Navigating the transition to ecosystem-based management of the Great Barrier Reef, Australia

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We analyze the strategies and actions that enable transitions toward ecosystem-based management using the recent governance changes of the Great Barrier Reef Marine Park as a case study. The interplay among individual actors, organizations, and institutions at multiple levels is central in such transitions. A flexible organization, the Great Barrier Reef Marine Park Authority, was crucial in initiating the transition to ecosystem-based management. This agency was also instrumental in the subsequent transformation of the governance regime and provided leadership throughout the process. Strategies involved internal reorganization and management innovation, leading to an ability to coordinate the scientific community, to increase public awareness of environmental issues and problems, to involve a broader set of stakeholders, and to maneuver the political system for support at critical times. The transformation process was induced by increased pressure on the Great Barrier Reef (from terrestrial runoff, overharvesting, and global warming) that triggered a new sense of urgency to address these challenges. The focus of governance shifted from protection of selected individual reefs to stewardship of the larger-scale seascape. The study emphasizes the significance of stewardship that can change patterns of interactions among key actors and allow for new forms of management and governance to emerge in response to environmental change. This example illustrates that enabling legislations or other social bounds are essential, but not sufficient for shifting governance toward adaptive comanagement of complex marine ecosystems.

adaptive governance | ecosystem services | transformation

The widespread degradation of marine ecosystems and their biodiversity (1–3) results to a large extent from a failure of governance (4, 5). Traditional focus on single-species resources in fisheries and aquaculture has created organizational and institutional structures with compartmentalized decision-making processes, leading to narrow policy instruments that create incentives for policies and actions that undermine sustainability (6–8). Such governance is ill prepared to respond to the complexity of dynamic ecosystems or build an adaptive capacity for coping with change and uncertainty (9–12). These approaches are often overwhelmed by global economic drivers (13–15) and cannot address the complex threshold dynamics of linked social–ecological systems (16–18). New and more effective governance systems are urgently needed.

The Millennium Ecosystem Assessment (19) highlighted the importance of incorporating an understanding of ecosystem dynamics into governance systems to build capacity for managing ecosystem services. The search for better approaches to ensuring sustainable outcomes has helped develop important principles and protocols for ecosystem-based management of marine resources (4, 5, 20, 21). These acknowledge ecosystems as complex dynamic systems and address the mismatch between social systems and ecosystem dynamics. Typically, prevailing approaches emphasize spatial planning, usage zoning, and marine protected areas (22–27). However, the burgeoning literature on ecosystem-based management offers few empirically based insights into social–ecological strategies that make transitions to such management possible. Different disciplines have studied pieces of the puzzle, for example, organizational (28) and institutional aspects (29), but have rarely analyzed broader social–ecological dynamics.

A literature on the role of leadership strategies in transitions to ecosystem-based management is emerging (30–33), focusing on the relationship between social structures and human agency (human capacity to make and impose choices). The scholarly debate in political science recognizes rigidity, veto points, and path dependence as common characteristics of institutions and public policymaking (34). This includes sudden change and "punctuated equilibrium" where long periods of stability and incremental change interact with abrupt, nonincremental, large-scale change (35–37). Windows of opportunity offer possibilities for large-scale change (38, 39). Windows may open because of exogenous shocks and crises, including shifts in underlying economic factors such as a rapid rise in energy prices, a change in the macropolitical environment, new scientific findings, regime shifts in ecosystems, or rapid loss of ecosystem services (32, 39). Ingram and Fraser (40) use such a punctuated equilibrium framework (37) to analyze policy innovations in water management in California, where water management and policy were locked into a highly engineered infrastructure that reinforced one policy and excluded others. A new awareness has now emerged among multistakeholders in California water management. Policy and management have shifted and broadened to incorporate a wider array of state and federal agencies as well as private and public organizations. This demonstrates how rigidity in policymaking can stifle innovations and capacity to deal with crises (41).

New frameworks are emerging for investigating the interplay between long periods of stability and abrupt change in social–ecological systems and analyzing shifts toward ecosystem-based management (9, 42, 43). In this context, there is an urgent need to identify strategies that have enabled transitions in management from a conventional focus on a single resource or habitat to large-scale ecosystem-based management. Management brings together existing knowledge from diverse sources into new perspectives for practice (44). Here, transition refers to a shift from one management system to another, often a discontinuous shift to a new management trajectory (45). We argue that, to understand such transitions, for dealing with the degradation of marine ecosystems (2, 3), there is a need to address governance systems and investigate transformations from one governance system to another. By governance systems we mean the interaction patterns of actors with conflicting objectives and the instruments chosen to steer social and environmental processes within a particular policy area (18). Institutions are a central component (46–48), as are interactions between actors and the multilevel institutional setting, creating

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Table 1. Strategies used by GBRMPA for facilitating the transition to ecosystem-based management

Strategies	Actions	Examples of barriers to change
Making internal organizational changes	Establishing Senior Managers Forum and four regional teams	Resource constraints
	Providing clear and transparent leadership at the relevant levels within the organization	Inability to innovate or deal with surprise
	Communicating a shared vision and goals	Lack of direction, shared vision, engagement, trust, leadership, cross-sector cooperation, and communication
		Having few leaders exacerbates vulnerability
Bridging science and policy	Drawing on existing networks of scientists, managers and industry to promote dialogue	Science is fragmented
		Lack of scientific certainty
	Workshops and forums for synthesizing knowledge	Different perceptions and views among scientists and managers, lack of trust
	Communicating shared vision and goals	
Changing public perceptions	Clear, simple, and tailored stakeholder information from a communication professional	Different knowledge and interests among stakeholder groups
		Low awareness of problems, threats, and ecological interactions
	Visualizing the entire GBR as an interconnected ecosystem	
	Creating a sense of urgency for conservation	
Facilitating community participation and public consultation	Building trust with communities: personal interactions and regional teams	Lack of trust
	Community information sessions	Conflicting views among key actor groups, misinformation
	Recasting problems as opportunities	Outreach to local communities difficult
	Periodic updates on the rezoning process	Lack of leadership
	Innovative submission routines	
Gaining political support	Prepared for change: politically expert staff, timing actions, having relevant information ready	Change of people in power
		Lack of support from key politicians
	Briefing key players well before the new zoning plan	Zoning plans can be stopped
	Allying with other key actor groups	Opposing views
	Pollsters for leverage and monitoring public opinion	

complex relationships between people and ecosystem dynamics (18). The adaptive governance framework specifically addresses such dynamic interactions and the social–ecological capacity to sustain ecosystem services in the face of uncertainty and change (49, 50).

The Great Barrier Reef Marine Park (GBRMP), the largest coral reef system in the world, has recently undergone a major rezoning and transformation in governance toward stewardship of the large-scale seascape, incorporating 70 bioregions (including many non-reef habitats). The rezoning was an ambitious effort to better manage the Great Barrier Reef (GBR) and associated ecosystems and strengthen their resilience in the face of climatic change, i.e., their ability to cope with disturbances and continue to generate essential ecosystem services (22, 51–53).

This article identifies social features and strategies that made it possible to shift the direction of an already-existing multilevel governance regime toward large-scale ecosystem-based management. We hypothesize that achieving such a shift is more complex than simply changing legislation, providing economic instruments, or introducing new restrictions on resource use. What triggered the transition? Which were the significant events? Who were the key stewards? What were the barriers to the transition? What strategies and actions were used to overcome barriers and mobilize the shift? How did these strategies and actions help to change incentives, perceptions, institutions, and patterns of interactions between actors? To investigate these issues, we analyze multilevel interactions among individuals, organizations, and institutions in relation to ecosystem management of the Great Barrier Reef. Following on our earlier studies of transformations in social–ecological systems (31), we were especially interested in how the rezoning was developed and the preparations that helped seize a political window of opportunity.

We focus on the main agency involved in the rezoning, the Great Barrier Reef Marine Park Authority (GBRMPA), which initiated the shift. Data collection included an extensive review of published and online sources, from 1975 to the present, to capture the history of legislation, governmental agencies, public opinion, and how the rezoning developed. Sources included scientific articles, legal documents, staff papers, annual reports, reports on the state of the reef, reviews, strategic plans, maps, and fact sheets, as well as the GBRMPA web site (www.gbrmpa.gov.au). We also conducted 22 open-ended, in-depth interviews (54, 55) with key informants involved in the rezoning. Interviewees were asked to describe significant events during the rezoning process, triggers for initiating zoning at the scale of the seascape, strategies and actions to make the shift, and barriers to change. The interviewees were asked to name key individuals instrumental in shaping change and navigating the transition. A "snowball sampling" technique was used for selecting interviewees (54).

We used qualitative data analysis (56) to analyze the collected data. The conceptual framework, hypothesis, and the research questions stated in the introduction were used to select, focus, and organize the data. A first analysis of written sources and interviews identified important events and interacting structures and processes that facilitated the shift. This information is presented in the sections that follow. The initial analysis also identified actions taken to deal with specific barriers to change. These insights guided the next step of the analysis: identifying individuals that could link actions to specific governance strategies and describe the motivation behind these strategies, how they were developed, and what triggered them. Five overall strategies emerged from our analysis described as Table 1 and in associated text.

Great Barrier Reef Marine Park

The Park covers 344,000 km^2, an area almost the size of California. Coral-dominated assemblages form discontinuous fringing reefs on the mainland and inshore granitic islands. Most reefs are found 30–200 km offshore, on the middle and outer edge of the continental shelf. Many other non-reef assemblages occur near the shore, on soft bottoms and in deeper water between the reefs (e.g., mangroves, seagrass beds, etc.). Like many other coral reefs, the Barrier Reef generates a multitude of essential ecosystem services (57). The GBR Marine Park contributes AU$6.9 billion annually to the Australian economy, >85% of which is from the tourism industry (58).

The Australian federal government enacted The Great Barrier Reef Marine Park Act in 1975 in response to public concerns about threats to the reef from oil drilling, mining, and unexplained outbreaks of coral-eating starfish (59, 60). The act established GBRMP, and in 1981 the Great Barrier Reef region was also declared a World Heritage Area. The marine park is a multiple-use marine park, allowing a range of uses based on spatial zoning (22). The seven marine zone types range from general use (the least restrictive zone, allowing most reasonable use) to preservation

(very small "no-go" areas set aside as scientific reference areas). Use and entry are allowed, either "as-of-right" or by permit in all zone types. The GBRMP generally extends inshore to the low-water mark but excludes some near-shore areas managed by the State of Queensland. The State has created the Great Barrier Reef Coast Marine Park to protect tidal lands and coastal waters. The State Park complements the federal GBRMP by adopting similar zone objectives and entry and use provisions. The comanagement between the federal and the state governments originates from a formal agreement signed in 1979. This federal–state cooperation is important for enabling ecosystem-based management of the region.

Zoning and Rezoning the Great Barrier Reef Marine Park. The Great Barrier Reef Marine Park Act established the GBRMPA in 1976 and required the new agency to initiate zoning plans for the marine park. The Authority grew in size and sophistication over time and since 2000 has a staff of >130 and an annual budget close to AU$30 million (GBRMPA annual reports). Between 1983 and 1988, each of the four sections of the GBRMP (the Far Northern, Cairns, Central, and the southern Mackay/Capricorn sections) were zoned for the first time. No-take areas together accounted for 5% of the marine park, mainly in the remote Far Northern area and predominantly covering coral reefs (reefs were considered the most important habitats at that time but actually make up only 6% of the entire GBRMP).

As scientific information accumulated from the 1970s onward, it became apparent that the Great Barrier Reef was showing signs of degradation, primarily from runoff of sediment from land, overharvesting, and more recently from global warming. Recent analysis of banded coral skeletons show that runoff of sediment from land increased between 5- and 10-fold after about 1870, when European settlement and overstocking of semiarid river catchments began (61). Recurrent outbreaks of crown-of-thorns starfish, which destroy large amounts of coral, have affected >200 reefs since the early 1960s (62). One theory for these outbreaks is that enhanced runoff of nutrients from land has shortened the starfish's larval phase, leading to population explosions (63). Stocks of mega-fauna species on the Great Barrier Reef including dugongs, turtles, and sharks have fallen dramatically since European settlement (1). Similarly, the size and densities of fish species targeted by recreational and commercial fisheries have declined in recent years. The biomass of coral trout is up to six times lower on heavily fished near-shore reefs compared with adjacent no-take areas established in the 1980s (64). Demographic and economic data gathered in the 1980s and 1990s showed rapid growth in human population, land clearing, coastal development, tourist visits, and fishing pressure. Gradually, it became clear that the initial level of protection did not adequately protect biodiversity within the GBRMP or ensure that the entire ecosystem remained healthy, productive, and resilient (1, 2, 62).

In the late 1990s there was growing awareness among scientists and reef managers that many biological communities on the GBR, such as inshore and deeper habitats, were poorly represented in existing no-take zones. They also realized that connectivity of larvae and other poorly understood interactions between reef and nonreef habitats were important to maintain the resilience of the entire ecosystem. Unprecedented regional bleaching occurred in the summer of 1997/1998, affecting large parts of the GBR and other reefs in the Western Pacific and most of the tropical Indian Ocean (65). It was a rude wake-up call to the dangers of global warming for coral reefs that required an urgent response.

In 1998, the GBRMPA initiated a major rezoning of the marine park called the Representative Areas Program (RAP) (22, 53) to systematically increase the protection of biodiversity within the GBRMP by protecting representative examples of each type of habitat within a network of no-take areas. Focus was on protecting biodiversity and maintaining ecosystem function and services rather than on maximizing the yield of commercially important fisheries. The RAP process began in 1998–1999 with a mobilization of scientific expertise to identify and map habitat types. Panels of experts compiled >40 existing data sets to characterize the biological and physical diversity of the GBRMP (53). Geographic information systems-based tools and analytical methods identified and mapped 70 bioregions, of which 30 were reef bioregions and 40 were non-reefal. (A map of the 70 bioregions in the GBRMP is available at www.gbrmpa.gov.au/_data/assets/pdf_file/0016/7315/bioregions_2001_06.pdf.)

Formal community participation in the RAP process took place in two phases (66), with informal consultation throughout the planning phase. Over a 3-month period from May 2002, GBRMPA sought formal community input for preparation of a Draft Zoning Plan for the entire GBRMP. This resource-intensive process used a range of techniques to ensure that all coastal communities adjoining the marine park were aware of the RAP. This first round of formal public participation resulted in 10,190 written submissions. By a combination of expert opinion, stakeholder involvement, and analytical approaches, different options for no-take area networks were identified by GBRMPA using a variety of planning tools to integrate biophysical, social, and economic information (51, 52, 67–69). This led to the completion of the Draft Zoning Plan and focused the second formal community participation phase (66), which resulted in 21,500 additional written submissions (70).

In late 2003, the Draft Zoning Plan was revised to incorporate information from the second consultation process, resulting in the Revised Zoning Plan, which increased the percentage of no-take areas in the GBRMP by >6-fold to 33%, including at least 20% of each of the 70 bioregions. In December 2003 the new zoning plan was submitted to federal parliament and passed into law in July 2004. The Australian Government also agreed to a structural adjustment package providing compensation for those (such as commercial fishers) adversely affected by the new zoning.

Key Strategies Behind the Shift to Ecosystem-Based Management. Through the methods and data analyses outlined in the introduction, we identified five general strategies that were used by GBRMPA to implement RAP and the new zoning plan. These are (*i*) internal organizational changes, (*ii*) bridging science and policy, (*iii*) changing people's perceptions, (*iv*) facilitating public consultation and participation, and (*v*) gaining political support. Our qualitative data analysis also revealed several actions taken to deal with specific barriers to change. The following section describes general strategies, actions, and examples of barriers, summarized in Table 1. A common feature of GBRMPA's strategy was anticipating and addressing potential barriers to the implementation of an ecosystem-based approach.

Internal organizational changes. The GBRMPA executive team during RAP comprised the chair, Virginia Chadwick, and two executive directors, to whom senior managers report. GBRMPA underwent major internal organizational changes from the late 1990s onwards. Some changes were based on a 25-year strategic plan (71) and a 1997 report that suggested that GBRMPA should be organized around four critical environmental issues (72). This was a turbulent time for GBRMPA, with a high staff turnover rate that facilitated internal reorganization (73). The emerging concept of rezoning the entire marine park initially occupied a small group, understaffed and underfinanced. By the early 2000s, however, almost all of GBRMPA was involved in the RAP process, led by the executive team (74). The executive team established a Senior Managers' Forum to coordinate activities, enhance communication, solve conflicts, tap into the expertise of senior managers to ensure a shared policy direction, and advise the organization's chair. As one of the executive directors describes:

> I realized that, in house, [the RAP] was not something that a section could handle . . . it was about the whole organization. It was about the marine park. So everyone had to have ownership of it. And everyone was needed. We had

> to almost stop doing many other things, to do this. Otherwise we couldn't do it. So we formed what was called the Senior Managers' Forum.

In this way, GBRMPA used its organizational flexibility to establish and nurture an environment where creativity was encouraged and innovative solutions to problems could emerge. Importantly, this process was achieved without any additional funding and relied entirely on a flexible internal redeployment of staff. The Senior Management Forum unified internal management and communicated a common vision throughout the organization, with leadership of the Forum shared by both of the executive directors. The Senior Managers Forum led to the establishment of four regional teams responsible for the comprehensive public consultations associated with the RAP. Using teams helped the GBRMPA to avoid competition between sectors, increase internal collaboration, and become more effective by pooling experiences and resources.

Bridging science and policy. The RAP process relied heavily on scientific expertise and a new synthesis of the best available data on species and habitats of the Great Barrier Reef. To harness this expertise, GBRMPA created new opportunities for interaction, dialogue, and information sharing with researchers. This included establishing committees and panels, facilitating workshops, and communicating to scientists GBRMPA's overall vision and goals for the RAP and rezoning. For example, two independent advisory committees (the Scientific Steering Committee and the Social, Economic, and Cultural Steering Committee) were convened to develop two sets of operating principles that guided the RAP process (53). Scientists were encouraged to think beyond their individual sample sites or specialized expertise to collectively reach a bioregional perspective on the GBR as a whole (53). This dialogue was facilitated by a longstanding relationship between GBRMPA and researchers at universities, the Australian Institute of Marine Sciences, and the Cooperative Research Centre for the Great Barrier Reef World Heritage Area (CRC Reef).

Changing people's perceptions. Because of its iconic status, there was overwhelming support both nationally and locally for conserving the Great Barrier Reef. GBRMPA tracked this support using pollsters and used the information during RAP for political leverage. However, not everyone was aware of the threats to the reef or agreed with the proposed management changes (75). Some local recreational fishers in particular were vocal in their opposition to no-take zones. Some within GBRMPA foresaw that the implementation of the RAP and rezoning the marine park would require an extensive communication strategy to bolster public support. Many people still perceived the Great Barrier Reef as a pristine environment, protected from human impacts by its sheer size and relative isolation.

To address this issue, GBRMPA hired a highly skilled communication officer to produce a "reef under pressure" information campaign showing that the reef is no longer a pristine wilderness but rather is subject to anthropogenic degradation caused by coastal development, land use, shipping, tourism, and fishing. The campaign raised awareness and created a sense of urgency about the need to better protect the GBRMP for future generations. The campaign included web sites, posters, pamphlets, and television advertisements showing well known local individuals advocating for the need for change. The information campaign, tailored for a range of audiences, was followed up by continuous polling to monitor the change in people's perceptions.

Facilitating community participation and public consultation. GBRMPA is required by the 1975 Act to inform the public about new zoning plans and provide two formal public consultation periods during their preparation. Public consultation for the RAP greatly exceeded the requirements of the Act and was by far the most extensive in the history of the marine park. GBRMPA staff had to learn quickly, and several new methods were trialed. There were several minor setbacks regarding public consultation, some anticipated and others unexpected. The goals of RAP and the zoning plan were sometimes misunderstood, and some members of local communities were suspicious about GBRMPA's agenda. On several occasions misinformation about the intended location of no-take zones (especially close to a town or the shore) resulted in public meetings with large audiences including distressed, angry individuals (75). GBRMPA turned these problems into opportunities for correcting misinformation and spreading key messages about the RAP and rezoning and produced a "Correcting Misinformation" fact sheet. GBRMPA attended every public meeting they were invited to. Whenever GBRMPA was in charge of organizing meetings they avoided large public meetings that could be dominated by one or a few people and instead held several hundred community information sessions in regional and local community centers. The reason for this is offered by a Senior Manager:

> We thought that was a more effective way of interacting with people because it gave everyone an even chance of getting heard, where if you have a public meeting quite often it is dominated by the loud and angry one.

Information sessions and follow-up meetings were a more effective way to interact directly with all of the people present and build trust. Typically, four or five GBRMPA staff presented posters, pictures, and other informative material and answered questions. Some communities had not had contact with GBRMPA for decades. Periodic updates on the RAP process were produced from May 2000 to November 2003 and were posted online (75).

For the second consultation phase, GBRMPA improved the formulation and design of the submission packages distributed to communities. New and innovative ways for dealing with the influx of submissions were required because of the overwhelming response from the public. The volume of submissions (>31,000 in total) came as a surprise to GBRMPA. A "factory" was set up for handling them, quickly allocating human and financial resources within the organization without the need for additional external funding. (Periodic updates on the progress of RAP are available at www.gbrmpa.gov.au/corp_site/key_issues/conservation/rep_areas/updates.)

Gaining political support. GBRMPA reports to the Australian Federal Minister for Environment and Heritage, whose support was crucial for the RAP process. The rezoning legislation had to pass through the two federal houses of Parliament. After the federal election in November 2001, a new minister for environmental issues, the Honorable David Kemp, was appointed in 2002. The new minister, and ultimately the prime minister, had to be reassured that there was an adequate scientific basis for the zoning, that it could be carried through to a successful conclusion within an acceptable time frame, and that GBRMPA had the skills necessary to lead an extensive public consultation process. After several sessions with the chair of GBRMPA, the minister was convinced that the RAP and the new zoning plan would be a major advance in conserving the biodiversity of the marine park that could be managed politically. In his interview for our study, the minister stated

> I made a judgment about Virginias Chadwick's capacity to lead the process. I came to the view that she could manage it ... she had an experience in mapping the political landscape and in talking with leaders of interest groups and in handling public meetings that were at times quite emotional.

The timing of submitting the plan to the Senate was crucial. The chair of GBRMPA and the minister agreed that the new zoning plan should be submitted in December 2003 for it to become operational by July 2004, before the upcoming federal election the same year. The chair of the GBRMPA states

> I realized . . . that we needed 15 sitting days of Parliament, and a simple examination of the parliamentary sitting timetable showed that if one wanted the 15 sitting days to end, say, around midyear, then the plan had to be submitted to Parliament before the Parliament got up for the Christmas break. If one didn't do that . . . one would have been looking at October, November, which would have been slap-bang in the middle of a federal election.

This provided a narrow political window of opportunity that set the time frame for GBRMPA. GBRMPA and the minister had to prepare a smooth passage of the plan through both houses of Parliament. Throughout the planning process, senior staff from GBRMPA made frequent trips to Canberra (a 5-hour journey by plane) and other key destinations to inform critical players such as governmental departments and agencies responsible for fisheries and the environment, members of Parliament and senators (especially those representing constituencies along the Queensland coast), shipping interests, port authorities, and the Defense Department. The political skills of GBRMPA's executive team and the director for communication were important for navigating the political system. Senior scientists, conservation nongovernmental organizations, and lobbyists for the tourism industry also played a role in convincing politicians of the need to pass the reef legislation. Fishing interests were also politically active.

Discussion

The study of the Great Barrier Reef shows the critical role of flexible governance systems that can deal with complex and dynamic ecosystems by linking individuals, networks, organizations, and institutions across multiple levels of human activity (49). We used a broad analytical approach to identify strategies and actions used by GBRMPA to overcome barriers to change and transform governance and management of the large-scale coral reef seascape. Interacting key strategies that emerged from our analysis are internal reorganization; coordination of scientists and other experts; tailored information campaigns about the state of the GBR; community participation and public consultation; and actively working to gain political support.

The GBRMPA case illustrates that policy development and implementation are complex, highly dynamic, and sometimes abrupt. Institutional inertia can develop into a major transition within a fairly short period, in our case between 1998 and 2004, when a policy window of opportunity was effectively used. The RAP, and its use in the rezoning of the reef, is an innovative approach, developed within the GBRMPA, adopted at the highest political level in Australia, and actively used to improve the governance of the GBR. Initially, there was the recognition that the existing zoning network did not adequately protect the range of biodiversity of the reefs and hence could not maintain the GBR's resilience in the face of recurrent ecological disturbances. Combined with increased human pressures on the GBR, including the challenges of climate change, individual actors within the GBRMPA were triggered to search for more holistic approaches to governance and management of this large marine ecosystem. The new, more sophisticated approach that emerged addressed both ecosystem dynamics and the intricate web of interactions between social and ecological systems.

GBRMPA focused on communication and information throughout the RAP process, hiring a skilled communication officer to develop communication strategies and information. Combined with new scientific insights, this shifted the perception of the GBR from a well protected pristine coral reef ecosystem to a vulnerable and complex seascape requiring active stewardship. Increased public and media interest helped to tip governance in the new direction of ecosystem-based management with broad stakeholder engagement (76).

Similar studies have shown the essential role of shifting people's perceptions. Such shifts are critical factors in altering the trajectory of natural resource management (77, 78). In The Netherlands, a recent shift to more integrated forms of water management demonstrates that a change in people's mental models, from "fighting the water" to "living with the water," was critical for adaptive management (79). In the Kristianstads Vattenrike Biosphere Reserve in Sweden, a comparable shift in the perception of local politicians was critical in the transition to ecosystems-based management (31). These examples and the GBRMPA case also point to the role of ecologists in social–ecological transformations (80) and the need to coordinate scientist interactions with each other, the public, and politicians.

Our study points to the need for research on policy windows and the ability to create the right links, at the right time, around the right issues (30, 31). Well timed actions that change interaction patterns among social actors can be crucial for governance transformations (18). GBRMPA's Senior Managers Forum, the regional teams, and the community information sessions are innovative evolving structures set up especially for the RAP to improve interactions between individuals and divisions within the GBRMPA and between the GBRMPA and other key actors across multiple levels.

Our study also shows the need to understand the dynamic processes that underlie the emergence of new forms of governance and management and the role of leadership in these processes. Initially, a small team working within the GBRMPA planned the rezoning of the entire marine park, which subsequently led to critical support from the Authority's executive team for the major rezoning effort. This happened in three stages, from (*i*) a relatively minor project within GBRMPA to (*ii*) incorporation across all parts of the Authority and status as an agency priority, to (*iii*) changing national legislation and influencing other areas in Australia (e.g., rezoning of Ningaloo Reef in Western Australia in 2004) and becoming a role model for policy development elsewhere.

The RAP process shows the role of skillful leadership (28) for moving between stages and across multiple organizational and political levels; first when the executive team allocated internal resources for developing the RAP and second when the chair of GBRMPA, Virginia Chadwick, won the critical support of David Kemp, the federal minister, for proceeding with RAP and the new zoning plan. Leadership issues have been addressed in several studies (81, 82) but not in the context of understanding transitions to ecosystem-based management.

The GBRMPA case suggests that enabling legislation or other social bounds is essential but not sufficient for achieving adaptive comanagement (83) of complex marine ecosystems. Bringing together science and policy is another important but singly insufficient component of transitions and transformations. Critical interacting strategies for transformations in social–ecological systems must be addressed to understand these shifts. Additional empirical studies, case-study analyses, and comparative studies can develop a better understanding of strategies for transformation in governance toward ecosystem-based management under various social–ecological conditions. For example, in contrast to the GBR case, marine zoning in the United States has been severely constrained because of inflexible institutions, lack of public support, difficulties developing acceptable legislation, and failures to achieve desired results even after zoning is established (8). Understanding successes and failures in marine governance systems is a first step in improving their adaptive capacity to secure ecosystem services in the face of uncertainty and rapid change.

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