-Fifth Meeting of the Commission*, *supra* note 124, ¶¶ 5.86–5.90.

181. CCAMLR, *Conservation Measure 24-04*, *supra* note 175, ¶ 3.

movement of the ice front such that there is a loss of more than 10 percent of the areal extent of an individual ice shelf, glacier, or ice tongue within any ten-year period from 2016 onwards," while collapse is defined as "the break up or disintegration of an ice shelf, glacier or ice tongue over a period that may be shorter than [ten] years."[182] During the first stage of protection, which will commence forty-eight hours after all members have been notified of the retreat or collapse, the area will be granted a provisional designation as a Special Area for Scientific Study for a period of up to two years, in order to allow detailed review of available data, including relevant fishery-research proposals.[183] The second stage of protection, to be accorded by the Commission on advice from the SC-CAMLR, will allow for designation as a Special Area for Scientific Study for up to ten years to enable research into ecosystem processes in relation to climate change.[184] While special conditions apply to fishery- and harvesting-related research, such research is permitted, although as with concerns raised over exploratory fishing, this may give rise to concerns of veiled commercial activity, or at least of serial overfishing by researchers from an increasing number of member states.

The second measure related to climate change, albeit in a less direct manner, is the Ross Sea Region MPA designation.[185] The 2011 general framework for the adoption of MPAs specifically notes that one objective of MPAs is the protection of areas to maintain their resilience and their ability to adapt to the effects of climate change.[186] In particular, MPAs can serve as control or reference areas for monitoring both natural variability and long-term change as well as the ecosystem effects of climate change and fishing. This function is specifically recognized in the stated objectives of the Ross Sea Region MPA,[187] although it is severely undermined by the limitation of the MPA to a period of thirty-five years.[188] At the time of writing, the possibility of CCAMLR adopting further MPAs seems speculative at best. However, even assuming new MPAs are adopted, their utility and efficacy as climate change reference zones (or for any other purpose) is likely to be highly circumscribed by the political and scientific compromises that have been necessary to secure their approval.

As noted above, the adoption of conservation measures relates to matters internal to CCAMLR. However, climate change also poses external challenges. As noted in Part II above, the CAMLR Convention Area is defined by reference to geographically fixed coordinates that approximate the location of the Antarctic Convergence as it was when the Convention was adopted.[189] Since 2008,

182. *Id.* ¶ 2.
183. *Id.* ¶¶ 3, 5–7.
184. *Id.* ¶¶ 3, 13–18.
185. CCAMLR, *Conservation Measure 91-05*, *supra* note 125.
186. CCAMLR, *Conservation Measure 91-04*, *supra* note 120.
187. CCAMLR, *Conservation Measure 91-05*, *supra* note 125, ¶ 3.
188. *See supra* Part II.C.
189. CAMLR Convention, *supra* note 8, at art. I.

however, it has been known that the Antarctic Convergence is moving poleward.[190] In other words, as ocean warming continues, the geographical limits of the Convention Area will increasingly be at odds with the biological boundary. While warm-water species may not be able to penetrate the Polar Front,[191] they will increasingly be able to penetrate into the CCAMLR Area.

Where species or stocks migrate outside the area of competence of one RFMO into an area regulated by another, this may lead to conflict between the two RFMOs as to the proper locus of managerial competence. CCAMLR was confronted with this very issue in 2005 when it was discovered that Southern Bluefin Tuna (SBT) were migrating southwards into the CCAMLR area.[192] The concern for CCAMLR was that vessels ostensibly fishing for SBT might either engage in unreported fishing for CCAMLR stocks or take CCAMLR-regulated stocks as unreported bycatch.[193] CCAMLR recognized that an overlap existed between its responsibilities and those of the Commission on the Conservation of Southern Bluefin Tuna (CCSBT), which has jurisdiction over SBT throughout their migratory range.[194] CCAMLR therefore decided to pursue conclusion of an agreement with the CCSBT defining the respective responsibilities of the two commissions in relation to SBT fishing in the CAMLR Convention Area.[195] The issue was eventually resolved on the basis of an agreement between CCAMLR and the CCSBT that provides, inter alia, for reciprocal exchange of data and information on fisheries and fishing activities relevant to each organization.[196] CCAMLR has adopted similar agreements with other RFMOs whose geographical competence borders the CAMLR Convention Area.[197]

In summary, as noted in Part II, climate change impacts can be moderated by reducing stresses from existing human activities. Thus, more effective implementation by CCAMLR of the ecosystem approach would already go some way to alleviating the climate change threat, thereby ensuring that CCAMLR meets its conservation objective. However, responding to the full range of climate-related changes, including changes in water temperature, oxygenation, ocean acidity, ocean currents, and species distribution and abundance, will

---

190. *See* Sarah T. Gille, *Decadal-Scale Temperature Trends in the Southern Hemisphere Ocean*, 21 J. CLIMATE 4749, 4760–61 (2008); Trathan & Agnew, *supra* note 27, at 390.

191. *See supra* Part I.

192. CCAMLR, *Report of the Twenty-Fourth Meeting of the Commission*, ¶ 15.21, CCAMLR-XXIV (2005).

193. *See id.*

194. Convention for the Conservation of Southern Bluefin Tuna Article 1, https://www.ccsbt.org/en/content/basic-documents-commission.

195. CCAMLR, *Report of the Twenty-Fourth Meeting of the Commission*, *supra* note 192, ¶¶ 15.21–26.

196. Arrangement between the Commission for the Conservation of Southern Bluefin Tuna and the Commission for the Conservation of Antarctic Marine Living Resources, CCSBT-CCAMLR, Oct. 30, 2015, https://www.ccamlr.org/en/system/files/CCSBT.pdf.

197. *See, e.g.*, Arrangement between The South East Atlantic Fisheries Organisation and The Commission for the Conservation of Antarctic Marine Living Resources, Jun. 2, 2017, https://www.ccamlr.org/en/organisation/cooperation-others.

require an even more highly integrated ecosystem-management approach that specifically considers the effects of climate-related changes on both individual species and on the broader marine ecosystem.

There is no doubt that CCAMLR has clearly recognized that climate change poses serious threats to the Antarctic marine environment. It has even taken the step of making climate change a regular reporting item on the Commission and SC-CAMLR agendas. However, to date CCAMLR has not fully evaluated and assessed the effects of current fishing activities on the Antarctic marine ecosystem, let alone the effects of future climate change. In addition, CCAMLR has yet to fully factor climate change into its decision-making processes or to adopt a comprehensive range of precautionary and ecosystem-based conservation measures capable of mitigating the adverse effects of climate change on the marine living resources under its management. As Miller puts it, "[s]hould ecological or marine living resources thresholds ('tipping points') be reached, reactive management alone is unlikely to achieve sustainable outcomes for target stocks,"[198] or, indeed, for the broader marine ecosystem. The Commission still needs to develop robust strategies and measures for responding to climate change-induced ecosystem changes if it is to achieve the Convention objective.

CONCLUSION

As noted at the outset, climate change-induced changes in species composition, distribution, and abundance pose significant threats to global fish stocks. They also pose significant challenges for international fisheries management. These challenges can be viewed not just as questions of ecosystem resilience, but also of the institutional resilience of the RFMOs charged with their conservation and management.

In terms of ecosystem resilience, it is generally recognized that an ecosystem-based management approach is needed. However, as the experience of CCAMLR demonstrates, implementing the ecosystem approach is not easy, and it is rendered even more difficult in the context of climate change. In terms of institutional resilience, while it may be true that the solution to climate change lies not with CCAMLR (or RFMOs in general), but rather with the international climate regime, it is CCAMLR that is charged with conserving Antarctic marine living resources. If it fails to do so, it fails to meet its responsibility to the international community, calling into question its continued utility.

CCAMLR is generally considered to be the preeminent regional conservation management organization that also manages fishing activities.[199] To maintain this position, CCAMLR needs to eschew narrow political interests and move forward on truly proactive precautionary ecosystem-based

198. Miller et al., *supra* note 85, at 96.
199. CCAMLR PR2 Report, *supra* note 75, ¶ 67.

management that adequately incorporates changes due not only to natural variability but to climate change as well. This will require moving from words to action on a host of matters. These include the adoption of outstanding MPA proposals, and the development of a strategy or timetable of work for SC-CAMLR to assess climate change impacts on Antarctic marine living resources and provide advice to the Commission on how to deal with climate change and ocean acidification. In addition, CCAMLR must implement the proposals of the ICG and develop approaches for integrating consideration of the impacts of climate change impacts into its work. If CCAMLR, with its express ecosystem-wide conservation mandate, cannot sustainably manage its fisheries in a climate change-challenged world, then there is little hope for other RFMOs.