Unravelling the Maze of Multilateral Environmental Agreements: A Macroscopic Analysis of International Environmental Law and Governance for the Anthropocene

by

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Declaration

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of the author's knowledge, it contains no material previously published or written by another person, except where due reference is made in the text.

With the exception of Chapter 1 (Introduction) and Chapter 6 (Conclusions), this thesis consists of a series of manuscripts that are published in peer-reviewed journals. Each manuscript is presented here as it appears in the relevant journal with the exception of minor changes in style and formatting. Because the key chapters of this thesis are manuscripts developed for independent publication, some repetition between chapters was unavoidable.

- A variant version of Chapter 2, co-authored with Brendan Mackey, is published in *International Environmental Agreements: Politics, Law and Economics* (2013) doi:10.1007/s10784-013-9225-2. (The author's contribution to the material in Chapter 2 is 95 percent.)
- A variant version of Chapter 3 is published in *Global Environmental Change: Human and Policy Dimensions* (2013) doi:10.1016/j.gloenvcha.2013.07.006.
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The author's name appears as **Rakhyun E. Kim** in the publications.

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Abstract

Earth has entered a new geological epoch, the Anthropocene, where humans have become a major driver of global environmental change. Many believe, however, that current international environmental law is a maze of international agreements, and it is unsuitable for navigating the Anthropocene. It is generally agreed that, for global sustainability, this institutional maze needs to be modelled in ways more appropriately aligned with the functioning of the Earth system itself.

For the purpose of improving the alignment, this PhD thesis explores the structural and functional dynamics of multilateral environmental agreements (MEAs) as a systemic whole in relation to Earth system dynamics. The thesis begins with a preliminary review of international environmental law through the lens of a specific systems theory called complex adaptive systems. It then provides two parallel empirical studies on the macroscopic structure and function of the MEA system. In terms of the structure, I quantitatively analysed and characterized the topological properties of the dynamic web of 747 MEAs as approximated by 1,001 cross-references found in their texts. This network analysis provided novel insights into how MEAs have self-organized into an interlocking network with complex topology and what the emergent order looks like. In terms of the function, I conducted a qualitative case study on ocean acidification to examine whether the networked system of MEAs is autonomously capable of filling the regulatory gap through mutual adjustments. Inherent weaknesses in the polycentric order were observed, which led to the conclusion that a new MEA on ocean acidification is necessary. Despite the interlocking structure, the MEA system is currently limited by its design to a piecemeal approach to global environmental governance.

The conceptual and empirical studies provided several implications for the design of international environmental law in the Anthropocene. In particular, the thesis makes a case that the absence of an international environmental *grundnorm* is preventing a more purposive, systemic continuum of laws, one that would ensure policy coherence across Earth's subsystems. The thesis concludes that international environmental law needs a clearly agreed, unifying goal to which all international regulatory regimes are legally bound to contribute. I suggest that this goal should be about the protection of the integrity of Earth's life-support systems.

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List of Treaties and Other International Instruments

The following list includes only treaties and other international instruments cited in this thesis. The complete list of 747 multilateral environmental agreements used in Chapter 3 can be found in Appendix B.

Agenda 21: Programme of Action for Sustainable Development, UN Doc. A/CONF.151/26, 14 June 1992.

Agreement between the United States of America and Canada on Great Lakes Water Quality, Ottawa (Canada), 22 November 1978, into force 22 November 1978.

Agreement Establishing the World Trade Organization, Marrakesh (Morocco), 15 April 1994, in force 1 January 1995.

Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, New York (United States), 4 December 1995, in force 11 December 2001.

Antarctic Treaty, Washington, D.C. (United States), 1 December 1959, in force 23 June 1961.

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Basel (Switzerland), 22 March 1989, in force 5 May 1992.

Charter of the United Nations, San Francisco (United States), 26 June 1945, in force 24 October 1945.

Convention for the Conservation of Antarctic Seals, London (United Kingdom), 11 February 1972, in force 11 March 1978.

Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris (France), 22 September 1992, in force 25 March 1998.

Convention on Biological Diversity, Rio de Janeiro (Brazil), 5 June 1992, in force 29 December 1993.

Convention on International Trade in Endangered Species of Wild Fauna and Flora, Washington, D.C. (United States), 3 March 1973, in force 1 July 1975.

Convention on Long-range Transboundary Air Pollution, Geneva (Switzerland), 13 November 1979, in force 16 March 1983.

Convention on the Conservation of Antarctic Marine Living Resources, Canberra (Australia), 20 May 1980, in force 7 April 1982.

Convention on the Conservation of Migratory Species of Wild Animals, Bonn (Germany), 23 June 1979, in force 1 November 1983.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London (United Kingdom), 13 November 1972, in force 30 August 1975.

Convention on Wetlands of International Importance, especially as Waterfowl Habitat, Ramsar (Iran), 2 February 1971, in force 21 December 1975.

Declaration of the United Nations Conference on the Human Environment, UN Doc. A/Conf.48/14/Rev. 1 (1973), 16 June 1972.

Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, UN Doc. UNEP(OCA)/LBA/ IG.2/7, 5 December 1995.

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997, London (United Kingdom), 2 November 1973, in force 2 October 1983 (1978 Protocol), 19 May 2005 (1997 Protocol).

Kyoto Protocol to the United Nations Framework Convention on Climate Change, Kyoto (Japan), 11 December 1997, in force 16 February 2005.

Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal (Canada), 16 September 1987, in force 1 January 1989.

North American Free Trade Agreement, Washington, D.C. (United States), Ottawa (Canada), Mexico City (Mexico), 17 December 1992, in force 1 January 1994.

Plan of Implementation of the World Summit on Sustainable Development, Report of the World Summit on Sustainable Development, UN Doc. A/CONF.199/20, 4 September 2002.

Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean, Barcelona (Spain), 10 June 1995, in force 12 December 1999.

Protocol on Environmental Protection to the Antarctic Treaty, Madrid (Spain), 4 October 1991, in force 14 January 1998.

Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, London (United Kingdom), 7 November 1996, in force 24 March 2006.

Rio Declaration on Environment and Development, UN Doc. A/CONF.151/26/Rev.1 (Vol. I), 14 June 1992.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, Rotterdam (The Netherlands), 10 September 1998, in force 24 February 2004.

Stockholm Convention on Persistent Organic Pollutants, Stockholm (Sweden), 22 May 2001, in force 17 May 2004.

The Future We Want, UNGA Resolution A/RES/66/288 (Annex), 11 September 2012.

United Nations Convention on the Law of the Sea, Montego Bay (Jamaica), 10 December 1982, in force 16 November 1994.

United Nations Framework Convention on Climate Change, New York (United States), 9 May 1992, in force 21 March 1994.

Universal Declaration of Human Rights, Paris (France), 10 December 1948.

Vienna Convention for the Protection of the Ozone Layer, Vienna (Austria), 22 March 1985, in force 22 September 1988.

Vienna Convention on the Law of Treaties, Vienna (Austria), 23 May 1969, in force 27 January 1980.

World Charter for Nature, UNGA Resolution A/RES/37/7, 28 October 1982.

List of Acronyms and Abbreviations

Basel Convention	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
$CaCO_3$	Calcium carbonate
CAS	Complex adaptive system
CBD	Convention on Biological Diversity
CCAMLR	Convention on the Conservation of Antarctic Marine Living Resources
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CO_2	Carbon dioxide
COP	Conference of the Parties
CS-SSGF	CO_2 Sequestration in Sub-seabed Geological Formations
Global Programme of Action	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
Kyoto Protocol	Kyoto Protocol to the United Nations Framework Convention on Climate Change
LBSMP	Land-based sources of marine pollution
London Convention	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter
London Protocol	1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972
Madrid Protocol	Protocol on Environmental Protection to the Antarctic Treaty
MARPOL Convention	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997
MEA	Multilateral environmental agreement
MEPC	Marine Environment Protection Committee
OSPAR Convention	Convention for the Protection of the Marine Environment of the North-East Atlantic
PhD	Doctor of Philosophy
ppm	Parts Per Million
Ramsar Convention	Convention on Wetlands of International Importance, especially as Waterfowl Habitat
Rotterdam Convention	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
SCAR	Scientific Committee on Antarctic Research
Stockholm Convention	Stockholm Convention on Persistent Organic Pollutants
UNCLOS	United Nations Convention on the Law of the Sea
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

UNFSA or United Nations Fish Stocks Agreement	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
UNGA	United Nations General Assembly
VCLT	Vienna Convention on the Law of Treaties

Chapter 1.

Introduction

Human societies are facing multiple interlinked global environmental challenges, such as climate change, biodiversity loss, and ocean acidification (Steffen et al. 2004). These planet-wide problems are threatening the integrity of Earth's life-support systems, hence the sustainability of humanity (e.g., Millennium Ecosystem Assessment 2005a).

At the international level, states have responded to the global environmental challenges principally by establishing issue-specific institutions and agreements (Carlarne 2008; Walker et al. 2009). Over time, the body of international environmental law has accumulated to over seven hundred multilateral environmental agreements (MEAs) (Mitchell 2013). The growing regime density (Young 1996) has naturally led to more institutional conflicts (Wolfrum and Matz 2003) and interactions (Young 2002; Oberthür and Gehring 2006; Oberthür and Stokke 2011). What has emerged as a result is a *de facto* 'system' of global environmental governance (Najam et al. 2004), which is typically understood as a messy and complex "maze of interlocking multilateral agreements" (UNEP 2012, p. v).

The analytical point of departure of this thesis is the proposition that global ecological sustainability is facilitated or impended in part by the degree of alignment between the institutional maze and the functioning of the Earth system itself (UNEP 2012; see also Young 2002; Cormac 2003; Robinson 2003; Galaz et al. 2008; Young 2008; Young and Steffen 2009). This so-called 'problem of fit' between the existing global institutional architecture and the dynamic behaviour of the Earth system has led to repeated calls for global institutional reform by the scientific community (e.g., Biermann et al. 2012a; Galaz et al. 2012a). However, the theoretical and methodological challenges of moving into an integrated analysis of the 'problem of fit' are enormous (Newell et al. 2005; Young et al. 2006; Galaz et al. 2008; Ekstrom and Young 2009).

For an integrated analytical framework, a detailed understanding of the internal complexity of both institutional and biophysical systems is a prerequisite (e.g., Underdal 2010; Steffen 2011). Without this knowledge, well-intended institutional reforms could backfire due to the double complexity within both the regulating and regulated systems (Galaz 2011; see also Senge 1990; Galaz et al. 2012b). Fortunately, the understanding of Earth as a complex system has significantly advanced in the last few decades through Earth system science

(Schellnhuber 1999; Lawton 2001; Schellnhuber et al. 2004; Steffen et al. 2004; Schellnhuber et al. 2009; Rockström et al. 2009a; Reid et al. 2010). However, we still have a limited understanding of what the maze of MEAs looks like and how it behaves as a whole (Biermann 2007; Biermann et al. 2009b). For the purpose of addressing the problem of fit, it is necessary to first unravel the institutional maze and comprehend its complexity.

In this thesis, I investigate the macroscopic structural and functional dynamics of the body of 747 MEAs in relation to Earth system dynamics. I take a *systems* approach to international environmental law and governance, paying particular attention to institutional relations. I investigate the validity and utility of conceptualizing the agreement network as a complex, and possibly adaptive, system. For the empirical part of this thesis, interdisciplinary research methods are employed, including quantitative network analysis and qualitative legal and institutional analysis.

The thesis aims to contribute to several bodies of scholarship by improving our understanding of the MEA system with unique perspectives and methods. The major areas of academic contribution include: (1) the architecture and fragmentation of international environmental law (e.g., Doelle 2004; Biermann 2007; Stephens 2007; Carlarne 2008; van Asselt et al. 2008; Biermann et al. 2009b; Bosselmann 2010; Boyd 2010; Scott 2011; van Asselt 2012); (2) the governance dimensions of planetary boundaries in the Anthropocene (e.g., Rockström et al. 2009; Walker et al. 2009; Young and Steffen 2009; Folke et al. 2011; Steffen et al. 2011b; Steffen et al. 2011c; Vidas 2011; Biermann 2012; Biermann et al. 2012a; Biermann et al. 2012b; Galaz et al. 2012a; Galaz et al. 2012b; Galaz et al. 2012c; Nilsson and Persson 2012; Griggs et al. 2013; Scott 2013); and (3) the application of complex systems theory and network analysis to law and governance (e.g., Emison 1996; Ruhl 1997; Post and Eisen 2000; Fowler et al. 2007; Smith 2007; Duit and Galaz 2008; Katz et al. 2008; Ruhl 2008; Bommarito and Katz 2009; Hegazi et al. 2009; Katz et al. 2009; Bommarito and Katz 2010; Boulet et al. 2010; Duit et al. 2010; Katz and Stafford 2010; Boulet et al. 2011; Ruhl 2012).

1.1. Research Context

1.1.1. Planetary Boundaries and the Anthropocene

Since the Industrial Revolution, human activities have significantly altered global environmental conditions (Steffen et al. 2004). The environmental impact of human resource use has rapidly increased in recent centuries as a function of population, affluence, and technology (Ehrlich and Holdren 1971; Holdren and Ehrlich 1974). In the face of the global ecological crisis, scientists have repeatedly warned that Earth has limited carrying capacity (Arrow et al. 1995; Wackernagel and Rees 1996; Steffen et al. 2004). About 40 years ago, for example, Meadows et al. (1972) argued that human societies were likely to face the limits of economic growth (see also Meadows et al. 1992; Meadows et al. 2004). Others introduced similar concepts, such as 'safe minimum standards' (Ciriacy-Wantrup 1952, Bishop 1978, Crowards 1998) and tolerable windows (German Advisory Council on Global Change 1995, Petschel-Held et al. 1999), which placed greater emphasis on the protection of the environment wherever thresholds of irreversible damage were threatened. In the law and policy arena, the precautionary principle has been repeatedly referenced in various laws and policies (Cameron and Abouchar 1991; O'Riordan and Cameron 1994; Raffensperger and Tickner 1999; Foster et al. 2000; VanderZwaag 2002; Sunstein 2005; Gillespie 2007).

Building on these approaches, a group of leading Earth system and environmental scientists has identified nine key "biophysical processes of the Earth System that determine the self-regulating capacity of the planet" (Rockström et al. 2009b): climate change; biodiversity loss; interference with the nitrogen and phosphorus cycles; stratospheric ozone depletion; ocean acidification; global freshwater use; changes in land use; chemical pollution; and atmospheric aerosol loading.[1] Each of these so-called 'planetary boundaries' is associated with a threshold, which if crossed, could push the Earth system beyond the Holocene state, that is, outside the envelope of natural variability (e.g., Petit et al. 1999). Planetary boundaries, therefore, represent a safe set of global environmental conditions within which human societies should operate (Rockström et al. 2009a).

However, three of these interlinked boundaries – biodiversity loss, climate change, and interference with the nitrogen and phosphorus cycles – have already been overstepped (Rockström et al. 2009a).[2] The current rate of species extinction is estimated to be 100 to 1,000 times the background rate, which is around 0.1 to 1 species per million per year (Mace et al. 2005). Due mainly to the combustion of fossil fuels and deforestation, the global average temperature has increased by about 0.8 degrees Celsius since the beginning of the 20th century (Hansen et al. 2010). The manufacture of fertilizer for food production and the cultivation of

[1] The scientists acknowledged that there could be need for additional planetary boundaries or the reformulation of existing ones as scientific research will continue to uncover more insights into the dynamics of the Earth system (Steffen et al. 2011c).

[2] For a detailed description of the method used to quantify planetary boundaries, see Rockström et al. (2009b).

leguminous crops convert around 120 million tons of nitrogen (N_2) from the atmosphere per year into reactive forms, which is more than the combined effects from all Earth's terrestrial processes (UNEP and WHRC 2007; Gruber and Galloway 2008; Cordell et al. 2009). Much of this new reactive nitrogen ends up in the environment, polluting the waters, accumulating in land systems, and exacerbating climate change (Foley et al. 2005; Pinder et al. 2012). Other planetary boundaries such as ocean acidification are also under serious pressure (Orr et al. 2005; Hoegh-Guldberg et al. 2007; Fabry et al. 2008; Doney et al. 2009).

Earth is no longer driven solely by natural physical processes, but increasingly influenced by humans (Steffen et al. 2004; Steffen et al. 2007). At the turn of the century, Crutzen (2000) suggested that Earth is entering a new geological epoch named the Anthropocene, where human societies have become a global geophysical force (see also Steffen et al. 2004; Steffen et al. 2007; Steffen et al. 2011a; Steffen et al. 2011b).

The planetary boundaries framework and the idea of the Anthropocene have significant implications for international environmental law and governance. They have reiterated the need to "set limits to the total human impact on planetary systems" (Biermann 2012, p. 5). This line of thinking goes to the root meaning of sustainable development, the current understanding of which needs to be revisited. Since the publication of the Brundtland Report, the popular notion became: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987, Chapter 2, para. 1). This single-sentence definition, however, is an anthropocentric conception that does not place necessary emphasis on the ecological foundation of the socio-economic system (Taylor 1998; Bosselmann 2008).[3] A revised definition in light of planetary boundaries science has been recently proposed as "development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depends" (Griggs et al. 2013, p. 306). This new definition acknowledges that development can be sustainable only if it respects the limited carrying capacity of Earth's ecosystems. It follows

[3] It must be noted that the Brundtland Report's definition of sustainable development also includes a couple of points which further elaborate on two key concepts: "the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs" (World Commission on Environment and Development 1987, Chapter 2, para. 1). Furthermore, pagagraphs 9, 10, 11 13 and 14, for example, make more detailed comments on ecological and environmental limits. Therefore, the oft-quoted definition of sustainable development (i.e., the first sentence of paragraph 1) is not what the Brundtland Commission intended (Bosselmann 2008).

that international environmental law and governance would need to reorganize around this reinterpreted sustainable development paradigm.

In addition to the challenge of development within a limited carrying capacity, governing institutions need to consider how to address the issues that arise from complex, non-linear *interactions* among planet's biophysical subsystems or processes (Galaz et al. 2012c; Nilsson and Persson 2012). The planetary boundaries are tightly coupled (Rockström et al. 2009a). If one transgresses, others follow, often accompanying "secondary effects that cascade rapidly in time and space" (Folke et al. 2011, pp. 730–731; see also Walker et al. 2009; Galaz et al. 2011). In fact, each boundary position assumes that no other boundary is transgressed (Rockström et al. 2009b). One solution may be to design institutions that match not only individual planetary boundaries, but also their interactions (Galaz et al. 2012c; Nilsson and Perrson 2012). To that end, as I will elaborate further in Chapter 2, a systems lens may provide a common language that could aid our understanding of the social and ecological systems within a single integrated framework (Newell et al. 2005).

The value in taking a macroscopic, *Earth system* perspective has gained recognition among natural scientists (Schellnhuber 1999; Lawton 2001; Schellnhuber et al. 2004; Steffen et al. 2004; Reid et al. 2010). Governance scholars are also recognizing its usefulness and significance, and have developed a new paradigm of 'Earth system governance', which is envisioned as one that facilitates the transformation from dedicated, single-institution environmental policy to governance systems that encompass all aspects of the Earth system (Biermann 2007; Young et al. 2008; Young and Steffen 2009; Biermann 2012; Biermann et al. 2012a; Biermann et al. 2012b). It is now timely to apply the Earth system perspective to the study of international environmental law and consider if it should be transformed into what might be called, 'Earth system law'. The concept of Earth system law is intended to mean a fully functioning complex adaptive system of environmental laws that adaptively manages other complex adaptive natural and social systems (c.f., Ruhl 2012). It would respect planetary scale tipping points and pays due consideration to the dynamic interconnections of Earth system components.

1.1.2. Reductionism in International Environmental Law

International environmental law comprises thousands of global and regional norms that aim to regulate state conduct for the protection of Earth's living and non-living elements and processes (Kiss and Shelton 2004). This legal system has grown in size as the international community has adopted over 1,100 MEAs (including amendments) and over 1,500 bilateral environmental agreements (Mitchell 2013). International environmental law today covers many areas of environmental concern, ranging widely from wetlands conservation to global climate change.

Despite the growing body of international environmental agreements, global environmental conditions have continued to deteriorate (Millennium Ecosystem Assessment 2005a; Intergovernmental Panel on Climate Change 2007b). There are a number of explanations for the apparent ineffectiveness of international environmental law and governance. One of the most discussed is the lack of political will to implement treaty provisions and the difficulty in enforcing them (e.g., Haas et al. 1993; Handl 1994; Chayes et al. 1995; Cameron et al. 1996; Sands 1996; Victor et al. 1998; Brown Weiss and Jacobson 2000; Raustiala 2000; Doelle 2005). This, however, only gives a partial explanation.

Consider, for example, whether the best intentions of individual regimes and full compliance with individual commitments would ensure adequate protection of the integrity of Earth's life-support systems. The answer to this question is not as obvious as it may seem. For environmental legislation to become effective, broader coverage and better enforcement are not enough (Bosselmann 2010). We also need to make sure that piecemeal efforts to protect the environment lead to net improvements, rather than simply transferring harm or hazards from one area or medium to another or transforming one type of harm to another (IUCN Environmental Law Programme 2010). In this context, a little discussed but significant issue is the flawed design of international environmental law which has so far prevented a holistic view of the complex interrelationship among different components of the environment.

The prevailing paradigm of environmental reductionism and the associated micro-legal focus on single problems are both at the root of the challenge. Reductionism is a philosophical position that considers a complex system as nothing but the sum of its parts, and that it can be understood in a deterministic and predictable manner in terms of how individual constituents work (Gallagher and Appenzeller 1999). Taking a reductionist approach to the global environment, states and international institutions have largely failed to recognize the important, non-linear and complex interconnections between Earth's subsystems (Ruhl 1997; Bosselmann 2010). For example, climate change and biodiversity loss have been viewed, by and large, as separate problems, hence the institutional interlinkages between the United Nations Framework Convention on Climate Change and the Convention on Biological Diversity have not been concretely established (Locke and Mackey 2009; van Asselt 2012). Environmental reductionism has resulted in what many scholars call the 'fragmentation' of international environmental law and governance (Doelle 2004; Stephens 2007; Carlarne 2008;

van Asselt et al. 2008; Biermann et al. 2009b; Bosselmann 2010; Boyd 2010; Scott 2011; van Asselt 2012).

The perils of environmental reductionism are clearly exemplified in how geoengineering has been treated under international environmental law (Victor 2008; Davis 2009; Victor et al. 2009; Scott 2013). Geoengineering typically involves some kind of large-scale technological intervention in a natural global biophysical process with an aim to reduce the impact of planetary-scale problems such as climate change (Keith 2000). It can be understood as the opposite approach to the planetary boundaries framework that focuses on the complex-system nature of Earth (Steffen 2011). Geoengineering's underlying assumption is that Earth is a simple, linear-response system that can be tinkered with like a car engine (Allenby 2012; see also Bellamy et al. 2012). But, Earth is a complex system, driven by non-linear feedbacks, and full of surprises (Steffen et al. 2004). By addressing symptoms rather than the underlying causes, geoengineering approaches are likely to result in unintended consequences for the planetary environment, some of which can be catastrophic to life on Earth (Allenby 2012).

Yet, international environmental law as a whole has no effective governing principle in relation to geoengineering (Victor 2008; Scott 2013). Its governance has been left to the discretion of individual, fragmented regimes. For example, the Convention on Biological Diversity put a moratorium on ocean fertilization (CBD 2010, Decision X/33), while the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 and 1996 Protocol Thereto are currently seeking to regulate it (London Protocol 2009; London Protocol 2010; London Protocol 2011). This apparent regime conflict highlights "the inadequacies inherent in the decentralized and fragmented international legal system" (Freestone and Rayfuse 2008, p. 232).

Due to such institutional fragmentation and the conflicts arising therefrom, metaphorically speaking, international environmental laws and policies may have saved some 'trees', but the 'forest' is being lost (Bosselmann 2010). It is imperative that we improve the design of international environmental law to safeguard the 'forest', that is, Earth's life-support system.

1.2. A Gap in the Literature

In the absence of a single legislature (Palmer 1992), the architecture of international environmental law (whatever that looks like) has not been shaped by institutionalized decision-making at the aggregate level. It has gradually evolved from the numerous decentralized decisions taken within individual institutions and their interactions (Oberthür and Gehring 2011). Therefore, a *macroscopic* approach (de Rosnay 1979) targeted at the aggregate level is required to understand the emergent structure and function of international environmental law.

However, scholars so far have either taken a telescopic or microscopic approach to the subject, leaving a significant gap in the literature. A telescopic approach considers international environmental law as more or less a unitary body and studies it in relation to other branches of international law (e.g., Boyle 2007). A microscopic approach, on the other hand, focuses on individual MEAs while ignoring the context in which they operate (e.g., Underdal 1992; Haas et al. 1993; Young 1999). Most textbooks on international environmental law indeed treat sub-special fields such as hazardous wastes and air pollution in separate chapters with little discussions on how these relate to each other (e.g., Sands 2003; Kiss and Shelton 2004; Louka 2006; Kiss and Shelton 2007; Birnie et al. 2009).

What law and governance scholars have so far claimed is that international environmental law is structurally congested (Brown Weiss 1993; Hicks 1999; Anton 2012b) and fragmented (Stephens 2007; Carlarne 2008; Biermann et al. 2009b; van Asselt 2012). It should be noted, however, that such claims are often based on anecdotal evidence (Ivanova and Roy 2007). In fact, the dismissal of international environmental law as simply fragmented in a binary manner might be a reflection of our inability to comprehend and embrace complexity in both the subject matter and the legal system itself. The presumptive notion of fragmentation would have prevented us from seeing systemic properties that emerge from interconnections therein.

In terms of functionality, the effectiveness of international environmental law as a whole has not received sufficient attention. Traditional benchmarks to measure its effectiveness include whether individual regimes or mechanisms succeed in addressing the challenges for which they were created and the degree to which states participate and comply (Jacobson and Brown Weiss 1995). Although there is increasing documentation of concerns over conflicts, coherence, and coordination among MEAs (Chambers 2008; see also Young 2002; Wolfrum and Matz 2003; Doelle 2004; Biermann et al. 2009a; Oberthür 2009), these studies have often been limited in scope to dyadic interactions (Biermann 2007). More recently, the scope has extended to regime complexes (Raustiala and Victor 2004; Keohane and Victor 2011), broader consequences (Underdal and Young 2004), and synergies (Oberthür and Gehring 2006). However, these studies still remain at the level of causal chains, clusters, and limited regime complexes, and fall short of unveiling the emergent dynamics of the entire MEA system.

This significant gap in the literature – the absence of a macroscopic approach – is largely due to methodological challenges (Gehring 2004; Chambers 2008), especially in the environmental law context (Fisher et al. 2009). Previous studies on environmental treaties "had to be methodologically reductionist to be successful" and the macro-level architecture of the *system* of institutions has remained largely outside the focus of the major research programs (Biermann 2007, p. 332). However, as noted above, a reductionist enquiry has inherent limitations to fully comprehend the dynamics of any complex system (Gallagher and Appenzeller 1999). Systems need to be understood as systems. Furthermore, it is contradictory to apply a reductionist approach when the problem is how to grasp the whole.

1.3. Research Questions and Scope

The overarching research question addressed by this thesis is: How does systems theory improve the macroscopic understanding and effectiveness of international environmental law? Sub-questions that are addressed by individual chapters are as follows:

Q1. Can international environmental law be validly thought of as a complex adaptive system of MEAs?

Q2. What are the network *structural* properties of the MEA system, and what do they reveal about international environmental law?

Q3. Is the existing MEA system structure *functionally* capable of self-organization to fill regulatory gaps?

Q4. What are the most important implications of system thinking for the design of international environmental law?

Neither the boundary of international environmental law nor the MEA system can be clearly defined. International law comprises international environmental law along with other sub-fields such as international human rights law and trade law. International environmental law, in turn, is composed of treaties and subsidiary agreements, general principles, and customs. However, it is important to note that the establishment of MEAs and their evolution have primarily driven the making and evolution of modern international environmental law (Sand 2007). In this thesis, therefore, I have placed the analytic focus on MEAs and their relationships. Further discussions on the scope of international environmental law for the purpose of this thesis and the method for deciding which international instrument is an MEA are provided in Chapter 2 and Chapter 3, respectively.

Global environmental governance is understood as a broader system that includes international environmental law and other non-legal institutions (Biermann and Pattberg 2008; Kotzé 2012). In terms of scope, this thesis does not consider in detail the role of other inter- and non-governmental organizations (see Section 6.2).[4] Therefore, while this study draws on and contributes to the global environmental governance literature, the use of the term 'governance' is restricted throughout the thesis.

1.4. Methodological Propositions

1.4.1. Environmental Law Methodology

My methodological approach is based on the framework of 'environmental law methodology' (Westerlund 1997; Ebbesson 2003; Carlman 2007; Westerlund 2008; Jóhannsdóttir 2009; Jóhannsdóttir et al. 2010). This methodology conceptualizes law as a control system (Carlman 2007; Westerlund 2008) and focuses on the active role of law in achieving the overall objective of ecological sustainability (Jóhannsdóttir et al. 2010). In other words, the methodology goes beyond a reactive, legal-dogmatic perspective; a common method that describes and analyses the existing instruments and forms of environmental protection (Ebbesson 2003).

The effectiveness of law as an instrument for reaching particular environmental objectives is assessed through *external* eyes from the perspective of its object (Carlman 2007). Such an external and instrumental perspective of law is based on the understanding that the environmental significance of law is not restricted to law as an instrument for command and control, but also includes law as something that might contribute to the negative environmental impact (e.g., climate mitigation measures adversely impacting biodiversity) (Westerlund 2008). Environmental law methodology, therefore, considers that it is critically important to "understand *how* law works from a systemic point of view and that any control system needs

[4] However, intergovernmental organizations are considered indirectly by including treaties that established them in Chapter 3.

to be as advanced as the objects being controlled by the system" (Jóhannsdóttir et al. 2010, p. 141).

This research is based on the underlying assumption that for international environmental law to be effective, it needs to be a model of the Earth system. In their studies, a number of environmental law and governance scholars have applied the Conant and Ashby theorem (e.g., Ruhl 1997; Ruhl 2008; Duit et al. 2010), which states that "every good regulator of a system must be a model of that system" (Conant and Asbhy 1970, p. 89). In particular, Duit et al. (2010) suggested that Ashby's Law of Requisite Variety – "only variety can destroy variety" (Ashby 1956, p. 207; see also Ashby 1958) – is the conceptual root of literature on institutional diversity and redundancy (Low et al. 2003; Ostrom 2005), polycentrism (McGinnis 2000; Ostrom 2010a; Ostrom 2010b; Aligica and Tarko 2011), adaptive governance (Dietz et al. 2003; Folke et al. 2005; Olsson et al. 2006), and reflexive governance (Orts 1995; Gaines 2003; Voss et al. 2006). It holds that for international environmental law to be efficaciously adaptive, the variety of its internal order (internal complexity) must match the variety of the environmental constraints (external complexity).

1.4.2. A Complex Adaptive Systems Perspective

This thesis explores international environmental law through the perspective of a specific systems theory called complex adaptive systems (CASs) as pioneered most notably by researchers at the Santa Fe Institute (e.g., Gell-Mann 1995; Holland 1995; Kauffman 1995; Arthur et al. 1997; Levin 1999; Mitchell 2009). A CAS is "a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behaviour, sophisticated information processing, and adaptation via learning or evolution" (Mitchell 2009, p. 13; see also Holland 1992; Dooley 1997; Levin 1998; Levin 2002; Miller and Page 2007). It has been proposed that examples of a CAS exist at multiple levels of organization, including fisheries (Wilson 2006; Mahon et al. 2008), ecosystems (Levin 1998), and Earth as a whole (Lenton and van Oijen 2002).

There are a few reasons why CAS theory has been applied. First, changes in the Earth system are interconnected in ways that are archetypal for the behaviour of CASs (see Section 2.2.2; see also Lenton and van Oijen 2002; Steffen et al. 2004). Second, CASs have characteristics that can handle the complex dynamics in a turbulent environment through self-organization (e.g., Dooley 1997). Third, as both a CAS and international environmental law share characteristics of decentralized networks, the CAS model may be an appropriate fit for international environmental law. For these reasons, the CAS framework has been applied to studies of environmental law (Ruhl 1997), policy (Emison 1996) and management (Ostrom, E. 1999; Dietz et al. 2003; Rammel et al. 2007). In particular, the 'new wave' of global environmental governance scholars, especially those of the Stockholm Resilience Centre (Folke et al. 2005; Folke 2006; Duit and Galaz 2008), the Resilience Alliance (Berkes et al. 2003; Walker and Salt 2006), and the Complex Adaptive Systems Initiative (Janssen and Martens 1997; Janssen 1998), have adopted CAS theory as a framework for addressing social-ecological challenges. They share a common premise that the command-and-control approach to natural resource management has inherent limitations (Holling and Meffe 1996), and that there is no panacea, or a single governance-system blueprint that solves all environmental problems (Ostrom et al. 2007). Drawing on the Santa Fe Institute's work and other systems thinkers (e.g., Ashby 1956; Schelling 1978; Capra 1996; Axelrod and Cohen 1999; Gunderson and Holling 2002), these scholars have emphasized the significance of institutional diversity (Ostrom 2005), redundancy (Low et al. 2003) and self-organization (Dietz et al. 2003; Folke et al., 2005; Olsson et al., 2006) in a polycentric (Ostrom 2010b; Cole 2011; Galaz et al. 2012c), nested (Dietz et al. 2003), or network organizational setting (Janssen et al. 2006).

1.4.3. Analytical Methods

A major challenge of this research was the task of *empirically* studying international environmental law as an integrated whole (e.g., Holland 2006). I asked the question: What analytical methods are available to go beyond a conceptualization exercise and empirically study international environmental law as a whole in addition to studying its constituents?

Such a task can be daunting as the units of international environmental law as a complex system are heterogeneous, they interact non-linearly, and external perturbations are constantly changing (Amaral and Ottino 2004). Nevertheless, specialized analytical tools exist for the study of complex systems (Ottino 2003; Newman 2011), such as non-linear dynamics and chaos, agent-based models (Janssen and Ostrom 2006; Janssen et al. 2010), network analysis (Strogatz 2001; Boccaletti et al. 2006), and case studies (Anderson et al. 2005; Duit et al. 2010). Taking into account their applicability to the study of international environmental law, this research employs network analysis and case study analysis as empirical methods for understanding the structural and functional dynamics, respectively.

1.4.3.1. Network Analysis

Network theory is a widely applied tool for the description, analysis, and understanding of complex systems (Ottino 2003; Newman 2011). A network approach, in essence, uncovers the underlying system architecture by reducing a system to an abstract structure capturing only the basics of connection patterns between its components (Newman 2010). Global environmental governance and natural resource management scholars have increasingly noted the merits of the network approach (Janssen et al. 2006; Bodin and Crona 2009; Booher and Innes 2010; Crona and Hubacek 2010; Newig et al. 2010; Rathwell and Peterson 2012). In particular, it has been applied to the study of the structure of legal systems (Katz et al. 2008; Katz et al. 2009; Casanovas et al. 2010; Katz and Stafford 2010), such as the United States' case law system and the Code of Laws (Post and Eisen 2000; Fowler et al. 2007; Smith 2007; Fowler and Jeon 2008; Bommarito and Katz 2009; Bommarito and Katz 2010; Katz and Stafford 2010), and the French system of legal codes (Boulet et al. 2010; Boulet et al. 2011).

Applying a network approach enabled the identification of underlying patterns in the organization of the MEA system and map out the complexity that underpins international environmental law. In particular, a network perspective shed light on the conceptual black box called 'fragmentation' by offering an empirical evidence-based approach to quantifying when, where, and to what extent the system was structurally fragmented. Furthermore, observing structural dynamics over time also enhanced our understanding of where the system is at in its evolutionary history with the possibility of projecting into the future.

Different ways exist for mapping out international environmental law as a network. One possibility is to consider MEAs as nodes, which would produce an agreement-level connectivity map of international environmental law. One proxy for inter-MEA relationships is cross-references that are found in MEA texts. Marine MEAs, for example, often cite the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 or the United Nations Convention on the Law of the Sea, including their rules by reference. Kiss and Shelton (2007, p. 87) argued that the result of such cross-referencing could be to "extend the legal effect of these instruments to states that have not ratified them but which ratify the texts that cite them". This cross-referencing effectively creates a web of law. Applying network analysis to this web of MEA cross-references could help visualize the overall structure of the system and reveal the complex interrelationships among the plethora of MEAs.

1.4.3.2. Case Study Analysis

According to Duit et al. (2010, p. 364), "[a]nalyses of governance and complex systems can gainfully be conducted using qualitative and case-study approaches". The key for such qualitative case studies would be to direct analysis towards identifying system dynamics and governance efforts to handle complexity (Duit et al. 2010). Existing studies on interplay and interlinkages, especially in the regime complex context (Keohane and Victor 2011), involving an array of institutions, would fall into this category of analysis.

Studies published in a special section of *Ecological Economics* provide a good set of examples (Galaz et al. 2012c; Nilsson and Persson 2012; Reischl 2012). These studies employed empirical cases for the analysis of multilevel governance challenges associated with planetary boundaries. For example, Galaz et al. (2012c) employed a case study of the Global Partnership on Climate, Fisheries and Aquaculture initiative, where the interplay between individuals and international organizations was found to give rise to collaboration patterns and polycentric order to address complex interactions among climate change, ocean acidification, and loss of marine biodiversity. In another study, Reischl (2012) explored how coordination has taken place within one specific issue area of environmental governance, the forest regime complex, through a case study of the Collaborative Partnership on Forests.

Furthermore, Young's studies on the institutional dynamics of environmental and resources regimes are noteworthy in this context (Young 2010a; Young 2010b). His book, a collection of case studies on institutional dynamics of environmental regimes at the international level (Young 2010a), demonstrated the usefulness of the case study approach to identifying the *emergent patterns* in international environmental governance. Such case studies can enhance our understanding of the emergent properties of laws and governance systems. In this thesis, I also used the case study approach to better understand how the MEA system behaves in response to an emerging environmental problem, namely ocean acidification.

1.5. Thesis Structure

This PhD thesis consists of four key chapters which are either already published or under consideration for publication in peer-reviewed journals (see Declaration). Given this, separate literature review and methodology chapters have not been written as it is more appropriate to include in each of the four main chapters their own literature review and methods sections. The overall thesis organization is illustrated in Figure 1.1.

Following this Introduction, Chapter 2 considers the validity of conceptualizing international environmental law as a CAS by reviewing relevant system theories and various multidisciplinary lines of evidence. This is intended as a preliminary review that sets the context for the following structural (Chapter 3) and functional (Chapter 4) analyses.

Chapter 3 analyses the macroscopic structure of international environmental law as approximated by 1,001 cross-references found in 747 MEAs concluded between 1857 and 2012. I employ network theory and its analytical tools to visualize and quantitatively measure the dynamic structural properties of the entire MEA system.

Chapter 4 examines the macroscopic behaviour of international environmental law through a qualitative case study on institutional responses to the newly emerging global environmental problem of ocean acidification. I investigate whether MEAs are able to fill the regulatory gap through mutual adjustments in the absence of an authoritative coordinator.

Based on the conceptual and empirical analyses in the preceding chapters, Chapter 5 makes normative recommendations for improving the effectiveness of international environmental law as a whole for the Anthropocene.

Finally, Chapter 6 summarises the key findings and contributions, reflects on the limitations of the research, and outlines future research directions.

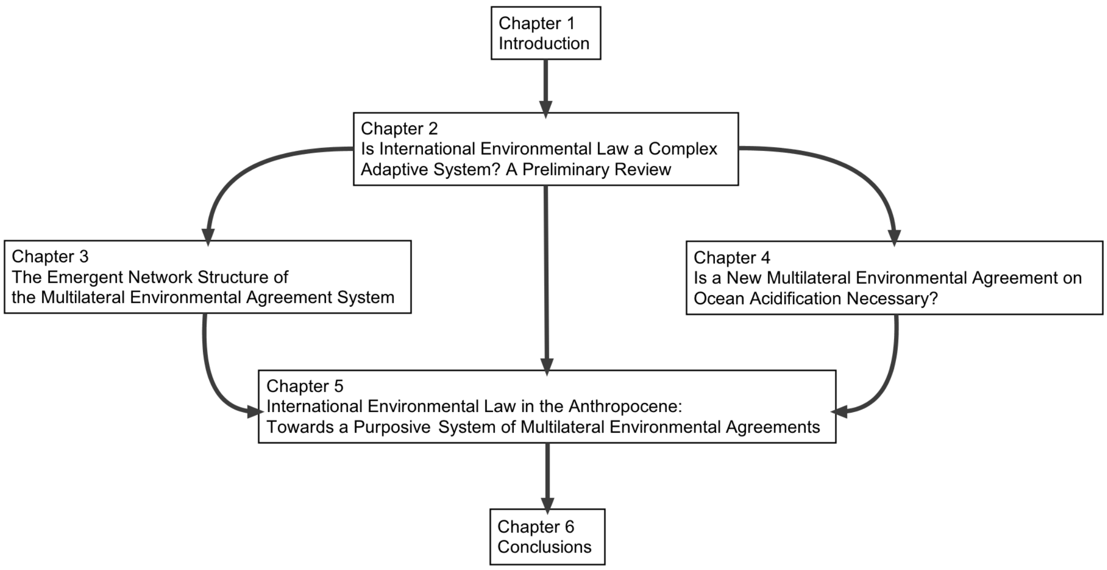


Figure 1.1. Organization of the thesis. Chapter 2 is a preliminary review that leads to parallel empirical analyses in Chapters 3 and 4. Chapter 5 contains normative recommendations made in light of the findings and conclusions of the three preceding chapters.

Chapter 2.

Is International Environmental Law a Complex Adaptive System? A Preliminary Review

Abstract

Complex adaptive systems are a special kind of system with emergent properties and adaptive capacity in response to external environmental conditions. In this chapter, I investigate the proposition that international environmental law, as a set of multilateral environmental agreements, exhibits the characteristics of a complex adaptive system. This proposition is premised on the scientific understanding that the subject matter displays properties of a complex adaptive system. If so, the legal system may benefit from the insights gained and from being modeled in ways more appropriately aligned with the functioning of the Earth system itself. I provide as context a scientific explanation of the Earth system as a complex adaptive system. I then consider if international environmental law can be understood as a system, which is complex and adaptive. From this exploratory review, I found evidence suggesting that international environmental law is a system with interactive elements. I also found indications of self-organization and emergence, suggesting that international environmental law is a complex system. However, it is still questionable whether the legal system has been autonomously adaptive to and co-evolving with global environmental and geopolitical change in ways that lead to net environmental improvement.

2.1. Introduction

Understanding social and ecological phenomena as systems can reveal useful insights (e.g., Senge 1990; Sterman 2000; Meadows 2008; Newman 2011). Examples where systems thinking has been useful range widely from ecosystems (Levin 1999) to international law (International Law Commission 2006; D'Amato 2009). Despite their obvious differences, a systems lens provides a common language that could aid our understanding of the social and ecological systems within a single integrated framework (Newell et al. 2005). This study lays the groundwork for ongoing studies that use the systems language to better align a human governance system, in this case, international environmental law, with the Earth system.

The application of systems thinking to international environmental law dates back at least to the 1970s (e.g., Birnie 1977; Kiss and Shelton 1986), when scholars began to ponder whether a distinctive system of law emerged, not just more random environmental norms. Acknowledging that a *de facto* system of international environmental law exists (Freestone 1994; Boyle and Freestone 1999; Najam et al. 2004; Bodansky 2006), scholars became increasingly interested in understanding how international environmental law works from a systemic point of view, especially in relation to achieving ecological sustainability (Jóhannsdóttir et al. 2010; see also Ebbesson 2003; Carlman 2007; Westerlund 2008). Accordingly, international environmental law has been approached as a control system (Decleris 2000; Carlman 2007), which needs to reflect the laws of nature to be successful (Robinson 2003).

Natural phenomena involving living nature (e.g., ecological communities, ecosystems, global biogeochemical cycles) have been considered as complex systems where responses to human perturbations are inherently uncertain and unpredictable (Steffen et al. 2004). In these circumstances, a traditional top-down, command-and-control approach may be of limited effectiveness in addressing global environmental change (Holling and Meffe 1996). What has been proposed as an alternative model is *adaptive* governance, which is believed to be best suited for enhancing institutional fit (Young 2002; Galaz et al. 2008) and coping with the complex dynamics of Earth's social-ecological systems (Holling 1978; Berkes et al. 2003; Walker et al. 2004; Folke et al. 2005; Olsson et al. 2006). This new governance model draws heavily from complex adaptive system (CAS) theory (e.g., Emison 1996; Ruhl 1997; Ostrom, E. 1999; Folke et al. 2005; Rammel et al. 2007; Ruhl 2008; Duit and Galaz 2008; Ahmed and Hegazi 2009; Cherp et al. 2011; Ruhl 2012), which has already been widely applied to various instances of environmental management (Gross et al. 2006; Mahon et al. 2008; Booher and Innes 2010; Ruhl 2011).

Against this backdrop, I take a CAS approach to explore international environmental law as a systemic whole. International environmental law comprises the rules of international law that have environmental protection as their primary objective (e.g., Kiss and Shelton 2004; Birnie et al. 2009; Bodansky 2010; Sands and Peel 2012). I examine whether these rules, as increasingly developed and implemented by multilateral environmental agreements (MEAs) (Churchill and Ulfstein 2000), have self-organized into a CAS. A CAS is defined here as a special kind of system with emergent properties and adaptive capacity in response to external environmental conditions (Holland 1995; Levin 1998; Miller and Page 2007; Mitchell 2009).

My approach builds on an existing system-theoretical proposition that, because the environment and its problems display CAS-like properties, we should think of international environmental law as a CAS, and international environmental law should behave like a CAS (Emison 1996; Ruhl 1997; Ruhl 2008; Ruhl 2012; see also Dooley 1997). As Ruhl (2012, p. 1) proposed, what is required is "adaptively managing the complex adaptive legal system to adaptively manage other complex adaptive natural and social systems".

I first discuss key features of a CAS and review the scientific explanation of the Earth system as a CAS. I then consider if international environmental law can be understood as a system, which is complex and adaptive. It is beyond the scope of this review chapter to prove international environmental law is a CAS or to suggest specific ways to design international environmental law as a CAS. Microscopic and telescopic analyses respectively focus on individual MEA regimes on one hand (e.g., Underdal 1992; Haas et al. 1993; Young 1999) and international environmental law as a unitary body of norms on the other (e.g., Boyle 2007). Here I explore the middle ground by focusing on *macroscopic*, systemic properties of international environmental law. By filtering details and amplifying the links that hold the system together, the macroscopic approach aims to map out the complex plethora of international environmental norms and institutions (de Rosnay 1979).

2.2. Complex Adaptive Systems Theory

2.2.1. What Is a Complex Adaptive System?

My definition of a CAS is informed by Meadows (2008, p. 2) who argued that a system is "a set of things […] interconnected in such a way that [they] produce their own pattern of behavior over time". Meadows further argued that we can know whether we are looking at a system rather than just a set of largely independent objects if: (1) one can identify parts; (2) the parts affect each other; and (3) the parts together produce an effect that is different from the effect of each part on its own. It follows that a system must consist of three kinds of things: elements, interconnections (flows of energy or information), and a function or purpose.

If "the collective behavior of [the] parts together is more than the sum of their individual behaviors" (Newman 2011, p. 800), the system might be complex. If not, the system is merely 'complicated' (Ottino 2003). Underlying all agent interactions of a complex system are often simple, deterministic rules. What makes the interactions complex, though, is how the rules, when set in motion among the diverse agents and physical attributes of a system, produce non-linear relationships including reinforcing and stabilizing feedbacks. Because of the non-linearity, local interactions give rise to complex larger-scale behaviour that is not implicit in the parts of the system. This property of complex systems is called emergence. An example is the stability of components of the atmosphere (Petit et al. 1999). This appearance of emergent features happens in the absence of an external controller or planner. In other words, no one designed the system to operate in a particular way, yet it maintains its system identity, and functions in ways supportive of its purpose. This second defining property of complex systems is called self-organization.

CASs are special cases of complex systems, although the line between them and a complex system is not clear. While many complex systems exhibit adaptive behaviour, not all complex systems are adaptive. Those with the ability to adapt to changes in the external environment as a result of experience via conditional action and anticipation are CASs (Holland 1995; Kauffman 1995; Bak 1996; Levin 1999). A CAS constantly evolves and unfolds over time in relationship to the larger environment in which it operates (Arthur 1999). This process is called co-evolution. Multiple elements of a CAS adapt or react to the aggregate patterns they co-create. Therefore, CASs are not only characterized by the sustained diversity and individuality of components, and their localized interactions, but also by an autonomous process that uses the outcomes of those interactions to select a subset of those components for replication or enhancement (Levin 1998; Levin 2002). Natural selection is the prototypical example of such an autonomous process.

Therefore, CASs by definition are "systems composed of interacting agents [which] adapt by changing their rules as experience accumulates" (Holland 1995, p. 10). As CASs "change, adapt, respond to events, seek goals, mend injuries, and attend to their own survival in lifelike ways" (Meadows 2008, p. 12), they are often capable of self-repairing over at least some range of disruptions, hence showing resilience. CASs exhibit coherence under change (Holland 1995). This critical state of stable disequilibrium is a hallmark of CASs (Bak 1996). However, there is a limit to the resistance and resilience of any CAS, and if pushed hard or persistently enough, a system may move into a phase transition through which a radically new system architecture is installed, which will then be locked in through a path dependency effect.

2.2.2. Earth as a Complex Adaptive System

Earth as a whole can be considered as a *complex* system, comprised of coupled sub-systems, non-linear feedbacks with delays, whose dynamics are characterized by critical thresholds and abrupt changes (Steffen et al. 2004). It has "many interwoven parts and properties that are not fully explained by an understanding of the parts" (Lenton and van Oijen 2002, p. 688). For example, the relationships between greenhouse gases in the atmosphere and the temperature are not a simple cause-effect relationship, but rather a complex coupling involving several global-scale feedback loops between the atmosphere, land, ocean and geosphere (Steffen et al. 2004). Earth's climate therefore can be considered as an emergent property of the Earth system.

In what sense might the Earth system be *adaptive*? Earth can be understood as comprising component ecosystems each of which it has been argued are adaptive systems (Holland 1995; Levin 1998). Ecosystems are assembled from biological parts (populations of species) that have evolved over longer time scales and broader spatial scales (Levin 1998). The collective experiences of populations of species across a range of ecosystems over time shape the collection of parts from which the ecological community's assembly occurs (Levin 1998). But what of the Earth system as a whole – can this be considered a CAS?

Vernadsky (1998) defined the biosphere in terms of the role the biota plays in modifying the chemical composition of the atmosphere, ocean, land surface, soil and substrate. Consistent with Vernadsky's early empirically based studies, it is now well established that the biota play a significant role in Earth's biogeochemical processes (Steffen et al. 2004). The Gaia hypothesis (Lovelock and Margulis 1974) proposed that the biota play the critical role in regulating Earth's physical environmental conditions and maintaining them in a condition fit for life. Strong evidence of planetary self-regulation comes from the 420,000-year isotope record contained in the Vostok ice core (Petit et al. 1999) which shows the regular pattern of inferred atmosphere carbon dioxide, methane concentrations and temperature through multiple glacial-interglacial cycles. The tightly constrained upper and lower bounds of all these variables are a typical feature of a CAS.

Lenton and van Oijen (2002) argue the biotic components of the Earth system fulfils the CAS criteria of Levin (1998) as it contains sustained diversity and individuality of components (populations of organisms), localized interaction among these components (ecosystems), and at least one autonomous selection process (natural selection). The biosphere (*sensu* Verdanksy 1998) can be understood as an emergent property of the Earth system *in toto* as it represents the consequence of interactions between life and the physical environment. The

Earth system therefore shares the generic CAS properties identified by Arthur et al. (1997) including dispersed interaction, the absence of a global controller, cross-cutting hierarchical organization, continual adaptation, perpetual novelty, and far-from-equilibrium dynamics (Lenton and van Oijen 2002).

Scientific debate continues as to (1) the extent to which biota and ecosystems *regulates* versus *influences* Earth's environmental conditions and (2) the relative strength of biological processes compared with the other physical components of the Earth system including those processes that involve exchanges of energy and matter between the ocean, atmosphere, land and geosphere. However, the extraordinary extent to which over geological time periods the biota and Earth's chemistry have co-evolved (Williams 2007) supports the proposition that the Earth system is complex and in many ways adaptive. Irrespective of the precise mechanisms by which the Earth system exhibits at least apparent self-regulation, the facts are that Earth has kept within the general boundaries supportive of life since the onset of life, the biota has both adapted to and altered Earth's chemistry, energy balance and climate sub-system, and our species, *Homo sapiens*, have evolved and flourished within an even narrower set of planetary environmental conditions (Rockström et al. 2009a).

With the rise of technology and population growth, humans are now a major forcing factor on the Earth system. As proposed by (Crutzen 2002), considering the growing impacts of human activities on Earth and atmosphere, at all scales, it is becoming widely accepted as appropriate to use the term Anthropocene for the current geological epoch (Steffen et al. 2007; Steffen et al. 2011b). Furthermore, it is now apparent that the Earth system has been altered by human forcing to the extent that global environmental degradation is evident and planetary boundaries are being exceeded or threatened (Millennium Ecosystem Assessment 2005a; Rockström et al. 2009a). Human forced rapid climate change is now evident which is in turn driving multiple, interacting effects that cascade through the Earth system in complex ways (Intergovernmental Panel on Climate Change 2007b). The interactions are driven by both positive and negative feedback and processes operating over a range of spatial and temporal scales, for example, between the global climate system and the South Asian monsoon system (Lenton et al. 2008; see also Folke et al. 2011; Galaz et al. 2011), and between regional ice melt and reduced planetary albedo (Matsoukas et al. 2010).

2.3. Can International Environmental Law Be Thought of as a Complex Adaptive System?

The complexity and adaptiveness evident in the Earth system poses both a significant challenge and potential opportunities for existing institutional arrangements, international environmental law, and global governance (e.g., Walker et al. 2009; Young and Steffen 2009; Folke et al. 2011; Galaz et al. 2012a). Unlike other spheres of law, such as property rights, which are framed by socially and cultural derived parameters, global environmental governance must come to terms with the ecological realities and constraints of the Earth system and its planetary boundaries. Given this, there may be benefit in reframing international environmental law as a CAS. However, what evidence is there that international environmental law shares the defining characteristics?

2.3.1. Is International Environmental Law a System?

The first question is: Does international environmental law constitute a legal *system* rather than merely a collection of discrete norms and regimes? As noted above, for something to be a system, there needs to be a set of components with interactions (that is, connections) and functional relationships. If components or their connections are disrupted so that the system is dysfunctional then it can be said to be fragmented. International environmental law is criticized for being a fragmented system, reflecting the influence of environmental reductionism (Stephens 2007; Carlarne 2008; van Asselt et al. 2008; Biermann et al. 2009b; Bosselmann 2010; Boyd 2010; van Asselt 2012). Since the mid 19th century, MEAs have been adopted in an *ad hoc* and piecemeal manner to deal with single problems, rarely crossing issue-specific lines to address more cross-cutting questions (Carlarne 2008). The notion of fragmentation in the international environmental law context is closely related to the concept of treaty congestion (Brown Weiss 1993) and arguments that the proliferation of MEAs (as well as courts) has led to chaos and anarchy (Hicks 1999; Stephens 2007; Anton 2012b). In no other domain of international law is such a large number of treaties found with the resulting lack of coordination among institutional arrangements and aggregate outcomes.

However, Galaz et al. (2012c) argued that fragmentation at the international level does not necessarily imply anarchy as individual components in a fragmented system may interact in a decentralized setting and give rise to a spontaneous order. Indeed, there are indications that a system of international environmental law has emerged, not merely more international law rules on the environment (Freestone 1994; Boyle and Freestone 1999; Najam et al. 2004). International environmental law can be understood as growing from a limited number of *ad hoc* treaties to a complex network of agreements and institutions. International environmental law scholars have taken a systems approach by focusing on relations between individual components including studies on institutional overlaps (Rosendal 2001), interactions (Young 2002; Young et al. 2008; Gehring and Oberthür 2004; Oberthür and Gehring 2006; Gehring and Oberthür 2008; Gehring and Oberthür 2009; Oberthür and Gehring 2011), interlinkages (Young 1996; Chambers 2008), broader consequences (Underdal and Young 2004), regime complexes (Raustiala and Victor 2004; Keohane and Victor 2011), conflicts (Wolfrum and Matz 2003; Fitzmaurice and Elias 2005; Voigt 2009), clusters (Oberthür 2002; von Moltke 2005), nexus (Hussey and Pittock 2012), and polycentricity (Ostrom 2010; Galaz et al. 2012c).

The critique of international environmental law as simply fragmented in a linear, binary manner arguably reflects out-dated thinking. The challenges humanity faces in the era of global environmental change amount to much more than fragmentation and require addressing environmental reductionism (Ruhl 1996a; Bosselmann 2010). We need to comprehend and embrace complexity in both the subject matter and the legal system itself. We need to know what kind of system international environmental law is if useful insights are to be gained. To address this question I next analyse international environmental law in terms of the basic characteristics of a system as revealed by (1) elements, (2) interconnections, and (3) function.

2.3.1.1. Elements – A System Consists of Individual Elements

MEAs are legally binding instruments between three or more states that deal with some aspect of the environment, and take the form of treaties, conventions, charters, statutes, protocols, or amendments (Mitchell 2003). An MEA typically contains specific prescriptions for addressing an environmental problem with a transboundary scope. Some address a wide subject area such as the ‘deep blue’ sea that lies outside State jurisdiction and biodiversity conservation. Others are specific, focusing on a particular problem such as persistent organic pollutants, threatened species like the polar bear, or a special habitat such as wetlands. The body of international environmental law primarily comprises these separately negotiated and institutionalized MEAs (Steiner et al. 2003; Gehring 2007; Carlarne 2008). It follows that MEAs can be understood as the primary building blocks of the international environmental law system.

Although states remain as the sole sovereign entities at the international level, MEAs are increasingly acting like legally independent organizations with 'autonomous institutional arrangements' that usually comprise a conference or meeting of the Parties with decision-making powers, a secretariat, and one or more specialist subsidiary bodies (Churchill and Ulfstein 2000; Ulfstein 2012). Gehring (2007, p. 496) similarly observed that MEAs have become "autonomous sectoral systems of international law, which increasingly internalize the management of conflicts about the interpretation of commitments as well as the treatment of cases of non-compliance". As actors in their own right, some MEAs are "reluctant to share or give away part of what they perceive as their 'sovereignty'" (UNEP 2001, p. 9). The legal autonomy of the treaties has been emphasised repeatedly because a broad mandate for an MEA to cooperate with another could lead to the perception that state sovereignty is eroded by importing concepts or rules from the latter (van Asselt 2012). Therefore, "any effort by actors in one regime to influence rule development in another will be limited by the extent to which memberships are congruent" (van Asselt 2012, p. 1265). Such institutional autonomy of MEAs supports their choice as the elementary system components of international environmental law, at least for the purpose of this exercise.

2.3.1.2. Interconnections – A System Consists of Interacting Elements

To say international environmental law is a system assumes there are meaningful relationships between the MEA elements (International Law Commission 2006). Given this, one factor which confers on international environmental law the status of a system is not the primary rules of conduct housed within each MEA but the secondary rules, that is, the normative values and principles enshrined in the body of international environmental law *in toto* and how these operate within and across MEAs to influence State actors (Bodansky 2006; Cardesa-Salzman 2012). The Vienna Convention on the Law of Treaties of 1969 provides some fundamental international norms, such as *lex specialis* and *lex posterior* (Borgen 2012). In addition to these universal maxims, many contemporary MEAs incorporate conflict clauses into their texts (Matz-Lück 2008). Such clauses regulate the extent to which the duties and obligations of the Parties arising under existing MEAs shall prevail or are modified or derogated by the MEA incorporating the conflict clause (Matz-Lück 2008).

De facto relationships arise when, in a more frequent basis, MEAs interact institutionally, often because their subject matters are interdependent, for example, the interactions among, for example, the Antarctic Treaty, the Protocol on Environmental Protection, and the Convention for the Conservation of Antarctic Marine Living Resources forming an integral part of the Antarctic Treaty System (Vigni 2000). Another example is the interaction between the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) regarding terrestrial ecosystems as these play a role in both greenhouse gas mitigation (climate regime) and the provision wildlife habitat (biodiversity regime) (Kim 2004). Universal norms are in operation to assist such interactions including the principle of mutual supportiveness (Sanwal 2004; Pavoni 2010) and the "duty not to transfer damage or hazards or transform one type of pollution into another" (UNCLOS Article 195). However, individual interactions vary in kind and effect and both positive and negative feedbacks among MEAs lead to synergistic, neutral, and even disruptive relationships (Gehring and Oberthür 2006; see also Biermann et al. 2009). The more positive complex interactions at least can be interpreted as further evidence in support of the system-status of international environmental law.

In order to enhance institutional cooperation and coordination, the Conferences of the Parties (COPs), the highest decision-making authorities of MEA regimes, increasingly utilize international organizations and intergovernmental and non-governmental bodies (UNFCCC Article 7.2(l)). Secretariats similarly engage in "integration by stealth" (van Asselt 2012, p. 1263; see also Biermann and Siebenhüner 2009) with the secretariats of other relevant international bodies (e.g., UNFCCC Article 8.2(e)). There are at least 320 secretariats as at January 2013 (Mitchell 2013), some of which entered into formal institutional arrangements with others for the purpose of enhancing cooperation and coordination. Sometimes Memoranda of Understanding (or Cooperation) are signed to set up more detailed Joint Work Plans or Programs for a set period of time. Multiple secretariats can establish informal forums such as the Biological Liaison Group among the six biodiversity-related conventions and the Joint Liaison Group among the three so-called Rio Conventions with the purposes of exchanging information, exploring opportunities for synergistic activities and increasing coordination.

The cases of institutional interactions typically involve the flow of information. MEAs exchange information, both formally and informally, on shared substantive issues (UNEP 2010). Treaty and administrative bodies share reviews and lessons learned regarding their functioning and frequently consult each other on administrative or legal issues that arise. Some interconnections in systems are more tangible than the exchange of information. The CBD secretariat has recently requested assistance for Parties' deliberations during meetings, for example, on climate change-related issues. Secretariats have also been entering into arrangements whereby they can share staff or consultants (UNEP 2010). Furthermore, a number of major secretariats regularly participate at other's COPs as observer organizations. A notable example is the CBD secretariat, which also chairs side events and organizes press conferences. Both the virtual and more concrete relationships between MEA secretariats speak to functional connections that further support the system-status of international environmental law.

2.3.1.3. Function – A System Is More than and Different to the Sum of Its Parts

Most international environmental legal norms are articulated in MEAs. Do these norms collectively give rise to an emergent function of international environmental law that are not fully explained by an understanding of the individual norms? Bodansky (2010) outlined three general types of functions that are served by international environmental law: (1) an increase in the demand for cooperation or the political will among states to establish effective regimes; (2) the supply of agreements that effectively exploit whatever level of demand or political will exists; and (3) enhancement in the capacity of states to respond. These can be considered emergent functions as they are not specified in any one MEA and are something different from the effect of each individual one.

Another kind of emergent functional property would be if international environmental law has a definable boundary and a degree of autonomy or at least distinctive operation from international law *per se*. An argument against international environmental law having system-status is it lacks a systematically codified single treaty or group of treaties; unlike other domains such as trade and human rights law (Brownlie 2005; Birnie et al. 2009). Boyle (2007, p. 127), for example, argued that international environmental law is "nothing more, or less, than the application of international law to environmental problems and concerns".

However, the institutional landscape that has emerged overall suggests that international environmental law has, to a significant degree, become a distinct and autonomous system (Bodansky 2006; Bodansky et al. 2007). Some date this moment back to the 1972 Stockholm Conference (Ellis and Wood 2006; Sands and Peel 2012). Freestone (1994) argued that the Earth Summit in 1992 signalled the emergence of a system of international environmental law, rather than simply more international law rules about the environment (Boyle and Freestone 1999), and that the Rio Process accelerated the emergence of a discrete discipline of international environmental law with its own distinctive principles, its own mechanisms and instruments designed to address issues that are different in kind from other issues of international law. It can be argued, therefore, that international environmental law is distinct from international law, not simply in the sense of addressing a discrete set of problems through a discrete set of substantive rules, but as Bodansky (2006) asserted, also in the stronger sense of having its own characteristic structure and legislative and administrative process, and its own set of conceptual tools and methodologies. As noted by Long (2010, pp. 47–48):

> International environmental law is a body of 'special' international law in that the various MEAs all seek to address problems involving the human relationship to the natural world. The field has developed a certain level of coherence through incorporation of unifying principles in nearly every major MEA, such as the obligation to avoid transboundary harm and the principle of common but differentiated responsibilities. Viewed as a part of the landscape of international law generally, then, it is justifiably understood as a closely connected and deeply intertwined field of law.

International environmental law can be considered a system of MEAs, even though this system lacks either a dedicated international environmental organization or an international dispute settlement process with the ability. Furthermore, we can conclude that international environmental law is more than a simple sum of its MEA elements as something different is emerging through complex interactions including between their decision-making, rules and implementation processes.

2.3.2. Is International Environmental Law a Complex System?

As reviewed above, over the last century MEAs have proliferated and grown into a system of international environmental law comprising a diverse set of interacting elements. Some of these MEAs are relatively wildly scoped whiles others are more specialised. They vary to a significant degree in terms of subject matter, underlying jurisprudence, regulatory mechanisms, legal nature, memberships, objectives, and the dates of their entry into force. The nature of their interactions are heterogeneous given that each MEA focuses on different sectors and issues and operates at different levels and scales. I illustrate this point with an example of the UNFCCC and the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR).

The CCAMLR was established in large part to respond to concerns that an increase in krill catches in the Southern Ocean could have a serious impact on populations of other marine life and environmental integrity in and near Antarctica. This treaty operates at a regional scale, but has 31 member states geographically widespread across the world. The UNFCCC has a membership of 196 states and operates at a global scale, with a mandate to avoid dangerous human-forced climate change. Earth's climate is defined by the characteristic atmospheric weather conditions for a given time period (typically 30 years). However, Earth's climate system involved more than just the atmosphere as atmospheric conditions are affected by natural exchanges of energy and gases with the ocean and terrestrial ecosystem such as forests, and degassing from volcanic activity. The UNFCCC is focused on regulating anthropogenic sources of greenhouse gas emissions from using fossil fuel for energy and from the depletion of ecosystem carbon stocks through land use impacts. The effectiveness of the UNFCCC has direct relevance to the CCAMLR because failure to mitigation anthropogenic greenhouse gas emissions will result in rising atmospheric carbon dioxide concentrations which will in turn impact on marine ecosystems through ocean acidification, warming and deoxygenation, and these impact will be particularly strong in the Southern Ocean (Kawaguchi et al. 2011) where the CCAMLR has jurisdiction. The consequences of such inter-MEA interactions across systems, levels, and scales are inherently complex. There are hundreds of such diverse MEAs interacting in comparably complex ways.

In terms of its structure, international environmental law has been described as a decentralized, polycentric network of embedded, nested, clustered and overlapping institutions (Young 1996). This web of MEAs is becoming increasingly congested as a result of *ad hoc* treaty-making, and accordingly, the United Nations Environment Programme called it a 'maze' (UNEP 2012). Although legally non-hierarchical, the web has an emergent nested hierarchy where more economically or politically potent MEAs such as the UNFCCC attract more public attention and resources, acting as 'attractors' or 'hubs' in the MEA system. The presence of a relatively small number of highly connected hubs implies that the relationships among MEAs can be approximated by a power law (a right-skewed degree distribution) rather than by a bell-curve distribution (Barabási and Albert 1999; see also Smith 2007; D'Amato 2010). Power law relationships imply the presence of complex system structures and the system in question is at the point of self-organized criticality (Bak 1996).

The proposition that MEAs have formed a complex system has been empirically supported by a recent study (Kim 2013), which created an agreement-level connectivity map of international environmental law by using cross-references in the MEA texts as proxies for inter-MEA relationships. The results show that, 747 MEAs so far concluded have self-organized into a complex network that exhibits several important properties of the real-world networks. The MEA network displays scale-free (characterized by a power law relationship) and small-world (characterized by short global path lengths and high local clustering) properties with a hierarchical and modular organization (Watts and Strogatz 1998; Barabási and Albert 1999; Ravasz et al. 2002). The observed structural features imply, *inter alia*, that

MEAs do not interact randomly, but preferentially with others that are already well connected (Barabási and Albert 1999), and they might be robust to random failures (Albert et al. 2000; see also Ruhl 2011).

It is important to note that the interlocking structures of the MEA system have not arisen from collective bargaining or institutionalised decision-making at the aggregate level. Rather, they have incrementally evolved from, and are continuously shaped and reshaped by, the numerous decentralized decisions taken within individual institutions and the interaction effects arising therefrom (Oberthür and Gehring 2011). There is no single legislative will behind this system of international environmental law; each MEA is an autonomous lawmaker (Churchill and Ulfstein 2000; Brunnée 2002; Wiersema 2009). Independently formed, heterogeneous MEAs that interact with a few non-randomly selected others make up the complex system of international environmental law.

2.3.3. Is International Environmental Law a Complex Adaptive System?

Complexity *per se* does not necessarily guarantee that mean that a system is an adaptive system. Ruhl (2008) identified criteria we can draw upon in evaluating if international environmental law understood as a complex system of MEAs exhibits characteristics that constitute adaptive system behaviour. Of particular interest is whether feedbacks exist and if in response there are changes in MEA behaviour. Feedbacks can involve individual MEA eliciting and receiving information from both other MEAs and the broader social-ecological environment in which they operate. Consequent changes in MEA behaviour can be interpreted as constituting an adaptive response.

2.3.3.1. MEAs as Dynamic Institutional Arrangements

MEAs and their regimes have typically evolved over time through trial and error (Bodansky and Diringer 2010). MEA regimes through incremental steps can become deeper (e.g., Convention on International Trade in Endangered Species of Wild Fauna and Flora; Ramsar Convention on Wetlands), broader (e.g., Antarctic Treaty System), more integrated (e.g., Convention on Long-range Transboundary Air Pollution; OSPAR Convention; UNCLOS), or along multiple dimensions (e.g., World Trade Organization) (Bodansky and Diringer 2010; see also Young 2010a). In the process, MEAs or their regime complexes demonstrate a degree of adaptability over time and flexibility across issues (Keohane and Victor 2011; Orsini et al. 2013).

The way in which MEAs have developed through incremental small steps mimics one aspect of biological evolution (Mayr 2001). This process has been made possible through a three-tiered approach of (1) framework agreement, (2) protocols and (3) annex/appendices that enables flexibility and adaptability by providing for the negotiation of protocols and allowing legal amendments or other changes (Klabbers 2008; Brunnée 2012). For example, the UNFCCC, as a framework convention, provided an institutional setting for the Kyoto Protocol to be negotiated to set emission reduction targets for specific greenhouse gases for its Parties. Between 1857 and 2012 there were 515 parent agreements adopted but during the same period 219 protocols and 437 amendments were negotiated which often modified or specified the contents of their parent agreements (Mitchell 2013). The proportion of amendments has gradually increased over time, which illustrates the adaptiveness of the MEA system.

Although some of the adaptability and flexibility is reflected in the rise of framework conventions, much of the change comes from the ability of COPs to respond to new information; especially scientific information about the state of the target environmental phenomenon (Huitema et al. 2008; Wiersema 2009). Contemporary MEAs, in comparison to traditional intergovernmental organizations, are more informal and more flexible, and often innovative in relation to norm creation and compliance (Churchill and Ulfstein 2000). Through COP negotiations, State members can collectively make adaptive decisions that are evidence-based. For example, the UNFCCC COP-7 adopted the Marrakesh Accords in one of its decisions to specify rules relating to land use, land-use change and forestry, which is a major greenhouse gas inventory sector under the Kyoto Protocol. In the COP-17 held in Durban South Africa, these rules were significantly altered through negotiation based on the lessons learnt from the Marrakesh rules' implementation (Grassi et al. 2012). As such, the climate regime has evolved incrementally through almost 400 decisions adopted by seventeen COPs that have been held so far.

MEAs no longer represent static contractual agreements among states at a particular point in time (Gehring 2007). Instead, they are dynamic institutional arrangements, which establish ongoing regulatory or legislative processes (Gehring 2007) and are *de facto* lawmakers (Brunnée 2002; International Law Commission 2006). The result is that in most international environmental regimes the treaty text itself represents just the tip of the normative iceberg (Bodansky et al. 2007). The majority of the norms are adopted through more flexible and dynamic processes, thus providing adaptive capacity in the system.

An important institutional arrangement for treaty evolution are subsidiary bodies that are commonly established to provide the COP with scientific and technical advice relating to the implementation of MEAs. Examples include the CBD's Subsidiary Body for Scientific, Technical and Technological Advice whose principal functions include providing assessments of the status of biological diversity. Such a treaty body effectively functions as a core unit in a mechanism that feeds the effects of the MEA on its subject matter back into the MEA's decision-makers in a timely manner. In some cases an external body aids the feedback process, such as the Intergovernmental Panel on Climate Change that supports the UNFCCC and the Scientific Committee on Antarctic Research for the Antarctic Treaty System, respectively.

More subtle and policy-driven changes in existing law may arise through the process of interpretation (Boyle 2007; Gardiner 2012), reflecting the notion that treaties are living instruments which should be interpreted in the light of contemporary conditions. Article 31(3)(c) of the Vienna Convention on the Law of Treaties (VCLT) provides a powerful means through which relationships of interpretation may be applied (McLachlan 2005). The interpreter of a treaty is required to take into account "any relevant rules of international law applicable in relations between the parties" (VCLT Article 31(3)(c)), and it may include other treaties, customary rules or general principles of law. This dynamic approach to interpreting MEAs provides additional adaptiveness in a way that builds a more cohesive system.

2.3.3.2. Is the MEA System as a Whole Adaptive?

Each MEA element may be capable of learning from the experiences of its State members in applying negotiated rules, but what about the whole MEA system? In what sense might international environmental law *in toto* be adaptive? To answer this question we can look for evidence that the MEA system is in some sense co-evolving with its external environment by inducing changes on itself and improving the 'fit' between itself and the target natural environmental phenomena (e.g., climate change) (Young 2002; Galaz et al. 2008). In this context, co-evolving means adaptive changes in response to feedbacks and interactions, the external environment includes both the social system out of which the legal system arises and the state of the natural environment, and fitness refers to more effectively addressing the environmental problems.

In any evolutionary process, there must be generation of new alternatives, selection among new and old combinations of attributes, and retention of those combinations that are successful in a particular environment (Ostrom, E. 1999). In natural systems, mutation introduces multiple forms into a given system, and through natural selection, the forms that are best fitted to the system's environment become the norm in the population (Mayr 2001). By analogy, the evolution of a legal system can be seen as involving the "innovation of forms" and the "emergence of norms" (Trujillo 2004, p. 528; see also D'Amato 2005; D'Amato 2009). Although human agents in a legal system do use reason, the process of choice always involves experimentation.

Variations among MEAs can be understood as a result of experimentation in the international environmental law context. When drafting a new MEA, states experiment with different norms, institutional forms, and regulatory mechanisms (Guzman 2005; Lejano 2006; Bodansky and Diringer 2010). They then select those actions arising in MEA negotiations that prove most useful and formulate them as rules and precedents of the system. The time at which such new norms ripen can be determined by the status of ratification of MEAs that incorporated the norms or the existence of *opinio juris*, that is, by testing whether states were acting under a belief that their actions were required by international environmental law.

Through the iterative process of experimentation, some norms and institutions become popular and authoritative while others never come into force and perish. For example, some international environmental norms (such as intergenerational equity, the precautionary principle, and common but differentiated responsibilities) have grown in influence among MEAs. Others (such as the duty not to transfer damage or hazards or transform one type of pollution into another) have been less popular and by comparison have withered on the vine. A similar process can be observed at the level of MEAs. Whereas the UNCLOS, for example, has become one of the most cited authoritative texts around which order is established, the International Convention for the Prevention of Pollution from Ships of 1973 never came into force, and the Kyoto Protocol was never ratified by a major greenhouse gas emitter (United States).

The autonomous selection process alone does not guarantee that the system has been adaptive. The extent to which the MEA system *in toto* co-evolves with the dynamics of the Earth system has apparently been limited (e.g., Kim 2012). The current system of international environmental law may be reflecting more the constraints of realpolitik. This is partly because the absence of a clearly stated system goal that binds the international environmental law network of MEAs, it is questionable to what extent international environmental law *in toto* is and can co-evolve in ways that lead to net improvements. At the moment, the purpose of the international environmental law system is what it does, not what it is mandated to do (whatever this end goal might be). In which case, the international environmental law system may not yet constitute a CAS (Jóhannsdóttir et al. 2010; see also Proelss and Krivickaite 2009).

2.4. Conclusion

A CAS is typically a heterogeneous and diverse network of interacting elements connected in a particular pattern of organization that gives rise to the ability to adapt to external change by learning from experience (Holland 1995; Levin 2002). Here I investigated the question of whether international environmental law as a system of MEAs exhibits the characteristics of a complex adaptation system. If so, the legal system may benefit from the insights gained and from being modeled in ways more appropriately aligned with the functioning of Earth system itself. These benefits relate to the fact that the subject matter of international environmental law is derived from and concerned with the Earth system and the disrupting impacts of human activities. Theoretically, benefit exists because, in a turbulent environment where change is constant, complex dynamics are best handled by a complex adaptive organization (Dooley 1997; Ruhl 1997; Ostrom, E. 1999; Duit and Galaz 2008).

There is evidence suggesting that international environmental law has evolved into a complex system of MEAs. Heterogeneous MEAs, many of which with own decision-making power and limited, yet adaptive learning ability, interact with others in the absence of an external authority. Self-organization is taking place through a process that can be likened to biological evolution's dynamic process of norm-generation and norm-selection (D'Amato 2005; D'Amato 2009), that is, in the absence of an external authority. However, it is not clear from the above exploratory analysis that the international environmental law system *in toto* has been adaptive to global environmental change in ways that lead to net environmental improvement. The international environmental law system is not yet functioning as an effective CAS.

However, international environmental law has the potential to become a CAS. It was beyond the scope of this chapter to explore specific ways to transform international environmental law into a CAS mode. Nonetheless, this preliminary review of international environmental law's systemic properties points to the need for a system-level goal and a set of fundamental principles under which the plethora of MEAs would operate. Such a goal-oriented approach to global environmental governance would allow adaptability and flexibility of the international environmental law system within the constraints of the legal principles. This conclusion resonates with the ongoing call for an international framework agreement that would consolidate and develop existing legal principles related to environment and development (Najam el al. 2004). A potential candidate would be the IUCN Draft International Covenant on Environment and Development (IUCN Environmental Law Programme 2010), whose ultimate objective is the protection of the integrity of the Earth’s ecological systems as an indispensible foundation for sustainable development.

Chapter 3.

The Emergent Network Structure of the Multilateral Environmental Agreement System

Abstract

The conventional piecemeal approach to environmental treaty-making has resulted in a 'maze' of international agreements. However, little is known empirically about its overall structure and evolutionary dynamics. This chapter reveals and characterizes the evolving structure of the web of international environmental law. The structure was approximated using 1,001 cross-references found in 747 multilateral environmental agreements (MEAs), which were concluded between 1857 and 2012. It was then analysed using known network analysis measures to address the following questions: Has a complex system of MEAs emerged? If so when, and what does it look like? What are its topological properties? To what extent is the MEA network fragmented? The network analysis suggested that, in the absence of an authority, MEAs have self-organized into an interlocking system with a complex network structure. Furthermore, the MEA system has defragmented as it coevolved with the increasing complexity and interconnectivity of global environmental challenges. This study demonstrates the need to approach MEAs in the context of a complex networked system, and recommends caution against a simple dismissal of the institutional structure as 'fragmented'. Any reform options for global environmental governance should pay attention to the emergent polycentric order and complexity and what these features imply for the function of the MEA system.

3.1. Introduction

It is generally accepted that a *de facto* 'system' of international environmental law and governance has emerged (Freestone 1994; Boyle and Freestone 1999; Najam et al. 2004; Bodansky 2006). This acknowledgement stems from the observation that international norms and institutions do not exist in isolation but as embedded in a maze-like structure (Young 1996; Young 2002). However, we know little about the macroscopic structure and evolutionary dynamics of this system (Biermann and Pattberg 2008; Young 2010a). Our understanding has not advanced much beyond the 'congestion' and 'fragmentation' rhetoric based on anecdotal evidence (Ivanova and Roy 2007). There is a clear need to study the system empirically and *in toto*, and unravel its institutional maze. Such an understanding of the emerging complexity would prove useful in improving the alignment between the governance system and the multifaceted challenges of governing interacting Earth system processes (Rockström et al. 2009a; Walker et al. 2009; Galaz et al. 2012c; Nilsson and Persson 2012).

This chapter attempts to fill the knowledge gap by revealing and analysing dynamic patterns in the structural organization of international environmental law and governance. I take a network-based approach, which uncovers the underlying system architecture by reducing the system to an abstract structure capturing only the basics of connection patterns between its components (Newman 2010). The core analytical unit is neither the whole system nor individual components, but rather the *relation* between components that gives rise to large-scale connection patterns. The emergent patterns are then treated as mathematical objects or graphs, and analysed with a tool chest of network measures and metrics such as modularity, clustering coefficient, and average path length. These topological properties are of scholarly interest because structural differences in governing systems may lead to significant differences in governance processes and outcomes (Bodin and Crona 2009; Orsini et al. 2013).

For constructing a network representation of the institutional structure of international environmental governance, I chose multilateral environmental agreements (MEAs) as nodes and their cross-references as links that define the relation between MEAs. MEAs are treaties, conventions, charters, statutes, or protocols between three or more governments relating to the environment (Mitchell 2003; Carruthers et al. 2007). They typically include cross-references to a number of other MEAs that their parties consider relevant. According to Kiss and Shelton (2007), these cross-references can be viewed as extending the legal effect of cited MEAs to the texts that cite them.

I compiled a complete list of 747 MEAs that were concluded between 1857 and 2012, and identified 1,001 cross-references to other MEAs in the list. Using this dataset, I produced a series of agreement-level connectivity maps of international environmental treaty law. The structural dynamics of the network were investigated by focusing on the following questions: Has a complex polycentric system emerged among MEAs through self-organization? If so, when, and what does it look like? What are its topological properties? To what extent is the MEA network fragmented?

The questions relating to the dynamics *on* the network, that is, how the functioning of the system depends on its topological properties, are beyond the scope of this chapter. Such an enquiry would require representing each MEA as a dynamical system in itself (Churchill and Ulfstein 2000; Brunnée 2002; Gehring 2007; Wiersema 2009; Young 2010a; Brunnée 2012) and further specifying the causal mechanisms of institutional interaction (Young 2002; Gehring and Oberthür 2009). As the MEA citation network is an abstract representation of symbolic relationships, it is yet unclear how its network measures such as modularity should be interpreted with respect to their consequences for some process on the network. Nonetheless, where possible, explanations were offered by juxtaposing the observed structural changes with what had actually happened in the real world.

This chapter proceeds as follows. It starts with a brief review of relevant literature to which the present network analysis contributes. The methods section then follows, explaining what cross-references mean in the MEA network context and how the data were collected. Key empirical findings are presented in two sections focusing respectively on the evolution of network topology from 1857 to 2012, and static topological properties of the MEA network in 2012. I conclude with a discussion on what the measured structural features might mean in terms of governance outcomes.

3.2. Fragmentation, Polycentricity, and Networks

The institutional fragmentation has received significant scholarly attention as a macroscopic feature of international environmental law and governance (e.g., Doelle 2004; Stephens 2007; Carlarne 2008; van Asselt et al. 2008; Biermann et al. 2009b; Boyd 2010; Scott 2011; van Asselt 2012). Although there is no consensus on its meaning and implications (Biermann et al. 2009b), the underlying idea can be traced to the notion of treaty congestion (Brown Weiss 1993; see also Hicks 1999; Anton 2012b), that institutional proliferation has led to chaos and anarchy.

From a polycentric perspective, however, "fragmentation at the international level does not imply anarchy" (Galaz et al. 2012c, p. 22). Many independent centers of decision-making may self-organize and make mutual adjustments for ordering their relationships with one another (Ostrom, V. 1999; Ostrom 2010). This process may give rise to different forms and degrees of polycentric order, where stronger forms can be denoted as polycentric systems (Galaz et al. 2012c). These systems are comparable in their structure and function to complex adaptive systems (Ostrom, E. 1999), which have the capacity to adapt to external conditions by changing their rules as experience accumulates (Holland 1995; Levin 1998; Arthur 1999; Miller and Page 2007; Mitchell 2009). Because of the complexity-handling capacity of these systems, polycentrism has been considered as one of normative models for international environmental law and governance (e.g., Ruhl 1997; Folke et al. 2005; Ostrom 2010; Ruhl 2012).

However, empirical research on fragmentation and polycentricity at the international level has been hampered by inadequate methods and a lack of large datasets. For example, whereas these concepts are about macro-level architecture in a time-dependent sense, the scope of most previous studies was limited to isolated cases of dyadic institutional interaction over a limited period of time. We need to go beyond the reductionist methodology and study the architecture, that is, the *system* of institutions at the macro-level (Biermann 2007). Many important questions remain unexplored from a dynamic systems perspective.

Network theory has recently emerged as a widely applied tool kit for studying complex systems (Amaral and Ottino 2004; Newman 2011). The most important breakthrough in network science has been the discovery of striking regularities in the macro-structures of many complex systems that exist in the real world (Barabási and Albert 1999; Watts and Strogatz 1998; Ravasz et al. 2002). These common design principles at play provide the most powerful justification of a network approach. By providing a common language and empirical methods, network theory has the potential to bring together fragmentation, polycentricity, and complexity studies, and provide some novel insights into the structure and dynamics of international environmental law and governance (e.g., Orsini et al. 2013).

3.3. A Citation Network Perspective on International Environmental Treaty Law

This study used cross-references as proxies for approximating the evolving structure of international environmental treaty law. As this is a novel approach to studying the subject, justifications and their interpretational limitations are discussed in detail below.

3.3.1. Cross-references as Proxies for Relationships among MEAs

In order to construct the complete network of MEAs, I needed to define the criteria by which to connect two MEAs, and decide on the connections objectively. In this study, I used "interrelated or cross-referenced provisions from one instrument to another" (Kiss and Shelton 2007, p. 74) or simply citations or cross-references (these terms are used interchangeably in this thesis) as proxies for an approximation of the relationships among MEAs. Most MEAs contain references to a small number of pre-existing MEAs (and/or other international binding and non-binding agreements) by including their titles in the treaty text, often in preambles, which the negotiating states consider as being highly relevant. This cross-referencing has been noted as a unique common characteristic of modern environmental treaties (Kiss and Shelton 2007). Kiss and Shelton (2007, p. 87) observed that:

> recent environmental agreements increasingly cross-reference other international instruments. Marine environmental treaties, for example, often cite to [the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978] or [the United Nations Convention on the Law of the Sea], including their rules by reference. The result could be to extend the legal effect of these instruments to states that have not ratified them but which ratify the texts that cite them, especially when the citation affirms the norms as customary international law.

There are a number of reasons why states participating in the drafting and negotiating of an MEA would cross-reference another MEA. The most frequently observed instances are when an MEA acknowledges the positive relevance of the cited MEA on the issue and build upon it. This type of cross-reference usually appears in the preamble where the parties to the agreed MEA are, for example, 'noting', 'recalling', 'reaffirming', 'recognizing', 'bearing in mind', or 'taking into account' relevant MEAs. A typical example can be found in the preamble to the 1992 United Nations Framework Convention on Climate Change, where its parties recalled the 1985 Vienna Convention for the Protection of the Ozone Layer and the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. In some cases, such as in the United Nations Convention to Combat Desertification, an MEA makes a cross-reference to recognise the potential contribution that it can make to the cited MEA.

Furthermore, regional MEAs often cite relevant global MEAs, such as the United Nations Convention on the Law of the Sea (UNCLOS), in order to include the basic norms previously articulated in the global instruments (UNEP 2001a; Kiss and Shelton 2007). Such cross-references are also used when sharing definitions of key terms, such as "pollution of the marine environment" (UNCLOS Article 1.1(4)) and "dumping" (UNCLOS Article 1.1(5)), through which consistency is achieved across international regimes.

Another key reason for citing an MEA is to define the relationship between citing and the cited MEAs, and this type of cross-reference is typically found in conflict clauses (Wolfrum and Matz 2003) or choice-of-law provisions (Kiss and Shelton 2007) in the body of the treaty text. One of the representative examples is provided by Article 104 of the 1992 North American Free Trade Agreement, which gives priority to the obligations set out in named MEAs in the event of any inconsistency. Moreover, a protocol to a framework convention often includes a specific provision that defines its relationship to the convention. In much less frequent cases, an MEA makes a cross-reference when replacing an existing MEA, and defines complex relationships between the old and new MEAs in the same regime until the former terminates.

It should be carefully noted at the outset how citation networks differ from other networks (Leicht et al. 2007; Radicchi et al. 2012). First, citation networks are *directed*. Citations go from one document to another and hence constitute an inherently asymmetric relationship between the MEAs involved. Second, citation networks are *acyclic*, meaning there are no closed loops of citations of the form 'A cites B cites C cites A', or longer. In other words, when a new MEA is added to the network, it can cite any of the previously existing MEAs, but it cannot cite MEAs that have not yet been created. This gives the network an 'arrow of time', with all links pointing backwards in time. Third, the time evolution of citation networks takes a special form, in that nodes and links are added to the network at a specific time and cannot be removed later. This permanence of nodes and links means that the structure of the network is mostly *static*: it changes only at the leading edge of the network, the current time at which new MEAs are being added.

In principle, citations suggest links that do not require any preceding or anticipated institutional interplay. They simply capture the interests of the parties at the time of treaty negotiations. Therefore, the MEA citation network should be considered as a 'symbolic' network, a network representation of abstract relations between discrete entities, as opposed to an 'interactive' network, whose links describe tangible interactions that are capable of transmitting information, influence, or material (Watts 2004). In other words, there is a clear limit to which one could draw a relationship between the citation network structure and the actual legal and governance processes taking place in the system.

For the purpose of estimating the basic system architecture of international environmental treaty law, however, the citation data should suffice. The validity of such a citation network approach to unravelling legal and institutional complexity has been proven in previous studies. For example, a number of scholars used legal cross-references when studying the aggregate structures of the United States' case law (Post and Eisen 2000; Fowler et al. 2007; Smith 2007; Fowler and Jeon 2008), Code of Laws (Katz and Stafford 2010; Bommarito and Katz 2009; Bommarito and Katz 2010), and the French legal system (Boulet et al. 2010; Boulet et al. 2011). In particular, Smith (2007, pp. 310–311) considered cross-references as linking "cases, statutes and other legal authorities" together, hence allowing a study of law's overall shape, that is, "how law is organized and evolves". Furthermore, given the immense technical difficulties associated with collecting other types of connection data (see Appendix A), cross-references are most practical and reliable proxies for the purpose of this research.

3.3.2. Dataset Compilation

Agreeing on what is and what is not an MEA is not a straightforward task (Mitchell 2003; Scott 2003; Kiss and Shelton 2007). To be as objective and comprehensive as possible in building my dataset, I combined the lists of MEAs contained in the two most comprehensive international environmental agreement databases: the IEA Database (Mitchell 2013) and the ECOLEX (IUCN et al. 2013). I also added a small number of MEAs that were missing from both of these databases, and ended up with 747 in my dataset (see Appendix B for the complete list). Amendments were excluded, as they are not separate agreements but form an integral part of a convention or a protocol (Carruthers et al. 2007).

The texts (title, preambular paragraph, operational provisions, and annexes) of 747 MEAs were examined thoroughly by the author. This process identified a total of 1,001 cross-references (see Appendix A for citation data collection rules). A computer programmed and automated search-and-find operation was not considered to be feasible, as the formal titles of MEAs were not used consistently across MEAs.

Once the dataset with information on MEAs and its cross-references was compiled, I used it to construct and visualize the institutional network. I conducted various analyses on it by using the tools developed by network scientists (e.g., Albert and Barabási 2002; Newman 2003). Network analysis computer programmes, Pajek and Netminer, were used to provide graphical and statistical representations of the system.

3.4. Evolution of the MEA Network Structure from 1857 to 2012

Topological changes of the MEA citation network between 1857 and 2012 are tracked and analysed below for an improved understanding of the evolutionary processes of the network.

3.4.1. Network Connectivity

The network representation of the MEA system I constructed evolved in 156 steps, from a single node in 1857 to 747 nodes with 1,001 directed links (or 986 undirected links with multiple lines removed) in 2012. Figure 3.1 shows eight graphical snapshots of the network taken at a ten-year interval from 1941 to 2011 (and 2012). Over the entire course of history, the cumulative number of MEAs adopted and cross-references made increased following the curves in Figure 3.2(a). MEAs concluded before the mid-1940s often did not contain any cross-references. The average number of cross-references made (i.e., outward citations) per MEA grew rapidly from around 1992, when the number of outward citations made each year clearly surpassed the number of MEAs adopted each year (Figure 3.2(b)). The total number of outward citations surpassed the total number of MEAs in 1996 when each MEA adopted thus far had, on average, one outward citation.

By 2012, the average MEA made and received 1.3 citations to and from other MEAs, which means that an average MEA has 2.6 direct neighbours. The number of outward citations varies from 0 to 18 with a standard deviation of 1.9 and a median of 1. The number of inward citations varies from 0 to 66 with a standard deviation of 3.7 and a median of 0. Among the 747 MEAs, 595 (80 percent) have at least one connection (i.e., either inward or outward citation), and 152 (20 percent) stand alone as isolated components.

3.4.2. (De)fragmentation

In the years preceding the birth of the United Nations, there were only a few MEAs, most of which were not related to each other. Roughly coinciding with the conclusion of the Charter of the United Nations in 1945, the number of MEAs increased incrementally over the next three decades, but without fundamentally changing their macro-structure. Small discrete components grew bigger in size, but at the same time more isolated nodes or dyads randomly appeared on the institutional landscape. This network representation corresponds to Birnie (1977) who observed that the development of international environmental law at the time was not systematic. The network was becoming an increasingly disaggregated set of discrete international institutions. This process seems to conform to the classic definition of fragmentation, that is, “the process or state of breaking or being broken into small or separate parts” (Oxford English Dictionary 1989).

Such structural changes could be quantified by a simple measure of the fraction of the largest component, which I plotted in Figure 3.2(c). The fraction of the largest component was 1 with a single node in 1857. It continued to decrease, as more and more nodes with no links were inserted into the network, until the fraction reached the minimum at 0.056 (or 5.6 percent) in 1975. The network then consisted of 252 MEAs grouped into small and separate 128 components, with the largest component consisting of only 14 MEAs. Since 1976, however, the fraction of the largest component has increased until today, and it stabilized around 0.564.

If we accept a definition of fragmentation based solely on the fraction of the largest component, the international environmental governance architecture was most structurally fragmented in 1975. Furthermore, the MEA network has since increasingly *defragmented*. I acknowledge that such a structuralist definition might be overly simplistic by neglecting the complex nature of institutional interaction, which may as well be cooperative as disruptive (Gehring and Oberthür 2006; Biermann et al. 2009b). The definition adopted here, however, focuses on a different aspect of fragmentation. Whereas the existing scholarship focuses primarily on the fragmented implementation of MEAs, this study is directed towards MEA texts, each of which is a product of negotiation. Therefore, the findings should not be considered to completely contradict the existing 'fragmentation' literature, but as providing a complementary perspective.

The beginning of structural defragmentation roughly coincided with the emergence of modern international environmental law, which was marked by the 1972 United Nations Conference on the Human Environment (also known as the Stockholm Conference) (Bodansky et al. 2007). The 1970s also witnessed the births of the earliest form of modern MEAs, such as the 1971 Convention on Wetlands of International Importance, especially as Waterfowl Habitat, the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, and the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora. Furthermore, the Regional Seas Programme was launched with the creation of the United Nations Environment Programme, which has led to the conclusion of a number of regional seas agreements. The emergence of these modern MEAs contributed significantly to the increasing network connectivity.

Does structural defragmentation alone indicate a 'systematization of anarchy' (Backer 2012)? Just as fragmentation does not imply anarchy (Galaz et al. 2012c), defragmentation does not necessarily imply order. Although the Stockholm Conference brought about a change in the old *laissez-faire* thinking, it is still questionable whether it introduced a new *system* of law (Birnie 1977).

3.4.3. Systematization of Anarchy

The density of local neighbourhoods as quantified by the clustering coefficient began to increase in the 1980s (Figure 3.2(d)). The clustering coefficient measures the proportion of connections among its neighbours which are actually realized compared with the number of all possible connections (Watts and Strogatz 1998). In other words, it quantifies how close the local neighbourhood of an MEA is to being part of a clique, where every MEA is connected to every other MEA. Therefore, the increasing average clustering coefficient of the MEA network indicates a corresponding increase in the level of redundancy and cohesiveness.

The 1990s was probably the most critical period in the evolution of the MEA network. The network reached a critical level of connectivity at which its structure changed from a loose collection of small clusters to a system dominated by a single 'giant component' (Janson et al. 1993; Dorogovtsev et al. 2008; Newman 2010). This system state transition happened around 1992 when new MEAs brought a few shortcuts into the network. These shortcuts shrunk the size of the network while maintaining the level of local clustering. The average path length, which had consistently increased since 1857, started its decreasing trend after reaching the peak of 6.53 in 1991 (Figure 3.2(d)). The average path length is the average number of links that must be traversed in the shortest path between any two reachable pair of nodes, and it can be understood as a global measure of separation (Watts 1999; Watts 2004). In just one year, the average path length dropped significantly to 5.47 (Figure 3.2(d)). The network diameter, which is the maximum internode distance, also declined from 16 to 13 in 1992. In 1992, the MEA network started to become a small-world, and it has become increasingly smaller ever since.

It can be argued that, during the 1990s, the "partial and uneven" body of international environmental law (Schachter 1991, p. 457) underwent systematization. The analysis of MEA cross-references questions the common perception that "since 1992, there had been a fragmentation of environmental governance and issues" (UNEP 2001b, p. 2). Empiricism rather confirms the claim that a *system* of international environmental law emerged on the landscape in 1992 from a mere collection of environmental norms (Freestone 1994; Boyle and Freestone 1999; see also Najam et al. 2004). It should be noted that this emergence coincided with the Earth Summit in 1992, when states adopted the landmark Rio Declaration on Environment and Development, Agenda 21, the Convention on Biological Diversity, and the United Nations Framework Convention on Climate Change.

3.4.4. Self-organized Growth

The MEA system matured in the 2000s, when only a few MEAs were concluded (Figure 3.2(b)). This recent trend can be attributed to what some called "negotiation fatigue" (Najam 2000, p. 4048; see also Muñoz et al. 2009). Anton (2012b), for example, noted that, since approximately 2002 and noticeably 2005, the negotiation and adoption of MEAs have slowed. Struggling to meet current MEA obligations, states may have become less interested in creating new MEAs, but instead are concerned about 'making law work'. This is also reflected in the 2002 Johannesburg Plan of Implementation. The noticeable shift of resources towards implementation after three decades of international cooperation can be considered as a sign of system maturity and self-regulation of its own growth.

Although the horizontal expansion of the MEA network has almost halted, its internal complexity has increased. This has occurred primarily through decisions and amendments adopted by treaty bodies, which this study did not consider. The internal changes have often been made in response to new scientific information about the state of the target environmental phenomenon (Gehring 2007; Huitema et al. 2008; Wiersema 2009; Brunnée 2012). Such "coherence under change" (Holland 1995, p. 4) exhibited in recent years implies that the MEA system may have self-organized at a critical state of 'stable disequilibrium' (Bak 1996). That is to say, international environmental law has reached maturity as a complex system which displays a degree of institutional resilience and adaptability. This may also suggest that the MEA system as a whole is now at a stage where institutional stresses may trigger abrupt, non-linear changes, through which a radically new system is installed (Young 2010b; see also Walker et al. 2009; Biermann et al. 2012a).

3.4.5. A Periodization of the Network Evolution

From a structural evolutionary perspective, the development of the MEA system can be divided into six stages: (1) from the 1850s to the mid-1940s (the 'beginning'); (2) from the mid-1940s to the mid-1970s (the period of 'incoherency'); (3) from the mid-1970s to the 1980s (the period of 'clustering'); (4) the 1990s (the 'emergence'); (5) the 2000s (the period of 'consolidation'); and (6) the 2010s (the period of 'criticality'). It is interesting to compare this periodization with the conventional description of the historical evolution of international environmental law, which identifies the years 1945, 1972, and 1992 as critical transition points (Brown Weiss 1993; Steiner et al. 2003; Redgwell 2006; Sand 2007; Birnie et al. 2009; Sands and Peel 2012). The network analysis also supports the contention that these years indeed were critical turning points in the course of development, given that we accept a lag of a few years since the year 1972 until an increasing number of modern MEAs started to appear in the mid-1970s.

3.5. Analysis of Static Topological Properties

Topological properties of the MEA network as at 2012 are characterized below with key network measures and metrics.

3.5.1. Small-world

The network has a giant component of 421 MEAs and 870 citations, constituting 56 and 87 percent of the entire network, respectively (Figure 3.1). The average path length is 4.70 (4.71 for the giant component) (Figure 3.2(d)), and the two reachable MEAs that are furthest apart are 12 steps away (Figure 3.3). The clustering coefficient for the network is 0.43 (0.41 for the giant component) (Figure 3.2(d)), which is orders of magnitude higher than 0.005 (±0.002), the clustering coefficient of a corresponding Erdős–Rényi random network which has the same number of nodes and links (Erdős and Rényi 1960).

The high clustering coefficient and short characteristic path length suggest that the giant component is a small-world network. In other words, most MEAs in the component can be reached from every other by a small number of steps. This is so despite the large number of MEAs in the network, each MEA is connected to an average of few other MEAs, and the network is decentralized with no dominant central MEA to which most other MEAs are directly connected.

3.5.2. Scale-free

The MEA network has an approximately scale-free topology. This means that the degree distribution, the probability that a node selected uniformly at random has a certain number of links, is far from random, but heterogeneous with a highly skewed tail that follows a particular mathematical function called a power law (Barabási and Albert 1999).

For testing whether the MEA network is scale-free, the method developed by Clauset et al. (2009) was applied. This method combines maximum-likelihood fitting methods with goodness-of-fit tests based on the Kolmogorov-Smirnov statistic and likelihood ratios. After goodness-of-fit tests with 1,000 iterations, with the null hypothesis that the degree distribution follows a power law, the result was p-values of 0.39 and 0.75 for the indegree and outdegree distributions, respectively. For the p-value is significantly larger than 0.1, it can be concluded that the data support the hypothesis in that they are drawn from a power-law distribution (Clauset et al. 2009). Furthermore, the degree distributions in log-log scale (Figure 3.4) show that straight lines would fit reasonably well through the dots, which is suggestive of approximate power-law scaling.

The heavily right-skewed degree distributions point to the presence of relatively few MEAs with extraordinary numbers of links, hence power and authority, despite the few links that an average MEA has. In fact, the top 10 percent of the 747 MEAs garnered about 65 percent of the total cross-references. The presence of such 'hubs' has originated from a micro-process called 'preferential attachment', whereby new MEAs are more likely to make connections to those that already have many links (Barabási and Albert 1999). From a network theoretical perspective, such degree heterogeneity may contribute to institutional resilience to random failures but low tolerance to the failure of hubs (Albert et al. 2000; Tu 2000; see also Young 2010b).

To identify the hubs, I used a variety of node-level algorithms and measures, such as the Hyperlink-Induced Topic Search (Kleinberg 1999) and betweenness that measures "the degree to which a point falls on the shortest path between others" (Freeman 1977, p. 35; see also Wasserman and Faust 1994). As at 2012, the United Nations Convention on the Law of the Sea, having received 66 citations, is by far the most structurally central and authoritative MEA. A possible explanation for its central position in the network is the sheer number of MEAs relating to regional fisheries management, most of which cite the Law of the Sea Convention. The runner up with a clear margin is the Convention on Biological Diversity with 34 inward citations and 1 outward citation.

3.5.3. Modularity

Modules are locally dense subgroups of MEAs that are relatively densely connected to each other but sparsely connected to MEAs in other dense groups (Porter et al. 2009; Fortunato 2010). In governance terminology, modules are what have been referred to as agreement clusters (von Moltke 2005) or regime complexes for different issue areas such as plant genetic resources (Raustiala and Victor 2004), climate change (Keohnae and Victor 2011), or the Arctic (Young 2011). The notion of clustering of MEAs has been the subject of increasing interest to governance scholars, especially for those concerned about the challenges of institutional fragmentation and coordination (Oberthür 2002; Roch and Perrez 2005; von Moltke 2005). However, their arguments have been largely normative based on anecdotal evidence of, for example, deliberate efforts in 'clustering experiment'. Here I take a broader view covering the whole MEA system and present empirical evidence for the presence of naturally emergent, topical MEA modules.

Modularity does not always mean clear-cut subgroups, but there may be a certain degree of overlap between modules. To find the best partition of the MEA network into modules, I applied a community detection algorithm developed by Newman (2006). This algorithm frames the problem of detecting modules as an optimization task in which one searches for the maximal value of the quantity known as modularity over possible divisions of a network (Newman 2006). Modularity is quantified by calculating "the number of edges falling within groups minus the expected number in an equivalent network with edges placed at random" (Newman 2006, p. 8578).

The results showed that the MEA network exhibits a modular structure consisting of a high modularity score of 0.75 (maximum is 1), which is comparable to the modularity of a co-authorship network of scientists working in condensed matter physics (0.72) (Newman 2006). The Newman's algorithm identified 20 modules within the giant component. A scan of MEAs in each module revealed that they share similar subject matter or topic, confirming the presence of homophily (McPherson et al. 2001). Sizeable and clearly distinguishable modules include the marine environment, biodiversity, maritime safety and liability, watercourses, atmosphere, hazardous wastes, plant protection, and nuclear-related. The modular structure conformed to the conventional organization of law with its modules correlating highly with underlying legal semantics (UNEP 2001a; von Moltke 2005; Smith 2007).

Furthermore, the high modularity score suggests the presence of sparse inter-module connections called 'weak' ties (Granovetter 1973). These weak ties play an important role in terms of global connectivity. For example, the MEA network would still retain its macro-structure even if some of the 'strong' intra-module ties were removed, whereas removal of the same number of 'weak' inter-module ties may lead to a fragmentation of the entire network.

3.5.4. Nested Hierarchy

It was observed that low-degree MEAs tend to belong to highly cohesive neighbourhoods whereas higher-degree MEAs tend to have neighbours that are less connected to each other (Figure 3.5). Such an inverse correlation between degree and clustering coefficient, taken together with a heterogeneous degree distribution and modularity suggest a hierarchically nested organization (Ravasz et al. 2002; see also Dorogovtsev and Mendes 2002).

This hierarchical organization does not, however, refer to dominance and subservience but to the nested structure of separate but interrelated layers which expand exponentially in width. In other words, modules are made up of smaller and more cohesive modules, which themselves are made up of smaller and more cohesive modules (Ravasz et al. 2002).

3.6. Interpreting the Emergent Order: From Structure to Function

What can we make out of the measured structural features in terms of collective dynamics? Unfortunately, the relationship between governance system structure and function is not straightforward (Ruhl 2008; see also Watts 2004). This is particularly so as cross-references do not necessarily provide information about the functionality of the connections between MEAs. Nonetheless, the observed structural patterns provide us with an insight into the nature of the emergent system, which in turn could be interpreted in terms of likely governance outcomes.

The MEA network seems to have coevolved in relationship to its target, the Earth system, in a similar manner as to the way in which road networks expand in response to dynamic traffic loads (Gross and Blasius 2008). For example, when a new environmental issue escaped the scope of pre-existing institutions, a new MEA was negotiated and inserted into the network to fill the regulatory gap. Most of these new MEAs connected to, by cross-referencing, a small number of pre-existing MEAs. In the process, the network has been structurally defragmented and a complex architecture emerged.

There were distinct moments when highly cited MEAs were adopted, such as the year 1982 that witnessed the conclusion of the United Nations Convention on the Law of the Sea (Figure 3.2(b)). Time-dependent analysis indicated that these years (e.g., 1982) were followed by other years (e.g., 1992) in which the initially favoured set falls out of favour to be replaced by a different one, such as the so-called Rio Conventions. A similar pattern could probably be observed at the level of norms. New norms such as 'precaution' and 'common but differentiated responsibilities' have emerged as unifying principles through repeated use, while others have been less popular and by comparison have withered on the vine.

This non-random process is similar in principle to natural selection which is key to biological evolution. From the existing pool of norms, a subset was selected for replication or enhancement through an autonomous process (Levin 1998). This process, however, does not necessarily mean that the international environmental governance system has been able to adapt adequately to the constantly changing *biophysical* environment. Given the apparently loose feedback loop between science and policy, institutional responses might have been more strongly influenced and constrained by international politics (Axelrod 2011). The structural analysis does not suffice to support the argument that the MEA system as a whole has been coevolving with its external environment by inducing changes on itself and improving the 'fit' with the target biophysical systems or processes (Young 2002; Galaz et al. 2008). Case studies at the level of regime complexes would be necessary (e.g., Kim 2012).

Nonetheless, the emergent network structure revealed here exhibits several important topological properties of the real-world systems, including those that are complex and adaptive. For example, the network has polycentric institutional arrangements, which may provide adaptive capacity and a balance between decentralized and centralized control (Ostrom, E. 1999; Folke et al. 2005; Olsson et al. 2006). MEAs vary to a significant degree in terms of subject matter, objectives, memberships, geographical scope, regulatory mechanisms, and underlying jurisprudence. Such institutional diversity may increase the capacity of international environmental law and governance as a control system to cope with uncertainty and complexity (Ashby 1956; Low et al. 2003; Ostrom 2005). The modular architecture is known to help accumulate 'local' knowledge and sustain 'local' mutualism, while facilitating efficient 'global' cooperation through bridges between modules (e.g., Levin 1999). The hierarchically nested structure tends to provide stability and flexibility at the same time, enabling both exploitation and exploration for enhanced adaptive capacity (Duit and Galaz 2008; Duit et al. 2010; Ebbesson 2010). These points make plausible hypotheses about the impact of the network structure, which could be tested in future research.

In particular, the small-world architecture may have dramatic implications for the collective dynamics of the MEA system (e.g., Watts and Strogatz 1998; Watts 1999; Watts 2004). Any response to environmental problems such as climate change requires that information about the external perturbation spread within the regulatory network. Thus, the short path lengths, which support rapid dissemination of information, are an imperative feature that may ensure fast and efficient reaction to global environmental change. Shortcuts provide alternative pathways and contribute to path redundancy that may enable the robust functioning of the system by relying less on individual pathways or mediators (Albert 2005). Furthermore, archetypical small-worlds are known to have an enhanced ability to synchronize (Watts and Strogatz 1998; Watts 1999). The structure may be a critical factor for explaining the current level harmonization of international environmental law achieved through the horizontal expansion of norms and their inclusion in different MEAs (Kiss and Shelton 2004; Long 2010).

A real test for the adaptability of international environmental law has recently begun as the MEA system has reached maturity with slow growth. However, the capacity of each MEA as an autonomous lawmaker and administrator is on the increase (Churchill and Ulfstein 2000; Brunnée 2002; Wiersema 2009). To the extent the governance processes such as information sharing, learning, collaborating, and resolving conflicts are effective, MEAs may self-organize and mutually adjust and may be said to function as a complex and adaptive, polycentric system (Galaz et al. 2012c).

3.7. Conclusion

Conventionally, the architecture of international environmental law and governance has been characterized by the concept of fragmentation (Biermann et al. 2009b). Fragmentation has been a useful concept in many ways, such as highlighting that MEAs rarely cross issue-specific lines to address more cross-cutting questions (Carlarne 2008). However, the presumptive notion of fragmentation may have prevented us from seeing systemic properties that emerge from institutional interconnections.

What this study revealed beyond a fragmented institutional landscape is a rather cohesive polycentric legal structure that forms the backbone of the international environmental governance system. If one focuses on MEA texts, the outcome of treaty negotiations, the MEA system has the architecture of a complex system that exhibits small-world and scale-free properties with a hierarchical and modular organization. International environmental law, in this sense, is neither a fragmented system nor a completely connected unity, but a complex network of norms and institutions.

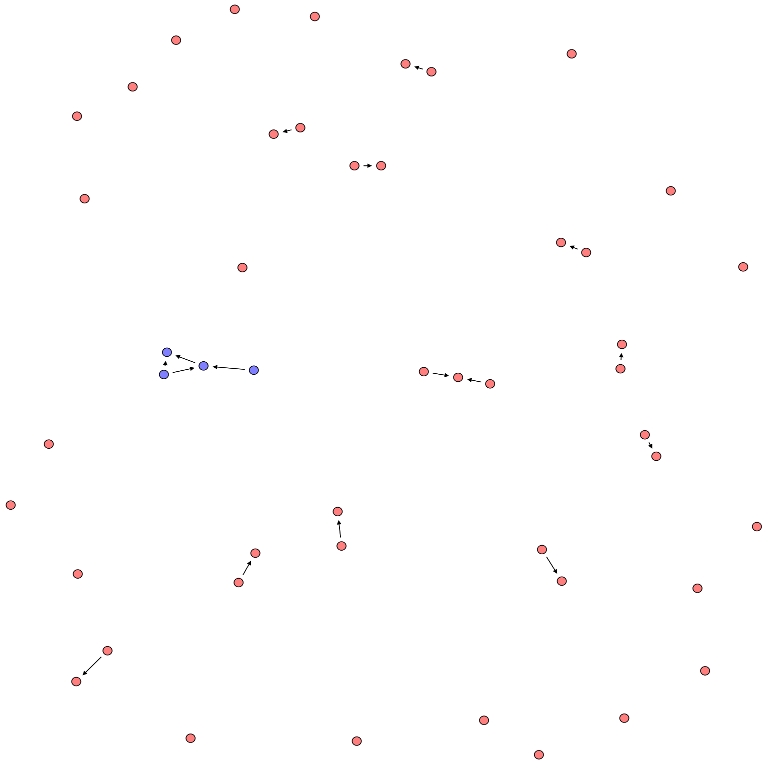
From an evolutionary perspective, MEAs were most disconnected in 1975. With the inception of modern MEAs in the mid-1970s, the MEA network has been structurally defragmenting. In 1992, a complex network structure dominated by the giant component emerged spontaneously. During the rest of 1990s, the then partial and uneven body of international environmental law underwent systematization. The emergent system matured throughout the 2000s with new MEAs forming increasingly dense and redundant connections. The growth of the MEA system almost halted in most recent years. In other words, the MEA system has evolved through different phases in time, and has become increasingly interconnected in complex ways.

Although the MEA network has coevolved with the increasing complexity and interconnectivity of global environmental challenges, it is questionable whether its institutional responses have been coherent. Structural defragmentation does not necessarily mean that multiple treaty regimes are in a functionally "compatible and mutually reinforcing" relationship (Keohane and Victor 2011, p. 16; see also Nilsson et al. 2012). What can be concluded, however, is that the observed network structure is suggestive of potentially a complex and adaptive, polycentric system of law and governance.

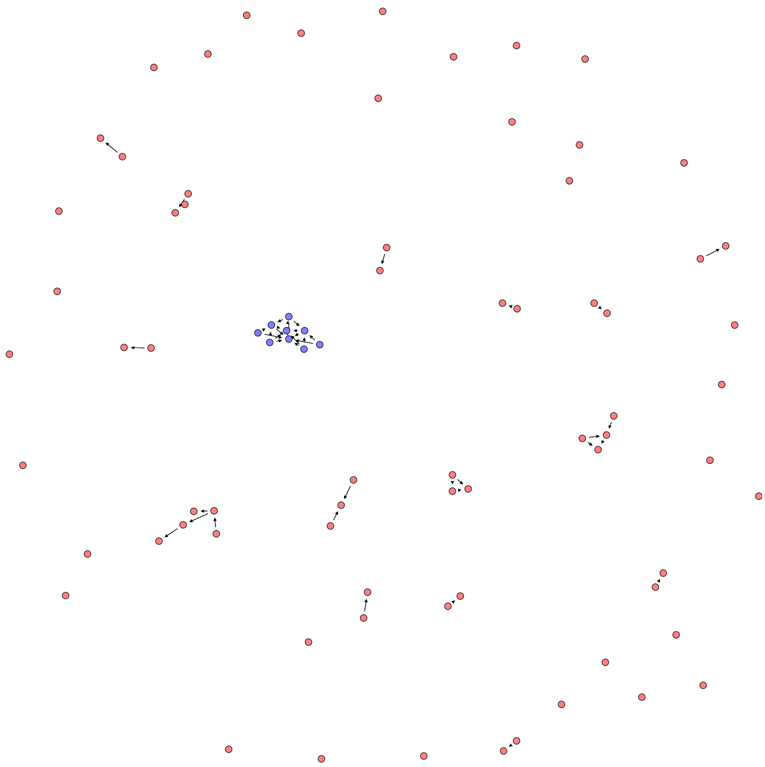
This study has demonstrated the need to understand the emerging complexity by approach MEAs in the context of a dynamic network system. I would recommend caution against a naïve dismissal of international environmental law as 'fragmented'. Such a dismissal might be a reflection of our inability to comprehend and embrace complexity in both the subject matter and the legal system itself. Rather than trying to reduce complexity through centralized control, I concur with the conclusion of Kanie (2007, p. 82) that the "strengths of the MEA system [are] mostly the same as the very strengths of a decentralized system" and that "MEAs should be placed in … a decentralized and densely networked system" (see also Haas et al. 2004). Therefore, any reform options for global environmental governance should pay attention to the emergent polycentric order and complexity and what these features imply for the function of the MEA system.

In terms of methodology, this chapter has demonstrated the analytical utility of a network approach to gaining system-level insights into the structure and dynamics of international environmental law and governance. There is a significant scope for additional research into this direction. The network analysis would greatly benefit from enriching the citation dataset with MEA membership data. Future research could also link the network of MEAs to a network map of global social-ecological systems (e.g., Janssen et al. 2006; Ekstrom and Young 2009; Ernstson et al. 2010; Stein et al. 2011; Rathwell and Peterson 2012). This would allow the design of a three-layer representation of the biophysical systems, international environmental law, and broader governance systems. The findings could be used as a basis for improving their alignment.

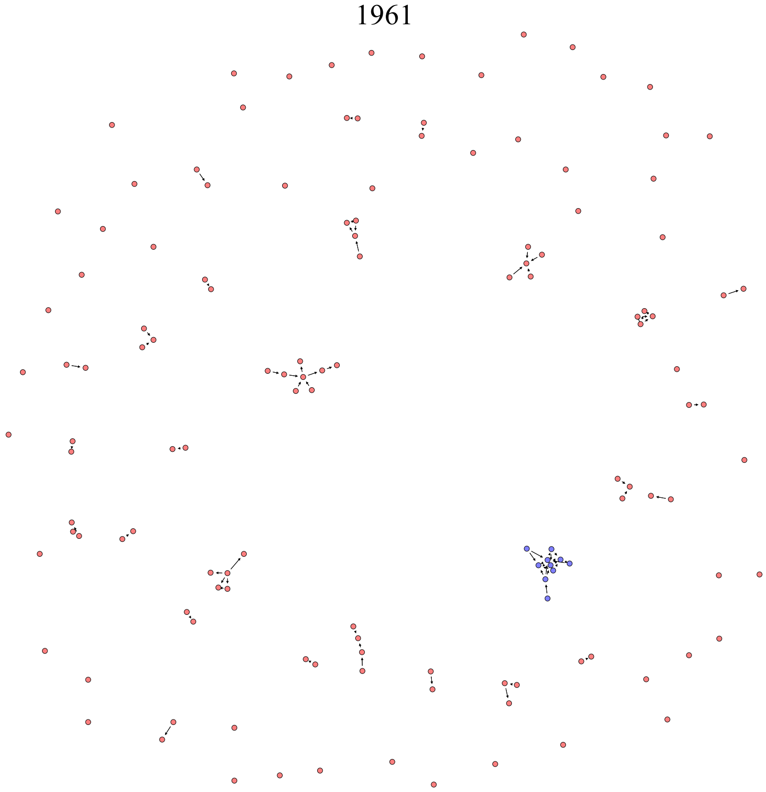
1941



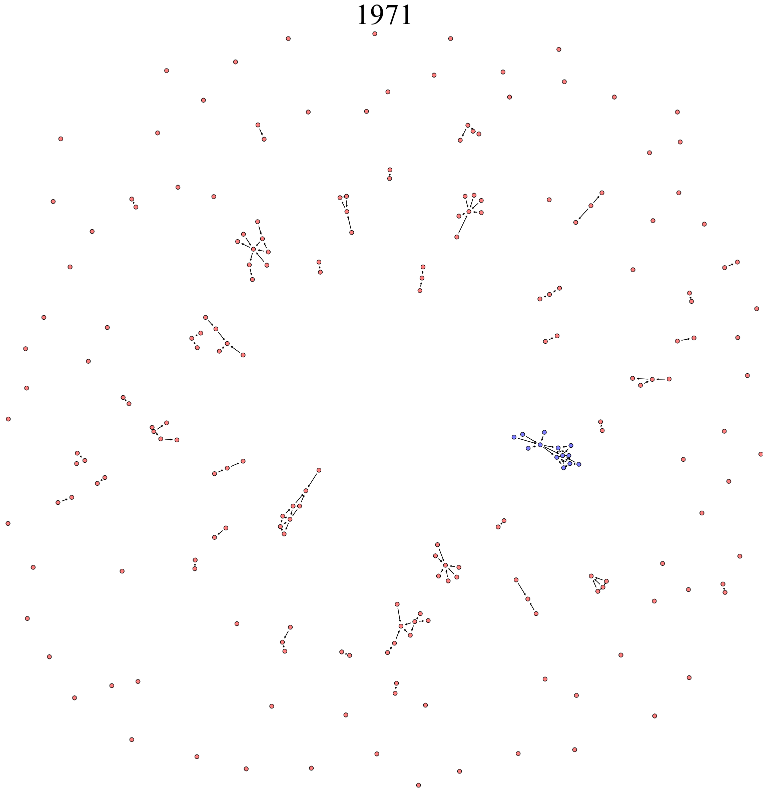
1951



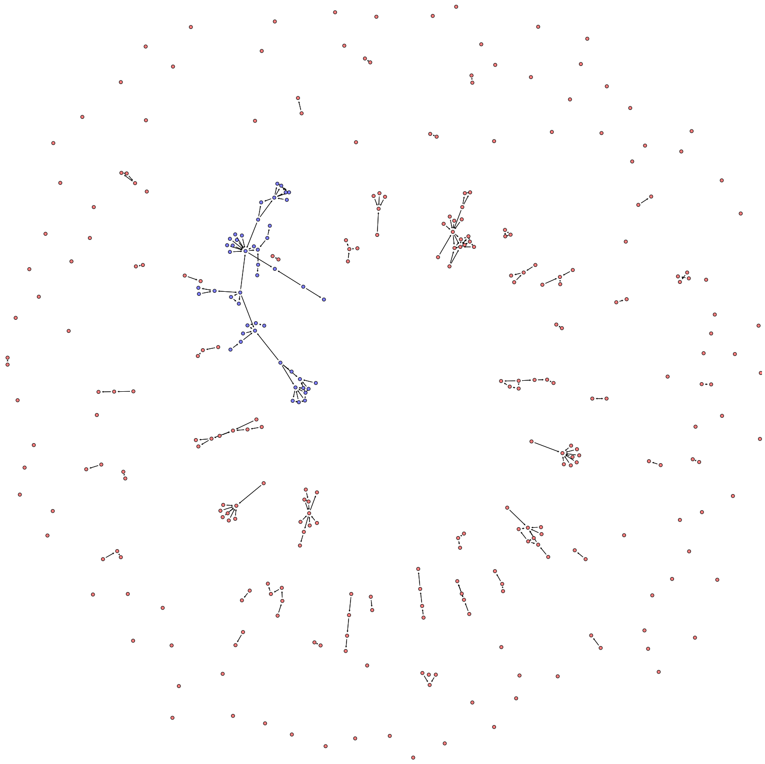
1961



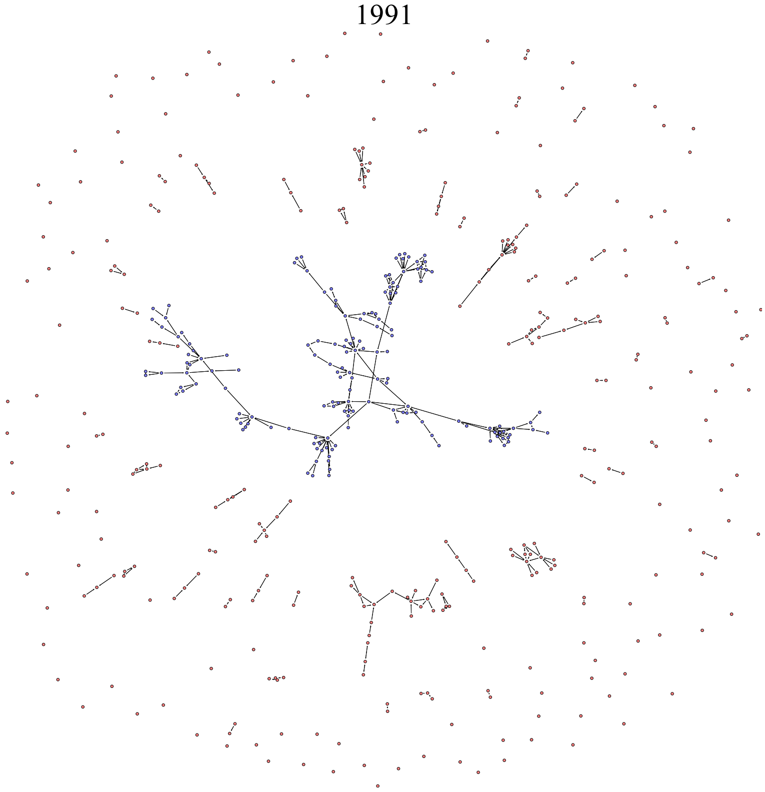
1971



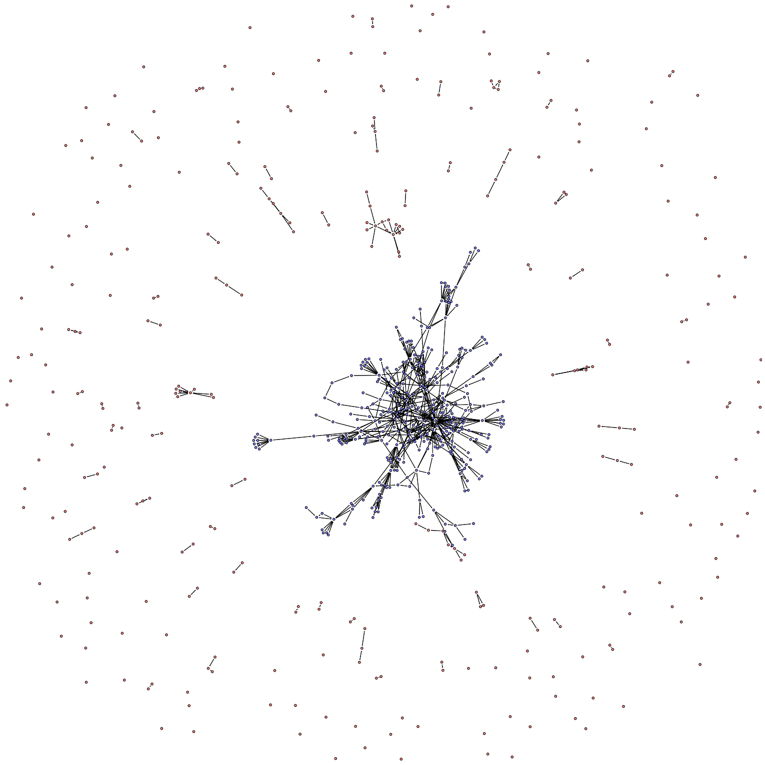
1981



1991



2001



2011 (and 2012)

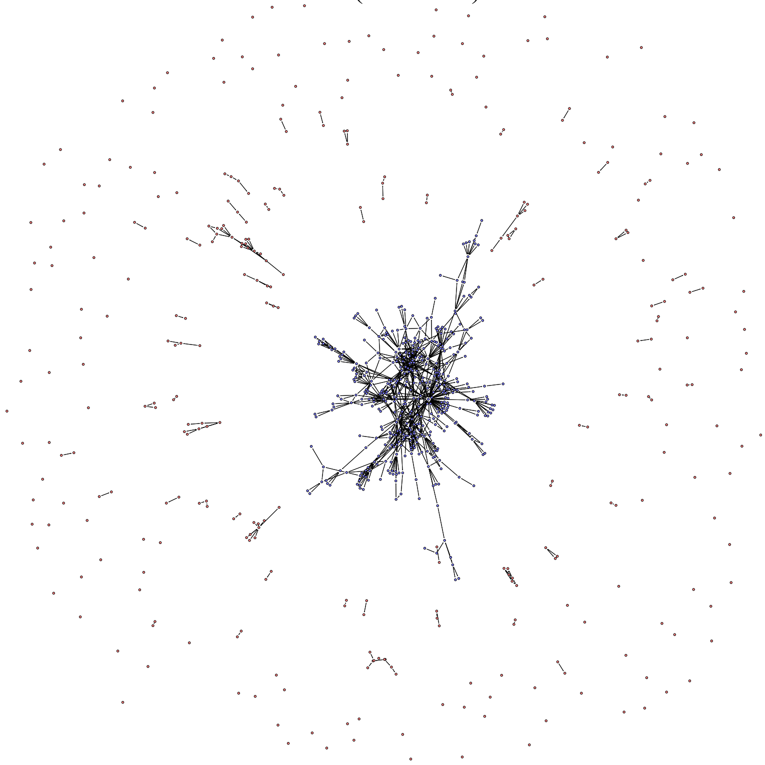
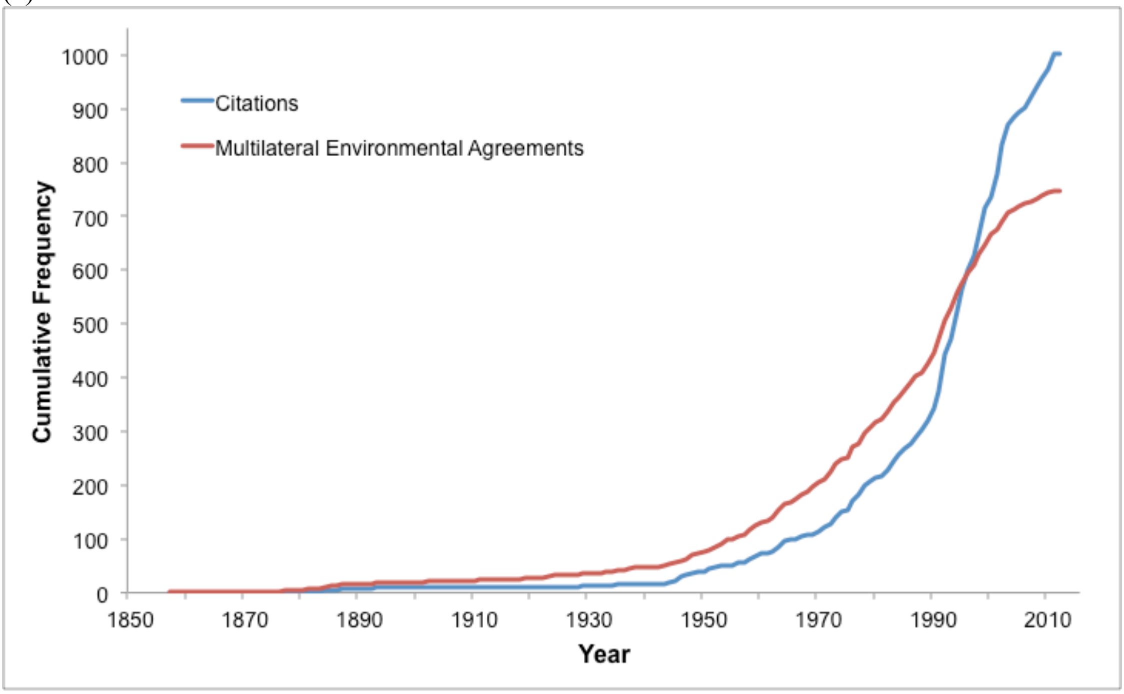


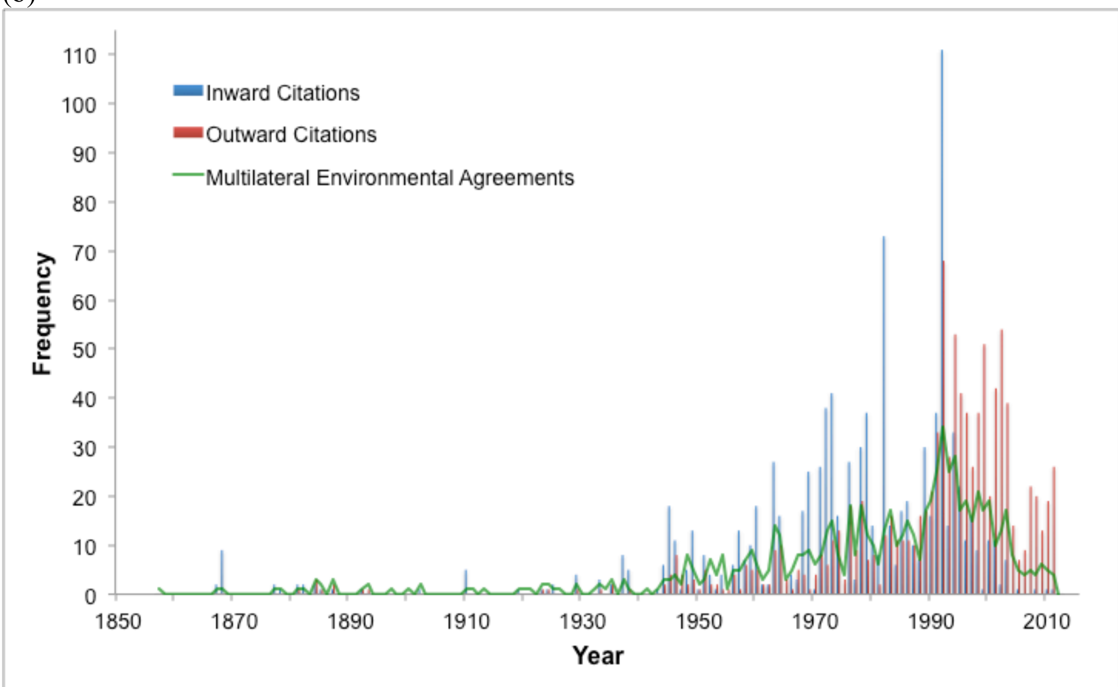
Figure 3.1. Graphical representations of the MEA citation network as at 1941, 1951, 1961, 1971, 1981, 1991, 2001, and 2011 (and 2012) drawn using the layout algorithm of Fruchterman and Reingold (1991). The nodes of the largest components appear in blue.

(a)



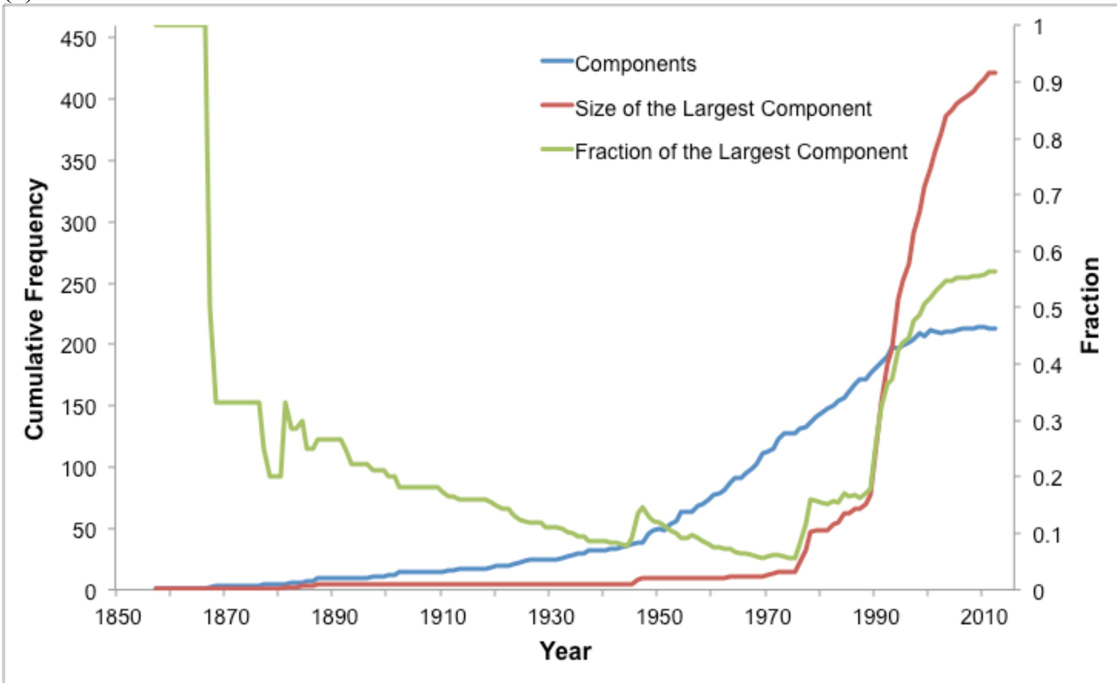
Citations
Multilateral Environmental Agreements
Cumulative Frequency
1000
900
800
700
600
500
400
300
200
100
0
1850
1870
1890
1910
1930
1950
1970
1990
2010
Year

(b)



Inward Citations
Outward Citations
Multilateral Environmental Agreements
Frequency
110
100
90
80
70
60
50
40
30
20
10
0
1850
1870
1890
1910
1930
1950
1970
1990
2010
Year

(c)



(d)

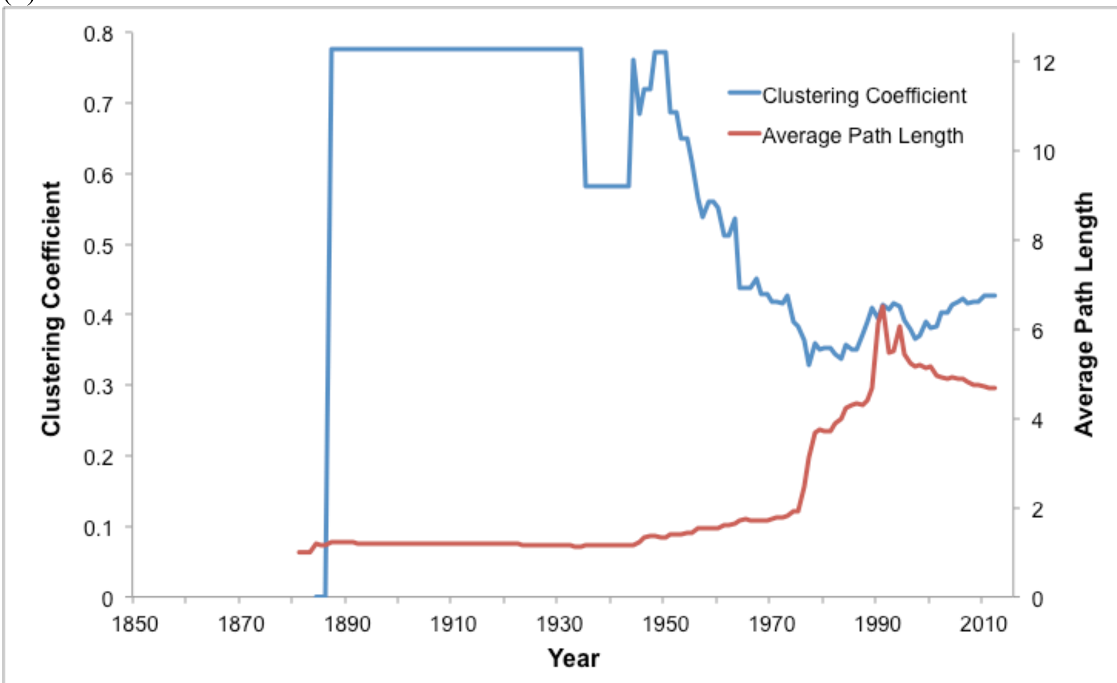


Figure 3.2. (a) Cumulative number of MEAs and cross-references. (b) Number of new MEAs each year, and different distributions of inward and outward citations as a function of the year in which cited and citing MEAs were adopted, respectively. This network is symmetric, where the total number of inward citations equals the total number of outward citations. (c) Number of components, the size of the largest component, and the fraction of the largest component. (d) The average path length and the clustering coefficient of the MEA network.

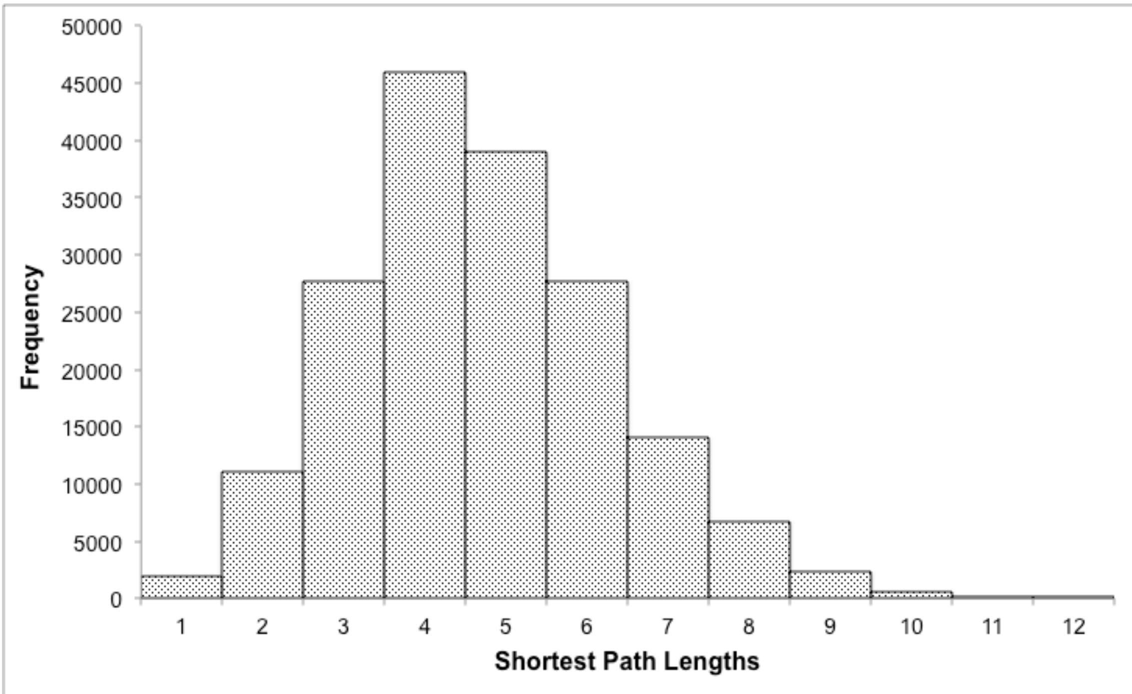
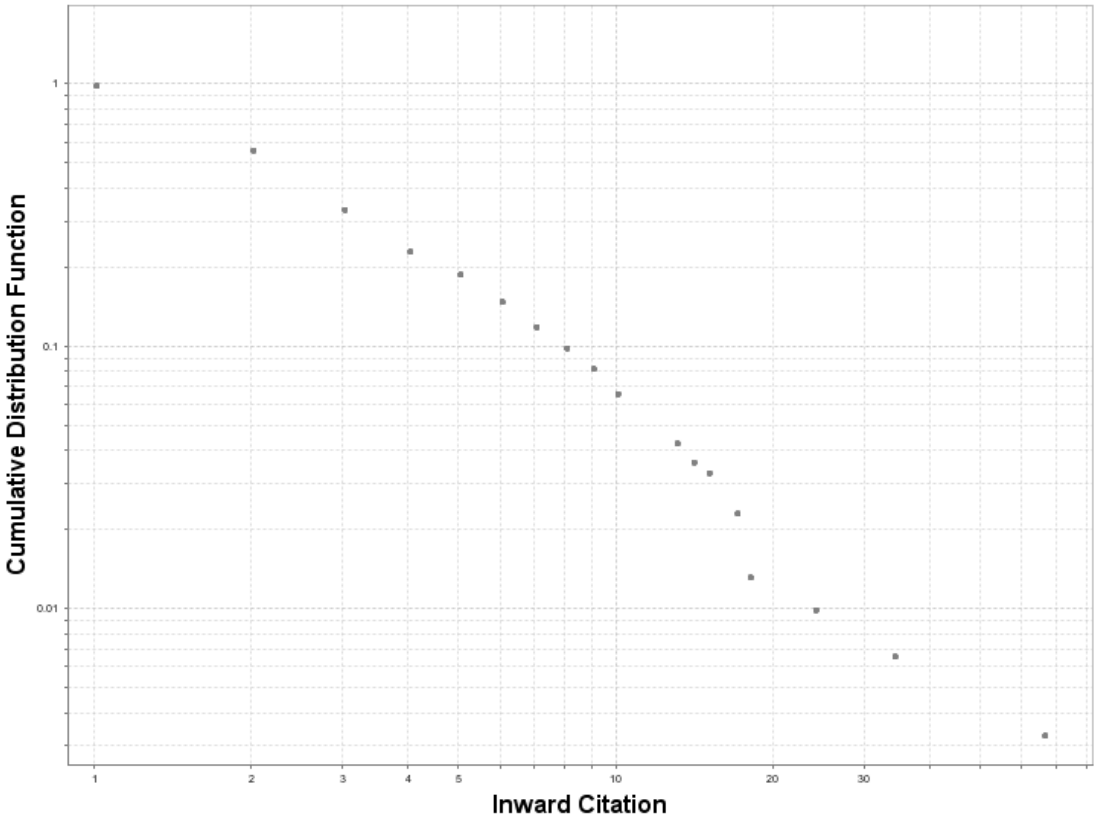


Figure 3.3. Distribution of shortest path lengths between all reachable pairs.



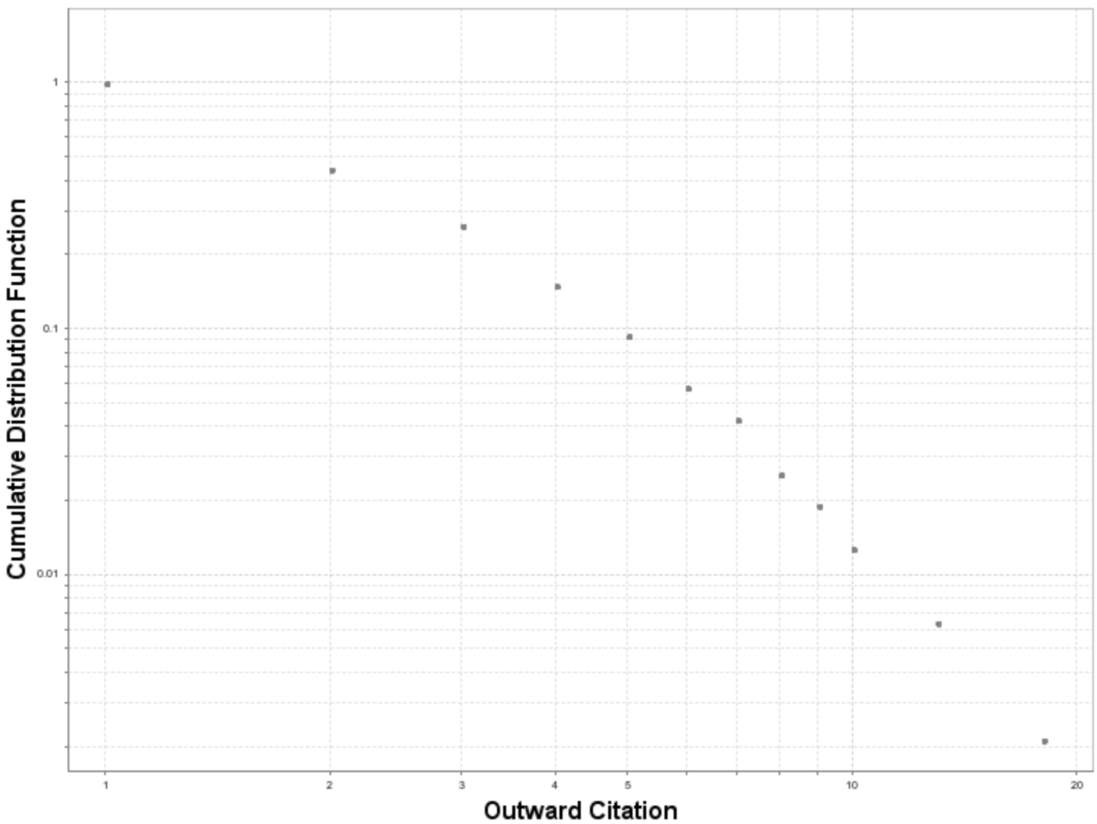


Figure 3.4. Inward citation and outward citation distributions in log-log scale. The data have been binned logarithmically to reduce noise.

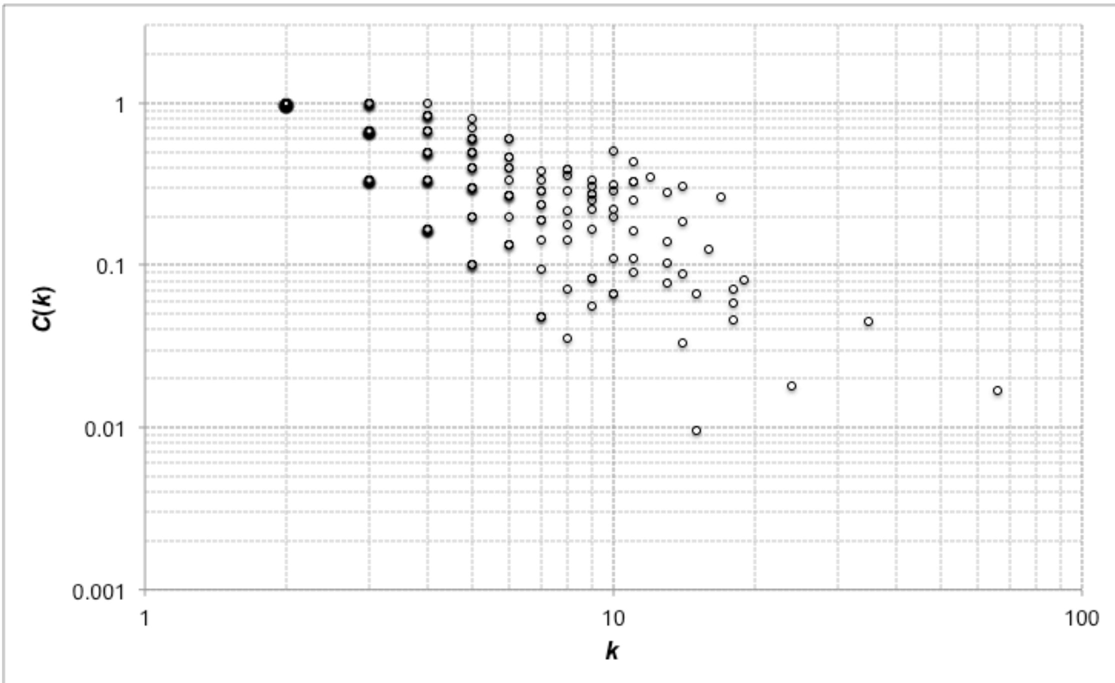


Figure 3.5. $C(k) \sim k^{-1}$ in a double logarithmic plot showing the higher a node's degree (k), the smaller is its clustering coefficient, asymptotically following the $1/k$ law.

Chapter 4.

Is a New Multilateral Environmental Agreement on Ocean Acidification Necessary?

Abstract

No multilateral environmental agreement (MEA) has so far been concluded with a view to addressing the problem of ocean acidification. The United Nations Framework Convention on Climate Change (UNFCCC) is considered by many as being capable of addressing ocean acidification as it regulates carbon dioxide emissions, the root cause of the problem. I argue that, on the contrary, the UNFCCC does not provide an adequate legal framework for the problem because ocean acidification is not an effect of 'climate change', meaning that it is outside the UNFCCC's jurisdiction. I then critically examine whether ocean acidification is likely to be addressed through the self-organization of existing MEAs or whether a new MEA is necessary. Specifically, I consider the extent to which the provisions of relevant MEAs are applicable to ocean acidification and how their decision-making bodies have responded to the problem. I observe inherent weaknesses in the emerging polycentric order and reach the conclusion that a new MEA on ocean acidification is necessary to fill the regulatory gap. I conclude by outlining two hypothetical candidates as a way of discussing key considerations informing the choice of an appropriate form and forum for an MEA on ocean acidification.

4.1. Introduction

Ocean acidification poses a serious global environmental challenge, but only recently caught the attention of the international community, having been overshadowed by the climate change problem. Ocean acidification is a direct consequence of the increased concentration of carbon dioxide (CO_2) in the atmosphere due to anthropogenic activity, and has been dubbed 'the other CO_2 problem' (Doney et al. 2009). Oceans naturally exchange CO_2 with the atmosphere, and constitute a significant carbon reservoir in the global carbon cycle (Archer et al. 2009). Over the past 200 years, the oceans have absorbed about 40 percent of the excess CO_2 that humans have emitted into the atmosphere (Zeebe et al. 2008). Although this natural buffering effect has helped to mitigate anthropogenic climate change, the extra carbon taken up by the oceans is decreasing their pH and making them more acidic (Caldeira and Wickett 2003). The increasing acidity is predicted to have dire consequences for many marine ecosystems and species, especially those organisms which form shells and plates out of calcium carbonate, such as coral reefs (Gattuso et al. 2011). Ocean acidification is now widely recognized among the most pressing global environmental challenges that humanity faces in the years to come (Rockström et al. 2009a).

Despite the significance of the problem, no multilateral environmental agreement (MEA) has so far been concluded with a view to addressing it. As a newly emerging global environmental problem, ocean acidification exists in an "international legal twilight zone" (Baird et al. 2009, p. 460). This chapter explores whether a separate MEA on ocean acidification is necessary to bring light to twilight and fully address the problem. This question is particularly relevant in the context of ocean acidification, because the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol could be considered as being both responsible for and capable of addressing the problem. Indeed, these MEAs regulate CO_2 emissions, the root cause of ocean acidification (Harrould-Kolieb and Herr 2012). However, it is questionable to what extent the UNFCCC and Kyoto Protocol impose an obligation on its parties to prevent ocean acidification. In addition, the presence of a plethora of MEAs governing some aspects of ocean acidification makes the question of 'to treaty not to treaty' worthy of a scholarly investigation. In this chapter, I approach the question through a survey of applicability and responses to ocean acidification of key MEAs, and an assessment of polycentric governance patterns that these MEAs have created.

This chapter proceeds as follows. Following a brief review of the science of ocean acidification, I argue that the UNFCCC, with its narrow atmospheric focus on climate change, does not provide an adequate legal framework for addressing ocean acidification. I then critically examine whether ocean acidification is likely to be addressed through the self-organization of existing MEAs or a new MEA on ocean acidification is necessary. Specifically, I consider the extent to which the provisions of relevant MEAs are applicable to ocean acidification, and how their decision-making bodies have responded to the problem, both individually and interactively. I observe inherent weaknesses in the emerging polycentric order and reach the conclusion that a new MEA on ocean acidification is necessary to fill the regulatory gap. Finally, as an attempt to initiate a scholarly discussion on these aspects, I outline some of the key institutional considerations informing the choice of an appropriate form and forum. I introduce a couple of hypothetical candidates, and explore the potential implications for the wider system of international environmental law and governance, especially in relation to the existing climate regime.

4.2. Ocean Acidification: A Planetary Boundary

The issue of ocean acidification is closely related to climate change through the global carbon cycle. CO_2 released from fossil fuel combustion equilibrates among the various carbon reservoirs of the atmosphere, the ocean, and the terrestrial biosphere on timescales of a few centuries (Archer et al. 2009). The oceans' exchange of carbon with the atmosphere is largely driven by the difference in the partial pressure of CO_2 between the atmosphere and the surface ocean water; a portion of the anthropogenic CO_2 dissolves in the surface layer of the sea, acidifying the oceans. The ocean acidity is largely restored by excess dissolution of calcium carbonate ($CaCO_3$) from the sea floor and on land and, ultimately, by silicate weathering on land, allowing more carbon to be soaked up, while maintaining ocean pH at a reasonably constant level (Archer et al. 2009), at near 8.25 in pre-industrial times (Jacobson 2005). However, humanity has perturbed the global carbon cycle by emitting too much CO_2 too quickly.

The oceans have taken up around 40 percent of the anthropogenic CO_2 emissions over the past 200 years (Zeebe et al. 2008). As a result, carbonic levels have risen and seawater has become increasingly acidic; pH has dropped by approximately 0.1 units since industrialization, which amounts to a considerable increase in acidity. Although there are other causes of ocean acidification from sulphur and nitrogen compounds (Kelly et al. 2011), the scale of the impact is not comparable to that of CO_2. Over the next century, seawater pH is projected to decline by 0.5 units, at a rate unprecedented in the past 55 million years (Zeebe 2011; Zeebe and Ridgwell 2011). Biological and ecological effects are generally considered large and negative (Kroeker et al. 2010). Calcification in both flora and fauna is reduced at lower pH values (Riebesell et al. 2000; Orr et al. 2005; Hoegh-Guldberg et al. 2007; Fabry et al. 2008), leading to changes in the composition of communities and global marine ecosystem services. The impact is not limited to the marine environment (Boyd 2011; Gehlen et al. 2011), and negative implications can be expected for sustainable development (United Nations Department of Economic and Social Affairs 2009), food security and the economy. Accordingly, ocean acidification has been identified among non-negotiable planetary boundaries that humanity needs to respect in order to avoid the risk of unacceptable environmental change at both the continental and global scales (Rockström et al. 2009a).

From a scientific perspective, there are no viable geoengineering quick fixes to reduce ocean acidity. Solar radiation management will not affect levels of anthropogenic CO_2 in the atmosphere, and ocean acidification will therefore continue. Some ocean-based CO_2 removal approaches, such as ocean iron fertilization, could, in theory, reduce the rate of increase of atmospheric CO_2, hence the rate of ocean acidification in the upper ocean. However, if deployed on a climatically-significant scale, these approaches would relocate acidification from the upper ocean to mid- or deep water (Cao and Caldeira 2010), where biota may be more sensitive to pH changes (Caldeira and Duffy 2000). Furthermore, ocean iron fertilization involves a high risk of acute local impacts and more diffuse, long-term changes in carbonate chemistry on a regional and global basis through subsequent mixing in the ocean interior and the return of deep waters to the surface via upwelling (Williamson and Turley 2012). Adding limestone powder to upwelling regions has been considered to cause large-scale ecosystem damage by locally raising pH beyond organisms' tolerance limits or decreasing light penetration through precipitation effects (Harvey 2008; Williamson and Turley 2012).

In the absence of feasible geoengineering remedies, future ocean acidity levels strictly depend on CO_2 emission pathways (Orr 2011). Rapid and deep reductions in CO_2 emissions or drawing atmospheric carbon into terrestrial biomass are the only viable solution to the ocean acidification problem (Royal Society 2005; German Advisory Council on Global Change 2006; InterAcademy Panel on International Issues 2009; Secretariat of the Convention on Biological Diversity 2009c). Present scientific knowledge suggests that a target of 350 ppm CO_2 may be required to maintain the integrity of marine ecosystems (Veron et al. 2009). An overshoot to 450 ppm CO_2 would involve considerable risk of large-scale ocean acidification impacts for the upper ocean (McNeil and Matear 2008), and would be catastrophic for corals (Hoegh-Guldberg et al. 2007).

4.3. Is the Climate Regime Capable of Addressing Ocean Acidification?

The UNFCCC is an international legal framework for regulating anthropogenic greenhouse gas emissions for the purpose of mitigating climate change. This section critically examines the adequacy and relevance of the UNFCCC's provisions in preventing ocean acidification.

4.3.1. Does the UNFCCC Impose an Obligation on Its Parties to Prevent Ocean Acidification?

It is commonly perceived that the UNFCCC provides "one framework within which both ocean acidification and climate change can be tackled" (Harrould-Kolieb and Herr 2012, p. 2). The German Advisory Council on Global Change, for example, contended that Article 2 of the UNFCCC encompasses an obligation to take into account the impacts of increasing atmospheric CO_2 levels upon the oceans (German Advisory Council on Global Change 2006). Article 2 obliges its parties "to achieve … stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system", which is in turn defined to include the oceans as an integral part. Oceans are part of the hydrosphere, its marine organisms are part of the biosphere, as well as the interactions of the oceans with the atmosphere and the biosphere (UNFCCC Article 1.3).

However, the Kyoto Protocol, in implementing the objective set out in the UNFCCC Article 2, imposes no specific requirement to reduce *CO_2* emissions, but rather aggregate anthropogenic CO_2 equivalent emissions of greenhouse gases (Kyoto Protocol Article 3.1). This means that Annex B parties to the Kyoto Protocol (i.e., developed countries) are allowed to increase their CO_2 emissions as long as there is a required reduction in their emission of other greenhouse gases, such as methane and nitrous oxide, even though this will worsen ocean acidity. Therefore, the climate regime's capacity to address ocean acidification occurs only incidentally as they attend to minimizing the effects of climate change (Baird et al. 2009).

For the above Kyoto Protocol provisions to be found in violation of, or incompatible with, the object and purpose of the UNFCCC, the parties to the UNFCCC and Kyoto Protocol need to recognize the legal causation that the stability of the climate system can only be maintained by preventing dangerous anthropogenic interference with ocean acidity. Such recognition would translate into regulation of human interference with all major carbon sinks and reservoirs in the global carbon cycle with a long-term view (taking into account the lifetime of CO_2), beyond the current Kyoto Protocol's focus on short-term fluxes of carbon in and out of the atmosphere. However, this transformation is highly unlikely to occur spontaneously.

This is in significant part because the uptake of atmospheric CO_2 by the oceans is currently presented in the climate regime as part of the solution to climate change (Baird et al. 2009). The UNFCCC and Kyoto Protocol obligate all parties to promote sustainable management, and promote and cooperate in the conservation, enhancement, and protection of the oceans as sinks and reservoirs (UNFCCC Article 4.1(d); Kyoto Protocol Article 2.1(a)(ii)).

This means that not only must parties act to enhance the 'passive' absorption of anthropogenic CO_2 into the oceans, but these provisions can even be read as encouraging 'active' ocean sequestration of CO_2 through marine geoengineering measures such as ocean iron fertilization (Baird et al. 2009).[5] In other words, by design, the climate regime has been externalizing the cost of mitigating climate change, which has manifested partly as the acidifying ocean. If parties to the UNFCCC were to acknowledge ocean acidification as a problem in and of itself, they would have to account for the excess carbon that the oceans naturally absorb. This will place a huge additional burden on the parties.

At a more fundamental level, there is a jurisdictional issue of whether the UNFCCC's language suggests that its parties are required to address ocean acidification. The UNFCCC is concerned about "change in the Earth's climate and its adverse effects" (UNFCCC Preamble; see also UNFCCC Article 3.3). Technically, ocean acidification does not fit into the definitions of either climate change or its adverse effects. Ocean acidification is neither "a change of climate" that is caused by dangerous anthropogenic interference with the climate system (UNFCCC Article 1.2 and Article 2), nor "changes in the physical environment or biota resulting from climate change" (UNFCCC Article 1.1). Rather, ocean acidification shares the same cause as climate change, as it is a change of *ocean acidity*, "which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere" (UNFCCC Article 1.2).

It is then questionable whether the parties to the Kyoto Protocol are required to determine 'dangerous anthropogenic interference' by reference to a dangerous ocean pH threshold (Baird et al. 2009). The UNFCCC states that any anthropogenic interference with the climate system is deemed 'dangerous' if the stabilization of greenhouse gas concentrations is not achieved "within a time-frame sufficient to allow ecosystems to adapt naturally to *climate change*" (UNFCCC Article 2, emphasis added). Although the climate system is broadly defined to include the oceans, significantly it is climate change, *not* oceanic (acidity) change, which conditions what is considered 'dangerous'. Therefore, the emissions targets set by the Kyoto Protocol are calibrated by reference to their atmospheric rather than oceanic effects (Baird et al. 2009), and parties have no obligation to do otherwise.

From a strictly legal perspective, therefore, the UNFCCC, with its narrow atmospheric focus on climate change, does not have jurisdiction over ocean acidification. In contrast to the claim of the German Advisory Council on Global Change (2006), the UNFCCC does not

[5] For discussions on the UNFCCC's position with regard to ocean iron fertilization, see Freestone and Rayfuse (2008) and Walker et al. (2009).

impose an obligation on its parties to prevent ocean acidification. This has created a major gap in international environmental law as full compliance with the UNFCCC and its Kyoto Protocol will not necessarily prevent further ocean acidification.

4.3.2. A Flawed Approach to Ocean Acidification as an Adverse Effect of Climate Change

The risk that ocean acidification poses on marine ecosystems has so far received little attention from the Conference of the Parties (COP) to the UNFCCC (Turley and Boot 2011). The first reference to ocean acidification in a COP decision appeared in 2010, when the COP began considering ocean acidification as a "slow onset event" under the Cancun Adaptation Framework's work programme on loss and damage (UNFCCC 2011, Decision 1/CP.16, para. 25). This work programme was established in recognition of "the need to strengthen international cooperation and expertise in order to understand and reduce loss and damage associated with the adverse effects of climate change, including impacts related to extreme weather events and slow onset events" (UNFCCC Decision 1/CP.16, para. 25). In a footnote, the COP specified what these slow onset events are, and they included ocean acidification along with sea level rise, increasing temperatures, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification. Significantly, ocean acidification was listed along with other 'adverse effects of climate change'.

As Harrould-Koleib and Herr correctly pointed out, this "suggests that the COP erroneously views rising ocean acidity as a symptom of climate change rather than as a concurrent problem" (Harrould-Kolieb and Herr 2012, p. 381). Although ocean acidification is closely related to climate change, sharing a common cause, ocean acidification is a threat additional to climate change. Therefore, the parties need to approach the problem of ocean acidification differently from other effects of climate change. It is not clear whether the observed misconceived view was a mistake made with intent, but it is in fact widespread within the UNFCCC (e.g., UNFCCC 2011, para. 24(b)). Given that ocean acidification sits outside the UNFCCC's jurisdiction, the COP might have no other choice but to consider ocean acidification as an adverse effect of climate change if it were to consider ocean acidification at all. This inherent structural design limitation translates to the limited applicability or potential effectiveness of the UNFCCC as an international legal instrument in mitigating ocean acidification.

4.4. Applicability and Responses of Other Multilateral Environmental Agreements Relevant to Ocean Acidification

In addition to the UNFCCC and Kyoto Protocol, the acidifying ocean poses a barrier to achieving the objectives of a significant number of MEAs. These MEAs can be identified as forming part of the emerging 'regime complex' for ocean acidification.[6] This section explores applicable provisions contained in these MEAs, and how their formal decision-making bodies have responded to the problem of ocean acidification.

4.4.1. The Existing Complex of Multilateral Environmental Agreements

4.4.1.1. United Nations Convention on the Law of the Sea

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) sets out the legal framework within which all activities in the oceans and seas must be carried out (UNGA 2001; UNGA 2011). Its objectives are broad enough to include "the conservation of their living resources, and the study, protection and preservation of the marine environment" (UNCLOS Preamble).

Ocean acidification falls within the scope of UNCLOS through the definition of "pollution of the marine environment" (UNCLOS Article 1.1(4)). In the language of UNCLOS, oceanic deposition of anthropogenic CO_2 translates to "substances" introduced into the marine environment, causing the oceans to become increasingly acidic, "which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities".[7] The anthropogenic emission of CO_2, therefore, clearly constitutes a violation of "the obligation to protect and preserve the marine environment" (UNCLOS Article 192), particularly "rare and fragile

[6] On the concept of 'regime complex', see Raustiala and Victor (2004) and Keohane and Victor (2011).

[7] For similar arguments made in the context of climate change, see Doelle (2006) and Burns (2006).

ecosystems as well as the habitat of depleted, threatened or endangered species and other forms of marine life" (UNCLOS Article 194.5).

In such circumstances, states are required to take all measures "necessary to prevent, reduce and control pollution of the marine environment from any source" (UNCLOS Article 194). This includes pollution from or through the atmosphere (UNCLOS Article 212). Although this provision was not drafted with either ocean acidification or climate change in consideration, it can now be reasonably interpreted to apply to both. Similarly, Article 207, dealing with pollution from land-based sources, is sufficiently broad to cover CO_2 emissions taking place on national territories.

However, the UNCLOS provisions are too general to establish specific international standards to control land-based sources of marine pollution. Instead, UNCLOS can be understood as an umbrella convention that provides the overarching legal framework for a number of agreements on marine environmental protection and marine species conservation. Most of its provisions, being of a general nature (especially as regards its provisions dealing with the protection and preservation of the marine environment), can be implemented only through specific operative regulations in other international agreements (IMO 2012, p. 8). In the absence of an implementing agreement to UNCLOS that regulates land-based activities, the law of the sea's potential for direct regulating CO_2 emissions is limited.

In 2007, ocean acidification made its first formal appearance in the United Nations General Assembly (UNGA) resolution on 'Oceans and the law of the sea'. In its preamble, the UNGA expressed "concern over the projected adverse effects of anthropogenic and natural climate change and ocean acidification on the marine environment and marine biodiversity" (UNGA 2007, Preamble). In the years following, the ocean acidification reference contracted to only an indirect reference stating that "climate change … has weakened the ability of reefs to withstand ocean acidification" (UNGA 2009, Preamble). However, from 2008 onwards, a reference to ocean acidification regularly appeared in the substantive section on the marine environment and marine resources (UNGA 2008, para. 81). It included, notably, specific requests for states and international organizations to address the cause and impact of ocean acidification, in cooperation with the Convention on Biological Diversity (UNGA 2009, para. 99).

4.4.1.2. Convention on Biological Diversity

The Convention on Biological Diversity (CBD) was adopted in 1992 as an international framework treaty for protecting biodiversity. Ocean acidification has been recognized as an important emerging issue within the context of the CBD with the potential to undermine the core principles upon which the Convention is founded. It is anticipated that ocean acidification will make it more challenging to implement the CBD's marine and coastal Programme of Work, and to comply with the Addis Ababa Principles and Guidelines for the sustainable use of biodiversity.

The CBD COP-9 in 2008 first considered ocean acidification in a decision requesting the CBD Secretariat to compile and synthesize scientific information on the problem (CBD 2008, Decision IX/16, para. 3; CBD 2008, Decision IX/20, para. 4). A technical report was consequently published by the Secretariat in 2009 (Secretariat of the Convention on Biological Diversity 2009a). At the next COP in 2010, a decision was adopted to formally acknowledge ocean acidification as one of emerging issues and assigned the Programme of Work on Marine and Coastal Biological Diversity to consider the impacts of ocean acidification on marine biodiversity and habitats (CBD 2010, Decision X/13, para. 2(a)). The parties to the CBD clearly defined ocean acidification as "a direct consequence of increased carbon dioxide concentration in the atmosphere" (CBD 2010, Decision X/29, para. 13(d) and para. 64). The COP endorsed "addressing … the potential adverse impacts on marine and coastal biodiversity of ocean acidification" as one of "climate change-related aspects of marine and coastal biodiversity" (CBD 2010, Decision X/29, para. 13(b)) requiring "the ecological effects of [which to] be considered in conjunction with the impacts of global climate change" (CBD 2010, Decision X/29, para. 65).

Significantly, the COP adopted a biodiversity target in terms of ocean acidification as part of the Nagoya Strategic Plan. It stated that, "[b]y 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning" (CBD 2010, Decision X/2, para. 13). However, the practical effectiveness of the target is limited because of the vagueness of the wordings such as 'minimized' together with often-discussed general weaknesses of the CBD regime (Chandler 1993; McGraw 2002; Morgera and Tsioumani 2010). While lacking mechanisms to regulate the causes and effects of ocean acidification internationally, the COP also called on parties, other governments and organizations to incorporate emerging knowledge on ocean acidification into national biodiversity strategies and action plans, national and local plans on integrated marine and coastal area management, and the design and management plans for marine and coastal protected areas (CBD 2010, Decision X/29, para. 67).

The CBD COP has made a series of requests to its Executive Secretary to collaborate with the secretariats of other MEAs on ocean acidification (CBD 2010, Decision X/29, para.

66; CBD 2008, Decision IX/16, para. 3). In 2010, for example, the Executive Secretary was requested to collaborate with the UNFCCC, Ramsar Convention, Antarctic Treaty, and other international organizations, and develop a series of joint expert review processes to monitor and assess the impacts of ocean acidification on marine and coastal biodiversity, and transmit the results to the UNFCCC Secretariat (CBD 2010, Decision X/29, para. 66; see also CBD 2010, Decision X/33, para. 8(a)).

4.4.1.3. United Nations Fish Stocks Agreement

The 1995 United Nations Fish Stocks Agreement (UNFSA) is applicable to the problem of ocean acidification to the extent that its objective to ensure the long-term conservation and sustainable use of straddling fish stocks and highly migratory fish stocks is impacted. The Review Conference held in 2010 made a specific reference to ocean acidification. It called on regional fisheries management organizations to "strengthen efforts to study and address environmental factors affecting marine ecosystems, including adverse impacts of climate change and ocean acidification, and, where possible, consider such impacts in establishing conservation and management measures for straddling and highly migratory fish stocks" (UNFSA 2010, p. 42). This gave effect to Article 5(d) of the UNFSA, which imposes an obligation on parties to "assess the impacts of … other human activities and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks".

In response to the request of the Conference, the Inter-American Tropical Tuna Commission has recently launched a research project in partnership with the Secretariat of the Pacific Community that would study the impact of projected ocean acidification upon the distribution and abundance of yellowfin tuna. The outcome of the project will be available for use by other regional fisheries management organization, such as the Commission for the Conservation of Southern Bluefin Tuna and the International Commission for the Conservation of Atlantic Tunas, which are not involved in ocean acidification (Deputy Executive Secretary, Commission for the Conservation of Southern Bluefin Tuna, email, 20 July 2011; Assistant Executive Secretary, International Commission for the Conservation of Atlantic Tunas, email, 25 July 2011).

4.4.1.4. London Convention and Protocol

UNCLOS defers to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and its 1996 Protocol (London Protocol) on the issue of dumping at sea, and in the 'sea, seabed and subsoil', respectively (UNCLOS Article 210.4; UNCLOS Article 210.6; UNCLOS Article 216.1). The London Convention and Protocol relate to ocean acidification primarily through their responsibility to protect the marine environment and associated jurisdiction over a number of marine geoengineering activities, such as CO_2 Sequestration in Sub-seabed Geological Formations (CS-SSGF) and ocean fertilization, which involve some form of dumping.

The 26th Consultative Meeting established a CO_2 Working Group to consider "whether the [London Convention and Protocol] had a role in relation to other work being carried out on CO_2 sequestration for example in partnership with the UNFCCC" (London Convention 2004, para. 6.30.2). The Working Group concluded in 2005 that, while other conventions and bodies are addressing the broader issue of climate change and how best to mitigate it by reducing emissions, increasing levels of CO_2 in the atmosphere are a serious concern to the marine environment, causing acidification of the oceans (London Convention 2005a). Accordingly, the 27th Consultative Meeting acknowledged that CS-SSGF would bring about direct benefits to the marine environment such as stabilization of ocean CO_2, carbonate, and pH levels (London Convention 2005b), and hence has a role to play, as part of a suite of measures to tackle the challenge of both climate change and ocean acidification. Furthermore, it was agreed that the London Convention and Protocol were appropriate global instruments to address the implications of CS-SSGF for the marine environment. In the 28th Consultative Meeting, the parties accordingly amended Annex 1 to the Protocol to provide a regulatory framework for CS-SSGF (London Protocol 2006, Resolution LP.1(1); for a detailed account, see Penca 2009).

Parallel discussions for establishing a global control and regulatory mechanism for ocean fertilization activities have been underway since 2007. However, ocean acidification has been little discussed in the context of ocean fertilization (London Protocol 2009; London Protocol 2010; London Protocol 2011), even though the potential risk of ocean fertilization to "contribute to lowering the pH of the seawater" has been internally recognized by the parties (London Convention 2010, para. 3.4.2.2.4 and para. 3.5.2.2.1). If due consideration were paid to the impact of ocean fertilization on ocean acidification, it would invoke Article 3.3 of the London Protocol that prohibits direct and indirect transfer of damage or likelihood of damage from one part of the environment to another or transform one type of pollution into another.

4.4.1.5. MARPOL Convention

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL Convention) aims to protect the marine environment by preventing and controlling the discharge of harmful substances from ships. The Convention is applicable to mitigating ocean acidification through its extended work on the prevention of air pollution from international shipping. The Kyoto Protocol contains a provision for reducing greenhouse gas emissions from international shipping, working though the International Maritime Organization (Kyoto Protocol Article 2.2), which serves as the Secretariat for the MARPOL Convention. The UNFCCC Secretariat and the International Maritime Organization have cooperated by exchanging information and by undertaking a study of emissions from ships. The International Maritime Organization regularly reports progress on its work to the UNFCCC.

In 2011, the Marine Environment Protection Committee (MEPC) adopted amendments to MARPOL Annex VI, and set mandatory measures to reduce emissions of “any substances that originate from fuel oil and its combustion process” from all ships of 400 gross tonnage and above. Despite the direct relevance of these developments to mitigating ocean acidification, however, the extent to which ocean acidification has played as a driver to regulating emissions from shipping is questionable. The International Maritime Organization’s comprehensive greenhouse gas studies (International Maritime Organization 2000; International Maritime Organization 2009), while recognizing regional ocean acidification due to the deposition of SO_X and NO_X, do not mention CO_2-induced ocean acidification. Ocean acidification caused by CO_2 emissions was only recently mentioned, in passing, by the MEPC at its 60th session in 2010 (MEPC 2010, para. 4.28).

4.4.1.6. OSPAR Convention

The 1992 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) is the legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. In 2007, OSPAR recognized that ocean acidification is a “cause of serious concern” (OSPAR 2007, Agreement 2007-12). Like the London Convention and Protocol, the Contracting Parties to the OSPAR Convention considered CS-SSGF as one of the mitigation options to reduce levels of atmospheric CO_2. In

2007, the OSPAR Commission amended the Annexes to the Convention to allow CS-SSGF and adopted decisions to guide its implementation and management (OSPAR 2007, Agreement 2007-12; OSPAR 2007, Decision 2007/2). At the same time, the Commission legally banned placement of CO_2 into the water-column of the sea and on the seabed, because of its potential acidification effects (OSPAR 2007, Decision 2007/1).

More recently, in 2010, the parties to the OSPAR Convention expressed concerns that "first effects of climate change and ocean acidification are apparent throughout the OSPAR maritime area" (OSPAR 2010, Agreement 2010-3; see also OSPAR 2010, Recommendation 2010/8; OSPAR 2010, Recommendation 2010/9; OSPAR 2010, Recommendation 2010/10). The Quality Status Report 2010 of the OSPAR Commission recommended the development of policies aimed at mitigating climate change and acidification. Similarly, the North-East Atlantic Environment Strategy 2010-2020 adopted as one of its objectives "to ensure integrated management of human activities in order to reduce impacts on the marine environment, taking into account the impacts of, and responses to, climate change and ocean acidification" (OSPAR 2010, Agreement 2010-3, para. 2.2). It was agreed that the OSPAR Commission would strengthen the network of marine protected areas, recognizing their contribution to the maintenance of ecosystem integrity and resilience against impacts of climate change and ocean acidification (OSPAR 2010, Agreement 2010-3, para. 4.4(f)). The Commission also agreed to monitor and assess the effects of climate change and ocean acidification on the marine environment and consider appropriate ways of responding to those developments (OSPAR 2010, Agreement 2010-3, para. 1.7). The Coordination Group and the Biodiversity Committee under the Commission are mandated to oversee climate change related issues including ocean acidification, and assess and monitor ocean acidification, respectively (OSPAR 2011, Agreement 2011-4).

4.4.1.7. Protocol on Environmental Protection to the Antarctic Treaty

The 1991 Protocol on Environmental Protection (Madrid Protocol) to the 1959 Antarctic Treaty aims for "the comprehensive protection of the Antarctic environment and dependent and associated ecosystems" (Madrid Protocol Article 2). At the 32nd Antarctic Treaty Consultative Meeting in 2009, the parties agreed that "acidification of the ocean has profound implications for the marine ecosystem of the Southern Ocean" (Secretariat of the Antarctic Treaty 2009, para. 241). The Southern Ocean is particularly vulnerable to acidification, due to the higher solubility of CO_2 in cold water and low saturation levels of $CaCO_3$ (McNeil and Matear 2008; Kawaguchi et al. 2011).

The applicability of the Madrid Protocol to addressing ocean acidification, however, is limited, as it only applies to 'activities in the Antarctic Treaty area', the area south of 60 degrees south latitude (Antarctic Treaty Article VI). Nevertheless, the Madrid Protocol provides a potential tool through which ocean iron fertilization activities can be partially regulated, as the Southern Ocean is among the key places where these activities need to take place due to iron deficiency.

The Scientific Committee on Antarctic Research (SCAR), an official observer to the Antarctic Treaty, published a review report called *Antarctic Climate Change and the Environment* in 2009, which identified ocean acidification among the chronic impacts of climate change (Turner et al. 2009). By considering the report's findings, the Antarctic Treaty Meeting of Experts considered that "ocean acidification must come high on the list of climate change related issues most likely to have maximum impact, likely as it is to have significant and 'rapid' impacts for management" (Antarctic Treaty Consultative Meeting 2010, para. 131). This report was transmitted to the UNFCCC COP and Secretariat (Antarctic Treaty Consultative Meeting 2009).

4.4.1.8. Convention on the Conservation of Antarctic Marine Living Resources

The 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) is concerned about the conservation of Antarctic marine living resources. CCAMLR forms part of the Antarctic Treaty System along with the Convention for the Conservation of Antarctic Seals, but has an independent secretariat. It is also one of UNEP Regional Seas Programme's partners along with the OSPAR Convention. Like the Antarctic Treaty and its Madrid Protocol, CCAMLR has limited jurisdiction. It only applies to activities taking place within the Antarctic Treaty area, such as illegal, unregulated and unreported fishing.

CCAMLR understands that ocean acidification is a threat to Antarctic krill and ecosystems (CCAMLR 2011, para. 8.1; Kawaguchi et al. 2011), and it will impact on the CCAMLR's ability to fulfill its mandate (CCAMLR 2007, para. 15.49). Cooperation with SCAR has been emphasized in relation to ocean acidification. In 2010, the CCAMLR Commission noted that "acidification is an important component for CCAMLR in the consideration of the impact of climate change" (CCAMLR 2010, para. 13.8). The Commission accordingly requested that the issue of ocean acidification be included in the developments of the Joint CCAMLR–SCAR Action Group (CCAMLR 2010), which was proposed in order to improve the strategic partnership between the two organizations.

4.5. An Assessment of Emerging Polycentric Patterns of Ocean Acidification Governance

This section discusses the emerging polycentric patterns of ocean acidification governance that the aforementioned MEAs have created. It assesses the degree of polycentric order, which in this context means, the processes and structures that allow MEAs to self-organize and make mutual adjustments in the absence of any authoritative coordinating mechanisms (Galaz et al. 2012c).

4.5.1. Is Polycentric Order Emerging through Self-Organization?

Among the MEAs identified above as relevant to ocean acidification, the CBD has so far been most proactive in engaging the problem. The potential role of the CBD as an effective in-house coordinator appears promising, especially in supporting mutually reinforcing relationships between the UNFCCC and UCNLOS. While acknowledging the CBD is not a focal point for discussions on greenhouse gas emission reductions, the CBD Secretariat has recognized the responsibility and opportunity to enhance cooperation for the achievement of the two inter-related yet distinct mandates under the CBD and UNFCCC (CBD 2011, p. 31). Furthermore, the CBD decisions have been influential in the development of international norms relating to the ocean, including those within the climate change nexus (CBD 2011).[8] The recent developments under the CBD on the moratorium on ocean fertilization (CBD 2008, Decision IX/16, Section C) and geoengineering (CBD 2010, Decision X/33, para. 8(w)), both of which are at the intersection between climate change and (marine) biodiversity, have demonstrated the CBD's view to ensuring environmental sustainability in a holistic way (Morgera and Tsioumani 2010; Morgera 2011).

The work of the CBD, generally speaking, strengthens the framework established by UNCLOS to protect and preserve the marine environment (Wolfrum and Matz 2000). An interesting connection is the general recognition that ocean acidification is a significant threat to biodiversity, and the further recognition that biodiversity is crucial to good ecosystem health (UNCLOS Article 194.5). By providing this context to the connection between ocean

[8] For discussions on the interplay of the climate and biodiversity agreements, see Jacquemont and Caparrós (2002), Doelle (2004), van Asselt et al. (2008), Carlarne (2008), Pittock (2010), Morgera (2011), and van Asselt (2012).

acidification and obligations to protect and preserve the marine environment under UNCLOS, the CBD plays a significant role in interpreting obligations of parties to mitigate ocean acidification. Furthermore, as the CBD lacks jurisdiction in areas beyond national jurisdiction (CBD Article 4), UNCLOS plays a complementary role by providing a legal framework for regulating activities impacting the biodiversity of these areas. An international instrument tailored for this purpose is looming on the horizon under the UNCLOS framework (UNGA 2012, para. 162). This agreement would provide a forum at which the CBD and UNCLOS could mutually work towards the protection of marine environment from, *inter alia*, acidification.

However, parties to UNCLOS seem to have taken the position that the UNFCCC is the competent forum to discuss ocean acidification governance. At the eleventh meeting of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea in 2010, for example, the Group of 77 and China emphasized the need to avoid choosing topics which fell within the mandate of specific international organizations or institutions (ICP 2010, para. 90; Diz et al. 2010). Climate change was presented as such an issue area. A bridge to this impasse, suggested by some states, was to discuss the adverse effects of climate change on the marine environment, including ocean acidification (ICP 2011, para. 58), but leave their governance to the UNFCCC. In its 2008 resolution on 'Oceans and the law of the sea', the UNGA had in fact agreed that efforts to reduce greenhouse gas emissions would need to occur in accordance with the principles contained in the UNFCCC (UNGA 2008, para. 83). The task of defining what is by and large a fragmented, informal relationship between the law of the sea and climate regime remains underexplored (Carlarne 2008; see also Burns 2006; Doelle 2006).

The non-hierarchical nature of international environmental law hinders the extent to which the MEAs can cooperate and coordinate. This is particularly an issue where treaty memberships are incongruent. For example, the CBD is actively prevented from influencing rule development in the climate regime in significant part because the United States is a Party to the UNFCCC but not to the CBD (van Asselt 2012). Consequently, an MEA seeking to extend its scope to link with the UNFCCC and influence its negotiations is often left with no other option but to merely make information available for use at the discretion of the climate regime. Regional MEAs, such as CCAMLR, generally respond more sensitively to environmental changes occurring on a regional scale, thereby sending warning signals to the UNFCCC. However, they needed to exercise due care to ensure that they are not seen as attempts to encroach on the work of the UNFCCC.[9] In fact, these smaller MEAs whose mandates are impacted by ocean acidification are more or less at the mercy of the UNFCCC. They 'sit and watch' without any remedy. A response from the Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) best illustrates this point (Associate Scientific and Technical Officer, CMS Secretariat, email, 17 August 2011):

> Ocean acidification is a subject of significant concern for CMS since a number of filter-feeding whales, as well as turtles (e.g. hawksbill turtle) and other marine species which depend on coral reefs and krill, are affected …. Ocean acidification is not explicitly addressed in a CMS climate change decision …, not least because the fundamental cause of ocean acidification (i.e. CO_2 emissions) cannot be directly addressed through this treaty.

It is important to strengthen the relationship among the UNFCCC, CBD, and UNCLOS for facilitating mutual adjustments with a shared aim to address ocean acidification. Unlike the CBD, however, the UNFCCC and UNCLOS have become "static documents unable to adapt to the increasing threat of ocean acidification" (Lamirande 2011, p. 205).[10] For the UNFCCC, in particular, "the connection with issues other than their own [has been] seen as an unwanted distraction" (Chambers 2008, p. 7), that overburdens the already crowded climate change agenda. The significance of ocean acidification has not been reflected within international climate change mitigation and adaptation strategies (Harrould-Kolieb and Herr 2012). At the time of writing, there are few indications that this will change.

4.5.2. Inconsistent Policy Approaches to Ocean Acidification

International environmental law on the protection of the marine environment, for which there is the biggest number of MEAs (see Chapter 3), is a relatively coherent body of law due primarily to the presence of UNCLOS as the 'constitution for the oceans' (Koh 1982). The London Protocol and the OSPAR Convention, for example, share the same definition of 'pollution' as provided under UNCLOS (UNCLOS Article 1.1(4); London Protocol Article 1.10; OSPAR Convention Article 1(d)). This has a significant implication for ocean acidification governance, as the shared definition means that CO_2-induced ocean acidification

[9] For a similar example, see Bull et al. (2011).

[10] For discussions on the evolutionary nature of the CBD, see Morgera and Tsioumani (2010).

should be consistently considered as a breach of the marine environmental protection provisions under a wide spectrum of MEAs. It is therefore important to examine to what extent MEAs relating to marine environmental protection have harmonized under the UNCLOS framework for a mutually supportive approach to ocean acidification.

At this early development stage of the regime complex for ocean acidification, inconsistencies have been observed among the marine environment conventions. For example, while the London Convention and Protocol have explicitly recognized ocean acidification as a direct threat to the marine environment and, therefore, CO_2 as a marine pollutant, this acknowledgement has yet to be repeated by other regimes such as the MARPOL Convention. During the 60th session of the Marine Environment Protection Committee in 2010, some delegations insisted, "CO_2 was not technically a pollutant and therefore had no place in the MARPOL Convention" (MEPC 2010, para. 4.29). Such inconsistent approaches to ocean acidification persist despite a large overlap in treaty memberships and the status of UNCLOS as customary international law that binds all states.

Policy inconsistency can also be observed even within an MEA. The London Protocol treated the problem of ocean acidification differently when discussing regulatory mechanisms for CS-SSGF and ocean fertilization. Whereas ocean acidification was much discussed and played as a rationale for justifying the London Protocol to regulate CS-SSGF, it was virtually ignored in the context of ocean fertilization, perhaps due to a tacit recognition among its parties that ocean fertilization could worsen the acidification of seawater (Cao and Caldeira 2010; Williamson and Turley 2012).

In this context, the collaborative interactions between the London Convention and Protocol (and the OSPAR Convention) and the UNFCCC to address ocean acidification (and climate change) through regulation of CS-SSGF need to be viewed critically. From the outset, the level of adaptability and flexibility displayed by the London Convention and Protocol in filling governance gaps seems to form an example for others to follow. However, the main drivers for the collaboration were, firstly, its potential to enable developed countries to offset their climate targets under the Kyoto Protocol through the Clean Development Mechanism, and secondly, the potentially attractive commercial benefits to industry that CS-SSGF and ocean fertilization offer through potential linkages with emissions trading schemes. Marine geoengineering measures such as CS-SSGF and ocean fertilization have indeed been criticized for transforming the climate change problem into its 'evil twin', ocean acidification (Purdy 2006). Some parties (such as Germany) had in fact voiced their concerns that any release of CO_2 to the water column from CS-SSGF may result in the acidification of seawater (London Convention 2004, para. 6.33).

At the root of the inconsistency in the approaches to ocean acidification lies the confusion over the problem being seen as a symptom of climate change. As empirically observed by this study, the various COPs have not been clear in their decisions that ocean acidification is a concurrent issue that shares the same cause as climate change (e.g., CBD 2010, Decision X/29, para. 7; CBD 2010, SBSTTA Recommendation XIV/9, p. 10). Rather, ocean acidification has frequently been considered amongst adverse effects of climate change, or as a consequence of increased carbon emissions framed within the broad categorization of climate change. The widespread misconception of ocean acidification as a symptom of climate change might even be dangerous because it fosters the delusion that ocean acidification will be automatically addressed when the parties to the UNFCCC comply with the Convention. This observation has an important implication for how ocean acidification should be approached institutionally.

4.5.3. Is a New Multilateral Environmental Agreement on Ocean Acidification Necessary?

Global forest governance provides a useful analogy for the purpose of assessing the (in)effectiveness of ocean acidification governance. International forest law consists of a multitude of treaties and non-treaty instruments in a polycentric setting. These instruments have been dealing with issues such as forest biodiversity, protection of forests as carbon sinks, and trade in timber in a rather unprincipled and uncoordinated manner (Brunnée and Nollkaemper 1996). In the absence of a 'forest convention', the legal implications of the affirmation that forest biodiversity protection is of 'common concern of humankind' (CBD Preamble) have been subject to debate (Brunnée and Nollkaemper 1996). In this setting, ecosystem-based climate change mitigation mechanisms incentivized under the UNFCCC framework are reportedly having unintended negative consequences or externalities on forest biodiversity (Caparrós and Jacquemont 2003; Totten et al. 2003; Sagemüller 2006). The lack of a single agreed definition of 'forest' shared among different regimes has also contributed to continued deforestation and forest degradation (Sasaki and Putz 2009). In other words, a high degree of polycentricity in global forest governance has caused malign diffusion of responsibilities, induced accountability problems, and allowed MEAs to externalize the costs of their actions onto others (Galaz et al. 2012a).

What this study has found in the context of ocean acidification governance is a similar accountability gap in international environmental law due to diffused responsibilities, legal uncertainties, policy inconsistencies and externalities. No regime assumes responsibility for the problem of ocean acidification, and the UNFCCC is no exception. The legal implications of the acidifying oceans have been unclear, and the approaches taken by MEAs have been inconsistent. The externalized cost of mitigating climate change has manifested as ocean acidification. Ocean acidification governance at present is relatively fragmented and its (as yet) weak polycentric order is unlikely to be strengthened to an adequate level without an institutional intervention.

The observed problems are not simply due to the fact that the emerging regime complex for ocean acidification is in its infancy, but because there are inherent structural limitations within and outside the climate regime that act as barriers to developing a strong polycentric system. Several MEAs have taken action to develop ocean acidification policies in their specific areas of interest, but they were often limited in their options to increase their scope of action beyond their agreed mandates. Significantly, the norm of respecting the legal autonomy of the treaties has been a hurdle for policy coherence across planetary boundaries. The uneasy tension between ‘problem shifting’ (Nilsson and Persson 2012) and what MEAs perceive as their ‘sovereignty’ (UNEP 2001a, para. 42) is not being adequately balanced in a polycentric governance organization. The challenge from a governance perspective is to simultaneously maintain the sub-systems within their boundaries without transfer of harm. Some MEAs such as UNCLOS do contain provisions obligating its parties “not to transfer damage or hazards or transform one type of pollution into another” (UNCLOS Article 195). However, this duty is not explicitly expressed in the UNFCCC, even though the convention recognizes that climate change can have “significant deleterious effects on the composition, resilience or productivity of natural and managed ecosystems[,] on the operation of socio-economic systems[, and] on human health and welfare” (UNFCCC Article 1.1).

As Lamirande argued, it may be true that “the time is ripe for an international treaty on ocean acidification” (Lamirande 2011, p. 205). While not being specific about the need for a new treaty, Baird et al. (2009) similarly suggested that it might ultimately prove necessary for positive change to be stimulated by what international relations scholars have called “strategic inconsistency” (Raustiala and Victor 2004, p. 301). This would involve parties to a particular regime seeking directly to regulate CO_2 even though this would cut across the competence of the climate regime. In the present study, I also conclude that the international community is in need of a new or amended MEA that expressly mandates its member states to prevent further ocean acidification and respect the planetary boundary. If left to the self-organization of individual MEAs, it is highly unlikely that the gap in international environmental law in relation to ocean acidification will be closed soon enough to prevent unacceptable marine environmental change.

4.6. Bringing Light to the International Legal Twilight Zone

It is beyond the scope of this chapter to provide a comprehensive assessment of a range of possible forms and forums that the proposed MEA could take. The question of the form and forum for such an agreement necessarily involves a very complex set of legal and political considerations. Nevertheless, I outline two potential candidates as a way of discussing some of the key considerations that need to be paid should states decide to negotiate a new MEA on ocean acidification.

4.6.1. The Durban Platform: A Window of Opportunity

The first possibility is to address ocean acidification within the UNFCCC framework by 'broadening' and 'deepening' the climate regime.[11] The UNFCCC COP-17 has established the Ad Hoc Working Group on the Durban Platform for Enhanced Action to initiate a new process to produce either a "protocol", "another legal instrument" (e.g., an amendment of the Convention or a new or amended annex), or an ambiguously termed, "agreed outcome with legal force" (UNFCCC 2012, Decision 1/CP.17, para. 4; Rajamani 2012). It was agreed that this new instrument or outcome should be adopted by 2015, at the latest, for it to come into effect and be implemented from 2020. This creates a window of reform opportunity for ocean acidification, or any other related matters, to be integrated into the UNFCCC framework.

For addressing ocean acidification effectively, an amendment to the Convention text itself might be desirable (that is, 'another legal instrument'), given its uncertain mandate on the problem of ocean acidification. An amendment of the Convention would involve restructuring the UNFCCC towards regulating dangerous anthropogenic interference to the *global carbon cycle*, which is what is fundamentally needed for addressing both climate change and ocean acidification simultaneously. At the very least, an amended convention needs to impose on its parties the duty not to resolve the climate change problem by transferring harm or hazards

[11] On the notion of 'broadening' and 'deepening' of MEA regimes, see Bodansky and Diringer (2010).

from one area or medium to another or transforming one type of environmental harm to another (IUCN Environmental Law Programme 2010, Article 17).

For any outcome of the Durban Platform, whether it is an amended convention or a new protocol, two elements would be essential for addressing ocean acidification. First, it needs to contain a separate target for CO_2 emission reductions (Baird et al. 2009; Lamirande 2011; Galland et al. 2012; Harrould-Kolieb and Herr 2012). This would not require an amendment to the UNFCCC, as the UNFCCC leaves the details of how greenhouse gas emissions should be regulated to be decided in the implementing agreement. In fact, for the purpose of establishing a mandatory target for emissions reduction of CO_2, a new annex to the UNFCCC could suffice. Second, the emissions reduction target for the atmospheric concentration of CO_2 must be set at a level that would avoid dangerous ocean change. The forthcoming Fifth Assessment Report of the Intergovernmental Panel on Climate Change (UNFCCC 2012, Decision 1/CP.17, para. 6), which is expected to include a dedicated chapter on ocean acidification, should inform what that level might be, as well as the work of the Intergovernmental Platform on Biodiversity and Ecosystems Services.

4.6.2. Regulating Carbon Emissions under the Law of the Sea Framework

The second possibility is to address ocean acidification through an implementing agreement on land-based sources of marine pollution (LBSMP) to UNCLOS. Ocean acidification is caused mostly by land-based activities that pollute the marine environment, mostly beyond national jurisdictions, through the atmosphere. Albeit aspirational (VanderZwaag and Powers 2008), UNCLOS does provide a general legal framework for regulating ocean acidification.

General principles and management approaches to LBSMP control are prescribed in the Global Programme of Action to Protect the Marine Environment from Land-based Activities. However, the role of the Global Programme of Action in studying and addressing ocean acidification (and climate change) remains uncertain. This is not only because its effectiveness is inherently limited by its non-legally binding approach (VanderZwaag and Powers 2008), but also because carbon emissions from land-based sources are not included in its nine source categories. Other than a mention of the UNFCCC as one of the MEAs important for the protection of the marine environment, the Global Programme of Action has been more or less silent about ocean acidification as well as climate change (VanderZwaag and Powers 2008; but see Global Programme of Action 2006; Global Programme of Action 2012).

Although the likelihood that the Global Programme of Action will be translated into treaty form does not appear promising (VanderZwaag 2007), the need for a stronger LBSMP regime cannot be argued away. The advantage of regulating carbon emissions under the law of the sea framework is that states could exploit largely untapped potential of the strongly worded environmental provisions of UNCLOS, as well as its dispute settlement regime (Doelle 2006). In a previous study, Hassan recommended essential components for a global LBSMP treaty, and they are an environmental liability regime, development of detailed and enforceable pollution standards, and a specific dispute resolution procedure for land-based pollution conflicts (Hassan 2006). In addition to those, CO_2 emissions from point and non-point sources, as one of the LBSMP categories, need to be regulated with emissions reduction targets set with the aim of avoiding dangerous ocean acidification. For this, the landward and geographical scope must expand beyond river basins, as typically found in the regional LBMSP protocols. Although limited in scope to one type of LBSMP, the Stockholm Convention on Persistent Organic Pollutants has demonstrated the possibility of regulating land-based marine pollution through the atmosphere on a global scale.

A global LBSMP treaty should aspire to provide a comprehensive framework, the first of its kind, to cross the rigid jurisdictional divide between the land and the sea or the areas of and beyond national jurisdiction. This would be an example for the new approaches that Vidas (2011) argues that we need in the Anthropocene (Steffen et al. 2007) in order to deal with human impacts on the marine component of the Earth system as well as governing planetary boundary interactions between the marine component and the rest of the Earth system.

4.6.2.1. Implications of Overlap with the Climate Regime

A case for adopting a new MEA on ocean acidification under the UNCLOS framework would have to justify having two treaty regimes regulating CO_2 emissions, which may well be "superfluous [and] confusing" (Harrould-Kolieb and Herr 2012, p. 379). One can only speculate on whether the relationship will engender healthy competition or result in unnecessary overlap and conflicts. Here, I focus on the positive side.

First, a parallel regime under UNCLOS could provide an opportunity for states to seek out the forum most favorable to their interests (Gillespie 2002). Some degree of institutional diversification is arguably necessary to engage all countries with different interests and capabilities. Second, a parallel regime could reduce climate policy externalities. Arguably, the UNFCCC has grown too big and powerful, scoping the entire Earth system, as countless issues are closely linked to a changing climate. The UNFCCC is increasingly creating perverse outcomes for these climate-related issues, but currently no other treaty regime has the capacity to seriously challenge that. A matching MEA on ocean acidification could keep the UNFCCC in check. Third, a new MEA could reduce the risk of policy failure by helping to diversify the portfolio of CO_2 emission reduction efforts. The new wave of Earth system governance scholars agrees that institutional diversity and redundancy are not necessarily bad for a resilient governing system (Dietz et al. 2003; Low et al. 2003; Folke et al. 2005; Ostrom 2005; Ostrom 2010b).

It is also worth noting that having multiple regimes regulating greenhouse gases is not totally new. The broader regime complex for climate change already exists (Bodansky and Diringer 2010; Keohane and Victor 2011). This complex includes the efforts to phase out hydrochlorofluorocarbons through the Montreal Protocol on Substances that Deplete the Ozone Layer (Velders et al. 2007), the recent discussions of black carbon in the Convention on Long-range Transboundary Air Pollution (United Nations Economic Commission for Europe 2009, Decision 2009/5), and the work on emissions from international transport in the International Maritime Organization and the International Civil Aviation Organization. Non-CO_2 emissions are increasingly being regulated outside of the UNFCCC by these more specialized regimes and this in turn may free up space for the UNFCCC to focus on CO_2 (Bodansky and Diringer 2010; Harrould-Kolieb and Herr 2012).

4.7. Conclusion

Ocean acidification is a global-scale, environmental change problem with far reaching consequences in multiple dimensions. From a governance perspective, ocean acidification is unique in that it shares a common cause with climate change, but creates a concurrent problem that may not necessarily be addressed by focusing solely on mitigating climate change. It sits within a very complex institutional landscape, at a rather cracked interface between the climate, biodiversity, and oceans regimes. The CBD and UNCLOS are the principal MEAs mandated to protect the marine environment and its biodiversity, but they do not regulate atmospheric CO_2 emissions. The UNFCCC and Kyoto Protocol do not have the jurisdiction or the clear mandate to prevent ocean acidification. Other MEAs express their concerns to the extent that the acidifying oceans pose a threat to achieving their mandates, but they are without remedy.

Some degree of emerging polycentric order for governing ocean acidification has been observed. However, the level of institutional interactions among the MEAs has been minimal without exhibiting self-organizing behaviour. While a model of polycentric governance has merits, its weaknesses such as those empirically observed in this chapter in the context of ocean acidification also need to be scrutinized before we adopt polycentrism as a normative model for global environmental governance. The MEA system, in its current position in the evolutionary path, is inherently limited in its ability to foster mutual adjustments among MEAs. This is due in part to the unsettled normative conflict between the principle of respecting the legal autonomy of the treaties and the duty not to transfer or transform environmental harm in international environmental law. In particular, the possibility of a strong polycentric order at the institutional landscape level is constrained by the underlying structural features of the climate regime, which takes advantage of ocean acidification in mitigating climate change. Therefore, it is highly unlikely that an emerging regime complex of MEAs will adequately address ocean acidification in the near future.

Ocean acidification is too important and rapidly occurring to be left to the self-organization of MEAs (and other international actors). It will simply be too late to save the oceans and the wider ecological integrity. Ocean acidification requires a conscious intervention and I suggested that this involves establishing a new MEA with a clear mandate on ocean acidification. This intervention may well form part of an adaptive process that enhances the fit between the Earth system and international environmental law, and thus strengthens the polycentric order.

Chapter 5.

International Environmental Law in the Anthropocene: Towards a Purposive System of Environmental Treaties

Abstract

The point of analytical departure is that the state of the global environment is deteriorating despite the accumulating body of international environmental law. By drawing on the recent Earth system science concept of interlinked planetary boundaries, this chapter makes a case for a goal-oriented, purposive system of multilateral environmental agreements. The notion of 'goal' is used here to mean a single, legally binding, superior norm – a grundnorm *– that gives all international regimes and organizations a shared purpose to which their specific objectives must contribute. A bird's eye view on the international environmental law system reveals how the absence of a unifying goal has created a condition that is conducive to environmental problem* shifting *rather than problem* solving*. I argue that a clearly agreed goal would provide the legal system a point of reference for legal reasoning and interpretation, thereby enhancing institutional coherence across Earth's subsystems. To this end, this chapter concludes by observing that the protection of the integrity of Earth's life-support system has emerged as a common denominator among international environmental law instruments. Accordingly, I suggest that this notion is a strong candidate for the overarching goal of international environmental law.*

5.1. Introduction

The point of analytical departure is that global environmental conditions have continued to deteriorate despite the accumulating body of international environmental law. According to one source, over 700 multilateral environmental agreements (MEAs) have been adopted since 1857 (Mitchell 2013; see also Mitchell 2003; Carruthers et al. 2007). However, during this period, the rate of anthropogenic global environmental change has been accelerating (Steffen et al. 2004). Compelling scientific evidence suggest that human activities have pushed the Earth system beyond three of its nine interlinked biophysical thresholds or ‘planetary boundaries’, which will likely translate into disastrous consequences for humanity in the years to come (Rockström et al. 2009a; see also its critiques, e.g., Brook et al. 2013). Earth has entered the Anthropocene, a new geological epoch where humans have become a major driver of global environmental change (Crutzen 2002; Steffen et al. 2007; Steffen et al. 2011a; Steffen et al. 2011b).

The current system of international environmental law and governance, with its maze of MEAs, is considered unsuitable for navigating through the Anthropocene (UNEP 2012). Many factors can be identified that contribute to the apparent ineffectiveness of international environmental law (Haas et al. 1993; Victor et al. 1998; Young 1999; Louka 2006). Of particular concern to this study is the tendency of the international community to treat interconnected environmental matters on a sectoral basis rather than in a comprehensive, joined-up manner. The result is that international legal responses are fragmented and issue-based according to the objective of individual treaty systems, resulting in differing or even contradictory positions adopted across or within various treaty bodies (Sands and Peel 2012; see also Brown Weiss 1993; Wolfrum and Matz 2003; Doelle 2004; Carlarne 2008; van Asselt et al. 2008; Biermann et al. 2009b; Scott 2011; Anton 2012b; van Asselt 2012). The inconsistencies have increased the risk of problem shifting, that is “improving the performance on one system by degrading another” (Nilsson and Persson 2012, p. 12), *within* the realm of international environmental law. For example, replacing gasoline with corn ethanol for the purpose of climate change mitigation may shift the net environmental impacts primarily towards increased eutrophication and greater water scarcity (Yang et al. 2012; see also de Sadeleer 2002).

A number of proposals have been put forward to better coordinate treaty regimes, ranging from clustering MEAs with the possibility of co-locating their secretariats (von Moltke 2006) to upgrading the ineffectual United Nations Environment Programme (UNEP) into a World Environment Organization (Biermann 2000; Biermann and Bauer 2005; Biermann et al. 2009a). The purpose of this chapter is not to assess the efficacy of these existing proposals. Rather, in this chapter, I shift the focus to a less noticed or discussed issue: the absence of a clearly agreed, unifying goal to which all international regulatory regimes and organizations are legally bound to contribute. I explore the practical implications of (not) having such a goal for institutional cooperation among treaty bodies and with regard to international environmental law as a whole. To the best of my knowledge, no previous research has seriously contemplated the implication of this missing component in the context of international environmental law.

This chapter adopts ‘environmental law methodology’ as its analytical framework (Ebbesson 2003; Carlman 2007; Westerlund 2008; Jóhannsdóttir et al. 2010). Environmental law methodology is grounded in the question of how to achieve and maintain ecological sustainability through the work of law as a control system (Westerlund 2008). The analysis goes beyond a reactive, legal-dogmatic perspective, which is a common method that describes and analyses the existing legal instruments for environmental protection (Ebbesson 2003). Instead, the aim here is to "understand *how* law works from a systemic point of view", and how it influences the environment (Jóhannsdóttir et al. 2010, p. 141). The effectiveness of law is assessed through *external* eyes from the perspective of its object, such as a migratory bird or biodiversity (Ebbesson 2003; Carlman 2007; Jóhannsdóttir et al. 2010). The analysis is grounded in the recognition that any control system needs to be as advanced as the system being controlled (Ashby 1956; Decleris 2000). The environmental law methodology approach is proactive as it deals with techniques for environmental legal control and consequently with solutions to environmental control problems (Westerlund 2008).

Here, I look through the lens of the entire biosphere to explore international environmental law as a control system governing human relationships and interactions with Earth-system processes. I pay particular attention to the *internal* dynamics of the international environmental law system. Up to now, microscopic and telescopic analytical approaches have predominated, with a focus on individual treaty regimes on one hand (Haas et al. 1993), and international environmental law as a unitary body of norms interacting with other branches of international law, such as trade and human rights on the other (Lafferty and Hovden 2003). The neglected macroscopic approach I offer here seeks to improve the understanding of how the network of norms and institutions actually functions and influences the global environment as a whole (Steiner et al. 2003).

This chapter begins by firmly establishing what the ultimate purpose of international environmental law should be: the protection of the biophysical preconditions that are essential for long-term sustainable development. I then discuss the institutional context in which international environmental law lacks an overarching goal or *grundnorm*, and how its absence has contributed to the dysfunction of international environmental law as a whole. More specifically, I illustrate how the current self-organized mode of institutional cooperation and coordination has been ineffective, and how international environmental law requires a legally binding overarching goal around which all international regulatory regimes must be situated and to which the regimes must contribute. The exact form and nature in which such a goal can be recognized is a subject for future research. However, I observe that the protection of Earth's ecological integrity has emerged as a common denominator among international environmental law instruments. The logical next step would be to recognize the emergent common denominator as a *grundnorm* of international environmental law that would restrain state sovereignty to the necessary extent.

5.2. Implications of Planetary Boundaries for International Environmental Law

A group of leading Earth system and environmental scientists have recently identified nine planetary biophysical subsystems or processes that determine the self-regulating capacity of the Earth system (Rockström et al. 2009a). The identified Earth-system processes are climate change, biodiversity loss, interference with the nitrogen and phosphorus cycles, stratospheric ozone depletion, ocean acidification, global freshwater use, changes in land use, chemical pollution, and atmospheric aerosol loading (Rockström et al. 2009a). The scientists argued that each subsystem or process has a certain 'boundary' (i.e., threshold or tipping point) which, if crossed, may trigger non-linear changes in the functioning of the Earth system, thereby challenging social-ecological resilience at regional to global scales. Collectively, therefore, these 'planetary boundaries' define the safe operating space for humanity with respect to the Earth system.

The planetary boundaries framework builds on a sound scientific knowledge base that has been developed over the past several decades, such as limits to growth (Meadows et al. 1972), safe minimum standards (Ciriacy-Wantrup 1952), the precautionary approach (O'Riordan and Cameron 1994; Raffensperger and Tickner 1999), and tolerable windows (German Advisory Council on Global Change 1995). One of the focal-points of the planetary boundaries approach is on *quantifying* these boundaries by a critical value for one or more measurable control variables, in relative terms to pre-industrial conditions (Rockström et al. 2009a). Although the exact positions of the boundaries cannot escape normative perceptions of risk (Biermann 2012), for the purpose of this study, it suffices to acknowledge that their existence is scientifically supported and it is possible to quantify them.

Implications of the planetary boundaries framework for international environmental law can be discussed at two levels. At a fundamental level, the concept clearly suggests that the individual biophysical thresholds must never be compromised, but must be respected as a non-negotiable bottom-line for all human activities. It defines the environmental target corridor, or the minimum level of environmental protection required, within the larger context of long-term sustainable development (Biermann 2012).[12] More specifically, the concept suggests a hierarchical order for the elements of sustainable development: the biophysical

[12] Sustainable development is arguably an emergent collective objective of the international community. See, for example, Weeramantry (2004), Tladi (2007), and Voigt (2009).

environment comes first, and human society and economy second.[13] It is therefore imperative to reflect this intrinsic hierarchy in the design and interpretation of laws governing state behaviour (Lafferty and Hovden 2003; Voigt 2009; Bosselmann 2013).

In this context, the planetary boundaries framework scientifically suggests the existence of a foundational environmental principle or *grundnorm*, which, for the purpose of this research, can be defined as a basic norm to bind any governmental power (Bosselmann 2013). This understanding differs from Kelsen's definition,[14] and is closer to Kant's argument that any positive law must be grounded in a 'natural' norm of general acceptance and reasonableness (*Vernunft*) to prevent pure arbitrariness (*blosse Willkür*) (Kant 1996). The existence of an environmental *grundnorm*, therefore, rests on the assumption that respecting planetary boundaries is a dictate of reason (*Gebot der Vernunft*) and general acceptance (*allgemeine Gültigkeit*).[15] Conceptually, a *grundnorm* exists independently of a legal system, but underpins legal reasoning in form of an inference rule (Feteris 1999). In this way, the legal decision-making process, for example in courts, will always be informed by some fundamental concerns along the lines of the Kelsian idea of a *grundnorm*. By contrast, the Kantian understanding suggests the prevalence of common interest or general acceptance. Only what can be assumed as reflecting the common interest could be considered as a *grundnorm*. Examples in this sense include a constitution, but also the rule of law or the idea of justice, the concept of human rights and similar values of fundamental importance.[16]

At another level, the concept of planetary boundaries directs our attention to the need to embrace the complex relationships among the planet's biophysical subsystems in our existing governing institutions. The individual planetary boundaries are tightly coupled through non-linear interactions where transgressing one boundary may have implications for

[13] Note that the planetary boundaries approach says nothing about the distribution of affluence and technologies among human societies. Thus, remaining within planetary boundaries is a necessary, but not sufficient, condition for sustainable development (Steffen et al. 2011c).

[14] Referring to the source (*Grund*) of the validity of positive law. According to Kelsen's pure legal theory, the validity of positive law is conditional to the acceptance of a (not predefined) *grundnorm*.

[15] Compare with the views of Earth system science and governance scholars who argued the planetary boundaries concept invites us to explore further the possible applicability of the concept of *jus cogens* in the international environmental law context (Walker et al. 2009; Biermann 2012; Galaz et al. 2012a).

[16] In his comprehensive analysis of legal reasoning in the context of international and domestic environmental law, Douglas Fisher concludes that 'the point of commencement' is the most important issue of any process of legal reasoning. Once this has been determined, the process of reasoning will assume the form that the point of commencement dictates (Fisher 2013). Crucially, the absence of an environmental *grundnorm* creates a vacuum that is currently filled with utilitarian, state-centered and other traditional considerations that can be perceived as in themselves reflecting a certain *grundnorm* or "core adjudicatory norm" (Bosselmann 2008, p. 67).

other boundaries.[17] Global environmental governance challenges that stem from the non-linear interactions are inherently complex (Duit and Galaz 2008; Duit et al. 2010; Galaz 2011). A changing climate puts biodiversity at both species and ecosystem levels under serious risk (Secretariat of the Convention on Biological Diversity 2009a). The degradation or loss of peatlands through land-use changes has a negative impact on local biodiversity and global climate change (Millennium Ecosystem Assessment 2005b; Parish et al. 2008). Converting the Amazon rainforest to a grassland or savanna through deforestation could influence atmospheric circulation globally and affect water resources in Tibet through changes in rainfall (Snyder et al. 2004; Lenton et al. 2008).

These are but a few examples of cross-system, cross-scale interactions among planetary boundaries. What these examples reveal is a governance challenge that goes beyond the conventional debate in environmental policy integration, that is the relationships between environmental and developmental policies (e.g., international trade) (Lafferty and Hovden 2003; Sanwal 2004; Boyle 2007; Pavoni 2010). They call for much stronger attention to the *internal* coherence of international environmental law with respect to strategies to stay within individual planetary boundaries.[18] For example, the climate, ozone, and biodiversity regimes would need to be implemented in a mutually supportive manner, without compromising one over the other.

As will be discussed later in more detail, a single unifying goal may provide the environmental treaty system a point of reference for legal reasoning and interpretation, thereby enhancing institutional coherence across Earth's subsystems. A *grundnorm* would specify this hypothetical goal, and help pull the system of law together. Such a goal-oriented approach to coordination would prove to be particularly relevant in a decentralized system, such as international environmental law, that lacks central control.

5.3. Does International Environmental Law Have a Goal?

Since the first multilateral environmental agreement was adopted in the mid 19th century, international environmental law has expanded horizontally in the absence of an

[17] In fact, each proposed boundary position assumes that no other boundaries are transgressed (Rockström et al. 2009b; see also Galaz et al. 2011).

[18] 'Coherence' means a state in which different institutional components are compatible and mutually reinforcing (Keohane and Victor 2011; see also Nilsson et al. 2012).

overarching goal or *grundnorm*.[19] The incentives for individual states to orient themselves around or promote a single environmental goal have been weak. Instead, the nature of medium-specific environmental problems has encouraged institutional diversification at every level of governance (Keohane and Victor 2011). And these institutions have usually come about in an *ad hoc* manner as a result of spontaneous reactions to politically salient environmental issues.

In the early years of the development of international environmental law, states were confronted primarily with geographically confined, transboundary environmental problems (Handl 2007). These problems had more or less identifiable causes and effects, and their remedies had relatively few unintended consequences. Notable examples include protection of the fur seals of the Bering Sea from commercial harvest in 1893 (Vicuña 1999), and the transboundary pollution by a Canadian smelter in the United States in the 1938 (Kuhn 1938; Hanqin 2003; Parrish 2005; Bratspies and Miller 2006). Such regional or bilateral issues gave rise to correspondingly regional norms or bilateral agreements, which, in fact, continue to comprise the majority of international environmental law today (Mitchell 2013).

More recently, environmental issues have become increasingly globalized.[20] Marine pollution, ozone depletion, acid rain, and climate disruption were among the first global environmental issues to receive the attention of the international community. MEAs with a global scope of applicability were adopted, some of which now enjoy near universal membership. Although the geographical divisions have become blurred to some extent, the sectoral divisions persist along the lines of sub-specialisms of international environmental law. We have separate laws by type of pollution or source of generation. For example, there are separate treaties for fisheries, marine pollution, and climate change regulation, which were developed independently of each other without reference to the ways in which they would interact or create regulatory gaps and overlap.

Therefore, each MEA is limited to the particular sectors or activities within its mandate, to the environmental media it is intended to address, and to its geographic area of application (Steiner et al. 2003). The result is a series of piecemeal international legal responses to the larger patterns of global environmental change through the proliferation of 'autonomous institutional arrangements' of modern MEAs (Churchill and Ulfstein 2000).

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[19] The notion of 'object and purpose' of a treaty is a relatively more concrete aim that can be achieved by following a certain number of steps, or used as a direct measure of the legality of state behaviour (Klabbers 2008).

[20] For the relationship between law, governance, and globalization in the environmental context, see Kotzé (2012).

International environmental law has evolved into a fragmented as opposed to an integrated and coordinated system (Ostrom, V. 1999; Ostrom 2010b). There is no single authority, but multiple, formally independent centres of decision-making with equal legal authority to act on different aspects of the global environmental crisis. Although international environmental law has developed a certain level of coherence through the inclusion of general principles in different legal instruments (Kiss and Shelton 2004; Long 2010), its core value system remains weak and vague (Birnie et al. 2009; Bodansky 2009; Sands and Peel 2012).

As such, the historical conditions have not been conducive to the emergence of a single goal. The concept of a goal here is intended to mean a *grundnorm* that gives all international regimes and organizations a shared purpose to which their specific treaty objectives must contribute. The goal or *grundnorm* would be in the form of an amalgamation of minimum environmental standards that are essential for protecting planetary boundaries. It would establish a normative hierarchy and function as a supreme norm that prioritizes planetary environmental concerns, to which all other subsidiary rules and principles must adhere.

In thinking about the integration of a *grundnorm* in this way, it is useful to juxtapose international environmental law with other branches of international law with clearly identifiable goals. The ultimate goal of international human rights law, for example, is to ensure that every human being can fully experience human security, particularly in relation to the government (Steiner et al. 2008). The Universal Declaration of Human Rights has been regarded as the constitution in that field of law, whose norms have now assumed acceptance at the level of customary law that bind all states. The goal of international trade law, 'free trade' or the liberalization of the trade systems worldwide, although still the subject of significant controversy, is nevertheless a dominant mode of practice.[21] Many of the different issue areas of world trade law are currently being regulated under the overarching principles enshrined in the Agreement Establishing the World Trade Organization (van den Bossche 2008). These are some examples of 'superior' norms that override other norms and bind almost all states (Sands 2001). Yet, international environmental law lacks such a normative hierarchy comparable to that of international trade and human rights law.

Some might opine that the 1972 Stockholm Declaration, the 1982 World Charter for Nature, or the 1992 Rio Declaration on Environment and Development set out fundamental goals of international environmental law. However, such a claim could arguably be dismissed

[21] Allen (2004, p. 346), for example, stated: "Free trade has achieved peremptory status by reason of the social power, market prominence, and ideological productivity of the social forces who support the EU, Nafta and WTO". See also van den Bossche (2008).

on the ground that none of them has constitutional features (Bodansky 2009). The Rio Declaration, which is probably the most authoritative document in international environmental law, provides a "framework of global reference", at best (French 2011, p. 155). It bears little resemblance to the Universal Declaration of Human Rights or to the international covenants on human rights (Sands and Peel 2012). In particular, the Rio Declaration, being soft law in nature (Dupuy 1991; Abbott and Snidal 2000), does not create a normative hierarchy (Shelton 2006), and lacks the capacity to exercise real constraint on the behaviour of states. As Bodansky (2009, p. 567) put it, "international environmental law as a whole lacks the hallmarks of a constitutional order". The system remains an incoherent set of commitments by states without a clearly established value-hierarchy (Bodansky 2009).

5.4. Dysfunction of International Environmental Law in the Absence of a Goal

An important, but often overlooked question[22] is how such the absence of a single unifying goal or *grundnorm* has affected the overall functioning of international environmental law. In the discussion that follows, I provide an explanation as to why we should agree on and specify a *grundnorm* of international environmental law and how it would make a difference.

5.4.1. The Current Mode of Institutional Cooperation and Coordination

UNEP has not been effective in accomplishing its mission of coordinating environmental programs within the United Nations system (Steiner et al. 2003; Mee 2005; Andresen 2007). The international community has, more or less, relied on the *self-organized* mode of coordination and cooperation among its international regulatory regimes (Watson et al. 1998; United Nations University 1999; UNEP-WCMC 2004). Many modern MEAs such as the United Nations Framework Convention on Climate Change (UNFCCC) include provisions that oblige their secretariats "[t]o ensure the necessary coordination with the secretariats of other relevant international bodies" (UNFCCC Article 8(2)(e)). Similarly, the Conferences of the Parties (COPs) are required to "[s]eek and utilize, where appropriate, the services and

[22] For a notable exception, see Taylor (1998).

cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies" (UNFCCC Article 7(2)(l)). The treaty bodies sometimes enter into formal arrangements by signing bilateral Memoranda of Understanding with other such bodies or international organizations with an aim to enhance cooperation and partnership (e.g., Memorandum of Understanding between the Secretariat and the Bureau of the Convention on Wetlands of International Importance, Especially as Waterfowl Habitat).

However, there are inherent limits to horizontal coordination. From a governance perspective, this method is one of integration by stealth,[23] in which coherence is advanced in a piecemeal approach through cooperation on technical matters, while avoiding the fundamental questions of *raison d'être* and organizing principles of international environmental law as a whole. Environmental conflicts are normative in nature and cannot be fully resolved solely by technical cooperation (Wolfrum and Matz 2003; Doelle 2004; Fitzmaurice and Elias 2005; Voigt 2009; van Asselt 2012).[24] Fostering linkages between individual regimes might be a pragmatic solution to institutional *ad hoc*-ism,[25] but insufficient to address normative fragmentation in the context of global environmental governance (Borgen 2012). The different environmental objectives of individual MEAs need to be balanced in a principled manner.[26]

Furthermore, from a legal perspective, the obligations of treaty bodies to cooperate and coordinate with others are conditioned by due respect for the "legal autonomy of the treaties" (UNGA 2005, para. 169). It has been noted that "any effort by actors in one regime to influence rule development in another will be limited by the extent to which memberships are congruent" (van Asselt 2012, p. 1265). For example, an important barrier to cooperation between the UNFCCC and the Convention on Biological Diversity (CBD) has been that the United States is party to the former, but not to the latter. In its submission to the UNFCCC, the United States noted that these "Conventions have a distinct legal character, mandate and membership", and insisted that biodiversity issues be dealt with outside the UNFCCC (UNFCCC 2006, p. 16). Similarly, at the 11th meeting of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea in 2010, the Group of 77 and

[23] The notion of integration by stealth was applied in the context of European political unification (Hayward 1996).

[24] For discussions on treaty conflicts in a more general context, see Pauwelyn (2003), Sadat-Akhavi (2003), Pauwelyn (2004), Borgen (2005), and Borgen (2012).

[25] On the notion of '*ad hoc*-ism' in the global environmental governance context, see Najam (2000).

[26] For a similar argument in the wider context of sustainable development, see Lafferty and Hovden (2003) and Voigt (2009).

China emphasized the need to avoid choosing topics such as climate change, which fell within the mandate of specific international organizations or institutions (Diz et al. 2010; ICP 2010).

The legal autonomy of the treaties has been emphasized repeatedly because 'importing' concepts or rules between treaties with different memberships is perceived as an erosion of national sovereignty (Wolfrum and Matz 2003; van Asselt 2012). This is a legitimate concern which relates to the question of accountability of the regime to its state parties and, more generally, to the legitimacy of that regime (Scott 2011). However, the same concern has made MEAs inward-looking, either unable or reluctant to share or give away part of what they perceive as their 'sovereignty' (UNEP 2001a). In a sense, national sovereignty of states has been translated into 'institutional sovereignty' of treaty regimes.[27] This is particularly problematic in the field of international environmental law. Although the same holds true for human rights treaties, most human rights norms have attained the status of *jus cogens*, and hence they are universally applicable irrespective of state consent.[28]

Where an MEA regime seeks to extend its scope to link with other agreements or organizations, due care needs to be exercised to ensure it is not seen to attempt to intrude on the work of other bodies. Often the best an MEA can do is merely to make information available for use (Bull et al. 2011). Information exchange between the UNFCCC and other institutions takes place largely on an *ad hoc* basis or relies on the submissions of individual parties or observers (Moncel and van Asselt 2012). For example, the CBD established the Ad Hoc Technical Expert Group on Biodiversity and Climate Change to issue a series of reports, in the hope that the reports' recommendations will be reflected in the future decisions of the COP to the UNFCCC. However, for the UNFCCC, the connection with issues other than their own has been seen as an unwanted distraction to achieving its narrowly defined and interpreted object and purpose (Chambers 2008).

5.4.2. Environmental Problem Shifting among the Planetary Boundaries

The neglect for cross-sectoral interactions on the part of MEAs comes with a high risk of transfer of harm or hazards from one area or medium to another or transformation of one type of environmental harm to another (Sands and Peel 2012). This so-called 'problem shifting'

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[27] For a review of the contemporary debate on sovereignty, see Bartelson (2006).

[28] Examples include the prohibition of aggression, slavery, genocide, racial discrimination, and torture (Brownlie 2003; Steiner et al. 2008). On the concept of *jus cogens*, see, for example, Frowein (2008) and Shelton (2006).

can even happen as an unintended consequence of action taken to *protect* a part of the environment (Teclaff and Teclaff 1991). A number of MEAs including UNCLOS have a provision aimed at preventing such environmental problem shifting (UNCLOS Article 195), yet the issue has received little attention. A quantitative analysis of the extent of problem shifting across the entire institutional landscape is beyond the scope of this chapter. What follows are some selected illustrative examples of problem shifting across planetary boundaries.

A notable example of environmental problem shifting across multiple planetary boundaries is the expansion of biofuel crop plantations for the purpose of climate change mitigation.[29] Biomass combustion is assumed to be carbon-neutral under the greenhouse gas accounting rules of the UNFCCC (European Environment Agency 2011). However, in many cases, expanding the cropland for the feedstock involves clearing of land, and incurs a 'carbon debt' that is unaccounted for (Danielsen et al. 2008; Fargione et al. 2008; Searchinger et al. 2008). The time required for biofuels to offset the carbon dioxide (CO_2) emissions released during land-clearing has been estimated to be 100-1,000 years, depending on the specific ecosystem involved in the land use change event (Kim et al. 2009). For example, converting forests currently sequestering CO_2 to bioenergy crops; harvesting live trees for bioenergy and allowing forest to regrow; diverting crops or growing bioenergy crops on otherwise high-yielding agricultural land are likely to result in a net increase in CO_2 emissions in the near term (European Environment Agency 2011). In terms of problem shifting, replacing gasoline with bioethanol shifts the net environmental impacts primarily towards increased eutrophication and water scarcity through greater use of fertilizers and freshwater (Jackson et al. 2005; Pimentel 2008; Yang et al. 2012). Furthermore, using agricultural land for cultivating biofuel feedstocks naturally leads to less production of food, endangering food security (Tilman et al. 2009).

Similar forms of problem shifting can be observed in afforestation and reforestation projects, which are driven partially by perverse incentives that promote the conversion of natural forests into monoculture tree plantations. At the heart of this problem is the definition of 'forest'[30] adopted in 2001 under the Marrakesh Accords of the Kyoto Protocol. It

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[29] Biofuels are fuels derived from biomass or waste feedstocks; includes ethanol and biodiesel (International Energy Agency 2013).

[30] "'Forest' is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 metres at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily

inadvertently allows continued unsustainable exploitation of forest resources principally because natural forests and plantations are not differentiated (Sasaki and Putz 2009; Glomsrød et al. 2011). Refining the definition is required to prevent problem shifting from climate change to biodiversity loss. It will also be an important factor in ensuring the successful operation of the Reducing Emission from Deforestation and Forest Degradation Program (REDD+) and delivering co-benefits to other environmental efforts such as biodiversity conservation (Putz and Redford 2009; Strassburg et al. 2010; Agrawal et al. 2011).

Ocean fertilization provides another example of potential environmental problem shifting. Ocean fertilization is a type of geoengineering based on the purposeful introduction of nutrients such as iron into the upper ocean to encourage phytoplankton growth, which in turn is expected to remove CO_2 from the atmosphere. However, there are many uncertainties involved with quantifying the amount of CO_2 removed on a long-term basis and the likely impact on marine ecosystems and biodiversity (Secretariat of the Convention on Biological Diversity 2009b; Williamson et al. 2012; see also Intergovernmental Panel on Climate Change 2007a). The 2008 COP to the CBD requested its parties, and urged other governments, to ensure that ocean fertilization activities do not take place until there is an adequate scientific basis on which to justify such activities (CBD 2008, Decision IX/16; CBD 2010, Decision X/33). However, arrangements for international governance of further field-based research on ocean fertilization are currently being developed,[31] primarily under the London Convention and its Protocol.

Our understanding of environmental problem shifting could probably be extended to include more passive forms of problem shifting such as the transformation of climate change to ocean acidification as inadvertently facilitated by the UNFCCC. Over the past 200 years, the oceans have absorbed about 40% of the excess atmospheric CO_2 that humans have emitted (Zeebe et al. 2008). Although this natural buffering effect has helped to mitigate climate change, the extra carbon taken up by the oceans is making them more acidic (Caldeira and Wickett 2003).[32] Although the UNFCCC and the Kyoto Protocol regulate CO_2 emissions, scholars have suggested the climate regime does not provide an adequate legal framework for the problem of ocean acidification (Baird et al. 2009; Lamirande 2011; Harrould-Kolieb and

unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest" (UNFCCC 2002, p. 58).

[31] For general discussions on the legal dimension of ocean fertilization, see, for example, Freestone and Rayfuse (2008), Warner (2009), Abate and Greenlee (2010), Bertram (2010), and VanderZwaag (2011).

[32] The increasing acidity is predicted to have dire consequences for many marine ecosystems and species, especially those organisms that form shells and plates out of calcium carbonate, such as coral reefs (Riebesell et al. 2000; Orr et al. 2005; Hoegh-Guldberg et al. 2007; Fabry et al. 2008).

Herr 2012; Kim 2012). Rather, the uptake of atmospheric CO_2 by the oceans is currently presented in the climate regime as part of the solution to climate change (Baird et al. 2009). In other words, by design, the climate regime has been knowingly externalizing the cost of mitigating climate change, which has manifested partly as the acidifying ocean. If parties to the UNFCCC were to acknowledge ocean acidification as a problem in and of itself, they would have to account for the excess carbon that the oceans naturally absorb. By failing to do so, however, the UNFCCC has been passively contributing to problem shifting.

Furthermore, the UNFCCC and the Kyoto Protocol obligate all parties to promote sustainable management, and promote and cooperate in the conservation, enhancement and protection of the oceans as sinks and reservoirs (UNFCCC Article 4(1)(d); Kyoto Protocol Article 2(1)(a)(ii)). This means that not only must parties act to enhance the 'passive' absorption of anthropogenic CO_2 into the oceans, but also, these provisions can even be interpreted as giving tacit consent to some form of 'active' ocean sequestration of CO_2 through, for example, ocean fertilization.[33]

Most of the above-illustrated examples of problem shifting involve a form of geoengineering. Described as the ultimate 'poster-child' of the Anthropocene (Scott 2013), the limits of international environmental law have become apparent in the face of geoengineering. The international environmental law system is not sufficiently more than the sum of its norms and institutions (Jóhannsdóttir et al. 2010). The existence of multiple parallel, overlapping MEAs might in effect not lead to a higher protection standard than one individual and selective agreement (Proelss and Krivickaite 2009). Contrary to the common perception, individual environmental protection efforts do not necessarily add up (Hirsch et al. 2011). Considering the significance of environmental problem shifting, we need to start paying greater attention to the *internal* incoherence of international environmental law.

5.4.3. Purposive Legal Reasoning in the International Environmental Law Context

International environmental law can be conceptualized as a system of MEAs with hundreds of objectives that point in different directions. Improving the performance of one

[33] Ocean iron fertilization could, in theory, reduce the rate of increase of atmospheric carbon dioxide, and hence the rate of ocean acidification in the upper ocean. However, if deployed on a climatically significant scale, this approach would relocate acidification from the upper ocean to mid- or deep water, where biota may be more sensitive to pH changes (Caldeira and Duffy 2000; Cao and Caldeira 2010; Williamson and Turley 2012).

MEA in isolation may come to constrain the actions of another MEA to the point of serious injury. In systems terminology, this is called the problem of sub-optimization, where optimizing each subsystem independently may ultimately worsen the overall system. The principle of sub-optimization explains why "it is more difficult than we realize to construct a coherent macro-legal system by applying a micro-legal focus" (Ruhl 1996b, p. 1444). This is also why, all too often, "[t]he 'letter of the law' is met, [but] the spirit of the law is not" (Meadows 2008, p. 137). We have been occupied by technical matters while losing our sight of the ultimate purpose of international environmental law.

According to Meadows, what we can do to make sure the *spirit* of international environmental law is met is "to design the law with the whole system, including its self-organizing evasive possibilities, in mind" (Meadows 2008, p. 137). This would begin with a realization that international environmental law is a complex, self-organizing system of norms and institutions. Even though self-organization and collaboration in polycentric settings hold a great potential, it requires institutional intervention to steer the direction of self-organization process (Folke et al. 2011). One may call this process a 'systematization of anarchy'.[34]

The goal of a system is a powerful leverage point in that regard (Meadows 2008). Here is an example from economics. Because of non-linear dynamics between micromotives and macrobehaviour (Schelling 1978), macroeconomics cannot be derived from microeconomics. In order to direct economic systems towards desired macroscopic outcomes, which might be keeping the market competitive, the self-organizing aspects of the market must be complemented by the top-down feedbacks. These feedbacks would come from goal-oriented central agencies, which modify local rules of interaction to prevent each individual corporation from eliminating its competitors (Levin 2002; Meadows 2008). Similarly, in ecosystems, the goal of keeping populations in balance and evolving trumps the goal of each population to reproduce without limit (Meadows 2008).

The significance of a system goal does not imply the need for a monolithic, top-down approach to global environmental governance through a World Environment Organization. However, it does mean that international environmental law as a system of MEAs is in need of firstly, a *grundnorm*, to which its myriad individual treaties and organizations would align and, secondly, functioning checks and balances to oversee that alignment.

This process requires purposive legal reasoning, where "the decision about how to apply a rule depends on a judgment of how most effectively to achieve the purposes ascribed to the rule" (Unger 1976, p. 194). In other words, the threats MEAs address and the solutions

[34] This notion is adapted from Backer (2012).

MEAs outline need to be evaluated in relation to an overall environmental goal (Steiner et al. 2003), which, in my opinion, should be protecting planetary boundaries, or the biophysical preconditions that are essential for human existence and development. International environmental law should not constitute a mere mechanical application of random rules or decisions that point in different directions, but the operation of a whole that is directed towards the shared purpose (International Law Commission 2006).

For a purposive system of international environmental law, legal interpretation needs to build systemic relationships between rules by envisaging them as part of the shared purpose. The principle of systemic integration of Article 31(3)(c) of the Vienna Convention on the Law of Treaties (VCLT) has the capacity to fulfil this critical role. Pursuant to this principle, international environmental instruments are interpreted and applied by reference to their normative environment, or "any relevant rules of international law", especially *grundnorms* (VCLT Article 31(3)(c)). In this manner, object and purpose of legally autonomous MEAs could be synchronized towards achieving a collective goal. For example, in implementing the UNFCCC, its provisions would need to be interpreted and applied in a way that would consider and address any unintended consequences on biodiversity, hence creating a mutually supportive relationship between the UNFCCC and biodiversity-related MEAs in light of a *grundnorm*.[35] This could possibly translate to less efficient climate change mitigation measures in the short term, but its aim is to ensure long-term global ecological integrity and sustainability. In other words, the principle of systemic integration is a critical component in establishing an intrinsic priority of maintaining planetary integrity over individual treaty objectives. As articulated by a judge at the International Court of Justice, the principle is the closest to being a master key to the house of international (environmental) law (International Law Commission 2006).

The coordination of international environmental regimes should then resemble receiver-based optimization found at play in many complex adaptive systems (Kauffman 1995).[36] Here, all the agents in a system that is trying to coordinate behaviour let other agents know what is happening to them. The receivers of this information use it to decide what they are going to do. They base their decisions on some overall specification of *'team' goal*, and, thus, achieve coordination (Kauffman 1995). This is, in principle, how a flock of birds, for

[35] I note that the formulation of Article 31(3)(c) of the VCLT has been criticized as unclear both in its substantive and temporal scope and its normative force (McLachlan 2005; Linderfalk 2008; Tzevelekos 2010).

[36] For a general introduction to complex adaptive systems, see Holland (1995), Levin (1999), Miller and Page (2007), and Mitchell (2009).

example, self-organizes and adapts to changes in the external environment in the absence of an authority. Accordingly, this approach would suggest that it is imperative that we define a *grundnorm* and evaluate the threats that MEAs address and the solutions they outline in relation to it (Steiner et al. 2003). International environmental law would then begin to assume the shape of a goal-oriented, purposive system, rather than a random collection of directives.

5.5. Ecological Integrity as an Emerging Common Denominator

The exact form and nature of the overarching goal, or *grundnorm*, is beyond the scope of this thesis.[37] However, here I identify and endorse the notion of protecting and restoring the integrity of Earth's life-support systems as a potential *grundnorm* or goal of international environmental law. As a goal, it has the necessary attributes, namely content and intensity, on what needs to be done and to what degree (Latham and Locke 1991).

5.5.1. Ecological Integrity in International Environmental Law

From a legal perspective, the notion of ecological integrity may sound as vague and unclear as the notion of sustainability. However, it has been used as a key concept in a wide range of international environmental agreements on regional issues or particular types of ecosystems. The concept first appeared in the international arena in 1978 with the Great Lakes Water Quality Agreement signed bilaterally between Canada and the United States, whose purpose was "to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem" (Great Lakes Water Quality Agreement Article II). The first MEA to include the notion of integrity was the Convention on the Conservation of Antarctic Marine Living Resources adopted in 1980. The parties to the Convention recognized "the importance of safeguarding the environment and protecting the integrity of the ecosystem of the seas surrounding Antarctica" (CCAMLR Preamble). Since then, more than a dozen MEAs have been adopted with some reference to ecological integrity in their

[37] Possibilities include fundamental ethical change promoted through a global treaty or the Earth Charter (Taylor 1998), jurisprudential advancements through academic literature or judicial reasoning, or incremental changes through legal agreements or institutional reform (Bugge amd Voigt 2008).

preambular or operative part of the treaty (e.g., Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean).

More importantly, a number of key international environmental soft law instruments contain the notion of ecological integrity in their cores. These instruments include the World Charter for Nature, the Rio Declaration on Environment and Development, Agenda 21, the Draft International Covenant on Environment and Development (IUCN Environmental Law Programme 2010), the Earth Charter (Earth Charter Initiative 2000), the Plan of Implementation of the World Summit on Sustainable Development, and The Future We Want.

The Rio Declaration, for example, states in the preamble that the United Nations Conference on Environment and Development worked towards "international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system" (Rio Declaration Preamble). Furthermore, one of its core principles obligates states to "cooperate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem" (Rio Declaration Principle 7). This was in the spirit of the World Charter for Nature of 1982, which firmly established the integrity of ecosystems or species as a non-negotiable bottom line when achieving "optimum sustainable productivity" of natural resources (World Charter for Nature Principle 4).

The Earth Charter, which was adopted as the civil society alternative to the Rio Declaration in 2000, puts the concept of ecological integrity among its four core principles. Here, "all individuals, organizations, businesses, governments, and transnational institutions" are urged to "[p]rotect and restore the integrity of Earth's ecological systems, with special concern for biological diversity and the natural processes that sustain life" (Earth Charter Principle 5).

Furthermore, the IUCN Draft International Covenant on Environment and Development states the following as the first fundamental principle: "Nature as a whole and all life forms warrant respect and are to be safeguarded. The integrity of the Earth's ecological systems shall be maintained and where necessary restored" (IUCN Environmental Law Programme 2010, Article 2).[38] Although still a draft, the inclusion here is significant because the Covenant is a codification of existing environmental law, and was intended to be a blueprint for an international framework agreement of the environment.

I acknowledge that such repeated references in legal documents *per se* would not suffice to suggest that the notion of protecting Earth's ecological integrity has become the

[38] This was reflected in the text upon consulting with the drafters of the Earth Charter to ensure consistency among the principles set forth in both texts.

ultimate goal of international environmental law. However, the concept of ecological integrity is emerging as one of the common denominators among the plethora of international environmental legal instruments. In this sense, the concept has the potential to be recognized and accepted as an environmental *grundnorm* and, as a result, help to transform environmental governance and law (Bosselmann 2008).

5.5.2. Relationship between Planetary Boundaries and Ecological Integrity

The notion of ecological integrity implies a condition that is determined to be characteristic of its natural region (Karr 1991; Karr and Chu 1995). At the planetary scale, the integrity of Earth's ecosystem would refer to the biophysical conditions of the Holocene, which preceded anthropogenic global environmental change that began with the Industrial Revolution. The climatically stable Holocene epoch is a good scientific reference point because it represents a period during which human species were able to develop agriculture, civilization, and modern societies (Griggs et al. 2013; see also Petit et al. 1999). In this sense, the ultimate purpose of international environmental law should be about safeguarding the integrity of Earth's life-support systems, or all identified and potential planetary boundaries as the non-negotiable biophysical preconditions for human existence and development (Rockström et al. 2009a).

In my view, the reference to ecological integrity is the missing planetary dimension to the conventional anthropocentric definition of sustainable development. The concept of ecological integrity refers to much more than just healthy ecosystems, and includes other 'planetary must-haves', which are materials use, clean air, nutrient (nitrogen and phosphorus) cycles, hydrological cycles, ecosystem services, biodiversity, and climate stability (Griggs et al. 2013). Therefore, the concept contributes to an updated definition of sustainable development tailored to the Anthropocene, that is, "development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depends" (Griggs et al. 2013, p. 306; see also Anton 2012a).

Importantly, the measurability of planetary boundaries could possibly enable the integrity of Earth's life-support system to be used as a direct measure of the legality of state behaviour (Rockström et al. 2009b; see also Running 2012). The application of the planetary boundaries framework as a measuring stick for environmental protection has proven to be legally feasible in the treaty context (Roderick 2011). For example, the climate regime hints at an environmental limit with its reference to holding global warming to a certain amount. The ozone regime performs a similar function in relation to the ozone layer protection. Similarly, the parties to the CBD have recently agreed on a set of non-binding but measurable biodiversity targets (CBD 2010, Decision X/2). Other examples can be pointed to in treaties for other issue areas. Vidas (2011, pp. 923–924), for example, remarked about the potential feasibility of the concept of planetary boundaries as follows in relation to the transnational marine environment protection:

> [The] proposed concept of planetary boundaries may offer an important new perspective for the law of the sea in the face of an Anthropocene epoch, in which it is conceivable that maintaining the type and level of activities within and beyond our jurisdictional boundaries—including maritime ones—may become conditional upon respecting certain overall, planetary-scale boundaries.

As an amalgamation of minimum environmental standards as informed by the planetary boundaries framework, the *grundnorm* of protecting the integrity of Earth's life-support system has the capacity to function as "the ultimate arbiter of the myriad trade-offs that need to be managed" (Steffen et al. 2011c). It should be the overarching goal of international environmental law, thereby underpinning and guiding the interpretation of existing, and the creation of new international environmental laws.

5.6. Conclusion

Humanity is facing the dual challenge of maintaining Earth subsystems within their planetary boundaries while limiting the risk of problem shifting across environmental media. The accumulating body of environmental treaties, which narrowly focus on particular problems or sectors, has not been able to ensure that its balkanized efforts lead to a net improvement. This research arose out of the need to identify a way to make international environmental law more effective as a whole in terms of planetary sustainability.

To this end, this study approached international environmental law from the perspective of the entire biosphere. I began by considering the implications of planetary boundaries for international environmental law. The presence of interacting thresholds or tipping points at the planetary scale points to the presence of an environmental *grundnorm*. However, I observed that the international environmental law system is missing a *grundnorm*, hence an overarching goal that binds the actions of international environmental actors and institutions.

By employing empirical examples of environmental problem shifting, I illustrated how the absence of an overarching goal has translated to an absence of a unifying reference point for legal reasoning and interpretation. The missing component, in my view, provides an explanation as to why international environmental law has been unable to function coherently and purposively.

I made a preliminary observation that the notion of protecting and restoring the integrity of Earth's life-support system is emerging as a common denominator among MEAs and other landmark international environmental documents. This concept makes a strong candidate for the environmental *grundnorm*. The ecological integrity at the planetary level implies maintaining and restoring environmental conditions of the Holocene. Planetary boundaries of the Anthropocene are quantifiable; hence integrity can be used as a measure of legality of state behaviour.

The step forward for the international community would be to recognize the emerging notion of protecting and restoring global ecological integrity as a *grundnorm* of international environmental law. I anticipate that this may require what some scholars call a constitutional moment in global environmental governance (Biermann et al. 2012a; Bosselmann et al. 2012).

Chapter 6.
Conclusions

This concluding chapter provides (1) a summary of the thesis' key findings and conclusions; (2) additional insights on the design and efficacy of international environmental law; (3) a review of the major limitations of this study; and (4) recommendations for future research.

6.1. Key Findings and Conclusions

This thesis conceptualized international environmental law as a system of multilateral environmental agreements (MEAs) and empirically analysed its macro-level structure and dynamics. Chapter 2 explored international environmental law through the lens of complex adaptive systems (CASs). Chapters 3 analysed and characterized the topological properties of the dynamic web of 747 MEAs with network analysis tools. A rich picture emerged illustrating how MEAs have self-organized into a network with complex topology. Chapter 4 investigated how MEAs collectively behave in response to an emerging environmental issue – ocean acidification – and assessed the degree of emerging polycentric order. It was found that international environmental law has a limited capacity to make mutual adjustments among its MEAs and prevent environmental problem shifting. Backed up by more empirical evidence of problem shifting in Chapter 5, I identified that the absence of a single, legally binding, overarching goal or *grundnorm* is a key design flaw in international environmental law. I suggested that this environmental *grundnorm* should be the protection of the integrity of Earth's life-support systems.

6.1.1. International Environmental Law Exhibits Properties of a Complex System

A major conclusion drawn from Chapter 2 is that international environmental law can be usefully conceptualized as a system of MEAs. The preliminary review suggested that international environmental law is a *system* consisting of autonomous interacting MEAs, and that it has emergent functions. Furthermore, international environmental law could be conceptualized as a *complex* system because these emergent functions cannot be fully explained in terms of microscopic components, that is, by understanding individual MEAs.

However, the preliminary review was not able to determine whether international environmental law meets the criteria for being a *CAS*. Although many modern MEAs individually have adaptive mechanisms for dealing with environmental changes, it was questionable to what extent international environmental law *in toto* has been adaptive to environmental changes.

Nonetheless, by demonstrating the usefulness of the conceptual approach, the exploratory chapter set the context for the rest of the thesis: to look for *emergent* properties in terms of macroscopic structure and function of the MEA system. In other words, what is it that happens within international environmental law that one cannot understand just by studying each regime or institution in isolation?

6.1.2. Multilateral Environmental Agreements Have Self-organized into a Complex Network

The analysis undertaken in Chapter 3 revealed the previously hidden network architecture of international environmental treaty law. The architecture was estimated by a dataset of 1,001 cross-references found in 747 MEAs concluded between 1857 and 2012.

The network analysis presented a set of novel findings that contravenes the common dismissal of international environmental law as being structurally congested and fragmented (e.g., Brown Weiss 1993). Rather, the findings suggest that international environmental law as conceptualized as a network of MEAs has self-organized into an interlocking system with complex internal structures. In other words, if we focus on MEA texts, a product of negotiation, international environmental law is not necessarily fragmented in the conventional sense. From the network perspective, the MEA network was most fragmented in 1975 and it has been structurally *defragmenting* since then. In 1992, coinciding with the Rio Conference, order and complexity emerged spontaneously in the MEA system.

The observed patterns of organization show that the system is actually following certain universal organizing principles found in many complex systems. For example, the self-assembled MEA network displays small-world and scale-free properties and it is hierarchically organized. The MEA network has a modular topology and shows a general tendency towards homophily whereby MEAs preferentially associate with others of a similar topic.

Such network structures could be interpreted as having important implications for the function of the MEA system. The small-world architecture has the potential to enable rapid and efficient communication for synchronized responses to external perturbations. Multiple short paths among MEAs may provide path redundancy, hence improve institutional resilience. The modular architecture is known to help accumulate 'local' knowledge and sustain 'local' mutualism, while facilitating efficient 'global' cooperation through bridges between modules. The hierarchically nested structure tends to provide stability and flexibility at the same time, enabling both exploitation and exploration for enhanced adaptive capacity.

The empirical findings in terms of the structure raised an important question of whether we are witnessing the emergence of a coherent polycentric order in the MEA system. However, due to inherent limitations associated with the use of cross-references (see Section 6.2.), the network analysis alone could not provide a comprehensive answer. These results, therefore, needed to be complemented by Chapter 4, a qualitative case study on how the MEA system *behaves* in response to the emerging, cross-cutting problem of ocean acidification.

6.1.3. Multilateral Environmental Agreements Are Unable to Fill Regulatory Gaps through Mutual Adjustments

The main conclusion drawn from Chapter 4 is that, functionally, international environmental law is limited in its ability to foster mutual adjustments among its MEAs. This conclusion emerged from a case study that surveyed legal applicability and institutional responses of over a dozen key MEAs, including the United Nations Framework Convention on Climate Change, to ocean acidification.

What this case study found in the context of ocean acidification is a regulatory gap in international environmental law and its inability to fill the gap through mutual adjustments among MEAs. Where no regime assumes responsibility for the problem, its legal implications have been unclear and the policy approaches taken by MEAs have been inconsistent. I found inherent structural limitations within and outside the climate regime that act as barriers to developing a strong polycentric system. Several MEAs have taken action to develop ocean acidification policies in their specific areas of interest, but they were often limited in their options to increase their scope of action beyond their agreed mandates. Against this backdrop, the externalized cost of mitigating climate change has manifested partly as ocean acidification.

Governance of ocean acidification at present is relatively fragmented and its weak polycentric order is unlikely to be strengthened to an adequate level without an institutional intervention.

Therefore, I came to the conclusion that a new MEA on ocean acidification is necessary to fill the regulatory gap. This case study explains the structural cause of the persistent piecemeal approach to international environmental lawmaking, through which new agreements have been negotiated and adopted every time new problems surfaced. It was identified that the norm of respecting the legal autonomy of the treaties has been a major hurdle for policy coherence across planetary boundaries. The uneasy tension between 'problem shifting' and what MEAs perceive as their 'sovereignty' is not being adequately balanced in a polycentric governance organization.

6.1.4. International Environmental Law Needs a *Grundnorm*

The point of analytical departure of Chapter 5 was that the state of the global environment is deteriorating despite the accumulating body of international environmental law (see Chapters 3 and 4). The sum of individual efforts to protect the global environment has so far failed to maintain Earth's subsystems within their boundaries. Many factors can be identified that contribute to the apparent ineffectiveness of international environmental law, including the lack of political will to implement treaty provisions and the difficulty in enforcing them. However, this chapter (and this thesis) focused on the tendency of international legal responses to be sectoral and issue-specific, resulting in a condition that is conducive to environmental problem shifting rather than problem solving.

I observed that the international community has been relying on the self-organized mode of coordination and cooperation among its international regulatory regimes. Treaty bodies such as secretariats and Conferences of the Parties coordinate themselves and cooperate where necessary. However, such a horizontal coordination with no reference point at a higher level has inherent limits, especially when treaties are autonomously pursuing their own interests.

In order to rectify the problem, I investigated implications of the absence of a clearly agreed unifying goal for institutional cooperation among treaty bodies and with regard to international environmental law as a whole. The notion of goal was used to mean a single, legally binding, superior norm – a *grundnorm* – that gives all international regimes and organizations a shared purpose to which their specific objectives must contribute. With empirical examples of environmental problem shifting, I argued that the absence of a goal is, at least in part, a cause of the dysfunction of international environmental law.

Although the system-level goal is not a panacea for effective global environmental governance, it is a powerful leverage point that can steer the direction of its self-organization process (Meadows 2008). A goal-oriented approach would allow adaptability and flexibility of international environmental law within the constraints of a *grundnorm*. It would also encourage or even bind all actors and institutions to break out of their bounded rationality. A goal in this sense would provide the legal system a point of reference for legal reasoning and interpretation, thereby enhancing institutional coherence across Earth's subsystems. With such a goal or *grundnorm* in place, international environmental law would begin to assume the shape of a purposive system, rather than a random collection of rules that point in different directions.

The exact form and nature in which such a goal can be recognized is a subject for future research. However, I observed that the protection of Earth's life-support system has emerged as a common denominator among international environmental law instruments. The Earth Charter and the Draft Covenant on Environment and Development were identified as mutually reinforcing international documents with the concept of ecological integrity and the principle of sustainability at their cores. They could serve as examples of what the necessary goal could look like.

The need to agree on an environmental *grundnorm* supports calls for a 'constitutional moment' in global environmental governance (Biermann et al. 2012a) and establishment of enabling institutions such the proposal for a World Environment Organization with a 'global trusteeship' mandate (Bosselmann et al. 2012). Chapter 5's conclusions also resonate strongly with the recommendations of other scholars working in the fields of global ecological integrity (Soskolne et al. 2008; Westra et al. 2008) and environmental law methodology (Ebbesson 2003; Jóhannsdóttir et al. 2010).

6.2. Other Insights for the Future of International Environmental Law and Governance

The findings and conclusions from Chapters 2, 3, 4, and 5 when considered *in toto* provide useful insights for transforming international environmental law into what might be called Earth system law (see Introduction): an ecologically inspired, fully functioning CAS of environmental laws.

It is a well-established idea in contemporary policy discourses that institutional diversity and decentralization increase the capacity of governance systems to handle complex dynamics (Duit et al. 2010; see also Dooley 1997; Dietz et al. 2003; Low et al. 2003; Haas 2004; Folke et al. 2005; Ostrom 2005; Olsson et al. 2006). Centralized institutions are 'unecological' as they run counter to the ecological principle of requisite variety or flexibility and inhibit random mutations (Haas 2004). Some degree of institutional diversity and redundancy in the performance of functions needs to be valued and preserved in the context of international environmental law. In this sense, the architectural problem of international environmental law is not the institutional proliferation *per se* (c.f., Koskenniemi and Leino 2002; Ivanova and Roy 2007), but the lack of mechanisms to stimulate and steer adaptive self-organization within the international environmental law system.

A reform option consistent with CAS theory is, to strengthen the 'web of relationships' among disparate international institutions and agreements by creating an interlocking network of obligations (Kimball 1992; Kimball and Boyd 1992; see also Werksman 1996) under a shared goal or *grundnorm*. As observed through a network analysis in Chapter 3, we already have the best institutional structure for dealing with complex and tightly-coupled problems, that is, the decentralized, dense network of MEAs. In fact, Kanie (2007, p. 82) observed that the "strengths of the MEA system [are] mostly the same as the very strengths of a decentralized system". Our task is then to preserve and enhance these very strengths (Kanie 2007; see also Haas 2004; Najam et al. 2004) by making meaningful relationships across single-issue silos.

By conceptualizing international environmental law as a system of MEAs, the thesis has highlighted sectoral divisions within the system, which have been overshadowed by the conventional focus on transboundary environmental impact (Handl 2007). Earth system law as a 'continuum of laws' that reflects the laws of nature would need to cut across, not only territorial boundaries (Robinson 2003), but also sectoral divisions by restraining institutional sovereignty of treaty regimes (see Chapter 5).

In this regard, the emergent treaty clusters identified in Chapter 3 need to be strengthened for enhanced 'local' learning and synergies. For example, states could consider organizing a joint Conference of the Parties following the model of the Simultaneously Extraordinary Meetings of the Conferences of the Parties to the Basel, Rotterdam, and Stockholm Conventions, or adopting an umbrella treaty such as a Law of the Atmosphere (Najam 2000). A related leverage point is strengthening of the inter-module ties. The Joint

Liaison Group for the Rio Conventions is an example of an attempt at formalising such bridging ties. However, these ties have so far been weak and rhetorical in practice (Pittock 2010).

The importance of a unifying goal in blurring issue-specific lines has been stressed. However, for the purpose of strengthening the web of law, a clearer set of secondary rules about "how the international legal process works" (Bodansky 2006, p. 304) is necessary. The current set provided in part by the Vienna Convention on the Law of Treaties (e.g., *lex specialis* and *lex posterior*) has been ineffective at creating synergies or resolving normative conflicts within international environmental law (Wolfrum and Matz, 2003; Voigt, 2009). We also need to note the significance of the roles of the principle of mutual supportiveness (e.g., Sanwal 2004, Pavoni 2010), the principle of systemic integration (VCLT Article 31(3)(c)), and the "duty not to transfer damage or hazards or transform one type of pollution into another" (UNCLOS Article 195). Together with a *grundnorm*, these principles hold the key to the future of international environmental law as a CAS of environmental laws.

Finally, I recommend utilizing the emergent hierarchy of the MEA system. The United Nations Convention on the Law of the Sea has grown to be by far the most influential MEA (see Chapter 3). Benefits of bringing issues such as climate change and ocean acidification under the umbrella of United Nations Convention on the Law of the Sea have already been noted (e.g., Burns, 2006; Doelle, 2006; Kim, 2012). Given the central position of the law of the sea convention, a relatively small change initiated by the convention would trigger a cascading effect. Furthermore, the law of the sea convention has the judicial branch, the International Tribunal for the Law of the Sea, which has heard highly significant cases in international environmental law such as the *Southern Bluefin Tuna*.

The reform option presented here takes a bottom-up approach by piecing together MEAs to give rise to an adaptively self-organizing system. Therefore, it needs to be differentiated from other options such as the case for a World Environment Organization (Biermann 2000; Biermann and Bauer 2005) and the managerial approach to institutional interplay (Oberthür 2009; van Asselt 2012). Furthermore, there are subtle but significant differences between the case for a single environmental *grundnorm* presented here and the case for overarching principles or peremptory norms of international law (Biermann 2012; Galaz et al. 2012a). The differences are that (1) a *grundnorm* is grounded in a natural norm of general acceptance and reasonableness and, arguably, it exists independently of a legal system (see Chapter 5), whereas general principles or peremptory norms of international law must be grounded on *opinio juris* (i.e., state practice); and (2) my case insists on a single *grundnorm* whereas the case for overarching principles tolerates multiple norms to guide international environmental law.

6.3. Limitations of This Study

There were three major limitations of this study. First, the scope was limited to MEAs when there are other actors and institutions that constitute the system of international environmental law and governance. The additional elements would include other types of international agreements, state actors, international courts, intergovernmental organizations, and, increasingly, non-state actors such as local governments and nongovernmental organizations (Najam et al. 2004). Despite the best efforts to provide a macroscopic overview, such omissions might mean an incomplete picture of international environmental law.

However, focusing on MEAs was justified as a feasible and informative way of examining the system of international environmental law. MEAs have been major components as well as forums where actors come together and make consensual decisions. They are increasingly considered as 'actors in their own right' with organization-like characters, whose functions are delegated by their member states (Churchill and Ulfstein 2000). Furthermore, as MEAs are used for establishing other international actors, many of which take the form of intergovernmental organizations or international courts (Ulfstein 2012), this thesis has indirectly taken these institutions into account through the consideration of MEAs.

A second limitation of this study was that cross-references, which were used to approximate the structure of the MEA system in Chapter 3, do not necessarily provide information about the functionality of the connections between MEAs. This particular limitation was extensively discussed, and to some extent defended, in Section 2.1. For example, I admitted that citation networks are directed, acyclic, and have an 'arrow of time', hence creating the possibility of misrepresenting the real system structure. However, there was no plausible alternative that fitted in the limited scope of a single PhD study. I also argued that the use of cross-references is still justified as an indication of relatedness of subject matter, institutional influence, and a higher likelihood of interactions. Furthermore, I quoted international environmental law scholars who have observed that the cross-referencing is a unique common characteristic of modern MEAs, which extend the legal effect of MEAs to the texts that cite them (Kiss and Shelton 2007).

A third limitation relates to the findings on the macro-level function of the MEA system through a case study on ocean acidification as the conclusions draw here can only be generalised to a limited extent. This is a typical limitation of any case study research strategy (Eisenhardt 1989; Yin 2009). Moreover, the case study research approach can only consider a limited number of analytical units (in this case, MEAs and their relationships) at a time. In addition, in the specific context of the ocean acidification case study, the available data for institutional responses span a relatively short time period. This is primarily because ocean acidification has only recently caught the attention of the international community. The short longitudinal data span has made it difficult to definitively determine if the MEA system has the potential to adapt to global environmental change and fill emerging regulatory gaps.

6.4. Suggestions for Future Research

There are four key areas for future research that follow issues raised in this thesis. First, there is significant scope for additional research into the dynamic network structures of the MEA system. One possibility is a study on the institutional network structure of planetary boundaries, which explores the existing institutional landscape in explicit relation to the underlying biophysical dynamics. This study could include a quantitative assessment of existing institutional-biophysical mismatches (c.f., Ekstrom and Young 2009).

Second, different and more sophisticated models of the MEA network could be constructed by using proxies other than MEA cross-references. The key is to find a proxy to represent actively functional connections between MEAs in practice. One could consider linking MEAs through identifying instances of actual institutional interactions (e.g., Gehring and Oberthür, 2006; Biermann et al. 2009b), as approximated by, for example, the frequency of email exchange between staff at different MEA secretariats. Future research could also create a multi-mode network of the coupled geopolitical-institutional-ecological systems by adding to the existing MEA network extra layers of, for example, member states and the ecological elements or processes (e.g., carbon cycle). Such a multi-layer representation would provide insights on, for example, which State has been the biggest hurdle for institutional cooperation and where critical regulatory gaps exist.

Third, more case study research is needed to better understand the functional dynamics of international environmental law with regard to governing the complex, non-linear interactions of the Earth system. For understanding functional dynamics, this thesis relied on a single case study on ocean acidification involving about a dozen key MEAs. Future research could, for example, go beyond relying heavily on document analysis and conduct interviews with key individuals in State members, treaty secretariats, and international organizations in order to glean insider insights. In addition, research into a *successful* case where an emerging issue in a regulatory gap was later adequately addressed through mutual adjustments among the MEAs would also be of value.

Fourth, research is needed to develop a new methodological framework that would more systemically study the relationship between the structural and functional dynamics of the international environmental law system. For this purpose, there is potential in marrying CAS and game theory (Hadzikadic et al. 2010). It may be possible to conceptualize the MEA system as a CAS and utilize game theory to define the rules of pairwise interactions between MEAs (e.g., Scott 2003). This would in turn allow multiple interactions and their cumulative feedbacks to be monitored and aggregated to better understand the overall effect.

Such research endeavors would take us a step closer to an ecologically inspired, CAS of environmental laws for the Anthropocene. Such a system, tentatively named here as Earth system law, would embrace the complexity of interacting planetary boundaries and safeguard the integrity of Earth's life-support systems. The scholarly pursuit for this next generation of international environmental law has already started, and this thesis has made a contribution to that end.

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Appendix A. Additional Notes on Methods for Chapter 3

Section 1. Justification for using the ‘adoption year’ of multilateral environmental agreements

The multilateral environmental agreement (MEA) citation network could have been constructed by considering that there are a number of MEAs which are (1) not yet in force (e.g., Nairobi International Convention on the Removal of Wrecks, 2007); (2) not intended to enter into force (e.g., International Convention for the Prevention of Pollution from Ships, 1973); and (3) terminated and/or not fully operational (e.g., International Convention for the Safety of Life at Sea, 1948).

However, constructing the complete network of only those MEAs that are in force is a tricky endeavour. Entry into force dates are definitive as an MEA enters into force when the specified number of states have ratified the MEA and if special conditions, where applicable, are met. However, determining when to take an MEA out of the network is not straightforward. Except in rare cases, an MEA does not specify an expiry date. It continues to remain in force until terminated by its parties, or is superseded by a new MEA.

Even if a new MEA comes into being by replacing the existing MEA, the old instrument, while no longer fully operational, typically stays in force until the last Party officially withdraws from it, creating a grey area in the law. Examples include the International Conventions for the Safety of Life at Sea of 1948 and 1960, which were never fully operational but were replaced by the International Convention for the Safety of Life at Sea, 1974. Given this, it might be meaningless to construct a network of MEAs in force only, especially for the purpose of this research.

Section 2. Consideration of other proxies for treaty relationships

Different and more sophisticated models of the MEA network could be constructed by using proxies other than MEA cross-references. The key is to find a proxy to represent actively functional connections between MEAs in practice.

I considered linking MEAs through identifying instances of actual institutional interactions (e.g., Gehring and Oberthür, 2006; Biermann et al., 2009), as approximated by, for example, the frequency of email exchange between staff at different MEA secretariats. However, this was considered unpractical, as it would be simply a far greater task than appropriate for a single research project.

Another possible option was to document interactions between MEA secretariats as sometimes they sign Memoranda of Understanding or Cooperation and/or develop and implement Joint Work Plans. This too, however, was considered unfeasible, as they are rare, hence it would not have been possible to construct a network that consisted of all MEAs based on their secretariats forming contractual relationships.

Section 3. Rules applied when collecting citation data:

a. MEAs cited in an open-ended manner were excluded (e.g., "as well as other Conventions and Agreements of relevance").
b. Organisations were excluded. However, in a few cases where the name of the organisation was stated, the agreement that established the organisation was considered as cited.
c. MEAs that were going to be adopted in the future were excluded (e.g., "An inter-American convention on human rights shall determine the structure, competence, and procedure of this Commission, as well as those of other organs responsible for these matters").
d. When amendments were vaguely referred to (e.g., International Convention on Civil Liability for Oil Pollution Damage, 1969, *as amended*), only the major amending protocols which replaced the original MEA (i.e., Protocol of 1992 to amend the International Convention on Civil Liability for Oil Pollution Damage, 1969) were inserted as separate nodes, along with the original MEA.
e. When revision or replacement of an MEA took place without an amendment or amending protocol (e.g., International Convention for the Safety of Life at Sea 1914, 1929, 1948, 1960, 1974), both the original and revised MEAs were inserted (until the original MEA expired, if applicable).
f. When the amendment took place through an amending protocol (e.g., Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage, 1969), both the original MEA and the amending protocol were inserted.

g. When the amendment took place through an amendment or adjustment (e.g., Agreement for the Establishment of the General Fisheries Commission for the Mediterranean), and when new cross-references were observed in the amended text, only new links were drawn.

h. Citations to other types of agreements including non-legally binding agreements, bilateral agreements, non-environmental agreements, European Union directives, and national legislation were also identified and noted during the data compilation process. However, these were excluded from the network because they are qualitatively different to MEAs.

Appendix B. List of 747 Multilateral Environmental Agreements Used in Chapter 3

No.	Year	Title
1	**1857**	Agreement respecting the Regulation of the Flow of Water from Lake Constance
2	**1867**	International Regulations Relating to Navigation on Lake Constance
3	**1868**	Revised Convention on the Navigation of the Rhine
4	**1877**	Convention between Alsace-Lorraine and the Two Initial Parties to the Convention between Baden and Switzerland concerning Fishing in the Rhine and its Influxes As Well As in Lake Constance
5	**1878**	Convention on Measures to Be Taken against Phylloxera Vastatrix
6	**1881**	International Convention respecting Measures to Be Taken against the Phylloxera Vastatrix
7	**1882**	Convention between Her Majesty, the German Emperor, King of Prussia, the King of the Belgians, the King of Denmark, the President of the French Republic, and the King of the Netherlands, for Regulating the Police of the North Sea Fisheries
8	**1884**	Additional Convention between Switzerland, Baden and Alsace-Lorraine concerning Fishing in Lake Constance and its Tributaries
9	**1884**	Final Protocol to the Additional Convention between Switzerland, Baden and Alsace-Lorraine concerning Fishing in Lake Constance and its Tributaries
10	**1884**	Protocol of Application to the Convention for Regulating the Police of the North Sea Fisheries
11	**1885**	Final Protocol to the Treaty concerning the Regulation of Salmon Fishery in the Rhine River Basin
12	**1885**	Treaty concerning the Regulation of Salmon Fishery in the Rhine River Basin
13	**1887**	Convention between Switzerland, the Grand Duchy of Baden, and Alsace-Lorraine, Establishing Uniform Provisions on Fishing in the Rhine and its Tributaries, Including Lake Constance, With Final Protocol
14	**1887**	Convention respecting the Liquor Traffic in the North Sea
15	**1887**	Treaty concerning the Jan Mayen Seal Fishery
16	**1892**	Protocol concerning a Revision of the International Regulations Relating to Navigation on Lake Constance
17	**1893**	Convention between Austria-Hungary, Baden, Bavaria, Liechtenstein, Switzerland and Wurttemberg Decreeing Uniform Regulations for Fishing in Lake Constance, Including a Final Protocol
18	**1893**	Protocol to the Convention respecting the Liquor Traffic in the North Sea
19	**1897**	Convention between Russia and Sweden/Norway Regulating the Salmon Fishery in the Tornea
20	**1900**	Convention for the Preservation of Wild Animals, Birds, and Fish in Africa
21	**1902**	Convention between Alsace-Lorraine, Baden, Bavaria, Hesse, the Netherlands and Prussia Relative to the Carriage of Inflammable Substances on the Rhine
22	**1902**	International Convention for the Protection of Birds useful to Agriculture
23	**1910**	Convention for the Unification of Certain Rules of Law Relating to Assistance and Salvage at Sea
24	**1911**	Convention respecting Measures for the Preservation and Protection of the Fur Seals in the North Pacific Ocean
25	**1913**	Act of Foundation of a Consultative Commission for the International Protection of Nature

26	**1919**	Treaty of Saint-Germain-en-Laye
27	**1920**	Convention regarding the Organization of the Campaign against Locusts
28	**1921**	Convention concerning the Use of White Lead in Painting
29	**1923**	Convention Relating to the Development of Hydraulic Power Affecting More than One State
30	**1923**	Protocol of Signature of the Convention Relating to the Development of Hydraulic Power Affecting More than One State
31	**1924**	International Agreement for the Creation at Paris of an International Office for Dealing with Contagious Diseases of Animals
32	**1924**	Organic Statutes of the International Office for Dealing with Contagious Diseases of Animals
33	**1925**	Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare
34	**1926**	Agreement between Iraq, Palestine, Syria, Transjordan and Turkey concerning the Creation of an International Office for Information regarding Locusts
35	**1929**	International Convention for the Protection of Plants
36	**1929**	International Convention for the Safety of Life at Sea, 1929
37	**1932**	Convention between Denmark, Norway and Sweden concerning the Preservation of Plaice in the Skagerak, Kattegat and Sound
38	**1933**	Convention Relative to the Preservation of Fauna and Flora in their Natural State
39	**1933**	Protocol to the Convention Relative to the Preservation of Fauna and Flora in Their Natural State
40	**1934**	Agreement concerning the Campaign against Locusts
41	**1935**	International Convention concerning the Export and Import of Animal Products (Other than Meat, Meat Preparations, Fresh Animal Products, Milk and Milk Products)
42	**1935**	International Convention concerning the Transit of Animals, Meat, and Other Products of Animal Origin
43	**1935**	International Convention for the Campaign against Contagious Diseases of Animals
44	**1937**	Convention between Denmark, Norway and Sweden concerning the Preservation of Plaice and Dab in the Skagerrak, Kattegat and Sound
45	**1937**	Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish, 1937
46	**1937**	International Agreement for the Regulation of Whaling
47	**1938**	Protocol of 24 June 1938 Amending the 1937 International Agreement for the Regulation of Whaling
48	**1941**	Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere
49	**1943**	Convention on the Regulation of Inter-American Automotive Traffic
50	**1944**	Chicago Convention on International Civil Aviation
51	**1944**	Convention on the Inter-American Institute of Agricultural Sciences
52	**1944**	Protocol of 7 February 1944 Amending the 1937 International Agreement for the Regulation of Whaling
53	**1945**	Constitution of the United Nations Food and Agriculture Organization
54	**1945**	Protocol of 26 November 1945 Amending the 1937 International Agreement for the Regulation of Whaling
55	**1945**	Supplementary Protocol regarding the Entry into Force of the 1944 Protocol to the 1937 International Agreement for the Regulation of Whaling
56	**1946**	Convention for the Regulation of the Meshes of Fishing Nets and the Size Limits of Fish, 1946
57	**1946**	International Convention for the Regulation of Whaling
58	**1946**	Protocol of 2 December 1946 Amending the 1937 International Agreement for the Regulation of Whaling
59	**1946**	Supplementary Protocol concerning the 1937 International Agreement for the Regulation of Whaling, as Amended by the Protocols of June 24, 1938 and February 7, 1944
60	**1947**	Agreement Establishing the South Pacific Commission

61	**1947**	Supplementary Protocol regarding the Entry into Force of the 1945 Protocol to the 1937 International Agreement for the Regulation of Whaling
62	**1948**	Agreement for the Establishment of the Asia-Pacific Fishery Commission
63	**1948**	Agreement for the Establishment of the Indo-Pacific Fisheries Commission
64	**1948**	Charter of the Organization of American States
65	**1948**	Constitution of the International Rice Commission
66	**1948**	Convention on the International Maritime Organization
67	**1948**	Convention on the Regime on the Navigation on the Danube
68	**1948**	International Convention for the Safety of Life at Sea, 1948
69	**1948**	Statutes of the International Union for Conservation of Nature and Natural Resources
70	**1949**	Agreement for the Establishment of the General Fisheries Commission for the Mediterranean
71	**1949**	Convention for the Establishment of an Inter-American Tropical Tuna Commission
72	**1949**	Convention on Road Traffic
73	**1949**	International Convention for the Northwest Atlantic Fisheries
74	**1949**	International Convention for the Permanent Control of Outbreak Areas of the Red Locust
75	**1950**	International Convention for the Protection of Birds
76	**1950**	Protocol to Establish a Tripartite Standing Committee on Polluted Waters
77	**1951**	Agreement Extending the Territorial Scope of the South Pacific Commission
78	**1951**	Convention for the Establishment of the European and Mediterranean Plant Protection Organization
79	**1951**	International Plant Protection Convention, 1951
80	**1952**	Agreement of 7 March 1952 concerning Measures for the Protection of Stocks of Deep-sea Prawns (*Pandalus Borealis*), European Lobsters (*Homarus Vulgaris*), Norway Lobsters (*Nephrops Norvegicus*) and Crabs (*Cancer Pagurus*)
81	**1952**	Agreement on the Organization of the Permanent Commission of the Conference on the Exploitation and Conservation of the Maritime Resources of the South Pacific
82	**1952**	Convention regarding the Supervision and Preventive Control of the African Migratory Locust
83	**1952**	Exchange of Notes Constituting an Agreement between the United States of America, Canada and Japan Relating to Scientific Investigations of the Fur Seals in the North Pacific Ocean
84	**1952**	International Convention for the High Seas Fisheries of the North Pacific Ocean
85	**1952**	International Convention on Certain Rules concerning Civil Jurisdiction in Matters of Collision
86	**1952**	Protocol Amending the International Convention for the High Seas Fisheries of the North Pacific Ocean, 1952
87	**1953**	Constitution of the European Commission for the Control of Foot and Mouth Disease
88	**1953**	Convention for the Establishment of a European Organization for Nuclear Research
89	**1953**	Protocol Modifying the International Convention for the Permanent Control of Outbreak Areas of the Red Locust
90	**1953**	Second Agreement of San Salvador Establishing the International Regional Organization of Animal and Plant Health
91	**1954**	Agreement Relating to a Special Marine Frontier Zone Under the Permanent Commission of the South Pacific
92	**1954**	Agreement Relating to Measures of Supervision and Control in the Maritime Zones of the Signatory Countries to the Permanent Commission of the South Pacific
93	**1954**	Agreement Relating to Penalties Under the Permanent Commission of the South Pacific
94	**1954**	Agreement Relating to Regulations Governing Whaling in the Waters of the South Pacific Under the Permanent Commission of the South Pacific
95	**1954**	Agreement Relating to the Issue of Permits for the Exploitation of the Maritime Resources of the South Pacific

96 **1954** Agreement Supplementary to the Declaration of Sovereignty Over the Maritime Zone of Two Hundred Miles to the Permanent Commission of the South Pacific

97 **1954** International Convention for the Prevention of Pollution of the Sea by Oil

98 **1954** Phytosanitary Convention for Africa South of the Sahara

99 **1955** Agreement Relating to the International Convention for Regulating the Police of the North Sea Fisheries Signed At the Hague on 6 May 1882

100 **1956** Convention between the Federal Republic of Germany, the French Republic and the Grand Duchy of Luxembourg concerning the canalization of the Moselle

101 **1956** Plant Protection Agreement for the Asia and Pacific Region

102 **1956** Protocol concerning Amendments to the Regulations of 24 April 1947 for the Agreement concerning the Regulation of Lake Inari in Connection With the Use of the Niskakoski Dam and to the Protocol of 29 April 1954 concerning Amendments to Paragraph 2

103 **1956** Protocol to International Convention for the Northwest Atlantic Fisheries

104 **1956** Protocol to the International Convention for the Regulation of Whaling

105 **1957** Convention on the Establishment of a Security Control in the Field of Nuclear Energy

106 **1957** European Agreement concerning the International Carriage of Dangerous Goods by Road

107 **1957** Interim Convention on Conservation of North Pacific Fur Seals

108 **1957** International Convention Relating to the Limitation of the Liability of Owners of Sea-going Ships

109 **1957** Statute of the International Atomic Energy Agency

110 **1958** Convention concerning Fishing in the Waters of the Danube

111 **1958** Convention on Fishing and Conservation of the Living Resources of the High Seas

112 **1958** Convention on the Continental Shelf

113 **1958** Convention on the High Seas

114 **1958** Convention on the Territorial Sea and the Contiguous Zone

115 **1958** Optional Protocol of Signature concerning the Compulsory Settlement of Disputes

116 **1958** Protocol of Amendment to the Convention on the Inter-American Institute of Agricultural Sciences

117 **1959** Agreement between the Government of the Union of Soviet Socialist Republics, the Government of Norway and the Government of Finland concerning the Regulation of Lake Inari by Means of the Kaitakoski Hydro-Electric Power Station and Dam

118 **1959** Agreement concerning Co-operation in the Field of Veterinary Science

119 **1959** Agreement concerning Cooperation in the Quarantine of Plants and Their Protection against Pests and Diseases

120 **1959** Agreement for the Establishment on a Permanent Basis of a Latin-American Forest Research and Training Institute

121 **1959** Antarctic Treaty

122 **1959** Convention between the Governments of the People's Republic of Bulgaria, the Romanian People's Republic and the Union of Soviet Socialist Republics concerning Fishing in the Black Sea

123 **1959** Convention Placing the International Poplar Commission Within the Framework of the Food and Agriculture Organization of the United Nations

124 **1959** North-East Atlantic Fisheries Convention

125 **1959** Protocol Amending the Agreement concerning Measures for the Protection of the Stocks of Deep-sea Prawns (*Pandalus Borealis*), European Lobsters (*Homarus Vulgaris*), Norway Lobsters (*Nephrops Norvegicus*) and Crabs (*Cancer Pagurus*)

126 **1960** Convention on the Protection of Lake Constance against Pollution

127 **1960** Indus Basin Development Fund Agreement

128 **1960** Indus Waters Treaty

129 **1960** International Convention for the Safety of Life at Sea, 1960

130 **1960** Paris Convention on Third Party Liability in the Field of Nuclear Energy

131	**1960**	Statutes of the Intergovernmental Oceanographic Commission
132	**1961**	International Convention for the Protection of New Varieties of Plants
133	**1961**	Protocol concerning the Constitution of an International Commission on the Protection of the Mosel against Pollution
134	**1961**	Protocol to Amend the Phytosanitary Convention for Africa South of the Sahara
135	**1962**	Agreement concerning co-operation in Marine Fishing
136	**1962**	Agreement concerning Protection of the Salmon Stock in the Baltic Sea
137	**1962**	Convention for the Establishment of the Desert Locust Control Organization for Eastern Africa
138	**1962**	Convention on Liability of Operators of Nuclear Ships
139	**1962**	Convention on the African Migratory Locust Organization
140	**1963**	Act regarding Navigation and Economic Cooperation between the States of the Niger Basin
141	**1963**	Agreement concerning an International Observer Scheme for Factory Ships Engaged in Pelagic Whaling in the Antarctic
142	**1963**	Agreement concerning the International Commission for the Protection of the Rhine against Pollution
143	**1963**	Agreement for the Establishment of a Commission for Controlling the Desert Locust in Southwest Asia
144	**1963**	Convention of 31st January 1963 Supplementary to the Paris Convention of 29th July 1960 on Third Parry Liability in the Field of Nuclear Energy
145	**1963**	Convention Relating to the General Development of the Senegal River Basin
146	**1963**	Convention to Amend the Revised Convention on the Navigation of the Rhine - 20 November 1963
147	**1963**	Nordic Mutual Emergency Assistance Agreement in Connection With Radiation Accidents
148	**1963**	Optional Protocol concerning the Compulsory Settlement of Disputes to the Convention on Civil Liability for Nuclear Damage
149	**1963**	Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals, 1963
150	**1963**	Protocol of Signature to the Agreement concerning the International Commission for the Protection of the Rhine against Pollution, 1963
151	**1963**	Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Harp and Hood Seals
152	**1963**	Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water
153	**1963**	Vienna Convention on Civil Liability for Nuclear Damage
154	**1964**	Additional Protocol to the Convention of January 31, 1963 Supplementary to Paris Convention of July 29, 1960 on Third Party Liability in the Field of Nuclear Energy
155	**1964**	Additional Protocol to the Paris Convention on Third Party Liability in the Field of Nuclear Energy, 1964
156	**1964**	Agreement as to Transitional Rights between Ireland on the one hand, and Belgium, France, the Federal Republic of Germany, the Netherlands, Spain and the United Kingdom of Great Britain and Northern Ireland on the other
157	**1964**	Agreement as to Transitional Rights between the Government of the United Kingdom of Great Britain and Northern Ireland on the one hand, and the Governments of Belgium, France, the Federal Republic of Germany, Ireland, and the Netherlands on the other
158	**1964**	Agreement concerning the Niger River Commission and the Navigation and Transport on the River Niger
159	**1964**	Convention for the International Council for the Exploration of the Sea
160	**1964**	Convention Relating to the Development of the Lake Chad Basin
161	**1964**	Convention Relating to the Status of the Senegal River
162	**1964**	European Fisheries Convention
163	**1964**	Indus Basin Development Fund (Supplemental) Agreement

164 **1964** Protocol of Provisional Application of the European Fisheries Convention

165 **1964** Statutes Relating to the Development of the Lake Chad Basin

166 **1965** Agreement for the Establishment of a Commission for Controlling the Desert Locust in the Central Region

167 **1965** Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Entry into Force of Proposals Adopted by the Commission

168 **1965** Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Measures of Control

169 **1966** Agreement between Denmark, Norway and Sweden on Reciprocal Access to Fishing in the Skagerrak and the Kattegat

170 **1966** Agreement Regulating Withdrawal of Water from Lake Constance

171 **1966** Agreement Relating to the International Legal Personality of the Permanent Commission of the South Pacific

172 **1966** International Convention for the Conservation of Atlantic Tunas

173 **1966** Protocol to the Agreement between Denmark, Norway and Sweden on Reciprocal Access to Fishing in the Skagerrak and the Kattegat

174 **1967** Additional Protocol I to the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean

175 **1967** Additional Protocol II to the Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean

176 **1967** Agreement between Denmark, Finland, Norway and Sweden concerning Co-operation to Ensure Compliance With the Regulations for Preventing the Pollution of the Sea by Oil

177 **1967** Agreement Establishing the Southeast Asian Fisheries Development Center

178 **1967** Convention on the Conduct of Fishing Operations in the North Atlantic

179 **1967** Convention on the International Hydrographic Organization

180 **1967** Phytosanitary Convention for Africa

181 **1967** Treaty for the Prohibition of Nuclear Weapons in Latin America and the Caribbean

182 **1968** African Convention on the Conservation of Nature and Natural Resources, 1968

183 **1968** Agreement for the Establishment for Arab Centre for the Studies of Dry and Barren Land

184 **1968** Agreement on Administrative Arrangements for the Prek Thnot (Cambodia) Power and Irrigation Development Project

185 **1968** Constitution of the Association of Natural Rubber Producing Countries

186 **1968** European Agreement on the Restriction of the Use of certain Detergents in Washing and Cleaning Products

187 **1968** European Convention for the Protection of Animals during International Transport, 1968

188 **1968** Protocol Amending the Agreement Establishing the Southeast Asian Fisheries Development Center

189 **1968** Treaty on the Non-Proliferation of Nuclear Weapons

190 **1969** Agreement Establishing a Food and Fertilizer Technology Centre for the Asian and Pacific Region

191 **1969** Agreement for Co-operation in Dealing with Pollution of the North Sea by Oil

192 **1969** Convention for the Conservation of the Vicuna

193 **1969** Convention on the Conservation of the Living Resources of the Southeast Atlantic

194 **1969** International Convention on Civil Liability for Oil Pollution Damage

195 **1969** International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties

196 **1969** Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Panel Membership and to Regulatory Measures

197 **1969** Treaty on the River Plate Basin

198 **1970** Agreement Establishing the Arab Organization for Agricultural Development

199 **1970** Agreement for the Establishment of a Commission for Controlling the Desert Locust in Northwest Africa

200 **1970** Agreement on the Regulation of North Pacific Whaling, 1970

201 **1970** Benelux Convention on the Hunting and Protection of Birds

202 **1970** Protocol to the Convention for the International Council for the Exploration of the Sea

203 **1970** Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to the Facilitation of Entry into Force of Amendments to the Convention

204 **1971** Agreement concerning Cooperation in Taking Measures against Pollution of the Sea by Oil

205 **1971** Agreement Establishing the International Pepper Community

206 **1971** Agreement on the Regulation of North Pacific Whaling, 1971

207 **1971** Convention concerning Protection against Hazards of Poisoning Arising from Benzene

208 **1971** Convention on Wetlands of International Importance, especially as Waterfowl Habitat

209 **1971** Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material

210 **1971** International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage

211 **1971** Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-bed and the Ocean Floor and in the Subsoil Thereof

212 **1972** Additional Protocol No.1 to the Revised Convention on Navigation on the Rhine - 25 October 1972

213 **1972** Agreement between the Government of Canada, the Government of the Republic of Iceland and the Government of the Kingdom of Norway concerning an International Observer Scheme for Land-based Whaling Stations in the North Atlantic Area

214 **1972** Agreement between the Governments of Iceland, Norway and the Soviet Union on the Regulation of the Fishing of Atlanto-Scandian Herring

215 **1972** Convention concerning the Protection of the World Cultural and Natural Heritage

216 **1972** Convention concerning the Status of the Senegal River

217 **1972** Convention Establishing the Senegal River Development Organization

218 **1972** Convention for the Conservation of Antarctic Seals

219 **1972** Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft

220 **1972** Convention on the International Regulations for Preventing Collisions at Sea

221 **1972** Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

222 **1972** Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction

223 **1972** International Convention for Safe Containers

224 **1972** Protocol Amending the Agreement concerning Protection of the Salmon Stock in the Baltic Sea

225 **1973** Agreement between the Governments of the Union of Soviet Socialist Republics, Iceland and Norway concerning the Regulation of Fishing of the Atlantic-Scandinavian Herring

226 **1973** Agreement Creating a Development Fund of the Chad Basin Commission

227 **1973** Agreement for the Establishment of a Regional Animal Production and Health Commission for Asia and the Pacific

228 **1973** Agreement of the Member States of the European Communities on Information for the Commission and for the Member States With a View to Possible Harmonization Throughout the Communities of Urgent Measures concerning the Protection of the Environment

229 **1973** Agreement on the Conservation of Polar Bears

230 **1973** Application of Safeguards on Implementation of Article III(1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons

231 **1973** Arrangement Relating to fisheries in waters surrounding the Faeroe Islands

232 **1973** Convention concerning Navigation on Lake Constance

233 **1973** Convention Establishing a Permanent Inter-state Drought Control Committee for the Sahel

234 **1973** Convention on Fishing and Conservation of the Living Resources in the Baltic Sea and the Belts

235 **1973** Convention on International Trade in Endangered Species of Wild Fauna and Flora

236 **1973** International Convention for the Prevention of Pollution from Ships

237 **1973** Protocol I, Provisions concerning Reports on Incidents Involving Harmful Substances to the International Convention for the Prevention of Pollution from Ships

238 **1973** Protocol II, Arbitration to the International Convention for the Prevention of Pollution from Ships

239 **1973** Protocol Relating to Intervention on the High Seas in Cases of Marine Pollution by Substances other than Oil

240 **1974** Agreement on an International Energy Program

241 **1974** Agreement on the Regulation of the Fishing of North-East Arctic (Arcto-Norwegian) Cod

242 **1974** Agreement Supplementing the Agreement on Information for the Commission and for the Member States With a View to Possible Harmonization Throughout the Communities of Urgent Measures concerning the Protection of the Environment

243 **1974** Convention for the Prevention of Marine Pollution from Land-based Sources

244 **1974** Convention on the Protection of the Environment between Denmark, Finland, Norway and Sweden

245 **1974** Convention on the Protection of the Marine Environment of the Baltic Sea Area

246 **1974** International Convention for the Safety of Life at Sea, 1974

247 **1974** Protocol Amending the Convention on the Canalization of the Mosel, 1974

248 **1975** Agreement concerning a Joint Project for Planning, Design, Experiment Preparation, Performance and Reporting of Reactor Safety Experiments concerning Containment Response

249 **1975** Implementing Agreement to the Agreement on an International Energy Program of November 18, 1974 on the Technical Exchange of Information in the Field of Reactor Safety Research and Development

250 **1975** Protocol Amending Article 14(3) of the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)

251 **1975** Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Payments

252 **1976** Agreement between the Government of the United States of America, the Government of the Republic of France and the Government of the United Kingdom of Great Britain and Northern Ireland regarding Monitoring of the Stratosphere

253 **1976** Agreement concerning the Protection of the Waters of the Mediterranean Shores

254 **1976** Convention for the Protection of the Mediterranean Sea against Pollution

255 **1976** Convention on Conservation of Nature in the South Pacific

256 **1976** Convention on Limitation of Liability for Maritime Claims

257 **1976** Convention on the Game Hunting Formalities Applicable to Tourists Entering Countries in the Conseil de l'Entente

258 **1976** Convention on the Protection of the Rhine against Chemical Pollution

259 **1976** Convention on the Protection of the Rhine against Pollution by Chlorides

260 **1976** European Convention for the Protection of Animals kept for Farming Purposes

261 **1976** Exchange of Notes between Denmark, Finland, Norway, and Sweden on the borders between the vicinity of nuclear installations safety issues associated with connecting to the guidelines Related to the Convention on the Protection of the Environment

262 **1976** North American Plant Protection Agreement

263 **1976** Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals, 1976

264 **1976** Protocol concerning Cooperation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency

265 **1976** Protocol for the Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft

266	**1976**	Protocol of 1976 to Amend the International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969
267	**1976**	Protocol to the International Convention for the Northwest Atlantic Fisheries Relating to Continued Functioning of the Commission
268	**1976**	Protocol to the International Convention on the Establishment of an International Fund of Compensation for Oil Pollution Damage
269	**1976**	Supplementary Agreement to the 1963 Agreement on the International Commission for the Protection of the Rhine against Pollution
270	**1977**	Agreement between France, the United States of America, Denmark, Finland, Norway, Sweden and the Netherlands on Reactor Safety Experiments
271	**1977**	Agreement for the Establishment of an Organization to Manage and Develop the Kagera River Basin
272	**1977**	Agreement on the Joint Regulations on Fauna and Flora
273	**1977**	Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure
274	**1977**	Convention on Civil Liability for Oil Pollution Damage Resulting from Exploration for and Exploitation of Seabed Mineral Resources
275	**1977**	Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques
276	**1977**	Protocol Amending the Benelux Convention on the Hunting and Protection of Birds
277	**1977**	Working Environment (Air Pollution, Noise and Vibration) Convention
278	**1978**	Agreement for the Establishment of a Centre on Integrated Rural Development for Asia and the Pacific
279	**1978**	Annex I to the International Convention for the Prevention of Pollution from Ships on Regulations for the Prevention of Pollution by Oil
280	**1978**	Annex II to the International Convention for the Prevention of Pollution from Ships on Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk
281	**1978**	Annex III to the International Convention for the Prevention of Pollution from Ships on Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form or in Freight Containers, Portable Tanks or Road and Rail Tank Wagons
282	**1978**	Annex IV to the International Convention for the Prevention of Pollution from Ships on Prevention of Pollution by Sewage from Ships
283	**1978**	Annex V to the International Convention for the Prevention of Pollution from Ships on Prevention of Pollution by Garbage from Ships
284	**1978**	Convention concluded between Mali, Mauritania and Senegal on the Legal Status of Joint Works
285	**1978**	Convention on Future Multilateral Cooperation in the Northwest Atlantic Fisheries
286	**1978**	Convention Relating to the Creation of the Gambia River Basin Development Organization
287	**1978**	Convention Relating to the Status of the River Gambia
288	**1978**	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
289	**1978**	Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution
290	**1978**	Protocol Amending the International Convention for the High Seas Fisheries of the North Pacific Ocean, 1978
291	**1978**	Protocol concerning Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency to the Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution
292	**1978**	Protocol of 1978 Relating to the International Convention for Safety of Life at Sea, 1974
293	**1978**	Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships
294	**1978**	Treaty for Amazonian Cooperation
295	**1978**	United Nations Convention of the Carriage of Goods by Sea
296	**1979**	Additional Protocol No.2 to the Revised Convention on Navigation on the Rhine - 17 October 1979

297 **1979** Additional Protocol No.3 to the Revised Convention on Navigation on the Rhine - 17 October 1979
298 **1979** Additional Protocol to the European Convention for the Protection of Animals during International Transport
299 **1979** Agreement for the Establishment of a Centre on Integrated Rural Development for Africa
300 **1979** Agreement Incorporating Colombia into the System of the Permanent Commission of the South Pacific
301 **1979** Convention for the Conservation and Management of the Vicuna
302 **1979** Convention on Long-range Transboundary Air Pollution
303 **1979** Convention on the Conservation of European Wildlife and Natural Habitats
304 **1979** Convention on the Conservation of Migratory Species of Wild Animals
305 **1979** European Convention for the Protection of Animals for Slaughter
306 **1979** International Plant Protection Convention, 1979
307 **1979** Protocol Amending the International Convention Relating to the Limitation of the Liability of Owners of Sea-going Ships
308 **1979** South Pacific Forum Fisheries Agency Convention
309 **1980** Agreement Establishing the Caribbean Environmental Health Institute
310 **1980** Convention concerning International Carriage of Goods by Rail
311 **1980** Convention creating the Niger Basin Authority
312 **1980** Convention on Future Multilateral Cooperation in the North-East Atlantic Fisheries
313 **1980** Convention on the Conservation of Antarctic Marine Living Resources
314 **1980** Convention on the Physical Protection of Nuclear Material
315 **1980** European Outline Convention on Transfrontier Co-operation between Territorial Communities or Authorities
316 **1980** Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals, 1980
317 **1980** Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources
318 **1980** Protocol Relating to the Development Fund of the Niger Basin
319 **1981** Agreement for the Establishment of a Regional Centre on Agrarian Reform and Rural Development of Latin America and the Caribbean
320 **1981** Agreement on Regional Cooperation in Combating Pollution of the South-East Pacific by Hydrocarbons or Other Harmful Substances in Case of Emergency
321 **1981** Articles of Association of the South Asia Co-operative Environment Programme
322 **1981** Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region
323 **1981** Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific
324 **1981** Protocol concerning Co-operation in Combating Pollution in Cases of Emergency
325 **1982** Benelux Convention on Nature Conservation and Landscape Protection
326 **1982** Constitutional Agreement of the Latin American Organization for Fisheries Development
327 **1982** Convention for the Conservation of Salmon in the North Atlantic Ocean
328 **1982** Nauru Agreement concerning the Cooperation in the Management of Fisheries of Common Interest
329 **1982** Protocol Agreement on the Conservation of Common Natural Resources
330 **1982** Protocol Amending the Convention on Fishing and Conservation of Living Resources in the Baltic Sea and the Belts to Provide for EEC Membership
331 **1982** Protocol concerning Mediterranean Specially Protected Areas
332 **1982** Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency to the Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment
333 **1982** Protocol to Amend the Convention of 31 January 1963, Supplementary to the

Convention of 29 July 1960, on Third Party Liability in the Field of Nuclear Energy, as Amended by an Additional Protocol of 28 January 1964

334 **1982** Protocol to Amend the Convention on Wetlands of International Importance especially as Waterfowl Habitat

335 **1982** Protocol to Amend the Paris Convention on Third Party Liability in the Field of Nuclear Energy, as Amended by the Additional Protocol of 28 January 1964

336 **1982** Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment

337 **1982** United Nations Convention on the Law of the Sea

338 **1983** Agreement between South Africa, Swaziland and Mozambique Relative to the Establishment of a Tripartite Permanent Technical Committee regarding Rivers of Common Interest

339 **1983** Agreement between the Central African States concerning the Creation of a Special Fund for the Conservation of Wild Fauna

340 **1983** Agreement for Co-operation in Dealing with Pollution of the North Sea by Oil and other Harmful Substances

341 **1983** Agreement for Cooperation and Consultation between the Central African States for the Conservation of Wild Fauna

342 **1983** Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region

343 **1983** Eastern Pacific Ocean Tuna Fishing Agreement

344 **1983** International Tropical Timber Agreement, 1983

345 **1983** Protocol Amending the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, 1983

346 **1983** Protocol Amending the Convention on the Canalization of the Mosel, 1983

347 **1983** Protocol Amending the European Agreement on the Restriction of the Use of Certain Detergents in Washing and Cleaning Products

348 **1983** Protocol concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region

349 **1983** Protocol for the Protection of the South-East Pacific against Pollution from Land-based Sources

350 **1983** Protocol on cooperation in natural resources between member states of the Economic Community of Central African States

351 **1983** Protocol on Energy Cooperation between Member States of the Economic Community of Central African States

352 **1983** Protocol to the Eastern Pacific Ocean Tuna Fishing Agreement

353 **1983** Statutes of the International Centre for Genetic Engineering and Biotechnology

354 **1983** Supplementary Protocol to the Agreement on Regional Cooperation in Combating Pollution of the South-East Pacific by Hydrocarbons or Other Harmful Substances in Case of Emergency

355 **1983** Treaty Establishing the Economic Community of Central African States

356 **1984** Agreement between the Governments of the Republic of Portugal, the People’s Republic of Mozambique and the Republic of South Africa Relative to the Cahora Bassa Project

357 **1984** Agreement on the Protection of Confidentiality of Data Related to Deep Seabed Areas for Which Application of Authorisation Has Been Made

358 **1984** Convention concerning the Regional Development of Fisheries in the Gulf of Guinea

359 **1984** Protocol Amending the Interim Convention on Conservation of North Pacific Fur Seals, 1984

360 **1984** Protocol Amending the International Convention for the Conservation of Atlantic Tunas

361 **1984** Protocol of 1984 to Amend the International Convention on Civil Liability for Oil Pollution Damage of 29 November 1969

362 **1984** Protocol of 1984 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage

363 **1984** Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Long-term Financing of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe

364 **1984** Provisional Understanding regarding Deep Seabed Matters

365 **1984** Third ACP-EEC Convention

366 **1985** Agreement Establishing an International Foot and Mouth Disease Vaccine Bank

367 **1985** Agreement for the Establishment of the Intergovernmental Organization for Marketing Information and Technical Advisory Services for Fishery Products in the Asia and Pacific Region

368 **1985** Agreement on the Control of Pollution of Water Resources in the South African Region

369 **1985** ASEAN Agreement on the Conservation of Nature and Natural Resources

370 **1985** Convention for the Establishment of a Sub-Regional Commission on Fisheries

371 **1985** Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region

372 **1985** Protocol concerning Cooperation in Combating Marine Pollution in Cases of Emergency to the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region

373 **1985** Protocol concerning Protected Areas and Wild Fauna and Flora to the Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region

374 **1985** Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent to the Convention on Long-Range Transboundary Air Pollution

375 **1985** Protocol to Amend the Agreement for the Establishment of a Regional Centre on Agrarian Reform and Rural Development of Latin America and the Caribbean

376 **1985** South Pacific Nuclear Free Zone Treaty

377 **1985** Vienna Convention for the Protection of the Ozone Layer

378 **1986** Agreement on the Preservation of Confidentiality of Data concerning Deep Seabed Areas

379 **1986** Agreement Relative to the Establishment of the Limpopo Basin Permanent Technical Committee

380 **1986** Convention concerning Safety in the Use of Asbestos

381 **1986** Convention for the Protection of the Natural Resources and Environment of the South Pacific Region

382 **1986** Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

383 **1986** Convention on Early Notification of a Nuclear Accident

384 **1986** Convention on Measures to Combat Pollution of the Tisza River and its Tributaries

385 **1986** European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes

386 **1986** Protocol Amending the Paris Convention on the Prevention of Marine Pollution from Land-based Sources

387 **1986** Protocol concerning Cooperation in Combating Pollution Emergencies in the South Pacific Region

388 **1986** Protocol for the Prevention of Pollution of the South Pacific Region by Dumping

389 **1986** Protocol I to the South Pacific Nuclear Free Zone Treaty

390 **1986** Protocol II to the South Pacific Nuclear Free Zone Treaty

391 **1986** Protocol III to the South Pacific Nuclear Free Zone Treaty

392 **1986** Single European Act

393 **1987** Agreement among Pacific Island States concerning the Implementation and Administration of the Treaty on Fisheries between the Governments of Certain Pacific Island States and the Government of the United States of America

394 **1987** Agreement between the Government of the French Republic, the Government of the Federal Republic of Germany, and the Government of the Grand Duchy of Luxembourg on Flood Warning for the Catchment Basin of the Moselle

395 **1987** Agreement Establishing the Economic Community of Cattle, Meat and Fishing in UDEAC Resources

396 **1987** Agreement for the Constitution of the Organismo Internacional Regional De Sanidad Agropecuaria

397 **1987** Agreement on the Action Plan for the Environmentally Sound Management of the

		Common Zambezi River System
398	**1987**	Agreement on the Resolution of Practical Problems With Respect to Deep Seabed Mining Areas
399	**1987**	European Convention for the Protection of Pet Animals
400	**1987**	Montreal Protocol on Substances that Deplete the Ozone Layer
401	**1987**	Protocol Amending the Convention on the Canalization of the Mosel, 1987
402	**1987**	Revised Convention creating the Niger Basin Authority
403	**1987**	Revised Financial Rules of the Niger Basin Authority
404	**1987**	Treaty on Fisheries between the Governments of Certain Pacific Island States and the Government of the United States of America
405	**1988**	Agreement on the Network of Aquaculture Centres in Asia and the Pacific
406	**1988**	Convention on the Regulation of Antarctic Mineral Resource Activities
407	**1988**	Joint Protocol Relating to the Application of the Vienna Convention on Civil Liability for Nuclear Damage and the Paris Convention on Third Party Liability in the Field of Nuclear Energy
408	**1988**	Protocol concerning the Control of Emissions of Nitrogen Oxides or their Transboundary Fluxes to the Convention on Long-Range Transboundary Air Pollution
409	**1988**	Protocol of 1988 Relating to the International Convention for the Safety of life at Sea, 1974
410	**1988**	Protocol of 1988 Relating to the International Convention on Load Lines, 1966
411	**1988**	Protocol to the International Convention for the Safety of Life At Sea - HSSC
412	**1989**	Additional Protocol No.4 to the Revised Convention on Navigation on the Rhine - 25 April 1989
413	**1989**	Agreement between Denmark (on behalf of Greenland), Iceland and Norway concerning the Stock of Capelin in the Waters between Greenland, Iceland and Jan Mayen, 1989
414	**1989**	Agreement between Denmark, Finland, Norway and Sweden on National Territorial Cooperation over Borders with the Aim of Preventing or Limiting Damage to Man or the Environment or Property in the Event of Accidents
415	**1989**	Agreement between the Governments of Argentina, the Federal Republic of Brazil, the Republic of Chile, the Republic of Paraguay and the Eastern Republic of Uruguay on the Establishment of the Regional Committee of Plant
416	**1989**	Agreement Creating the Eastern Pacific Tuna Fishing Organization
417	**1989**	Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
418	**1989**	Constituent Agreement of the Central American Commission on Environment and Development
419	**1989**	Convention concerning Indigenous and Tribal Peoples in Independent Countries
420	**1989**	Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific
421	**1989**	Convention on Civil Liability for Damage Caused during Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels (CRTD)
422	**1989**	Fourth ACP-EEC Convention
423	**1989**	International Convention on Salvage
424	**1989**	Port of Spain Accord on the Management and Conservation of the Caribbean Environment
425	**1989**	Protocol Amending the Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, 1989
426	**1989**	Protocol concerning Marine Pollution Resulting from Exploration and Exploitation of the Continental Shelf
427	**1989**	Protocol for the Conservation and Management of Protected Marine and Coastal Areas of the South-East Pacific
428	**1989**	Protocol for the Protection of the South-East Pacific against Radioactive Contamination
429	**1990**	African Regional Cooperative Agreement for Research, Training and Development Related to Nuclear Science and Technology

430	**1990**	Agreement on the Conservation of Seals in the Wadden Sea
431	**1990**	Agreement on the Organization for Indian Ocean Marine Affairs Cooperation
432	**1990**	Agreement regarding the Establishment of the Nordic Environment Finance Corporation
433	**1990**	Arrangement Implementing the Nauru Agreement Setting Forth Minimum Terms and Conditions of Access to the Fisheries Zones of the Parties
434	**1990**	Constitution of the International Plant Genetic Resources Institute
435	**1990**	Convention between the Federal Republic of Germany and the Czech and Slovak Federal Republic and the European Economic Community on the International Commission for the Protection of the Elbe
436	**1990**	Convention concerning Safety in the use of Chemicals at Work
437	**1990**	Convention for a North Pacific Marine Science Organisation
438	**1990**	Convention Zoosanitaire between the Member States of the Economic Community of the Countries of the Large Lakes
439	**1990**	Cooperation Agreement for the Protection of the Coasts and Waters of the North-East Atlantic against Pollution
440	**1990**	International Convention on Oil Pollution Preparedness, Response and Co-operation
441	**1990**	Protocol concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region
442	**1990**	Protocol I to the Convention for the Prohibition of Fishing With Long Driftnets in the South Pacific
443	**1990**	Protocol II to the Convention for the Prohibition of Fishing With Long Driftnets in the South Pacific
444	**1990**	Protocol of Termination to the Convention on the Conservation of the Living Resources of the Southeast Atlantic
445	**1990**	Protocol to the Kuwait Regional Convention for the Protection of the Marine Environment against Pollution from Land-based Sources
446	**1990**	Second Arrangement Implementing the Nauru Agreement Setting Forth Additional Minimum Terms and Conditions of Access to the Fisheries Zones of the Parties
447	**1990**	Statutes of the Nordic Environment Finance Corporation
448	**1991**	Agreement Establishing Common Fisheries Surveillance Zones of Participating Member States of the Organisation of Eastern Caribbean States
449	**1991**	Agreement for the Establishment of Southern African Centre for Ivory Marketing
450	**1991**	Agreement for the Establishment of the Intergovernmental Organization for Marketing Information and Cooperation Services for Fishery Products in Africa
451	**1991**	Agreement on the Conservation of Bats in Europe
452	**1991**	Agreement on the Establishment of the International Plant Genetic Resources Institute
453	**1991**	Annex I to the Protocol on Environmental Protection to the Antarctic Treaty - Environmental Impact Assessment
454	**1991**	Annex II to the Protocol on Environmental Protection to the Antarctic Treaty - Conservation of Antarctic Fauna and Flora
455	**1991**	Annex III to the Protocol on Environmental Protection to the Antarctic Treaty - Waste Disposal and Waste Management
456	**1991**	Annex IV to the Protocol on Environmental Protection to the Antarctic Treaty - Prevention of Marine Pollution
457	**1991**	Annex V to the Protocol on Environmental Protection to the Antarctic Treaty - Area Protection and Management
458	**1991**	Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa
459	**1991**	Caribbean Community Agreement on Cooperation in the Development and Management of the Living Resources of the Exclusive Economic Zone
460	**1991**	Constitutional Agreement for the Central American Commission for Environment and Development
461	**1991**	Convention on Environmental Impact Assessment in a Transboundary Context
462	**1991**	Convention on Fisheries Cooperation among African States Bordering the Atlantic Ocean

463	**1991**	Convention on the Protection of the Alps
464	**1991**	Convention on the Western Indian Ocean Tuna Organization
465	**1991**	Cooperative Agreement among the United States, Canada and Mexico Supplementary to the North American Plant Protection Agreement, 1991
466	**1991**	Protocol Additional to the Convention for the Protection of the Rhine from Pollution by Chlorides
467	**1991**	Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes to the Convention on Long-Range Transboundary Air Pollution
468	**1991**	Protocol on Environmental Protection to the Antarctic Treaty
469	**1991**	Protocol to the Constituent Agreement of the Central American Commission on Environment and Development
470	**1991**	Protocol to the Convention between the Federal Republic of Germany and the Czech and Slovak Federal Republic and the European Economic Community on the International Commission for the Protection of the Elbe
471	**1991**	Treaty Establishing a Common Market between the Argentine Republic the Federal Republic of Brazil the Republic of Paraguay and the Eastern Republic of Uruguay
472	**1991**	Treaty Establishing the African Economic Community
473	**1992**	Agreement between Denmark (on behalf of Greenland), Iceland and Norway concerning the Stock of Capelin in the Waters between Greenland, Iceland and Jan Mayen, 1992
474	**1992**	Agreement between the Republic of Kazakhstan, the Republic of Kirgyzstan, the Republic of Uzbekistan, the Republic of Tajikistan and Turkmenistan on Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources
475	**1992**	Agreement Establishing the Inter-American Institute for Global Change Research
476	**1992**	Agreement on Cooperation in Research, Conservation and Management of Marine Mammals in the North Atlantic
477	**1992**	Agreement on Cooperation in the Sphere of Ecology and Environmental Protection
478	**1992**	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
479	**1992**	Agreement on the European Economic Area
480	**1992**	Central American Regional Agreement on the Transboundary Movement of Hazardous Wastes
481	**1992**	Complementary Protocol 1 to the Constitution of an International Commission on the Protection of the Mosel against Pollution and With the Protocol concerning the Constitution of an International Commission on the Protection of the Saar against Pollution
482	**1992**	Complementary Protocol 2 to the Constitution of an International Commission on the Protection of the Mosel against Pollution and With the Protocol concerning the Constitution of an International Commission on the Protection of the Saar against Pollution
483	**1992**	Convention for the Conservation of Anadromous Stocks in the North Pacific Ocean
484	**1992**	Convention for the Conservation of the Biodiversity and Protection of Wilderness Areas in Central America
485	**1992**	Convention for the Protection of the Marine Environment of the North-East Atlantic
486	**1992**	Convention on Biological Diversity
487	**1992**	Convention on the Protection and Use of Transboundary Watercourses and International Lakes
488	**1992**	Convention on the Protection of the Black Sea against Pollution
489	**1992**	Convention on the Transboundary Effects of Industrial Accidents
490	**1992**	Cooperation Agreement on the Forecast, Prevention and Mitigation of Natural and Technological Disasters
491	**1992**	Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area
492	**1992**	La Jolla Agreement on the Reduction of Dolphin Mortality in the Eastern Pacific Ocean
493	**1992**	Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region
494	**1992**	North American Free Trade Agreement

495	**1992**	Palau Arrangement for the Management of the Western Pacific Purse Seine Fishery
496	**1992**	Protocol of 1992 to Amend the International Convention on Civil Liability for Oil Pollution Damage, 1969
497	**1992**	Protocol of 1992 to Amend the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage of 18 December 1971
498	**1992**	Protocol of Amendment to the European Convention for the Protection of Animals kept for Farming Purposes
499	**1992**	Protocol of Madrid to Amend Paragraph 2 of Article X of the International Convention for the Conservation of Atlantic Tunas
500	**1992**	Protocol on the Programme for the Regional Study on the El Niño Phenomenon (ERFEN) in the South-East Pacific
501	**1992**	Protocol on the Protection of the Black Sea Marine Environment against Pollution by Dumping
502	**1992**	Protocol on the Protection of the Black Sea Marine Environment against Pollution from Land-based Sources
503	**1992**	Protocols on Cooperation in Combating Pollution of the Black Sea Marine Environment by Oil and other Harmful Substances in Emergency Situations
504	**1992**	Treaty of the Southern African Development Community
505	**1992**	Treaty on European Union
506	**1992**	United Nations Framework Convention on Climate Change
507	**1993**	Agreement between Denmark, Finland, Iceland, Norway and Sweden on Cooperation in Combatting Pollution of the Sea Caused by Oil or Other Harmful Substances
508	**1993**	Agreement Establishing the South Pacific Regional Environment Programme
509	**1993**	Agreement for the Establishment of the Indian Ocean Tuna Commission
510	**1993**	Agreement on Joint Actions in the Prevention of and Response to Emergencies of Natural and Technological Disasters
511	**1993**	Agreement on Joint Activities in Addressing the Aral Sea and the Zone Around the Sea Crisis, Improving the Environment, and Ensuring the Social and Economic Development of the Aral Sea Region
512	**1993**	Agreement on the Establishment of the Near East Plant Protection Organization
513	**1993**	Agreement to Constitute the International Center for Living Aquatic Resources Management as an International Organization
514	**1993**	Agreement to Promote Compliance With International Conservation and Management Measures by Fishing Vessels on the High Seas
515	**1993**	Charter of the Commonwealth of Independent States
516	**1993**	Constitution for the Center for International Forestry Research
517	**1993**	Constitution of the Centre for Marketing Information and Advisory Services for Fishery Products in the Arab Region (Amended 1995)
518	**1993**	Constitution of the International Center for Living Aquatic Resources Management
519	**1993**	Convention for the Conservation of Southern Bluefin Tuna
520	**1993**	Convention on Civil Liability for Damage Resulting from Activities Dangerous to the Environment
521	**1993**	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction
522	**1993**	Convention regarding the Determination of Conditions of Access to and Exploitation of Fisheries Resources off the Coasts of the Sub-Regional Fisheries Commission Member States
523	**1993**	Convention Under the Sub-Regional Commission on Fisheries on Cooperation in the Exercise of the Rights of Maritime Pursuit
524	**1993**	Establishment Agreement for the Center for International Forestry Research
525	**1993**	North American Agreement on Environmental Cooperation between the Government of Canada, the Government of the United Mexican States and the Government of the United States of America
526	**1993**	Prevention of Major Industrial Accidents Convention

527	**1993**	Protocol Adjusting the Agreement on the European Economic Area
528	**1993**	Protocol Amending Article 1(a), Article 14(1) and Article 14(3)(b) of the European Agreement of 30 September 1957 concerning the International Carriage of Dangerous Goods by Road
529	**1993**	Protocol on Methods of Coordination of Surveillance Operations to the Convention Under the Sub-Regional Commission on Fisheries on Cooperation in the Exercise of the Rights of Maritime Pursuit
530	**1993**	Regional Convention for the Management and Conservation of the Natural Forest Ecosystems and the Development of Forest Plantations
531	**1993**	Regional Convention on Climate Change
532	**1994**	Agreement between the Governments of the Republic of Angola, the Republic of Botswana, and the Republic of Namibia on the Establishment of a Permanent Okavango River Basin Water Commission
533	**1994**	Agreement on Agriculture
534	**1994**	Agreement on the Application of Sanitary and Phytosanitary Measures
535	**1994**	Agreement on the Preparation of a Tripartite Environmental Management Programme for Lake Victoria
536	**1994**	Agreement on the Protection of the (River) Meuse
537	**1994**	Agreement on the Protection of the (River) Scheldt
538	**1994**	Agreement Relating to the Implementation of Part XI of the United Nations Convention on the Law of the Sea of 10 December 1982
539	**1994**	Constitution of the Centre for Marketing Information and Advisory Services for Fishery Products in Latin America and the Caribbean
540	**1994**	Convention Establishing the Association of Caribbean States
541	**1994**	Convention for the Establishment of the Lake Victoria Fisheries Organization
542	**1994**	Convention on Cooperation for Protection and Sustainable Use of the Danube River
543	**1994**	Convention on Nuclear Safety
544	**1994**	Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea
545	**1994**	Convention Reaffirming the Creation of the Permanent Inter-State Drought Control Committee for the Sahel
546	**1994**	Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects
547	**1994**	Energy Charter Treaty
548	**1994**	Federated States of Micronesia Arrangement for Regional Fisheries Access
549	**1994**	Instrument for the Establishment of the Restructured Global Environment Facility
550	**1994**	International Tropical Timber Agreement, 1994
551	**1994**	Lusaka Agreement on Co-operative Enforcement Operations Directed At Illegal Trade in Wild Fauna and Flora
552	**1994**	Marrakesh Agreement Establishing the World Trade Organisation
553	**1994**	Protocol for the Implementation of the Alpine Convention concerning Mountain Agriculture
554	**1994**	Protocol for the Implementation of the Alpine Convention concerning Nature Protection and Landscape Conservation
555	**1994**	Protocol for the Implementation of the Alpine Convention concerning Town and Country Planning and Sustainable Development
556	**1994**	Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil
557	**1994**	Protocol on Energy Efficiency and Related Environmental Aspects to the Energy Charter Treaty
558	**1994**	Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions
559	**1994**	United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa

560	**1995**	Additional Protocol to the European Outline Convention on Transfrontier Co-operation between Territorial Communities or Authorities
561	**1995**	Agreement between the Government of the Republic of Lithuania, Government of the Republic of Estonia, and the Government of the Republic of Latvia on Cooperation in the Field of Environment Protection
562	**1995**	Agreement Constituting the Trilateral Commission for the Development of the Riverbed Rio Pilcomayo
563	**1995**	Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks
564	**1995**	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
565	**1995**	Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin
566	**1995**	Convention concerning Safety and Health in Mines
567	**1995**	Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean
568	**1995**	Convention to Ban the Importation into the Forum Island Countries of Hazardous and Radioactive Wastes and to Control the Transboundary Movement and Management of Hazardous Wastes Within the South Pacific Region
569	**1995**	International Convention on Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel
570	**1995**	Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean
571	**1995**	Protocol for the Prevention and Elimination of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea
572	**1995**	Protocol on Shared Watercourse Systems to the Treaty of the Southern African Development Community
573	**1995**	Protocol to the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin
574	**1995**	Protocol to the Treaty on Southeast Asia Nuclear Weapon Free Zone
575	**1995**	Statutory Framework of the World Network of Biosphere Reserves
576	**1995**	Treaty on the Southeast Asia Nuclear Weapon Free Zone
577	**1996**	African Nuclear Weapon Free Zone Treaty
578	**1996**	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
579	**1996**	Agreement on the Control of Transboundary Shipments of Hazardous and Other Wastes between States Members of the Commonwealth of Independent States
580	**1996**	Agreement regarding Transfrontier Cooperation between Territorial Communities or Authorities
581	**1996**	Comprehensive Nuclear-Test-Ban Treaty
582	**1996**	Convention concerning the Collection, Storage and Discharge of Waste from Ships Navigating Along the Rhine and Other Inland Waters
583	**1996**	Convention on the International Commission for the Protection of the Oder
584	**1996**	European Agreement on Main Inland Waterways of International Importance
585	**1996**	International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea
586	**1996**	Protocol for the Implementation of the Alpine Convention concerning Mountain Forests
587	**1996**	Protocol I to the African Nuclear Weapon Free Zone Treaty
588	**1996**	Protocol II to the African Nuclear Weapon Free Zone Treaty
589	**1996**	Protocol III to the African Nuclear Weapon Free Zone Treaty
590	**1996**	Protocol of 1996 to Amend the Convention on Limitation of Liability for Maritime Claims
591	**1996**	Protocol on Energy to the Treaty of the Southern African Development Community
592	**1996**	Protocol on the Conservation, Rational Utilization and Management of Norwegian

Spring Spawning Herring (Atlanto-Scandian Herring) in the Northeast Atlantic

593 **1996** Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and Their Disposal

594 **1996** Protocol to the Comprehensive Nuclear-Test-Ban Treaty

595 **1996** Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

596 **1997** Additional Intergovernmental Agreement between Germany and Luxembourg concerning Flood Warning for the Catchment Basin of the Mosel

597 **1997** Agreement for the Functioning and Strengthening of CORECA for the Period 1997-2001

598 **1997** Agreement on eternal friendship between Uzbekistan, Kazakhstan and Kyrgyzstan

599 **1997** Agreement on International Humane Trapping Standards between the European Community, Canada and the Russian Federation

600 **1997** Convention on Supplementary Compensation for Nuclear Damage

601 **1997** Convention on the Law of the Non-Navigational Uses of International Watercourses

602 **1997** Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction

603 **1997** Inter-American Convention for the Protection and Conservation of Sea Turtles

604 **1997** International Agreement in the Form of an Agreed Minute between the European Community and the United States of America on Humane Trapping Standards - Standards for the Humane Trapping of Specified Terrestrial and Semi-Aquatic Mammals

605 **1997** Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

606 **1997** Kyoto Protocol to the United Nations Framework Convention on Climate Change

607 **1997** Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978

608 **1997** Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage

609 **1997** Treaty between El Salvador, Guatemala and Honduras for Execution of the Plan Trifinio

610 **1998** Agreement between Denmark, Finland, Iceland, Norway and Sweden on the Nordic Environment Finance Corporation

611 **1998** Agreement between Norway, Greenland/Denmark, and Iceland About the Capelin Stock in the Area between Greenland, Iceland, and Jan Mayen

612 **1998** Agreement between the Government of Republic of Kazakhstan, Government of Kyrgyz Republic and Government of Republic of Uzbekistan on Cooperation in the Sphere of Biological Diversity Conservation of West Tien Shan

613 **1998** Agreement between the Government of the Republic of Kazakhstan, the Government of the Kyrgyz Republic and the Government of the Republic of Uzbekistan on Cooperation in the Area of Environment and Rational Nature Use

614 **1998** Agreement between the Governments of the Republic of Kazakhstan, the Kyrgyz Republic, and the Republic of Uzbekistan on the Use of Water and Energy Resources of the Syr Darya Basin

615 **1998** Agreement of Cooperation for the Conservation of the Marine Turtles in the Caribbean Coast of Costa Rica, Nicaragua and Panama

616 **1998** Agreement on the International Dolphin Conservation Program

617 **1998** Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters

618 **1998** Convention on the Protection of the Environment through Criminal Law

619 **1998** Protocol for the Implementation of the Alpine Convention concerning Energy

620 **1998** Protocol for the Implementation of the Alpine Convention concerning the Protection of Soils

621 **1998** Protocol for the Implementation of the Alpine Convention concerning Tourism

622 **1998** Protocol III on Industrial Policy Amending the Treaty Establishing the Caribbean Community

623 **1998** Protocol No 2 to the European Outline Convention on Transfrontier Cooperation between Territorial Communities or Authorities concerning Interterritorial Cooperation

624	**1998**	Protocol of Amendment to the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes
625	**1998**	Protocol of Amendment to the Treaty for Amazonian Cooperation
626	**1998**	Protocol on Heavy Metals to the Convention on Long-Range Transboundary Air Pollution
627	**1998**	Protocol on Persistent Organic Pollutants to the Convention on Long-Range Transboundary Air Pollution
628	**1998**	Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and Other Wastes to the Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution
629	**1998**	Protocol V on Agricultural Policy Amending the Treaty Establishing the Caribbean Community
630	**1998**	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
631	**1999**	Additional Protocol No.5 to the Revised Convention on Navigation on the Rhine - 28 April 1999
632	**1999**	Additional Protocol No.6 to the Revised Convention on Navigation on the Rhine - 21 October 1999
633	**1999**	Agreement between Iceland, Norway and Russia concerning Certain Aspects of Cooperation in the Area of Fisheries
634	**1999**	Agreement concerning the Creation of a Marine Mammal Sanctuary in the Mediterranean
635	**1999**	Agreement for the Establishment of the Regional Commission for Fisheries
636	**1999**	Agreement of the Heads of State of CIS Member States regarding cooperation in the sphere of ecological monitoring
637	**1999**	Agreement on the Status of the International Aral Sea Fund and its Organizations
638	**1999**	Convention on the Protection of the Rhine
639	**1999**	International Convention on Arrest of Ships
640	**1999**	Protocol concerning Pollution from Land-based Sources and Activities to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region
641	**1999**	Protocol of Signature to the Agreement concerning the International Commission for the Protection of the Rhine against Pollution, 1999
642	**1999**	Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and Their Disposal
643	**1999**	Protocol on Water and Health to the Convention on the Protection and Use of Transboundary Watercourses and International Lakes
644	**1999**	Protocol on Wildlife Conservation and Law Enforcement to the Treaty of the Southern African Development Community
645	**1999**	Protocol to Abate Acidification, Eutrophication and Ground-Level Ozone to the Convention on Long-Range Transboundary Air Pollution
646	**1999**	Protocol to Amend the Convention for the Establishment of an Inter-American Tropical Tuna Commission
647	**1999**	Treaty Establishing the East African Community
648	**2000**	Agreement for the Establishment of a Commission for Controlling the Desert Locust in the Western Region
649	**2000**	Agreement for the Establishment of the International Organisation for the Development of Fisheries in Eastern and Central Europe
650	**2000**	Agreement No. 1 between Chad, Egypt, Libya and Sudan for Monitoring and Sharing Data for the Sustainable Development and Proper Management of the Nubian Sandstone Aquifer System
651	**2000**	Agreement No. 2 between Chad, Egypt, Libya and Sudan for Monitoring and Sharing Data for the Sustainable Development and Proper Management of the Nubian Sandstone Aquifer System
652	**2000**	Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway
653	**2000**	Cartagena Protocol on Biosafety to the Convention on Biological Diversity

654 **2000** Constitution of the African Network for the Development of Horticulture

655 **2000** Constitutive Act of the African Union

656 **2000** Convention on the Conservation and Management of the Highly Migratory Fish Stocks of the Western and Central Pacific Ocean

657 **2000** Cooperative Agreement Establishing the Tri-National de la Sangha Park

658 **2000** Cotonou Agreement

659 **2000** European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways

660 **2000** European Landscape Convention

661 **2000** Framework Agreement for the Conservation of the Living Marine Resources of the High Seas of the South Pacific

662 **2000** Protocol for the Implementation of the Alpine Convention concerning Dispute Settlement

663 **2000** Protocol for the Implementation of the Alpine Convention concerning Transportation

664 **2000** Protocol of 2000 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1971

665 **2000** Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances

666 **2000** Revised Protocol on Shared Watercourses to the Treaty of the Southern African Development Community

667 **2001** Agreement on an Environmental Framework of Mercosur

668 **2001** Agreement on the Conservation of Albatrosses and Petrels

669 **2001** Convention Establishing the Sustainable Tourism Zone of the Caribbean

670 **2001** Convention of the African Energy Commission

671 **2001** Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean

672 **2001** International Convention on Civil Liability for Bunker Oil Pollution Damage

673 **2001** International Convention on the Control of Harmful Anti-Fouling Systems on Ships

674 **2001** International Treaty on Plant Genetic Resources for Food and Agriculture

675 **2001** Protocol on Fisheries to the Treaty of the Southern African Development Community

676 **2001** Stockholm Convention on Persistent Organic Pollutants

677 **2002** Agreement Establishing the Caribbean Community Climate Change Centre

678 **2002** Agreement Establishing the Caribbean Regional Fisheries Mechanism

679 **2002** ASEAN Agreement on Transboundary Haze Pollution

680 **2002** Black Sea Biodiversity and Landscape Conservation Protocol to the Convention on the Protection of the Black Sea against Pollution

681 **2002** Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the Northeast Pacific

682 **2002** Framework Agreement on the Sava River Basin

683 **2002** International Agreement on the River Maas/Meuse

684 **2002** International Agreement on the River Scheldt/l'Escaut

685 **2002** Protocol concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea

686 **2002** Protocol on Forestry to the Southern African Development Community

687 **2002** Protocol on the Navigation Regime to the Framework Agreement on the Sava River Basin

688 **2002** Treaty between the Government of the Republic of Mozambique, the Government of the Republic of South Africa and the Government of the Republic of Zimbabwe on the Establishment of the Great Limpopo Transfrontier Park

689 **2002** Tripartite Interim Agreement between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-operation on the Protection and Sustainable Utilisation of the Water Resources of the Incomati and Maputo Watercourses

690 **2003** African Convention on the Conservation of Nature and Natural Resources, 2003

691 **2003** Agreement between the Republic of Botswana, the Republic of Mozambique, the Republic of South Africa, and the Republic of Zimbabwe on the Establishment of the Limpopo Watercourse Commission

692 **2003** Agreement on a Testing Ground for Application of the Kyoto Mechanisms on Energy Projects in the Baltic Sea Region

693 **2003** Agreement on the Institutionalisation of the Bay of Bengal Programme as an Inter-Governmental Organisation

694 **2003** Convention for the Strengthening of the Inter-American Tropical Tuna Commission Established by the 1949 Convention between the United States of America and the Republic of Costa Rica

695 **2003** Convention on the Sustainable Management of Lake Tanganyika

696 **2003** European Convention for the Protection of Animals during International Transport, 2003

697 **2003** Framework Agreement on a Multilateral Nuclear Environmental Programme in the Russian Federation

698 **2003** Framework Convention for the Protection of the Marine Environment of the Caspian Sea

699 **2003** Framework Convention on the Protection and Sustainable Development of the Carpathians

700 **2003** Protocol for Sustainable Development of Lake Victoria Basin to the Treaty for the Establishment of the East African Community

701 **2003** Protocol of 2003 to the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage, 1992

702 **2003** Protocol on Claims, Legal Proceedings and Indemnification to the Framework Agreement on a Multilateral Nuclear Environmental Programme in the Russian Federation

703 **2003** Protocol on Pollutant Release and Transfer Registers to the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters

704 **2003** Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context

705 **2003** Protocol to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes and to the 1992 Convention on the Transboundary Effects of Industrial Accidents

706 **2003** World Health Organization Framework Convention on Tobacco Control

707 **2004** Additional Protocol on Environmental Cooperation and Assistance in Emergencies to the Agreement on an Environmental Framework of Mercosur

708 **2004** Agreement for the Establishment of the Global Crop Diversity Trust

709 **2004** Agreement on the Establishment of the Zambezi Watercourse Commission

710 **2004** Constitution of the Global Crop Diversity Trust

711 **2004** Cooperative Agreement among the United States, Canada and Mexico Supplementary to the North American Plant Protection Agreement, 2004

712 **2004** International Convention for the Control and Management of Ships' Ballast Water and Sediments

713 **2004** Protocol on the Privileges and Immunities of the European Organization for Nuclear Research

714 **2004** Protocol to the Convention Establishing the Sustainable Tourism Zone of the Caribbean

715 **2005** Agreement on the Establishment of the ASEAN Centre for Biodiversity

716 **2005** Council of Europe Framework Convention on the Value of Cultural Heritage for Society

717 **2005** International Olive Oil and Table Olive Agreement

718 **2005** Protocol concerning the Conservation of Biological Diversity and the Establishment of Network of Protected Areas in the Red Sea and Gulf of Aden

719 **2005** Treaty on the Conservation and Sustainable Management of Forest Ecosystems in Central Africa and to Establish the Central African Forests Commission

720 **2006** Framework Convention for the Protection of the Environment for Sustainable Development in Central Asia

721	**2006**	Interim Agreement between the Government of the Republic of Angola and the Government of the Republic of Namibia and the Government of the Republic of South Africa on the Establishment of the Beneguela Current Commission
722	**2006**	International Tropical Timber Agreement, 2006
723	**2006**	Southern Indian Ocean Fisheries Agreement
724	**2007**	Agreement of Application of the Agreement on Flood Warning for the Catchment Basin of the Mosel
725	**2007**	Agreement on the Conservation of Gorillas and Their Habitats
726	**2007**	Convention for the Establishment of the Fishery Committee for the West Central Gulf of Guinea
727	**2007**	Nairobi International Convention on the Removal of Wrecks
728	**2007**	Protocol to the Statutes of the International Centre for Genetic Engineering and Biotechnology on the Seat of the Centre
729	**2008**	Agreement on Joint Management of the Transboundary Biosphere Reserve W
730	**2008**	Protocol on Conservation and Sustainable Use of Biological and Landscape Diversity to the Framework Convention on the Protection and Sustainable Development of the Carpathians
731	**2008**	Protocol on Integrated Coastal Zone Management in the Mediterranean
732	**2008**	Third Arrangement Implementing the Nauru Agreement Setting Forth Additional Minimum Terms and Conditions of Access to the Fisheries Zones of the Parties
733	**2009**	Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing
734	**2009**	Agreement on the Central Asian and Caucasus Regional Fisheries and Aquaculture Commission
735	**2009**	Convention on the Conservation and Management of High Seas Fishery Resources in the South Pacific Ocean
736	**2009**	Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships
737	**2009**	Protocol on the Protection of the Marine Environment of the Black Sea from Land-based Sources and Activities
738	**2009**	Statute of the International Renewable Energy Agency
739	**2010**	Amended Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Western Indian Ocean
740	**2010**	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of the Benefits Arising from their Utilization to the Convention on Biological Diversity
741	**2010**	Nagoya-Kuala Lumpur Supplementary Protocol on Liability and Redress to the Cartagena Protocol on Biosafety
742	**2010**	Protocol for the Protection of the Marine and Coastal Environment of the Western Indian Ocean from Land-based Sources and Activities
743	**2010**	Protocol to the International Convention on Liability and Compensation for Damage in Connection With the Carriage of Hazardous and Noxious Substances by Sea
744	**2011**	Agreement between the Governments of the Republic of Korea and the Member States of the Association of Southeast Asian Nations on Forest Cooperation
745	**2011**	Protocol concerning Regional Preparedness, Response and Co-operation in Combating Oil Pollution Incidents to the Framework Convention on the Protection of the Marine Environment of the Caspian Sea
746	**2011**	Protocol on Sustainable Forest Management to the Framework Convention on the Protection and Sustainable Development of the Carpathians
747	**2011**	Protocol on Sustainable Tourism to the Framework Convention on the Protection and Sustainable Development of the Carpathians