Learning from Climate Variability: Adaptive Governance and the Pacific ENSO Applications Center

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ABSTRACT

Adaptive governance is a pattern that began to emerge from conflicts over natural resources in the American West a few decades ago. This was a pragmatic response to the emerging evidence that effective control was dispersed among multiple authorities and interest groups, that efficiency was only one of the many goals to be reconciled in policy decision processes, and that science itself was politically contested. Climate change as a policy problem exhibits many of these same features and has similarly led to gridlock in international and national forums. But humankind is not without guidance in securing the protection of life, limb, and livelihood in the face of environmental distress, particularly with regard to the challenge of adaptation. One effective analogy can be drawn to adaptations in the face of large climate variability such as El Niño. This paper compares adaptive governance with the tradition of scientific management in the international climate change regime, and it explores an example of adaptive governance in responding to the effects of a severe El Niño event in the Pacific islands. This event illustrates some of the specific kinds of human choices that will be made by those who are concerned about climate change as a policy problem. The basic choice is not scientific management or adaptive governance but continuing with business as usual or opening the frame to a wider range of possibilities.

1. Introduction

Climate change as a natural science problem is considered to be globally irreducible because the geographic origins of long-lived well-mixed greenhouse gases are irrelevant to the physics of radiative transfer (e.g., Karl and Trenberth 2003). Climate change as a policy problem over the last two decades has absorbed this framing, leading to a focus on international assessments and agreements as a prerequisite for action. It also led to formalizing the existing community of scientists focused on the earth system through science programs such as the World Climate Research Programme and the U.S. Global Change Research Program (now the U.S. Climate Change Science Program; Edwards 1996). This global community of scientists can be termed an "epistemic community" (Haas 1992), that is, a professional group that shares recognized expertise, a set of values, and an interpretative framework. Its ability to stake an authoritative claim to knowledge is what gives the community its voice. This epistemic community, participating most directly through the scientific assessments of the Intergovernmental Panel on Climate Change (IPCC), became an integral part of the coalition supporting the establishment of the international climate change regime[1] through the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, and will continue through a successor agreement that remains outstanding after limited progress at the United Nations Climate Change Conference on 7–18 December 2009 in Copenhagen.

This epistemic community has delivered dramatic progress in observing and understanding the changing climate system. Global mean temperature and sea level

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[1] "Regime" in this sense refers to a set of rules or norms that regulate a system of governance and its interactions with wider arenas.

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since 1990 are rising at a rate in the upper range or higher that projected in the most recent scenarios conducted for the IPCC Fourth Assessment Report (Rahmstorf et al. 2007). Concentrations of greenhouse gases in the atmosphere are sufficient to force significant changes on natural and human systems (Parry et al. 2008; Hoegh-Guldberg and Bruno 2010). And perhaps losses from climate change have already arrived through extreme weather events [Table SPM.2 of Alley et al. (2007), p. 8]. These observations are consistent with a long history of inquiry into the physics of climate, starting with John Tyndall in 1861.

Despite a rigorous understanding linking laboratory science, empirical observation, and numerical simulation to human activities, global emissions are growing at a faster rate than any of the emissions scenarios considered in the Fourth Assessment Report (Raupach et al. 2007; Le Quéré et al. 2009). It appears that as a policy problem, we understand less than we require to set human activities on a more sustainable path, particularly in developing countries. As noted by Clark and Holliday (2006), ''Myths accumulate and blunders are repeated.'' But we are not without exemplars that have secured the protection of life, limb, and livelihood in the face of environmental distress. A particularly effective analogy can be drawn between the challenges faced by communities in adapting to the effects of climate change on the one hand and adaptations in the face of large climate variability on the other (Cash and Buizer 2005; McPhaden et al. 2006).

What has been made clear in many studies of responses to large climate variability is that, to paraphrase O'Brien et al. (2000), information alone is not enough. For example, Patt (2009), in a comparative evaluation of seasonal forecast value in Africa, distinguished two important factors that promoted actual benefits to people on the ground: (i) both formal cooperation and opportunities for informal interactions between forecaster and forecast user and (ii) development of a fit-for-purpose forecast product.

There is no doubt that climate change presents a more complex and challenging problem than adaptation to seasonal extremes of drought, flood, or temperature. Indeed, actions to secure communities in the face of seasonal variations can result in maladaptations to long-term trajectories (e.g., Adger 2000). The challenge for researchers, however, is to understand practices of science, policy, and decision making that will provide insights demanded by those experiencing the growing effects of climate change.

In this paper, we explore a pattern of governance that has emerged in practice in areas as diverse as natural resource policy and the development of the Internet (Brunner et al. 2002, 2009). The term ''adaptive governance'' is used for overlapping concepts in Dietz et al. (2003), Folke et al. (2005), Gunderson and Light (2006), Nelson et al. (2008), and Hoff (2009). A grounded interpretation of the term depends on the particular context in which it is used, but, not surprisingly, recognition of the pattern in the last decade followed innovations in practice. We compare this pattern with the tradition of scientific management in the international climate change regime (section 2) and explore an example of adaptive governance in responding to the effects of a severe El Niño event in the Pacific islands (sections 3 and 4). We argue that through adaptive governance, many climate adaptation and mitigation problems have already been solved on a small scale, and that it is possible that these solutions can be scaled up and out.

2. The international climate change regime

In this paper, we refer to hypothetical pure specimens of two distinguishable patterns of governance: scientific management and adaptive governance (Table 1). These two patterns can be considered ''ideal types'' (Gerth and Wright Mills 2002). Ideal types are formed from characteristics of the patterns in question. They are not intended to represent all real cases but rather to stress common or typical elements in most cases. In this sense, they operate similarly to the role of composites in atmospheric science. Hence, the patterns of governance described here are ''a 'speculative model', which is as useful in calling attention to *deviations* from the type as in characterizing the few cases that exactly conform to it'' (Lasswell and Kaplan 1950, emphasis added). Actual cases of governance in diverse and dynamic societies are mixed, with aspects of emerging patterns complementing (or competing with) the established pattern.

Consider the first column in Table 1. This table lists characteristics of an ideal type of scientific management. Centralized decision making is generally applied to comprehensive policy decisions with major consequences of broad scope and complexity; that is, big decisions about big problems such as health care, space policy, and financial regulation. Any such decision attracts the interest of many groups concerned about opportunity costs if not other consequences, reinforcing tendencies to assert control from the top down. The cost of policy failure in these cases tends to be large, justifying the recruitment of experts for extensive research and planning that attempts to get policy right the first time, and provides the scientific foundation for a decision above politics. This planning approach is termed ''technical rationality.'' The second column lists approaches for opening this frame to improve outcomes in cases in which uncertainties are large

TABLE 1. Hypothetical pure specimens of two distinguishable patterns of governance: scientific management and adaptive governance.

Scientific management	Adaptive governance
Decision making: Centralized	*Decision making: Decentralized*
Top down. Central authorities at the top of international and national hierarchies make the important policy decisions.	Bottom up. Needs shared in networks can help central authorities allocate resources to support what worked on the ground.
Bureaucracies. Policies are implemented uniformly and impersonally by subordinates accountable to central authorities.	Networks. Case studies of local policies that worked can be diffused by networks for voluntary adaptation by other communities.
Expertise. Disinterested experts develop technologies and integrated scientific assessments for central authorities.	Experience. Local communities working in parallel can adapt and field-test policies in their own contexts; diversity is an asset.
Policy: Technical rationality	*Policy: Procedural rationality*
Planning. Policy process is discrete, relying on formal methods and metrics to evaluate planned alternatives and avoid failure.	Appraisal. Policy processes are serial, relying on appraisals for terminating failed policies and building on successful ones.
Targets. Comprehensive policy depends on science.	Interests. Incremental policies integrate or balance interests in a community to advance its common interest; politics are necessary.
Linear. Unfettered basic research to reduce scientific uncertainty is a prerequisite for rational and cost.	Cooperative. Scientists and policymakers work together toward overlapping practical aims, sharing differently informed insights.
Science: Extensive	*Science: Intensive*
Generalized. Research generalizes across human or natural systems for results of broad national or international scope.	Centered. Inquiry focuses on understanding and reducing losses from extreme events in single cases; context matters.
Predictive. Stable and standard parts are integrated into numerical models to derive falsifiable predictions to reduce uncertainty.	Integrative. Each factor is contingent on a working model of the whole case; gaps and inconsistencies in it prompt revisions.
Reductive. Research selects from diverse systems separate parts relevant to a stable relationship or standard measure or method.	Comprehensive. Inquiry strives to cover all the major interacting factors, human and natural, shaping outcomes in the single case.

and planning is challenging. Decentralized decision making is appropriate to factoring policy decisions into many smaller ones, each with relatively modest consequences of limited scope and complexity in a somewhat different context. This attracts fewer interest groups, facilitates action on innovative policies adapted to the particular context, and enables field-testing to terminate failed policies and to build on successes. It also justifies intensive scientific research to assist in harvesting experience to inform subsequent policy decisions. This is termed ''procedurally rational policy,'' which relies more strongly on a posteriori appraisal rather than a priori planning. This is explored further in section 4.

The formal structure of decision making in the international climate change regime requires that the important decisions on climate change are made by national governments working together in the Conference of the Parties to the UNFCCC and in joint implementation schemes, and working separately to implement their respective policy commitments by national means. International cooperation is manifest most directly in commitments by industrialized countries to reduce greenhouse gas emissions. The IPCC institutionalizes expert advice from the epistemic community of climate scientists (both natural and social) for national and international policymakers. This international construction of climate change science, policy, and decision-making structures reflects the aspirations of scientific management.

Scott (1998) traced parts of the pattern of scientific management back to the origins of modern states in Europe, when monarchs standardized measures and practices to extract more revenues, conscripts, and control more efficiently from diverse subject communities. From such origins, ''scientific management has worked its way into the fabric of all modern industrial societies, where it is now so common as to go unnoticed by most people'' (Merkle 1998). In the United States not long after the turn of the twentieth century, ''scientific management aspired to rise above politics, relying on science as the foundation for efficient policies made through a single central authority – a bureaucratic structure with the appropriate mandate, jurisdiction, and expert personnel'' (Brunner et al. 2005). Such an approach to governance has proved highly successful in many challenges of the industrial era. But during recent decades, it has become increasingly clear, in the United States and many other democracies, that effective control is dispersed among multiple authorities and interest groups; that efficiency is only one of many interests to be reconciled in decision processes; and that science on important issues from stem cell research to water allocations is politically contested.

As noted in section 1, the aspirations of scientific management in the climate change arena has not been matched by achievements. Indeed, scientific assessments of dangerous anthropogenic interference in the climate system has had little direct bearing on the targets and timetables for emissions reductions set in article 4(2) of the UNFCCC, in the Kyoto Protocol, or in current commitments (Meinshausen et al. 2009). In the Kyoto Protocol, for example, the industrialized parties in ANNEX I made compliance with commitments voluntary, withheld severe sanctions to effectively enforce compliance, and continue to rely on self-reporting of compliance by the separate parties. Nevertheless, the industrialized country parties still took more than seven years to ratify the Kyoto Protocol.

New initiatives are pending. One is the Waxman–Markey bill in the U.S. Congress, officially called the American Clean Energy and Security Act (passed 26 June 2009). The goal is to reduce the 2005 level of greenhouse gas emissions in the United States 17% by 2020, and 83% by 2050. This has yet to be reconciled with the Bingaman–Specter bill being debated in the Senate in mid-2010. Another initiative is the Australian Emissions Trading Scheme, with a goal to reduce the 2000 level of greenhouse gas emissions in Australia 5% by 2020 with similar means. The scheme was debated in the Australian Parliament in November 2009 and has now been shelved until 2011 or later. Being subject to a range of interests, both schemes have been subject to similar lobbying campaigns for free permits by the most polluting or trade-exposed industries. While these initiatives are a step along the road to the atmospheric concentrations of greenhouse gases indicated by scientific assessments, the outcome of the currently articulated national commitments, the so-called current best pathway, is sobering. Rogelj et al. (2009) note that "with global emissions under the 'current best' pathway being at least 67 per cent above 2000 levels in 2050, our results indicate that the level of ambition from countries at present is insufficient to limit warming to 2°C, let alone 1.5°C."

The regime may yet pay off in terms of stabilizing or reducing greenhouse gases sufficiently to prevent "dangerous climate change."[2] In any case the national governments in the Conference of the Parties control many of the resources necessary to deal with climate change problems. But in view of the limited outcomes after two decades of effort, including an expenditure of at least $38.8 billion (U.S. dollars) on climate change research in the United States alone (between 1989 and 2007; Brunner and Lynch 2010), there is clearly potential for opening the regime to a larger range of opportunities.

One such opportunity is to harvest experience from local communities that have made significant progress in mitigating greenhouse gas emissions or in adapting to climate effects, with or without outside assistance. This is one possible manifestation of factoring a large complex problem into smaller ones, more amenable to decentralized decision-making and procedurally rational policy processes. The Pacific ENSO (El Niño–Southern Oscillation) Applications Climate (PEAC) Center presents one example of this experience.

3. The PEAC Center

ENSO is a Pacific Ocean phenomenon that occurs on a time scale of about 4–7 years. It is manifest most clearly in surface temperature changes in the eastern Pacific Ocean that influence a range of atmospheric processes around the Pacific and beyond, including extreme weather events. Because of the longer than annual time scale, ENSO has represented a significant challenge for adaptation. Successful programs for coping with the influence of ENSO on local climate can be useful in developing responses to climate change, particularly in the Pacific where adaptation rather than mitigation is likely to be the most pressing problem in the light of failures in the international regime.

The Pacific islands case involved the 1997/98 El Niño, one "so intense that scientists have since labeled it 'The El Niño of the Twentieth Century.'" (Glantz 2001). In the context of this event, the PEAC Center successfully field-tested a model for research in support of action on adaptation. Responding to the recommendations of a 1992 forecast applications workshop held in Honolulu, Hawaii, the PEAC Center began in the early 1990s as a pilot project to test the feasibility of integrating climate variability research, forecasts, and application services "end to end" on an operational basis. Participants credited Eileen Shea in the National Oceanic and Atmospheric Administration (NOAA)'s Office of Global Programs (OGP) for securing initial grant support. The PEAC Center was established in August 1994 as a joint venture of the University of Guam, the University of Hawaii, the Pacific Regional Office and the Climate Prediction Center of the U.S. National Weather Service, NOAA OGP, and the Pacific Basin Development Council. It focused on providing seasonal to interannual forecasts of El Niño–Southern Oscillation and related

[2] The ultimate objective of the UNFCCC is stated in article 2 as the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference in the climate system" (UNFCCC 1992).

information products for the U.S.-affiliated Pacific islands: American Samoa, the Commonwealth of the Northern Mariana Islands, the Federated States of Micronesia, Guam, Hawaii, the Republic of the Marshall Islands, and the Republic of Palau.

In an extensive science mode, the project initially explored how large-scale coupled ocean–atmosphere models could produce ENSO-related forecasts that could be turned into useful information products for Pacific Islanders and other potential forecast users around the globe. However, the spatial resolution of large-scale models did not meet the needs of the people the Center was intended to serve (Hamnett et al. 2000). The PEAC Center supplemented the global-scale model forecast with empirically based statistical models that would forecast rainfall on specific islands using historical rainfall data (Yu et al. 1997). This adapted research outputs to the different interests and other circumstances of different island communities.

Meanwhile, the PEAC Center also conducted workshops, focus group meetings, and local briefings at each of the U.S. affiliated Pacific islands during 1995 and 1996. From these briefings, researchers identified the specific information needs and key concerns of residents regarding the effects of El Niño and La Niña events. Research and applications came together in the *Pacific ENSO Update*, a quarterly newsletter distributed in hard copy and on online beginning in August 1996 (available online at http://www.prh.noaa.gov/peac/update.php). These resources were in place in February and March 1997 when the PEAC Center found indications of a rapidly developing El Niño event in several coupled atmosphere–ocean models it consulted regularly.

The PEAC Center began alerting clients through the newsletter and informing national and territorial government officials that a strong drought could be expected beginning in late 1997 and running through May or June 1998 (Shea and Colasacco 2005). Working with other members of the PEAC Center's scientific team, Charles (Chip) Guard and the Water and Energy Research Institute (WERI; now the Water and Environmental Research Institute) at the University of Guam produced seasonal forecasts of the expected percent of normal rainfall for Guam, Micronesia, and Palau, at the request of officials in those countries. The forecast for the Marshall Islands was qualified because of mixed signals in the historical record. The PEAC Center's researchers began traveling across the affiliated Pacific islands to brief government officials on the forecasts and to suggest immediate preparations for impacts to come. The personal briefings were later identified as a key component of motivating people to action (Shea and Colasacco 2005). The PEAC Center experienced some difficulties, including skepticism about the center's ability to forecast rainfall up to a year in advance and about the expected drought when briefings occurred during rainstorms in several jurisdictions. In December 1997 Supertyphoon Paka brought rain and destruction to many of the Micronesian islands; however, by January significant rainfall deficits began to spread and eventually affected all the islands.

Despite the heavy December rainfall calling the forecasts into question, the PEAC Center succeeded in catalyzing action in response to its forecasts. The Marshall Islands, state and national governments in the Federated States of Micronesia, Palau, the Northern Mariana Islands, and Guam developed task forces and mitigation plans similar to those already in place on Yap in Micronesia. The task forces mounted public information campaigns to explain measures to conserve water and to prevent outbreaks of diseases, and to warn of the increased wildfire risk. All the jurisdictions served by the PEAC Center in Micronesia eventually established El Niño or drought task forces. Specific actions included completing repairs on water catchment and distribution systems before the onset of the drought and preordering of new household water catchment tanks by commercial vendors. Rainfall forecasts also helped prepare for wildfires associated with drought, by stimulating plans to use brackish and other gray water supplies rather than drinking water for fire fighting. Most of the islands imposed restrictions on water consumption during drought; however, their policy responses differed according to their circumstances.

In 1997/98, the PEAC Center was the catalyst pulling together participants and resources scattered throughout a distributed decision-making structure. The PEAC Center put the scattered task forces in contact with each other and provided useful information before and during the drought: "The task forces maintained weekly contact by using PEACESAT [Pan-Pacific Education and Communication Experiments by Satellite] satellite teleconferencing, where Chip could regularly inform them of updates and provided technical information through WERI, such as specific catchment design requirements and estimates of water needed per person to withstand the drought" (Hamnett et al. 1999). The drought conditions were extensive enough to require water rationing in some jurisdictions; for example, in the case of the Marshall Islands, 7 hr every 14 days.[3]

[3] Dr. Nancy Davis Lewis, director, Research Program, East-West Center–Cooperative International Efforts on Climate, in testimony to the U.S. Commission on Ocean Policy, Hawaii and Pacific Islands Regional Meeting, 13–14 May 2002, Honolulu, Hawaii.

The PEAC Center sought external resources to help the affiliated Pacific islands cope. As early as November 1997, Chip Guard recommended that agencies of the U.S. government provide new wells and preposition reverse osmosis units in certain areas. ''PEAC staff in Hawaii actively consulted and discussed these recommendations with federal officials, trying to impress on them the fact that the cost of providing disaster assistance could be reduced significantly should plans be implemented before water needs became critical. Unfortunately, response to these opportunities required a US presidential disaster declaration before the agencies could take action against the impending disaster'' (Hamnett et al. 1999). That declaration came near the peak of the drought in March 1998. It allowed the Federal Emergency Management Agency to provide assistance to the Marshall Islands and Micronesia, including six reverse osmosis units for Yap.

4. Adaptive governance in the PEAC Center

The three sections below consider, respectively, examples of intensive science, procedurally rational policy, and decentralized decision making in the context of the 1997/98 El Niño event.

a. Intensive inquiry

Intensive science in this example describes a systematic empirical inquiry *centered* on—but not bounded by—efforts to reduce net losses from climate change and variability in local communities initially considered as individual case studies. Such inquiry strives to be *comprehensive*, covering all the major interacting factors, human and natural, shaping important outcomes in each case. Such inquiry is also *integrative*, construing the significance of relevant observations as contingent on a working ''model'' of the individual case as a whole. Gaps in comprehensiveness and inconsistencies arising from the integration of additional observations prompt revisions in a working model of an individual case. Thus, a model of the individual case is both falsifiable and open to cumulative improvements with additional observations and integration.

In the Pacific islands in advance of the 1997/98 El Niño event, the PEAC Committee centered its drought forecasts on specific U.S.-affiliated islands by developing statistical models based on each island's own historical rainfall data; large-scale numerical models informed the statistical models but lacked requisite spatial resolution. The PEAC Center's personnel helped integrate these local drought forecasts into local policy processes through publications and personal briefings. Shea and Colasacco (2005) described these crucial steps as problem-focused (versus forecast focused) approaches and as early, continuous partnerships with the local government officials. Differences in local policy responses indicate that local policymakers took responsibility for integrating local knowledge into their decisions to secure water supplies.

Intensive scientific inquiry is an area in which climate impact studies have made important progress in the last decade (e.g., Hamilton et al. 2003; Westerhoff and Smit 2009), often but not always learning from modes of inquiry in weather forecasting, natural hazards research, and the like. It should be understood, however, that the ideas and approaches exemplified in these sections are overlapping and mutually reinforcing aspects of adaptive governance, not discrete parts of it. Opening the established regime depends on integrating the proposals to the extent practical as niche opportunities arise in the regime's continuing evolution.

b. Procedural rationality

As noted in section 2, procedural rationality in policy making places more emphasis on *appraisals*, especially in the aftermath of climate-related disasters that reveal specific problems of vulnerability and open windows of opportunities for corrective actions. Corrective actions are constrained by the historical context of each community in the short run. They terminate failed policies and build on relatively successful ones in a series of approximations. To accommodate inevitable uncertainties, they also rely on portfolios of policies, reserves, and redundancies, learning by doing and the like. In these policy processes, scientists and policymakers can work collaboratively toward overlapping aims, sharing differently informed insights on the same context. But scientific understanding is neither a substitute for local knowledge in the community nor is scientific certainty a necessary condition for rational policy decisions by the community. Such processes can adapt policies to differences and changes in context, including surprises, and to uncertainties that inevitably expand as the time horizon for planning extends further into the future.

Procedural rationality is an adaptation to profound uncertainties arising from complexity in the world at large and human cognitive constraints, among other resource limitations. Cognitive constraints include limited time and attention, knowledge and information, and other factors subsumed under the principle of bounded rationality. They directly affect policy appraisal and intelligence (including plans) for corrective actions. They indirectly affect the allocation of funds, authorities, and other scarce resources through corrective actions (Simon 1996). Procedurally, rational policies can be improved through intensive scientific inquiry in each community. What works on the ground in each local community can inform policies elsewhere, in similar local communities and at higher levels, in decentralized decision making. Choices and decisions tend to reveal subjective values and identifications and their supporting expectations.

The PEAC Center's forecast of impending drought prompted officials in the U.S.-affiliated Pacific islands to reconsider their respective water policies and to divert attention and other resources to corrective actions. We lack detailed information on any local politics involved and the details of subsequent corrective actions; we suspect that islanders are still building on what they learned in 1997/98. We do know that the PEAC Center capitalized on its success by making the transition from a pilot project to operational status around 2001. The PEAC Center now works closely with similar international programs in the Pacific region, including programs at the Australian Bureau of Meteorology, the National Institute of Water and Atmospheric Research in New Zealand, and the South Pacific Regional Environment Programme in Samoa. Further, building on the work of the PEAC Center and subsequent programs, and using the trusted relationships developed therein, the Pacific Climate Information System (PaCIS) is being instituted with a goal of supporting ''resilient and sustainable communities using climate information to manage risks and support practical decision making in the context of climate variability and change'' (Anderson 2009). The PaCIS Steering Committee has representatives from meteorological services in the region, the disaster management community, Pacific regional organizations, and sector representation (e.g., fisheries, coral reefs).

c. *Decentralized decision making*

Adaptive governance in this example includes opening centralized decision making to the experience of local communities, working in parallel, that have field-tested adaptation and mitigation policies in their own unique contexts. The diversity of contexts across communities as they evolve through time is an asset for generating creative policy alternatives; experience on the ground is essential for selecting what worked according to local policy goals. Networks of similar local communities can clarify what external resource needs they have in common, to advise central authorities who are willing and able to support what works on the ground but lack the understanding of realities on the ground. As such, many communities proceeding from the bottom up can influence the resource allocation decisions of central authorities from the top down. Those decisions are matters of politics; they must reconcile shared interests in local communities and their networks with the interests of state, national, or international communities. This approach to constitutive policy is decentralized. It increases at the margin the power of local communities. It can also increase at the margin the power of those higher-level officials who choose to cooperate with local communities.

Decentralized decision making is an adaptation to cognitive constraints on the capacity of central authorities to govern large complex systems. The significance of these constraints increases with the scope and domain of their jurisdictions. Decentralization encourages intensive inquiry and the adaptation of policies on a procedurally rational basis; it depends in turn on intensive inquiries and procedurally rational approaches. This represents an opportunity for more intensive research, since as Rayner and Malone (1998) observed, ''almost all of the climate change policy research and analysis is aimed at high-level policymakers.''

It seems clear that the PEAC Center's outside assistance was important to help islanders reduce their losses from the 1997/98 El Niño event. In doing so the PEAC Center demonstrated the value of adapting research to the different needs of decision makers on the ground, engaging them directly in their own policy processes, and mobilizing external resources in support of their local policy decisions where needed. The PEAC Center also demonstrated how federal and local government assets and universities can be combined to provide a service whose ''integrated capabilities are greater than the sum of its parts.''[4] Note that the PEAC Center accomplished this in an advisory capacity; it was policy relevant, not policy prescriptive. Local governments made and implemented the decisions, and agencies of national governments decided to support them. As noted, the PEAC Center made the transition from a research pilot project to operational funding, and it continues to be supported by the National Weather Service.

5. Concluding remarks

This case study highlights many important features with the ideal type that describes adaptive governance; however, there is a broader significance. The principle of subsidiarity, as promoted by the Assembly of European Regions, holds that decisions should be made and government functions undertaken at a level as close to the citizen as possible (Declaration of the Assembly of European Regions on Regionalism in Europe 1996, article 3.1). The principle has legal authority in the European Union's Treaty of Maastricht (1992, article 3b) and Treaty of Nice (2003), and political influence in the assembly's

[4] Dr. Nancy Davis Lewis, in response to James D. Watkins, chairman, U.S. Commission on Ocean Policy, on a follow-up question to testimony, 2 August 2002.

efforts to highlight the role of regions, including the exchange of regional experience, within the European Union's larger effort on climate change. In this context, decentralization of some decisions in globally inclusive arenas, such at the UNFCCC, can provide global benefits. More specifically, ''In some contexts decentralization may maximize the potential for democratic participation at lower levels of interaction, permit the most rapid decision, encourage the establishment of appropriate specialized arenas, be most sensitive to the special circumstances and conditions prevailing in sub-arenas, and allow for the integration of the widest range of diverse cultural forms in constitutive decision'' (McDougal and Reisman 1981).

Opening climate science and policy to adaptive governance would also advance our interest in democracy. People on the ground, in the communities where they live and work, can be participants in local decisions that bear directly on their multiple interests. They can contribute knowledge of local facts and values and take responsibility for direct consequences they cannot avoid. Climate researchers in the natural and social sciences can contribute by working with local communities in planning and evaluating local decisions, and by finding and correcting malfunctions that inhibit scaling up and scaling out what works on the ground through networks. There is more to be gained at the margin by encouraging adaptive governance than by relying exclusively on business as usual.

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