Public Officials’ Knowledge of Advances and Gaps for Implementing the Ecosystem Approach to Fisheries in Chile

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Abstract: The United Nations calls on the international community to implement an ecosystem approach to fisheries (EAF) that considers the complex interrelationships between fisheries and marine and coastal ecosystems, including social and economic dimensions. However, countries experience significant national challenges for the application of the EAF. In this article, we used public officials’ knowledge to understand advances, gaps, and priorities for the implementation of the EAF in Chile. For this, we relied on the valuable information held by fisheries managers and government officials to support decision-making. In Chile, the EAF was established as a mandatory requirement for fisheries management in 2013. Key positive aspects include the promotion of fishers’ participation in inter-sectorial Management Committees to administrate fisheries and the regulation of bycatch and trawling on seamounts. Likewise, Scientific Committees formal roles in management allow the participation of scientists by setting catch limits for each fishery. However, important gaps were also identified. Officials highlighted serious difficulties to integrate social dimensions in fisheries management, and low effective coordination among the institutions to implement the EAF. We concluded that establishing clear protocols to systematize and generate formal instances to build upon government officials’ knowledge seems a clear and cost effective way to advance in the effective implementation of the EAF.

Keywords: conservation; social; governance; equity; collaboration; institutions; adaptive management; traditional knowledge

1. Introduction

Oceans provide fundamental ecosystem services, including food provision, weather regulation, and cultural significance [1]. In particular, fisheries support livelihoods and provide food security for billions of people worldwide [2]. However, more than 34% of fish stocks are overexploited, and 60% are fully exploited [3]. Additionally, fisheries are increasingly coupled to global dynamics, and influenced by pollution, international market fluctuations, ocean acidification, and other drivers of anthropic degradation, which can hinder sustainability [4–6]. Concomitantly, an important proportion of the world coastal population are in a situation of poverty, illness, and malnutrition [7–9]. The conservation and sustainable use of marine organisms is fundamental to achieve equity and human wellbeing in the 21st century [10].

Transforming from unsustainable pathways towards novel forms of management that ensure sustainable and equitable access to ecosystem services in the oceans is a critical challenge [11,12]. To achieve this, the United Nations calls on the international community to implement an ecosystem approach to fisheries (EAF), which considers the complex interrelationships between fisheries and marine and coastal ecosystems, with social and economic dimensions [13]. The purpose of EAF is “to balance diverse societal objectives,
by taking account of the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries” [14]. Accordingly, the EAF promotes sustainable development of the oceans, ensuring the provision of ecosystem services for humanity in the long term.

The EAF is widely advocated internationally to promote the sustainable management of fisheries [3]. Fundamental principles of the EAF have been agreed in a series of international conferences (e.g., Convention on Biological Diversity in 1992, FAO Code of Conduct for Responsible Fisheries in 1995, Reykjavik Conference on Responsible Fisheries in the Marine 2001, Sustainable Development Goals in 2015). The Convention on Biological Diversity (CBD) and Food and Agriculture Organization of the United Nations (FAO) have both proposed key guiding principles to achieve an EAF (Table 1) [14,15]. These principles draw attention towards the protection of biological and ecological systems, the social impacts of natural resource use, the integration of scientific and traditional knowledge, as well as towards an understanding of stakeholders’ interests, motivations, and values [14–17]. However, the implementation of EAFs is a complex process, which presents significant national challenges [12,18–21]. Countries have experienced difficulties in operationalizing the fundamental concepts and dimensions of EAF into action plans, as well as in identifying and prioritizing specific progress and gaps for action [20–23].

Government agencies are active spaces where knowledge is generated and practiced, which can contribute to face the challenges of implementing the EAF [24]. Fisheries managers and government officials hold valuable information to support decision-making [25]. They actively use this knowledge to implement policies and projects [24]. This type of knowledge has been termed bureaucratic, which arises within administrative or civil service bodies [26]. Bureaucratic knowledge is eminently practical and used on a daily basis to identify and prioritize problems, as well as to explore solutions [27]. Bureaucratic knowledge involves expertise to analyze the consequences of decision-making and to identify gaps and challenges for public policy [25]. Therefore, bureaucratic knowledge is key to anticipate and identify gaps in the implementation of EAF.

Chile is one of the top ten global capture producers in the world, with more than 2 million tons in 2018 [3]. In 2013, Chile enacted Law N° 20,657, which modified the General Fisheries and Aquaculture Law (GFAL), introducing substantial amendments to the administration of fisheries. The GFAL recognizes the conservation and sustainable use of resources as a fundamental objective, establishing that its application will be done through the precautionary principle, an ecosystem approach to fisheries, and the safeguarding of marine ecosystems in which these resources exist. In 2016, at the request of the government of Chile, FAO conducted a review of the GFAL, recognizing advances in the new regulatory framework and highlighting as a critical challenge the need to advance in the application of the EAF [28]. Accordingly, the implementation of EAF in Chile provides an opportunity to use bureaucratic knowledge in identifying gaps and leverage points for the implementation of EAF at national scales.

In this article, we evaluate the current state of EAF in Chile, identifying key dimensions that ought to be prioritized in the short and medium term to promote the institutionalization and implementation of the EAF principles. We used public officials’ knowledge, which was understood as a reliable platform of information for the Chilean experience. While our study focused on the implementation within Chile, it provides valuable insights for other countries attempting to transition towards EAF.
Table 1. Key principles for EAF and definitions [14,15].

| Dimensions                              | Definition                                                                                                                                 |
|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Conservation of the ecological system  | EAF seeks to ensure the health of the entire ecological system, especially safeguarding the capacity of the ecosystem to maintain its structure and functioning |
| Application of a multi-species approach | the EAF pursues a multi-species approach rather than a monospecific approach to resource management, considering the interconnection among the various species present in the ecosystem |
| Protection of the biological resource   | EAF ensure the maintenance of living resources by preventing them from being threatened by over-exploitation, based on target reference limits |
| Inclusion of social components          | The EAF proposes a sustainable view of fisheries, incorporating humans and their cultural diversity as explicit objectives in the management |
| Participatory Governance                | EAF requires a decentralized management of resources, engaging stakeholders in decision-making processes |
| Economic benefits                       | The EAF recognizes the potential economic benefits derived from the extraction of marine resources, improving marketing processes, and generating added value in the products |
| Distributional equity                   | The EAF promotes conditions to reduce market distortions, and the equitably distribution of benefits from fisheries |
| Individual skills and institutional support | EAF requires individual competencies and institutional support for its effective implementation, including instances of accompaniment, and capacities for conflict resolution |
| Collaboration and coordination within and between institutions | EAF implementation is based on effective coordination and collaboration among institutions and social organizations |
| Regulatory framework                    | The EAF requires adequate regulatory frameworks to enable a multidimensional and sustainable development |
| Adaptive management                     | The EAF has a dynamic and adaptive character, based on a collective learning process in decision-making spaces for fisheries administration |
| Time and spatial flexibility            | the EAF recognizes that marine resource management must be adapted to multiple spatial and temporal variations |
| Best available scientific knowledge     | the EAF is characterized by the use of the best available scientific information for decision-making, considering the knowledge generated by multiple disciplines |
| Integration of traditional knowledge    | The EAF promotes a holistic perspective to understand environmental problems, integrating the traditional knowledge of local communities as valid information |

2. Materials and Methods

2.1. Chilean Fisheries Management

Chile has committed to implement international recommendations and agreements on the implementation of EAF [22]. In 1991, after returning to democracy, Chile implemented a GFAL (Law No 18,892) which included definitions of industrial and artisanal fleets, five mile exclusive access to artisanal fisheries, individual quota systems, territorial user rights to artisanal fishers, and the creation of marine parks and reserves [22,29]. The official status of Chilean fisheries show that both artisanal and industrial fisheries landed in 2019 around 2.4 million tons, 57% of which comes from the artisanal sector. The artisanal sector is composed by more than 90,000 artisanal fishers who are legally registered for the extraction of benthic, crustacean, pelagic, and demersal resources [30]. The artisanal fishers are organized in hundreds of unions along the coast. In 2019, the principal resources landed by artisanal fleets were anchoveta (*Engraulis ringens*), sardina comun (*Sardina pilchardus*), huiro negro (*Lessonia nigrescens*), huiro palo (*Lessonia trabeculata*) y pelillo (*Gracilaria chilensis*),
and the principal resources landed by industrial fleets were anchoveta (*Engraulis ringens*), caballa (*Scomber japonicus*), jurel (*Trachurus murphyi*) and jibia (*Dosidicus gigas*) [30].

During the past 30 years there have been a diversity of policy responses and governance transformations that can be related to the implementation of EAF principles [22]. One of the fundamental fisheries governance innovation was the implementation of territorial user rights to artisanal fishers (TURF) in 1994. The Chilean TURF system is recognized by its innovative and transformative character [31], reporting positive biological and ecological trends [32]. In March 2004, an initial decree on the use of trawl fisheries for crustaceans was published (Decree 200, Ministry of Economy and the Undersecretary of Fisheries), which established restrictions for industrial and artisanal fisheries. In 2013, overexploitation of key resources pushed important changes to the GFAL. The resulting policy established the need to create Management Committees for the co-administration of marine resources in de facto open access areas [33]. In contrast to TURFs that establish exclusive access zones, each Management Committee regulates the extraction of a resource (or a group of related resources) in areas of historical open access (benthic, crustaceans, pelagic and demersal fish) [34,35]. The Management Committees establish rules of operation for a resource or a group of resources in determined geographic areas that can range from a gulf or bay to a macro-zone which encompasses a whole region or set of regions (i.e., 400 km). Currently, 36 Management Committees have been formed, 20 for benthic fisheries and 16 for pelagic and demersal fisheries. The Fisheries Management Committees are intersectoral spaces that allow the participation of stakeholders in the development of management plans, which are integrated by government services, and artisanal and industrial fishers. The modifications to GFAL also increase the role of science in fisheries management, constituting Scientific Committees. The Scientific Committees determine the status of each fishery, the Biological Reference Points, and the total allowable catch limits for each fishery [34]. In essence, the two policies mentioned above (TURF and Management Committees) provided a general grounding but other policies, such as bycatch policies or marine conservation policies have also been important in supporting the implementation of specific EAF principles.

2.2. Research Strategies

2.2.1. Knowledge on Advances and Gaps

This study focused on identifying public officials’ knowledge of advances and gaps in the application of EAF in the following dimensions: Participatory governance, Institutional capacity, Regulatory framework, Conservation of the ecological system, Protection of biological resources, Economic benefits and social equity, Adaptive management, Interdisciplinary knowledge, and Spatial and temporal scales. For each of the selected dimensions, a desired state was defined, based on the literature review and key principles (Appendix A). For the evaluation of progress in the dimension, a four-level scale with anchor points almost nothing, regular, acceptable, and complete was used. Each interviewee evaluated the state of progress for each dimension based on the scale provided, identified in which of the four levels the advances were classified. Thus, for each principle, a percentage of advance was assigned for each level, which reflects that the principles can have a complete advance in some aspect and limited in another. In some dimensions, no advances were identified in one of the four levels, which was reported as “no (almost nothing, regular, acceptable, or complete) advances were identified”. For example, in the application of a multi-species approach, we identified minor (almost nothing) and acceptable advances, but not regular or complete. Additionally, semi-structured interviews allowed to record the arguments for each evaluation, identifying gaps and advances in a qualitative form.

The sample selection consisted of public officials of the government services in charge of the administration of the pelagic, demersal, benthic, and crustacean fisheries, as mandated by the GFAL to apply the EAF (N = 18). Researchers (N = 6) and leaders of artisanal fisher meta-organizations (N = 3) were also interviewed. A total of 27 in depth interviews were conducted during 2018. Interviews were recorded and transcribed, except in four cases where the interviewees requested not to be recorded. For the analysis, the texts of
the interviews were coded and then organized in an analysis matrix [36]. This method of analysis is based on making emerging codifications on the transcribed texts of the interviews [36]. The higher level coding allow the addition of criteria on common dimensions or themes. The qualitative analysis allowed to support the experts’ semi-quantitative estimates, recording the arguments that justify the estimates.

2.2.2. Prioritization of EAF Dimensions

In December 2018, a workshop on gaps and strategies for the application of the EAF was held in the city of Valparaiso, Chile. The objective of the workshop was to generate a space for dialogue and analysis on the EAF, including gaps, advances, and priorities for its implementation. Strategic approaches were also evaluated to generate a national EAF plan. Twenty-eight people from public services, responsible for implementing the EAF, participated in the workshop. The workshop consisted of two main stages, a discussion of previous findings stage and a prioritization stage. In the first stage, the preliminary interview results were presented at the workshop as a basis for discussion. In the second stage, for the prioritization of fundamental dimensions, a work dynamic was designed with the participants, differentiated according to benthic (N = 7), crustacean (N = 3), demersal (N = 8) and pelagic fisheries (N = 10). The prioritization exercise focused both on the short term (2020) and medium term (2021–2024). Each participant received 20 tokens for the short-term exercise, and 20 tokens for the medium-term exercise. Participants distributed the tokens on a worktable divided into eight sections, each section represented the EAF dimensions evaluated. To facilitate the prioritization process, some of the principles were grouped into broader categories: (1) Conservation of the ecological system and Application of a multi-species approach were grouped into Ecological and biological dimensions; (2) Inclusion of social components and Regulatory framework were grouped into Regulatory framework and social components; (3) Individual skills, institutional support and Collaboration and coordination were grouped into Institutional capacity; (4) time flexibility and spatial flexibility were included into Adaptive management; (5) finally, Best available scientific information and Integration of traditional knowledge were grouped into Interdisciplinary knowledge. The total number of tokens were added up by dimension, and then normalized between 1 and 100 in order to calculate a percentage of relative importance for each dimension. Finally, we performed a set of interviews with key individuals, that potentially could play important roles for EAF in the fisheries agency (N = 3) and who did not participate in the workshop, with the objective of assessing overall trends and validation of results.

3. Results
3.1. Knowledge on Advances and Gaps for the Application of the Ecosystem Approach to Fisheries (EAP) in Chile
3.1.1. Ecological and Biological Dimensions

Conservation of the Ecological System

Various types and levels of advances were identified in this principle (Figure 1). Interviewees considered as an ‘acceptable’ advance (18.2%) the implementation of the Discard Law (No. 20,675) that regulates the impact of non-selective fishing, controlling by-catch and accidental capture of birds, turtles, and marine mammals, as well as the suspension of trawling on 117 seamounts. Notwithstanding these acceptable advances, interviewees stated that the majority of national fisheries do not evaluate their interaction with the environment, and the impacts that the extraction of resource may cause on adjacent ecosystems considering advances as ‘regular’ (54.5%). In addition, interviewees highlighted that bad practices in the use of fishing gear, illegal extraction of algae, illegal fishing, and low compliance with norms and rules hinder the proper implementation of control measures.
Application of a Multi-Species Approach

In the transition to a multi-species approach to fisheries management, no significant progress was identified (Figure 1). The majority of the interviewees evaluated the advances in this principle as ‘almost nothing’ (72.7%). The GFAL has an ecosystem mandate, but the management tools are still monospecific. The whole system is essentially designed towards monospecific management (except for specific exception in some benthic management plans). Decisions taken by Scientific Committees and allocation of quotas are still analyzed in a monospecific manner. Only the Discard Law (No. 20,675) was mentioned as ‘acceptable’ advance for this principle (27.3%).

Protection of the Biological Resource

The protection of biological resources presents diverse results in the type and level of progress (Figure 1). In fin-fish fisheries, the protection of the resource is operationalized with the Maximum Sustainable Yield (established in the GFAL), which was considered as achieving the level of ‘complete’ advance by some of the interviewees (18.2%). In benthic resources, advances are being made towards the definition of Biological Reference Points, which was considered as an ‘acceptable’ advance by some interviewees (45.5%). However, the establishment of maximum sustainable yield and biological reference points does not ensure the effective protection of resources, for which decision rules and compliance with agreements by fishers should be strengthened.

3.1.2. Social and Economic Dimensions

Inclusion of Social Components

A large majority of interviewees indicated that advances in this principle have been ‘almost nothing’ (90.9%) (Figure 2). The GFAL does not provide definitions or tools to address social elements in fisheries management. The gap in the social and economic components is reflected in the lack of indications and guidelines for addressing social and economic objectives in fisheries management plans. ‘Regular’ advances were identified based on the inclusion of social objectives in specific fishery management plans, which were
attributed to the voluntarism of officials, and not to a legal and organizational structure that promotes it (9.1%).

| Principles                  | Advances                                                                 |
|-----------------------------|--------------------------------------------------------------------------|
| Inclusion of social components | - The law does not provide indications or tools to address social components |
| Participatory Governance    | - Lack of protocols and methodologies to integrate participation in decision making |
| Economic benefits           | - No almost nothing advances were identified                              |
| Distributional equity       | - Few marketing programs are promoted                                     |

Figure 2. Social and economic dimensions in the application of EAF. The size of the bubble indicates the percentage of progress for each of the four levels (almost nothing, regular, acceptable, or complete). The sum of the size of the bubbles adds up to 100% for each principle. The phrases synthesize key qualitative responses.

Participatory Governance

Stakeholder participation is promoted through the Fishery Management Committees, which was reported as ‘acceptable’ advance (27.3%) (Figure 2). The Management Committees are constituted as formal spaces where the multiple interests of the participating actors converge. On the other hand, the participation of experts and scientists is ensured through the Scientific Committees. However, some interviewees described these advances as ‘regular’ (27.3%). These interviewees highlight that Management Committees are legally defined as consultative and advisory spaces for decision-making. This consultative nature of the Management Committees tends to discourage the participation of some fishers. Second, not all stakeholders are involved in the fishery and commercialization chain are represented. Additionally, a lack of organizational maturity was identified in the management committees, which makes it difficult to equally address the diverse interests of stakeholders. Accordingly, the lack of structured methodologies to integrate participation into a decision-making process emerges as a fundamental gap. There is no clear protocol or procedures on how to articulate multiple interests in a systematic decision-making process. Thus, advances in this principle were evaluated as ‘almost nothing’ by an important group of interviewees (45.5%).

Economic Benefits

In this dimension, relevant advances were identified, and officials considered them as ‘complete’ and ‘acceptable’ (45.5% for each of both principles) (Figure 2). The capacity to generate wealth and economic benefits is assured in the administration of the fisheries, which are recognized as productive systems. Officials made the point that the use of
financial instruments is still under-developed in this sector and could be improved. Some gaps were also identified, related to the excessive bureaucracy that limits the enterprise, and the limited capacity of fisheries to access certifications.

Distributional Equity

Substantial gaps in the equitable distribution of benefits were identified, where advances were evaluated as ‘almost nothing’ by most of the interviewees (72.7%) (Figure 2). Structural inequalities among stakeholders cannot be addressed by the fisheries administration. The distribution of quotas entails rights acquired by the benefited fishers, which could only be modified through constitutional modifications. Officials also highlighted issues of initial allocation of rights within the artisanal sector. Several fisher organizations have accessed TURF areas with abundant resources, as opposed to other organizations that access only to areas with low relative value. Some interviewees considered as a ‘regular’ advance the current promotion of national consumption of resources obtained from small-scale fisheries (27.3%).

3.1.3. Institutional Dimensions

Critical gaps related to individual skills and institutional support for EAF were identified (Figure 3). Consequently, the majority of interviewees evaluated the advances in this principle as ‘almost nothing’ (78.3%). Officials signaled that a high workload due to the successive implementation of new roles associated with their responsibility in leading participatory processes could jeopardize well intended initiatives. In addition, participatory management plans presents constant conflict situations. These conflict situations, on the one hand, generate high levels of stress in officials who are not trained in conflict resolution methods. On the other hand, officials mentioned the need for stronger institutional support to implement management measures to legitimize their participation and leadership. Officials also recognize that reduced budgets to implement an EAF makes it difficult to implement management actions. ‘Acceptable’ advances were recognized (10.9%), especially related to the development of individual technical capacities to design management plans, but not as part of institutional learning.

Collaboration and Coordination within and between Institutions

Collaboration and coordination within and between institutions was evaluated as ‘almost nothing’ (63.6%) (Figure 3). For the interviewees, the main gap in this category referred to the lack of formal and institutional spaces to generate networks, coordination, and support among the institutions. Despite this gap, ‘acceptable’ advances were recognized based on officials’ individual leadership and networking capacities (36.4%).

Regulatory Framework

The advances in regulatory frameworks were mostly evaluated as ‘almost nothing’ (65.7%) (Figure 3). Reasons for this were the following: first, that the GFAL does not provide definitions and tools to address social and economic elements, focusing exclusively on the protection of single biological resources. Second, the GFAL does not allocate resources to improve officials’ competencies in applying the ecosystem approach to fisheries management. In addition, regulation is rigid with a limited capacity to promote flexibility and adaptive management. Interviewees recognized some ‘regular’ advances (34.3%), mainly associated with the fact that the ecosystem approach and precautionary principle have been acknowledged explicitly as objectives in the GFAL.
Figure 3. Institutional dimensions in the application of EAF. The size of the bubble indicates the percentage of progress for each of the four levels (almost nothing, regular, acceptable, or complete). The sum of the size of the bubbles adds up to 100% for each principle. The phrases synthesize key qualitative responses.

3.1.4. Knowledge Systems and Scale Dimensions

Adaptive Management

In the adaptive management principle, diverse types and levels of advances were identified (Figure 4) with most officials assessing advances as ‘almost nothing’ (45.5%). A central gap for adaptive management refers to the rigidity of the regulatory framework, which does not allow constant adaptation to the dynamics of each fishery. Additionally, there is insufficient monitoring and evaluation of the management measures’ impacts. Interviewees highlight the general willingness of officials to apply the principles of adaptive management, which was evaluated as a ‘regular’ advance (27.3%). However, participants pointed out the limited availability of space, time and formal processes for institutional learning. An ‘acceptable’ advance for interviewees (27.3%) was the mandatory rule to review, evaluate and reformulate management plans (every 3 years) This potentially promotes institutional learning.

Time Flexibility

Most interviewees evaluated the advances in this principle as ‘almost nothing’ (72.7%) (Figure 4). Implementation of most management committee decisions is slow. This is due to the centralization of management decisions. However, under certain exceptional conditions, central authorities may transfer to regional authorities the competence to approve management measures, which allows decisions to be implemented in a timely manner. This was considered as an ‘acceptable’ advance (27.3%).

Spatial Flexibility

In this principle, important advances were reported by the interviewees (Figure 4). In benthic fisheries, the Management Committees can delimit the geographical range of each fishery, based in the spatial distribution of the resources, which was evaluated as a ‘complete’ advance (54.5%). In fish fisheries, the GFAL determines the spatial scale of the management committee, which may restrict the spatial flexibility in decision-making. This was evaluated as a ‘regular’ advance (45.5%).
Best Available Scientific Information

Different types and levels of advances were described for this principle (Figure 4). Officials indicated that some Scientific Committees have access to the best available information, which is a ‘complete’ advance (18.2%). Likewise, research institutions such as IFOP, universities or research centers generate relevant knowledge for decision-making, which was evaluated as an ‘acceptable’ advance (18.2%). However, a relevant gap refers to the scarce information on social and economic impacts of management measures. Most of the research focuses on biological aspects of the ecosystem. Officials also point to the fact that in many circumstances poor-data methods must be used but still need improvement to follow best practices.

Integration of Traditional Knowledge

Advances and gaps were identified in the integration of traditional knowledge (Figure 4). Officials signal towards methodological gaps regarding how to quantify, weight, and use traditional knowledge for fisheries management. These elements were evaluated as having ‘almost nothing’ advance (54.5%). However, interviewees also identified ‘acceptable’ and ‘complete’ advances in this area (27.3% and 18.2%, respectively) due to regulations that provide institutional alternatives for traditional knowledge to be integrated into formal management.

### 3.2. Prioritization of Dimensions for Strengthening the Ecosystem Approach

In the short term, participants highlight the need to improve institutional capacity and the regulatory framework to strengthen the application of the ecosystem approach

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**Figure 4.** Knowledge and scale dimensions in the application of EAF. The size of the bubble indicates the percentage of progress for each of the four levels (almost nothing, regular, acceptable, or complete). The sum of the size of the bubbles adds up to 100% for each principle. The phrases synthesize key qualitative responses.

| Principles                          | Almost nothing | Regular | Acceptable | Complete |
|-------------------------------------|----------------|---------|------------|----------|
| Adaptive management                 | The regulations are rigid, which obstruct adaptive management | There is a disposition for learning but there is no space or time | Management Plans are evaluated every 3 years or less | No complete advances were identified |
| Time flexibility                    | Most of the administration measures have no flexibility | No regular advances were identified | Some decisions can be decentralized | No complete advances were identified |
| Spatial flexibility                 | No almost nothing advances were identified | The Law determines the spatial scale in fish fisheries | No acceptable advances were identified | In benthic fisheries, management committees can consider different spatial scales |
| Best available scientific knowledge | There is a deficiency of scientific information for the management of several fisheries | Resources are scarce for additional monitoring | Institutions such as IFOP, universities and research centers generate relevant research | In certain fisheries, scientific committees have access to the best available information |
| Integration of traditional knowledge| Scientific committees do not have procedures to include traditional knowledge | No regular advances were identified | There is a willingness on the part of officials to integrate traditional knowledge | Management committees offer spaces to incorporate traditional knowledge |

![Circle sizes ranging from 91–100 to 1–10](image-url)
(Figure 5a). However, there are differences according to the types of fisheries evaluated. In demersal fisheries, institutional capacity and the adequacy of the regulatory framework are the main challenges in the short term. In pelagic fisheries, the need to strengthen adaptive management, along with institutional capacity, are the dimensions with the highest priority. In benthic fisheries, the integration of interdisciplinary knowledge emerges as the main challenge to be promoted. In crustacean fisheries, the short-term challenge is related to promoting the generation of economic benefits and social equity among stakeholders, as well as protecting the ecological system and the resource.

Figure 5. (a) Prioritization of the effort in the short term (2020) to reduce the gaps in the implementation of the EAF (N = 26). (b) Prioritization of the effort in the medium term (2021–2024) to reduce the gaps in the implementation of the EAF (N = 26).

In the medium term, strengthening the regulatory framework and institutional capacity continue to be central elements (Figure 5b). These two dimensions are established as a special priority for crustacean and demersal fisheries. In pelagic fisheries, the need to
4. Discussion

The EAF is widely recognized as a strategy for sustainable management of marine resources, which integrates the multi-dimensional components of social-ecological systems [14–17]. Countries face challenges in operationalizing the fundamental dimensions of the EAF, as well as in identifying advances and gaps that facilitate the institutionalization of sustainable management [12,18–23]. Bureaucratic knowledge can play a critical role supporting informed decision-making [24]. In Chile, bureaucratic knowledge is mainly available from government services responsible for implementing the EAF [34]. Bureaucratic knowledge can reproduce and synthesize institutional learning, creating new forms of knowledge that guide decision-making and public policy design [24]. Bureaucratic knowledge can allow for the aggregation of information of multiple dimensions, ecological, social, and economic, which emerges on the basis of practice, decision-making, and management [26]. In order for this knowledge to inform EAF, it is critical to enable ways in which bureaucratic knowledge can be systematized and scaled to higher levels of decision-makers such as the heads of the agencies.

Our results show that fishery management officials interviewed have important and relevant knowledge for EAF implementation. They perceive important advances towards EAF since the amendments to the GFAL in 2013. Foremost among these is the fact that EAF was established as a mandatory requirement for fisheries management. They highlight that Chile has also regulated the by-catch and incidental capture of birds, turtles, and marine mammals, as well as banned trawling on 117 seamounts. They perceive that institutions responsible for fisheries management have more and better instruments to protect marine resources, establishing Maximum Sustainable Yield and Biological Reference Points as mandatory measures to control overexploitation. Fishers’ participation is promoted within Management Committees, which are constituted as inter-sectorial spaces to elaborate fishing management plans. Likewise, Scientific Committees allow the participation of scientists by setting catch limits for each fishery.

Despite advances, important gaps were also identified. In Chile, most of fisheries do not consider adjacent potential impacts associated with the use of different fishing gear, illegal fishing, and low compliance of rules. While the system has embraced the idea of EAF, in practice, fishery officials still perceive it is strongly oriented towards a monospecific fishery management approach exercised through individual quotas. With some exceptions, Management Committees are established for single resources, even in cases where the fisheries share the same habitat. Additionally, the inclusion of maximum sustainable yield, as the primary indicator for establishing quotas, is considered an advance in fisheries management [37], but as currently implemented, omits the importance of species-environment interactions for population viability [38].

The difficulties for implementing EAF can be explained by deep socio-political and institutional drawbacks, linked to relations of inequity, poverty, and distribution of benefits generated in the fishing system [12,39]. In Chile, officials identified important limitations in capacities, linked to the availability of resources, coordination between institutions, and individual competencies to lead participatory processes. This is reinforced by a general crisis of confidence in Chile and Latin America towards formal institutions (political parties, authorities, religious institutions), which promotes the need to generate spaces for citizen participation in decision-making [40]. Accordingly, the challenges of fisheries management go beyond the purely natural scientific aspects into the realm of the humanities and social sciences [41,42].

Addressing the constraints identified by fishery officials can contribute to strengthen emerging paradigms in the governance of the oceans [10,43]. The EAF proposes an approach to fisheries management that overcomes the disciplinary restrictions of perspectives focused solely on the resource and its ecological system [18,44,45]. In Chile, this would
provide solutions for the effective integration of, on the one hand, traditional and scientific knowledge, and on the other hand, of social sciences with natural sciences. The EAF involves an inter and trans disciplinary approach to fisheries management in which social, political, cultural, biological, and ecological dimensions must be analyzed under the lens of a linked social-ecological system [40,46].

Officials highlighted serious difficulties to integrate social dimensions in fisheries management. In fact, struggling with a practical application of EAF has been common in different countries around the world [47–49]. The implementation of the EAF is a human endeavor, with social and political challenge that reflect inherently interests and values [50–52]. In Chile, the regulatory framework does not define a common framework and methodologies to include social objectives in management plans. Understanding the human components of fisheries requires a multidisciplinary approach, which has high economic and institutional costs [41]. Similarly, the participation processes, promoted in the Management Committees, are hindered by the lack of preparation of the teams in charge to facilitate collective decision-making, without validated protocols for conflict resolution. Moreover, the facilitation of the Management Committees has generated an increase in the workload of public officials, who are exposed to stress and emotional wear.

Regarding institutional capacity, the major gap is a low effective coordination among the institutions responsible for fisheries management for the implementation of the EAF. Additionally, there is a low access to learning spaces for good practices among public officials. This is consistent with internationally reported capacity challenges [53,54]. The challenge is to engage multiple sectors that have different roles in fisheries management, institutional and private, which in turn display different threats and risks to the sustainability of fisheries [48]. In this sense, there is a call for a paradigm shift in the institutions to address the EAF, which certainly includes greater coordination among institutions, but also greater strengthening of stakeholder participation, and the ability to balance competing objectives [50,54]. Moreover, a key element for institutional capacity building concerns the development of competencies in public officials in charge of implementing the EAF. In this study, we identified a risk related to work overload and stress due to facilitating participatory instances in the context of conflict. Resistance to change toward EAF has also been reported in the literature [48,55].

A second critical element concerns the improvement of the regulatory framework. Currently, a variety of countries have made modifications to their regulatory bodies in order to incorporate the EAF principles, although with different nomenclatures and perspectives [56]. For example, experiences in Canada [57], Australia [58], and the European Union [56]. While the amendments to the GFAL included the EAF as a mandate, some gaps and omissions make it difficult to effectively implement it. A central improvement relates to the need to clarify the definitions and methodologies, such as participatory multi-criteria analysis for the inclusion of social components in the EAF [59]. Especially in relation to the elaboration of the Management Plans, which emerge as one of the main tools for the application of the EAF in the administration of the fisheries for Chile. In this respect, definitions are required to establish clear social goals in the formulation of management plans.

Fisheries should transition towards multidimensional management approaches that consider a wide range of environmental, ecological, social, cultural, and economic challenges. This transition is riddled with obstacles, related not only to practices of over-exploitation of marine resources, but also to gaps in institutional capacities. Bureaucratic knowledge enables the identification of these gaps based on the experience of actors in charge of implementing the EAF. Thus, bureaucratic knowledge offers a possibility to improve policies and management strategies. Raising officials’ knowledge allows to prioritize efforts and strategies to implement the EAF, which has a relatively low cost for the institutions. Government services officials are a particularly valuable source of information for seeking solutions and opportunities to implement the EAF. However, bureaucratic knowledge needs to be systematized and raised in a structured way. Otherwise, it can reveal individual biases or political interests. Establishing clear protocols to systematize
and generate formal instances to build upon bureaucratic knowledge seems a clear and cost effective way to advance in the effective implementation of the EAF.

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### Appendix A

| Dimensions                              | Desired State                                                                                                                                 |
|----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Conservation of the ecological system  | Fisheries management regulates the extractive processes of the resource to protect the functioning and structure of the ecological system of which the resource is a part. |
| Application of a multi-species approach| Fisheries recognize the interconnectedness and potential impact of management actions on other ecosystems and resources, management measures consider multiple species simultaneously. |
| Protection of the biological resource  | The fisheries establish a Target Reference Point or the maximum sustainable yield through a scientific method, the compliance with this estimated value ensures the long-term maintenance of these resources avoiding overexploitation. |
| Inclusion of social components         | Fisheries management considers the human, cultural, and social dimensions, ensuring the long-term sustainability of each of these elements. |
| Participatory Governance               | Fisheries management recognizes that management is a multi-group decision, and allows for participation in decision-making. |
| Economic benefits                      | Fisheries management is recognized as a productive system, promoting the generation of economic benefits. |
| Distributional equity                  | Fisheries management allows the economic benefits generated to be distributed equitably among the participating stakeholders. |
| Individual skills and institutional support| The government offices in charge of implementing the ecosystem approach to fisheries management have the individual skills and institutional support to lead the process. |
| Collaboration and coordination within and between institutions | Institutions with responsibilities in fisheries management coordinate and collaborate for their efficient management. |
Table A1. Cont.

| Dimensions                          | Desired State                                                                 |
|-------------------------------------|-----------------------------------------------------------------------------|
| Regulatory framework                | Fisheries management is regulated by an appropriate legal framework for the   |
|                                     | implementation of the EAF, considering the multidimensionality of sustainable |
|                                     | development.                                                                |
| Adaptive management                 | Fisheries administration generates conditions for adaptive management,     |
|                                     | especially understood as the capacity for institutional and collective      |
|                                     | learning in those decision-making instances.                               |
| Time flexibility                    | Fisheries management is flexible to establish management decisions          |
|                                     | considering the time scale.                                                 |
| Spatial flexibility                  | Fisheries administration is flexible to establish management decisions     |
|                                     | considering spatial scale.                                                  |
| Best available scientific information| Fisheries management uses the best available scientific information, which  |
|                                     | is generated in a timely manner by universities and research centers.       |
| Integration of traditional knowledge | Fisheries management considers the traditional or local knowledge available  |
|                                     | for decision-making.                                                        |

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