Navigating transformations in governance of Chilean marine coastal resources

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Marine ecosystems are in decline. New transformational changes in governance are urgently required to cope with overfishing, pollution, global changes, and other drivers of degradation. Here we explore social, political, and ecological aspects of a transformation in governance of Chile's coastal marine resources, from 1980 to today. Critical elements in the initial preparatory phase of the transformation were (*i*) recognition of the depletion of resource stocks, (*ii*) scientific knowledge on the ecology and resilience of targeted species and their role in ecosystem dynamics, and (*iii*) demonstration-scale experimental trials, building on smaller-scale scientific experiments, which identified new management pathways. The trials improved cooperation among scientists and fishers, integrating knowledge and establishing trust. Political turbulence and resource stock collapse provided a window of opportunity that triggered the transformation, supported by new enabling legislation. Essential elements to navigate this transformation were the ability to network knowledge from the local level to influence the decision-making processes at the national level, and a preexisting social network of fishers that provided political leverage through a national confederation of artisanal fishing collectives. The resultant governance scheme includes a revolutionary national system of marine tenure that allocates user rights and responsibilities to fisher collectives. Although fine tuning is necessary to build resilience of this new regime, this transformation has improved the sustainability of the interconnected social–ecological system. Our analysis of how this transformation unfolded provides insights into how the Chilean system could be further developed and identifies generalized pathways for improved governance of marine resources around the world.

artisanal fishing | ecosystem services | human dimensions | social–ecological systems | window of opportunity

As the magnitude of human impacts on ecosystems continues to grow and becomes more apparent (1), there is an increasing appreciation of the intimate coupling between ecosystems and human well-being. This represents a fundamental paradigm shift, from the traditional view of people as external disrupters of otherwise pristine ecosystems, to a focus on the dynamics of linked social–ecological systems (SES) (2, 3). Most current approaches to governance and management of marine ecosystems do not adequately link social and ecological processes and have demonstrably failed to halt or reverse environmental decline at a global scale (refs. 4 and 5; but see refs. 6 and 7). The reasons behind this failure are complex. Often governance is ineffective because of political impediments, missing or dysfunctional institutions, weak environmental legislation, lack of public support, inadequate enforcement, or poor monitoring and evaluation systems (8). Typically, management of marine systems focuses on a few exploited species in an attempt to deliver efficiency, reliability, and optimization of fisheries yields. This approach ignores other critical species and processes that sustain functioning ecosystems and is often incapable of dealing with ecological thresholds and surprises (2, 3). Therefore, shifts to new governance systems that support flexible, adaptive management approaches are urgently needed (2, 3).

Shifting from conventional management to new governance approaches has proven to be difficult, and there is a general lack of understanding about critical conditions and the range of spatial scale under which such shifts are possible. Scholars in sustainability science recognize the need for fundamental change (9, 10) and have recently offered empirically based insights into policy development within linked SES (11–13). Progress in this field reveals the need to understand SES dynamics that facilitate shifts in governance (11). Specifically, there is still a lack of understanding of how to steer away from unsustainable development pathways toward improved social–ecological trajectories that sustain and enhance marine ecosystem services and human well-being (3).

Existing knowledge of transformation in governance is fragmented, and different disciplines have studied pieces of the puzzle, but these have rarely been analyzed together in a broader social–ecological context. Although many scientists argue for the need to change institutions to move into new pathways, others argue that whole societal regimes have to change to prompt major shifts in governance (14). This literature recognizes that transformation in governance requires more than mere institutional change. Rather they are systemic shifts that include changes in management paradigms, regulatory frameworks, underlying norms and values, knowledge production systems, equity, and power distribution (9, 15, 16).

To understand such processes we use the concept of *path dependence*. A system is path dependent if future choices are canalized by previous decisions into a particular pathway channel and these constraints make it difficult to move forward in a different direction (17). Because of such stabilizing feedback mechanisms, shifting into new pathways might be very difficult. For example, in the United States and elsewhere marine zoning and shifts to ecosystem-based management have been severely constrained by inflexible institutions, limited public support, and difficulties in developing acceptable legislation (8). Attempts and initiatives to move toward place-based ecosystem management often fail because there are mechanisms like peoples' attitudes and worldviews, economic incentives, power relations, and institutions that do not facilitate such shifts.

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Despite difficulties in changing trajectory, the literature recognizes that there are *critical junctures* from which policies and governance move into new pathways (18). Studying the sequence of events that leads to such junctures is of crucial importance for understanding transformations in SES (19). Such shifts are often multilevel and multiphase processes that involve incremental as well as abrupt change. Transformation is about shifting to a fundamentally new SES when ecological, economic, or social structures make the existing system untenable. Recent studies suggest that transformations consist of three phases: (*i*) preparing for transformation, (*ii*) navigating the transition, and (*iii*) building resilience of the new governance regime. Phase 1 is often protracted until a window of opportunity allows progression to phases 2 and 3 (20–22). Important factors for accomplishing transformations include innovation and strategies developed by key players. Using the three-phase model to guide our analysis, in this article we focus on the conditions under which governance transformations have been possible in the management of Chilean artisanal coastal fisheries. We analyze the role that local ecosystem and management experiments, cross-level interactions, and socio-political context played in shifting from an open-access governance regime to a user-right, space-based zoned regime. By synthesizing information on the key processes involved, our goal is to establish a better understanding of the foundations for navigating successful transformations in marine SES more broadly.

Fishery Governance Transformation in Chile

A change in Chile's national government to a democracy in 1990, after 17 y of a dictatorship, provided a window of opportunity for policy innovation (23). Furthermore, recognition of stock collapse, social processes including learning and communication about ecosystem dynamics between fishers and scientists, and strong social networks (which had been latent for 17 y) provided critical elements for a governance transformation. In 1991 new fishery legislation was passed in Chile. The 1991 Fishery and Aquaculture Law No. 18 892 (FAL), drastically reformed the right to fish within and between the industrial and artisanal fishing sectors. The FAL regulated mobility of the fleets through zoning, allocated exclusive territorial users rights for fisheries (TURFs), and introduced a differential individual transferable quota for fully exploited species (23, 24). This legislation enabled a national-scale transformation in governance toward a more sustainable pathway, particularly for the socially and economically important artisanal sector (15, 23). However, achieving this transformation was more complex than simply changing legislation or introducing new restrictions on resource use.

In Chile, under the terms of FAL, an artisanal fisher must be officially registered by the National Fisheries Service. Artisanal vessels must not exceed 18 m in length and 50 gross register tons (23). Larger vessels are considered industrial fleet. Artisanal fishers in Chile can be divided into two groups. The first, small-scale artisanals, is composed of divers, inshore fin-fishers, and coastal gatherers. They supply reef-fish, inshore fin-fish, benthic invertebrates, and algae. This group mainly operates from deckless boats (<10 m in length), using diving gear (hookah or free diving) or without boats in the case of intertidal and shallow subtidal gathers. Between 2005 and 2008, *ca.* 32,000 small-scale artisanals extracted *ca.* 295,000 tons y^{-1} of benthic resources (excluding algae), worth *ca.* $US 250 million y^{-1} (25). The second group, midscale artisanals, comprises fin-fishers using boats of up to 18 m, mainly targeting high-value fin-fish and small-pelagic species (23). In 2005–2008 they extracted between 1.50 and 1.84 million tons y^{-1}. In 2008 they landed *ca.* 1 million tons of small-bodied pelagic species (anchovy, sardine, mackerel), approximately 43% of the total small-pelagic species landed in Chile, with a value of *ca.* $US 222 million (25).

The FAL provided formal recognition of artisanal fishers and incorporated two new regulations that established user rights. First, artisanal fishers were assigned exclusive fishery access rights (to all species) within a zone that extends 5 nautical miles (9.3 km) from the shoreline along *ca.* 2,500 km of coast (18°36′–41°27′ S) and around Chilean oceanic islands (Fig. 1); This regulation aimed to reduce conflict, especially between midscale artisanals and the industrial fleet. Second, the FAL assigned TURFs over inshore areas of seabed to registered artisanal fisher associations (unions, cooperatives) for the management of benthic resources, under the term Management and Exploitation Areas for Benthic Resources (MEABR). This regulation targets small-scale artisanals (Fig. 1) as a response to overexploitation of benthic fisheries (15).

Governance Transformations in Small-Scale Artisanal Benthic Fisheries. The MEABR policy is the most innovative and transformative management instrument of the FAL (26). It regulates small-scale artisanal benthic fisheries, which harvest more than 60 different species of invertebrates and algae. The gastropod Loco (*Concholepas concholepas*), the red sea urchin (*Loxechinus albus*), keyhole limpets (*Fissurella* spp.), and algae (e.g., *Lessonia trabeculata*) are the most important in terms of landing and income. Species are mostly harvested through hookah diving, within 15–25 km from base ports, from depths of less than 25–30 m (26).

The Loco, historically the most economically important shellfish in Chile, and its collapse in the late 1980s served as a major trigger for governance transformation. Before its collapse, the Loco fishery operated under an open access regime, fishers had no incentives to cooperate, and short-term individualism prevailed. Until 1974 the Loco fishery was characterized by landings of ≈2,000–6,000 tons y^{-1}, used mainly for domestic consumption. In 1973–1974, shortly after a military coup, Chile adopted a neoliberal policy framework. This together with the implementation of an aggressive exchange rate policy substantially improved fishing export earnings (27). As export markets grew, artisanal fishers intensified their mobility

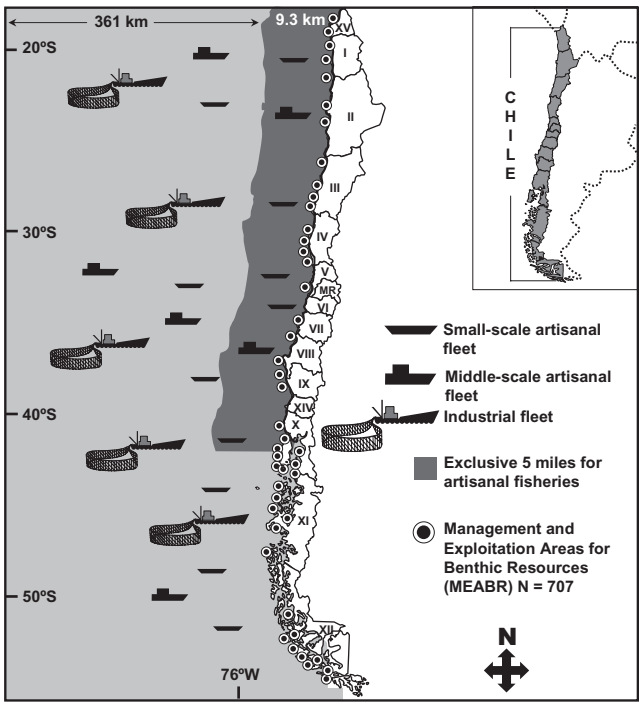

Fig. 1. Schematic representation of fisheries zoning in Chile. Map is not to scale. Roman numerals indicate administrative regions.

along the coast to take advantage of the new opportunities. More than 15,000 Loco divers moved around Chile, increasing landings but sparking conflicts between locals and outsiders. Landings of Loco declined between 1980 and 1988 (Fig. 2), almost certainly owing to overexploitation, precipitating a series of management steps that attempted, unsuccessfully, to prevent clandestine catches and smuggling (28, 29). The Loco fishery was a path-dependent system, trapped in an undesirable state that finally collapsed, resulting in a closure from 1989 to 1992 (Fig. 2). The fishery only reopened after a legislative window of opportunity, when democracy returned to Chile (Fig. 2).

A key starting point, which prepared for the governance transformation associated with the MEABR policy, was an increased understanding of basic ecological concepts pertaining to the role of fishers in structuring marine ecosystems in Chile. This information came initially from two small experimental no-take coastal reserves, administered by universities, in central (Las Cruces; 5 ha) and southern (Mehuín; 10 ha) Chile. Research at these reserves (1981–1988) showed that humans controlled the abundance of intertidal and shallow subtidal Loco populations, which in turn determined the species composition of the intertidal communities (30). When Loco is absent, the ecosystem shifts to a mussel-dominated intertidal seascape, which has little or no economic value. Consequently, human harvesting is a key driver of intertidal and shallow subtidal ecosystem dynamics (Fig. 3) (30, 31). In addition, research showed that when harvesting was experimentally curtailed, benthic resources, such as Loco, sea urchins, keyhole limpets, and algae, could be restored via "natural seeding" over a period of 3–5 y (31, 32). The enhanced understanding of the role of fishers in these linked SES came at a time when artisanal fishers were acutely concerned about the depletion and recovery prospects of several key benthic resources. It created the opportunity for scientists and existing fisher associations to exchange information and develop participatory research at a larger scale, encompassing specific fishing coves, or "caletas" (33). Such collaboration involved the implementation of experimental MEABR undertaken jointly by marine ecologists and artisanal fisher associations christened as "natural shellfish restocking via rotational exploited areas" (30). To experimentally track the recovery of stocks, fishing was voluntarily suspended in these trials years before MEABRs became a legal management tool.

The first pilot management and exploitation experimental area (*ca.* 52 ha) was implemented in 1989, after an agreement between scientists from Las Cruces Research Station and the fisher association of Quintay, under a special government decree (D.S. 203, 1991) and funded by the Chilean National Fund for Research and Technology (Grant Fondecyt no. 3503-89). Two other "caletas" followed. Within these experimental areas, fishers and scientists engaged in research that led to a learning process about stock recovery times, ecosystem dynamics, and wider ecosystem responses to management and protection (34). Importantly, catch per unit effort and mean size of economically important resources such as Loco increased, whereas searching and traveling time by divers were significantly reduced within the restocking areas (33). These pilot experiences constituted a set of critical learning platforms, which generated new knowledge and practices and helped to develop a shared vision of local fisher associations having exclusive rights and responsibilities to collectively manage local benthic resources.

This shared vision became a dominant discourse among fishers involved in the trials (15). At the same time, artisanal fishers in Chile were in the process of reorganizing into a single national confederation or metaorganization that grouped all artisanal fisher associations. This confederation was in effect a "shadow network" that had been suppressed by the dictatorial regime for the preceding 16 y (1973–1989). The confederation became a significant national player because it had grassroots support. This social reorganization provided the necessary political leverage to successfully navigate the major shifts in governance that included the new FAL legislative framework in 1991.

The governance transformation did not end after legislation granting TURFs had been constituted. A transition phase in which the details as to how marine tenure was going to be allocated to fishers was negotiated in lengthy debates among fishers, managers, scientists, and politicians (35). This was immersed in bureaucratic indecision and power struggles, until 1997 when decrees for regulating fishers' duties and responsibilities in MEABRs were approved (36). Between the publication of the FAL in 1991 and MEABR implementation in 1997, Chile experimented with a national Loco quota, which was costly to administer and easily circumvented by individual divers. During these transitional years, fisher associations that wished to engage with the emerging MEABR policy could only do so on an informal basis, supported by teams of university-linked biologists (26, 28). The first area to be granted officially under the new MEABR system was decreed in 1997. Key stewards in the Undersecretary of Fishery, jointly with the national confederation of fishers and support of the marine scientific community, had finally navigated the transition toward legal MEABR implementation (Fig. 2). Importantly, the MEABR policy is not compulsory. MEABR regulations require the payment of rent for the

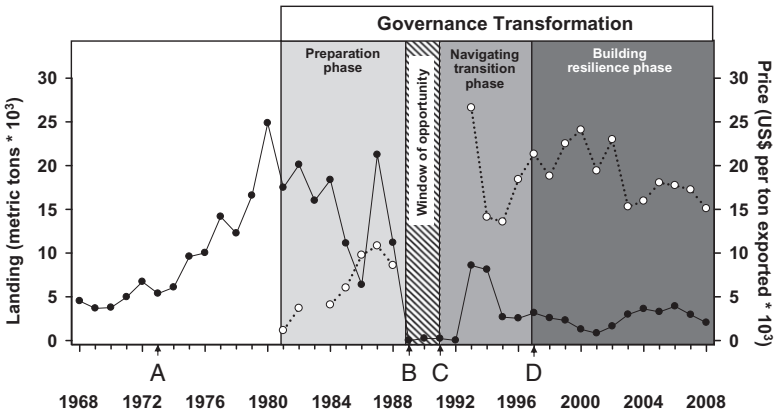

Fig. 2. Loco landings (black circles), 1968–2008. Loco price is represented on the secondary axis (white circles). Arrows represent the timing of (*A*) military coup, (*B*) democratic elections, (*C*) FAL implementation, and (*D*) first legal MEABR. Background colors represent different phases of the governance transformation. Overlap between phases is not represented.

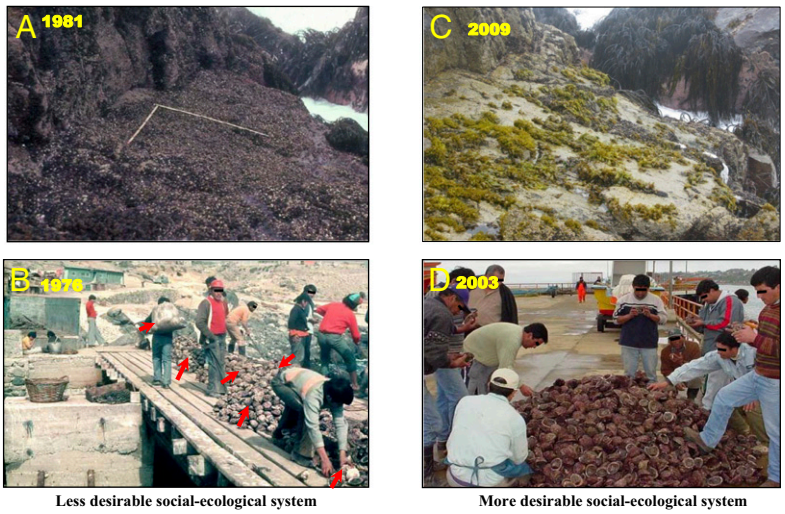

Fig. 3. Alternative SES states. (*A* and *B*) SES under open-access regimes. (*C* and *D*) SES after governance transformation, under a user rights MEABR system. In *A*, because of human overharvesting of Loco, the rocky intertidal environment is dominated by mussels. In *C* (same site 20 y later), because of human exclusion, populations of Loco are persistent in the ecosystem, which has shifted toward one dominated by barnacles, algae, and bare rock (50). In *B*, the individualistic short-term behavior of fishers is represented in an open-access regime: red arrows show individual Loco harvests. In *D*, a collective management approach, associated with MEABR policy, is represented by all fishers sharing the Loco harvest.

exclusive use of benthic resources and the provision of an initial baseline study and a management plan. For each harvested area, annual monitoring must be performed by universities or registered consultants. On the basis of the monitored condition of stocks within each MEABR, total allowable catches are granted for a set of species that are harvested each year. Other species cannot be taken from the area.

The governance transformation represented by the MEABR policy improved the trajectory and dynamics of Chile's benthic coastal SES. Resources harvested from MEABR areas are typically capped at 15–25% of the annually assessed stocks. Fishers can now better schedule their harvesting period to capitalize on market fluctuations and to allow stocks to mature. In many cases, harvesting can now be completed in a few weeks, allowing fishers the option of diversifying their incomes from other types of employment. Official landing statistics of the most important species, the Loco, have stabilized at the levels before the opening of foreign markets. In addition, official reports show that both the prices and the value of landings have increased (Fig. 2). Although the MEABR policy was implemented primarily for the management of Loco, currently there are a total of approximately 45 different benthic species included in management plans for MEABR areas in Chile (34).

The fishery success of the MEABR policy includes a significant increase in abundance and individual size of targeted resources within MEABR areas, in comparison with open-access sites that continue to be heavily harvested by fishers (37, 38). Furthermore, MEABR areas also afford substantial benefits for biodiversity conservation, because they are effective no-take areas for all species other than the handful (generally two to five) chosen each year for harvesting (38). Moreover, the perceptions and environmental awareness of fishers who have engaged with the MEABR policy has changed markedly (36, 39), with evidence of fishers themselves becoming environmental stewards (40). The new governance system created the conditions for the fisher communities to replace the role of an external authority, creating their own institutions. They established local rules for the extraction of the common pool resources and developed a surveillance system to curtail poaching within MEABR areas (although poaching is still one of the major management problems that must be addressed). Currently in Chile there are 707 MEABR areas decreed to fisher organizations (Fig. 1). These account for more than 1,100 km^2 of the nearshore seascape, with a distance between them of 4–10 km (41), thus generating important connectivity among MEABRs.

It is important to state that the radical transformation associated with MEABR brings new challenges for the governance of the small-scale artisanal sector. Open-access diving grounds have become scarce and overexploited (35), affecting the livelihoods of divers who are not associated with MEABR areas (15, 40). The responsibilities and costs associated with surveillance for preventing poaching have increased, and variability in financial returns is becoming evident (40). Illegal fishing (35, 42) has increased conflict and eroded trust (40), and the power relations of different players have changed (15). However, there is no formal mechanism for the periodic review and adjustment of the system (35). These problems require fine-tuning of the policy, which may take many years to accomplish, to build resilience of the new regime (15, 40, 42).

Middle-Scale Artisanal Fishery Governance Transformations. The new fishery governance arrangements also established space-based zoning affecting the "midscale artisanal fishery" along the richest upwelling waters and productive Chilean coastal areas (Fig. 1). In essence, a 5-nautical-mile exclusive access zone was granted to artisanal fisheries, and a pseudo-individual transferable catch quota system was implemented for fully exploited species (mainly for small-pelagic species). This quota is nontransferable between industrial and artisanal fleets (23). These regulations controlling fishing rights have led to a continuous and sustained increase in landings by the midscale artisanal fleet from *ca.* 200,000 tons in 1991 to 1.84 million tons in 2008. In turn, the industrial fishery landings decreased from *ca*. 6 million tons in 1991 to *ca*. 1.4 million tons in 2008. Additionally in Chile, between 1997 and 2006 the industrial purse seine vessel holding capacity has decreased by ≈50%. In summary, the 1991 Chilean fishery governance reforms and innovative management tools seem to have counteracted the overexploitation of fish that is characteristic of common pool resources in open-access systems (23).

Discussion

Transdisciplinary studies of transformations for improved systems of governance in the management of natural resources are not common in the literature (but see refs. 13 and 43), probably because changes in governance are typically small and incremental. Investigations focusing on radical transformations in SES, such as fishing reserves in the Phillipines (44), the Great Barrier Reef (19), and the Helgeå River catchment in southern Sweden (21), share a number of key insights, together with the Chilean case, on how these shifts happen. Transformations involve a series of elements and decisions to convert a system trapped in a determined undesirable pathway to a different, potentially more beneficial system (22). This study illustrates how a window of opportunity for change can emerge when current policies fail. In Chile, the collapse of stocks and a change in government provided this opportunity for rapid policy innovation. Such reform did not occur in a vacuum; rather, it built on existing strengths, social structures, local and scientific knowledge, and skills that recombined for new innovative solutions. This required the identification of dysfunctional states and alternative pathways. Importantly, the transformation was not completed once the new fisheries policy was implemented. The needs to navigate a transition phase toward a sustainable pathway and to keep building resilience of the new system are shown to be critical issues. The Chilean case supports the utility of the three-phase model (preparation, transition, and building resilience of the new regime) linked by a window of opportunity. It represents a transformation from an undesirable path-dependent system to more favorable trajectories and provides empirical insights on critical factors of specific phases (Fig. 2).

Critical elements that allowed preparing for the transformation were (*i*) recognition of the depletion of resource stocks, (*ii*) new scientific knowledge on the ecology and resilience of targeted stocks and their role in ecosystem dynamics, and (*iii*) demonstration-scale experimental trials, building on smaller-scale scientific experiments. The Chilean experience illustrates the importance of identifying new pathways or alternative states for an effective transformation. The experiments carried out by scientists and local fishers generated the necessary knowledge to develop this new pathway for the management of coastal SES (26). The three initial experimental/pilot sites where fishers and scientist collaborated constituted important learning platforms from which the new management approaches could be tested at an appropriate spatial and temporal scale (26, 33). The development of a communication network between researchers and the emerging confederation of artisanal fishers was crucial to create the technical and political support for a transformation in governance that incorporated new information and understanding of ecosystem dynamics.

Importantly, the Chilean case helps identify enabling factors for going from one phase to the next. Political turbulence and resource stock collapse provided a window of opportunity that triggered the transformation, allowing the consolidation of enabling legislation. Critical elements to further navigate this transformation were the ability to communicate new knowledge from the experiments by harnessing a preexisting social network of fishers. In particular, the reemerged fisher confederation provided the capacity and political leverage to link the initiative of the three pilot trials to change institutions at the national level. Members of the confederation of artisanal fishers acted as institutional entrepreneurs (19) and facilitated the cross-scale and the cross-organizational interactions that were required to transform the social–ecological regime (22). In effect, the confederation of fishers represented a bridging organization (45) that could enhance vertical integration from local to national levels among different players.

The existence of social mechanisms for transformability, such as those identified in this article, are key for moving toward a social–ecological trajectory with the capacity to manage ecosystems sustainably for human well-being. However, the resource management task is not over once a policy is implemented. It is essential to build resilience and adaptability of the new system (46). In Chile, the achievement of the MEABR management regime has been seen as an end point, and consequently colearning processes have been weakened, with negative consequences for the system and individual fishers. The Chilean system still needs to develop incentives for fisher associations to continuously experiment and foster values of stewardship (36). At present the Chilean MEABR policy has left few legal options for fishers to undertake experiments as the basis for future adaptations or transformations (45, 47). This is unfortunate, because mechanisms for colearning need to continue evolving to deal with change (48, 49).

Building resilience of the new regime is an ongoing task. Indeed, current collaborations between researchers and fishers may be an unrecognized phase in which the system is preparing for a new transformation. For example, new collaborative research on the role of MEABRs as biodiversity offsets (38) and fisher-managed marine protected areas (40) might be providing basic elements of future plausible alternative states. Only with a historical perspective will we know whether these initiatives are building resilience of the existing system or preparing for a new transformation in governance.

In Chile, a transformation in governance reorganized the fishing rights of individuals, communities, and fleets. Different social processes were needed to achieve the current management arrangements, and it is encouraging to see that the Chilean FAL has helped to ameliorate overexploitation (23, 24, 36, 42). However, the increased dialogue between resource users, academics, and policy makers decreased after policy implementation. We urgently advocate for the need to reinforce dialogue to prepare for the future. As we have seen, governance transformations toward improved pathways are ongoing processes that involve a preparation phase. Elements of this phase, although very hard to anticipate, will involve identifying dysfunctional states, alternative pathways, change agents, and strategies for overcoming social and ecological coastal problems.

Conclusions

Our analysis of evolving systems of governance for coastal marine resources in Chile reveals several general conclusions that may act as lessons for the future. A common theme with other studies on transformations (19, 21, 22, 44) is how new knowledge is developed and built into novel governance systems for managing ecosystem services and how the ideas and practices developed in shadow networks were connected to political leadership to create a governance transformation. In addition, transformational change is most likely to occur when a window of opportunity for change arises and when stakeholders agree that the current system is dysfunctional. Further research to understand critical elements in guiding transformations toward improved stewardship of marine ecosystem services will help prepare and recognize windows of opportunity (22). This is an imperative issue, considering the current global marine resource crisis and the difficulties in implementing new governance models to tackle future global social–ecological changes.

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