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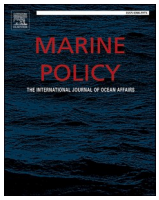

Full length article

Characterising the co-management system in the Biobío Region, Chile, based on fishers' and experts' knowledge: A dual perspective

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ABSTRACT

The conceptualizations of Territorial Use Rights for Fisheries (TURF) management, as perceived by both fishers and experts, offer valuable insights into the human component of social research in fisheries. These conceptualizations also contribute to accumulating local knowledge shared by fishers and other stakeholders involved in governance processes. This study aims to characterize the perspectives of both groups regarding selected TURFs in the Biobío Region, Chile. The information collected through surveys and interviews revealed significant variations in the quality and reliability of the data provided by participants. Our study combines a participatory systems approach, incorporating local inputs, with a structural analysis of influential and dependent attributes. According to the results, the TURF system can only be considered transformational from the fisher's perspective if it leads to improved outcomes for their livelihoods and the ecosystem. Both fishers and experts have a deep mistrust of TURF's future due to the current problems observed. The structural analysis identified organizational weakness, poaching, and conflicts between external actors and users as the main problems. Specifically, our study revealed that the participation and knowledge of fishers and experts are key processes for these complex, dynamic, and diverse social-ecological systems. Finally, we recommend greater integration between both parties to facilitate more sustainable and effective forms of collaborative management, such as including new stakeholders associated with the TURF through a transdisciplinary approach to obtain a more comprehensive view of the system.

1. Introduction

Co-management systems based on Territorial Use Rights for Fisheries (TURF) have proven to be partially effective in managing resources allocated to collective groups of artisanal fishers [1–4]. However, the effectiveness of such systems could be enhanced by actively involving fishers and experts in the decision-making process related to fisheries management [5,6]. In addition to the shared responsibilities between governing bodies and fishers, it is essential to adapt management policies to local needs and incorporate local knowledge [1,7,8].

Despite the efforts exerted with the co-management system, the need to transform pre-existing conflicts and promote a more equitable

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distribution of benefits among users persists [9–12]. On the other hand, fishing rights or privileges have been adopted as a management strategy in many fisheries worldwide [13]. But they have often been implemented without due consideration of the socio-ecological systems-SES in question, as is the case of the artisanal benthic invertebrate fishery in Chile [14,15]. Primarily, the uncontrolled exploitation of the "loco" *Concholepas concholepas*, fueled by an open access policy, led to a severe crisis in its fishery, causing significant socioeconomic and environmental damage [16]. This critical situation prompted the authorities to implement the TURF system and contribute to recovering the "loco" over the years.

Inspired by experiments demonstrating the positive impacts of territorial use rights for fishers (in some cases excluding human intervention and, in other cases, self-regulating benthic resources harvest levels) [17–24], TURFs emerged as a promising approach. These experiences highlight the need for a comprehensive management strategy for TURFs and artisanal fisheries, considering the intricate interplay between social and ecological factors. Although TURFs have contributed significantly to strengthening social cohesion and collective actions of artisanal fisher organizations-AFO, their focus has primarily been on ecological and fisheries aspects [17−22,24,25]. This limitation has led fishers' organizations to demand a more comprehensive approach encompassing social, economic, cultural, and institutional dimensions [26–28].

Undoubtedly, TURFs, when managed by fishers' organizations, present heterogeneity in their results due to various factors. In addition, there is a lack of consensus among users regarding the problems faced by their organizations and their environment [12,27,29−31]. Compounding the challenge is the current public institutional framework, which often fails to align with the principles of sustainability, citizen participation, and equity essential for effective TURF management [32]. Due to the above considerations, the challenges faced by TURFs transcend management aspects, involving the lack of support, enforcement capacity, and compliance [24]. It is essential to recognize the importance of strengthening the artisanal fishers' conceptualizations and decision-making capacity, as they have a deep and practical knowledge of the environment and fishing conditions [33,34]. Previous studies have shown that fisheries management has focused mainly on resources, neglecting the fundamental role of the people who depend on them [35].

This local knowledge of the fisher, although often underestimated because it does not always have[3,36−40]. Knowledge that can be an additional source of information that can help in the evaluation and decision-making for fisheries management [41]. In our case study leads us to consider new ways of incorporating the human dimension in its various aspects within the TURF system, because the accumulated experience provides valuable information for evaluation and decision making. Therefore, alternative ways of collecting data, such as obtaining information from expert knowledge, are necessary [42]. It should be added that expert and local knowledge can play a fundamental role for the interactions between the components of the SES in the management of fishery resources [43]. In addition, what other stakeholders (scientists, professionals and managers) or experts want and need is information that leads to a better understanding of the ecosystem [44].

Therefore, involving diverse stakeholders, including fishers, scientists, and managers, is crucial for effective governance. By integrating diverse knowledge sources [25,45,46], we can gain a more comprehensive understanding of the social-ecological system and make more equitable and sustainable decisions [47]. Since the increasing demand to integrate different perspectives has led to the development of a variety of qualitative and semi-quantitative methods for this purpose [46, 48−54]. In such a sense, there are tools to be developed and implemented when data are insufficient and an understanding of concepts is required. For example, elicitation techniques can be used to formalize substantive informal knowledge and assess a range of topics to understand their effects and identify research priorities [55–57]. While expert consultation is a valuable practice for informed decision-making, it leads to erroneous conclusions if not executed rigorously [58].

For the above reasons, our research highlights the need for a qualitative thematic analysis based on expert and local knowledge about how TURFs work in the Biobío Region, Chile. In order to achieve this objective, several specific objectives will be established: (i) to identify the categoriesand thematic areas of the content of the responses by the stakeholders, (ii) to understand the idealpreferences of these groups in relation to the functioning of the TURFs, as well as to identify andanalyze the possible disparities existing in this context, and (iii) to study the relationships betweenthe different conceptions that the stakeholders have of the TURF system, through structural analysisbased on the proposed attributes. This research continues the work of two prior studies [25,59] and offers general recommendations for TURFs based on the perspective of fishers and experts. The value of our research lies in the local significance of TURFs, their contribution to regional artisanal fisheries, and the existing gap in socio-ecological research on their management and underlying issues. Consequently, it is relevant and could be of interest to other geographies facing similar problems.

2. Materials and methods

2.1. Brief description of the study area

The Biobío Region, in central Chile, has a coastline 598 km long, where numerous economic activities, are carried on. These activities range from steelmaking to traditional agriculture, as well as forestry and fishing, among others, mainly along the coast. The region has the second largest number of fishers and vessels on the artisanal register in Chile, after Los Lagos Region [60]. The Biobío Region consists of 15 coastal communities and three inhabited islands: Quiriquina, Mocha and Santa Maria. This includes access to and use of the Marine and Coastal Areas for Indigenous Peoples policy (ECMPO in Spanish), mostly occupied by "Mapuche" communities for customary use [61]. But also includes conflicts between different stakeholders (indigenous and non-indigenous) over the use of the coastal edge, that must be addressed [62]. There are approximately 76 fishing coves ("caletas" in Spanish) along the coast, 69 on the mainland and 7 on the islands (Mocha and Santa María). Furthermore, 67 % of the fishing coves in the region are rural with lower connectivity (https://mapas.subpesca.cl/ideviewer/) [32]. Despite the fishing coves' economic growth in the mid-twentieth century, they have evolved differently in recent decades.

On the one hand, there are fishing coves where management has had high social costs in terms of employment, income and the viability of small businesses. As a result, fewer and fewer people can make a living in these coastal areas. At the same time other fishing coves have continued to develop due to the social and economic benefits of artisanal fishing, such as the presence of natural benthic resources, pelagic and demersal species (anchovy, sardine, hake, among others) [63]. This gives them an advantage, but many inhabitants of these fishing coves view the future with uncertainty, unable to see the trades associated with fishing as being sustainable. However, they have employed various adaptation strategies to preserve their habitat and identity, and the skills that shape both [64]. In addition, there are geographic differences in how management measures impact fishery sustainability, and these require further study. In 2017, the number of TURFs in the region covered a total of 127, of which 78 are officially recognized, 31 are not and 18 applications are being reviewed [25].

TURFs are managed by 47 legally incorporated AFOs, which represent the 'users' of fishing resources, among which are trade unions, trade associations, indigenous communities and cooperatives [60,65]. The case study of the TURF system in the Biobío Region is ideal for our analysis by several reasons, the main one is because the system itself has not been free of problems such as heterogeneity in the abundance of benthic resources, as some TURFs have acceptable levels while others do not (http://www.sernapesca.cl/informes/estadisticas). In addition, there is a high income disparity, and some TURFs have monthly incomes of less than US$ 300, contributing less than 10 % of family incomes [66].

On the other hand, illegal fishing is, a very frequent activity in the region and cannot be ignored [3]. Finally, it is also necessary to take into account human and technological efforts and certain socioeconomic and institutional norms, as prerequisites for sustaining their operation in the long term. For this reason, the existing TURFs in the region are not immune to changes such as variations in the resource, market interaction, governance, and user particularities.

2.2. Research design

Due to the diverse geomorphological-coastal characteristics of the Biobío Region, such as those semi-closed areas (e.g., Gulf of Arauco and the bays), exposed (e.g., Mocha and Santa María islands) and the coastal strip (e.g., Cobquecura, Dichato, etc.), we established four zones: gulf, bay, coastal edge, and insular territory (islands) (Fig. 1). The TURFs were grouped to describe and know their origin according to these zones (see Appendix 1 and 2). The selected TURFs, legally constituted and administered by the AFOs, were distributed as follows: 3 TURFs corresponded to bays, 7 to the coastal edge, 4 to the gulf, and 7 were located in the insular area, both on Mocha Island and Santa María Island (see Appendix 1).

The TURF selection process described in [25], and it was carried out in several stages:

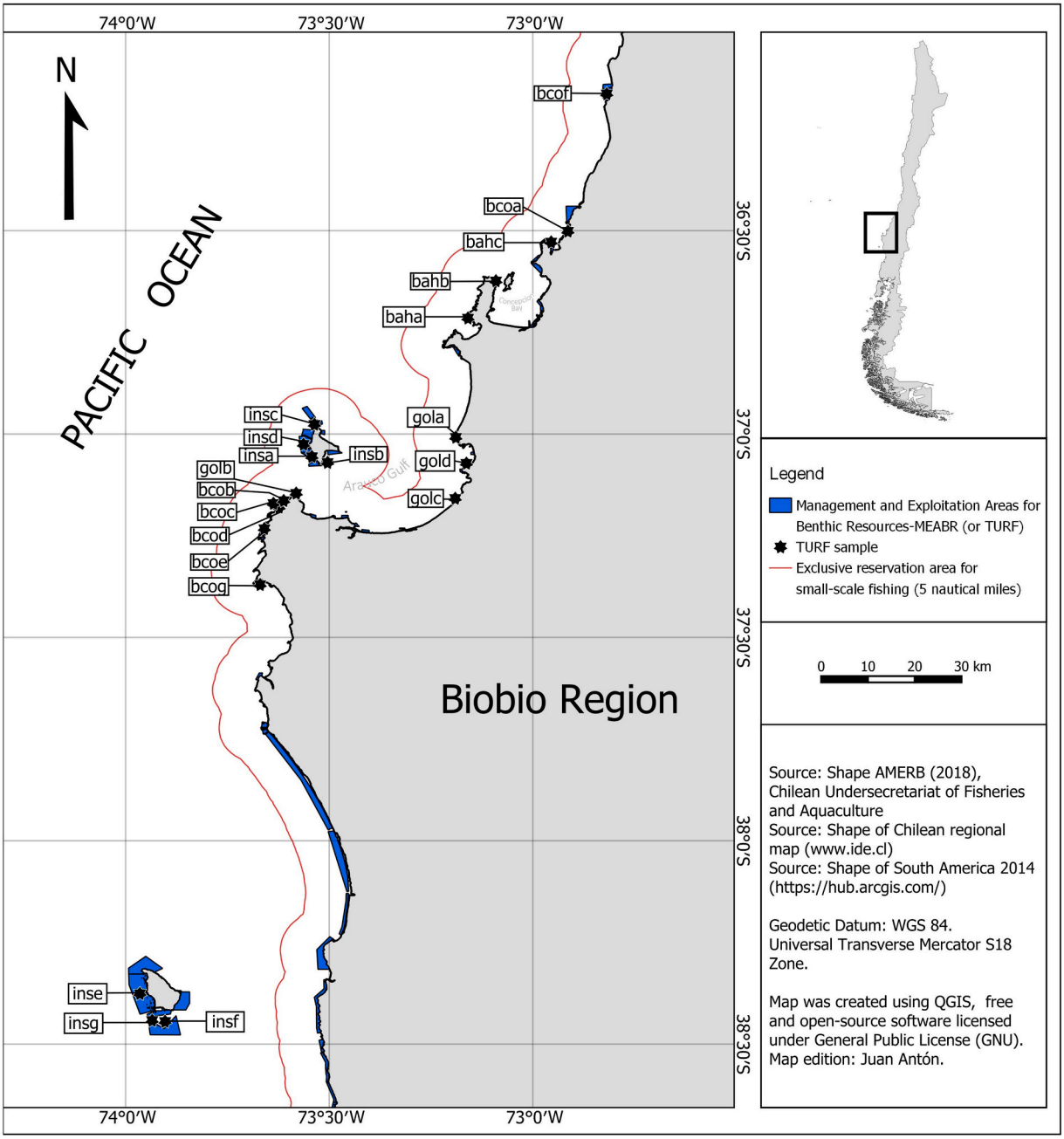

Fig. 1. Map of the study area: Fishing coves or "caletas" and TURFs in the Biobío Region, Chile. TURFs' Codes description (sampled): baha = San Vicente, bahb = Candelaria-Cantera, bahc = Rari, bcoa = Dichato, bcob = Punta Raimenco, bcoc = Bajo Rumena, bcod = Rumena, bcoe = Los Piures, bcof = Cobquecura sector A, bcog = Puerto Yana, gola = Maule, golb = Punta Lavapie, golc = Pueblo Hundido, gold = Laraquete, insa = Los Partidos, insb = Puerto Sur, insc = Pueblo Norte sector B, insd = Punta Cadena, inse = Weste Isla Mocha, insf = Quechol, insg = Quechol Sur. Source: Reprinted from Shape AMERB (2018), Chilean Undersecretariat of Fisheries and Aquaculture-SUBPESCA.

I. TURF selection. - Of the 78 TURFs officially recognized and awarded in the region, only 21 met the following selection criteria: they present a long history of studies, focus on *C. concholepas* species and have multiple records of approved harvests.
II. Classification and grouping. - Subsequently, a cluster analysis was performed to classify the 21 selected TURF into homogeneous groups. Considering variables such as yield, effective substrate and available area per fisher, three distinct strata were identified as a result. This classification made it possible to determine the sample size stratum.
III. Final adjustments. - In order to ensure a more equitable representation of the different realities of the AFOs, the TURF selection was adjusted by prioritizing those organizations led by women and with irregular extractive activities. This adjustment allowed maintaining the original number of 21 TURFs represented by 18 AFOs.

A sample size of 88 fishers was calculated, but in order to account for possible non-responses and unusable responses an additional 50 % was added to the sample size, resulting in a final sample size of 132. In the case of the other interest groups (hereafter, "experts") conformed by scientists, consultants, and public managers, the inclusion of key informants was considered, and their selection followed a logic of purposive or convenience sampling to ensure the presence of informants at the regional and national levels.

In order to evaluate and monitor the sustainability of the system in an integrated way, this research used conceptualizations of fishers and experts; using two components and six dimensions, as proposed in previous studies [25,59]: the ecological component (ecological-fishery dimension) and the human component (social, technological, institutional, economic and ethical dimensions). In this work, we used the following definitions and terminology:

- Conceptualizations. - The process of forming concepts, particularly abstract ones, out of experience or learned material (https://dictionary.apa.org). These conceptualizations have also been called "images", "views" or "perceptions".
- Components. - A part that combines with other parts to form something bigger (https://dictionary.cambridge.org/dictionary). In our case, the "ecological" and "human" components are part of the TURF socio-ecological system.
- Dimensions. - A part or feature or way of considering something (https://dictionary.cambridge.org/dictionary). Following Franco-Meléndez [25], we used six dimensions: ecological-fishery, technological, economic, ethical, social and institutional.
- Attributes. - These are the variables of each sustainability dimension. The attributes are chosen based on the following criteria: i) they should be readily and objectively available; ii) extreme values can be associated with "good" and "bad" sustainability benchmarks or states; and iii) the attributes should be available for all fisheries and periods analyzed by Pitcher and Preikshot [67]. For our transdisciplinary study, we used 51 attributes: 9 attributes (ecological-fishery dimension), 7 attributes (technological dimension), 9 attributes (economic dimension), 7 attributes (ethical dimension), 9 attributes (social dimension) and 10 attributes (institutional dimension).
- Themes. - They are mostly prominent expressions, terms or ideas which the respondents mentioned. In this case, we identified common themes that come up repeatedly in our surveys [68].
- Category. - Each of the classes or divisions established when classifying something (https://dle.rae.es/). In this work, 10 categories of conceptualizations were observed in participants' surveys.

2.3. Sampling design

The primary data collection was carried out in two stages. In the first stage (November 2018-March 2019), surveys of 117 fishers among members and leaders of the AFOs were carried out. Of the total surveyed artisanal fishers, 77 % were men (n = 90), and 23 % were women [25]. Each individual survey of fishers took approximately 45 minutes to one hour, and included open questions. In the second stage (July-September 2019), surveys and interviews of a total of 15 experts from both the regional and national levels were carried out. For this we used snowball sampling in order to identify more individuals and mitigate any convenience sampling bias [69,70]. We asked directly contacted experts to recommend one or two peers who might have relevant specialized knowledge and experience [42]. The experts selected included professionals with extensive experience in benthic resource research and regulation as well as TURF management at national and regional levels. Of the 15 participants, 47 % have more than 20 years of experience in the sector (Appendix 3). The questionnaires applied to each expert had a similar duration of approximately 30 minutes.

The participants were selected by preferential sampling according to particular attributes, in the case of fishers, most of them knew the TURF system and part of them participated in local or regional representative bodies. The list of questions for fishers (leaders and members) and non-fishers (experts) can be found in Franco-Meléndez [25]. After the information has been processed, the anonymity of the participants is maintained. Expert elicitations allowed us to understand how the scientific and governmental community can provide a preliminary knowledge base to evaluate the TURF's performance. According to the scientific literature, there are different methodologies for collecting and aggregating expert elicitation on public policy and management [57,71,72].

In this way, the research was designed using as a reference the sustainability attributes proposed by Franco-Meléndez [59], where the ecological and human components are represented by transdisciplinary dimensions: ecological-fishery, social, institutional, economic, technological, and ethical, in order to evaluate and monitor in an integrated manner the sustainability of the TURF system, through conceptualizations gathered from fishers and experts. For this, two methods of data collection were chosen: surveys and interviews. The interviews used open questions to provide a complete and detailed description of the participant's perceptions. The questionnaire was structured in two sections where the participants gave their opinion on the status, benefits, problems, and future of the TURFs locally or globally. The first section included the question: "What are the forcing factors for the development and permanence of TURFs in the Biobío Region?" and the second section included the question: "What do you expect from the TURFs in a 10-year horizon?". These questions seek to elicit the most relevant ideas that participants have about the governance and objectives of the TURF system. In addition, the open approach of the questions helped minimize response bias since the interviewees were free to address any issue that they consider.

To understand the conceptualizations of 117 fishers, the attributes proposed in this research were organized as described in the Appendix 4. The attributes were ranked according to the most frequent responses, and we considered the level of influence they represent in each dimension of sustainability [59]. In addition, Appendix 4 indicates the most important attributes and categories, as well as those that are infrequent, because despite some attributes being less salient according to the frequency of the responses recorded, they could play specific roles in shaping TURF conceptualizations. Also, it is important to point out the differences in knowledge and practices of the respondents, both as individuals and as a group of individuals. Under this condition, the attributes were more focused on 'resource', 'environmental protection', 'organization' and 'management', and those linked to the 'marketing' and 'economic productivity' of the TURF. Despite being a qualitative analysis with intuitive terms, it represents an integrating perspective, based on the fisher's own and local knowledge.

On the other hand, we interviewed 15 experts to understand another perspective on the operability of the TURF. Responses to open-ended

questions were categorized using an inductive approach in which summary themes were created by examining the data and then analyzed as frequencies [42]. The purpose was to identify common conceptualizations that could facilitate improvements in the TURF management system, locally and globally. The participants agreed to answer one open question in person, by telephone, or by email. The objective of the consultation was to collect the experts' relevant approaches to identifying benefits or deficiencies in the TURF and how they project its permanence in the future. The question was: "What factors (negative and/or positive) have been forcing the development and permanence of the TURFs? (locally and/or globally)". The experts focused their concepts on the operability of the TURF in terms of 'performance', 'access to the resource' and 'organizational capacity of the fishers'. The latter is closely related to the ethical and institutional dimensions. Therefore, both dimensions have much to do with the behavioral position of the fishers as a TURF user. Under this gaze, the local management of the TURF could begin to improve the conventional measures by adding research and policy co-designed strategies that generate solid bridges between interest groups.

2.4. Analysis of the information

2.4.1. Identification of patterns in responses

Data were analyzed using a bottom-up procedure allowing salient patterns within a data set to be highlighted and responses transcribed and coded [46,53]. From the responses to the proposed questions, one or more patterns were identified regarding operability and influential factors that affect in the TURF's performance. It was also important to deepen the aspects of more interest to the interviewee based on the questionnaire prepared so that the analysis linked to the current situation in the sector would be more rigorous. Thus, the in-depth interview made it possible to reconstruct the informant's world based on their perception and how they know, believe, or conceive it [73]. The experts freely expressed their opinions and for a more in-depth analysis of the responses, transcriptions of the audio recordings corresponding to each interview were made.

2.4.2. MICMAC structural method

The MICMAC method is a qualitative structural analysis that allows to establish collective reflections under different perspectives, which complement each other. This analysis makes it possible to obtain a map with the direct relationships between the proposed attributes, and from the relationship, a logical structure of causality can be established according to the degree of influence-dependence, i.e., which has more influence and more dependence on the remaining attribute [74,75]. For the development of this technique, the information compiled in Franco-Meléndez [25] was taken into consideration by adding the responses fishers and experts surveyed since both groups provide essential experiences about TURF. The analysis was executed using the free software LIPSOR-EPITA-MICMAC version 6.1.2 (http://en.laprospective.fr/methods-of-prospective/softwares/59-micmac.html). The following is a description of the phases of the MICMAC analysis:

- Phase 1. Attribute identification. – For our case study, we have a list of 51 proposed attributes, which address the question: What are the ecological-fisheries, technological, social, ethical, economic, and institutional attributes that influence the sustainability of TURFs in the region? This exercise requires individual and collective reflection by those knowledgeable about the situation.
- Phase 2. Description of relationships between attributes. – For the development of this phase, initially, each of the selected attributes is listed in a matrix ("Attribute structural matrix"), and the abbreviation of the attributes is used to reduce the space in the elaboration of maps and networking diagrams. In this process, we generated a double-entry matrix with the qualifications (Appendix 5 and 6), for which the proposed attributes were evaluated through the following question: Is there an influence relationship between attribute i and attribute j? If the answer is negative, the assessment is 0; otherwise, we ask ourselves if this relationship is weak (1), moderate (2), strong (3), or potential (P) [76]. In the matrix, the sum of rows and columns initially describes the relationship of the essential attributes in its evolution.
- Phase 3. Identification of influential attributes with MICMAC. – This phase consists of identifying those attributes with great influence on the system, focusing on the analysis of the direct influences and also the intensity of attributes using qualitative evaluations. Based on this analysis, the characteristics of attributes are obtained. The attributes are projected on the influence-dependence map, allowing them to be grouped into four important categories: (i) key attribute or "challenge attribute", (ii) determinant attribute, (iii) autonomous attribute, and (iv) result attribute (Fig. 2).

In addition, network diagrams of the direct potential relationships among attributes in the system were carried out both for fishers and experts' conceptualizations.

3. Results

Based on the responses of fishers (members and leaders), the attributes proposed in this research were organized as shown in Appendix 7. The attributes according to the most frequent responses by fishers were categorized. We considered the level of influence they represent in each dimension of sustainability. Furthermore, Appendix 6 tells us which attributes and categories are most important, as well as those that are infrequent within the responses. Despite being less prevalent according to the frequency of the responses recorded, the additional categories play certain functions in the formation of conceptualizations about the TURF system. Regarding the expert's answers (Appendix 8), coincidences were identified whose approach could facilitate improvements in the operability of the TURF system, whether at the local or regional level. Additionally, the benefits or deficiencies of the TURF were identified and how they (fishers and experts) foresee its permanence in the future.

3.1. Perceptions and opinions about the operability of the TURF system: conceptualizations of fisher and expert

3.1.1. From fisher

For the fisher (in member's role), the questions applied in the survey

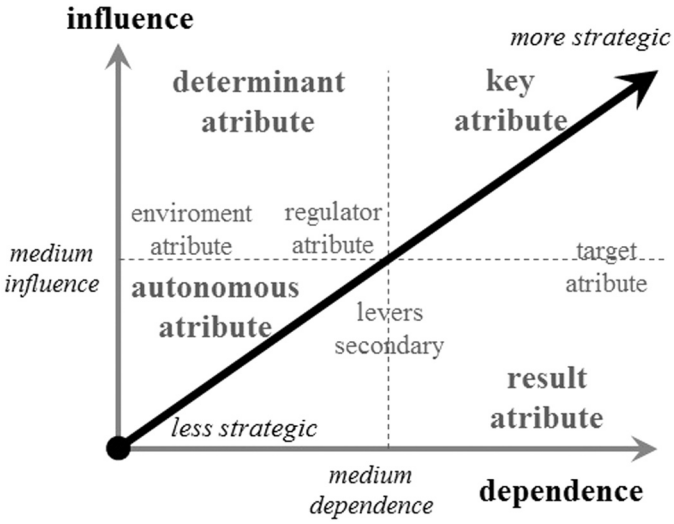

Fig. 2. Influence-dependence map: sectorization and arrangement of attributes by typology, according to the MICMAC classification(Source: Villegas [74]).

allowed corroboration of certain positions regarding what they perceive and how they conceptualize the TURF. One of the questions asked to fishers was: "How has the productive activity changed at the beginning (pre) and after (post) the TURF implemented (i.e., since the TURF was assigned to your organization)?" According to Table 1, we can observe ten categories cited by most of them. Their responses reflect how they saw the TURF in its beginnings, and among these categories, two stand out as being the most frequent in the interviewees' answers. One is related to the "value of the benthic resource to be sustainably exploited in the TURF". The other is the "complementary economic support that this activity offers to fishers", which refers to temporary income from artisanal fishing in addition to other livelihoods such as livestock and/or agriculture.

Respondents expressed discontent and concern about the TURF when the term 'after' was mentioned. Threats to the resource due to intense extraction during closed seasons, conflicts, and competitive fishing practices (poaching) by external agents or the TURF's own users were reported. The participants' conceptualizations focused on the "high costs of TURF maintenance and lower profitability" and the "lack of generational replacement within AFOs". Table 1 displays additional important categories for conceptualizing the TURF system.

The responses to the questionnaires by fishers in both roles (member and leader) allowed them to corroborate certain positions regarding what they perceive and how they conceptualize the TURF. In this part of the analysis, we asked the following question: according to your perception "What are the main advantages and disadvantages of the TURF managed by your organization?" The positive (advantages) and negative (disadvantages) themes were described by each participant in order to compare both responses to find common grounds. In general, on the one hand, the main advantages observed of the TURF system were the preservation of the commercially important resource and the safety of its extraction. Moreover, on the other hand, the main disadvantages detected were the problems of illegal extraction (poaching) and the increase in conflicts since its implementation.

3.1.1.1. Advantages. Regarding the positive factors, first of all, the fishers' members economically value the management in the TURF. They define it as a "complementary activity", the TURFs are favorable in critical times, and despite their temporary nature, they are part of their livelihoods. Moreover, secondly, they consider "care of the TURF" as another positive factor, a much-needed measure to protect the resources within the space granted and prevent their overexploitation. It is also important to note that fishers are very closely aware of changes in the availability of commercial species, which depend on careful, sustainable use. However, unlike the members, the leader fishers prioritized sustainable exploitation in the TURF. According to Fig. 3, the fisher's response not only contains information on the extractive activity in the TURF, but also assesses the space granted. Among the points in common, both the fisher member and the fisher leader highlight that a beneficiary organization is "recognized" to manage the TURF. In the same way, the majority of those surveyed refer to "colleagues" and shared "responsibility" as favorable points in the organization. In this way, being a recognized organization, they can access or apply for public and/or private projects.

3.1.1.2. Disadvantages. Despite the advantages mentioned by the fishers, the TURF system also presents operational limitations and, as far as possible, need to be resolved. Among the disadvantages, both parties (fishers' members and leaders) recognize that "permanent poaching" are a threat. This unfair competition provokes the indignation of the fishers' subject to sanctions, while the offending fishers are not so controlled, in their opinion. In this sense, poaching is one of the biggest problems, not only because of the local depletion of the benthic resource but also because of the economic losses it generates. The fishers' member mentions the "conflicts" produced within and outside their organization and outside it as another disadvantage, either due to different interests that come into confrontation, to the heterogeneity in their agreements, or "losing guarantees" as an organization. On the other hand, they mentioned "little interest" or "little participation in the care of the TURF", "lack of support from the authority", and "little supervision", among others. Regarding the leader fishers, they list some disadvantages similar to those described by the fishers' members (Fig. 4).

3.1.2. From expert

According to the expert's answers, some of them seemed to coincide, but in some cases, they had an opposite vision of the TURF system; here we point out the following forcing factors of TURF operability described by experts (Fig. 5):

3.2. Financing and continuity in projects

Although government institutions play an important role in improving fishing sector and, in this case, of benthic artisanal fisheries, experts indicated: "There was much funding in the early years (granted subsidy for equipment, training, projects, and so on)", but later, this was reduced, and the studies were distanced. In other words, the implementation of the TURF opened the possibilities of financing at the beginning. In general, the TURFs were born from the fishers who requested it through their organization, but then the issue of care and how to obtain financing came. In this way, few organizations apply for projects as TURF managers, except at the artisanal fishing level. The fishers often have no idea how to apply for projects that allow them to obtain some resources (monetary, infrastructure, equipment, or training, among others) and benefit the organization. For this reason, project financing for organizations requires some support for adequate information and the follow-up of those approved projects.

3.3. Sales and market

According to the experts, another forcing factor that influences the

Table 1
Themes and categories of the conceptualizations from fisher's point of view (in the role of member) on the pre and post TURF productive activity in the Biobío Region.

Dimension	Themes	Category	Pre (Freq.)	Post (Freq.)	Total	Pre (%)	Post (%)
Ecological-fishery and Technological	Environmental protection.	Contamination and threats due to natural events.	0	12	12	0.0	100.0
	Sustainable exploitation in the TURF.	Conservation and territoriality.	6	6	12	50.0	50.0
		Benthic resource value, productivity.	45	13	58	77.6	22.4
		Threats to the resource, overexploitation.	1	58	59	1.7	98.3
Social, Economic and Ethical	Economic stability.	Income, livelihood activities.	15	3	18	83.3	16.7
	Lifestyle and renewal.	High costs, lower profitability, lack of generational replacement.	0	20	20	0.0	100.0
	Community connection.	Conflicts, competitive fishing practices (poaching).	0	22	22	0.0	100.0
	Involvement in management.	Weak social influence of fishers.	0	3	3	0.0	100.0
Institutional	Organizational capacity.	Commitment to the development of TURF.	1	2	3	33.3	66.7
	Capacity building.	Advice and assistance.	0	6	6	0.0	100.0

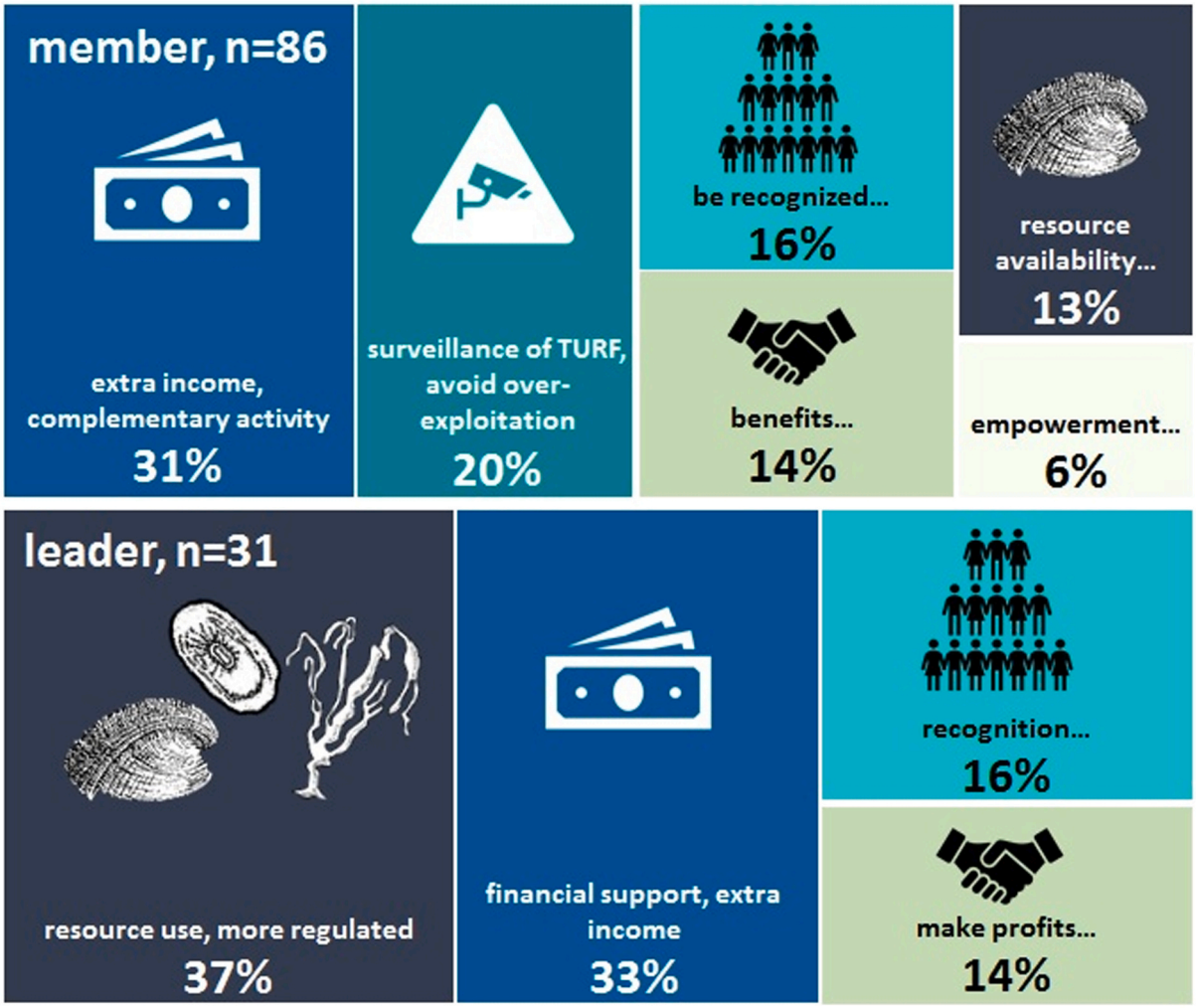

Fig. 3. Conceptualizations of benefits in the TURF, according to fishers surveyed in their roles as member (n = 86) and leader (n = 31) who belong to the artisanal fisher's organizations selected in the Biobío Region.

operability of the TURF is the "market". There is little knowledge of the marketing channels and little commercial associativity between the organizations, which generates limitations and makes them less economically profitable [66]. However, some experts emphasized that in some TURF where the target resource is the "loco" *C. concholepas*, they did good marketing, although, in most TURFs, the species is overfished. As occurs in a large part of the artisanal fishing sector, marketing is carried out by the intermediaries due to the lack of bargaining power of the fishers; consequently, a dependency relationship is produced [77,78]. While the topic of a good marketing channel can have strengths for organizations, sometimes weaknesses make TURFs fail or become unstable. In this sense, visualizing TURF as a business unit that involves all the elements of the system could be a good measure to boost its productive capacity and stability. Thus, there must be mechanisms that promote and facilitate more efficient marketing so that organizations can sell their production directly to consumers.

3.4. Economic diversification

Several experts agree that the TURF has become an important tool for maintaining property and access privileges. Although it is considered a complementary activity for fishers, it helps them improve their working conditions. In our study area, most organizations grouped into unions and associations have decreed TURFs, and others are in the application process [25]. These organizations have been receptive to joining to the system, understood from fishers' productive diversity: they alternately fish, dive and/or collect activities. Likewise, there is a relatively positive view of the TURF system based on its economic results, which has incentivized organizations not to specialize in benthic resources. *"There are several ideas from some places, such as in the northern part of Chile with seaweed extraction, where organizations have managed to sell their product without the intermediary. So they not only stay with the extraction phase, but they have processing plants with all the required sanitary standards, and they manage to export the product. So it depends on how people want to see it, but today, the best thing is, if you want to have a better price, you have to be the one who sells directly, you have to eliminate the channels that are intermediaries that lead to the final buyer"* (Expert #12, Scientific).

In general, the TURF system was initially positive because it encouraged the artisanal fishers to formalize the activity as a direct user, to organize, and come to an agreement. Likewise, it opened possibilities for projects and financing. Therefore, it has often been used to obtain state or private benefits. Nevertheless, later, it became insufficient in a large part of the TURFs because there were many users, and the benefit ended up diluting and it stopped being attractive. However, the TURF system is still an alternative for fishers to access projects, but they must be channeled with more continuous long-term advice.

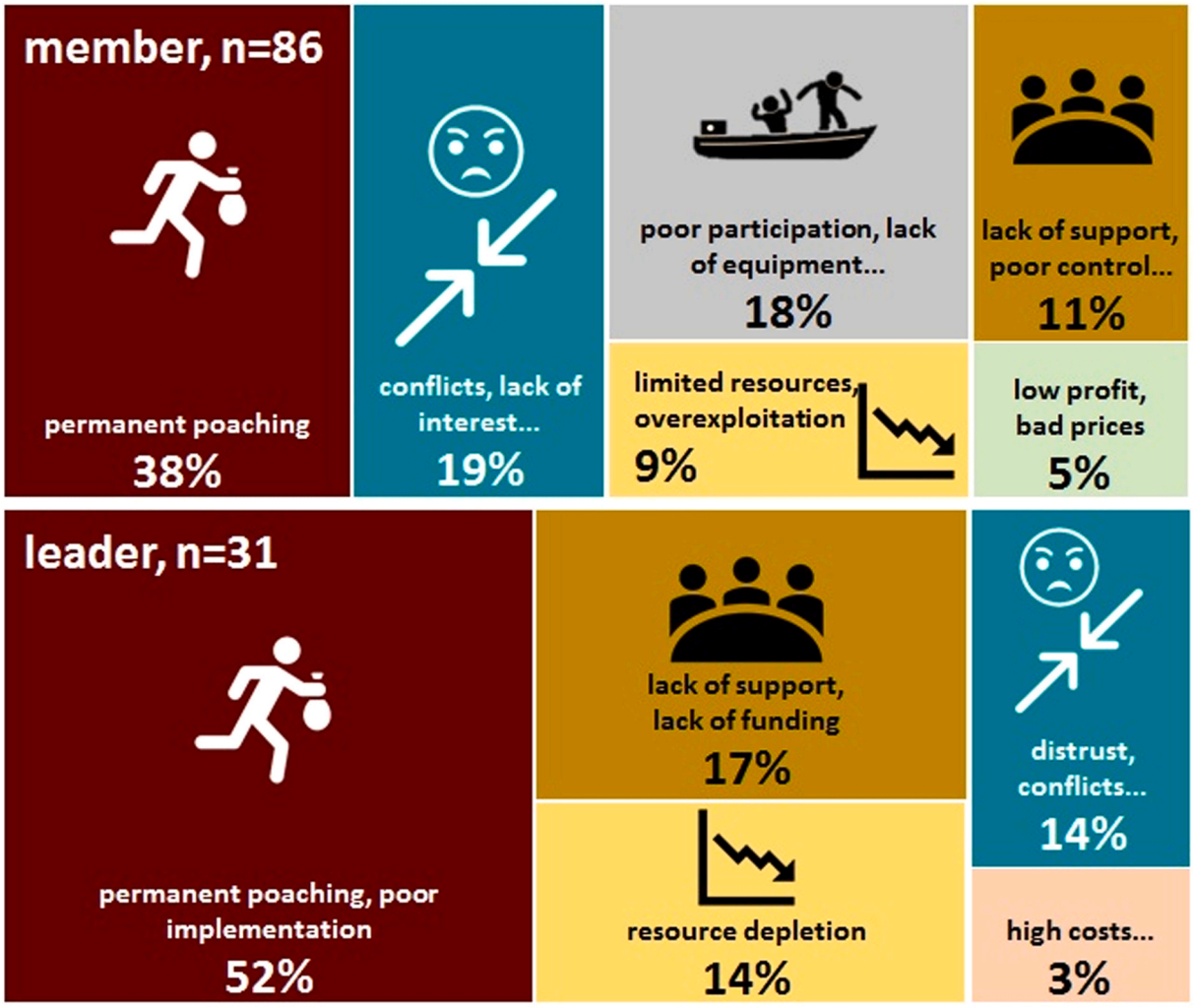

Fig. 4. Conceptualizations of disadvantages in the TURF, according to fishers surveyed in their roles as member (n = 86) and leader (n = 31) who belong to the artisanal fisher's organizations selected in the Biobío Region.

Fig. 5. Main forcing factors (positive and negatives) in the operability and permanence of TURFs identified by the experts interviewed (n = 15).

3.5. Organization

There is significant variability in the management of AFOs at national, regional, and local levels, as confirmed by experts. This complexity is particularly evident in fishing coves or "caletas", where multiple organizations are involved. However, it is crucial to involve all interest groups in the decision-making process, and transparency is necessary. These include being clear about how decisions are made and ensuring a high level of democracy in the agreements. Effective management performance is dependent on the dynamics of an organization. Unproductive TURFs may persist over time, but the organization's quality is reflected in the strength of its leadership and capacity for leadership. As the informant indicates: *"I think human capital is a fundamental element and it has been maintained, but not much has been invested in it. When decision-making is concentrated in two or three people huh, I think the results are not that good. In community terms, you are adding other capacities, new ideas, more criticism and improvement of what you are doing, more minds that think, all the people are more concerned"* (Expert #06, Public manager).

In short, management capacity and how visionary organizations can be in terms of innovation depend on the human component. It is also necessary to promote the participation of the different interest groups in generating measures and other more participative actions, prioritizing the contribution from fishers.

3.6. Compliance and fishing practices

Based on the answers given by the experts, they agree that the most significant social problem present in the TURF is illegal fishing (poaching). This phenomenon at the national level presents different characteristics depending on the geographical environment, biological productivity, economic incentives, distance to urban centers and socio-demographic conditions. Illegal fishing creates permanent tension in fishing communities, affecting decisions related to compliance with current regulations [79]. In addition, a high level of poaching and impunity for offenders can have a demotivating effect on TURF care, as well as an increase in illegal activities [69].

Along the same lines, illegal fishing is a problem that weakens the exercise of care and its initiatives to improve the benefits of TURF. In other words, some TURF that are taken care of, others are little taken care of, and others are not taken care of since there are diverse scenarios. Nevertheless, even so, fishers have the option of exercising their right to be a kind of monitor of what is happening in the environment. In this sense, illegal fishing is an element that undoubtedly determines the success or not success of many TURFs, later producing a discouraging effect on users. For this, there must be mechanisms to identify the irregularities that drive fishers to extract resources from TURFs illegally.

3.7. Expectations about the TURFs operability: both fisher and expert conceptualizations

3.7.1. From fisher

We start with the following question: "What do you expect from TURF in the coming years?". The member and leader fishers surveyed feel that keeping the TURF on the coastal border and insular zone has created a challenge for their organization. Because after almost three decades of TURF implementation, doubts and discontent about the system persist, but there are also encouraging expectations on their part. It is surprising to review the expressions of the fishers in the sense of the managerial and critical capacity they have of the TURF system.

Firstly, the fishers in both roles, express their hope to get back what the TURF offered them before and even before its implementation. However, the need for credibility on the part of the authorities, even at the level of organization and management, plays a crucial role in the equity of their interests. Both groups emphasize the improvement of TURF's productivity for the Biobío region, expressed in the following terms: "good production/recovery of the resource/ diversification into other resources". It is worth noting that they have an encouraging position when describing the quality of this co-management system's operation: "The TURF is good, and we hope the authorities will help us" (see Table 2).

Secondly, the fishers manifest greater control and territorial surveillance of the TURF in possession of their organization: "greater care of the TURF/improve sanctions". That is to say, more support from the authority that regulates fishing in the sea with the control and application of sanctions for those who commit infractions. They also state: "Eliminate poaching/zero contamination", both expressions lead to a shared reality, not only at the local level. On the one hand, poaching constitutes a disturbing element for the TURF regarding good fishing practices. Furthermore, the degradation of the ecosystem due to pollution generates frequent conflicts of interest. Without any doubt, it has seriously endangered the conservation and sustainability of benthic resources, contrary to the initial objectives of the TURF.

Finally, a third point in common is the ability of fishers to recognize each other as peers, organize themselves, and work together for common interests. For fishers, the future also lies in improving participatory work, influencing their identity constructions: "greater commitment/ better management/better known".

Table 2
Interview quotes across fishers' expressing the expectations of TURFs in the Biobío Region. In their roles as members and leader within the organizations, according to the question: "What do you expect from TURF in the coming years?".

Stakeholder	Textual quote
Fisherman member #01	*"I would like to see the TURF return to the way it was before 2007: highly productive with increased seafood, economically much better and with more member participation in studies".*
Fisherwoman member #79	*"For example, before, if you wanted to eat something, you would come to the sea and now you can't do that".*
Fisherman leader #15	*"I want to go back to when we were just given the TURF on Mocha Island. I know it will be difficult, very difficult […] Well, it depends on the authorities, as well as on the initiatives of the leaders themselves".*
Fisherman leader #24	*"We hope to keep it there, to keep the people there. The TURF is good and we hope the authorities will help us. Without poaching it improves the people's quality of life".*

3.7.2. From experts

In order to identify negative and/or positive factors in the future performance of the TURFs, the answers to this question were analyzed: "What do you expect from the TURFs in a 10-year horizon? (Is it convenient to keep all of them? or Is it better to opt for profitable ones, not only because of the economic benefits but also because of the current state of the resource?)".

From the answers provided by the experts, they agree that TURFs are divided into two groups: those that work well and those that do not. Thus, the TURF system, as an administrative measure and due to its requirements and environmental characteristics, is not granted to everyone, nor does it guarantee a successful production. That is to say, not all AFOs have the capacities to be able to reach a successful conclusion, either because the TURFs granted are not abundant in benthic resources. Except in those places called 'loqueros' (due to Chilean abalone) because they were traditional extraction places in the past, and those places will keep as they can. Or as well as some TURFs have been maintained due to the proper management of the AFO because they have had some marketing channels. But others have not complied with that, which was unfavorable to their operation.

In particular, the activity in the TURF beyond the resource involves humans working temporarily, so this issue is quite complex today. Furthermore, one of the identified factors is focused on the interactions between fishers and experts, who determine the orientation of this activity. It is precisely the constant incorporation of scientific knowledge achieved with the experience in management and the contribution of the fishers, which are necessary to solve current problems. It is necessary the inclusion of fishers in social studies, in the methodological design, data analysis and results communications, in order to get knowledge of their organization and power relationships with other stakeholders [80]. On the other hand, the expert's conceptualizations are necessary for the TURF to continue (Table 3).

In summary, as a fisheries management tool, the TURF system is an excellent opportunity for sustainable livelihoods, regardless of negative results, such as low biological productivity or weakly organized associations. It is important to note that both the fisher and the expert show concern about the performance of the TURF, considering the positive or negative aspects according to their assessments. Therefore, the operability and permanence of the TURFs do not only involve economic aspects; their sustainability requires consideration of social organization, inter-TURF networks, cultural legitimacy, environmental resilience, and political ecology.

The TURF as a SES is characterized by complex interactions, where the human component and its relationship with the environment play a fundamental role. This approach generated a more comprehensive look, allowing the development of a multidimensional and integrated analysis of the main problems and perspectives, which allowed us to understand the whole TURF system, balancing the ecological-fishery and human components towards a more transdisciplinary perspective. Both components must be understood and addressed in the TURF fisheries

Table 3
Interview quotes across experts' expressing the expectations of TURFs. According to the question: "What do you expect from the TURFs in a 10-year horizon?".

Stakeholder	Textual quote
Expert #03 (background: Consultants)	*"Not many changes will happen because there are already […] but if there is no change in the attitude of the organizations towards their TURF, there will be no future, and it will take a long time because they are concerned about profits. The future of the TURF will depend on the organization".*
Expert #06 (background: Public managers)	*"The organizations with TURF already have backing there, perhaps in economic terms, but also support in management terms and invested work that will not 'tirar a la borda' (be thrown away). I believe that this helps them to access other things".*
Expert #09 (background: Scientists)	*"There is a mosaic of possibilities that TURFs have. I don't think fishers are going to give them up […] I think it will be around for a long time. Fishers are ingenious enough to figure out and capable of adapting to the coming changes".*
Expert #11 (background: Scientists)	*"The TURF as an administrative measure and due to its characteristics is not for everyone […] in my opinion an important group will be disaffected (out of use), because they do not have the conditions, they are not available".*
Expert #15 (background: Scientists)	*"I see it as an effective administrative figure, but it should continue to promote other strategies to encourage the fishers' participation and motivate them to do more things".*

management process to minimize negative impacts and increase benefits. The fishers are fundamental in the SES framework and the fishery's co-management. For this reason, incorporating the human dimension is critical for its success.

3.8. The MICMAC structural analysis: identification of influential and dependent degree based on the proposed ecological-fishery and human attributes

The blue ellipses in the upper right quadrant of the direct and indirect influence-dependence maps of the fishers (Fig. 6 and see the Appendix 4) encompass the "key attributes" according to the MICMAC structural analysis. The fishers focused on the attributes belonging to the institutional and ethical dimensions. The "key attributes" focused on improving the capacity for participation in decision-making based on the knowledge of fishers and experts. In addition, the fishers indicated that the social relations are broader, including networks with other fisher's organizations ('Nwk_AFO') and institutions ('Nwk_Instit'), the interaction of the leader ('Int_Leader') as well as proper management ('Rght_Manag'). For these reasons, these attributes are unstable and represent challenges for the TURF system. As these attributes are key for TURFs, they should be included in future proposals of co-management systems that correspond to global challenges of sustainability.

Source: LIPSOR-EPITA-MICMAC software. The ellipses in blue indicate the "key attributes" and red boxes indicate attributes involved in proposed solutions. Codes: Abun_Level = Abundance level of target specie; Other_Sp = Re-orientation to other species; Ch_Size = Changes in the mean size of target spp; Ch_Cond = Change of the condition index; Ch_Density = Change of the Mean density; Hab_Propor = Fraction of habitable area; Harv_Index = Harvest compliance rate; Harv_Area = Harvest per suitable area; Stab_Abun = Abundance stability; Econ_Prod = Economic production; Cost_Kilo = Cost per kilo or unit; Cost_Benef = Cost-benefit; Percap_Inc = Per capita income TURF; Alt_Income = Indirect total income; Subsi_Rece = Subsides received; Lev_Of_Deb = Debt level; Avera_Wage = Average wage; Market = Market; Cult_Value = Cultural value; Act_Access = Access to activity; Rght_Manag = Right management; Evol_Destr = Evolution destruction ecosystem; Vul_Outsid = Vulnerability to outsiders; Evol_Poach = Evolution of illegal fishing; Mitigation = Damage mitigation program; Pres_Advic = Presence and advice; Acc_Comuni = Communication access; Int_Confli = Internal conflicts level; Ext_Confli = External conflicts level; Int_Resolv = Internal conflicts resolve mechanisms; Ext_Resolv = External conflicts resolve mechanisms; Nwk_Instit = Networks with institutions; Nwk_AFO = Networks with other artisanal fisher organizations; Goal_Ful = Level of compliance goals; No_Projec = Number of development projects; Str_SNwk = Strength of social networks; Input_Expe = Contribution of fisher's knowledge; Partic_Org = Fisher's participation in the AFO; Rate_Memb = Change rate in the number of members; Int_Leader = Level of leader's interaction; Rep_Leader = Leader's replacement; Educ_Level = Education level; Perm_TURF = Tenure of TURF; Dev_Index = Fishing cove development index; Fleet_Capa = Fleet capacity (No. of boats or active divers); Ch_Vessel = Change of vessel size; Ch_Pract = Change of harvest practice; Ch_Trip_Le = Change of trip duration; Ch_Cpud = Variation catch per unit diver; Sys_Survei = Surveillance system; Other_Acti = Other activities.

The results obtained through different classifications give a great variety of information and the possibility of analyses that allows us to understand the operability of the TURF system in the Biobío Region. We can also visualize the relationships between all the attributes, considering the netwok diagram of the direct potential relationships (Fig. 7), where we corroborate which attributes have more significant predominance in the system. In this diagram, the networks ('Nwk_AFO') and ('Nwk_Instit') are evident as the focal point, as well as the attributes of access to the activity ('Act_Access'), surveillance system ('Sys_Survei'), adequate management ('Rght_Manag'), probability of foreign vessels entering the TURF ('Vul_Outsid') and level of achievement of objectives ('Goal_Ful'). We can also observe in Fig. 7 the strong relationship of the attribute 'Rght_Manag' on 'Str_SNwk'. In turn, the latter influenced other ones, such as TURF permanence, access to communication, and conflicts within the AFOs as well as outside it.

Collectively these results show that network strengthening ('Str_SNwk') and proper system management ('Rght_Manag') are necessary elements for the future permanence of TURFs. Therefore, they must be considered and addressed to co-design strategies that guarantee improvements in the operation, continuity, and strengthening of the TURFs in the Biobío Region. However, most fishers state that the interactions between the government and the organizations they belong to are inadequate and infrequent to address sustainability challenges. To change this image, it is necessary to have a more coordinated, reflective, and participatory interaction.

Similarly, using the list of attributes and the experts' perceptions, we logically organized the attributes described in Fig. 2. To establish the structural aspects related to the performance of the TURF, Figs. 8 and 9 show the characteristics and position of each attribute within the map. According to the direct and indirect influences map, we identified the attributes that characterize the management of the TURF co-management system for our case study. We focused on the "key attributes", since they are the most impressive elements, without neglecting the importance of the rest of the attributes according to the influence-dependence map. Variability of responses of surveys was integrated by expert consensus, through facilitated discussions as a valuable tool, however it is susceptible to cognitive biases such as group thinking, the dominance of strong-minded individuals, and shared biases among group members [81].

Source: LIPSOR-EPITA-MICMAC software. The ellipses in blue indicate the "key attributes" and red boxes indicate attributes involved in proposed solutions.

The direct and indirect influence-dependence map, according to the conceptualizations of the experts (Fig. 8), shows that the "key attributes" are: participation of the organization ('Partic_Org'), rate of change of the number of members in the organization ('Rate_Memb'), level of achievement of objectives ('Goal_Ful'), among others. Additionally, in the upper left quadrant of the map, the "regulatory attributes" are the presence of authorities in the TURF ('Pres_Advic') and the institutional networks level ('Nwk_Instit'), among others. In the lower right quadrant,

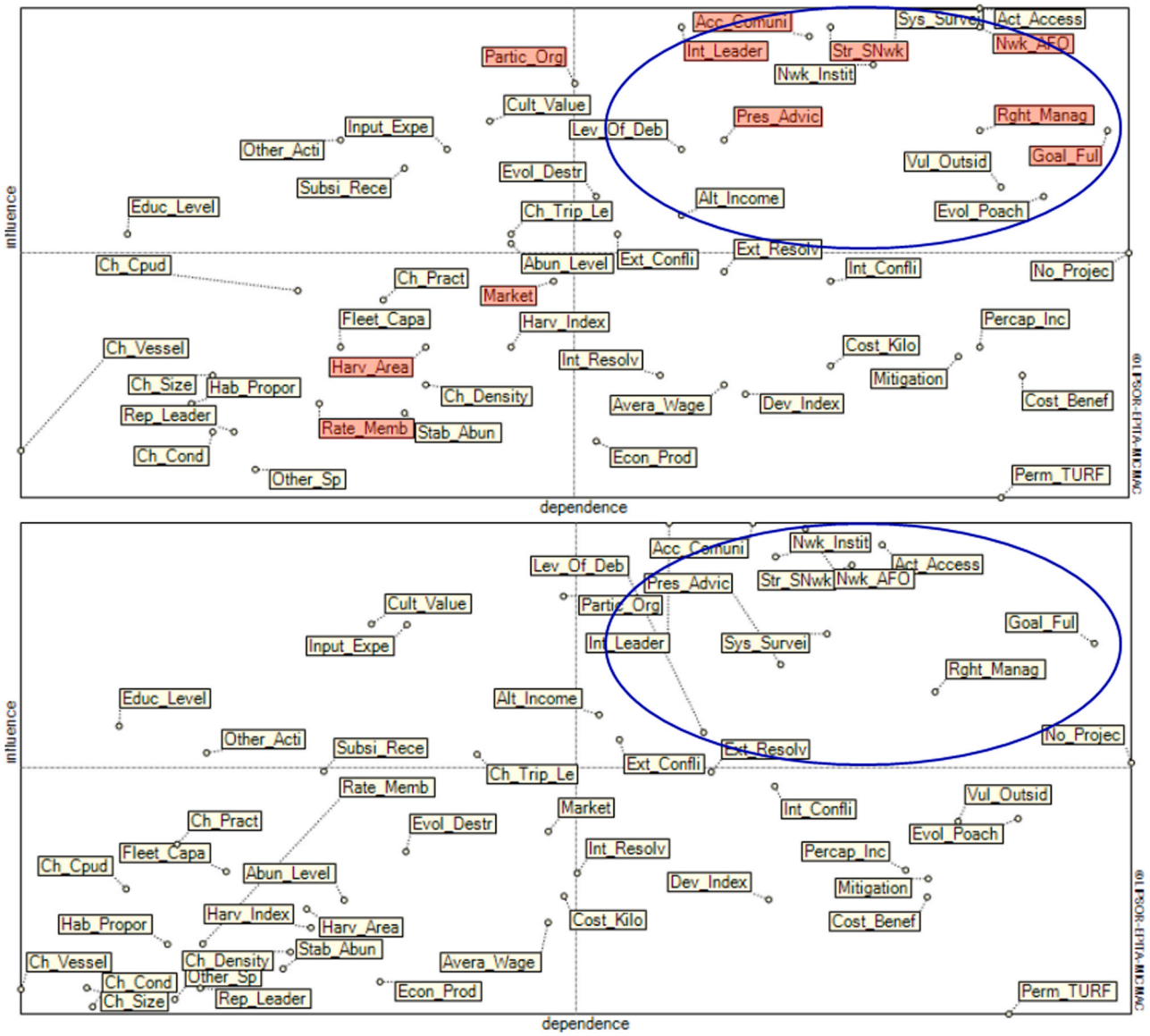

Fig. 6. Influence-dependence map of attributes based on fisher' perceptions (top panel: direct and bottom panel: indirect influence/dependence).

the "result attributes" are what the fisher receives monetarily ('Percap_Inc'), market ('Market') and development index of the cove ('Dev_Index'), among others. Finally, in the lower left quadrant, the "autonomous attributes" are the reorientation of other species ('Other_Sp') and the size variation of the main species extracted ('Ch_Size').

The previously described results show the reality of the system according to the expert and, in turn, allow an in-depth study of the proposed attributes. Besides considering the social and institutional dimensions, the map's most interesting aspects are other ecological-fishery and economic dimensions. Following the attributes' description and location on the influence-dependence map, the graph of the relationships between attributes is presented (Fig. 9). This chart establishes the effects between the attributes that go from a weak to a strong influence within the TURF system. The diagram shows the organization's participation ('Partic_Org') as a focal point, as well as attributes related to the level of abundance ('Abun_Level') and poaching ('Evol_Poach'); attributes that must be considered and attended to in the search for strategies that guarantee improvements in the sustainability of the TURF co-management system.

In this analysis (Figs. 7 and 9), it could be observed that the fishers consider stronger links directed to the fulfillment of objectives (Goal_Ful); while experts perceive stronger links toward the number of projects developed (No_Projec). For the fisher, these key attributes depend mainly on other attributes linked to the social and institutional dimensions, such as networks with other artisanal fishers' organizations (Nwk_AFO), access to information (Acc_Comuni), and interaction with the leader (Int_Leader) within the TURF organization. However, from the expert's perception, the fulfillment of objectives strongly depends on the networks generated with other fisher organizations (Nwk_AFO), but in turn, regularly influences the TURF's per-capita income (Percap_Inc). Both perceptions converge in the need to strengthen networks with other AFOs and even with institutions to reduce the associativity and development gaps of the TURF.

4. Discussion

In our study, we observed, through the conceptualizations of both the fisher and the expert, common themes that influence the sustainability of the TURF for the Biobío Region. The introduction of the TURF is a way to reduce the incentives for the users to over-exploit the available populations and with this exercise of sustainable extraction methods, satisfies both the biological needs of the resources and the

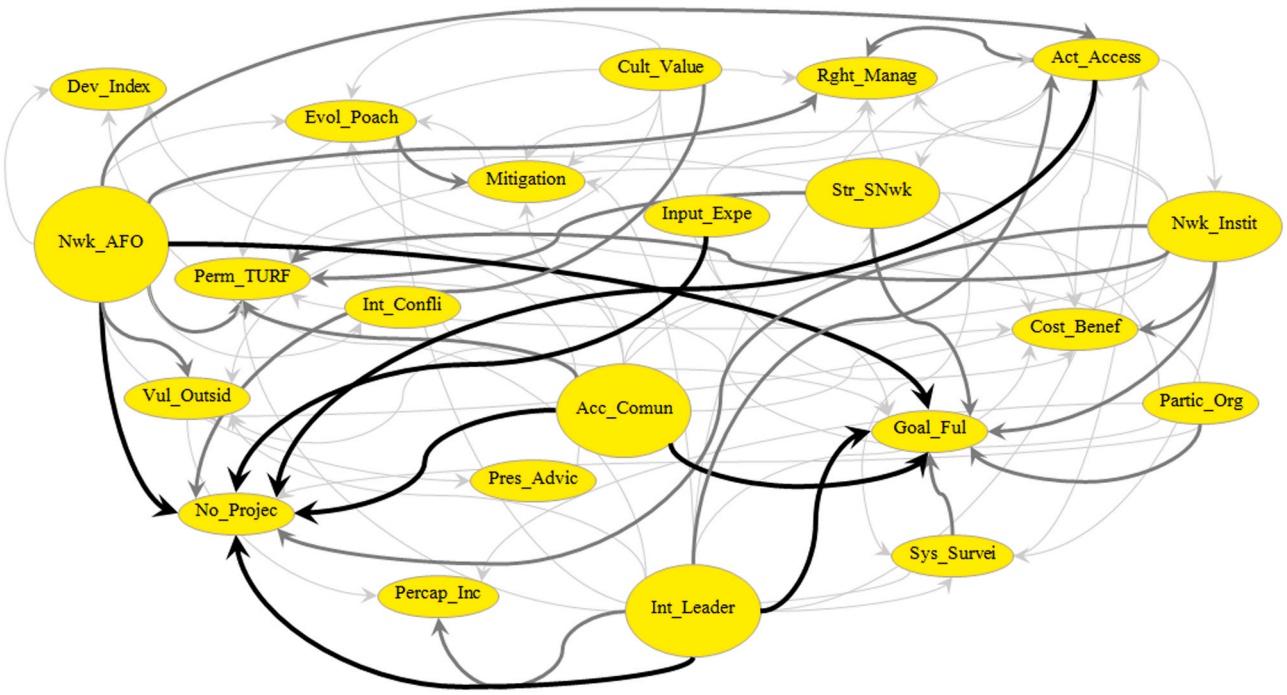

Fig. 7. Network diagram of the direct potential relationship among attributes in the system based on fisher' perceptions. Where thick black lines represent very strong influences; thick dark gray lines, relatively strong influences; and thin light gray lines, weak influences. Source: LIPSOR-EPITA-MICMAC software.

market demand. However, from these delimited spaces (regardless of their extension), a series of positive and negative forcings emerge. Below, we summarize the problems, solutions, and expectations associated with TURFs, extracted from the analyses of fishers and experts' surveys:

4.1. Problematics

In addition to the problems of the natural system (ecological component) where the majority of fishers work and live daily, there is also the human component (within social, economic, technological, ethical, and institutional dimensions). It is necessary to highlight that a management approach or strategy which includes the human component promotes integrative, transdisciplinary, and participatory methodologies through better balancing both components [82].

For this reason, it is assumed that "the human dimension is a complex adaptive system, embedded in another complex adaptive system -the natural environment- on which it depends for its sustenance" [83]. Based on this assumption, it leads us to question the effectiveness of the TURF, demonstrating the existence of unfavorable forcings described by fishers and experts. Among these negative forcings, we found illegal fishing (poaching), conflicts, overexploitation, lack of support, little participation in care, poor information, and high costs. Despite these problems, some TURFs have been maintained due to proper management of the organizations and because they have had some marketing channels. However, some TURFs have not performed satisfactorily and have gradually declined until they have been returned to the government or abandoned. According to our results, both the probability of foreigners entering the TURF ('Vul_Outsid') and illegal fishing ('Evol_Poach') are negative attributes in ethical terms (see Figs. 8 and 9). In addition, we coincide with the study of [84], who indicated that low natural capital and high levels of poaching generated limitations in the productive biological level of the TURFs.

From the responses provided by both parties, experts agree that TURFs in the Biobío Region fall into two groups: those that still work and those that don't. Although most of the TURFs have been in operation catching "loco" for over two decades, during this period, several organizations have been allowed to reorient towards other species, such as seaweeds, or into small-scale aquaculture [59]. However, not all organizations had the capacity to reach a successful performance, sometimes because the TURFs granted were not abundant enough in benthic resources. So, among the problems which prevented the development and sustainable maintenance of the activity in the TURF for our study area, we can mention the following ones:

- The intense exploitation of the main benthic resources has occurred in most of the TURFs in Chile, from the past to the present [7,85,86]. An exception are those places, which due to their important production of "loco", were called traditional fishing areas in the past, and they are carefully maintained, as the most productive zones in the Biobío Region [59]. In addition, another problem is the uncertainty about the status of the benthic resources at spatial scales larger than TURF.
- Generational renewal of fishers can increase the scenarios of hiring fishers outside the TURF to develop the fishery, distorting the sense of traditional fishery users and assigning rights to users.
- A low level of organization among the different artisanal fishers' organizations (AFOs) benefited from the TURF.
- Limited associativity to market, since there is little knowledge of the marketing channels. Most AFOs do not have a direct marketing channel as they depend on an intermediary, whether external or by the leader as responsible. For this reason, fishers don't know (most of cases) neither the dynamics of the market associated with the unknown resources, nor how to give aggregated value to their products.
- Lack of marine spatial planning in the TURF, leading to conflicts of interest, which most organizations have to deal with. There are other more complex types of occupation, such as historic spaces, the aquaculture industry, and environmental damage from mining, among other pressures.
- Few initiatives for recovering populations of benthic resources of commercial interest, through actions such as diversification of fishery towards other resources, repopulation and aquaculture.

It would also be necessary to add those problems related to the

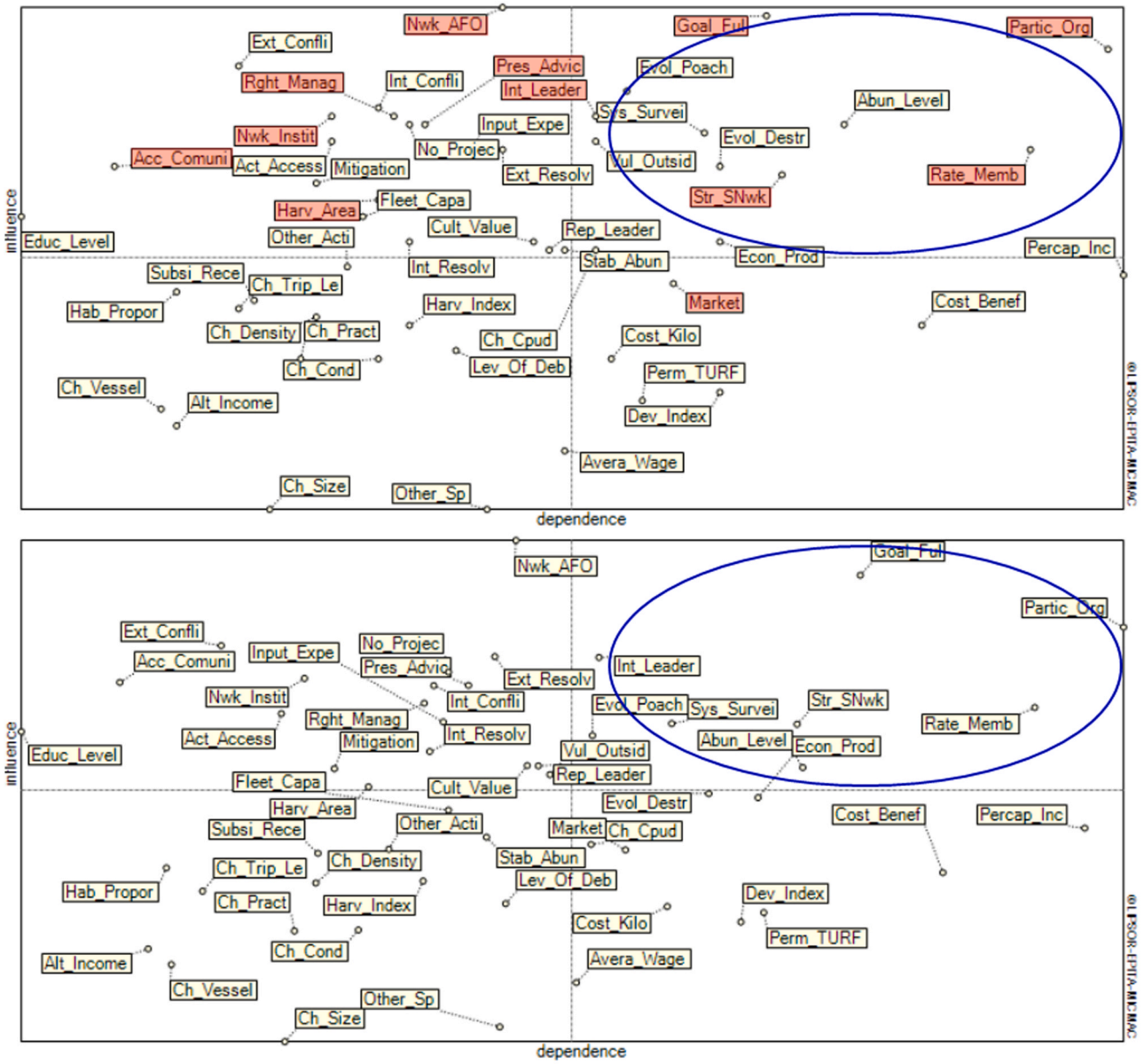

Fig. 8. Influence-dependence map of attributes (top panel: direct and bottom panel: indirect influence/dependence) based on expert' perceptions.

conflicts produced within the AFOs due to the spatial and temporal heterogeneity of productivity of the TURFs, and the little interest of users when a TURF that does not produce as in its beginnings. Our study was based on selected TURFs in operational condition, which achieved a sustainability rating from low to fair (score:>50 %) [59]; however, future studies should gather information also from the non-operative TURFs, as they represent a significant percentage of the total [25].

4.2. Solutions

From the conceptualizations of fisher versus expert, we have emphasized strengthening the TURF system, its regulations and evaluating the characteristics of the activity considering both parties. As we have worked grouping the TURFs by zones (gulf, bay, coastline and islands), this allowed us to know diverse scenarios. It must be emphasized that the sustainability of TURF as a fundamental aspect of fishers' livelihoods is the greatest challenge for current artisanal fisher organizations, and the solutions must be addressed from the different TURFs and on a case-by-case basis.

Faced with the problems described in the previous section, we propose that the human component must be increasingly involved beyond conventional management. In this context, Swyngedow [87] argued in his study - Politicizing urban political ecologies - that human activity cannot be seen as external to ecosystems. Thus the "socio--ecological metabolism", as he calls it, involves the dynamic and complex relationships between humanity and nature, together with factors such as gender, ethnicity, and others involved in socio-ecological transformations.

Solutions require understanding the specific causes of the problems, such as illegal fishing, one of the most influential attributes described in our study. Among the most urgent solutions that minimize threats to the resource and therefore ensure the permanence of the TURF, we recommend:

- The government agencies should establish clear objectives for the AFOs, promoting a more outstanding commitment and interest in the care of the TURF. In addition, the permanent support of government agencies should have a crucial role in enforcing regulations, thanks to their capabilities for control, technological support, and legal support for sanctions, which must be more rigorous.

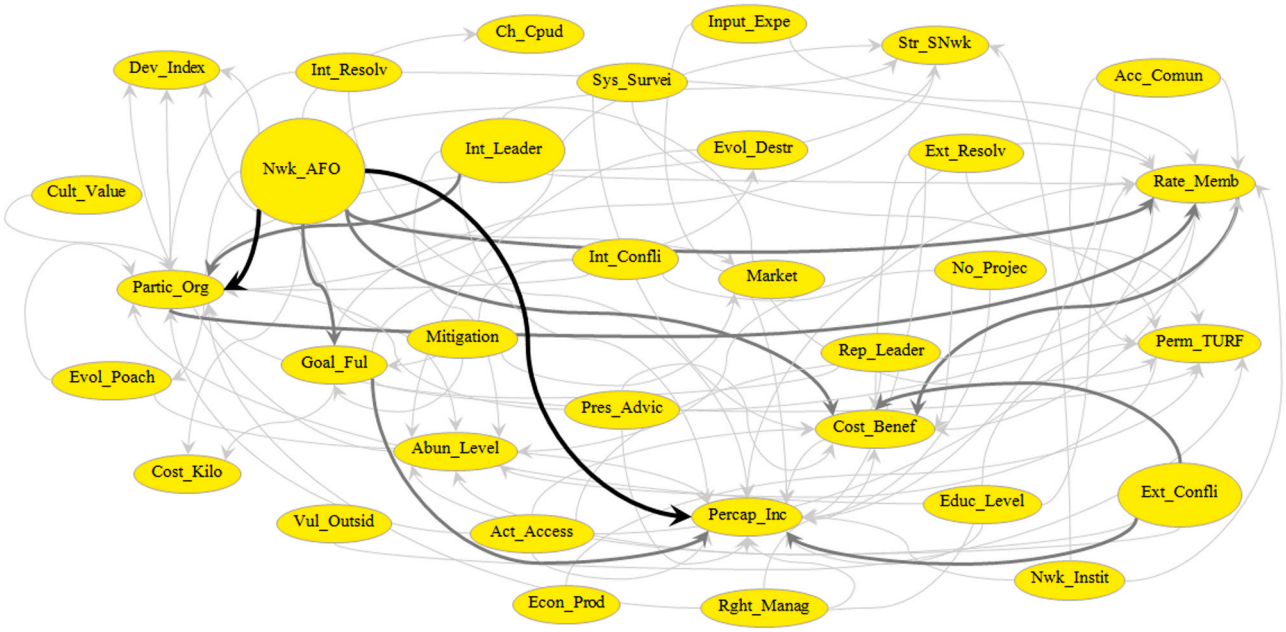

Fig. 9. Network diagram of the direct potential relationship among attributes in the system based on expert' perceptions. Where thick black lines represent very strong influences; thick dark gray lines, relatively strong influences; and thin light gray lines, weak influences. Source: LIPSOR-EPITA-MICMAC software.

- Properly distribute and plan the marine spaces according to the background and knowledge of the region. That is, to re-evaluate and identify entirely suitable TURFs and in good productivity conditions, which will contribute to recovering, maintaining, and sustainably exploiting the stocks. In this context, an important point for future studies is to understand those TURFs in a non-operational condition, which could allow us to respond with greater certainty to the recurring problems that led to the collapse of these TURFs.
- Implement control measures for consultants, so they should fully assume the standardization of data collection methods, and SUBPESCA can prioritize a registry of consultants based on their quality.
- Generate equitable and inclusive discussion spaces (workshops, forums, others) that facilitate dialogue between fishers and other interest groups, incorporating coastal communities. Use of "common languages" that allow the exchange of ideas and information in a fluid way for improved problem-solving. For example, to promote permanent communication between fishers and experts, favoring participatory processes and generating trust between both parties. Allow fishers to take a greater part in matters that concern them and take advantage of different knowledge and experiences.
- Complement the "permanent" technical advice (by the government, consultants or other specialists) with training on how to apply for competitive funds to promote artisanal fishing; diversification of activities in fishers (both men and women), for example, venture into processing, tourism, gastronomy or aquaculture.
- Shorten marketing chains, while at the same time strengthening the fisher-consumer relationship and/or direct sales to restaurants; improve processes involving products and/or raw materials, with the incorporation of best practices and/or new technologies.
- Finally, improve the internal and external management of AFOs, by strengthening association networks, accompanied by transdisciplinary socio-ecological research. For this, it is necessary to strengthen governance and apply the commoning approach, which involves establishing rules or protocols for access and use of resources, taking care of and accepting responsibility for the resources, and distributing the benefits in ways that consider the well-being of others [88,89].

Notably, the solutions expressed by the fishers, are enclosed in the blue ellipses of the influence-dependence map as "key attributes" (Fig. 6), consequently, they are essential for future co-management plans [25]. In the case of the experts, part of the solutions was also well represented as key attributes in the influence-dependence map (Fig. 8). In this way, MICMAC structural analysis allowed us to identify attributes with more incidence in the system to ensure permanence and improve the performance of the TURFs. It is necessary to point out that fishers have an impressive amount of contextual and experiential knowledge about the social and ecological system of which they are a part. This knowledge goes beyond the target species, extends to the ecosystem, and includes various social, economic, and governance aspects and human behavior in the fishery [90]. However, the challenge is how to best incorporate their presence, experience, and knowledge to understand and manage the system.

4.3. Expectations and perspectives

From the previous evidence, the conceptualizations about the future evolution of the TURF show appreciation of how they have developed over time, their problems, needs, and perspectives. Despite the deep mistrust regarding the future of the TURF, many fishers hold a positive view regarding the quality of its operation: *"will be better [the TURF], but with more support from the authorities to prevent poaching"* (Fisherman member #57) or *"It is good [the TURF], but it could still be improved because there are parts where the algae have been lost and it is necessary to restock"* (Fisherwoman member #82).

From the position of the fisher, there is an expectation of a sense of ownership and collective appropriation of regulations within their organization. The regulations' legitimacy reinforces fishers' desire to concentrate on common, voluntary interests, giving up personal ambitions and strengthening the TURF system [91]. For example, the leaders of each organization stated that they are responsible, committed, and motivated, and they are the link through which the State can transfer rights and property. Those leaders committed to the collective benefit promote a strong social cohesion among the organization's members, which could be observed by their intense and positive relationship [25]. However, fishers demand more significant participation in decision-making, listened to, and that the authorities commit to supporting them.

Regarding territorial ownership, the assignment of fishers' organizations to apply for a TURF has been an ongoing, voluntary, and application-based process [92]. These requests include capture rights for specific species within a geographically defined area [93]. Therefore, these rights allow organizations only to use the assigned space, although illegal fishing breaks these schemes. Thus, there is a need to explore and carefully design other tools that help spatial planning and regulation, such as exclusive territorial access rights [94–97] and long-term marine reserves [98–101], which is worth mentioning.

The TURF system will be considered transformational only if it leads to new outcomes for the livelihoods and ecosystem conditions, from the fishers' perspective. The fishers also recognize a more outstanding commitment in their capacity both as leaders and members and for future generations. Collaboration between fishers and experts is possible despite differences in knowledge and practice. Fishers are aware that they need the knowledge of experts to help them understand the changes that are taking place in the marine ecosystem and the processes of fishing management. One way to involve these links is to lay the foundations for developing effective collaboration, fostering trust, and jointly proposing solutions. The collaboration between both groups must be stable in the long term to ensure sustainable management and improvement of the TURF system in the region. Because "cooperative research" becomes "collaborative" when fishers are involved in all phases of the research process [102].

From the point of view of the experts, who bring solid personal training and experience to the TURF system, decision-making becomes a fundamental management act, and to fight against uncertainty, they seek to obtain the clearest vision of the future. Among their concerns about management, they highlight the relationship of fishing resources with human well-being and their conservation for future generations [103]. Regarding the expectations of the TURF, the majority have an optimistic and, at the same time, critical sense, although in some cases pessimistic. We make a parenthesis in this last appreciation. The negativity expressed by some experts is that as long as there is no behavioral, individual, or local change of the fishers, the continuity of the TURF will fail. In this way, adequate renewal mechanisms are the condition that organizations need to continue with TURF distributed on the continent and islands. On the other hand, an important group of TURFs will gradually be abandoned or disaffected because they do not have the adequate conditions that make them successful over time. This rather drastic appreciation arises because, unfortunately, the system could not develop enough for certain zones with many users, and the benefit dissipated.

According to the experts' optimistic position, the TURFs will be maintained but with adjustments. However, they will be vulnerable as long as illegal fishing continues. And, if the government does not solve the problem of illegal fishing, it will affect the other co-management efforts. Also, not many changes will happen, but it will depend on how a form of governance is applied at a local/regional level that gives a sense of empowerment to fishers. To better use what is available and the formation of human capital, an evolutionary leap will be necessary within the organization and in the state, leading to a more transparent decision-making process involving all interest groups and with a long-term vision. In this context, transparency is important concerning access to information and participation in decision-making [104]. However, there are circumstances where confidentiality is necessary when providing relevant and reliable information to those responsible [105]. Generally, it takes time for the different interest groups to build trust, positively influence governance, and for the TURF system to be truly sustainable.

It is important to note that participatory research can also enhance capacity development through training local community members. In this way, they are made aware of the need to manage resources and participate in decision-making [106,107]. At this point Stanley and Rice [108] suggest that focusing on fishers only as a source of data or knowledge is a mistake, ignoring their skills in interpreting results. According to the authors, participatory research represents a more effective intuitive framework for incorporating all fisher's knowledge into fisheries research. Substantial innovation in the governance and protection of the oceans is promoted, with a lot of community contribution in delivering of knowledge and sustainable management [109, 110]. Together, decision-makers are in the process of including fishers by collecting basic knowledge or using their various degrees of participation [111–113].

Enhancing relationships and knowledge-sharing among fishers and other stakeholders through collaborative research is essential to achieve this goal. It will effectively address the challenges posed by the TURF activity in the region and facilitate its management. Collaborative research can also aid in addressing potential legitimacy issues in TURF sustainability-oriented decisions and identifying barriers that may affect the fishers themselves. It can be achieved by seeking joint strategies that consider horizontal and equitable spaces. To effectively manage the system, it is imperative to promote robust transdisciplinary relationships and a comprehensive view of the situation. The presence, experience, and knowledge of fishers and experts must be incorporated to ensure a thorough understanding of gaps and recommendations for an effective management of the system (Fig. 10). Schwermer et al. [114] recommend building trust between fishers and other stakeholders through forums, workshops, and other methods to improve cooperation between both groups. Overcoming barriers and constraints is crucial for a collective learning process, that is necessary for effective decision-making [115].

4.4. Study limitations

- Although this research analyzed the TURFs officially approved and awarded in the region, TURFs that were not granted or rejected in the sample were not considered. It is hoped that future research will include the analysis of the different conditions of TURFs to have a more representative sample and allow for a more comprehensive view of the system.
- Another of the necessary points in this study was to deepen how the TURF system is developed based on a gender perspective. Therefore, for future work, studies that explore gender issues should be increased, even though TURF management is mainly led and integrated by men.
- We can also add the cognitive bias in fishers' responses, which is very common in perception-based studies. Surveyed fishers may be inclined to provide answers they consider socially acceptable rather than reflecting their accurate opinions. As a strategy, it is necessary to corroborate the information obtained through different sources, such as official records, observational data, or interviews with key informants.
- On the other hand, experts' opinions are also subject to cognitive biases, and experts' knowledge is likely to be influenced by diverse factors specific to individual experts, making it hard to achieve impartiality.
- Another limitation in this research was to ignore some participatory components for example, the fishers' organization opinions in the design process and later collaboration in the study. It remains a future pending challenge to present at the AFOs these preliminary results, and key conclusions.

5. Conclusions

As we have been able to appreciate throughout this work, the fishers' conceptualizations, knowledge, and perceptions provide important information for the evaluation of the TURF system. Nevertheless, we can add their skills to gain a major sense of stewardship and ownership by being part of the organizations that benefit from TURFs. In short, local knowledge provides information at the specific spatial and temporal scales where the artisanal fishing activity related to TURFs occurs. These results support our hypothesis that both components (ecological and

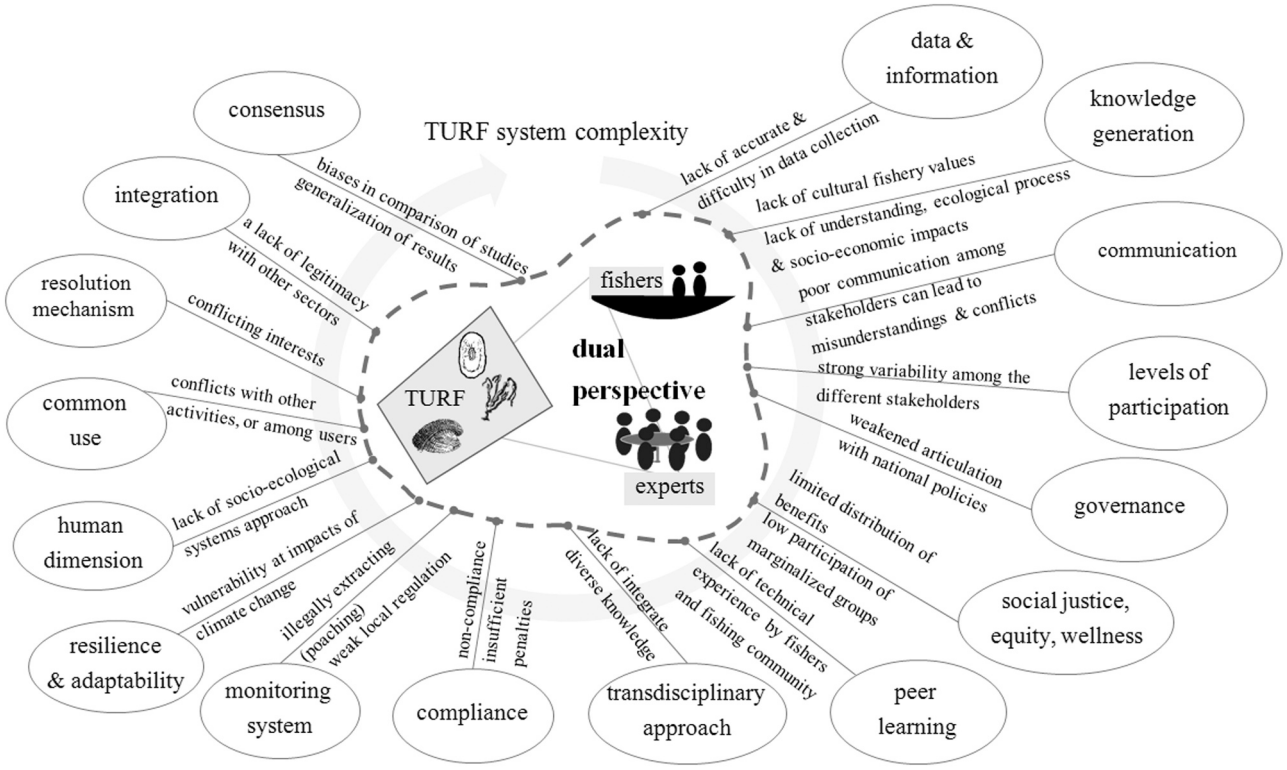

Fig. 10. Synthetic scheme showing gaps (lines) and recommendations (ellipses) in the TURF co-management system of the Biobío Region from the dual perspective of fishers and experts.

human) significantly influence the development, management, and permanence of the TURF for the region. However, there is a need to integrate and strengthen this local knowledge with scientific knowledge since this has not yet been fully achieved.

As a resource user, the fisher's knowledge is of great value for fisheries management, especially when scientific data is limited. Therefore, the need arises to collect such knowledge with the joint participation of fishers and other interest groups to develop successful management plans. However, in most cases, those responsible for the evaluation process and decision-making ignore fisher's traditional knowledge. Given the system's complexity, the need arises to adopt new, more inclusive, and creative approaches to understanding and managing the activity. In addition, promoting the active participation of fishers ensures its viability by increasing the perception of responsibility towards the TURF. A joint collaboration between fishers and experts is possible despite differences in knowledge and practice.

Involving fishers in managing and conservating the TURF requires cooperation with other interest groups since it will depend on how the information is transmitted. Lack of knowledge and access to information about the state of resources will likely negatively affect their interest in participating in collective action initiatives. Furthermore, communicating the risk to fishers is crucial because, ultimately, the danger of collapse in fishing stocks must consider social values and the system itself. In this sense, progress is being made as management incorporates the participation of interest groups through participatory-inclusive processes and fostering trust among them.

Conceptualizations from fishers and experts present some differences. Fishers emphasized the importance of organizational capacity and participatory involvement in decision-making to management regulations. At the same time, experts highlighted as key issues the compliance with good fishing practices and monitoring the functioning of the TURF as a socio-ecological system. However, both parties complemented each other, with the common need for improvement and commitment for this system to continue over time. It is important to note that both parts show concern about the performance of the TURF, considering the positive or negative aspects according to their assessments. Therefore, the operability and permanence of the TURF not only encompass socio-economic features, but the sustainability of the TURFs goes beyond these issues.

It should be noted that the sustainability of the TURF is governed by the socio-ecological complexity of the system, where many local factors intervene, and there is no single solution at all. Therefore, the results of our research support this vision, and in this way, the TURF's co-management plans, investigations, and monitoring should broaden their horizons. We refer to the transdisciplinary approach in management spaces such as TURFs contributing to a common understanding among scientists and stakeholders. That is, to incorporate new components to the TURF system and the need for a robust link with the various disciplines and actors to obtain a more comprehensive view of artisanal fishing development.

Author Statement

We hereby declare that this manuscript is original, has not been previously published, and is not currently under consideration for publication elsewhere. Additionally, we confirm that the order of authors listed in the manuscript, as well as the CRediT authorship contribution statement, has been approved by all authors.

All authors contributed to the design and interpretation of the study. **Milagros Franco-Meléndez** is the corresponding author.

CRediT authorship contribution statement

Milagros Franco-Meléndez: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing-original draft, Writing-review & editing. **Jorge Tam:** Conceptualization, Supervision, Validation, Writing-review & editing. **Simón Hernández Aguado:** Conceptualization, Supervision, Validation,

Writing-review & editing. **Luis A. Cubillos:** Conceptualization, Project administration, Funding acquisition, Resources, Supervision, Validation, Writing-review & editing. **Beatriz Cid-Aguayo:** Conceptualization, Writing-review & editing. All authors have read and agreed to the published version of the manuscript..

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2025.106749.

Data availability

Data will be made available on request.

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