



Polycentric systems and interacting planetary boundaries – Emerging governance of climate change–ocean acidification–marine biodiversity

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ABSTRACT

Planetary boundaries and their interactions pose severe challenges for global environmental governance due to their inherent uncertainties and complex multi-scale dynamics. Here we explore the global governance challenge posed by planetary boundaries interactions by focusing on the role of polycentric systems and order, a theoretical field that has gained much interest in the aftermath of claims of a stagnant UN-process. In the first part we work toward a clarification of polycentric order in an international context, and develop three propositions. We then present a case study of the emergence of international polycentricity to address interacting planetary boundaries, namely the climate change, ocean acidification and loss of marine biodiversity complex. This is done through a study of the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA) initiative. As the case study indicates, a range of mechanisms of polycentric order (ranging from information sharing to coordinated action and conflict resolution) operates at the international level through the interplay between individuals, international organizations and their collaboration patterns. While polycentric coordination of this type certainly holds potential, it is also vulnerable to internal tensions, unreliable external flows of funding, and negative institutional interactions.

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1. Planetary Boundary Interactions and Global Environmental Governance

Is it at all possible to govern the complex, non-linear interactions of the Earth system? While this certainly might sound like an overambitious question, the issue hits the very core of a fundamental Earth System governance challenge (Biermann et al., 2009b): the ability of international institutions and actors to deal with complex, nonlinear and interacting bio-geophysical thresholds at the planetary scale. These have been denoted “planetary boundaries” (Rockström et al., 2009a,b) and represent estimates of potential limits within which the global human community can act, without seriously challenging the continuation of the current planetary state. The boundaries have been set at the lower end of zones of uncertainty about such critical thresholds, and are not fixed. On the contrary, the processes that underpin each of them are dynamic and estimated targets are likely to change over time. This is not only due to possible scientific

advances which can result in improved understanding of individual planetary boundaries, but also to critical interactions among the boundaries (Lenton et al., 2008; Rockström et al., 2009a,b; Steffen et al., 2004).

It should be noted that the notion of “planetary boundaries” remain controversial within the wider Earth system science community,¹ and the main concerns are summarized in the introduction article of this Special section. Nevertheless, the framework does capture a more general insight from the Earth system science community: that global environmental change unfolds between complex and multiple bio-geophysical systems with possible non-linear dynamics (for a summary, see Steffen et al., 2004).

While these planetary wide interactions have gained attention from the Earth system science community in recent years, we know little about their implications for global institutions and governance (Biermann et al., 2009b). Taking on an institutional analysis of planetary boundary interactions is however far from a simple task for at least two reasons. First, underlying drivers of changes in planetary boundaries and their interactions, such as land use change and increased extraction of freshwater resources, are affected by regime complexes, rather than by a set of simply defined international institutions (Young, 2008). Second, because the type of environmental stresses implied by interacting planetary boundaries incorporate many of the characteristics that make the emergence of effective

Abbreviations: BCC, Benguela Current Commission; COFI, Committee on Fisheries of the FAO; COP-15, 15th Conference of the Parties to the UNFCCC; FAO, Food and Agriculture Organization of the United Nations; ICRI, International Coral Reef Initiative; IPCC, Intergovernmental Panel on Climate Change; PaCFA, Global Partnership on Climate, Fisheries and Aquaculture; UNEP, United Nations Environment Programme; UNFCCC, United Nations Framework Convention on Climate Change; UNESCO, United Nations Educational, Scientific and Cultural Organization.

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¹ See for example the seven invited responses in Nature's Climate Feedback blog http://blogs.nature.com/climatefeedback/2009/09/planetary_boundaries.html.

institutions very difficult. The reason is that these interactions are not well understood scientifically; and they are difficult to match or “fit” institutionally due to their multilevel (local–global) interactions (Young, 2008). Hence we cannot take for granted that international institutions will emerge to deal with planetary boundaries and their interactions, despite their possible critical impacts on human well-being (Dimitrov et al., 2007).

1.1. Polycentric Systems and Order

However, fragmentation at the international level does not imply anarchy. Several forms of self-organizing and polycentric approaches (Ostrom, 2010; Ostrom et al., 1961) seem to emerge to tackle cross-sectoral problems despite considerable institutional and actor complexity. Examples here include transnational and regional initiatives in climate governance (Andonova et al., 2009; Ostrom, 2010), collaboration patterns in international humanitarian relief (Stephenson and Schnitzer, 2009), and emerging infectious disease preparedness and response (Lieberman, 2011) and multinational cooperation aimed at reducing illegal fishing (Österblom and Sumaila, 2011). These forms of multi-actor and multi-level responses can be viewed as providing polycentric order, in the sense that they include the self-organizing relationship between many centers of decision-making that are formally independent of each other (Ostrom, 2000, 2010; Ostrom et al., 1961:831).

Polycentric systems have gained increased interest from institutional scholars in the field of environmental governance for several reasons. One is that they highlight mechanisms for self-organization that are multi-level, and multi-sector in scope (McGinnis, 1999, 2000, 2005), even in settings where formal institutions seem to fail. These mechanisms have hence become more interesting in a more general and lively debate about what is perceived as a stagnant UN-process and failing multilateral negotiation processes (Dimitrov, 2010). In addition, polycentric order seems to facilitate experimental efforts and learning at multiple levels (Ostrom, 1999, 2010), a prerequisite for dealing with problems that cut across administrative domains (such as the “problem of fit”, Galaz et al., 2008), uncertainty and complex system behavior (Folke et al., 2005; Pahl-Wostl et al., 2007). From a theoretical perspective, polycentric systems could also be viewed as being more robust to external stresses and shocks as the system can recover more quickly due to its diversity (Low et al., 2003).

Despite an increased interest in polycentric systems and order as a potential strategy to deal with complex global environmental problems, we know very little about their features and outcomes (Aligica and Tarko, 2011). This makes it difficult to empirically assess whether polycentric systems and order at all are an effective and viable strategy to deal with global environmental stresses. Four main theoretical problems could be raised here.

The first is that it is currently unclear how theoretical development around polycentricism relate to similar research fields such as bridging organizations (Cash et al., 2003, 2006), multilevel governance (Hooghe and Marks, 2003), policy networks (van Waarden, 1992), governance of social–ecological systems (Berkes, 2010; Gunderson et al., 1995), network governance (Koppenjan and Klijn, 2004; Provan and Kenis, 2007), and transnational partnerships (Andonova et al., 2009; Kern and Bulkeley, 2009).

The second stems from the fact that few scholars have explicitly addressed the strengths, mechanisms and costs of polycentric systems at the international level (see however Ostrom, 2010; Österblom and Sumaila, 2011). This is surprising considering that the very fragmented nature of global environmental governance (Andonova and Mitchell, 2010), and the variety of international policy problems that require cross-national and cross-sectoral collaboration (Walker et al., 2009), makes a polycentric approach highly relevant.

Third, while the features of polycentric systems have been explored repeatedly, few analyze the possibility that polycentric

order is a matter of *degree*, rather than a simply defined binary variable (Biermann et al. (2009a) make a similar argument for fragmentation in global governance).

Finally, there is currently no literature elaborating the processes that explain transitions from lower to higher degrees of polycentric order, and in particular not in relation to the biosphere and global change. Aspects of this question have been covered by scholars studying transitions to adaptive modes of governance (e.g. Olsson et al., 2006; Pahl-Wostl et al., 2007; Rotmans et al., 2001) but never at the international level. Although Ostrom (2010) explicitly addresses the role of polycentric systems for global climate change, the analysis does not distinguish between different degrees of polycentric order, nor does it identify the features that drive governance from one end of the continuum to another.

1.2. Aim of the Article

In the following article, we intend to address these theoretical shortcomings by working toward a clarification of polycentricity in an international context. We formulate three propositions about their features and present a case study that illustrates international attempts to address interacting planetary boundaries, namely the climate change, ocean acidification and loss of marine biodiversity complex. The case is the Global Partnership on Climate, Fisheries and Aquaculture (PaCFA) initiative. As we intend to elaborate, the strengths and weaknesses related to polycentric order at the global level brings to light a number of insights related to the features of adaptiveness and resilience in the *Anthropocene* (Biermann et al., 2009b; Walker et al., 2009).

It should be noted that our emphasis is not on international collaboration and transnational network building in general, but rather on the creation of polycentric order in institutionally fragmented settings. By “polycentric order” we refer to the processes and structures that allow complex actor constellations not subject to any single authoritative coordinating mechanisms or authority, to self-organize and make mutual adjustments (Aligica and Tarko, 2011; McGinnis, 1999; Ostrom, 2000, 2010; Stephenson and Schnitzer, 2009).²

2. Features and Propositions about Polycentric Order

Which are the basic features of polycentricity? While the question might sound simple, there is little agreement in the literature (Aligica and Tarko, 2011; McGinnis, 1999, 2000; Ostrom, 1999, 2000, 2010). In what follows, we elaborate different forms of polycentricity, as well as their underlying features. These are formulated to not only contribute to an ongoing theoretical debate, but also as a tool to study processes of polycentric order empirically at the international level (Section 4). It should be noted that the emphasis here is on the features of networks, as they provide a simplified way to bring to light processes of polycentric order. Studies of polycentricity could nevertheless also involve other theoretical approaches such as institutional analysis, multilevel strategic games, equilibrium analysis (e.g. Aligica and Tarko 2011; McGinnis, 2000), or the role of institutional interplay and management (e.g. Chambers, 2008; Oberthür, 2009).

2.1. Generic Processes of Polycentric Order

Based on existing literature, we suggest that there exist four generic processes in polycentric systems at the international level, namely information sharing, coordination of activities, problem solving, and internal conflict resolution. It should be noted that the processes

² Our emphasis on polycentric *order*, rather than *systems* is important here. As the next sections will explore, we believe that the term order is analytically more useful to describe the suite of coordination and collaboration mechanisms that are at play at the international level.

described here can overlap in empirical settings where networks are difficult to bound (e.g. [Koppenjan and Klijn, 2004](#)).

Information sharing and mutual adjustment is probably the weakest form of polycentric order at the international level. It is “weak” in the sense that all it requires from actors are investments in creating a joint platform of communication, or routines for information sharing. This process is radically facilitated by recent decreases in costs for information collection and dissemination ([Galaz, 2009](#)). Information sharing is a key component in all types of transnational networks ([Andonova et al., 2009](#)) but also supports polycentric order by allowing actors such as international organizations, to adjust their behavior to each other in multilevel settings. [Ostrom, \(1999:528\)](#) notes that polycentricity allows actors to continuously share information on what has worked in one setting, and therefore support trial-and-error learning processes.

From a structural perspective, a network of relatively loose relations among actors characterizes this “weak” form of polycentricity. The density of relations among actors is high as the cost of information sharing is relatively low ([Yamagishi and Cook, 1993](#)). This loose network is focused on information sharing and as such does not, in principle, require any coordinating actor.

However, this form of weak polycentric order is likely to evolve into the emergence of informal arrangements of collaboration, an approach that requires a higher degree of investment and trust than mere information sharing ([Yamagishi and Cook, 1993](#)). These sorts of arrangements are ‘informal’ as decision-making is coordinated through continuous communication in social networks at multiple organizational levels ([Ostrom et al., 1961:841](#)). They remain ‘informal’ in the sense that they do not result in any formalization of collaboration between international organizations – such as partnerships – but can still be viewed as providing polycentric order through the negotiation of common interest, and repeated coordinated action. The informal nature of this arrangement makes them difficult to pin down empirically, but examples include a suite of “shadow networks”, or “shadow spaces” that seem to evolve between actors trying to influence influential institutions ([Gunderson, 1999](#); [Loorbach, 2010](#); [Olsson et al., 2006](#)).

These in many ways resemble the bridging organizations described by [Brown \(1991\)](#). Such organizations work to connect networks of actors, they provide a forum for networking and a clearing-house for information sharing. They differ in several regards from boundary organizations that are also often invoked in discussions of environmental governance. Although boundary organizations involve participation by actors from multiple communities (policy, science, NGOs) and serve to mediate and promote networking between these, they assume accountability by the organization to all actors ([Guston, 1999, 2001](#)). Furthermore, boundary organizations are often established to promote a shared vision, while bridging organizations tend to evolve around a shared vision ([Brown, 1991](#); [Guston, 1999](#)).

Structurally there is little to suggest that network arrangements that promote information sharing, and those that facilitate informal arrangements of collaboration should differ markedly. The higher degree of trust and investment needed for coordinating actions, albeit informal, would suggest that some of the relations in the previously homogeneously loose network, would start to become stronger for a smaller set of actors ([Fig. 1b](#)).

Examples of this simplest form of polycentric order include the information sharing mechanisms provided by the World Health Organization in dealing with infectious disease outbreaks of global concern ([Galaz, 2009](#)), the UNEP Global Programme of Action “clearing house” mechanism to rapidly integrate and disseminate information and data from governments and international organizations, and a suite of additional information sharing mechanisms created to facilitate coordination amongst international organizations and secretariats ([Chambers, 2008](#)).

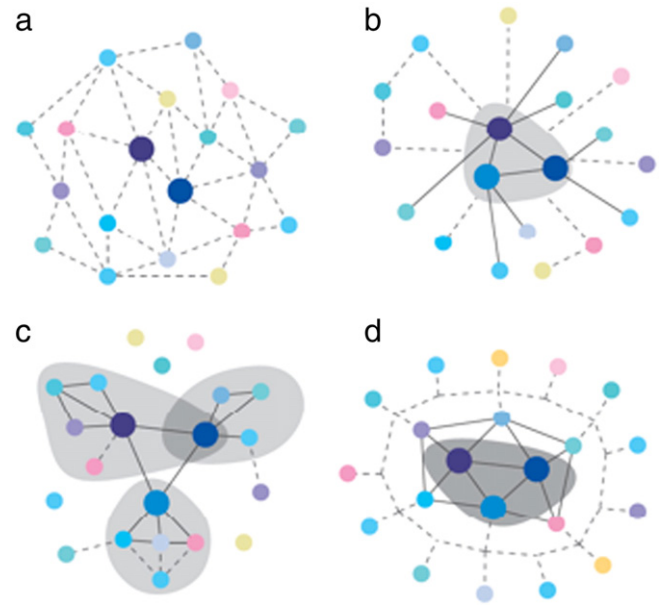


Fig. 1. From “weak” to “strong” polycentricity. *Comment:* The figure illustrates different processes of polycentric coordination and order. The first (a) illustrates a simple communication network that allows for mutual adjustment in multi-actor settings. (b) illustrates a stronger form of coordination as it combines communication linkages (dotted lines), with formal partnerships arrangements (regular lines). (c) denotes a stronger form of polycentricity involving tangible joint projects/experiments between actors (shaded areas) often with overlap. (d) is the strongest form of polycentric order, and involves strong formal ties between key actors as well as a suite of joint projects and the evolution of rules. Some external communication linkages to peripheral actors (dotted lines) co-exist with this stronger form of polycentric order often denoted as “polycentric system”. Colors illustrate the diversity of actors, and sizes are rough illustrations of the importance actors’ (nodes) play in the evolving network.

A stronger version of polycentric order ([Fig. 1c](#)) requires a larger investment in formal partnerships, and coordination of joint projects and experiments. This can involve a suite of cooperative projects, ranging from investments in monitoring systems, knowledge production activities, to the deployment of field projects. Joint investments of this kind also open up space for learning and experimentation at multiple levels ([Ostrom, 2010](#); [Österblom and Sumaila 2011](#)). Note that this is denoted a “stronger” version of polycentric order as it requires higher levels of commitment and trust, but also embeds higher potential benefits. For example, cross-organizational knowledge production at the international level (such as global environmental assessments) requires considerable coordination, but has been proven to have an important agenda setting function ([Miller, 2006](#)).

From a structural perspective, the formalization of a partnership requires that social relations change in character from purely information sharing, to relations that require a mutual commitment among actors. The cost of maintaining ties therefore increase and as a result the structure changes; from a network with high density of relations to fewer but stronger relations ([Carpenter et al., 2003](#); [Coleman, 1988](#)). Some purely information sharing ties remain, but those actors who do not engage in more costly trust building are eventually left out of the partnership of joint collaboration ([Fig. 1b](#)). The clearer focus on joint collaboration also requires some coordination and in a response to this, a few central actors emerge to coordinate the activities and communication of the partnership ([Fig. 1b](#)) ([Bavelas, 1950](#); [Leavitt, 1951](#)). As the collaboration evolves towards gradually stronger collaboration, the modularity of the network is likely to increase ([Bodin and Crona, 2009](#); [Uzzi and Spiro, 2005](#)). This means that clusters begin to form around joint sub-topics and on-the-ground projects. Some of these may overlap, and there is still a discernible core of coordinating actors ([Fig. 1c](#)).

Global partnerships in the private sector (Pattberg, 2005), international investments in global epidemic laboratory networks (Galaz, 2009), multilevel coordinated action to combat forest fires in the Amazon (Foster Brown, 2006), international cooperation aimed at monitoring remote marine areas (Österblom and Sumaila, 2011), and transnational municipal networks (Kern and Bulkeley, 2009) are only a few examples of formalized multilevel patterns of collaboration with the ability for self-regulation, coordinated action, and polycentric order.

Internal problem solving and conflict resolution (Fig. 1d) are likely to be the strongest, and most demanding processes of polycentric order (McGinnis, 2005:14; Ostrom et al., 1961:838). The reason is that novel challenges (e.g. ecological surprise or shocks) forces actors to invest considerable time and resources in sense making (Westley et al., 2002). Sense making implies the capacity to interpret often-conflictive information, and create a shared understanding internally, of what is likely to be dynamic problems with complex and poorly understood drivers (Galaz et al., 2010; Walker et al., 2009). Conflicting interpretations can lead to conflicts within a partnership. As such, these processes can put existing collaboration patterns under severe stress, and if left unresolved can potentially break apart collaboration patterns in polycentric settings (cf. Young, 2010).

From a structural perspective, problem solving and conflict resolution arguably requires enduring ties, built on strong trust, as turbulent or changing conditions create high uncertainty. Here actors need to be able come together and discuss conflicting ideas and information, and make sense of the changing environment (e.g. Olsson et al., 2006). Large groups can provide for a diversity of information and perspectives, but sense making and problem solving can be negatively affected by large group size due to increasing coordination costs (Guimerà et al., 2005; Provan and Kenis, 2007).

As such, it is unlikely that large formal partnerships will be able to maintain their size without some structural adjustments. The strong relations needed for problem solving and conflict resolution are maintained within a core of actors, who continue to invest significant amounts of time and effort to maintain them. Some central, coordinating actors may still be present to steer this process, and may appear as an inner core (the shaded area in Fig. 1d). Other actors may still be tied to the partnership through individual partnership members. These continue to provide information but are not formally involved in the activities undertaken by the formal partnership. Examples of this type of very strong polycentric order are found in federal type of systems, such as the United States and the European Union, cross-border governance arrangements or multilevel co-management systems (Hooghe and Marks, 2003). This strongest form of polycentric order is what in the literature is denoted as “polycentric system” as it implies dense collaboration patterns and institutionalization that allow for uniformity and consistency, and provide a degree of predictability and problem-solving (McGinnis, 2005; Ostrom et al., 1961; Sovacool, 2011).

2.2. Summary: Propositions about Polycentric Order

Summarizing this review and integration of polycentric order and network perspectives we emerge with three propositions, which we suggest can be used to empirically analyze how polycentric order plays out at an international scale.

Proposition 1. *Polycentricity is a matter of degree, ranging from weak coordination to strong polycentric order.*

Proposition 2. *Degrees of polycentric order are defined by features such as communication dynamics, degree of formalization, and network structural patterns.*

Proposition 3. *External and internal tensions affect the ability of actors to maintain a certain degree of polycentric order.*

In short, these propositions imply that there are likely to exist multiple forms of polycentric order, and that multi-actor networks can move back and forth between these forms. The propositions also highlight the need to not only look at processes of polycentric order, but also the emerging network structures as these are likely to affect the outcomes of collaboration.³ It should be noted that transitions *between* degrees of polycentric coordination and order, is likely to exit and be driven by both internal (such as number and constellation of participants) and external factors (such as changing environmental circumstances, steering attempts from other actors), as elaborated by (Young, 2010:14f) and (Aligica and Tarko, 2011). Due to space limitations however, here we only focus on elaborating these degrees, and exploring some empirical evidence at the international scale.

3. The Need for Polycentric Order in Global Marine Governance

Climate change is already having an impact on marine ecosystems as illustrated by increasing ocean temperatures, and melting sea ice in the Arctic. Oceans are the largest active carbon sinks on the planet and approximately one third of anthropogenic emissions are “captured” by the oceans. However, this process is changing ocean chemistry, and as the oceans take up more carbon dioxide, they are slowly turning more acidic. A continued decrease in pH could have enormously negative consequences for a wide range of species (Hoegh-Guldberg et al., 2007), and contribute to the bleaching of corals with severe implications for marine biodiversity, and thereby also for the tens of millions of people who depend on living marine resources for their survival (Bellwood et al., 2004; Millennium Ecosystem Assessment, 2005).

The global arena has, despite an ambitious international legal framework embodied in the *UN Convention on the Law of the Seas* (UNCLOS), been largely characterized by a lack of integration among the different policy arenas of marine biodiversity, fisheries, climate change, and ocean acidification. Marine living resources in the high seas, beyond areas of national jurisdiction, are managed under UNCLOS through Regional Fisheries Management Organizations (RFMOs) reporting to the FAO (Cullis-Suzuki and Pauly, 2010; Lugten, 2010). Regional environmental governance institutions such as the UNEP Regional Seas Program overlap geographically with fisheries governance bodies, but have a different mandate (UNEP, 2010), a situation that creates lack of policy coherence with detrimental impacts on fisheries all over the world (Berkas, 2010). At the national level, environmental agencies often work with a different mandate and towards different goals than fisheries management authorities (Murawski, 2007).

The Convention of Biological Diversity (CBD) is an additional overarching global mechanism of relevance. However, the focus of CBD has been on identifying protected areas, with relatively marginal success in the high seas thus far. There is an ongoing discussion on the role of the CBD in relation to fisheries management organizations. During COP10 of CBD in Nagoya, governments noted the need for an increased collaboration between the FAO, UNEP and RFMOs, UNFCCC, ICRI and others, to assess the interacting challenges of climate change, ocean acidification and marine biodiversity loss.⁴ Although recent decisions are promising, the existing incoherence creates severe coordination challenges in attempts to address the potential future impacts of climate change and ocean acidification (Cheung et al., 2009, see also FAO, 2011). This is clear at the international level

³ A special note should be made here. The interplay between individuals, institutions, and cross-sectoral organizational collaboration and polycentric order is far from simple. As our analysis indicates, this means that individuals interact as representatives from international organizations, meaning that the results of their joint individual attempts play out at the scale of international networks (cf. Olsson et al., 2006). This is in line with parallel attempts to specify social mechanisms, and the interplay between micro-macro agency (see Hedström and Ylikoski, 2010 for a review).

⁴ COP Decision X/29, paras 53 and 66, <http://www.cbd.int/decision/cop/?id=12295>.

where marine issues have been virtually absent from the international climate change agenda.

An additional challenge stems from the vast diversity of international players acting at the marine biodiversity–climate–ocean acidification interface, summarized in Table 1. This has resulted in uncoordinated and ineffective attempts to influence the international policy agenda (e.g. climate and biodiversity negotiations), and overlap of activities in field settings.

The treatment of these policy issues as virtually disconnected silos, and the absence of an overarching institutional framework, hence creates a clear need for polycentric order. This includes processes and structures that allows international organizations (such as the FAO and UNEP), nation states and other actors (such as local NGO's and regional research networks) to self-organize, and make mutual adjustments in their ongoing work at international, national and local level.

3.1. The Case Study

The following case study was conducted from May 2009 to October 2010. During this time we followed a set of international actors who were trying to address the problems posed by institutional fragmentation and actor complexity. Their work addressed the interaction between climate change, ocean acidification, and loss of marine biodiversity (i.e. three of the planetary boundaries presented by Rockström et al., 2009a). The initiative became known as the Global Partnership on Climate, Fisheries and Aquaculture (from hereon referred to as PaCFA), and has been continuously evolving since 2008. It currently includes representatives from FAO, UNEP, WorldFish, The World Bank's Profish Programme and 13 additional international organizations, and can be viewed as an attempt for polycentric order as it involves deliberate attempts for mutual adjustments and self-organized action.

Data is based on 13 in-depth interviews with key representatives of a majority of the member organizations, and document analysis of the activities associated with PaCFA's work. Interview questions were designed to capture milestones in the development of the initiative; each organization's missions and goals, and the motivations for joining PaCFA; the goals of PaCFA over time; strategies for influencing policies and to keep the initiative going; challenges and opportunities associated with the partnership, as perceived by member organizations.⁵

In the remainder of this paper we use the propositions presented earlier, to explore the four features and degrees of polycentric order (a to d) empirically. We do not however, assume a formal network analysis due to the small size of the network. Instead, we first describe how this initiative emerged, its underlying motive, and its capacity to address cross-system interactions by creating polycentric order. In Section 4, we return to the theoretical aspects of the study.

3.2. The Evolution of PaCFA

The general feeling of duplication of efforts in marine governance, and the challenges ahead posed by climate change and additional environmental stresses, led some of the international organizations centrally involved in fisheries (notably the FAO, WorldFish and the World Bank ProFish Programme) to embark on a process of identifying gaps and coordination possibilities. As explained by one respondent from a major international biodiversity NGO, when asked to explain his view of the policy arena on marine governance and climate change issues⁶:

"If anything, there's too many [organizations]. I mean marine work is very fractured in that you have different industries that are engaged

like the oil gas industry shipping, fisheries, tourism and so on. So it's a whole flora of different sections and they never tend to get together because they have, you know, very different types of specialties and interests and so on. Beyond that there is also the scientists get together in lots of things. We are often quite active in the different scientific fora that pull together different meeting. And in many of these fora we arrange side events, or we host seminars, or we present new technical reports. So it's quite a broad range of things." (I12)

Or by an FAO representative when asked about the reason to collaborate in the emerging partnership:

"[it was] just a common desire to coordinate because there is a lot of redundancy out there and, sometimes it's embarrassing, when you are doing the same thing, there is no reason to do that. It can happen you go to a country and you've organized a workshop on something and you realize another organization has already had the same type of workshop. So, there was no reason to have that workshop. That happens all over the place in any domain." (I10)

In March of 2008, in conjunction with a high-level conference on climate change and food security convened by the FAO, an expert workshop on climate change implications for fisheries and aquaculture, was organized. The workshop evolved as the result of repeated discussions between a small group of key individuals within the FAO, The World Bank, WorldFish, and UNEP. A wider range of organizations working on fisheries and marine issues were invited to the workshop however, including members from academia (see FAO, 2008 for list of participants). The list of invitees was mainly based on the personal networks of the members in the identified key group (I11).

The very initial phase of the partnership (i.e. around the time of the first few meetings at FAO in May 2008) hence was characterized by a loose network of individuals, who had agreed to work towards greater integration of marine related issues both internationally and in the field, with the aim of coordinating activities and better influence the international policy agenda. The early link to academia also provided the network with scientific input (cf. Haas, 1992). This ambition did not require more than a loose coalition based on continuous communication, and stated interests from organizations (Fig. 1a).

3.2.1. The Birth of PaCFA

The emerging partnership thus started out as a network of organizations linked through individuals within each organization. In many cases these individuals had worked together in different networks and fora in the past, and thus the formation of a loose partnership based on informal connection lay close at hand. As one senior management representative from a research institute describes it:

"There's also been, in the past, interactions in terms of climate change and I think the group of us that were associated with a bunch of other climate project networks were the people that sort of brought climate change issues into the fisheries department in FAO quite substantially. [...] FAO began to commission external reviews and things, and some of the people that were involved in that work were commissioned and by then we'd also formed a new network with a bunch of climate and fisheries oceanography [...]" (I11).

During the process of identifying and pulling together the scientific knowledge on impact pathways and implications and adaptation and mitigation opportunities (summarized in report FAO, 2009), the idea of a more formal partnership arose (Fig. 1b). This idea was rooted in the feeling that as a partnership including the group of organizations could achieve stronger coordination than if each was working independently (I10).

⁵ For a more detailed description of the methodology, see Appendix.

⁶ Code in end of quote denote identification number for interviewee, see Appendix for clarification.

Table 1

Selection of international organizations, and programmes at the climate–ocean acidification–marine biodiversity interface.

Organization	Responsibilities/aims	Monitoring capacities
UN Food and Agricultural Organization (FAO)	Food security including fisheries and marine resources through its department of fisheries and aquaculture.	Statistics about fisheries and aquaculture, including national profiles and aquatic species distribution maps. Key collaborator of FishBase Consortium which holds descriptions on all marine species, including pictures and common names. Leads the UN Atlas of the Oceans.
International Council for the Exploration of the Sea (ICES)	Coordinates network of scientist and promotes marine research on oceanography and marine living resources in the North Atlantic.	Scientists working through ICES gather data about the marine ecosystem, develop databases, conduct integrated ecosystem assessments, fish stock assessments and produce scientific advice primarily in relation to fisheries management.
World Bank	Offers financial and technical assistance to developing countries. Supports a range of projects at both national and local level related to fisheries and aquaculture. Hosts ProFish, a funding partnership between «key fishery sector donors, international financial institutions, developing countries, stakeholder organizations, and international agencies».	Hosts a range of databases based on country profiles and development indicators, as well as general environmental data, e.g. CO2 emissions, freshwater use, and deforestation.
International Union for Conservation of Nature (IUCN)	Global network of NGOs and governments that supports scientific research, manages field projects all over the world and brings governments, nongovernment organizations, United Nations agencies, companies and local communities together to develop and implement policy, laws and best practices.	Hosts a Global Marine Programme and the Global Ocean Biodiversity Initiative. Includes Integrated assessments and guidelines. Collaborator of FishBase Consortium.
United Nations Environment Programme	Coordinates and supports a range of international projects around sustainable development, including capacity building, education. Hosts a range of secretariats (e.g. CBD, Montreal Protocol).	Promotes global and regional environmental assessments (e.g. GIWA, GEO-4, Africa Environment Outlook), GEO Data Portal, PEARL (Prototype Environmental Assessment and Reporting Landscape), including coastal and marine waters. Supports the Global Ocean Observing System (GOOS) together with UNESCO, IOC, UNEP, WMO and the International Council for Science.
WorldFish Centre	International NGO with the mission “to reduce poverty and hunger by improving fisheries and aquaculture”. Conducts research-for-development with a range of partners in 25 countries.	Hosts i) database ReefBase on coral reefs, and ii) Trawlbase which contains species abundance data from the coastal waters of South and Southeast Asia. Also houses social and economic data on the 10 million people involved in the fishing industry in the region. Also part of FishBase.
UNESCO Intergovernmental Oceanographic Commission	Promotes international cooperation and coordinates programmes in marine research, services, observation systems, hazard mitigation and capacity development. Hosts a range of regional programmes including tsunami warning. Includes 138 Members States. UNESCO also hosts the World Heritage Marine Programme as a means to protect marine areas with Outstanding Universal Value.	Manages the Global Ocean Observing System (GOOS). Is also key in the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) – an inter-governmental body of technical experts that provides international coordination of oceanographic and marine meteorological observing, data management and services. Also hosts the International Oceanographic Data and Information Exchange (IODE) programme which facilitates the exploitation, development, and exchange of oceanographic data and information between participating member states.
Multi-organizational and/or multinational initiatives		
Global Forum on Oceans, Coasts, and Islands	Composed of experts from governments, intergovernmental and international organizations, and nongovernmental organizations. Hosts a range of working groups dealing with e.g. marine spatial planning, fisheries and aquaculture, and integrated coastal management. Includes International Coastal and Ocean Organization, UNEP, FAO, UNESCO, UNDP/GEF, World Bank, and a range of national environmental or fisheries agencies	Mainly comparative policy analysis and policy briefs.

UN-OCEAN	Enhance cooperation and coordination among Secretariats of the International Organizations and Bodies concerned with ocean related activities. Tasks include the establishment of a UN interagency mechanism on oceans and coasts, and the development of networks of marine protected areas.	Develops the UN Atlas of the Oceans (with FAO)
Global Partnership Climate, Fisheries and Aquaculture (PacFa)	Global level initiative among 20 international organizations and sector bodies, focus on climate change interactions with global waters and living resources and their social and economic consequences. Includes IOs such as FAO, UNEP, UNDP, the World Bank, UNESCO, WorldFish, GLOBEC, ICES, CBD, OECD and others.	No particular related to monitoring, but works with information dissemination and participation in major international meetings such as the United Nations Climate Change Conference in Copenhagen in December 2009, and
Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA-Marine)	Global intergovernmental initiative directly addressing the link between watersheds, coastal waters and the open ocean, hosted by UNEP. Provides guidance to national and/or regional authorities for devising and implementing sustained action to prevent, reduce, control and/or eliminate marine degradation from land-based activities.	Has established an information and data clearing-house as a means to mobilize experience and expertise, including facilitation of effective scientific, technical and financial cooperation, as well as capacity-building.
The International Coral Reef Initiative (ICRI)	ICRI is a partnership among governments, international organizations, and non-government organizations. Strives to preserve coral reefs and related ecosystems by implementing Chapter 17 of Agenda 21, and other relevant international conventions and agreements. Active international organizations UNEP, IUCN, CBD, World Resources Institute.	No specific hosting of data or monitoring, but coordinates a suite of international meetings on the behalf of its members, and represents the Initiative at international conventions or meetings.
Island Nations Climate and Oceans Program (INCOP)	INCOP is providing support to help find solutions to global warming and climate change problems including extreme weather, vanishing mangroves and ocean acidification. Includes Island Nations (IN), Earth Council Alliance (ECA), The Secretariat for the Pacific Regional Environment Programme (SPREP), The Foundation for the Peoples of the South Pacific (FSPI), Oceania Sustainable Tourism Alliance (OSTA), South Pacific Island Nations including Australia, Cook Islands, East Timor, Federated Islands of Micronesia, Fiji, Kiribati, New Zealand, Palau, Samoa, Vanuatu, and Papua New Guinea.	INCOP provides advocacy support and helps mobilize technical and financial resources to help Island Nations address their common challenges and find solutions to the catastrophic human and environmental consequences they face from climate change.
Reefs at Risk Revisited	Map-based assessment of threats to coral reefs, includes International Coral Reef Action Network (ICRAN), UNEP World Conservation Monitoring Centre (UNEP-WCMC), The Nature Conservancy, Global Coral Reef Monitoring Network (GCRMN), Reef Check, WorldFish Centre, Conservation International, National Oceanic and Atmospheric Administration (NOAA), International Society for Reef Studies (ISRS), World Wildlife Fund, National Center for Ecological Analysis and Synthesis (NCEAS), Wildlife Conservation Society (WCS), Coral Reef Degradation in the Indian Ocean (CORDIO), Oceana, Coral Reef Initiatives for the Pacific (CRISP), University of the South Pacific, L'Institut de Recherche pour le Developpement (IRD), International Union for the Conservation of Nature (IUCN), Atlantic and Gulf Rapid Reef Assessment (AGRRA).	Has assembled global datasets, modelling and development of indicators of climate related stresses on coral reef ecosystems.

Comment: The list is not a complete selection, but focuses on organizations and initiatives that operate at the international scale.

At the onset the partnership had, according to key individuals behind the initiative (I8, I9, I10, I11) two goals. The first was to influence the agenda of the UNFCCC COP-15 negotiations. Specifically, PaCFA wanted to highlight the implications of climate change on fisheries and aquaculture, to ensure that adaptation of coastal communities was not left out of the process of allocating adaptation funds, and to get marine issues into the negotiation text. The second goal was to be more active in the field, and to find ways to work together in the partnership to evaluate risks and plan for adaptation strategies of coastal countries (I9).

One of the first PaCFA outputs was a policy brief and one editorial piece in *Nature Reports Climate Change* (“A Place at the Table”, May 28th 2009), aimed specifically at the UNFCCC process and the IPCC itself, to emphasize that the 4th Assessment Report (AR) paid little attention on oceans and fisheries. A key objective was also to get a stronger representation of marine issues on the 5th AR.⁷

In this initial stage most of the communication was carried out over e-mail, but several meetings, some smaller and some bigger, were carried out with different assemblages of PaCFA members. As described below, PaCFA members who attended the Bonn climate change talks in June 2009, met in conjunction with this conference to develop a strategy to influence the negotiation text, by joining forces with other groups and linking up with Indonesia. The clear goal and sense of urgency, appears to have facilitated the collaboration and communication in the network, and the evolution of communication networks to more formalized patterns of collaboration (c, Fig. 1).

3.2.2. Strategies and Struggles to Achieve Impact

Individual PaCFA members attended the Bonn climate change talks in June 2009 under their own, or closely related organizations. At this occasion they met with a number of people, primarily NGOs – such as the Nature Conservancy – with much more experience in conducting organized lobbying. Members of PaCFA also came in contact with another UN-based organization with overlapping interests and mandate, the *Global Forum on Oceans, Coasts and Islands*. As one key individual from an international research network states:

“[T]he trick then was to get it into the negotiating text which was released to be discussed in Bonn in the first two weeks of June 2009 and when we got there, we hadn't planned a side-event which is one way of getting these things mentioned and we had no specific plan or experience but [person X] went with the FAO delegation and I went with the CGIAR delegation. [My organization] did not have representation, so I went under the International Water Management Institute badge, one of our sister organizations, and when we were there we met a number of people with NGOs who were clearly more experienced at lobbying on this, including the Nature Conservancy, who were very well represented there and they had an interest, and an organization called the *Global Forum on Oceans, Coasts and Islands*...” (I11)

In addition, the Indonesian government organized a side event about the Manado Ocean Declaration – a declaration calling for a more explicit focus on marine issues in UNFCCC COP 15 signed by representatives from 76 countries.

“[T]here was also a side-event run by the Indonesian Government to talk about the MANADO Oceans Declaration. So, we got this group of people together and basically, there were a few of us who were concerned with oceans and fisheries who somehow found each other at this conference by a series of half connections and we sort of formed, a loose coalition and divided the responsibility of going around and talking to governments and sort of pushing this...” (I11)

⁷ This goal is something that appears to have been successful as the 5th AR will now include more chapters dealing with marine issues.

This flurry of related activities and ideas appear to have resulted in several outcomes; i) it connected the PaCFA members present at the Bonn meeting to individuals and organizations with greater experience of lobbying on the international arena, ii) it opened their eyes to the importance of such side-events and tactics for influencing the high-level process, and iii) it appears to have strengthened the determination of the core partners to strive for a more coherent and coordinated process in order to influence the UNFCCC COP-15 agenda later that year.

The relations thus moved from being simply about communication (Fig. 1a), to some actual coordination of activities (Fig. 1c) that would support attempts to create higher degrees of polycentric order. The frequency of member interactions increases in the time leading up to COP15, and at this point the network moves from a looser format, to a system where connections become stronger, at least among the coordinating group (i.e. FAO, WB, UNEP and WorldFish). In addition, there is a more explicit focus on one or several joint outputs (e.g. policy brief,⁸ suggested negotiation text,⁹ a panel and writing of several funding application to support integrated field projects involving multiple organizations [I10]).

3.2.3. COP-15

During the Copenhagen climate negotiations in December 2009, a range of international organizations and states tried to bring marine issues to the fore. PaCFA in particular organized a side event on “Fisheries, aquaculture and aquatic systems in a changing climate”, on December 15th 2009. Several of key members of the partnership also participated in side events. FAO-representatives for example, participated in the side-event *Seas the Future* organized and hosted by the Government of the Faeroes in partnership with the Governments of Indonesia and Norway, as well as on *Oceans and Climate Change* organized by the Government of Denmark. Other marine related activities during COP-15 were organized by for example, UNESCO, Guinea-Bissau, Kiribati and others.

COP-15 nonetheless failed to agree on a binding multilateral agreement, and resulted in the Copenhagen Accord. This document does not include any mentioning of marine systems, nor does it direct any of the adaptation funds to projects related to fisheries, or coral reef ecosystems.

3.2.4. Post COP-15

The intensity of collaborations and the amount of efforts put into the process leading up to COP-15 was high, and the tangible outcome almost non-existing. After the COP-15 the network therefore seems to have suffered some fatigue. One FAO representative for example, notes:

“No, so we are going to again pick up with the global oceans community and PaCFA to try and understand again this year, how we think we can best assist the process [of influencing the COP16]. We haven't done that yet, Copenhagen fatigue.” (I11)

Many members begin to focus more of their attention on the tasks and agendas of their organizations, and the intensity and frequency of interaction/communication in the PaCFA network slowed down. What at the time before COP-15 was a tightly coordinated network (Fig. 1c) seems to once again settle around informal collaboration and information sharing (Fig. 1a–b). There appears to be several reasons for this. First, the intensity of work leading up to the big event

⁸ PaCFA policy brief “Fisheries and Aquaculture in our Changing Climate” 2009, available online http://ftp.fao.org/FI/brochure/climate_change/policy_brief.pdf.

⁹ Global Forum on Oceans, Coasts, and Islands – “Oceans, Coasts, and Climate Change – Contribution to the United Nations Framework Convention on Climate Change (UNFCCC)”, August 6, 2009.

was exhausting in itself, and drained both human and capital resources. In addition, the feeling that success was limited (all text on marine issues was virtually deleted in the final amended version of the negotiation text), probably added to the sense of fatigue and perhaps even disillusion. Another important point is that in the post-COP15 phase, the network no longer had a clear and well-defined task to unite around.

The second goal, that of collaborating on the ground and hence evolving into a stronger polycentric order (Fig. 1c–d), was not attainable in the immediate future as no funding had been secured for such work, and given the economic slump at the global level, the perceived likelihood of acquiring any big money was low. The steam and energy that characterized the initial phase of the partnership began to fade. In April in 2010 a conference in Japan seemed to offer a point where PaCFA members could rekindle their engagement, and a side meeting was convened to discuss the future goals of the partnership. A draft strategy was developed and circulated within the network, but it is unclear at this point how this draft will affect the future development of PaCFA.

4. Linking the Case to Polycentric Theory

The case of PaCFA not only provides insights into how actors in international organizations try to influence global agendas and multi-lateral negotiation processes. It also brings to light attempts by international organizations of various types, to make mutual adjustments and self-organize activities at the local, national and international level to face global and interacting environmental stresses. At the same time, they also highlight some critical and possibly generic challenges for polycentric governance of planetary boundaries and their interactions.

4.1. Opportunities

As explored above, much of the type of collaboration that evolves around the actors in PaCFA builds on loose linkages between individuals, their respective organizations, and a formalized partnership. Loose does not automatically imply powerless however. Many of the members are adamant that PaCFA serves as an important platform for learning and exchange of knowledge, ideas, and information (I5, I6, I7, I8, I13), not only as a way to link to existing epistemic communities, but also as one fundamental aspect of polycentric order (Proposition 2). This also includes what are generally viewed as large international organizations like the FAO and UNEP.

Other organizations such as the BCC, but also UNEP, find that the partnership greatly increases their access to scientific and technical advice, which can facilitate their work and speed up the process of getting important new findings into a policy process.

There is also an interesting multilevel aspect. While collaboration and knowledge sharing seems to be mainly centered amongst organizations at the international level, there are also links to actors working regionally and locally. For example WorldFish Centre coordinate a range of project on the field, ranging from Asia, Africa, South Pacific, while FAO's projects cover practically all regions of the world, implying that learning between international actors could diffuse downwards to more locally placed actors (e.g. I5).

From a polycentric point of view, these sorts of multilevel linkages could in a longer time perspective, allow for not only information diffusion and learning across scales (Pahl-Wostl et al., 2007), but also for coordinated action in multilevel governance settings (Brondizio et al., 2009). In line with Haas (1992), global networks like PaCFA can help to support and enable regional and national program development and local initiatives that address planetary boundary interactions. Examples here include the Coral Triangle Initiative (including Indonesia, Malaysia, the Philippines and other), and Partnerships in Environmental Management for the Seas of East Asia (PEMSEA). However, the short

existence of PaCFA does not allow for a robust estimate of whether it has been able to truly coordinate local level learning and experimentation.

4.2. Challenges

Building a capacity to promote experimentation and learning in a polycentric setting – denoted c in Fig. 1 – nonetheless requires a different type of structure than those loose ties maintained by pure information sharing and adhoc collaboration. PaCFA has over time tried to explore that option by attempting to find joint funding (I10), but has until now only been able to create collaboration around policy documents, and activities at major international negotiation processes such as UNFCCC COP 15. As the interviews indicate, several critical challenges emerge in actors' attempts to increase the strength of the partnership and hence in their attempt to create polycentric order. These include the challenge of *keeping the network together*, *negative institutional interactions*, and *lack of resources*.

4.2.1. Keeping the Network Together

As elaborated earlier, the frequency of member interactions increases in the time leading up to COP15, and the network moves from a looser format, to a system where connections become stronger, at least among the coordinating group, and there is a explicit focus on several joint outputs. As the goal to influence the UNFCCC process emerges, the ambitions of PaCFA also become more explicitly political.

This shift in focus and re-organization (Fig. 1a–c) started to create some tension within the initiative. The nature of coordination at the start was one of collaboration and knowledge exchange – it had no mandate to influence any political process, and in fact, the political nature of some of its goals conflicted with the mandate of some of the member organizations. Some of the more science-based organizations for example, felt they did not have the mandate to engage in the “political game” which PaCFA has now launched itself into (I3 and I4). This quote from a senior representative of one of the scientific organizations is illustrative in this sense:

“PaCFA involves cooperation with NGOs, and as you know they have some different *modus operandi* which is not purely science based. So this is for [organization X] a bit of a delicate territory to move. We have been supporting the very first steps of PaCFA, and the very first preparation of some documents because those were science-based and of course [organization X] has no problem joining those activities and those initiatives. [...] But, then it became a little bit political, which is mostly, I mean it is legitimate, [...], but that for [organization X] is always a reason to drop out of the business and say “sorry folks we are purely science-based” [...]” (I4, similar reasoning in I3).

Thus, the inclusion of scientific partners in the partnership – which can be seen as a strength in that it allows for science based capacity building, and the possibility for connecting global and local scales – also presents a challenge as this creates a tension between those that champion scientific legitimacy credibility, and those that who want to influence global policies. This tension is far from uncommon for governance networks (Provan and Kenis, 2007), and makes it difficult for the initiative to fully evolve into a strong polycentric system (Fig. 1d).

Several members however, stress that this is a natural progression of a partnership like this (I2) and that PaCFA can still serve as an important platform for information and knowledge exchange. Perhaps the ‘shadow network’ (Olsson et al., 2006) can emerge again as in the future if funding becomes available and other opportunities emerge. However, the lack of formalization around the interactions of participating actors in PaCFA suggests that some of the benefits often

associated with both bridging and boundary organizations may not materialize. Accountability and the ability to adequately resolve conflicts emerging from tensions between goals are real challenges that will face any endeavor to create a polycentric order capable of persisting over time (c.f. Brown, 1991). The next section explores such tension in more detail.

4.2.2. Vulnerability to Negative Institutional Interactions

The sort of polycentric coordination assumed by PaCFA emerges partly to overcome institutional fragmentation and lack of clear steering mechanisms to deal with cross-system interactions. However, this does not make them robust to existing organizational and institutional tensions (Chambers, 2008; Gehring and Oberthür, 2009). As an example, FAO is one of the primary driving agencies behind the partnership, especially by convening the first critical meetings in 2008 and 2009. While the idea to create such a partnership had been around amongst key individuals at the FAO and WorldFish for some time (19, 110, 111), the opportunity first presented itself in 2008 when COFI explicitly requested that FAO take steps to “identify the key issues on climate change and fisheries, initiate a discussion on how the fishing industry can adapt to climate change, and for FAO to take a lead in informing fishers and policy makers about likely consequences of climate change for fisheries” (FAO, 2009).

The same member states that gave FAO its mandate to coordinate a global partnership around climate change and fisheries, are nonetheless the same that fail to include marine issues in the negotiation texts related to the UNFCCC. For PaCFA, the failure to achieve some tangible outputs from the UNFCCC COP-15 process, seems to have led to lost momentum, and the risk of the partnership to dissolve rather than to evolve into providing a stronger form of polycentric order. While these sorts of inconsistencies are very common at the international level (Gehring and Oberthür, 2009; Oberthür, 2009) it is interesting to note how polycentric initiatives which hold potential for dealing with cross-system challenges in a multilevel setting, are highly vulnerable to multilateral negotiation processes outside their control.

4.2.3. Lack of Resources

Finally, besides from lack of funding for promoting joint projects, the interviews indicate that many of the smaller organizations do not have the funding to attend meetings or set aside human resources to work on joint issues. In the longer term, this is a matter of not only impact in the field but also external legitimacy (Provan and Kenis, 2007), as financially weaker partners might have problems participating in key meetings, and conferences.

This is not to say that investments in issues related to ocean acidification, losses of marine biodiversity or climate change impacts on marine ecosystems are non-existent. On the contrary, as our synthesis of major global initiatives indicated (Table 1), there exists a range of scientific collaborations and joint projects that try to address aspects of the problem complex. Hence, the challenge is not whether global initiatives emerge to deal with the problem complex climate change–ocean acidification–marine biodiversity. The question is instead whether any of these initiatives will be truly able to create a polycentric order by organizing, funding and maintaining collaboration and knowledge sharing mechanisms over time. Whether PaCFA ever will evolve into a stronger and more synergistic version of polycentric order, remains to be seen.

5. Conclusions

Can polycentric systems and order contribute to the governance of planetary boundaries, and complement existing and often failing international institutions (Dimitrov, 2010; Ostrom, 2010)? While polycentric order certainly has a number of potential benefits, we have also elaborated some remaining theoretical and practical challenges.

Table 2
Polycentric coordination and order – a summary.

	(a) Weak polycentric coordination	(b) Polycentric coordination	(c) Polycentric order	(d) Strong polycentric order
Key characteristics	Coordination through information sharing and mutual adjustment	Information sharing key, but emerging informal arrangements of coordination	Information sharing and joint investments e.g. monitoring systems, field projects, experiments.	Enduring ties and strong trust between coordinating actors. Emergence of mechanisms for internal problem solving and conflict resolution.
Communication patterns	Information sharing uncoordinated	Information sharing mainly uncoordinated	Information sharing is key, with denser patterns between a core of coordinating actors.	Information sharing strategically coordinated by key actors.
Degree of formalization	Weak	Weak	Medium	Strong
Structural characteristics	Non-hierarchic communication network	Non-hierarchic communication network, however stronger relationships between small set of actors	Increased modularity of network, key coordinating actors identifiable	Strong ties between core group of actors, and communication links to a wider set of peripheral actors
Key outputs	Investments in information sharing platforms (e.g. email lists, Internet interfaces)	Investment as in (a), additional investments in knowledge syntheses, physical meetings	As in (a) and (b), but also investments in joint sub-projects such as information campaigns, field projects.	As in (a)–(d), but also emergence of institutionalized mechanisms for problem solving and conflict resolution.
Examples	Information sharing mechanisms such as UNEP “clearing house” mechanisms, or information sharing platforms such as HealthMap	“Shadow networks”, “shadow spaces”, “bridging organizations”.	Global partnerships, transnational municipal networks, laboratory networks for epidemic surveillance	Federal governance systems, crossborder governance arrangements, comanagement systems

In this article, we have made a first attempt to define, identify and illustrate key features of polycentric order at the international level based on three propositions: 1) Polycentricity is a matter of degree, ranging from weak coordination to strong polycentric order; 2) Degrees of polycentric order are defined by variables such as communication dynamics, degree of formalization, and network structural patterns; 3) External and internal tensions affect the ability of actors to maintain a certain degree of polycentric order. The next table (Table 2) summarizes key features of polycentric order elaborated both by the theoretical summary, and informed by the empirical case presented above. Future analyses of polycentricity at the international level should in addition, place more emphasis on identifying empirically, the factors that drive polycentric order between states. Unfortunately, this particular study has only been able to touch upon the issue due to space limitations and the research design.

However, as the case study indicates, mechanisms of polycentric order ranging from information sharing to coordinated action (Proposition 1), do seem to operate at the international level through the interplay between key individuals, international organizations and their attempts to overcome severe institutional fragmentation and actor complexity (Proposition 2). An important part of this work is centered on not only attempts to coordinate activities on the field, but also to influence international negotiation processes as a way to secure funding and international acknowledgement. This also affects the type of collaboration structures that emerge at the international level (Proposition 3).

While polycentric order of this type certainly holds potential (Folke et al., 2005; Ostrom, 1990, 2010), it is also vulnerable to a number of tensions. For example, even though multi-actor coordination and experimentation would clearly make attempts to create polycentric order more effective, it also creates tensions between actors with different mandates and logics of operating (Proposition 3). The case study also indicates that even the weakest forms polycentric order at the international level, is dependent on anchoring with more formal negotiation processes, hence making collaboration and information sharing patterns vulnerable to unreliable external flows of funding, and negative institutional interactions. These vulnerabilities add to those identified in the literature (e.g. Ostrom, 2010; Aligica and Tarko, 2011:22), and pose severe challenges for the effectiveness of polycentric order at the international level (Proposition 3).

Trying to “design” institutions that match not only individual planetary boundaries, but also their interactions, pose severe challenges. The role of self-organized and multilevel responses as those explored here, will hence be of increasing interest to explore and evaluate critically by Earth system governance scholars. Furthermore, the need for a more theoretically rigid and empirically founded evaluation of polycentric systems and order is obvious. This article has hopefully contributed to highlight these challenges, and offered a way forward.

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Appendix A. Supplementary Data

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