



Research, part of a Special Feature on [Resilience Through Multi-scalar Collaboration](#)
**Governance for Resilience: CALFED as a Complex Adaptive Network for
Resource Management**

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ABSTRACT. A study of California’s water planning and management process, known as CALFED, offers insights into governance strategies that can deal with adaptive management of environmental resources in ways that conventional bureaucratic procedures cannot. CALFED created an informal policy-making system, engaging multiple agencies and stakeholders. The research is built on data from 5 years of field work that included interviews with participants, review of documents, and observation of meetings. We argue that CALFED can be seen as a self-organizing complex adaptive network (CAN) in which interactions were generally guided by collaborative heuristics. The case demonstrates several innovative governance practices, including new practices and norms for interactions among the agents, a distributed structure of information and decision making, a nonlinear planning method, self-organizing system behavior, and adaptation. An example of a resulting policy innovation, a method to provide real-time environmental use of water while protecting a reliable supply of water for agricultural and urban interests, is described. We outline how ideas about complex adaptive network governance differ from ideas about traditional governance. These differences result in ongoing tension and turbulence as they do for other self-organizing governance processes that operate in a context of traditional governance.

Key Words: *adaptive management; collaborative governance; complex adaptive systems; consensus building; policy network; resilient resource management; water policy*

“There is nothing so hard as to change the existing order of things.” (Machiavelli 1952:9)

INTRODUCTION

We argue that the resemblance of California’s program for water management (CALFED) to a complex adaptive system (CAS) allowed it to function to address some of the complex interrelated and fast-moving problems, and ecological and political conditions, in California water management. Adaptive management of environmental resources presents a challenge to traditional government, with its reliance on bureaucratic procedures, the lengthy processes of legislative deliberation, and the often arbitrary nature of judicial decision making. We contend that a fundamental transformation in our ideas about governance is needed to assure the flexibility, timeliness, and learning required for resilience of our social–ecological systems. We explore ideas for adaptive governance by examining

the experience of CALFED during the period from 1994–2003 when its efforts were most successful.

CALFED began in 1994 as a self-organizing entity without a federal or state legislative structure, to meet the challenges of water management in California. Water is one of the most deeply contested and economically important issues in the state. With rain occurring in only six months of the year, and most of the state’s water stored in the snow pack of the northern Sierra Nevada, a vast infrastructure of dams, channels, levees, and pumping facilities is required to move water to urban populations and to the state’s massive agricultural industry. At the center of this system is the Sacramento-San Joaquin Delta, including the San Francisco Bay Estuary (hereafter the Bay-Delta). Sierra water is funneled through the Bay-Delta to most of California’s population through a maze of marshes, islands, and sloughs the size of Rhode Island. This ecosystem nurtures half the birds using the Pacific flyway and 80% of the state’s

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commercial fisheries. A thousand miles of poorly built and aging levees protect Bay-Delta farmland, residents, and businesses, as well as the city of Sacramento, from flooding. The Bay-Delta and California's major rivers and marshes are home to a variety of endangered species and a multitude of other wildlife. To complicate matters further, the state has a bewildering array of overlapping and competing water-rights laws, water contracts, and informal water-use practices.

A wide variety of federal and state agencies and nongovernmental stakeholders have been at odds about these issues for decades. Public agencies have diverse and conflicting mandates, with regulatory agencies attempting to protect wildlife or water quality, and other agencies shipping water to urban or farm users in accord with longstanding contracts. Well-organized stakeholder groups have routinely battled each other before administrative agencies, in the legislature, in the courts, and at the polls. North was pitted against south and interest against interest in paralyzing "water wars" dating back to the early 20th century.

From 1994–2003, in an unconventional and sometimes messy way, CALFED implemented numerous innovative actions to manage water resources adaptively in this contested context. Recent research in complexity science and recent practice in collaborative governance together provide a valuable framework for thinking about governance in the context of contested resources, uncertainty, fragmentation, and interdependence. Applying this framework to CALFED, we identify several innovations in governance that emerged in this program and demonstrate how complex adaptive system thinking can be useful in understanding how governance can enhance resilience. We contrast ideas about traditional governance and complex adaptive governance, and argue that both are relevant to resilient governance.

The Challenge of Governance in the 21st Century

The problems facing policy making in the 21st century seem to overwhelm the organizations society depends upon on. Uncertainty and complexity, fragmentation and diversity, interdependence, and new spaces for decision making all contribute to a changing context for governance (Hajer and Wagenaar 2003). Almost forty years ago, J. D.

Thompson, in his now classic book, warned: "Bluntly speaking, social purposes in modern societies increasingly exceed the capacities of complex organizations, and call instead for action by multi-organization complexes" (2003:157). In his review of the field of public administration, Kettl contends that: "The challenge facing government administrators in the 21st century is that they can do their jobs by the book and still not get the job done" (2002:22). He argues that fundamental transformations are occurring in policy and governance, but practice and scholarship has not integrated these. Jody Freeman, an administrative law scholar, concurs, arguing that the most serious weaknesses of the present system of policy governance is that it is based on an adversarial administrative decision-making process driven by interest representation. To address natural resource issues requires, in her view, collaborative governance, joint problem solving, broad participation, sharing of regulatory responsibility across the public–private divide, and flexible, engaged agencies (1997).

A growing literature documents experiments in emergent forms of environmental policy governance in, for example, the Everglades, Chesapeake Bay (Koehler 2001), and other large water systems: New York–New Jersey Harbor (Mandarano 2008); the Sacramento Water Forum (Connick 2006); the New York Bight (McCreary 1999); Queensland, Australia (Margerum 1999); Oregon (Margerum and Whittall 2004); and Florida (Scholz and Stiffler 2005). A companion literature analyzes and interprets such efforts (Wondolleck and Yaffee 2000, Connick and Innes 2003, Fiorino 2004, Sabatier et al. 2005). Those that go beyond immediate conflict resolution to ongoing management are typically caught in the dilemma of traditional governance versus self-organization. In response, they develop hybrid versions of governance, trying to combine traditional norms and practices with the emergent ones.

We have found in our research that the science of complexity offers insights into ways to address these and helps to develop ideas about the nature of adaptive governance for resilient resource management. A growing literature uses CAS to understand resilience of social–ecological systems (Berkes et al. 2003, Olsson et al. 2004, Gunderson and Holling 2008). There is also a significant literature exploring the implications of CAS thinking for organizations (Stacey 1996, Axelrod and Cohen 1999, Allen 2001, Cilliers 2001,

McKelvey 2001, Stacey 2001, Capra 2002, Bar-Yam 2004, Richardson 2005, Tsoukas 2005). Finally, the futurist Alvin Toffler anticipated a CAS approach to business, saying: "Instead of being routine and predictable, the corporate environment has grown increasingly unstable, accelerative, and revolutionary...The adaptive corporation, therefore, needs a new kind of leadership. It needs managers of adaptation equipped with a whole set of new, nonlinear skills" (1984:2). A significant literature focuses on case studies from business that offer possible lessons from CAS. For example, some of these look at product design (Chiva-Gomez 2004), innovation (Rose-Anderssen et al. 2005), organizational development (van Eijnatten and van Galen 2005), successful computer businesses (Eisenhardt and Tabrizi 1995, Brown and Eisenhardt 1997), and business process and strategy (Allen et al. 2005). There have been relatively few comparable studies in public policy, with notable exceptions such as case studies on urban regeneration (Moobela 2005), water (Medd and Marvin 2005), health services (Kernick 2005), resource management (Connick and Innes 2003), policy networks (Booher and Innes 2002), consensus building (Innes and Booher 1999a), metropolitan development (Innes and Booher 1999c), and indicators for sustainable development (Innes and Booher 2000).

MAKING SENSE OF CALFED GOVERNANCE: COMPLEX ADAPTIVE SYSTEMS AND COLLABORATIVE PRACTICES

We set out to investigate the phenomenon of collaborative governance in the CALFED process, focusing on the period from its inception in 1994, to 2003 when a new structure made it less collaborative. After interviewing numerous participants, observing scores of meetings, and reviewing hundreds of documents, we began to see the potential of CAS thinking for understanding the dynamics of CALFED and to explore its implications as an emergent form of policy governance. As Stacey contends: "...we have to give up the notion that we can understand the system by formulating hypotheses and then seeking to disconfirm them. Instead we have to reformulate what we are doing as trying to make more sense of our own and others' experience of organizational life" (1996:262). As we interpreted the data, we recognized that meaningful use of CAS in this case

depended upon flexible application and translation of complexity concepts (Uden 2005). Our purpose, following Stacey's, was "...to undertake how conditions might be established within which spontaneous self-organization might occur to produce emergent outcomes" (1996:264).

To inform our interpretation, we used five features of CAS and undertook to focus on the interactions and relationships rather than the "system" as a whole, which is in any case difficult, if not impossible, to grasp (Stacey 2001, Cilliers 2005, Tsoukas 2005). The five features we used are:

1. **Agents:** The system comprises large numbers of individual agents connected through multiple networks.
2. **Interactions:** The agents interact dynamically, exchanging information and energy based upon heuristics that organize the interactions locally. Even if specific agents only interact with a few others, the effects propagate through the system. As a result, the system has a memory that is not located at a specific node, but is distributed throughout the system.
3. **Nonlinearity:** The interactions are nonlinear, iterative, recursive, and self-referential. There are many direct and indirect feedback loops.
4. **System behavior:** The system is open, the behavior of the system is determined by the interactions among the agents, and the behavior of the system cannot be understood by looking at the components (Schelling 1978, Stacey 2001). Coherent and novel patterns of order emerge.
5. **Robustness and Adaptation:** The system is potentially resilient, as it has both the capacity to maintain its viability and the capacity to evolve. With sufficient diversity, the heuristics evolve, the agents adapt to each other, and the system can reorganize its internal structure without the intervention of an outside agent.

In this approach, agents represent the diversity of the system in which they are interdependent. The interactions of the agents are organized around the collaborative heuristics we call "authentic

dialogue” (Innes and Booher 2003). Collaborative practices provide the conditions and heuristics for the selection of agents in the network and the organization of the interactions of those agents.

“Collaboration” encompasses many types of cooperative efforts (Healey 1997, Innes and Booher 2003, Booher 2007). Our research has focused on a subset of those processes, in which individuals representing differing interests engage in long-term, face-to-face dialog, seeking agreement on strategy, plans, policies, or actions. The processes are often ad hoc and self-organizing. They are sometimes established by government agencies or legislative bodies to deal with what seem to be intractable problems, and sometimes put together by developers, environmentalists, and other private players frustrated by years of conflict and stalemate, or a community’s use of a limited, common resource (Ostrom 1990, Innes et al. 1994).

Such processes may themselves be understood as CAS, ranging in size from a handful of participants to hundreds organized into interlocking committees and task forces, each working on different aspects of complex issues and tasks. A professional facilitator or a chair acting as a neutral facilitator may establish equality among diverse stakeholders and achieve a free-wheeling dialog. The processes use special meeting management techniques that allow all participants to be heard and be informed, and encourage dialog that is both respectful and open-ended (Susskind and Cruikshank 1987, Susskind et al. 1999). The techniques discourage the taking of positions, instead following the interest-based model of bargaining (Fisher et al. 1991). Our research has shown that storytelling, role playing, and group intellectual bricolage are more prevalent forms of discussion and joint reasoning than trade-offs and logical argumentation (Innes and Booher 1999b). Assumptions and constraints are explored by participants often using a process of joint fact finding (McCreary 1999).

Thus, these dialogs are exploratory, generating and testing ideas, and constantly getting feedback from stakeholders who are actively working outside the dialog. They take account of on going events in real time, and they absorb information of many kinds. Such face-to-face communication allows the sincerity, legitimacy, comprehensibility, and accuracy of statements to be tested; and the inclusion of opposing stakeholders makes it highly likely that assumptions are questioned. This

communicative ideal draws on the concept of communicative rationality as articulated by the social theorist Jurgen Habermas (1984; Innes 2004).

INNOVATIONS IN THE EMERGENCE AND DYNAMICS OF CALFED

Although CALFED had many of the features of a communicatively rational process, it was in many ways a complex adaptive network (CAN). It emerged to address stalemate in California water policy and evolved to develop many heuristics and practices of collaborative processes. We characterize CALFED as emergent and evolving because it was not formally created at the outset. Indeed, it never assumed a fixed form with a unitary agenda or definite boundary around its tables of participants. It began as a rudimentary interagency agreement among state and federal agencies, that in turn emerged from a number of water-related social networks. In December 1994, state and federal agencies signed a memorandum of understanding in which they committed to address jointly four major (and sometimes conflicting) goals in the management of California water policy: water quality, ecosystem quality, water supply reliability, and levee system integrity. This agreement became known as the Bay-Delta Accord (Rieke 1996). It became a collaborative effort to manage the state’s water system, involving 25 state and federal agencies and more than 35 major stakeholder groups. The immediate stimulus for the agreement was the economic, environmental, and political strains from the stalemated decision making on water issues. The governance system of interest group pressure on legislatures, hierarchical public agencies with narrow and conflicting mandates, and adversarial legalism through the courts offered no opportunity for collective problem solving and solutions that would address the systemic issues (Freeman 1997). No one was happy.

The 1994 agreement was possible because many of the agencies and stakeholder groups had already been engaged with each other in forums and networks. These included the San Francisco Estuary Project (Innes and Connick 1999), a policy council set up by the governor, and years of dialog among the three major stakeholder groups. This context created a favorable interest group configuration, representing north and south, agriculture and urban water purveyors, who had come to understand that they could not get their needs met working on their

own (Rieke 1996). In addition environmental groups were well organized and able to participate in a knowledgeable way and the business community was mobilized. Ultimately these players came not only to see their interests as interdependent, but also to agree that ecosystem restoration was essential. Hence, in a sense CALFED was not a new network. It was an evolution from several preceding it.

Governance Innovations in CALFED

Over the 10-year period, CALFED generated several governance innovations to respond to its challenges. Here, we briefly describe four that are most useful in thinking about CALFED as a CAN. These include a distributed network structure, collaborative heuristics for agent interactions, a nonlinear planning method, and self-organizing system behavior.

A distributed network structure

CALFED was led by a policy group made up of heads of state agencies and high level officials from federal agencies. It was officially accountable to the governor and the U.S. Secretary of the Interior, both of which took a hands-off approach, allowing CALFED to select and work through issues in its own way. A management team of agency deputy directors turned policy group decisions into action. The CALFED agencies had diverse and conflicting mandates. They came together, each with individual objectives, as they were motivated in part by internal organizational needs, such as ensuring the agency's ability to put its appropriations to good use, and securing the support of their constituencies and the legislature. The interdependence of their missions, their varied interests, resources, and power created both additional motivation and a negotiating space.

CALFED depended on a shifting set of diverse ad hoc task groups, engaging hundreds of agents over time and typically building trust and joint learning as well as finding creative solutions to issues. These work groups offered forums for ideas to be aired, developed, tested, and improved, and created many of the ideas and programs that were carried forward. These groups also played key roles in what became CALFED's system of distributed intelligence and adaptive policy making. The stakeholders linked to agents across the state and brought into

deliberations up-to-date information from their direct knowledge about conditions and political issues (Innes et. al. 2006).

Four interlinked groups played a central role in CALFED by collectively providing advice about changes in operations of the water projects. The policy group typically followed this advice. These were made up of agency staff and stakeholder representatives from around the state. The operations group (Ops) coordinated operations of the water projects, another group evaluated water supply alternatives, a third looked at the effects of water diversions on fisheries, and a fourth was a coordinating team made up of members of all the groups. Participants provided indicators about fish or water levels, which they monitored in their areas. They met by conference call when conditions required and worked together to analyze the implications of the data. Thus, they were able to operate on a real-time basis, reacting quickly to changing conditions. This is in contrast to traditional bureaucratic procedure where formal decisions must await formal analysis, rule-making, and public comment. Yet the process had a remarkable degree of legitimacy among stakeholders, because they were engaged in it themselves and the effort was so transparent.

CALFED's Bay-Delta Advisory Council (BDAC) became a forum for stakeholders to air concerns and in turn to communicate with the members of their organizations about the issues. Subcommittees to BDAC did much of the work that became part of how CALFED learned and decided. These operated in an informal way, relying largely on collaborative interactions. They focused on such key issues as ecosystem restoration, finance, water-use efficiency, water transfers, drinking water, and watersheds. Subcommittee composition depended on the topic, but each committee included a diverse set of knowledgeable stakeholders, experts, and agency personnel. One group created the process for reviewing funding proposals and developed much of CALFED's watershed program. Some broke down in conflict. These were not professionally facilitated and participants were not trained in collaborative processes, so much depended on the skills and social capital members already had acquired in earlier network activity.

The agencies and stakeholders in CALFED had numerous individuals actually participating, but an

accurate account of the total number of agents is impossible because of the fluidity and open nature of the system. However, there were at least hundreds of agents directly involved in it, and perhaps thousands of agents indirectly involved. As the above description illustrates, CALFED's structure was characterized by the "patching" hierarchy that Kauffman has articulated (1995), that is, networks are structured in clusters instead of all agents being directly connected with each other. According to Stacey, "patching reduces the number of connections across the whole system and so tends to stabilize it enough to avoid the destructiveness of highly unstable dynamics" (2001:177). It also resembled a core-periphery structure, that is, the core groups were linked to other stakeholders at the periphery (Ernstson et al. 2008).

Collaborative interaction heuristics

CALFED also changed heuristics and norms for interactions of those involved in California water management. Staff, participants, and observers referred to "the CALFED way" as shorthand for the difference between the new way of doing governance and the old. Staff identified seven elements of this contrast, depicted in Table 1, to which we have added an eighth based upon our observations.

In the CALFED way, the agents recognized that collaboration largely replaced gridlock and litigation as a form of governance. Instead of each agency making project decisions independently, CALFED created the Programmatic Record of Decision (ROD) as the framework for decisions, offering principles for choice and action. Participants understood that there must be balance and linkages among projects to keep all stakeholders at the table. Most understood that they needed to support the whole package and, thus, the whole system, if they were to get what they needed. The CALFED way also involved a shift from individual agencies pursuing single-purpose projects, to coordinated multiple-purpose projects that met several objectives. In the past, grants for projects were offered and administered by separate agencies, each with its own requirements and timelines, but CALFED developed an integrated grant-making process. Another major change was a shift toward more local and regional initiatives and problem solving to replace top-down, centralized decisions. CALFED provided technical and fiscal support to

regional efforts, conducted statewide grant programs that required regional review, appointed regional coordinators and teams, conducted regional workshops, and integrated regionally developed goals and objectives into CALFED implementation.

CALFED was more open and inclusive of public involvement than its member agencies had been, with its many stakeholder teams, open meetings, and Internet postings of agendas and minutes. It established the Independent Science Program and interdisciplinary board to assess the science, which until then had been the purview of individual agencies and their consultants. No matter what agency sponsored the study, many observers had regarded the data as untrustworthy, and CALFED aimed to change that. CALFED was also predicated on transparency, opening up the workings of various agencies to each other and to the public. Finally, CALFED embraced the idea of adaptive management and learning to address the uncertainty, rapid change, conflict and complexity of California water systems, in ways that traditional hierarchical government had been unable to do.

Nonlinear planning method

CALFED's nonlinear planning method emerged from a tension between the need to comply with the procedural mandates for agency decision making, and the desire to have a collaborative, long-range planning process for an extremely complex resource system using extensive stakeholder and public involvement. Agencies were constrained by federal and state "sunshine" laws that, although designed to assure public involvement, ironically interfered both with open-ended, evolving, collaborative interactions and incorporation of stakeholders directly into the dialog (Boxer-Macomber 2004). In addition, the National Environmental Policy Act (NEPA), and California's equivalent (CEQA), called for linear, stepwise decision processes, that are at odds with the dynamic of collaborative interactions that go back and forth between such tasks as idea-generating and addressing implementation issues.

To comply with procedural mandates, CALFED players tried to follow standard early steps in the first phase: defining issues and problems, identifying possible actions, and refining them into alternatives for evaluation, but soon discovered

Table 1. Comparison of governance heuristics before and after CALFED.

| Before CALFED | After CALFED |
|---|--|
| Gridlock and litigation-driven process | Collaborative process |
| Project-by-project decisions | Comprehensive framework with linkages and balancing requirements |
| Single agency, single-purpose projects | Multiple purpose, interagency projects |
| Centralized decision making | Emphasis on local and regional solutions |
| Limited public involvement | Extensive public involvement and leadership |
| Internal agency science; no peer review | Independent science reviews |
| Limited or no accountability or transparency | Public governing body and planning and tracking systems |
| Mechanistic decision making based upon assumptions and mandates | Flexible, adaptive management and learning |

these steps were not working. In collaborative processes, defining issues and problems takes time and only occurs once agreement begins to emerge on solutions. Much happens simultaneously as participants become aware of complexities and uncertainties. Moreover, participants in CALFED began to realize there would have to be a package of actions with linkages among them and assurances to all the parties that their needs would be met. None of this could be done in a linear way.

Accordingly, participants moved away from the linear approach in subsequent planning as they worked on the options and began taking agreed-on actions even before the plan was complete. They developed six solution criteria in the planning process that provided useful heuristics for further exploration of options. These criteria for choosing actions included that solutions should be affordable, equitable, implementable, and durable, and that they should reduce conflict and not redirect negative impacts. Establishing such criteria early on in a

collaborative process follows best negotiation practice (Fisher et al. 1991), and it provides heuristics for agent decision making. Critical to the success that CALFED had in its planning was the fact that the agencies began with an agreed-on framework for working together on an agreed-on set of issues. No one had to precommit to anything. Moreover, they did not set up detailed procedures. They could develop their interactions in their own way, relying on trial and error learning.

In 2000, CALFED moved from planning to implementation by creating the ROD. The ROD was not really a plan but, rather, a marker of the agreements so far to guide the process, ostensibly for the next 30 years. It had holes in it and areas that remained unsettled, but participants were eager to have a document recording what had been agreed on because they hoped to get buy in from the incoming federal administration. A formal plan was not compatible with the ongoing collaboration and with its adaptive evolving nature and its learning.

Self-organizing system behavior

CALFED was an open system. Indeed, it is hard to identify a specific boundary for the process. Rather, participants defined and redefined their task and scope along the way, adapting to new problems and information. The system's behavior was determined by their interactions and relationships, not by the formal roles of the agents in their agencies. As a result, the agents evolved their interaction heuristics, regularly reorganized their internal structure by creating new task forces and eliminating others, and created new practices for adaptive management of the system.

Although each group had a clear purpose, they were self-organizing and allowed to pursue their tasks in their own way. They had access to high-quality information and could do joint fact-finding among themselves, as they did in the Ops group. They were not constrained to stick to the status quo. They could and did challenge assumptions, as their many innovations amply testify. As participants challenged one another, offered one another unfamiliar information, and created shared understandings, they produced new strategies for dealing with thorny issues. Groups did not settle on the lowest common denominator solutions, but hammered out proposals that dealt with the concerns and information of all members before sending recommendations forward. Innovation emerges from such free-flowing, networked systems among interdependent agents, because it brings their diverse ideas into play, along with diverse needs. As Lebel et al. proposed, the capacity to manage for resilience is enhanced by participation that builds trust and deliberation that leads to shared understanding and by a polycentric and multilayer structure to improve the fit between knowledge, action, and social-ecological contexts (2006).

The interactions and the subsequent patterns of system behavior did not eliminate conflict or remove the effects of power dynamics. As Stacey argues, power enables as well as constrains (Stacey 2001). Although at times conflict and power disrupted the collaborative interactions, "...without such disruptions to current patterns of collaboration and power relations there could be no emergent novelty in communicative interactions and hence no novelty in any form of human action. The reason for saying this is that disruptions generate diversity [and] ...the spontaneous emergence of novelty depends upon diversity" (Stacey 2001:149).

Despite the power dynamics coherence emerged "... in the vast complexity of communicative interactions across enormous numbers of local situations because of the intrinsic capacity of self-organizing interaction to pattern itself coherently" (Stacey 2001:176). The resulting system dynamic was one both of stabilizing continuity and of transformation.

The environmental water account

One of CALFED's policies, the Environmental Water Account (EWA) may best exemplify how collaborative CAN governance can provide for adaptive management of a resource. It was born in 2000 in dialogs of Ops and its associated groups and supported by almost all major interests (Hudzik 2003). The idea of the EWA is to acquire water for endangered species protection through voluntary sales and contracts, and hold this water in reserve to use when it is needed most. This reduces the likelihood of restrictions on water deliveries to agricultural and urban users.

One of EWA's original architects emphasizes how it differed from the traditional governance approach.

EWA creates a water supply for fishery needs without relying on regulatory edicts. Instead, its operators ...acquire water for the environment from existing water right holders or from maximizing the use of water project facilities. With this water supply at their disposal water project operators can make timely, critical adjustments in operations to make water available to fulfill the needs of listed species and project contractors while preventing reductions in deliveries due to such adjustments. EWA ... [works] better than fixed prescriptive standards that restrict water project operations for the benefit of several particular listed species. Such an account can share the benefits of wet hydrology and new facilities, allowing both the ecosystem and water users to enjoy improved conditions. (Brandt 2002:427-428)

Setting seasonal pumping restrictions by biological opinion under the Endangered Species Act does not allow for a quick response to constantly changing conditions. Under this regime, only when project operations exceed official fish take limits do the

fishery agencies seek pumping reductions. At this stage, the required reductions are often substantial, but too late to prevent the excess fish take. With EWA water as collateral, the fishery agencies can instead call for early and moderate pumping reductions that are less problematic for other water users. Thus, the EWA is anticipatory, rather than solely reactive.

Running the EWA became one of CALFED's most important activities. It involved extensive data gathering and detailed modeling, done in a transparent, inclusive, and collaborative way, that largely assured buy in from the stakeholders. It used computer modeling of the water flows and fish impacts, and gaming and simulations among the stakeholder experts to develop and improve the models, as well as to anticipate scenarios. Stakeholders questioned data and brought new information and insight into the process. Participants shared their knowledge and understanding, that in turn became part of the analysis. This effort is an excellent example of joint fact finding (McCreary 1999), which is at the core of collaborative planning and contributes to both resilience and robustness.

According to an independent review panel, the EWA assured supply reliability to contractors, while providing a level of fish protection that was probably higher than could have been attained by the fixed standards that would have otherwise been applied. The panel found that the EWA succeeded in getting agencies and stakeholders to work together in real-time collaboration to provide water for fish protection, instead of feuding. Wildlife-management and water-operations agencies came to understand each other's needs and perspectives. Despite the technical and political complexity of acquiring environmental water in a timely and economical manner, the process was functioning smoothly (Environmental Water Account Review Panel 2005).

The report also said that the ability to make timely, reasonable decisions in the presence of scientific uncertainty had become one of the hallmarks of the program. Importantly too, the panel found that the EWA advanced scientific knowledge and that new insights were incorporated into improved models. These insights, in turn, fueled critical and creative thinking and formed a basis for more effective management. The panel found that the gaming and modeling were valuable in identifying unanticipated

consequences of proposed actions and allowing rapid management response. Finally, the panel noted that management criteria had grown more complex as the EWA moved away from using a single indicator (usually fish take at the pump, a simple measure which works with a traditional regulatory approach) to looking at multiple, interrelated dynamics of the fish populations.

Robustness and Adaptation: Water Management since CALFED

The extent to which CALFED has enhanced the resilience of the Bay-Delta, and of California water management, remains an open question. The ecology of the Bay-Delta and the reliability of California's water supply are still imperiled. In 2003, the state legislature established a state oversight body, the California Bay-Delta Authority, partially because legislators were frustrated by not understanding how CALFED worked and partially because the federal agencies under the new Bush administration had withdrawn from engagement in it. The policy group was disbanded, and CALFED was folded into the state's Resources Agency. The collaborative heuristics dissipated, state and federal governments were no longer providing leadership and funding, and agencies and stakeholders retreated to more adversarial relations as their understanding of interdependence was lost. However, by 2005, there was a growing sense that the authority was not working as a governance structure and a return to a more collaborative approach was needed. The California Little Hoover Commission carried out a comprehensive review of the Bay-Delta Program. It recommended: 1) repeal of the authority, 2) return to a state-federal partnership, 3) restoration of the policy group, and 4) inclusion of stakeholders in a new structure (Little Hoover Commission 2005).

In 2006, the Governor and Legislature required a cabinet committee to present recommendations for a Delta vision. The Governor created a Delta Vision Blue-Ribbon Task Force to advise the cabinet committee and a coordinating committee of 43 stakeholders, many of whom were participants in CALFED, to advise the task force. The task force and coordinating committee utilized professional facilitation services. In 2007, the task force presented its Delta vision that reflected the input of the stakeholders. Its recommendations included that the "institutions and policies for the Delta should be

designed for resiliency and adaptation” (Blue-Ribbon Task Force 2007:2). The task force then prepared a strategic plan in 2008 that was adopted by the cabinet committee and submitted to the Legislature in 2009 (Blue-Ribbon Task Force 2008). In late 2009, the Governor and Legislature enacted a package of laws to implement the recommendations. Among other things, this legislation repealed the Bay-Delta Authority and set goals for the Bay-Delta similar to the goals first adopted by CALFED.

Through all of this, many of the innovations of CALFED continue to function. For example, the ROD remains in effect, as do the EWA and the Independent Science Program. A program to encourage conjunctive use, the Integrated Storage Investigation, has expanded to include collaborative processes in numerous groundwater basins throughout the state. After 2005, agency and stakeholder networks began to re-emerge, first collaborating on the creation and work of the Blue Ribbon Task Force, and later negotiating on the details of the legislative package. These events suggest that the governance innovations emerging from CALFED are indeed adaptive and robust, as they persisted through the numerous transformations of structure and percolated into other decision domains.

COMPLEX ADAPTIVE NETWORKS AS AN ALTERNATIVE GOVERNANCE PROCESS

Drawing on the experience of CALFED and the literatures of CAS, collaborative governance, and policy network theory (Kickert et al. 1997, Sorensen and Torfing 2008, Innes and Booher 2010), we suggest that a new process for governance of complex social-ecological systems is emerging. We believe that this emergent governance form is more resonant with effective approaches to adaptive management that enhance resilience for resource management than are traditional government practices. Adaptive and traditional governance ideas differ along many dimensions, as we outline in Table 2.

Classic ideas about traditional governance involve a top-down hierarchy under central control, with a closed boundary and a single authority. In contrast, a collaborative CAN, such as CALFED, is characterized by interdependent network clusters under distributed control, with an open boundary

and shared authority. The goals of agencies in traditional governance are ideally clear with defined problems. The goals in a collaborative CAN are various and changing, as they were in CALFED.

The management and leadership functions are also different. For traditional governance, the manager is an organization controller who plans, designs, guides, and directs the organization processes. A directive leadership approach is often thought to be the most efficient. In a collaborative CAN, the manager is a mediator and process manager who selects agents and resources, influences conditions to guide interactions, and provides opportunities for the agents to interact. The optimal leadership approach is generative, enabling participants to jointly learn and decide on actions (Roberts 1997). This is similar to the management and leadership patterns of managers that evolved in CALFED.

In traditional governance, planning is linear and the criterion for success is the attainment of policy goals. In a collaborative CAN, planning is nonlinear and the criterion for success is the realization of collective action by the agents. Although planning was nonlinear in CALFED because it functioned in the shadow of traditional governance, it was constantly under pressure to establish goals and be judged by the degree to which they were achieved. Finally, in traditional governance, the theory of democratic legitimacy that is thought to be appropriate is representative democracy. Alternatively, the legitimacy of collaborative CAN may best be grounded in deliberative democracy (Richardson 2002, Booher 2008). Because CALFED operated in the shadow of traditional governance, there was constant tension between its patterns of interaction and the demands of representative democracy, including the need to take direction from the Legislature.

The CALFED experience shows us that both approaches to governance will be with us for some time and that those engaged in governance will have to learn to live in two worlds, just as its participants did (Sorensen and Torfing 2008). Indeed, the tension between collaboration and traditional governance may be a source of novelty contributing to resilience (Stacey 2001). In the long term, governance strategies for resilience may require a combination of strategies depending on the context. For example, the rate of change and the predictability of the outcome of change may imply different strategies. Collaborative networks may

Table 2. Comparing traditional governance and collaborative CAN governance ideas

| Governance dimension | Traditional governance | Collaborative CAN governance |
|------------------------|---|--|
| Structure | Top-down hierarchy | Interdependent network clusters |
| Source of direction | Central control | Distributed control |
| Boundary condition | Closed | Open |
| Goals | Clear with defined problems | Various and changing |
| Organizational context | Single authority | Shared authority |
| Role of manager | Organization controller | Mediator, process manager |
| Managerial tasks | Planning and guiding organization processes | Guiding interactions, providing opportunity |
| Managerial activities | Planning, designing, leading | Selecting agents and resources, influencing conditions |
| Leadership approach | Directive | Generative |
| Nature of planning | Linear | Nonlinear |
| Criterion of success | Attainment of goals of formal policy | Realization of collective action |
| System behavior | Determined by component participant roles | Determined by interactions of participants |
| Democratic legitimacy | Representative democracy | Deliberative democracy |

work better as change becomes faster and more uncertain. On the other hand, traditional governance may be more appropriate in times of stability and predictability (Duit and Galaz 2008). Similarly, the degree of fragmentation of preferences for ends and means may imply different approaches. Contexts with high fragmentation may require CAN governance, whereas traditional governance may work well in contexts with relatively minor fragmentation in preferences. Also, it may be useful to distinguish between a collaborative role and an enforcement role in governance (Hahn et al. 2006). Finally, it may be that resource systems are multiscale, requiring different management approaches at different scales simultaneously (Berkes 2002).

COMPLEX ADAPTIVE SYSTEMS AND THE FUTURE FOR GOVERNANCE

As we have learned from physical and biological sciences, a complex adaptive system is constantly at the edge of chaos. In this state, it can cross a phase transition into a new basin of stability. The risk is that it could also transition into actual chaos or fall back into stasis and essentially die. Using complexity thinking to better understand resilience of resource systems focuses attention on the need for governance approaches like CALFED that help create learning and innovation from the turmoil. This and similar experiments can help us understand both the contested boundaries and the interactions between traditional and collaborative CAN governance. They can help us see how such informal efforts operate at the interstices of formal

government, doing what formal government cannot (Innes et al. 2007). The experience from CALFED indicates a need to think in terms of new processes for governance, particularly for controversial, complex, and fast-changing environmental issues that require adaptive management. Self-organizing processes such as this, facilitated by leadership and incentives of higher levels, can make governance systems more resilient in the face of change and complexity (Olsson et al. 2004).

Charles Lindblom offers a vision of a self-guiding society in which solutions to problems emerge, not from design or central authority, but from continual reconsideration of problem definitions and mutual adjustment of volitions. In this context, there “exists no route to be discovered, only routes [participants] must create” (Lindblom 1990:302). CALFED may be seen as such a self-guiding system, its agents trying in a turbulent context to create their own shared path to the future.

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/vol15/iss3/art35/responses/>

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