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REVIEW

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Comanagement of small-scale fisheries and ecosystem services

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Abstract

Marine ecosystem services are in global decline, which requires new transformational changes in governance to cope with multiple anthropogenic stressors. We perform a systematic literature review of the biodiversity and ecosystem services outcomes of a governance transformation toward comanagement through the allocation of territorial user rights to artisanal fisher associations (TURFs) in Chile. We synthesize the implications of more than 25 years of establishing a TURF policy over ecosystem services. Results show TURFs sustain biodiversity and all typologies of ecosystem services when they are well enforced. Research on provisioning services is most prevalent, however cultural services have been gaining traction with studies assessing the role of leadership, sanctions, and social capital in determining TURF outcomes. The results suggest that TURFs can play an important role in creating social and ecological enabling conditions for local stewardship. While this is encouraging, there is a bias toward positive results and few studies address negative consequences of TURFs aimed at identifying constraints for further development. The review shows that there has been a continuous transition toward interdisciplinary social–ecological research. Research on TURFs faced with drivers of global change and uncertainty are urgently needed, in order to anticipate unintended outcomes and adapt accordingly.

KEYWORDS

governance, local stewardship, marine ecosystem services, social–ecological systems, transformation

1 | INTRODUCTION

Marine ecosystems provide multiple benefits, or ecosystem services, to people including food provision, carbon sequestration, coastal protection, and recreation opportunities (Liquete et al., 2013; Worm et al., 2006). The degraded condition of marine ecosystem services and consequent social, health, and economic impacts have prompted calls for major transformational changes in governance (Carpenter et al., 2012; Kittinger et al., 2014). Comanagement approaches that grant territorial user rights for fisheries (TURFs) are one of various policy alternatives that are being promoted to transform marine governance and enhance the sustainability of small-scale fisheries. TURFs are currently being promoted by NGOs, governments, and philanthropic foundations across the globe (Gelcich et al., 2017). Unfortunately, evidence-based social–ecological assessments of marine governance transformation outcomes are scarce. That jeopardizes the monitoring of costs, benefits, and unexpected outcomes.

A number of studies have addressed the implications of assigning TURFs over specific ecosystem services (Auriemma, Byler, Peterson, Yurkanin, & Costello, 2014; Matsuda, Makino, Tomiyama, Gelcich, & Castilla, 2010; Molares & Freire, 2003; Nguyen Thi Quynh, Schilizzi, Hailu, & Iftekhar, 2017). Foremost among these are those that have assessed the potential for TURFs to increase provisioning services (i.e., fishery yields) and/or profits (Molares & Freire, 2003; Rivera, Gelcich, García-Flórez, & Acuña, 2017). A few studies have focused on assessing the role of TURFs on the provision of cultural ecosystem services (e.g., esthetic quality, cultural heritage, educational, and inspirational; Outeiro, Gajardo, & Oyarzo, 2015). They have, for example, assessed the roles of taboos and traditional institutions (Auriemma et al., 2014; Nakandakari, Caillaux, Zavala, Gelcich, & Ghersi, 2017) and recreation (Murphy, Campbell, & Drew, 2018). Studies have further analyzed some determinants of TURF and comanagement outcomes highlighting the role of leadership, trust, and social capital (Cinner et al., 2012; Molares & Freire, 2003; Rivera, Gelcich, García-Florez, Alcázar, & Acuña, 2014).

Despite this global research effort devoted to assessing comanagement and TURFs policy implementation and outcomes, research thus far assessing TURFs and ecosystem services has generally been based on specific case studies that have assessed services separately. In addition, these case studies encompass a range of resource systems operating under different institutional and legal settings. While research has been important to signal key benefits and determinants, there has not been an integrated assessment of a suite of ecosystem services under a single TURF policy instrument, managing similar sets of species and ecosystems. This integrated assessment of the potential implications of TURF policies over ecosystem services is important to indicate ecosystem services synergies, tradeoffs, and enabling conditions that can inform a policy improvement or further transformation.

In 1991, Chile undertook a governance transformation, which resulted in a national TURF policy that gave the Undersecretary of Fisheries the legal authority to assign exclusive access rights to artisanal fisher organizations for the sustainable harvesting of benthic resources (Castilla, Manriquez, & Alvarado, 1998). As of 2013, there were around 450 TURFs in full operation, making up >1,100 km^2, decreed to fisher organizations throughout mainland Chile (Gelcich et al., 2017). This large TURFs network, which has been established for more than 20 years, places Chile at the forefront of implementing rights-based approaches for small-scale artisanal fisheries and provides unique opportunities to assess the implications of TURF policy over ecosystem services.

The Chilean TURF network essentially comprises a large number of TURF areas established by numerous associations of fishers, along a wide geographic range, under one policy instrument (Gelcich et al., 2010). This network serves as a basis to integrate knowledge of TURF policy implementation over ecosystem services. Research on TURFs functioning and implementation has been ongoing for the past 25 years, based on case studies that suggest mixed and heterogeneous results (Aburto et al., 2013; Gelcich, Edwards-Jones, Kaiser, & Castilla, 2006; Gelcich et al., 2010). Here, we attempt to provide broad insights beyond specific case studies, focused on one policy instrument, by performing a systematic literature review on the implication of TURFs implementation over biodiversity and ecosystem services in Chile.

The study aims to synthesize more than 25 years of territorial user rights based management research in Chile to explore the implications of assigning comanaged TURF areas over a suite of ecosystem services. We then discuss the interplay between the effects of TURFs over ecosystem services and stewardship as an enabling condition to identify new management pathways. While we focus on Chile, our results are relevant for other countries considering TURF policies that could benefit from strengthening support for place-based, long-term, social–ecological monitoring from the onset.

2 | METHODS

We used the ISI Web of Science core collection database (Timespan: 1990–2017), and applied four search filters. Our first filter identified the literature addressing comanagement through TURFs, our second filter targeted papers performed in Chile, our third filter identified empirical papers, and our fourth filter excluded papers not dealing with TURFs or our study objectives (Figure 1). We identified 53 English and Spanish language, peer-reviewed papers published between 1998 and 2017 for a qualitative analysis. For this analysis, we registered the broad themes covered by the papers according to the ISI web categories (biodiversity and conservation, economics, environmental sciences, social sciences, and marine biology). We registered the specific location of the studies, calculated the number of studies by administrative region, mapped the study sites, and identified the type of ecosystem services addressed.

For the identification of marine ecosystem services, we defined ecosystem services as the benefits people obtain from coastal social–ecological systems (Millennium Ecosystem Assessment, 2005) and identified the category of the ecosystem services addressed in the papers. The four ecosystem services categories that we distinguished are:

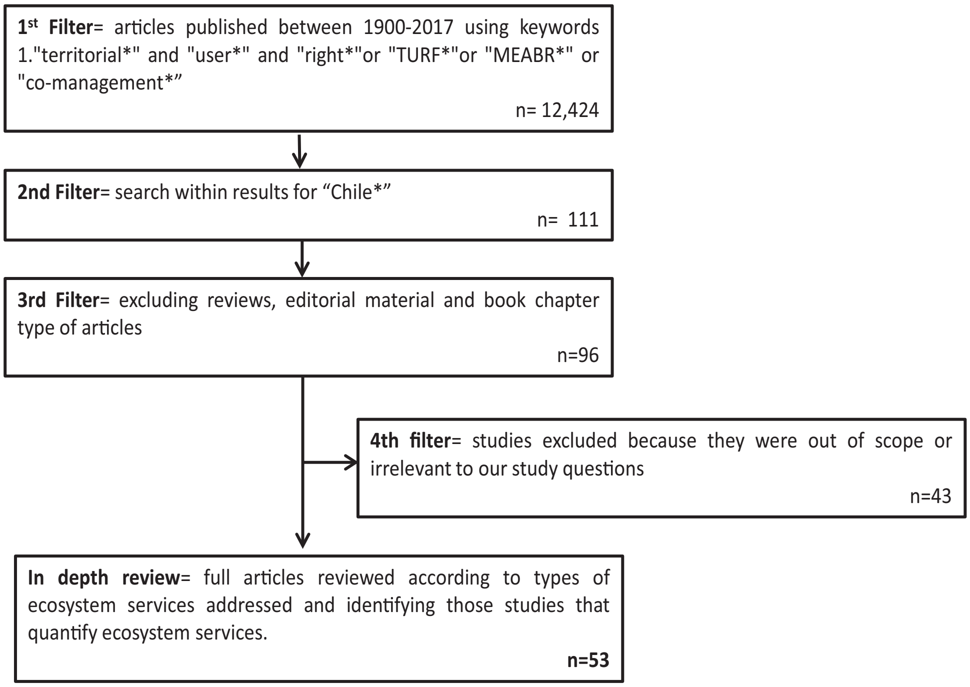

FIGURE 1 Decision tree for the identification of peer-reviewed studies for review. See Martínez Harms (2018), Appendix A for the complete list of papers selected and database

supporting, provisioning, regulating, and cultural services (Millennium Ecosystem Assessment, 2005; Sukhdev, 2010; Wallace, 2007). The first category was defined as the supporting services that refers to the conditions, structure, and functioning of coastal social–ecological systems that are required for the provision of ecosystem services. In the supporting category, we identified studies dealing with the biodiversity component using species richness and habitat conditions as proxies. Provisioning services are the goods that can be extracted and consumed from marine ecosystems that are often already valued in markets, such as food provision, biotic materials, biofuels, and water provision (Liquete et al., 2013). Regulating services are the benefits derived from the regulation of ecosystem processes, such as the water purification, coastal protection, weather regulation, biological regulation among others (Liquete et al., 2013). Cultural services are the intangible benefits that emerge from interactions between humans and nature (Chan et al., 2012a), for instance, sense of identity, spiritual value, esthetic value, and cognitive development (Liquete et al., 2013). A further description of the categories can be found elsewhere (De Groot, Alkemade, Braat, Hein, & Willemen, 2010; Sukhdev 2010; Wallace, 2007). We synthesize the 53 studies according the provision of each one of these four ecosystem services categories in Chilean TURFs.

We include a quantitative analysis identifying a subsample of the papers that quantified the amount of ecosystem services provided inside TURFs and outside in open access areas ($n = 13$). We calculated the effect size (lnR) for both samples considering the observed means of ecosystem services provision inside the TURFs X_1 and in open access X_2, registering the standard deviations of the samples S_1 and S_2, and the sample sizes n_1 and n_2. Then the log-transformed ratio of means (also called log response ratio) is given by:

$$Y = \ln\left(\frac{X_1}{X_2}\right) \quad (1)$$

For which we estimated the sampling variance with the equation:

$$Var\,[Y] = \frac{S_1^2}{n_1 X_1^2} + \frac{S_2^2}{n_2 X_2^2} \quad (2)$$

We developed a forest plot representing the response ratio of each ecosystem service addressed by the subsample of the papers. Considering each ecosystem service addressed within each of the 13 references, this analysis had 32 entries. Positive values of response ratios indicated greater ecosystem services (supporting, regulating, and provisioning) inside TURFs relative to open-access sites. Negative values indicated that the amount of services was higher in open-access sites. A ratio of zero meant the amount of services or ecosystem services were similar between open-access sites and TURFs. Cultural ecosystem services were excluded from this analysis as the papers addressing this type of services rely on methodologies from social sciences such as interviews (Gelcich, Godoy, & Castilla, 2009), group meetings (Gelcich, Kaiser, Castilla, & Edwards-Jones, 2008b), and social network analysis (Marin

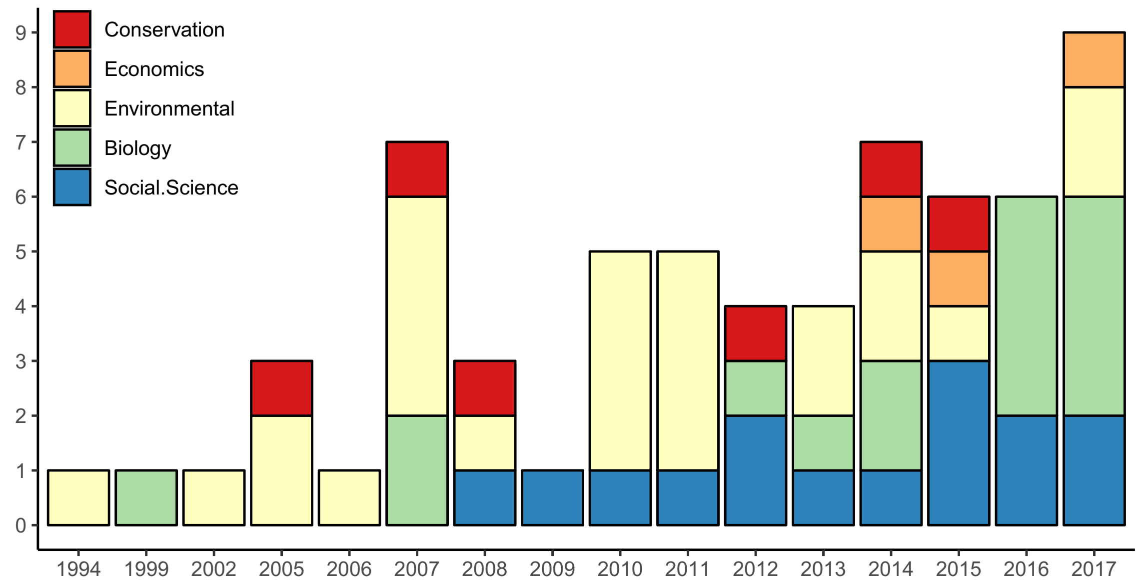

FIGURE 2 Distribution of the number of studies per broad theme from 1994 until 2017 per subject according the ISI web of knowledge

& Berkes, 2010; Marin, Bodin, Gelcich, & Crona, 2015; Marin, Gelcich, Castilla, & Berkes, 2012). We qualitatively analyzed the cultural ecosystem services by registering the type of cultural ecosystem service, the objective of the study, social method used, social outcome, and bibliographic source (see more details in the database Martínez Harms (2018), Appendix A). We provide table 1 with examples of studies for the three categories of cultural ecosystem services identified in this review (social relations, knowledge systems, and recreation).

3 | RESULTS

3.1 | Review of marine ecosystem services in Chilean TURFs

We identified 53 publications dealing with comanagement and TURFs in Chile (see Martínez-Harms (2018), Appendix A for the complete list of papers selected). There has been a move toward more interdisciplinary studies during the past 10 years covering biological responses, social, economic, environmental, and conservation dimensions (see Figure 2). Most of the research about coastal ecosystems and comanagement in Chile have focused attention in addressing environmental dimensions (39% of the studies), followed by biological (23% of the studies), social science (23% of the studies), conservation (9% of the studies), and economic (5% of the studies) dimensions. There has been a change of focus in time from papers with a natural science foundation, to a growingly interdisciplinary nature of studies dealing with TURFs (Figure 2). The shift is mainly represented the inclusion of social science and governance approaches with a policy-oriented focus.

Spatially the majority of studies and study sites have been biased to the central coast of Chile focusing in the administrative region of Valparaiso (region V in Figure 3), followed by the region of Coquimbo (region IV), Libertador Bernardo O'Higgins (region VI), Bio-Bio (region VIII), and Los Lagos (region X). The central region of Chile concentrates the main urban settlements in which most of the country's population resides. Thus, in central Chile, the demand for marine ecosystem services is higher. There are important research gaps in the southern regions of Chile such as Aysen (region XI) and Magallanes (region XII) and in northern regions such as Arica (region XV). There are also important geographic representation gaps in in some south-central regions like Maule (region VII), Araucania (region IX), and Los Rios (region XIV).

We identified that nine marine ecosystem services have been addressed (see Figure 4). Considering some papers address more than one ecosystem service, the 53 references analyzed resulted in a database of 60 entries. The most commonly addressed marine ecosystem service is food provision (40% of the entries) with research focusing on the provision of commercial species (e.g., gastropod *Concholepas concholepas* and key-hole limpet *Fissurella* ssp.). Cultural ecosystem services have been well addressed by the literature with 39% of the entries. The most common cultural ecosystem services addressed have been social relations (19% of the entries) and knowledge systems (14% of the entries). Supporting ecosystem processes related to biodiversity persistence was present in 16% of the entries and regulating services were assessed in 6% of the literature reviewed.

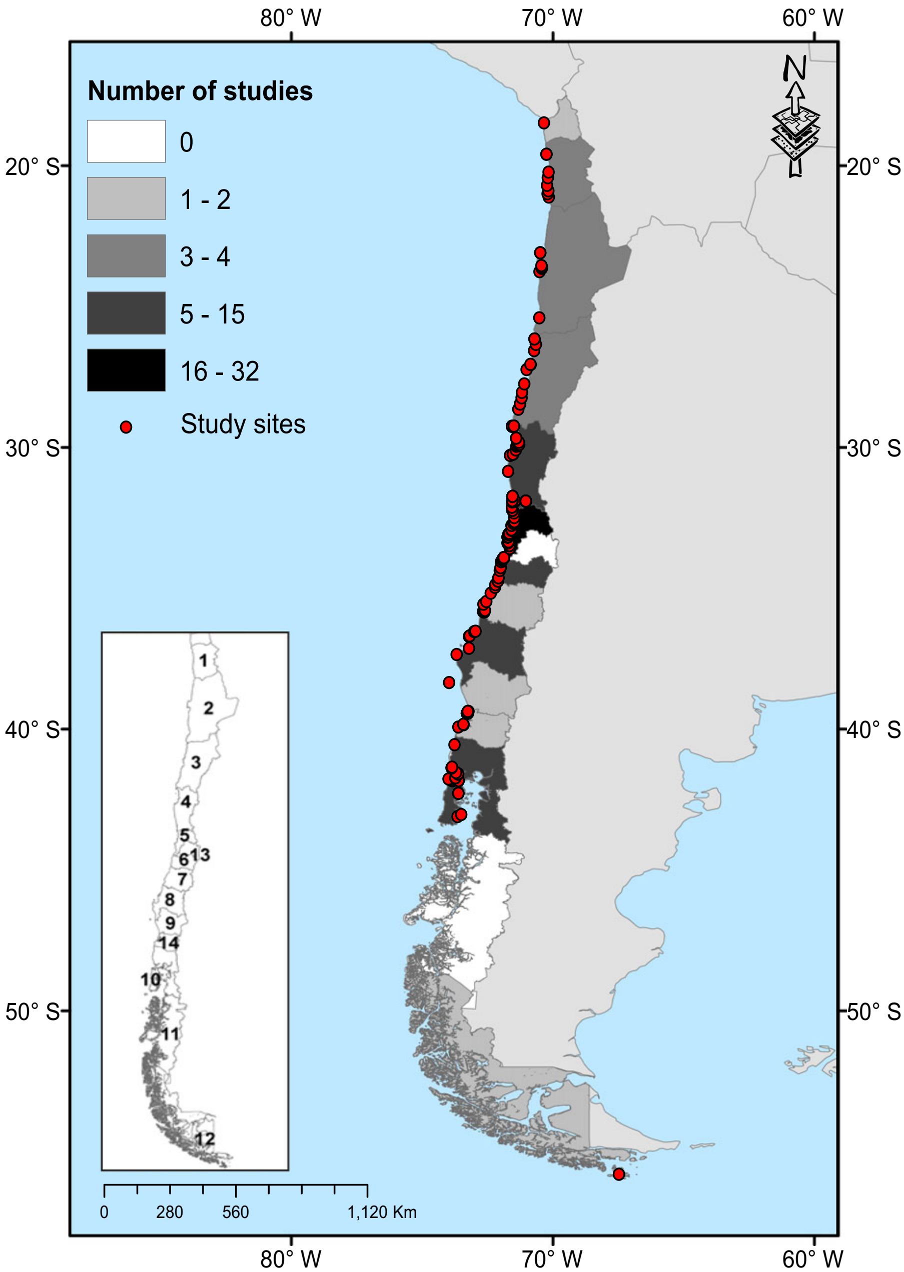

FIGURE 3 Map of the number of studies per administrative region (administrative division of the country and its coding is represented in in left side map) and the specific location of the 268 study sites of the 53 identified studies

3.2 | Marine ecosystem service categories and TURFs

3.2.1 | TURFs and supply of ecosystem services: Supporting biodiversity conservation

In general, studies on TURFs show positive responses on biodiversity (see Figure 5). However, this pattern is not observable in every TURF (Aldana, Maturana, Pulgar, & Garcia-Huidobro, 2016; De Juan, Gelcich, Ospina-Alvarez, Perez-Matus, & Fernandez, 2015; Gelcich, Godoy, Prado, & Castilla, 2008a; Perez-Matus, Carrasco, Gelcich, Fernandez, & Wieters, 2017). While several studies have reported, significant differences in species richness between open access and TURFs (Aldana et al., 2016; De Juan et al., 2015), other studies have shown that species richness is similar in TURFs when compared to open access sites (De Juan et al., 2015; Gelcich et al., 2008a; Perez-Matus et al., 2017). TURFs and their effects on biological communities will vary depending on the fishery context, the level of enforcement, and the role of illegal poaching within the areas. When TURFs are well enforced, studies have proposed that they can sustain densities and biomasses that are significantly greater than those in comparable open access areas (Gelcich et al., 2012). Evidence suggests that the level of enforcement, aimed at

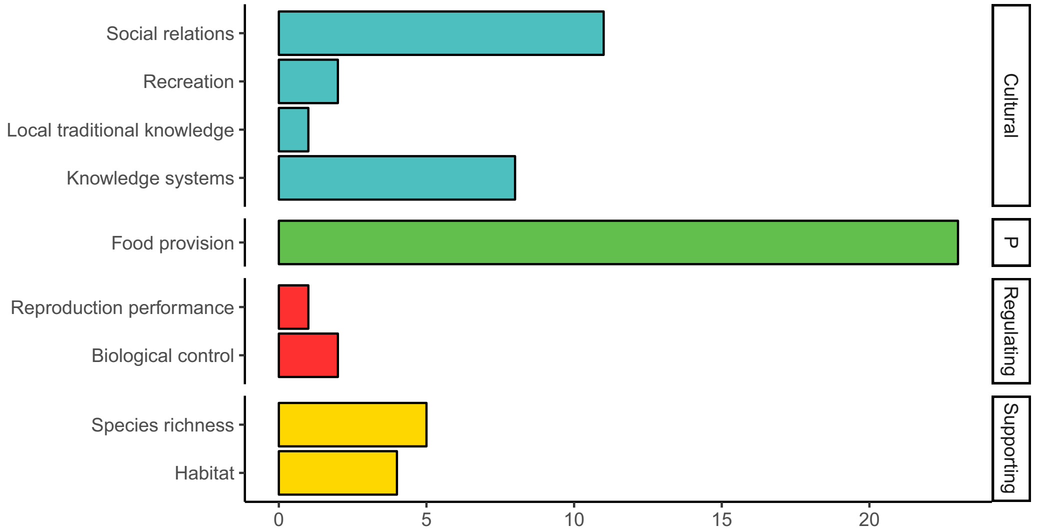

FIGURE 4 The types of ecosystem services addressed in the literature review. Because most of the studies consider several ecosystem services, the sum of entries in this figure exceeds the total number of 53 studies reviewed (P = provisioning ecosystem services)

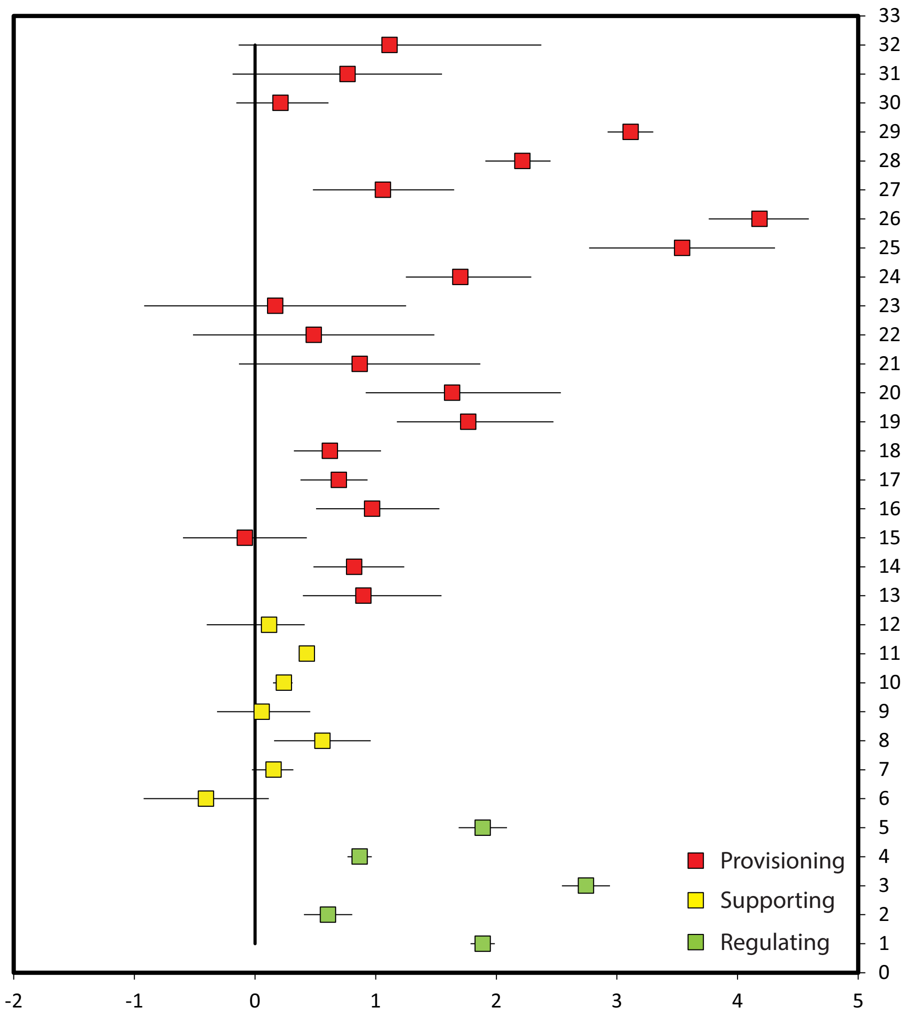

FIGURE 5 Forest plot representing the ratio response of each ecosystem service (supporting, regulating and provisioning) addressed by the sub-sample of the papers that quantified the amount of ecosystem services provided by TURFs and open access areas ($n = 13$). See Martínez-Harms (2018), Appendix B (https://doi.org/10.17632/px6sr52zpb.2) for the complete list of papers included in this analysis

preventing poaching in TURFs, is associated with biodiversity (Davis, Kragt, Gelcich, Schilizzi, & Pannell, 2015). One paper highlights that despite the benefits provided by TURFs for the subtidal communities, they cannot replace no-take marine protected areas (Gelcich et al., 2012).

3.2.2 | TURFs and regulating services: Larvae production and climate regulation

The systematic review results suggest that well-enforced TURFs have the potential to sustain regulating services (see Figure 5). Regulating services have been mainly represented as the production of larvae that contributes to the regulation and stability of the marine ecosystem (Berkeley, Hixon, Larson, & Love, 2004). For example, regulating services measured as larvae production of economically important gastropods commonly known as loco (*Concholepas concholepas*) have been registered as the number of fertilized egg capsules (Manríquez & Castilla, 2001). Capsules contain fertilized eggs and each female individual can lay up to 580 capsules, each of which contains between 2,000 and 7,000 eggs (Castilla, 1977). Larger females, which are more abundant within TURFs (Castilla et al., 1998), produce larger capsules that in turn harbor more eggs (Manríquez & Castilla, 2001). TURFs present a surface covered by loco (*Concholepas concholepas*) capsules that is 10 times higher than open access areas in similar subtidal zones, having relevant implications on the number of larvae that are being released to the ocean (Manríquez & Castilla, 2001). In open access areas, it has been estimated that 22 million larvae are released every 90 m^2. On the other hand, in TURFs, a 20-fold increase in release of larvae is estimated (Blanco, Ospina-Alvarez, Gonzalez, & Fernandez, 2017). Other invertebrate benthic species of commercial importance (the keyhole limpet *Fissurella latimarginata* and the red sea urchin *Loxechinus albus*) also have higher potential fecundity within TURFs than in open access areas as they reach larger size and consequently produce larger gonads (Fernandez, Blanco, Ruano-Chamorro, & Subida, 2017). There is no difference in gonadosomatic index of *Fissurella latimarginata* and *Loxechinus albus* inside and outside TURFs (Fernandez et al., 2017).

The conservation of kelp forest habitats within TURFs has also important consequences in the supply of regulating services. Kelp forests provide many regulating ecosystem services such as climate regulation, erosion control, and coastal defense (Smale, Burrows, Moore, O'Connor, & Hawkins, 2013). However, most services in this category are not well understood and there is not enough scientific data available to quantify them (Hattam et al., 2015; Liquete et al., 2013). The climate regulation provided by kelp forest was assessed in one study in Northern Chile using data of the surface covered by kelp forest, the capacity of the species to capture carbon and the economic value of tradable carbon credits and resulted in a total value of US$ 21,440,680 (Vásquez et al., 2014). One article proposes that higher density and biomass of adult kelp plants that are found in TURFs when compared to open access areas in Northern Chile might capture more carbon and therefore provide more regulating ecosystem services (Vásquez et al., 2014).

3.2.3 | TURFs and provisioning services: Small-scale fisheries

Studies show that provisioning services have increased in TURFs compared to open-access areas for many species (see Figure 5). Provisioning services measured as abundance, size, and catch per unit effort (CPUE) of commercial species have increased in well-enforced TURFs when compared to open access areas (Castilla & Fernandez, 1998; Gelcich et al., 2012; Gelcich et al., 2008a; Ruano-Chamorro, Subida, & Fernandez, 2017). Studies conducted in central Chile, show that the density of economically important gastropods such as loco (*Concholepas concholepas*) can be up to 10-fold in TURFs when compared to open access areas of similar characteristics in terms of habitat complexity, wave exposure, and depth (Gelcich et al., 2008a, 2012). Differences in densities between TURFs and open access areas can result in differences in CPUE, being 190 loco/hr extracted within TURFs and 20 locos/hr extracted in the open access areas (Castilla et al., 1998). Other commercial species that are targeted inside TURFs, such as red sea urchin (*Loxechinus albus*) and key-hole limpets (*Fissurella* ssp.) have reported similar trends (Molina et al., 2014). Fished species that are not under TURFs management plans, such as reef fish, also show higher biomass and density within well-managed TURFs than in open access areas or TURFs that are poorly managed (De Juan et al., 2015). In addition, the density and size of the intertidal kelp *Lessonia nigrescens,* which has become an important fishery in the past decades in Chile (Vásquez et al., 2014; Vásquez, Piaget, & Vega, 2012), is also affected by these management regimes in Northern Chile. Within TURFs, fishers adopt management recommendations for sustainable kelp harvesting (Vásquez et al., 2012) while in open access areas, kelps are indiscriminately exploited resulting in significantly different percentage of available adult plants for harvesting between TURFs (25% of the population) and open access areas (10% of the population; Vega, Broitman, & Vásquez, 2014). Some species such as surf clams (*Mesodesma donacium*) have not shown positive responses when the TURFs system was implemented. For this type of species natural variability, the lack of recruitment, and natural mortality resulted in low densities that reduced incentives and resulted in the abandonment of TURFs (Aburto & Stotz, 2013).

TABLE 1 Sample of selected studies addressing the three categories of cultural ecosystem services (SR: social relations, R: recreation, KS: knowledge systems) classified by objective of the study, social science method, and social outcome

Ecosystem Services	Objective	Method	Outcome	Source
SR	Assess social capital and leadership in Chilean TURF.	Social survey and social network analysis	Engaged leadership and agreement around sanctions best explains outcomes	Crona et al., 2017
SR	Understand fishers' perceptions on TURFs problems and benefits	Social survey	TURFs have provided incentives for innovation and stewardship	Gelcich et al., 2017
SR	Assess the comanagement system from an organizational network perspective	Social network analysis	Decision making is highly centralized and power is concentrated in government, with little horizontal exchange and cooperation among fisher associations	Marin & Berkes 2010
R	Investigate the potential for synergies between nature-based tourism and TURFs	Social survey	Nature-based tourism opportunities in TURFs (Recreational divers prefer TURFs)	Biggs et al., 2016
KS	Links between customary uses of indigenous communities and marine ecosystem services	Social survey	Customary tenure system as an opportunity to enable social cohesion	Outeiro et al., 2015
KS	Assess the determinants of fishers' perceptions within comanagement	Social survey and workshops	Fishers' environmental awareness of the benefits of comanagement	Gelcich et al., 2008b
KS	Comanagement is assessed as a tool for mitigating impacts of overfishing in the area	Social survey	Efforts targeted to a continuous process of stakeholder collaboration	Pollack, Berghofer, & Berghofer, 2008
KS	Examined benefits predicted to result from comanagement	Social survey	Analyzes the principal benefit of"consciousness" of the value of management	Schumann, 2007
KS	Assessed differences in attitudes of participating fishers toward comanagement	Social surveys	Distinct world views toward the marine environment and its management	Gelcich et al., 2005
KS	Explore the links among fishers and marine scientists for establishing comanagement	Policy review	Need to balance contradictions in a management model that strives to be a conservation and profitable system	Meltzoff, Lichtensztajn, & Stotz, 2002

SR: social relations; R: recreation; KS: knowledge systems,

3.2.4 | TURFs and cultural services: Social relations, knowledge systems, and recreation

Cultural services are the intangible benefits that emerge from interactions between humans and nature (Chan et al., 2012a; Chan, Satterfield, & Goldstein, 2012b). Examples for this category are: recreation and tourism, sense of identity, social relations, knowledge systems, spiritual value, scenic beauty, and cognitive development. We identified three categories of cultural ecosystem services: social relations, knowledge systems, and recreation addressed in TURFs system (see Table 1). The building and strengthening of social relations associated with the implementation of TURFs has been the most common cultural service addressed in the reviewed literature. Studies have also shown that social relations nurtured for the purpose of comanagement can promote resilience to natural disasters but that conflict between cooperatives can jeopardize the system (Marin et al., 2015). Studies have highlighted the importance of fisher cooperation as determinants of TURFs performance (Gelcich, Guzman, Rodriguez-Sickert, Castilla, & Cardenas, 2013; Rosas, Dresdner, Chavez, & Quiroga, 2014). For example, findings of Crona, Gelcich, and Bodin, (2017) show that engaged leadership and agreement among TURFs members around decisions are closely linked to TURFs performance. In addition, research using experimental economic approaches (Gelcich, Guzmán, Rodríguez-Sickert, Cárdenas, & Castilla, 2013) show how fisher associations with well-functioning TURFs exhibit mutual collaboration and internalize pro-social norms, while fishers who are not in associations do not cooperate or internalize pro-social norms (Gelcich et al., 2013).

Knowledge systems have also been addressed in the literature on TURFs. For example, it has been revealed that fishers' environmental awareness of the benefits of management have increased in TURFs (Gelcich et al., 2008b; Schumann, 2007) along with more environmentally friendly behaviors (Gelcich et al., 2008b). However, studies also stress heterogeneity and different world views among fishers' that has increased conflict (Gelcich, Edwards-Jones, & Kaiser, 2005) and the erosion of traditional management institutions that could be affecting resilience for the management of some algae resources (Gelcich et al., 2006).

A series of studies have assessed fishers' environmental perceptions in Chile (Gelcich et al., 2008a, 2008b). One study highlighted that the time engaged with managing TURFs at an individual and at the cooperative level proved to be a significant determinant of fishers' environmental perceptions (Gelcich et al., 2008b). Studies assessing fishers' perceptions have stated that although fishers have not increased their income significantly through TURFs, different benefits such as conservation of resource stocks, consolidation of associations, territorial empowerment, and access to projects are perceived after two decades of its implementation (Gelcich et al., 2017). Fishers also perceived a better functioning, discipline, and organizational structure in the association and an increase feeling of safety against possible exclusion from the TURFs (Aburto, Stotz, & Cundill, 2014; Zúñiga, Ramírez, & Valdebenito, 2008, 2010).

Recreation and/or tourism in natural ecosystems is one of the most common and valued cultural services. However, few of the reviewed studies have assessed tourism services associated to TURFs. In Chile, a study assessed 135 recreational divers' perceptions and willingness to pay for diving in well enforced TURFs (Biggs, Amar, Valdebenito, & Gelcich, 2016). Results show that almost half of recreational divers were willing to pay US$ 6 and 21% were willing to pay more than US$ 6 to dive inside TURFs. Recreational divers that were willing to pay to dive in TURFs perceive that inside these areas there is high biodiversity and abundance of marine organisms and the species that they prefer to see include rocky reef fish, sea stars, nudibranchs, and sea sponges. In Chile, diving activities are a touristic attraction in some fishing villages, but in general, tourists are not interested in this activity (De Juan et al., 2015). However, diving has the potential to become an important touristic activity in Chile as it has been observed in other countries (Hall, 2001).

4 | DISCUSSION

Managing for the effective, efficient, and equitable provision of multiple ecosystem services is challenging (Bennett et al., 2015; Halpern et al., 2013). Here, we perform an integrated assessment of a suite of ecosystem services under a single TURFs policy and provide empirical evidence that comanagement in Chile has the potential to enhance the provision of multiple ecosystem services simultaneously. Using the lens of ecosystem services, this review has allowed to explore both social and ecological outcomes of TURF implementation.

Food provision, and in particular fisheries, is the most frequently addressed ecosystem service in the literature, mainly because of its direct economic relevance (Liquete et al., 2013). In general, results show increases in food provision, which include biomass, abundance, size, and CPUE of target species in well-enforced TURFs. These findings are consistent with assessments in other countries with TURF like systems, such as Spain (Molares & Freire, 2003), Japan (Matsuda et al., 2010), and those in the Indo-Pacific (Auriemma et al., 2014; Nguyen Thi Quynh et al., 2017). The review shows that enforcement is the key for TURF outcomes to be achieved (Gelcich et al., 2012; Perez-Matus et al., 2017) and that access rights can play an important role in fishers internalizing enforcement rules (Gelcich et al., 2013). They also suggest that best performing fisher organizations are those with higher levels of linking and bridging social capital (Marin et al., 2012) and that engaged leadership and agreement around sanctions best explains TURF outcomes (Crona et al., 2017). Even when many of these social factors are considered, some commercial species, such as razor clams, have not responded to TURFs management (Aburto et al., 2013), signaling to the fact that community-based management is constantly conditioned by specific place-based context (Berkes, 2007).

Results show TURFs can sustain cultural services. In fact, cultural ecosystem services are the next most commonly assessed service represented by the study of social relations and knowledge systems. This synthesis shows that TURFs policy has enhanced attitudes and behaviors of fishers engaged in this comanagement scheme. Fishers have been empowered through the TURFs comanagement experience (Gelcich et al., 2009), social relations have been reinforced helping to promote resilience (Marin et al., 2015) and TURFs policy has promoted cooperation and collaboration (Gelcich et al., 2013; Rosas et al., 2014). The systematic review also signals that TURFs need to be implemented according to the needs and strengths of specific knowledge and value systems as a way to be legitimate for fishers (Gelcich et al., 2006). They also stress the important role of government and fishers capacity to enforce TURFs. With weak legal support, authority to prosecute, or inadequate infrastructure, ecosystem services provided by TURFs are jeopardized (Oyanedel, Keim, Castilla, & Gelcich, 2018).

The belief that the ecosystem services approach can lead to better environmental decision making underpins much of the increasing interest in ecosystem services in both science and policy agendas. Nonetheless, the implementation of the ecosystem services into decision making remains challenging and has yet to change real-world decisions (Martinez-Harms et al., 2015). In Chile, multiple marine ecosystem services enhanced in the TURFs system are locally experienced by fishers, and could therefore provide an enabling condition to develop local environmental stewardship. Stewardship has been defined as "the actions taken by individuals, groups or networks of actors, with various motivations and levels of capacity, to protect, care for or responsibly use the environment in pursuit of environmental and/or social outcomes in diverse social-ecological contexts" (Bennett et al., 2018). Chile's TURFs network is an attractive setting for understanding how the positive consequences over ecosystem services could trigger positive feedbacks toward stewardship. Stewardship associated with TURF outcomes could even constitute a platform to build new opportunities and development pathways.

This synthesis also shows that most of the research has been performed in TURFs, which are fully operational. In the Chilean coast, there are 40% of TURFs that are inactive or currently abandoned (Gelcich et al., 2017), thus these areas might not be responding in terms of cultural or other ecosystem services. This bias toward fully operational TURFs raises the need to address research on the determinants of nonfunctioning and abandoned TURFs, as they might be signaling future problems in the system that need to be urgently addressed. Adapting a bright/dark spot analysis to TURFs could be particularly novel way forward. Bright spots, or positive deviance analyses focus on learning from anomalies. They have recently been used to address marine conservation issues in coral reefs (Cinner et al., 2016). From an environmental perspective, bright spots are places where ecosystems are substantially better and dark spots would be those worse than expected, given the environmental conditions and socioeconomic drivers they are exposed to (Bennett et al., 2016; Cinner et al., 2016). Research on dark spots could be key to identify social–ecological characteristics that are constraints to TURF development and help identify what type of interventions are needed to address these constraints. A pioneer study in this direction has begun exploring why fishers stop enforcing their TURFs (Davis et al., 2015).

Results from this review suggest that the Chilean TURFs policy has the potential to sustain the supply of multiple ecosystem services. However, research also stresses that the mere existence of the TURFs policy does not ensure sustained provision of these services. TURFs will depend on the way the policy continues to be implemented, operationalized, enforced, and adapted to new challenges posed by markets and global change. Many TURFs have failed or might fail when confronted with global change stressors not because of bad ecological accounting or metrics; rather, because we fail to sufficiently understand the local socioeconomic conditions and global scale teleconnections, which allow for a successful adaptation of TURFs policy (Morrison, 2017, Oberlack et al., 2018). We also need a better understanding of changes over time to allow analyzing the evolution of governance systems, including the emergence of new governance spaces and the termination of others. Yet, these topics have been still little studied.

5 | CONCLUSIONS

Comanagement decisions such as TURFs policies should be underpinned by the best available science. Our systematic review provides a reliable and quantitative overview of the quantity of evidence related to the effects of the TURFs policy on biodiversity and the provision of ecosystem services. Results from the review in general show TURFs potential to sustain biodiversity and all typologies of ecosystem services. While this is encouraging, there seems to be a bias toward positive results and a lack of studies that address nonsignificant or negative consequences of TURFs. In addition, an important gap in the literature relates to the evolution of ecosystem services from TURFs under different drivers or stressors. Research on TURFs resilience faced with drivers of global change and uncertainty are urgently needed in order to anticipate future unintended desirable and/or undesirable outcomes of TURFs policies, and adapt the policy accordingly.

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