Adaptive governance, ecosystem management, and natural capital

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To gain insights into the effects of adaptive governance on natural capital, we compare three well-studied initiatives; a landscape in Southern Sweden, the Great Barrier Reef in Australia, and fisheries in the Southern Ocean. We assess changes in natural capital and ecosystem services related to these social–ecological governance approaches to ecosystem management and investigate their capacity to respond to change and new challenges. The adaptive governance initiatives are compared with other efforts aimed at conservation and sustainable use of natural capital: Natura 2000 in Europe, lobster fisheries in the Gulf of Maine, North America, and fisheries in Europe. In contrast to these efforts, we found that the adaptive governance cases developed capacity to perform ecosystem management, manage multiple ecosystem services, and monitor, communicate, and respond to ecosystem-wide changes at landscape and seascape levels with visible effects on natural capital. They enabled actors to collaborate across diverse interests, sectors, and institutional arrangements and detect opportunities and problems as they developed while nurturing adaptive capacity to deal with them. They all spanned local to international levels of decision making, thus representing multilevel governance systems for managing natural capital. As with any governance system, internal changes and external drivers of global impacts and demands will continue to challenge the long-term success of such initiatives.

ecosystem services | bridging organizations | Kristianstads Vattenrike | Great Barrier Reef | Southern Ocean

Nature's capital generates essential ecosystem services for people. Providing knowledge and metrics of ecosystem services, their interactions, and how they are generated is crucial for ecosystem-based management of landscapes and seascapes (1–3). It is increasingly appreciated that, in a human-dominated world, ecosystem services are not generated by ecosystems alone, but by social–ecological systems (4, 5). Adaptive governance for ecosystem management employs a social–ecological systems approach (6). "Governance" is here defined as the structures and processes by which people in societies make decisions and share power, creating the conditions for ordered rule and collective action, or institutions of social coordination.

Adaptive governance refers to flexible and learning-based collaborations and decision-making processes involving both state and nonstate actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social–ecological systems and ecosystem services across landscapes and seascapes (6–8). The collaboration involves building knowledge and understanding of ecosystem dynamics and services, feeding such knowledge into adaptive management practices, supporting flexible institutions and multilevel governance systems, and dealing with external perturbations, uncertainty, and surprise (6). Practices of natural capital management such as protected areas, environmental subsidies, quotas, or regulations (9) serve as part of the toolbox. Adaptive governance expands the measures available and provides the coordination and the context for choosing between tools, monitoring their effect, and adjusting them as the social–ecological system evolves.

Research on adaptive governance for management of ecosystems and their services in real social–ecological landscapes and seascapes has illuminated the intricate interplay, of individual actors, social networks, organizations, and institutions, that enables or hinders societies to nurture natural capital and implement ecosystem management (10–12). The limited, but rapidly growing, body of governance literature that explicitly addresses the capacity to manage ecosystems adaptively has recently been reviewed (8).

Here, we compare three well-studied empirical cases of adaptive governance, spanning local, national, and international regions: Kristianstads Vattenrike (Southern Sweden), the Great Barrier Reef (Australia), and fisheries in the Southern Ocean (International). First, we present the cases and compare the emergence of adaptive governance in the three regions. Then, we assess changes in natural capital and ecosystem services (cultural, supporting, regulating, and provisioning) in the landscapes and seascapes subject to adaptive governance. We also investigate the capacity of actors in these governance systems to respond to change and new challenges and to handle complexity. Finally, we discuss the cases and findings in relation to three other efforts aimed at conservation and sustainable use of natural capital: Natura 2000 in Europe, lobster fisheries in the Gulf of Maine, North America, and the Common Fisheries Policy in Europe. Methods are presented in *SI Text*.

The Three Cases

The adaptive governance systems studied here represent transformations from uncoordinated or sector-based management to a broader ecosystem approach and have emerged independently from each other. They are founded on the notion that humans

Significance

Adaptive governance (AG) has been suggested as a suitable approach for ecosystem management in changing environments. It rests on the assumption that landscapes and seascapes need to be understood and governed as complex social–ecological systems rather than as ecosystems alone. We compared three AG initiatives and their effects on natural capital and ecosystem services. In comparison with other efforts aimed at conservation and sustainable use of natural capital, adaptive governance developed capacity to manage multiple ecosystem services and respond to ecosystem-wide changes and enabled collaboration across diverse interests, sectors, and institutional arrangements. Internal and external pressures continuously challenge the adaptive capacity of the initiatives.

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benefit from nature, that these benefits are generated by whole landscapes and seascapes rather than by individual resources, and that these landscapes and seascapes are shaped by human activities. They combine conservation and development, and, although the concept "ecosystem services" was not used in the early days of the initiatives (i.e., during the 1970s and 1980s), it has now become of regular use in their reports and management plans.

Kristianstads Vattenrike (KV) covers a river basin of 1,040 km^2 within one Swedish municipality (Table S1 and Fig. 1). Since 1989, the cultural landscapes of the area have been managed by a municipal organization in flexible, project-based collaborations with farmers, local steward associations, local entrepreneurs, the county board administration, and national and international actors (10, 13). The organization was established in response to environmental change (e.g., land abandonment, eutrophication, water pollution) to develop and promote conservation and sustainable use of ecological and cultural values of the region's landscapes (13). The area was designated a biosphere reserve (BR) in 2005 by United Nations Educational, Scientific and Cultural Organization (UNESCO) (14). All categories of ecosystem services are generated in KV, from substantial amounts of agricultural food products to recreational, aesthetic, and educational services (Table S1) (15). Other services are the buffer against flooding provided by the wetlands and provision of habitats for more than 700 nationally red-listed species (*SI Text*).

The Great Barrier Reef Marine Park (GBR), Australia, covers an area of 345,000 km^2 (Fig. 1) and contributes AU$5.7 billion annually to the Australian economy (16), with a major part from the tourism industry. The Australian federal government enacted the Great Barrier Reef Marine Park Act in 1975 in response to concerns about threats to the reef from oil drilling, mining, and unexplained outbreaks of coral-eating starfish (16). In 1981 the GBR region was declared a World Heritage Area (Table S1). The governance of GBR is a comanagement arrangement between the Federal State of Australia and the state of Queensland through the Great Barrier Reef Marine Park Authority (GBRMPA), established in 1976. In 1998, the GBRMPA initiated a major rezoning of the marine park called the Representative Areas Program (RAP) to systematically increase the conservation of biodiversity through a network of no-take areas representing different habitats. The RAP, adopted at the highest political level in Australia, was actively used to improve the governance of GBR (11). It was developed in response to the recognition of the need to maintain GBR's resilience in the face of recurrent disturbances, like human pressures and the challenges of climate change. The GBR generates fish as well as recreational and educational services, attracts tourists, protects the coastline from erosion, and supports biodiversity (Table S1).

The Southern Ocean (SO) is a region of 20,327,000 km^2 covering the waters around the Antarctic continent, including several national territories and large areas beyond national jurisdiction (Fig. 1). Fisheries are monitored and managed by CCAMLR (Commission on the Conservation of Antarctic Marine Living Resources), a bridging organization connecting governments, environmental nongovernmental organizations (NGOs), such as Antarctic and Southern Ocean Coalition (ASOC), and the licensed fishing industry through Coalition of Legal Toothfish Operators (COLTO), acting as observers or members in national delegations (17). CCAMLR was established in 1982. Being responsible for the conservation of Antarctic marine ecosystems, CCAMLR practices an ecosystem-based management approach (www.ccamlr.org). CCAMLR manages, e.g., krill *Euphausia superba*, and Patagonian toothfish *Dissostichus elegonoides* (18). When the Toothfish fishery developed in the mid-1990s, it had very high levels of illegal fishing (18, 19). This situation represented a major challenge for CCAMLR and required substantial adaptive capacity to address because illegal operators continuously change their activities, vessel color, name, and flag to escape detection and enforcement (17, 20). Reducing illegal fishing has been critical to conserving Southern Ocean fish populations and globally threatened Antarctic seabirds of spiritual and symbolic value, which are caught as by-catch in

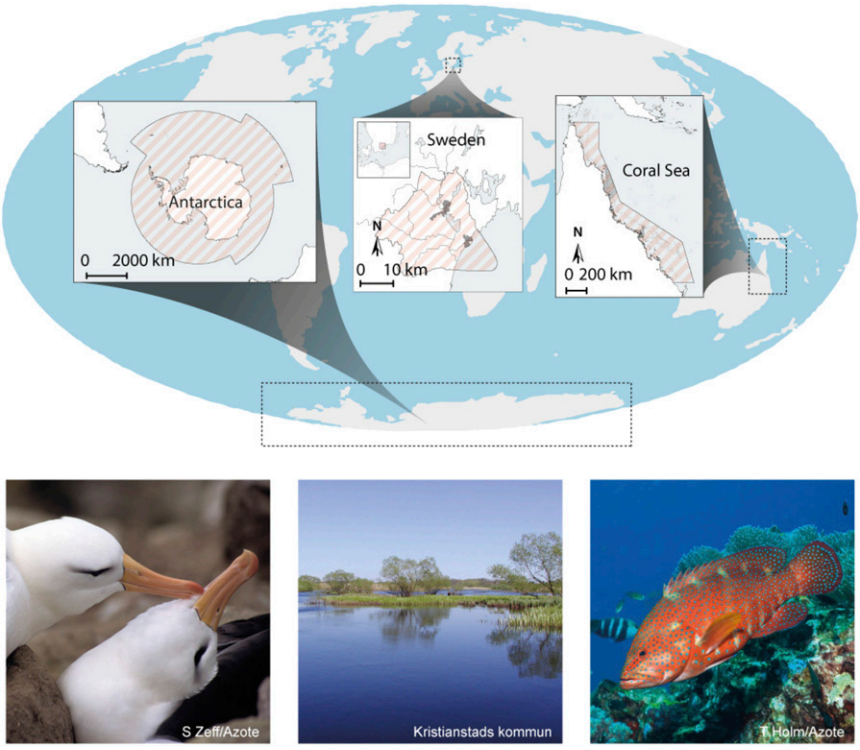

Fig. 1. Geographic location, size, and images of Southern Ocean, Kristianstads Vattenrike, and Great Barrier Reef.

fishing gear. Antarctic marine ecosystems hold a range of other regulating, supporting, and cultural services (21) (Table S1).

Development of Adaptive Governance

In all three cases, the move to adaptive governance of whole landscapes and seascapes was triggered by an awakening crisis. In KV, deteriorating water quality hindered people from swimming in the lake, and encroachment of shrubs on grasslands led to decreasing bird populations and reduced options for recreation (10). In the GBR, the risks of climate change with severe coral bleaching events, combined with overfishing, and eutrophication with damaging outbreaks of crown-of-thorns starfish led to recognition of an iconic coral reef under severe stress (11). The projected collapse of valuable fish stocks and threatened seabirds in the SO, as a consequence of illegal fishing (22), threatened globally relevant values and thus the credibility of CCAMLR.

In each case, the awakening crises mobilized a few key individuals who built trust and knowledge, connected networks, and developed a systems vision combining conservation and development. In hindsight, this process could be described as a mental shift, a reframing of the human–nature relation. In KV, the key actors realized that the wetlands were a result of agricultural practices and that they provided a range of beneficial ecosystem services (10). In the GBR, key actors realized that the reef was not as pristine and resilient as previously believed (11). In the SO, key actors realized that illegal catches dominated the fisheries and that licensed fisheries, conservation activists, and governments had a shared interest in prohibiting illegal fisheries and the erosion of multiple values of the seascape (17).

For this initial awakening and reframing among individuals to spread, we find umbrella concepts crucial in all three cases. In KV, the concept of Ecomuseum Kristianstads Vattenrike (Water Realm) brought five sectors together, including education, cultural (i.e., agricultural) heritage, nature conservation, tourism, and research (10). GBRMPA produced a "reef under pressure" information campaign to raise awareness of the situation and build support across stakeholders and sectors for the rezoning (11). In the SO, a small number of individuals started the new organization the International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH) to reduce illegal fishing (12, 23) and later the fishing industry in CCAMLR developed the Coalition of Legal Toothfish Operators (COLTO) with the same purpose (12). These actors carried out substantial investigations of illegal fishing and helped reframe the issue as transnational, organized crime (24), and gained political support. A broad mobilization of ecological knowledge and ongoing activities took place in all cases, connecting previously disconnected actors, such as farmers and conservationists in KV (10), and fishermen, scientists, tourism, and conservation organizations in GBR and the SO (12, 25). Scientific knowledge and scientists played important roles in each case.

There also seems to be alignment with regard to the need for a bridging organization that connects scales to take each initiative forward (13). In KV, a new organization was formed when opportunities coincided, i.e., when the local idea of an Ecomuseum met the municipal need for a new profile at a time when environmental issues were high on the political agenda. In the GBR, the GBRMPA was radically restructured during the rezoning process into a bridging organization that mobilized actors and user groups of concern, building trust and gaining support for an emergency plan to save the reefs (11). In the SO, the mentioned initiatives became truly effective when connected to the existing bridging organization: the CCAMLR secretariat (12).

Effects on Natural Capital

In Kristianstads Vattenrike, the area of wetlands and sandy grasslands under active management (grazing and mowing) has increased (from 1,222 ha in 1989 to 1,660 ha in 2008 for wet grasslands) (*SI Text*). Restoration of wetlands, sandy grasslands, and aquatic habitats contributes to all four categories of ecosystem services, including nutrient cycling, flood protection, aesthetic values, and habitats for associated organisms (*SI Text*). The visitors center Naturum was built in 2010 as an entrance to the biosphere reserve, attracting around 110,000 visitors per year. The Biosphere Office has enhanced access to the wetland areas, supporting recreational and educational services, and the area of nature reserves has also increased (*SI Text*). Wading bird populations increased between 1990 and 1997, but some species have decreased between 1997 and 2009 (*SI Text*). Suggested reasons include deterioration of nesting grounds by geese grazing, increased predation by fox and birds of prey, and less spring rainfall, reducing the life span of wet ponds (*SI Text*). In 2007, farmers of wet grasslands experienced a prolonged flooding, leaving the fields covered in brown sludge (26). The sludge made the grass unfeasible for grazing and mowing, thereby affecting provisioning services negatively that year and nesting of wading birds the following year. The reasons for the so-called brownification of water are still unclear and cannot be combated by local responses only because this trend prevailed across all of Southern Sweden (27).

In the Great Barrier Reef, the 2004 rezoning that increased nontake areas (NTA) from 5% to 33% was accompanied by changes in fisheries management and new monitoring programs. McCook et al. (28) summarized the major effects of the changes on biodiversity, ecosystem resilience, and social and economic values of the Great Barrier Reef Marine Park. Russ et al. (29) showed that the abundance and size of fish increased as a result of establishing NTA. The NTA also seemed to have decreased the frequency of outbreaks of the coral-eating crown-of-thorns starfish, *Acanthaster planci* (29, 30), although outbreaks remain a problem in the GBR as a whole (31). There is evidence that larval export from marine reserves helped replenish fish populations on both reserves and fished reefs and supports connectivity within the network of marine reserves (32). NTAs may be important in providing postdisturbance refuges to climate disturbances for spawning stocks, which may be critical to regional-scale population persistence and recovery (31, 33).

However, it seems that the rezoning and the network of NTAs have not been sufficient to curb the reduction in hard coral cover of the GBR. Large-scale disturbances, especially tropical storms, coral bleaching events, and starfish outbreaks, seem to be the major reasons for the continued decline (31, 33). These disturbances are interacting with anthropogenic drivers like rising seawater temperatures and ocean acidification, water pollution from terrestrial runoff, and dredging and fossil fuel use (34). There are major concerns to what extent the governance system will be able to deal with the increasing pressures on the reef (35). The limited success and progress in the GBR have caused UNESCO to discuss including the GBR on the List of World Heritage in Danger (36).

In Southern Ocean, quotas are substantially higher for the licensed industry because illegal fishing has been reduced (17). Given the limited knowledge about fish stocks dynamics in these remote areas, scientists have been unable to establish the effects on fish stocks from a reduction of illegal fishing. However, the reduction of illegal longline fishing has substantially reduced the mortalities of seabirds, with a direct positive effect on the population numbers of globally important black-browed (*Thalassarche melanophrys*) and gray-headed (*Thalassarche chrysostoma*) albatrosses (37).

Capacity to Deal with New Challenges

In Kristianstads Vattenrike, the decline in wading bird populations was identified by the annual nesting bird inventories conducted by bird watchers and biosphere office employees. In response, the biosphere office raised funds and mobilized their networks to identify causes and potential responses, through

expert workshops, university research, and experimentation (*SI Text*). The brownification of the water sparked several initiatives led by the biosphere reserve office, including fund raising to assess drivers behind deteriorating water quality, mapping effects on ecosystem services, actors being involved in management and use of these services, and conducting a resilience assessment of the drainage basin of the River Helgeå (*SI Text*). The Swedish Agency for Marine and Water Management have substantially increased their funding to improve regional water quality, mainly through wetland restoration, an investment in natural capital influenced by KVs efforts to put brownification on the national agenda (*SI Text*).

The initial focus in 1989 on restoring wet grasslands has expanded to include 10 landscape themes, including sandy grasslands, coastal areas, and ground water, all combining the three biosphere reserve functions of conservation, development, and learning. A number of projects are underway in all of the themes, including restoration of habitats, inventories of species and management practices, facilitating dialogue and collaboration between stakeholders, improving access to recreational ecosystem services, and providing educational support (*SI Text*). The adaptive governance network is in the process of expanding collaboration with upstream actors, drawing on national and international levels of decision making and support.

During the rezoning of the Great Barrier Reef in 2001, GBRMPA approached the Australian Government about the increasingly poor water quality of the GBR and the necessity to address up-stream issues and land-based activities (38). This information triggered collaboration with the Queensland Government, with jurisdiction of the watershed, and the production of the "Reef Water Quality" report in 2003. Comanagement and adaptive governance arrangements developed, involving a range of stakeholders, to achieve substantial change in anthropogenic nutrient, sediment, and pesticide runoff. The GBRMPA is one of eight organizations involved in an intergovernmental committee overseeing the operational implementation of reef plans in collaboration with other actors, such as farmers and conservation organizations. There are several achievements, including the implementation of the AU$9 million-a-year Paddock to Reef program, which is an innovative approach to integrating monitoring and modeling at paddock (pasture), catchment, and seascape scales.

Despite these efforts, nutrient runoff and water quality are still major issues in GBR (39). The ability to manage land–sea interactions is a critical challenge for the adaptive governance initiative, including the GBRMPA and the Queensland Government. Pressures from port development, dredging, and other land-based activities are challenging the GBR. Scientists stress that dealing with these local and regional pressures is of crucial importance to strengthen the resilience of the GBR social–ecological system to large-scale drivers like climate change-induced heat stress and intensifying tropical storms (31, 40). Resilience assessment and capacity-building workshops that included managers, scientists, local community members, and other stakeholders have been used to identify management responses to climate change (41).

In Southern Ocean, initial collaboration between governments, environmental NGOs, and the fishing industry to reduce illegal fishing built important trust and collaboration between individuals and networks and generated substantial positive results. The diverse stakeholders benefited from reducing illegal fishing (e.g., reducing pressure on commercially valuable fish stocks, conserving globally threatened seabirds, and ensuring the integrity of national marine borders). Recent discussions in CCAMLR have focused on setting aside large areas in the SO (e.g., the Ross Sea) as protected. This issue has been politically contentious, in part driven by environmental NGOs and with potentially substantial effects on commercial (licensed) fishing activities (42).

Discussion

There is a need to champion approaches to governance capable of supporting ecosystem management in a manner both flexible enough to address highly contextualized social–ecological issues and responsive enough to adjust to complex, unpredictable feedbacks between social and ecological system components (8, 43–45). The real-world cases of adaptive governance presented here shared three such approaches. First, they built system-wide knowledge and awareness of ecological dynamics, providing an improved foundation for actors to respond in an informed manner. Second, they enabled coordination, negotiation, and collaboration across whole landscapes and seascapes, across sectors, and across institutional levels, allowing issues to be addressed in a holistic manner at the appropriate scale. Third, by drawing on the diverse competences of state and nonstate actors, they used a number of informal means of governance beyond incentives and regulations applied by governments. In the following, we will discuss the usefulness of these approaches through a comparison with three other multilevel governance efforts aimed at conservation and sustainable use of natural capital: Natura 2000 in Europe, lobster fisheries in the Gulf of Maine, North America, and the Common Fisheries Policy in Europe.

Illuminating Contrasts. The Natura 2000 is one of the European Union's (EU's) most important instruments for biodiversity conservation (46) and one of the most ambitious supranational initiatives for nature conservation world-wide (47). Initiated in the mid 1990s, its aim was to create a coherent network of different habitat types, with a view to establishing a solid ecological foundation at the European level for sustainable development. Local administrations were tasked with identifying suitable sites covering at least 10% of national territory, based on lists of threatened species and habitats, and within a very short time frame (48). In numerous cases, implementation of the directive caused conflicts with landowners and users of nature, such as hunters, fishermen, and farmers, who felt excluded from the planning process. Reports from France, Poland, Greece, Germany, and Finland (46, 49–52) show that the lack of genuine stakeholder participation and the narrow focus on biodiversity protection reduced local acceptance and engagement and caused delays and difficulties in implementation. In some cases, landowners destroyed conservation values of their land to avoid the new enforced layer of protection, and, in Karvia (Finland), landowners went on a hunger strike in protest (52). What made sense at the European level and from a biodiversity conservation point-of-view was met by resistance at the local level and by other sectors of society, and there was limited capacity to adapt the process to accommodate their perspectives and solve the conflicts.

In contrast to the tensions created by the Natura 2000 implementation, KV succeeded in bringing stakeholders to the table early on and drew on both scientific and local knowledge. The initiative connected local action with regional and global institutions, identified and acted on synergies between conservation and development in the broader landscape and across sectors, and built social–ecological capacity to monitor and respond to changes in natural capital.

The Maine lobster fishery is an example of successful collective action and multilevel governance connected to global markets. In contrast to earlier fishing activities, the lobster population has not been overexploited. The fishers, whose conservation ethic is aligned with maintaining lobster abundance, have worked collectively to minimize illegal actions and preserve reproductive lobster populations through close monitoring (53). However, shifting focus from one resource or resource system to the broader ecosystem dynamics, it seems like centuries of intense fishing in the Gulf of Maine have reduced lobster predators like cod and haddock to such an extent that their role in regulating lobster populations has been lost. As a consequence, the lobster population has become a widespread

monoculture. Simplified ecosystems, like monocultures, are vulnerable to disturbance. In New England, south of Maine, there has been >70% decline in lobster abundance due to a lethal shell disease related to increases in ocean temperature (54).

In contrast to the single-species focus in Maine, adaptive governance of the GBR expanded beyond single-species and coral reefs alone to over 70 habitat types and interactions across sectors. Recognizing that GBR generates multiple ecosystem services for multiple beneficiaries, GBRMPA involved diverse user groups and stakeholders, from local to national levels, in conservation for development of the whole seascape.

In the European Common Fisheries Policy (CFP), the European Council of Ministers decide on fishing quotas around all European Seas, based on scientific advice and political priorities, through a species-by-species approach. However, scientific advice has limited influence on the political negotiations of quotas, and the centralized top-down approach leaves little room for stakeholders to contribute to monitoring and enforcement (55, 56). Consequently, fish stocks have been substantially reduced due to ecosystem change, the legitimacy of scientific advice and political decisions is limited, and noncompliance has been problematic (56). The outcomes of the 2013 reform of this policy toward more adaptive ecosystem-based approaches are as yet unclear.

In the Southern Ocean, in contrast to the CFP's top-down species-by-species approach with weak compliance, scientific advice actively took into consideration the effects of fisheries on dependent species (18). Clear decision rules that relate the quota for the licensed fishery to the level of illegal fishing provided direct incentives for the industry to engage in monitoring and enforcement (17). A scientifically legitimate estimate of the imminent collapse of seabirds and fish stocks, combined with a high level of trust between actors, mobilized critical monitoring at sea and investigations with direct implications for CCAMLR. In addition to informal policy tools (naming and shaming strategies), both environmental NGOs and the fishing industry, through their active engagement within and beyond CCAMLR, contributed substantially with developing innovations in policy tools, including a black list for illegal vessels (17). These actors also contributed key information in investigations, leading to convictions and sentencing of illegal fishing operators and thus provided critically needed resources and competence that governments were unable to provide (25, 57). These actors are perceived by other actors as critical to the effectiveness of CCAMLR (25), in part due to their complementary capacity and resources and their ability to improve the adaptive capacity of CCAMLR (57).

To summarize, the case of Maine illustrates the importance of building system-wide knowledge and awareness of ecological dynamics, the case of Natura 2000 emphasizes the importance of enabling coordination, negotiation, and collaboration across sectors and institutional levels, and the case of CFP highlights the usefulness of drawing on informal means of governance to ensure compliance and the importance of legitimacy. The three adaptive governance cases continuously built capacity to monitor, learn, communicate, and respond to ecosystem-wide changes. They explicitly used ecosystem services and multiple beneficiaries as part of the governance approach. Furthermore, they developed system-wide capacities to mobilize and act in the face of changing conditions, conflicts, and unexpected events. As illustrated by the comparisons, it is unlikely that holistic, systemic knowledge, about the social–ecological systems in focus and the potential for action from on the ground to the multiple levels of governance, will emerge in sector-based resource management, where knowledge and action tend to be produced in silos (58–60). Single NGOs or government-appointed regulatory bodies might respond as fast or faster to anticipated events, such as a forest fire, or an incremental decrease in lobster populations, but would seldom have the capacity to use coordinated ecosystem-based management across the landscape or seascape in the face of unexpected change.

So, what can be said about the visible effects of adaptive governance on natural capital? In KV, without the platform for collaboration between farmers and conservationists, many of the areas now under active management would have been abandoned or used for urban expansion. Without the mobilization of experts and managers to detect, make sense of, and respond to brownification, investments by national government authorities in upstream land management for improved water quality would have been less likely. Access to educational and recreational experiences would have been lower without the outdoor museum and Naturum, direct results of the work of KV. In GBR, the rezoning would not have happened without the GBRMPA. As a result, nontake areas have increased, with positive effects on fish populations, but the rezoning has not been sufficient to curb the reduction in hard coral cover. In the SO, the successes in curbing overfishing would have been impossible without the monitoring, policy development, and investigative capacity of nonstate actors (17).

The Stewardship Challenge. The three initiatives can be described as early movers and motivators that have inspired followers and influenced policy in several parts of the world (*SI Text*). However, the strategies used to initiate, coordinate, and maintain adaptive governance need to resonate with the individuals, organizations, and institutions in place. The initiation of adaptive governance often involves a major shift in perceptions and procedures, as well as alignment between actors and opportunity contexts (61). In the three cases of adaptive governance, we found an interplay between key actors or policy entrepreneurs working actively to reframe perceptions of the stewardship challenge, existing or emerging bridging organizations to channel resources, gather knowledge, mobilize action, and make collaboration possible, and the linking and development of social–ecological networks and institutions across multiple levels (from local to international) engaging with and supporting the initiative. In other words, the three cases used ecosystem management of landscapes and seascapes, allowed for negotiation and coordination between multiple ecosystem services and multiple interests across multiple levels and were adaptive, were learning-based, and developed with change. These features together are central in adaptive governance of social–ecological systems and ecosystem services.

The flexible nature of adaptive governance structures may challenge accountability (14). All our cases have developed with democracies and high-income countries involved and in situations where policy tends to leave room for and support innovation and bottom-up initiatives for ecosystem management. It is valid to ask whether adaptive governance would be possible without such a context.

Adaptive governance faces the same challenges as all attempts to manage natural capital in the Anthropocene. Today's connectivity and speed and scale of human action require constant navigating of the larger environment (10, 62). The question remains whether adaptive governance, which largely builds on human relationships and trust, is able to respond to large-scale intensifying drivers and interests. For example, in the KV, the bridging organization now needs to extend collaborations to a diverse set of state and nonstate actors upstream and downstream, and, in GBR, to strengthen the resilience of the reef, GBRMPA will have to successfully deal with and navigate national and international interests and pressures, like dumping of dredge spoil or climate change policies (34). In the SO, the challenge of CCAMLR is to move from the win–win situation of curbing illegal fisheries to negotiating trade-offs between fisheries and conservation, like the attempts to define international no-take areas as part of its ecosystem-based management mandate.

In other words, adaptive governance will always involve a continuous learning process, nurturing of trust, reflection of procedures and structures, and developing collaboration toward common goals. These initiatives are continuously subject to new challenges, whether political, environmental, and economic, and the jury is

still out as to what extent the three cases in focus here will be resilient enough to handle such changes for improved stewardship of natural capital in dynamic landscapes and seascapes.

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