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ARTICLE

A participatory decision making framework for artisanal fisheries collaborative governance: Insights from management committees in Chile

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Abstract

Fisheries management is increasingly transitioning towards collaborative governance. Collaborative systems depend on stakeholders' capacity to design and implement legitimate and scientifically robust management plans within collective action arenas. Here we propose that collaborative governance outcomes, in fisheries management, will benefit from using structured participatory decision making frameworks that enhance deliberative thinking among stakeholders. We tested our approach in the artisanal fishery of Chile, an important producer of marine resources. Recently in 2013, Chile made important changes to fisheries policies by creating multi-sectorial management committees to manage de facto open access fishing areas. We applied a structured decision making framework to inform the restructuring of a management plan within a committee. As a result, we identified goals,objectives and indicators, including social, economic, biological and ecological dimensions; we explored tradeoffs, assessing the relative importance of the objectives; finally, we created scenarios and prioritized alternatives, reflecting on the interplay between self-regulation and government control. Members of the management committee were able to rationalize the different steps of the framework and identify ways forward which highlighted the importance of self-regulation in comparison to central authorities' control. We concluded that structured decision making promotes spaces for rational analysis of

alternatives costs and benefits. Promoting deliberative thinking in fisheries management can improve equity, legitimacy and sustainability of collaborative governance.

KEYWORDS
benthic fisheries, Chile fishing, collaborative governance, deliberation, Ensis macha, polycentrism, scenario analysis, self-regulation, structured decision making, Tagelus dombeii

1 | INTRODUCTION

Management of marine resources is moving away from traditional top-down and single-stock strategies and towards bottom-up and ecosystem based approaches (Armitage et al., 2009). Accordingly, collaborative governance has been highlighted as a critical enabling condition to achieve sustainable and equitable fisheries (Nunan, 2018). Collaborative governance approaches emerged as a way to overcome the social and institutional problems associated to the implementation of environmental policies and regulations (Agrawal & Lemos, 2007; Ansell & Gash, 2008). Collaborative governance generally refers to the processes and structures of public policy and management that engage stakeholders in consensus-oriented decision making (Emerson, Nabatchi, & Balogh, 2011). It can be defined as a type of governance in which public and private stakeholders formally collaborate to achieve a policy outcome, through direct engagement in the decision making process (Ansell & Gash, 2008).

Collaborative governance is particularly well suited for small-scale fisheries where it can integrate government concern for efficient resource use with local concern for self-determination (Gelcich, Kaiser, Castilla, & Edwards-Jones, 2008). Numerous studies have showed the benefits of successful implementation of collaborative management in marine environments (García Lozano & Heinen, 2016). For example, long-term collaboration has promoted the establishment of spatial regulation and rules in marine protected areas (Stratoudakis, Farrall, & Vasconcelos, 2019). Collaborative governance has also strengthened peoples' involvement in marine management and conservation, promoting greater sense of ownership (Wells, Samoilys, Makoloweka, & Kalombo, 2010). Additionally, co-management systems have shown to provide ecological benefits (Gelcich, Martínez-Harms, Tapia-Lewin, Vasquez-Lavin, & Ruano-Chamorro, 2019) and increase fisheries adaptive capacity (d'Armengol, Castillo, Ruiz-Mallen, & Corbera, 2018).

Unfortunately, the creation of a collaborative governance arrangements is not enough to ensure successful implementation and management effectiveness (Birnbaum, 2016). In practice, decision makers, communities and practitioners confront real-world constraints when implementing collaborative governance. A key limitation refers to the lack of experience in designing and implementing, legitimate and scientifically robust, management plans within the collective action situations that are promoted under collaborative arrangements (Estévez & Gelcich, 2019; United Nations, 2019). A collective action situation is a social space, formally or informally structured, in which participants (e.g., fishers, farmers, gleaners) make decisions to commonly administrate resources (Ostrom, 2005). Collective action could enforce rules to manage resources in an operational space (Ostrom, 2005). The operational space is the social arena in which actors extract, sell, buy and consume resources (McGinnis & Ostrom, 2014). The actions and decisions allowed in each collective action situation may be supported by informal practices of community members (Agarwala & Ginsberg, 2017) and/or formally delimited by regulatory bodies (e.g., laws, Supreme Decree) as in many co-management policy frameworks.

Ensuring participation of relevant stakeholders in decision making is critical to ensure legitimacy and social feasibility (Ostrom, 2005). In this sense, the outcomes from collaborative policies are expected to improve when the decision making process enhances deliberative thinking among participants (Gregory, Long, Colligan, Geiger, & Laser , 2012). Deliberative thinking goes beyond basic stakeholder participation protocols and refers to the argumentative analysis of benefits and costs of management alternatives in a collective decision making process (Estévez &

Gelcich, 2019). While there are many examples of collaborative governance in small scale fisheries (e.g., Berkes, Mahon, McCooney, Pollnac, & Pomeroy, 2001; Cinner et al., 2012), systematic approaches to promote deliberative participatory decision making have not received the attention they deserve (Estévez & Gelcich, 2015).

The Participative Multi-Criteria Decision Analysis (MCDA) framework provides a multi-objective approach and a series of analytical tools which can support deliberative thinking and structured decision making in fisheries management (Estévez & Gelcich, 2015; Gregory, Failing, et al., 2012). The structured participatory decision making process promotes spaces for rational analysis of alternatives, costs and benefits, thus, promoting argumentative dialogue in collective decision making (Gregory, Long, 2012). Structured decision making articulates individual value judgements and preferences to systematically explore alternatives, consequences, tradeoffs and outcomes (Gregory, Failing, et al., 2012). Particularly, this framework supports qualitative assessments in data-poor conditions, where community knowledge can be incorporated into decision models (Pascoe, Bustamante, Wilcox, & Gibbs, 2009).

Sustainable Development Goal 14 calls to effectively regulate fisheries harvesting, implementing science-based management plans. Concomitantly, scientists and international *fora*, such as the Sustainable Blue Economy Conference in Kenya, have advocated for increased equity and stewardship of ecosystem services through collaborative governance arrangements (Bennett et al., 2019). Unfortunately, the empirical operationalization of frameworks that can aid the structuring of a participative decision making process has not received the attention it deserves. Against this background, the aims of this study are to present and empirically apply a framework to support participatory decision making, improving deliberative thinking, using small-scale fisheries management in Chile as a case study. Chile provides a unique opportunity to explore participatory deliberative decision making as it has recently established a policy that creates multisectoral management committees, a novel collective action arena, which is required to design and implement science-based management plans. As such, results of the study have informed actual management decisions and should be of interest for other geographies and sectors considering governance transitions towards novel collaborative governance arrangements.

1.1 | Chilean fisheries transitions towards collaborative governance

Chile is one of the largest producers of marine resources, providing seafood for global markets. Between 2005 and 2014 average marine resources capture for human consumption was more than 2 million tons (FAO, 2018). With a population of only 19 million, the sustainable management of marine resources in Chile has implications for hundreds of millions globally. In Chile, approximately 90,000 artisanal fishers are registered to formally extract marine resource, including benthic, pelagic and demersal fishes. Hundreds of unions are organized along the coast where they participate in different types of co-administration, associated to regulations from the Fishery and Aquaculture Law (FAL) (No. 18892).

During the last 30 years, Chilean artisanal fisheries governance has been transitioning towards a collaborative polycentric system, which reflects the coexistence of many decision making centers, which have relative operational independence to establish rules for self-regulation (Gelcich, 2014; Gelcich et al., 2010). Initially in 1991, Chile implemented co-management through a policy aimed at managing benthic resources. This policy granted artisanal fisher organizations exclusive territorial user rights for fisheries (TURF) (Gelcich et al., 2012). A recent study has synthesized the benefits of this policy for multiple ecosystem services (Gelcich, Martínez-Harms, et al., 2019).

In 2013, Chile made important changes to the FAL, in what has been termed the management plan policy. Through this policy the FAL attempts to regulate de facto open access areas and to include ecosystem and precautionary approaches as basic management principles (Law N°20.657). As part of the management plan policy, Management Committees were created as a new participatory arena to manage open access areas, which were subject to overexploitation and illegal fishing (Gelcich, Reyes-Mendy, & Rios, 2019). Management Committees have the main task of designing and implementing a sustainable management plan for a fishery. Each Management Committee operates as an autonomous center of decision making, establishing operational rules for fisheries (Estévez & Gelcich, 2019). In addition to Management Committees, the law creates Scientific Committees which establish the

maximum sustainable yield and extraction quota for each fishery. In benthic fisheries, Management Committees are constituted by 11 titular members (seven representatives of artisanal fishers, three representatives of government agencies and one representative of formal processing plants). Each stakeholder group (artisanal fishers, formal plant processors and government agencies) directly elect representatives according to procedures established by Law (Supreme Decree N°95–2013).

In Chile, more than 30 Management Committees have been created to administrate benthic, crustacean, demersal and pelagic fisheries. Despite institutional advances, Management Committees have confronted implementation problems (Gelcich, Reyes-Mendy, & Rios, 2019). Foremost among these, it is the lack of participants experience to establish clear decision making frameworks which can guide deliberative thinking for the establishment of participatory management plans. In this article, we operationalized a framework and methods to aid decision making in these collaborative governance arenas. In essence, we implemented Participatory Multi-Criteria Decision Analysis (MCDA), within a benthic resource Management Committee, which was in the process of restructuring their management plan, in the Arauco Gulf of Chile. This allowed us to explore the complexities of using the different stages of a decision-making framework that integrates multiple interests and promotes structured dialogue and deliberative thinking, while also dealing with the Management Committees challenge of synthesizing fishers' needs, values and objectives for the specific artisanal fishery management plan which was being restructured.

2 | METHODS

2.1 | Research setting

In southern-central Chile, the Arauco Gulf contains some of the most important benthic and small pelagic fisheries of the country (IFOP, 2016) (Figure 1a). In addition, a diversity of stakeholders operates in the Arauco Gulf, including a multipurpose seaport, a thermoelectric power plant, and an industrial pulp production factory (Marín, Gelcich, & Castilla, 2014).

The Arauco Committee Management Committee (onwards Arauco Committee) was established in 2012 to administrate one of the most important benthic fisheries in southern-central Chile. By Law, this committee is responsible for the design and implementation of the Arauco Gulf Management Plan (AGMP) for three filter-feeding mollusks: huepo (*Ensis macha*), navajuela (*Tagelus dombeii*) and taquilla (*Mulinia edulis*). In 2015, huepo was the most valuable resource (US$1.45/kg), followed by the navajuela (US$0.87/kg.) and taquilla (US$0.23/kg.) (IFOP, 2016). Approximately 1,000 artisanal divers operate in the Arauco Gulf from seven landing piers to extract these resources: Tubul, Llico, Punta Lavapié, Rumena, Laraquete, Arauco and Santa María Island (SUBPESCA, 2014).

Artisanal fishers extract huepo, navajuela y taquilla using small boats (less than 12 m) (Figure 1b). In the boats, assistants provide air to divers with a "hookah" air compressor. Divers extract the resources by hand or using a specially designed clip instrument. Resources are landed in the towns of Tubul (approximately 80%), and to a lesser extent in Punta Lavapié and Arauco (IFOP, 2016) (Figure 1c). After landing, intermediaries buy the fresh product at the pier. Then, intermediaries make direct agreements with four formal processing plants. Formal processing plants purchase 100% of huepo and around 65% of navajuela (IFOP, 2016). In the processing plants, resources are frozen, preserved and, to a lesser extent, fresh cool packaged. Resources are mostly exported to Spain, United States and Japan (IFOP, 2016). In Tubul, approximately 25 informal processing plants acquire the remaining 35% of navajuela, which is frozen or fresh cool packaged, and distributed to local and national markets (IFOP, 2016) (Figure 1d).

The Arauco Committee had the task of designing and implementing the AGMP for the fishery. The Fisheries Research Institute (INPESCA, by its acronym in Spanish), an independent research center, provided technical support to elaborate the AGMP, which was approved in 2015 by the Under Secretary of Fisheries and Aquaculture (onwards SUBPESCA). The AGMP must be assessed every 2 years. This study aided in the design of a participatory science-

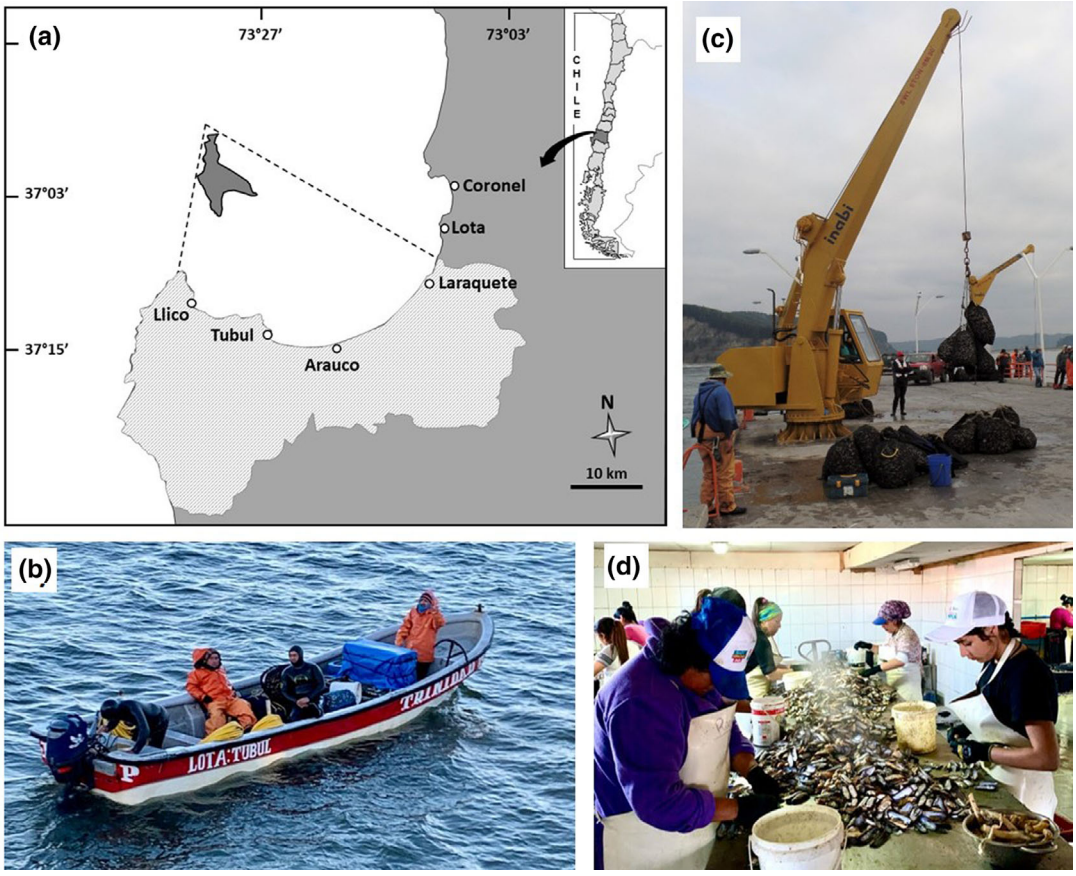

FIGURE 1 (a) The Arauco Gulf map. Dotted lines indicate the area administered by the Arauco Committee, and the light gray area is the Arauco Council area. (b) Small boats (less than 12 m) where assistants provide air to divers with a "hookah" gear to extract resources. (c) Resources are mostly landed in the Tubul pier. (d) Informal processing plants where part of the resources are processed and distributed to local and national markets [Color figure can be viewed at wileyonlinelibrary.com]

based management plan, to inform the restructuring of the AGMP. The focus of the management plan was the sustainable maintenance of the fisheries, including the roles that self-regulation and government control should play.

2.2 | Fieldwork

Fieldwork extended between September 2015 and March 2018. Once every 3 months we visited the fishing towns of the Arauco Gulf to implement the different approaches. Meetings were held every month with the teams of SUBPESCA, both at regional level (Concepción) and national level (Valparaíso) to coordinate activities and analyze ongoing results. This project had the approval of the research ethics committee of the Pontificia Universidad Católica de Chile 170,522,004.

We conducted workshops and semi-structured interviews for each stage of the framework (details are presented below). Interviews and workshops were facilitated by the first author of the article. Each workshop lasted between 5 and 8 hr. Ten to 15 people participated in each workshop. Participants were members of the Arauco Committee, that included SUBPESCA, National Fisheries and Aquaculture Service (onwards SERNAPESCA), fishers'

representatives from Tubul, Punta Lavapié, Llico and Laraquete, indigenous Lafquenche communities and INPESCA staff.

2.3 | Structured decision making framework

The structured decision making approach consisted of six stages, which were concatenated (Figure 2): (a) Setting the problem, (b) Establishing objectives and indicators, (c) Creating scenarios and alternatives, (d) Estimating consequences, (e) Weighting objectives, and (f) Prioritizing alternatives.

2.3.1 | Setting the problem

In the structured decision making framework, considerable time was spent in stakeholders exploring how problems were defined and the gaps, values and trade-offs, which allowed setting a common understanding of the decision problem (Estévez & Gelcich, 2015). In this stage, we conducted 18 semi-structured interviews with members of the Arauco Committee (82%), exploring fundamental values, trade-off and management approaches. As a result, participants reached a consensus about a decision problem definition, which was schematized in a decision tree (Gregory, Failing, et al., 2012).

2.3.2 | Establishing objectives and indicators

In collective action situations, defining objectives is an open negotiation of interests (Stratoudakis et al., 2019). Thus, in the structured decision making framework, objectives represented values, which were potentially affected by a decision (Estévez, Walshe, & Burgman, 2013). Quantitative indicators and ordinal scales were used to measure objectives (Keeney & Gregory, 2005). A worst and best outcome was established for each indicator. These bounds circumscribed the creation of scenarios and provided a point of reference to explore the consequences of determined objectives.

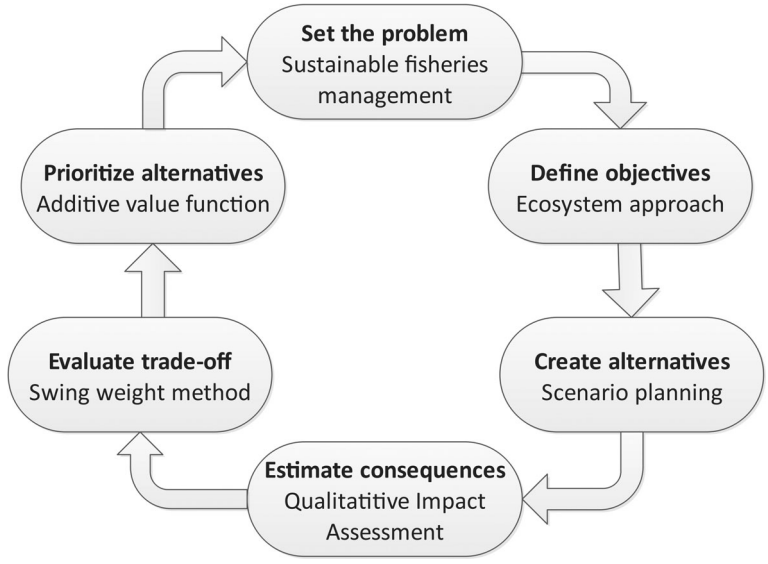

FIGURE 2 Steps in the structured decision making applied in the Arauco Committee. *Source*: Adapted from Estévez and Gelcich (2015)

We implemented three workshops to develop goals and objectives, and two workshops to identify indicators to estimate objectives; in addition, we conducted five semi-structured interviews, including local governments (two) and local fishers (three). The AGMP was used as reference to define objectives and indicators (SUBPESCA, 2014).

2.3.3 | Creating alternatives and scenarios

In the structured decision making framework, alternatives were understood as comparable ways of organizing multiple actions to impact objectives (Gregory, Failing, et al., 2012). In data poor situations, as the Arauco Gulf benthic fisheries, scenario analysis is a helpful tool to structure alternatives (Gregory, Failing, et al., 2012). In the scenario analysis, we developed a discrete set of management situations to impact objectives, in which key external drivers and consequences were uncertain (Schoemaker, 1995). This approach has been recommended as a way to promote deliberative thinking, challenging preconceptions about the future (Wright & Goodwin, 1999).

We implemented two workshops to create scenarios, which represented different components of the fishery management. To create scenarios, we identified 92 actions included in the AGMP (Supporting Information in Appendix S1). Each action was planned to impact one of the objectives presented in the AGMP. Each scenario was composed of actions, ranging from 1 to 20 actions, which were logically concatenated, and organized in flowcharts. Actions were categorized by (a) Training of users, (b) Controlling of landing, (c) Broadcasting information, (d) Financing research, (e) Monitoring compliance, and (f) Establishing rules. Additionally, new actions were identified to explore scenarios of self-regulation. Management alternatives were constructed to explore the joint impact of a group of scenarios. Accordingly, each management alternative was composed by a set of scenarios.

2.3.4 | Estimating consequences

The available information about potential consequences of actions is a critical component in collective action situations (Ostrom, 2005). In the Arauco Committee, participants had scarce information about the potential impacts of the actions on the objectives. This gap made it difficult to directly estimate consequences. In the structured decision making framework, participants were encouraged to collectively incorporate scientific, expert and community knowledge to estimate consequences (Estévez et al., 2013). Qualitative impact assessment provided tools to collectively explore consequences in the decision analysis (Pascoe et al., 2009).

We facilitated two workshops to perform a qualitative impact assessment. Additionally, we conducted 10 semi-structured interviews with relevant stakeholders, to define the bounds of the potential consequences for each indicator. Interviews included scientists (five), local fishers (two) and NGs members (three). In the workshops, participants discussed the consequence of each scenario in the fulfillment of an objective. Then, participants independently estimated the consequences of the scenarios over the objectives, using five-level scales: Just like now = 1, a little better = 2, moderately better = 3, much better = 4, and ideal scenario = 5 (Pascoe et al., 2009). For each scenario, the individual estimates were aggregated using a simple average. Average scores were normalized from 0 to 100. The normalized values correspond to the Qualitative Impact Score (QIS) for each scenario.

2.3.5 | Weighting objectives

In collective action situations, participants rarely formalize their thinking to make opportunity costs and tradeoffs explicit (Law et al., 2017). Here, costs and benefits were framed as incentives and deterrents determined by the subjective valuation of a consequence (Ostrom, 2005). We used the swing weight method to elicit informed tradeoffs, establishing individual value models (Estévez, Alamos, Walshe, & Gelcich, 2017). Value models assigned weights to

objectives as a scaling factor, relating consequences on one objective to consequences on all other objectives. The swing method encourages explicit consideration of the range of consequences, avoiding an excessive focus on the individual importance of an objective independent of context (Estévez & Gelcich, 2015).

Eleven members of Arauco Committee assigned weights for the objective using this method (50% of the total members). Members included five representatives of artisanal divers (Tubul, Laraquete, Arauco, Punta Lavapié and Lafquenche communities), four representatives of government agencies, and one representative of formal processing plants. First, participants were asked to move (or swing) the indicator of one objective to its best level, assigning 100 points to this most important objective. Then, participants were asked to choose the second most desirable objective, assigning a maximum of 100 and minimum of 0 points, compared to the importance of the first objective selected. This procedure was continued with the remaining objectives. Finally, values were normalized between 0 to 1, calculating the different objectives' weights (Gregory, Failing, et al., 2012).

2.3.6 | Prioritizing alternatives

Alternatives were analyzed and prioritized by their performance score. For this, we used widely known protocols from MCDA (Gregory, Failing, et al., 2012). We specifically operationalized the additive value function, commonly used to calculate performance scores for each alternative based on a weighted sum of its consequences was used to prioritize alternatives (Estévez et al., 2017) through workshops.

3 | RESULTS

3.1 | Defining goals, objectives and indicators

In the workshops, participants established three goals for the sustainable management of the fishery: (a) "Recovering and maintaining stocks", (b) "Increasing revenues," and (c) "Promoting social equity." Additionally, participants identified objectives and indicators (Table 1). Table 1 shows the worst and best outcomes for each indicator.

The goal "Recovering and maintaining stocks" focused on the extraction process, which is the main threat for marine resources. This goal includes the objectives *Maintaining landing under a limit* and *Reducing juvenile capture*. In addition, this goal included objectives to protect the habitat: *Reducing impact of siege ships* and *Reducing the levels of pollutants in fishing areas*. Siege ships extract anchovies and sardines in the Arauco Gulf, and artisanal divers have constantly reported that siege ships produce serious ecological damage over the substrate (see constructed scale in Supporting Information in Appendix S2). On the other hand, pollutants are a constant threat in the Arauco Gulf, which concentrates important industrial activities (see constructed scale in Supporting Information in Appendix S3).

The goal "Increasing revenues" is composed by the objective *Improving handling of raw material* –particularly, reducing the number of broken shells during landing–, and the objective *Improving commercial management*, focused in the subsequent commercialization. The goal "Promoting social equity," includes the objective *Regularizing employment opportunities* that attempts to incorporate informal divers into the legal Artisanal Fishing Record, providing them the legal right to extract resources. In addition, organizational objectives, such as *Increasing self-regulation* and *Strengthening organizational development* focused on improving compliance with the decisions reached in the collective action arena (i.e., Management Committee).

Weights for each one of the goals and objectives was calculated. The goal "*Recovering and maintaining stocks*" was the most valued for participants and concentrated more than 50% of the weights (see details in Supporting Information in Appendix S4 and S5). Particularly, the objectives *Maintaining landing under a limit* and *Reducing juvenile capture* had the greatest relative importance for participants, representing around 12% each. These objectives are directly related with the extraction process of resources.

TABLE 1 Goals, objectives, indicators (with their respective worst and best outcome), and the objectives' mean weights for the management of the huepo, navajuela and taquilla fisheries (N = 11 participants assigned weights for the objectives, representing 50% of Arauco Committee members)

Goals / objectives	Weights		Indicators	Worst outcome	Best outcome
	Mean	SD			
Goal 1: Recovering and maintaining stocks	51.53				
1. Maintaining landing under a limit	11.77	0.29	Total landing huepo (tons) [a]	1.600	1.078
			Total landing navajuela (tons) [a]	10.000	6.946
2. Reducing juvenile capture	12.06	0.26	Change in capture under the minimum size limit (%) [b]	25%	5%
3. Maintaining biodiversity of macro-invertebrates	10.19	0.48	Density of Polychaeta (individual/0,00636 m^2) [b]	4.21	Unknown
4. Reducing the levels of pollutants in fishing areas	8.55	0.53	Avoid presence of pollutants [c]	1	5
5. Reducing impact of siege ships	8.96	0.30	Avoid impact of siege ships (constructed scale) [c]	1	5
Goal 2: Increasing revenues	20.98				
6. Improving handling of raw material	8.53	0.27	Change in broken shells (%) [d]	20	5
7. Improving commercial management	7.69	0.35	Price of huepo in beach (Chilean pesos) [e]	900	1,200
			Price of Navajuela in beach (Chilean pesos) [e]	480	600
8. Promoting complementary initiatives	4.76	0.49	Number of initiatives developed	0	20
Goal 3: Promoting social equity	27.49				
9. Regularizing employment opportunities	9.39	0.28	Change in artisanal divers regularized	40%	80%
10. Increasing self-regulation	8.21	0.51	Capacity to develop self-regulation (constructed scale) [c]	1	5
11. Strengthening organizational development	9.89	0.35	Organizations strengthened	0	10

Notes:
[a]The best outcome corresponds to landing limit established by the authority, and the worst outcome considers a 40% of over landing.
[b]SUBPESCA (2014) establishes a baseline for 2015. The baseline value was nominated as the worst outcome, considering uncertainties about soft-land ecology in the Arauco Gulf and the precautionary principle.
[c]Constructed scale in Supporting Information.
[d]There is not official information about the total of broken shells during the landing. We adjusted worst and best outcomes based on the interviews.
[e]We considered the prices for the last 10 years, adjusting worst and best outcomes based on the interviews.
[f]In 2016, the management measure allowed a maximum of 20% of total landing under the legal minimum size.

The objectives focused on protecting the habitat (*Maintaining biodiversity of macro-invertebrates* and *Reducing the levels of pollutants in fishing areas*) had a high relative importance for participants (10.2 and 8.5%, respectively). Similarly, the goal "Promoting social equity" was relevant for participants. Particularly objectives *Regularizing employment opportunities* and *Strengthening organizational development* (9.4 and 9.9%, respectively) had high levels of

TABLE 2 Scenarios developed in the structured decision making framework, including qualitative impact assessment results

Objective	Scenario name	Description of the scenarios	N	QIS	SD
1	1. Authority control of landing	Authority (SERNAPESCA/DGTM) increase inspection at the Tubul pier from 1 day to 3 days a week, controlling landing.	14	75.0 (+)	17.0
1	2. Auto-monitoring landing	Artisanal divers implement an auto-monitoring program for controlling total landings at piers.	14	67.9	24.9
1	3. Broadcasting of landing	Authority (SERNAPESCA/DGTM) generates technical reports and implements broadcasting actions to communicate weekly the total landing status.	14	32.1 (–)	26.7
2	4. SERNAPESCA control minimum legal size	Authority (SERNAPESCA/DGTM) increases inspection at the Tubul pier from 1 day to 3 days a week, controlling the minimum legal size.	14	73.2	20.7
2	5. Auto-monitoring minimum legal size	Artisanal divers implement an auto-monitoring program for controlling the minimum legal size. For example, monitors on the pier observe compliance of rules.	13	59.6	19.2
2	6. Training on minimum legal size	Arauco committee implements a training program for divers on juvenile capture and minimum legal size, to raise awareness among users.	14	78.6 (+)	23.7
2	7. Broadcasting of minimum legal size	Authority (SERNAPESCA/DGTM) generates technical reports and implements broadcasting actions to communicate juvenile capture status.	7	35.7 (–)	24.4
3	8. Training on biodiversity	Arauco committee implements a training program for the community (including divers and their families) regarding the care of habitat in the Arauco gulf	13	30.8 (–)	27.3
3	9. Research on biodiversity	An annual study is carried out for a period of 3 years on the conservation status of the macro-invertebrate biodiversity in the areas of natural stocks.	7	28.6 (–)	17.2
4	10. Access to information about pollutants	Bivalve molluscan sanitary program (PSMB) becomes an instrument of public access. The Arauco committee has direct access to the PSMB results.	13	25.0 (–)	20.4
4	11. Auto-monitoring pollutants program	The Arauco committee implements an independent monitoring program for early detection of pollutants in the Arauco gulf.	13	50.0	17.7
4	12. Training on pollutants program	The Arauco committee implements a pollutant monitoring training program associated to scenario 11.	13	55.8	30.9
5	13. Install GPS for siege ships	Authority (SERNAPESCA/DGTM) implements a satellite monitoring program of siege ships. It includes a new protocol for processing complaints.	13	53.8	17.2
5	14. Training for siege ships' crew	A training program for crew members, captains and ship-owners of siege ships to raise awareness about the impact of siege ships activities.	13	25.0 (–)	27.0
6	15. Training in raw material handling	The Arauco committee establishes procedures for handling the raw material. Arauco committee implements training program for divers.	14	83.9 (+)	18.6

(Continues)

TABLE 2 (Continued)

Objective	Scenario name	Description of the scenarios	N	QIS	SD
7	16. Training on commercialization	The Arauco committee implements a marketing skills training program. The program seeks to encourage associative commercialization among divers.	14	69.6	26.3
7	17. Agreements with formal processing plants	The Arauco committee implements commercial agreements with the formal processing plants, establishing direct sales between the formal plants and the diver.	14	69.6	24.4
7	18. Agreements with informal processing plants	The Arauco committee prioritizes an agreement with the informal processing plants. The management committee supports the regularization of these plants.	13	75.0 (+)	20.4
8	19. Training for retired divers	The Arauco committee implements a training program for retired divers, in diverse types of activities.	14	67.3	21.4
9	20. Training to access official right to fish	A training plan is generated to provide official right to fish to divers without the license.	14	80.4 (+)	24.4
10	21. Auto-monitoring program to compliance	The Arauco committee establishes a sub-committee to coordinate self-regulation and auto-monitoring, designing a program to promote compliance	14	60.7	23.4
11	22. Training on leadership	The Arauco committee implements a training program for organizational development, focused on developing leadership.	13	66.1	21.0

Note: Scenarios with values greater than 75 are indicated with the plus; in the other side, the minus sign indicate the scenarios with values less than 50. QIS, Qualitative Impact Score. Values were normalized from 0 (Minimum) to 100 (Maximum). N, number of participants who made the estimate. SD, Standard deviation.

relative importance. The goal "Increasing revenues," showed lower levels of relative importance when compared with the ecological and social objectives.

3.2 | Scenarios and estimation of consequences

Twenty-two scenarios were co-created among participants to identify future strategies capable of promoting sustainable use and avoiding degradation of habits (Table 2). Scenarios represented management actions which can impact over the probability of achieving the objectives. Some scenarios related with control and monitoring activities (1, 2, 4, 5, 11, 13 and 21). Other scenarios focused on training fishers for sustainable management (6, 8, 12, 14, 15, 16. 19, 20 and 22). Two scenarios considered fair trade agreements between fishers and processing plants (17 and 18). Scenarios also focused on improving access to information and internal communication channels (3, 7, 9 and 10).

Table 2 includes the QIS for all scenarios. As we expected, the QIS significatively vary among scenarios (Figure 3). Scenarios 15–22, which focused on socio-economic objectives, presented satisfactory results (values between 60.7 and 82.9 out of a maximum of 100). Scenarios 1 and 4, which proposed a greater government control (75.0 and 73.2, respectively), presented better results than scenarios 2 and 5, which were based exclusively on community organizations control (67.9 and 59.6, respectively). On the other hand, scenarios 7–13, which related with habitat and biodiversity protection, presented worrying results, with values between 25 and 55.8. Similarly, scenarios 3 and 7, which focus on extensive information campaigns about fisheries regulations presented QIS lower than 40.

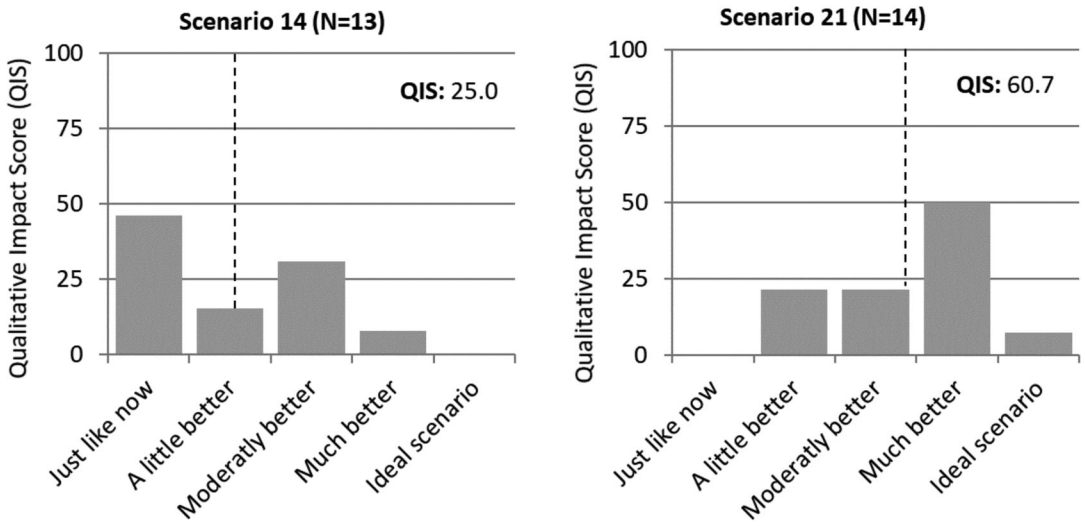

FIGURE 3 Example of consequences estimates for two of the 22 scenarios. Scenario 14 (Training for siege ships' crew), composed of three activities, was created to impact objective 5 (*Reducing impact of siege ships*). Scenario 21 (Auto-monitoring program to compliance) was created to impact objective 10 (*Increasing self-regulation*). The dotted lines represent the average of the estimates for each scenario. N = number of participants who made the estimate. *Source*: Author's elaboration

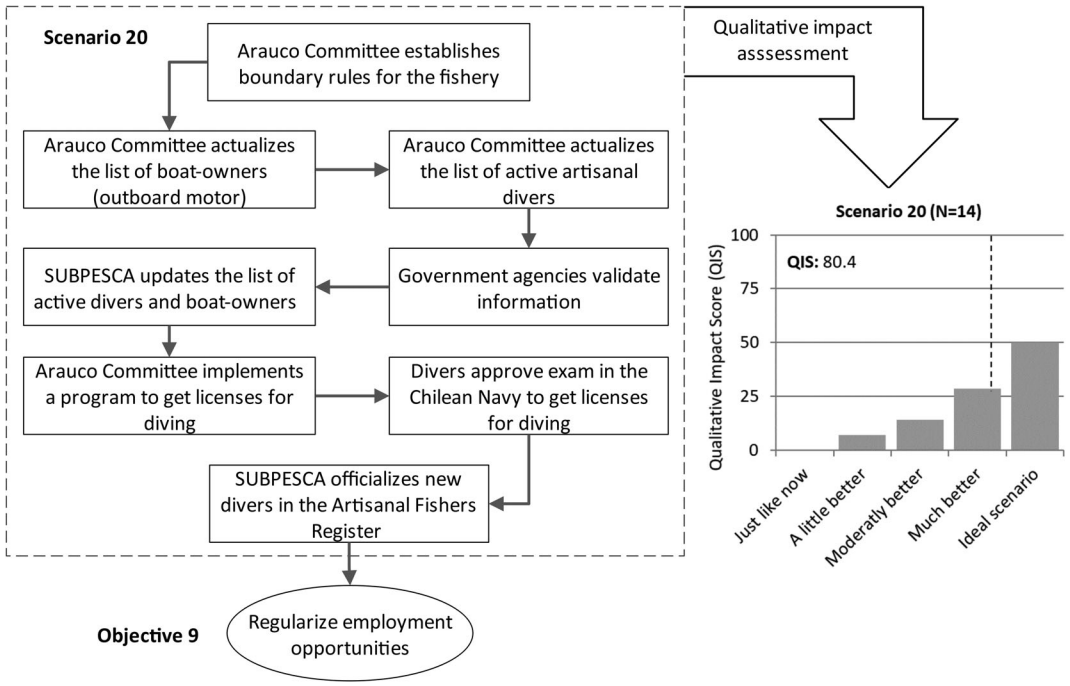

FIGURE 4 Action flowchart of scenario 20 "Training to access official right to fish" and qualitative impact assessment to the objective Regularizing employment opportunities (N = number of participants who made the estimate). *Source*: Author's elaboration

TABLE 3 Consequence matrix for the impact of the management strategies on objectives. Values are normalized from 0 to 100

Objectives	Basic management plan	Intensive government control	Fishers self-regulation
1. Maintaining landing under a limit	32.2	75.0 (+)[a]	67.7
2. Reducing juvenile capture	35.7	73.2	78.5 (+)
3. Maintaining biodiversity of macro-invertebrates	30.7	30.7	30.7
4. Reducing the levels of pollutants in fishing areas	25.0	25.0	55.7
5. Reducing impact of siege ships	25.0	53.7	25.0
6. Improving handling of raw material	84.0 (+)	84.0 (+)	84.0 (+)
7. Improving commercial management	69.7	69.7	72.2
8. Promoting complementary initiatives	67.2	67.2	67.2
9. Regularizing employment opportunities	80.2 (+)	80.2 (+)	80.2 (+)
10. Increasing self-regulation	0.0	0.0	60.7
11. Strengthening organizational development	66.0	66.0	66.0
Alternatives' performance	45.4 (38.1–50.0)	57,5 (52.2–63.1)	62,6 (55.1–68.6)

Note:
[a]Symbol (+) indicates a value >75.

To exemplify scenarios, Figure 4 presents the flowchart of scenario 20 "Training to access official right to fish". This scenario is composed of eight actions. First, the Arauco Committee will establish boundary rules for the fishery, including entry requirements and causes for exit or exclusion. Then, considering the new rules, the Arauco Committee will elaborate a list of active fishers and boats, including formal and informal participants. This information will subsequently be validated by government agencies, which will update their own list of active divers. As informal fishers require an official divers license to be registered the Arauco Committee will implement a program to train fishers, preparing them for the exam. The fishers that pass the exam will receive a diver license from the Chilean Navy. This information will enable the publication of a new official fisher registry. This scenario deals with the current problem of legalizing informal fishers and allows them to access the Artisanal Fishers Register.

3.3 | Prioritizing of management alternatives: exploring the impacts of self-regulation

We constructed three management alternatives to explore pathways for increased control and monitoring, namely: (a) *Basic management plan*, which contains the core actions included in the AGMP (scenarios 3,7–9, 14–16, 19, 20, 22), (b) *Intensive government control*, which increases three times government agencies control and monitoring activities (scenarios 1,3, 4, 7–10, 13–16, 19, 20, 22), and (c) *Fishers self-regulation*, which promotes self-regulation, auto-monitoring and auto-control activities (scenarios 2, 3, 5–9, 11, 12, 14–22). Self-regulatory activities occur under a framework of officially established rules. Therefore, *Fishers self-regulation* activities are not in conflict with *Intensive government control* activities.

Table 3 presents the performance score for the three management alternatives. The performance score of the alternative Basic Management Plan is 45.4 (out of a maximum of 100). The alternatives Intensive Government Control and Fishers Self-Regulation presented a performance score of 57.5 and 62.6, respectively. Results showed that monitoring and controlling activities are critical to achieve better outcomes in the different objectives. Fishers Self-

Regulation performs slightly better than the Intensive Government Control. No alternative presents a result over 70. This can be explained because management alternatives consistently reached low scores in objectives related to habitat protection, which depend on other stakeholders' activities in the Gulf.

4 | DISCUSSION

In the Arauco Committee, the structured decision making framework was able to integrate multiple values associated to the management of the fishery, generating spaces for deliberative thinking. Stakeholders highlighted values associated to social equity, and habitat protection, but particularly prioritized objectives aimed to control resource extraction. Qualitative impact analysis was an effective way to explore the social, economic and environmental consequences generated by management actions. As a result, fishers were able to rationalize different management alternatives and scenarios, identifying that self-regulatory measures may have better performance than control based on the central authority.

Enhancing collaboration and participative decision making for natural resources management constantly confronts real-world constraints (Amel, Manning, Scott, & Koger, 2017; Bodin, 2017). Collaborative governance does not ensure the consolidation of sustainable practices in the management of natural resources (Ostrom, 2010). For example, asymmetric power relationships or inequalities in access to knowledge may hamper collaborative strategies (Bodin, 2017). The implementation of structured decision making in collective action situations can aid practitioners to identify internal imbalances that could block well-intended participatory policies (Ostrom, 2005).

In the Arauco Committee, we identified two internal structural weaknesses that obstruct collaborative practices and agreements. First, participants have incomplete information about the status of the fishery. Imbalances in access to information include those related to the sources and levels of pollutants in the Arauco Gulf, the landing of illegally extracted resources, international market dynamics and participants values in the decision making process. In collective action situations, access to complete information is critical for the achievement of agreements. However, in practice, participants generally confront incomplete information about consequences of actions and other participant valuations of priorities (Ostrom, 2005). These imbalances of information generate mistrust and promote strategic action, putting self-interest over the achievement of collective agreements (Habermas, 2004).

The second weakness refers to participants' capacity to ensure that the links established between actions, scenarios and outcomes are met. That is, the Arauco Committee has little control over the consequences of actions. For example, there is no evidence that self-control measures adopted by the Committee will increase compliance in the artisanal divers, boat-owners, intermediates, and other actors. Results show that in the absence of effective monitoring and control activities, management measures may have low levels of compliance. This is a common diagnosis for common pool resources (Ostrom, 2005), which reaffirms the need to strengthen surveillance systems to reduce illegal fishing and increase rules compliance (United Nations, 2019).

Results support the importance of developing capacities and guidance, on how to structure decisions in these relatively new collective action arenas for fisheries management. Therefore, it is relevant to highlight some key elements that should be considered to improve decision making in collective action situations, when institutions have structural weakness. We stress four lessons from our experience with trailing the participatory decision making framework.

First, the lack of deliberative practice in decision making among participants was a challenging difficulty applying structured decision making. The co-management system for open-access fisheries, approved in 2013, has been gradually implemented. Therefore, there were no installed capacities in social actors to solve management problems based in structured decision making and deliberative thinking (Estévez & Gelcich, 2019). Results illuminate on the potential benefits of the management plan policy to invest in building capacities and methods associated to implementing structured participatory frameworks for deliberation. This should be a key element associated to the increasing implementation of collaborative governance policies.

Second, in deliberative settings, participants should publicly reflect in pursuit of the common good, based on transparent negotiation processes and fair agreements. These conditions are based on previously established relationships of trust (Habermas, 2004). In our case study, the dynamics to build trust occurred in the course of meetings, negotiations and agreements. In the structured decision making framework, participants made explicit their value judgments operationalized in individual value models and relative weights. Thereby, the structured decision making helped to clarify discrepancies, building trust among participants. Trust also emerged in informal spaces, particularly meetings prior to the implementation of workshops.

Third, in the Arauco Committee, institutional learning gradually emerged in systematic and structured patterns of reflective interactions among participants. It was through carrying out analysis about the positive and negative consequences of incentives and deterrents, assessing expected outcomes of scenarios and management strategies, and communicating local knowledge that a shared understanding began to emerge. Moreover, the structured decision making framework became a democratic learning process to reach agreements.

Fourth, our experience highlighted the role of the facilitator to promote argumentative dialogue in structured decision making. In collective decision making, facilitation is an important resource for the achievement of agreements (García Lozano & Heinen, 2016; Stratoudakis et al., 2019). For this, we focused on two elements; (a)The neutrality of the facilitator team was ensured, which was composed by interest-free university researchers, and (b) Facilitation required a common technical language among participants, which promoted the expression of minority visions (Stratoudakis et al., 2019). Throughout the decision making framework, participants' values and interests were logically integrated at each stage of the process through tailored workshops aimed at deliberating on objectives, actions, strategies, consequences and trade-offs.

5 | CONCLUSION

Chile has constantly transitioned towards a polycentric collaborative governance system. Fisheries governance transitions towards collaborative systems do not only depend on the formal constitution of independent collective action situations, they are also related with stakeholders' capacity to identify and institutionalize best practices, including structured decision making and deliberative thinking. Thus, systematic and validated mechanisms for decision making are an important feature to enhance self-regulation, particularly when faced with multiple interests.

Results highlight the importance of using a structured decision making framework in collaborative governance arenas to share experiences, validate knowledge systems and promote interactions among governments, fishers and researchers. The lack of collective learning capacity may generate uncertainties about the political validity of the governance system, losing opportunities for regulatory improvements. We propose a transparent and systematic methodological approach to integrate participants' value judgments and scenario analysis in fisheries decision making, integrating local knowledge of participants. Self-regulation, structured decision making, and deliberative thinking is key to improve sustainable management of fisheries.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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