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HAL Id: hal-03219435
https://hal.inrae.fr/hal-03219435

Submitted on 6 May 2021

Research

What does comanagement offer? Exploring users' knowledge through mental models in the fishery of La Encrucijada Biosphere Reserve, Mexico

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ABSTRACT. In the context of collaborative resource management, mental models can provide insights on participants' understanding of the resource management system and in so doing allow researchers and practitioners to derive lessons about the success or failure of comanagement approaches. We analyzed individual and group mental models in the comanaged small-scale fishery of La Encrucijada, Mexico, active since 2009. Mental models reveal a strong consensus around the idea that the comanagement initiative is a government-led partnership to subsidize fishers. This belief reflects a history of state paternalism and coexists with a diversity of views about who are the actors involved in comanagement, their role in the fishery, and the resources mobilized through comanagement. We argue that local participants' limited understanding of the collaborative mechanisms established by the comanagement initiative suggests a failure of the promoting actors to communicate the initiative's environmental and social goals and to exploit its transformative potential in terms of actors' empowerment and participation in the long term. This research contributes to the burgeoning literature on the use of mental models as a means to unravel the cognitive aspects that may lie underneath the success or failure of natural resource governance.

Key Words: *collaborative management; protected area; shared decision making; small-scale fishery*

INTRODUCTION

Collaborative resource management, the sharing of decision-making power between at least resource users and government (Berkes 2009), has proven successful in managing natural resource systems through, for example, enhancing the fit between regulatory norms and local conditions (Gutiérrez et al. 2011, d'Armengol et al. 2018). Comanagement can improve the ecological conditions of fisheries and the livelihoods of users through strengthening compliance with management rules and facilitating social learning among participants (Evans et al. 2011). These participants (e.g., public authorities, private business, scientific experts, groups of users, social interest groups, and non-governmental organizations) collaborate by sharing problem perspectives and working with different kinds of knowledge and competencies (Bouwen and Taillieu 2004). When collaboration is combined with adaptive management processes in which norms are continuously revised and changed, comanagement becomes better suited to deal with uncertainty and complexity (Holling 1978, Sandström and Rova 2010).

Collaboration through social learning processes involves different parties framing and reframing the definitions of the issues at stake (Bouwen and Taillieu 2004, Armitage et al. 2008). There should however be certain agreement on some issues, usually referred to as shared understanding (Olsson et al. 2004, Sandström and Rova 2010). A shared understanding is a structure of collectively created meaning that emerges in and helps coordinating activities of a group to achieve shared goals (Ansell and Gash 2008, Berkes 2010, Mathevet et al. 2011). This requires acknowledging different understandings and identities and including a diversity of inputs (Bouwen and Taillieu 2004). Achieving a shared understanding or common view is thus often mentioned as a facilitator of successful comanagement (Olsson et al. 2004, Sandström and Rova 2010).

Ideally, the stakeholders involved in comanagement should share an understanding of the problem to be solved, the goals of collaboration, and the management strategy (Carlsson 2000, Ansell and Gash 2008, Berkes 2010, Sandström and Rova 2010, Sandström 2011). It is argued that the lack of common views on these issues can lead to the failure of comanagement processes because they can deter effective and inclusive collaboration (Baird et al. 2016). However, other authors suggest that the achievement of a shared understanding can be illusory in the context of, for example, protected areas in which competing interests and expectations among conservationists and locals may be the norm (Oldekop et al. 2016). In this regard, a competing approach calls for embracing the diversity of understandings and working with dissent (Peterson et al. 2006, Matulis and Moyer 2017). We want to gain insights into this debate by exploring to what degree the participants involved in fishery comanagement have a shared understanding of this system.

Stakeholders' individual and shared understandings can be analyzed through individual mental models (Jones et al. 2011, Mathevet et al. 2011). Mental models are internal cognitive representations of an external reality that people construct and use to interact with this reality (Lynam and Brown 2012, Jones et al. 2014). They show the understanding of how a given social-ecological system works according to different people (Lynam and Brown 2012). They are by nature subjective and therefore incomplete representations, the result of personal experiences, perceptions, and understandings of the world, that people use to filter new information, reason and make decisions, and adapt to changing circumstances through learning (Jones et al. 2011). Mental models can be elicited through individual interviews or collective workshops aimed at building individual or collective representations of social-ecological systems (Mathevet et al. 2011).

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Fig. 1. Location of La Encrucijada Biosphere Reserve and the cooperatives participating in comanagement. Sources: GADM the Database of Global Administrative Areas (https://gadm. org/), Gobierno del Estado de Chiapas: Geoweb Chiapas 3.0 (http://map.ceieg.chiapas.gob.mx/ geoweb/), Comisión Nacional de Áreas Naturales Protegidas.
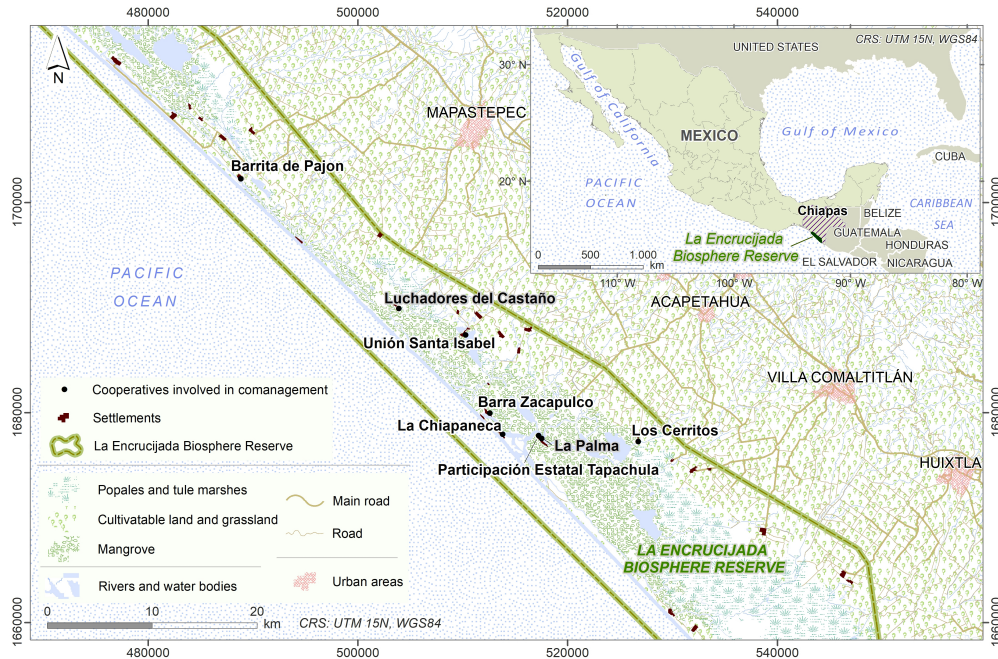
In natural resource management literature, recent research has used individual or collective elicitation of mental models to explore to what extent participants share understandings of four key comanagement aspects: (1) the social-ecological system in focus (Vuillot et al. 2016, Salliou and Barnaud 2017); (2) the management problem, such as perceptions of the causes of fish decline (Stone-Jovicich et al. 2011, Horowitz et al. 2018); (3) goals and visions, such as priorities for water use (Stone-Jovicich et al. 2011); and (4) management strategies (Pahl-Wostl and Hare 2004, Mathevet et al. 2011, Galafassi et al. 2017). We use mental models to represent and explore understandings of a comanaged small-scale fishery located in La Encrucijada Biosphere Reserve, Mexico. We assess the degree of shared understanding of the comanagement system among the participants and discuss why a shared understanding of comanagement as a subsidy-driven resource management strategy was enough to prompt collaboration, despite a lack of consensus on which collaboration mechanisms were made available to participants and what these should be for.

METHODS

The fishery of La Encrucijada
The protected area of La Encrucijada (Fig. 1) was established in 1996 and extends over 144,868 ha along the Mexican Pacific coast, in the state of Chiapas, Mexico. It is a UNESCO Biosphere Reserve, as well as a Ramsar wetland of international importance. The reserve's estuarine system is home to the most productive and well-developed mangroves of the American Pacific coast (Instituto Nacional de Ecología 1999), sheltering a high biological

diversity (Contreras 2010) and encompassing the highest fish richness of all the estuarine-lagoon systems along the Mexican Pacific (Gómez González et al. 2012). As for many other protected areas around the world, the establishment of the reserve resulted in conflicts between locals and the national government because the reserve's management plan imposed restrictions on resource access and use and was regarded as illegitimate by local communities (Romero-Berny and Guichard-Romero 2015).

Eighty-two communities encompassing approximately 27,000 people are located within the reserve (Instituto Nacional de Ecología 1999). Their main economic activities are agriculture, livestock breeding, and fishing. The latter is the main livelihood source for those living in the core areas of the reserve, who fish for subsistence and commercial purposes. Educational levels among fishers are low and, on average, they have about four years of school attendance (Rodríguez Perafán 2014). From a total of 24 fishing cooperatives, 18 have territorial use rights through concessions in the estuarine system and 6 have fishing permits to fish in open waters. Those using the estuarine system can fish up to 46 different species of fish, including crustaceans and bivalves (Rodríguez Perafán 2014), often on fibre-made cayucos with outboard motors, and employing a variety of fishing gear, including cast nets, trammel nets, hooks, harpoons, stow nets, and the collective shrimp corral. The other 6 cooperatives use boats and trammel nets to fish in open waters and harvest more than 21 species of fishes and crustaceans (CONAPESCA 2015).

In 2009, the local office of the National Commission of Natural Protected Areas (CONANP) in La Encrucijada started a

comanagement system. The initiative was regarded by fishers and CONANP as an opportunity to collaborate on minimizing the decline of fish stocks observed and to improve the livelihoods of fishing families, while adhering to the conservation objectives of the reserve. The initiative also attracted NGOs to the area and enhanced the collaboration with research institutions, which until then had only focused on studying the ecological aspects of La Encrucijada while overlooking fishers' interests. The eight fishing cooperatives involved gathered most fishers around one of the main lagoon systems, Chantuto-Panzacola. Six of the cooperatives, including those that were involved in our study and known as La Palma and Luchadores del Castaño (hereafter El Castaño), fished in the estuaries, and two others operated in open waters. The comanagement system also involved government agencies with fisheries responsibilities at different administrative levels: (1) at the local level, municipality councils (*Acapetahua* and *Mapastepec*); (2) at the regional level, the Chiapas' government Fishery and Aquaculture Department (SEPESCA); and (3) at the national level, the National Commission of Aquaculture and Fishing (CONAPESCA). Two research centres contributed with their knowledge about the fishery: El Colegio de la Frontera (ECOSUR) and the Universidad de las Artes y las Ciencias de Chiapas (UNICACH). Finally, the NGOs Centro de Agroecología San Francisco de Asís (CASFA), first, and Acción Cultural Madre Tierra (ACMT), later, were contracted by CONANP to facilitate comanagement meetings. A third NGO, Ser Integral Chiapas, supported activities to promote the commercialization of local fishery products in regional and national markets.

Although CONAPESCA was (and still is) the legal authority when it comes to regulating fisheries' management in Mexico, participants in the comanagement initiative of La Encrucijada regularly use formal and informal mechanisms to make joint resource-management decisions at the fishery and cooperatives levels. At the fishery level, they all meet twice per year in the technical-scientific committee to discuss the performance of comanagement and advise the leaders of the fishing cooperatives. In turn, such leaders meet every month in the intercooperative committee with CONANP to define a shared commercialization strategy and to negotiate and establish common fishing norms (insofar as these would not contradict national legislation). For example, they agreed on not fishing juveniles and establishing voluntary local no-take areas. At the cooperative level, members of each cooperative meet regularly to implement the agreements reached in the technical-scientific committee, for instance, to determine the exact location of no-take areas. Finally, CONANP organizes training activities for fishers, in which researchers or representatives of governmental agencies are often invited to talk.

Data collection
Fieldwork was conducted by the first author from April to September 2015 and comprised participant observation and semistructured and diagrammatical interviews to elicit individual mental models. Participant observation was performed during one of the monthly meetings of the intercooperative committee and the only meeting of the technical-scientific committee that took place during fieldwork. The first author also attended the fishers' biannual assembly in La Palma and one of the fishers' weekly meetings in El Castaño. During these meetings, she listened and took notes, and only talked if requested for

explaining the purposes of her research and answering related questions. She also engaged in one monitoring trip and two fishing trips that were documented in field notebooks.

Semistructured interviews were conducted in an initial phase of fieldwork to investigate the history and the outcomes of the comanagement system and to identify the two most relevant fishing cooperatives for further investigation. The first author interviewed 12 key informants who were directly involved in the comanagement system, including members of government agencies, fishing cooperatives, the NGOs ACMT and CASFA, and the research centre ECOSUR. After this process, the cooperatives of La Palma and El Castaño were chosen because they were the two most active at the time of fieldwork and had been involved in the initiative since the beginning.

Next, we elicited individual mental models, i.e., graphs in which the nodes are concepts or objects and the links connecting nodes are relationships or associations between these concepts or objects (Dray et al. 2006). Following Horowitz and colleagues (2018), we differentiated the stakeholders at the fishery level into four main types: fishing cooperatives, government agencies, NGOs, and academic institutions. The first author interviewed one representative of each of these organizations, who were actively participating in the committees of the comanagement system (Table 1). Interviewees were those staff members having more regular contact with the comanagement initiative or holding a post of responsibility. We could only interview one researcher who had studied the social organization of fishers in the region and had engaged with comanagement activities during the first two years. A few other academics could not be interviewed because they were not available at the time fieldwork was conducted.

We asked interviewees to provide responses as the organization (not as individuals) to capture the organization's understanding of comanagement. We acknowledge, however, that this reduced sampling could entail limitations because we could miss nuances in such understanding. At the cooperative level, we also elicited the mental models of the members (local fishers) of La Palma and El Castaño. In total, 31 diagrammatic interviews were conducted with members of 14 organizations (Table 1). Interviews were held at the individual's workplace or at the correspondent cooperative's office, and only in one case was the interview held in a public café. Finally, the first author also interviewed fishers: 8 members of La Palma and 11 members of El Castaño who were selected with convenience sampling as they approached the cooperative facilities.

Prior to starting each interview, the first author explained that the purpose of the exercise was to draw a diagram of the actors, resources, and activities related to the "responsible fishing program," which was the way all participants referred to the comanagement system. She explained to each interviewee that the term "actors" referred to any organization, individual, or group of people related to the program, while the term "resources" referred to natural or other material goods that were important for the program. In the case of fishers, she emphasized that such resources could include those goods extracted from nature, the community, or from outside that the program needed to be effective. These two terms were drawn from the actors, resources, dynamics and interactions (ARDI) method that has been commonly employed in the elicitation of individual mental

models (IMMs; Etienne et al. 2008, Mathevet et al. 2011, Vuillot et al. 2016). The first author did not ask interviewees about dynamics or drivers of change as in the ARDI method but instead asked for activities involving actors and resources in the program. This modification was aimed at adapting the methodology to the representation of the local management system and to facilitate comprehension by less literate interviewees. Toward the end of the interview, she asked interviewees to describe with a verb all connections between two concepts (actors, resources, or activities).

Table 1. Sampling strategy for the mental models' interviews. Note: CONANP = National Commission of Natural Protected Areas; CONAPESCA = National Commission of Aquaculture and Fishing; SEPESCA = Chiapas' Government Fishery and Aquaculture Department; ACMT = Acción Cultural Madre Tierra; CASFA = Centro de Agroecología San Francisco de Asís; ECOSUR = El Colegio de la Frontera; UNICACH = Universidad de las Artes y las Ciencias de Chiapas.

By type of comanagement stakeholder		
Type of stakeholder	Organizations involved in the comanagement initiative	Interviewees
Fishing cooperatives	Barra Zacapulco, Barrita de Pajón, La Chiapaneca, La Palma, Los Cerritos, Luchadores del Castaño, Participación Estatal Tapachula, Unión Santa Isabel	6 interviewees: the leader of each cooperative at the time of fieldwork (except Barra Zacapulco and La Chiapaneca)
Government agencies	Acapetahua city council, CONANP, CONAPESCA, Mapastepec city council, SEPESCA	4 interviewees: a staff member of each agency (except Mapastepec city council)
NGOs	ACMT, CASFA, Ser Integral Chiapas	3 interviewees: one staff member from each organization
Research centres	ECOSUR, UNICACH	1 researcher from ECOSUR
By fishing cooperative		
Fishing cooperative	Members (i.e., fishers)	Interviewees
La Palma	126	8
El Castaño	36	11

To start illustrating the mental model and overcome any initial discomfort toward drawing, the first author asked each interviewee to explain, in their own words, what the responsible fishing program was. As the interviewee talked, the interviewer identified the actors, resources, and activities from their words and wrote them down on post-its, displayed them on a whiteboard made of two DIN A4 laminated cardboards, united them through arrows, and labeled each arrow with a verb that described the relation between every pair of concepts united. Next, she asked the interviewee if the resulting diagram corresponded to what they meant and modified accordingly as needed. When the interviewee agreed with the representation, the interviewer encouraged them to continue drawing the mental model themselves. However, if the interviewee did not feel confident, she assisted in the drawing until all actors, resources, activities, and interactions among them were represented. This assistance of the

interviewer enabled capturing the mental models of less literate interviewees (some fishers) who otherwise would have been omitted from the sample. When this happened, and to avoid any subjective interpretation, the interviewer wrote down the concepts exactly as the interviewee named them. Also, when the diagram was done, she asked the interviewee if what she wrote matched their meaning. As many cardboards as necessary were added to fit the growing diagram.

All fieldwork interviews were conducted after receiving prior informed consent, and they were carried out in Spanish. Most of them were recorded after being granted permission by the interviewee, and typically lasted between 30 minutes and 1 hour and a half. In the case of diagrammatic ones, each diagram was coded and photographed for subsequent analysis. Appendix 1 shows images of the elicitation process and an original representation of a mental model.

Data analysis
We analyzed IMMs and consensual group mental models (GMMs), which are aggregations of several IMMs representing only the most shared features, through a qualitative approach (Vuillot et al. 2016) by comparing how actors, resources, activities, and interactions were displayed in each mental model. The analysis of GMMs was aimed at revealing insights about the shared understanding within and across stakeholder types whereas the analysis of IMMs was intended to counteract the simplification of information in GMMs and reveal interesting differences within stakeholder types.

We built three GMMs of cooperative leaders, representatives of government agencies, and representatives of NGOs. We grouped these stakeholder types because it is usually assumed that each type shares similar versions of reality based on shared values and norms (Horowitz et al. 2018). We did not build a GMM of the research centers because, as noted earlier, we could only interview one researcher. We also built two GMMs from the IMMs of the members of two fishing cooperatives, La Palma and El Castaño.

To facilitate the analysis of the IMMs and the construction of the GMMs, we homogenized all concepts with similar meanings appearing in different IMMs (Vuillot et al. 2016). For instance, "fishers", "cooperative members," and "cooperative" were always transcribed as "fishers," because all fishers involved in comanagement are cooperative members and, locally, when people talked about the cooperative they referred to the cooperative members. Similarly, "fish," "fish species," and "fishery resources" were always transcribed as "fish stock." We are aware that such homogenization of concepts may imply a certain degree of subjectivity but establishing a predefined set of concepts to choose from would have been more biased. Also, when applicable, groups of concepts and relations (subgraphs) were condensed and replaced by a single concept that captured the meaning of the subgraph (Özesmi and Özesmi 2003). For instance, "generating added value," "better harvest registration," "better facilities," and "better prices" were grouped under the term "commercialization," and "wood," "wild fauna," and "birds" under the term "natural resources" (see Appendix 2 for the list of homogenized and aggregated concepts). When a concept was not clear, we checked the recorded interview to clarify its meaning. Appendix 3 shows all the IMMs elicited.

We then created five adjacency matrices (Özesmi and Özesmi 2003, Vuillot et al. 2016) to capture the information of the IMMs of cooperative leaders, government, and NGOs representatives and the fishers of La Palma and El Castaño. All concepts of the IMMs headed the rows and columns of the matrix, and each link uniting two concepts was identified in the corresponding cell with the code/s of the IMMs that mentioned the link. Those interactions connecting the two same concepts that were mentioned by at least 30% of the IMMs were represented in the GMMs (Vuillot et al. 2016). This percentage was increased to 50% in the NGOs' GMM to represent interactions mentioned in at least two of the three IMMs from NGO members analyzed. This consensus criterion was used to simplify the group model using a percentage of interactions that allowed the showing of the important interactions without getting overwhelmed by concepts and interactions (Fairweather 2010).

RESULTS
We compare the GMMs of interviewed stakeholder types at the fishery level, i.e., the leaders of the fishing cooperatives (Fig. 2), the representatives of the government agencies (Fig. 3), and the representatives of NGOs (Fig. 4), as well as the IMM of the researcher (Fig. 5). We also compare the GMMs of the cooperative members of La Palma and El Castaño at the cooperatives' level (Fig. 6). The comparison of mental models revolves around four key components emerging from the analysis: actors, transfer of resources, the role of fishers, and collaborative decision making.

Fig. 2. Group mental model of the leaders of fishing cooperatives.
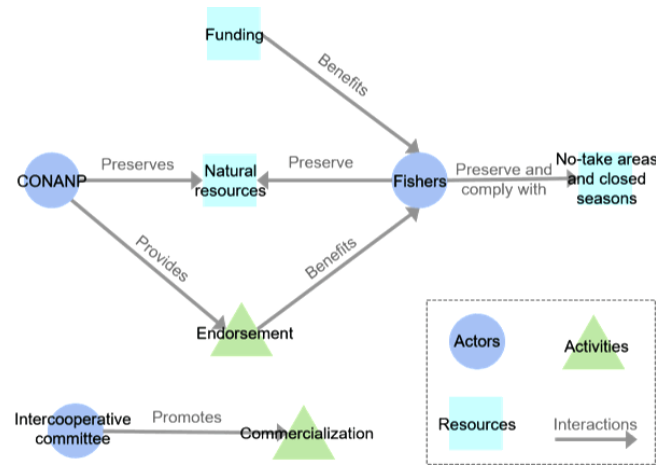
Actors
All GMMs identify fishers and government as key actors of the comanagement initiative. However, the models differ in the kind of government agencies represented. The leaders of fishing cooperatives and the fishers of La Palma and El Castaño only identify CONANP, which has always been the agency promoting comanagement activities and thus in regular contact with fishers. The GMM of the NGO representatives also represents SEPESCA, the fisheries department of the regional government. The mental model of the researcher also includes CONAPESCA,

the fisheries department of the national government, and the GMM of the government representatives also identify city councils. Rather surprisingly, one cooperative leader and three fishers do not represent government agencies in their IMMs (Coop4, LaPa6, LuCa02, and LuCa06; Appendix 3), reflecting a community-based management approach.

Fig. 3. Group mental model of the representatives of the government agencies.
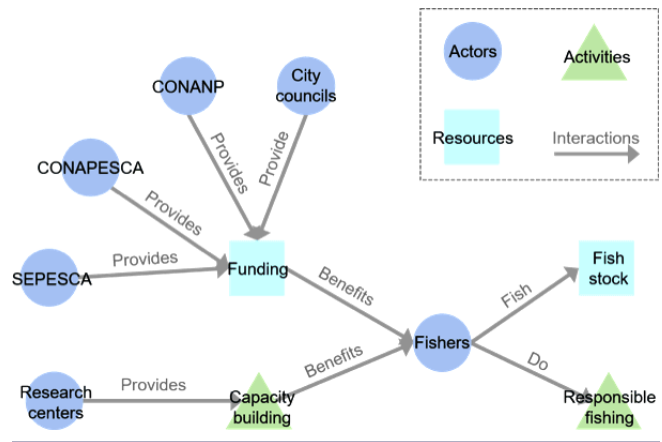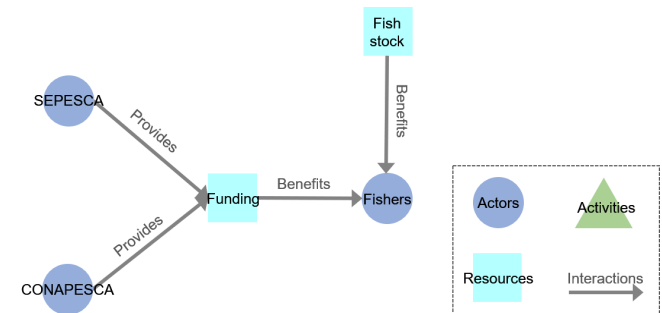

Fig. 4. Group mental model of the representatives of nongovernmental organizations (NGOs).

Both government representatives and the researcher identify research centers as a third actor in the comanagement system, whereas the fishers' leaders represent the intercooperative committee. Other actors appearing in several IMMs (Appendix 3) are NGOs, illegal fishers, community children, fishers' families, and donors. Finally, some actors of the comanagement system only appear in one IMM each (Appendix 3), including the technical-scientific committee, the federation of cooperatives, cooperative leaders, companies, and intermediaries (LaPa5).

Transfer of resources
All GMMs represent the transfer of resources as the central tenet of the comanagement initiative. These resources are mostly economic and flow from government to fishers. The GMM of government representatives also shows the mobilization of knowledge through capacity building from research centers to fishers. In contrast, the GMM of El Castaño reflects that fishers consider that these activities are implemented by CONANP and

not by academics. The GMM of fishers' leaders and the IMM of the researcher share the idea that CONANP transfers resources to fishers as a means to incentivize and guide the latter in the pursuit of comanagement goals.

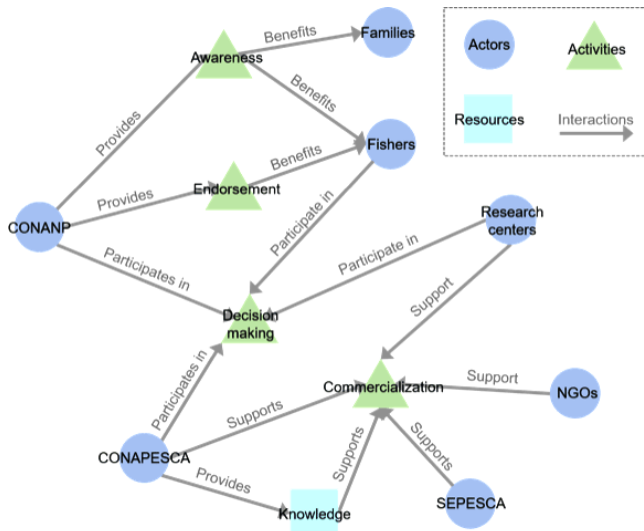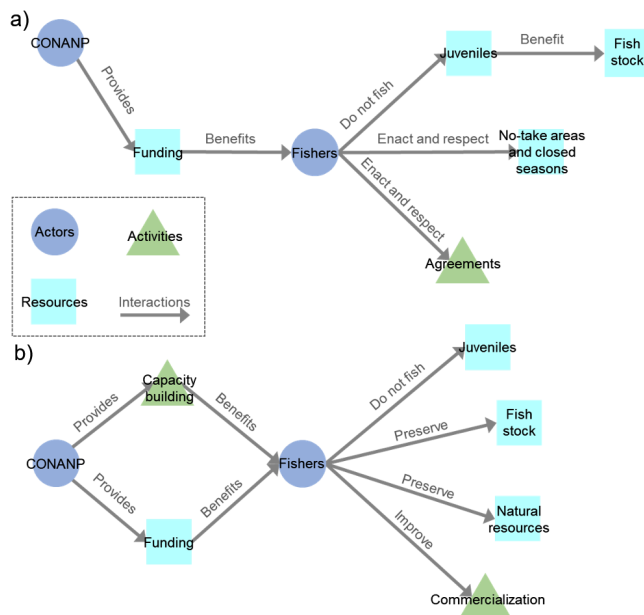**Fig. 5**. Individual mental model of the representative of a research center.

Fig. 6. Group mental model of members of two fishing cooperatives: (a) La Palma and (b) El Castaño.

The IMMs (Appendix 3) represent other resources mobilized within comanagement. A cooperative leader notes that fishers receive infrastructure from government agencies (Coop1). Three other IMMs highlight that capacity building activities, which benefit fishers, are conducted by government agencies and

research centres, as well as by NGOs (LaPa2, LuCa01, and Gov1) and donors (LaPa2). Other IMMs include capacity building activities that benefit other actors besides fishers, such as children (LuCa07 and LuCa08,) and families (Gov1). Finally, the IMM of an NGO staff member considers that CONANP benefits fishers as well as NGOs (NGO1).

Fishers' role
Although all GMMs seem to agree on the fact that government is supporting fishers through funding, they differ greatly in representing what fishers do. The GMM of the cooperatives' leaders represents fishers as those actors who conserve natural resources and comply with local no-take areas and closed seasons. The GMM of La Palma represents fishers as those who reach agreements and establish and enforce no-take areas and closed seasons, including the act of not fishing juveniles. Similarly, the GMM of El Castaño represents fishers as actors who do not fish juveniles and who conserve fish and other natural resources. This GMM also represents fishers as actors who aim to improve the commercialization of fish harvests. Interestingly, the IMM of the researcher is the only mental model that represents fishers as key participants in collaborative decision making, alongside CONAPESCA, CONANP, and research centers.

By contrast, the GMM and IMMs of government representatives consider fishers as those responsible for fishing activities and its sustainability, which is a more general understanding than those highlighted above. Surprisingly, the IMMs of the three NGOs' representatives (Appendix 3) show very different representations of what fishers do in the comanagement context, which are not reflected in the GMM of the NGOs' representatives. Although one mental model does not show any action from fishers (NGO1), another one represents fishers communicating with CONANP (NGO2), and the last one represents a number of activities fishers do, from updating knowledge to changing public policies and promoting actor alliances (NGO3).

Other IMMs (Appendix 3) also show other activities performed by fishers within the comanagement system. For example, the IMM of a cooperative leader represents fishers as key surveillance actors. The IMMs of some members from La Palma and El Castaño represent fishers as people who use legal gears for fishing and who educate children about resource management. Finally, the IMMs of some government representatives also illustrate fishers reaching management agreements and promoting new forms of fish commercialization.

Collaborative decision making
Only the GMMs of La Palma fishers and of the cooperatives' leaders represent decision-making processes. In the former model, fishers reach internal agreements and declare no-take areas and closed seasons, and there is not any other actor involved in decision making. In addition to fishers, the second model also identifies the intercooperative committee as a key actor in decision making, although no other actor is made explicit in this regard. In the case of IMMs (Appendix 3), only a few fishers and government representatives represent shared decision-making components between government and fishers (LaPa1, LaPa2, LaPa7, LuCa03, LuCa05, and Gov1). The mental model of the researcher also does it and adds a third actor, research centers.

DISCUSSION

Our results suggest that participants in c-management share an understanding of the system as a framework that facilitates the economic support of government toward fishers instead of one that promotes collaborative decision making. Participants have a diversity of views on the actors involved, the other resources transferred, the role of fishers, and who (if any) participates in decision making. These results nuance previous studies showing that shared understandings favor collaboration (e.g., Berkes 2010, Mathevet et al. 2011), and suggest that agreement on a key aspect of the comanagement system is enough to start collaborating, and that contrasting views on who participates in decision making do not jeopardize comanagement, at least in the short term. A diversity of understandings might coexist in a context of collaborative decision making, as suggested by authors such as Leach and Fairhead (2001) who claimed that collaboration does not necessarily need to be based on consensus, and that it is important instead to recognize the plurality of stakeholders' perspectives and interests.

Sandström and Rova (2010) suggested that participants in comanagement approaches need to share at least a common perception of the state of the resource system and a common goal to trigger collaboration. In La Encrucijada, a shared understanding based on the support provided by the government to fishers, together with a perception of declining fish populations and the desire to conserve fish stocks and improve the fishers' livelihoods, was sufficient to trigger the start of the comanagement initiative. However, a shared understanding of the collaborative mechanisms underlying comanagement might be necessary to sustain comanagement in the long term. Also, a shared understanding of the social rules underlying the comanagement system might help to increase the social legitimacy of the system.

Our findings align with the well-established pattern of paternalistic resource provision in Mexico (and elsewhere) in which the State has sought to involve cooperatives and other rural groups in development and conservation projects through the provision of subsidies and infrastructure, particularly since the 1920s (Young 2001, García Lozano et al. 2019). In our case study, and despite the opening of the rural sector to private investment and the reduction of agrarian subsidies from the 1980s onward (García Lozano et al. 2019), cooperative members have continued to receive support from CONAPESCA in the form of fuel and fishing equipment subsidies, and from SEPESCA through direct payments to support fishers' income. This can explain why fishers continue to regard government-led projects mostly as sources of additional revenue and not as projects that entail collaborative decision making. Mental models are indeed subjective and incomplete representations of reality, which are based on long-term knowledge structures, assumptions, and normative ideas (Jones et al. 2011); based in our case on assumptions of how relationships between fishers and government work. The actors may hold ingrained representations of a past reality that resists change. They filter new information from experience and communication in a way that reinforces rather than challenges their previous mental models (Abel et al. 1998, Daw 2008), because it is cognitively easier than acquiring new assumptions for fundamentally new systems (Galafassi et al. 2018).

Armitage and colleagues (2018) suggested that comanagement requires that participants move beyond single-loop learning, i.e., changing behaviors, and second loop-learning, i.e., changing values and norms, to achieve triple-loop learning, i.e., challenging the governance system that frames the way people learn (Armitage et al. 2008). For instance, in an Inuit's narwhal comanagement experience, the dominant management worldview or model changed from the distinct management paradigms of hunters and government to a collaborative community-based management approach (Diduck et al. 2005). Similarly, in the Vietnamese Mekong Delta, collaboration between local governments and farmers resulted in a shared understanding of the local water management system that included collaborative mechanisms for decision making (Tran et al. 2019). Unlike these cases, our analysis of La Encrucijada shows an absence of triple-loop learning. The fishers involved in c-management have been able to fix routine errors, such as reducing the fishing of juveniles, evidencing single-loop learning. Similarly, fishers' leaders and the representatives of the other organizations involved in comanagement have agreed on the goals of the comanagement process, which reflects second-loop learning (Diduck et al. 2005). The IMMs reflect that some individuals understand the new joint decision-making mechanisms in comanagement, but this individual learning has not been encoded in social memory (Diduck et al. 2005). Therefore, social triple-loop learning in La Encrucijada has not yet occurred.

The literature suggests that mental models evolve slowly and mainly through experience and communication with other actors (Lundholm and Stöhr 2014). The absence of triple-loop learning might mean that six years of comanagement have not been enough to guarantee sufficient time and social interactions to trigger these profound cognitive changes (Suškevičs et al. 2019). It might also mean that further commitment to shared decision making by all actors is required (Armitage et al. 2018). Government actors, in particular, should dedicate more time and resources to consultation and participatory processes with all actors involved to increase the knowledge about comanagement means and ends and to readapt management rules so that these better fit with changing ecological conditions and local aspirations. In doing so, the transformative potential of comanagement in terms of social empowerment may surface.

CONCLUSION

Our findings suggest that stakeholders in La Encrucijada have a shared understanding of the new management system as a government-led partnership to support fishers economically, which mostly reflects the previous institutional design, based on governmental protectionism and lack of collaborative decision making. This shared understanding has allowed the emergence of comanagement despite a diversity of understandings on the actors involved, the kind of resources transferred, and the role of fishers in comanagement. However, more time, resources, social interactions, and collaboration are necessary to trigger more profound social-learning processes that challenge the actual representations of the management system and include collaborative decision making in participants' views of comanagement. The findings suggest that a shared understanding among stakeholders of the new collaborative mechanisms in place is not a prerequisite for comanagement but might be necessary to sustain a socially legitimate collaboration in the long term.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/12177

Data Availability:

The data that support the findings of this study are available on request from the corresponding author, L. d. C. The data are not publicly available they contain information that could compromise the privacy of research participants.

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Appendix 1. Elicitation of mental models

A)

B)

Fig. A1.1. Mental model drawing by A) a leader of a fishing cooperative, and B) a representative of an NGO.

Fig. A1.2. Diagrammatic representation of a mental model.

Appendix 2. Mental models' analysis

Table A2.1. Qualitative aggregation of actors

Final concept	Concepts in the IMMs that have been homogenized	Concepts in the IMMs that have been aggregated
Children	Children Kids School children Children or our children's children	Students + Fishers' children
City councils	City councils Local government Municipal fishery [department]	City council of Acapetahua + City council of Mapastepec
CONANP	CONANP CONANP – Reserve CONANP La Encrucijada La Encrucijada Biosphere Reserve Reserve – CONANP Reserve (Institute) SEMARNAT Those that organize (biologist)	CONANP + La Encrucijada Biosphere Reserve, Biosphere Reserve + CONANP, CONANP + Biologists, Federal government + CONANP + FANP + SEMARNAT
CONAPESCA	CONAPESCA CONAPESCA's quarters INAPESCA	CONAPESCA + INAPESCA + CRIP, CONAPESCA + SAGARPA, CRIP + CONAPESCA, Federal government + CONAPESCA + INAPESCA, INAPESCA + CONAPESCA
Cooperative directives	Cooperative Cooperative administratives Directives	
Donors	RARE Society (for instance businessmen, institutions, banks, nature lovers) USAID	USAID + RARE
Families	Family Fishers' families Next generations	Family + Elders + Wives + Children + Schools
Federation of cooperatives	Soconusco's federation of cooperatives	
Fishers	Cooperative Cooperative men Cooperatives Cooperative society Cooperative society's members and directives Fisher Fishermen and fisherwomen Fishers Fishers and cooperative [Cooperative] members Men Society Society (all fishers)	Cooperative + Cooperative directives, Cooperative + Fishers Cooperative + Fishers + 6-7 cooperatives, Cooperative societies + Communities, Fishers + Adults, Fishers + Cooperatives, Fishers + Cooperatives + Dads, Fishers + Members, Open waters' fishers + Estuarine fishers, Fishing cooperatives + Fishers, Teams + Working teams + Cooperatives + Human beings,

Table A2.1. Continued

Fishers from other cooperatives	Cooperatives Other cooperatives People from other cooperatives People from other places	
Governmental organizations	Government Other institutions Mexican state's departments	
Inter-cooperative committee	Chanpanic Responsible fishing committee	Responsible fishing committee + Facilitator,
NGOs	Acción Cultural Madre Tierra Civil society organizations (ACMT) Pronatura RARE Madre Tierra	CASFA + ACMT, Madre Tierra + CASFA, Razonatura + ACMT + CASFA
Research centres	Academics ECOSUR Institutions of scientific research Scientific-technical side UNICACH	ECOSUR + Academic side (universities), UNICACH + UNACH + ECOSUR
Responsible fishing	Responsible fishing Those that come	
SEPESCA	Fishery Department Fishery and Aquaculture Department SEPESCA SEPESCA's quarters State's government	
Trade intermediaries	Coyote Trader	

Table A2.2. Qualitative aggregation of resources

Final concept	Concepts in the IMMs that have been homogenized	Concepts in the IMMs that have been aggregated
Agreements	20 agreements Agreements Inter-cooperative agreements Internal agreements To agree	Rules + Resolution of the use of fishing gears, 20 agreements + [listing of several of the 20 agreements]
Fish stock	Fish Fish and shrimp Fish species Fishery resource Fishery resources Resource Species	Big fish + Biological resource (eggs), Fish + Crab, Future harvest + Little fish
Fish with roe	Animals with roe Fish with roe Product with roe	Flathead grey mullet with roe + Cichlids with roe
Funding	Economic resources Funds and financial resources Money Supports Temporary jobs Temporary work	Fishing infrastructure, motors + Social support for social peace during the six months of low season + Fishing gears, Resource + economy, Resources + Temporary jobs, Resources + Temporary work, Supports + Economic resources, Supports + Nets + SEPESCA's annual support + Temporary jobs + Resources, Temporary jobs + Economically
Future	Future (Living better) in future Thinking in tomorrow Tomorrow's day	
Habitat	Environment Lagoons Mangroves Nature (trees, estuaries, sea) Water	Fauna and flora + Mangrove
Harvest	Good production Permanent production Product Production	Production + Sized fishable product
Illegal gears	Forbidden gears [Shrimp] shelter	Forbidden fishing gears + Stow net
Infrastructure	Ice machine and cooperative's facilities	Money for buying motors + Nets,
Juveniles	[Catch] big fish [Catch more] fish with ideal size and weight Juvenile product Product Small fish Small species	[Catch more] fish with commercial size + [Release] small fish

Table A2.2. Continued

Knowledge	Information Knowledge Knowledges Research Socio-economic studies of the concession Research, validate	
Natural resources	Animals Environment, nature and trees Flora and fauna Mangroves Species (fish and other animals) The natural environment	Birds + Crocodiles + Mangrove, Environment, Flora and fauna and ecologic equilibrium + Crocodile, Hydric connectivity + Birds + Forest + Ecological diversity + Non- commercial species + Mammals + Natural resources, Nature (trees, estuaries, sea) + Resource found here, Water resources + Fauna (mammals and birds) + Wood resources (mangrove, *tulares*, *popales*), Wood + Wild fauna and birds,
No-take areas and closed seasons	Areas Closed lagoons Closed seasons No-take areas	Closed seasons + No-take areas, Forbidden areas + Closed season, No-take areas + Closed seasons, No-take areas + Local closed seasons,
Responsible fishing	Fishing with responsibility Fishing with responsibility and care Program Respect, make the activity responsibly Responsible fishing Responsible fishing process Responsible fishing program Responsible fishing project The fishing they know, the responsible fishing	Fishing with responsibility + They talk about responsible fishing

Table A2.3. Qualitative aggregation of actions

Final concept	Concepts in the IMMs that have been homogenized	Concepts in the IMMs that have been aggregated
Capacity building	Courses Talks Train Training Trainings Workshop	Consultancy + Courses, Courses + Events+ Exchange of experiences, sport events + cayuco races, Courses + Learn, Games + Tournaments for motivation, Talks + Workshops, Training + Exchange of experiences, Trainings + Teach how to participate in assemblies,
Commercialization	Joint commercialization	Cool box + Very good quality + Selling + Favourable market + Better price, Commercialization + Products, Differentiate, certificate + Product quality + Improve post-harvest processes to add in situ value + Improve commercialization processes, Generating added value + Better harvest registration + Better facilities + Better prices, Improving + Price, Integrating company + Organic certificate + Filleting + Fish transformation + Fish added value, Joint commercialization + Product classification + Cool box, Good price, Increase value + Marketing to better markets, Product's size and weight + Prices, Projects + Cool boxes + Premise + Fridge + Offices + Selling to international and local market, Selling + Product, Selling + Product with quality + Direct marketing + Market or restaurant,
Endorsement	Accompaniment and support Validation Guidance	Accompaniment + Endorsement + Reference + Credibility
Preserve	Care Respect	Care, respect + Control through Environmental Management Unities, To do not finish up + Work harmoniously,
Surveillance	Monitoring Monitoring respect Supervision tours Surveillance	Surveillance + Monitoring and surveillance tours + Water quality, fish size + Fishing gears that meet the rules

Appendix 3. Individual mental models

a) Coop1
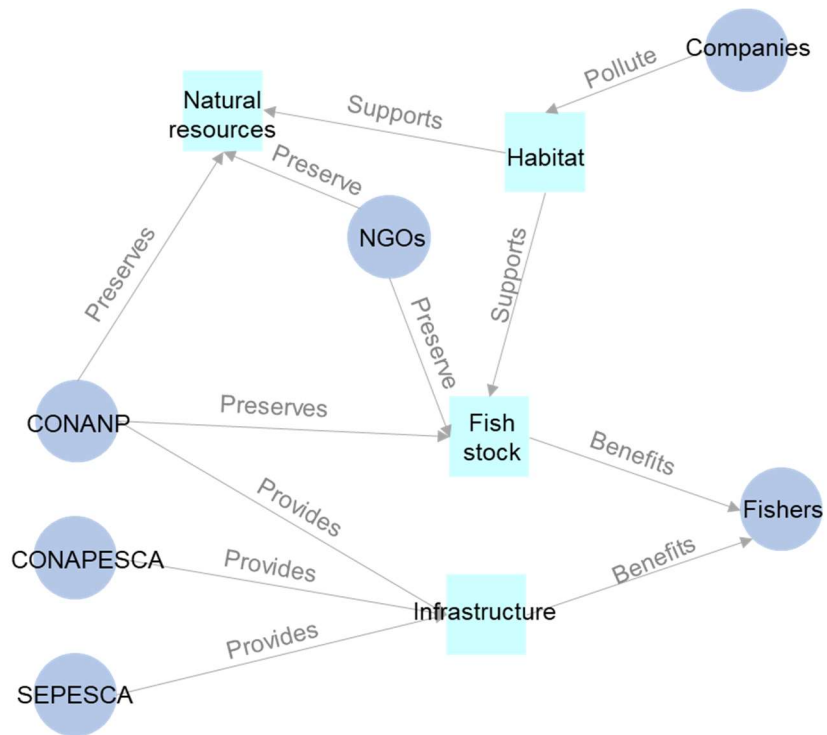
b) Coop2
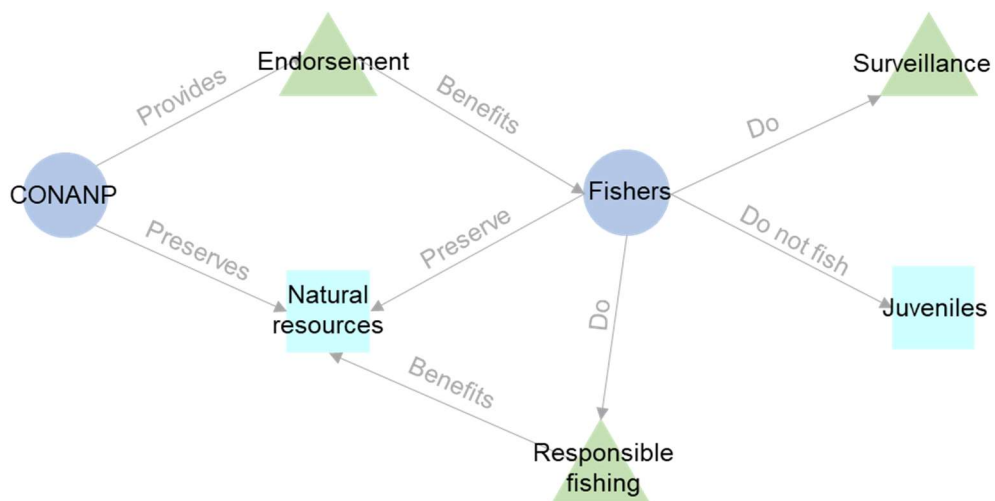
c) Coop3 (LaPa4)
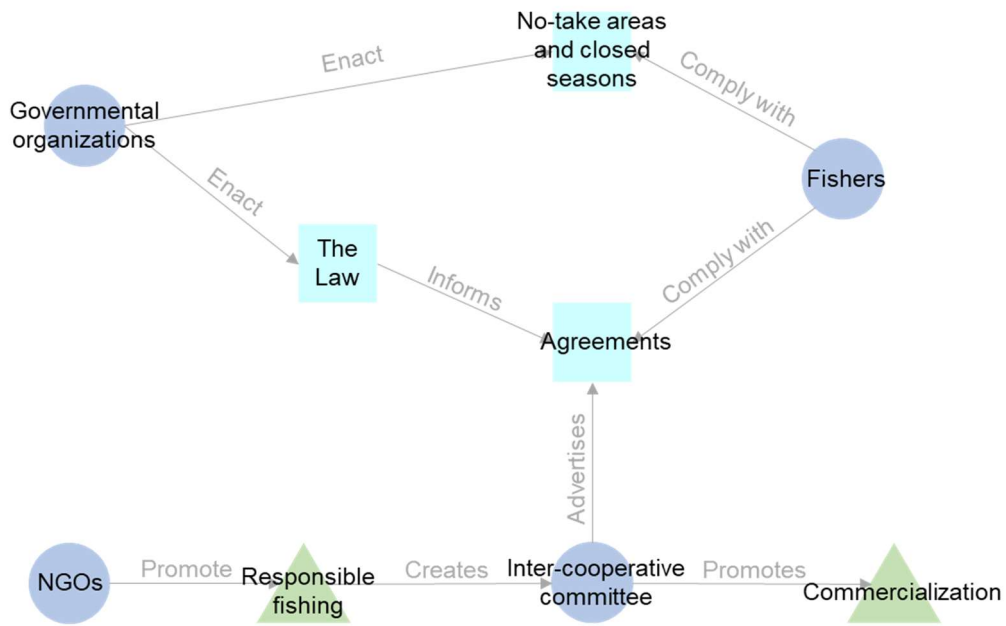
d) Coop4
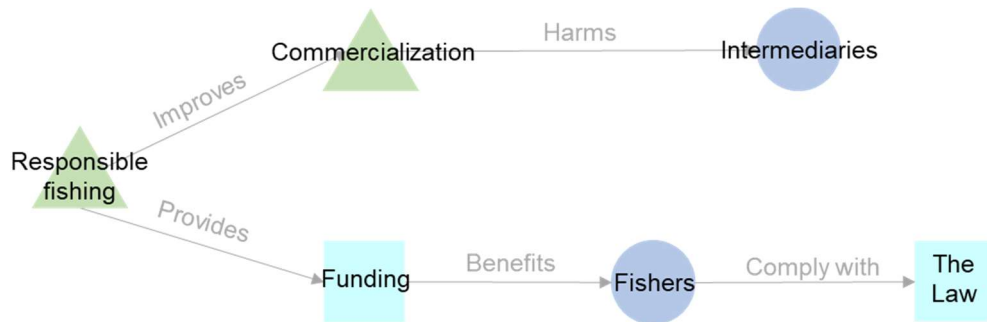
e) Coop5 (LuCa10)

e) Coop6

Legend

Actors

Activities

Resources

Interactions
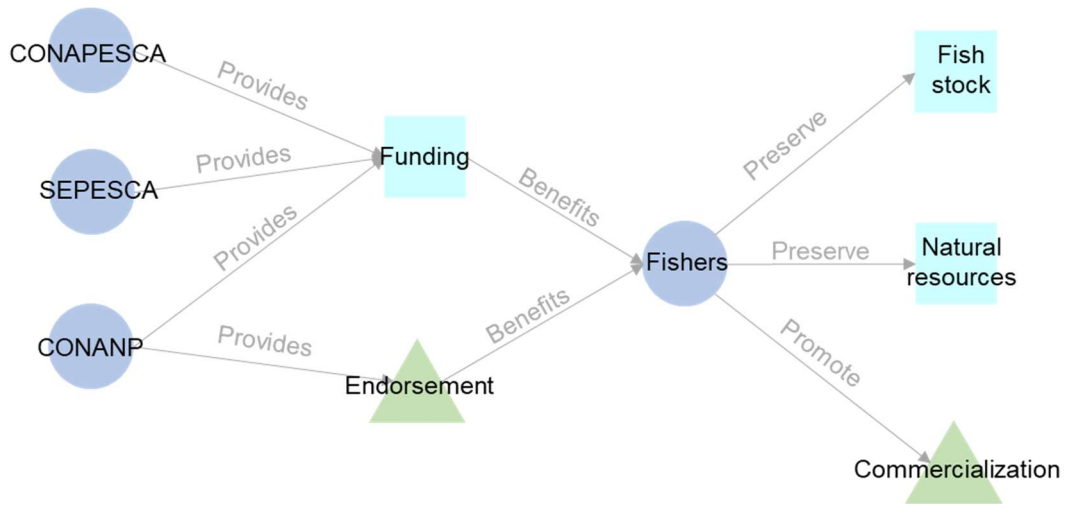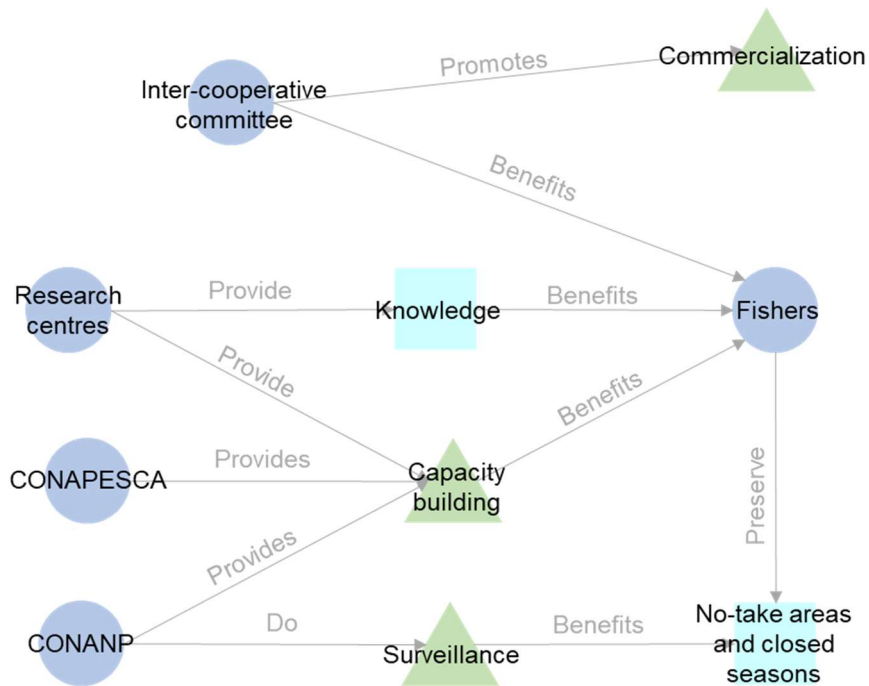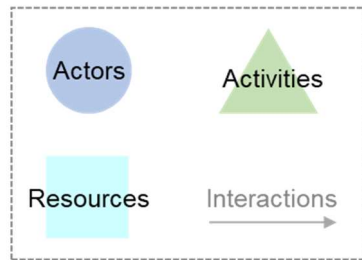
Fig. A3.1. Individual mental models of the leaders of six fishing cooperatives

a) LaPa1
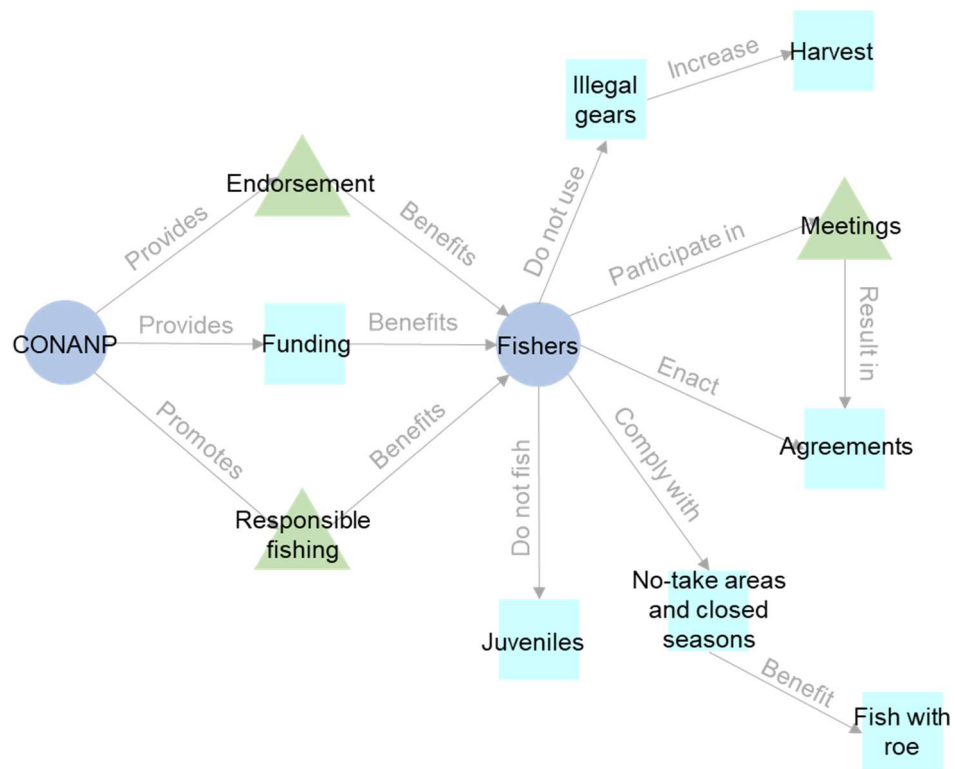
b) LaPa2

c) LaPa3

d) LaPa4 (Coop3)

Governmental organizations —Enact→ No-take areas and closed seasons

Governmental organizations —Enact→ The Law

No-take areas and closed seasons ←Comply with— Fishers

The Law —Informs→ Agreements

Agreements ←Comply with— Fishers

Inter-cooperative committee —Advertises→ Agreements

NGOs —Promote→ Responsible fishing

Responsible fishing —Creates→ Inter-cooperative committee

Inter-cooperative committee —Promotes→ Commercialization

6

e) LaPa5

CONANP —Raises awareness→ Fishers —Benefits→ Fish stock

CONANP —Provides→ Funding —Benefits→ Fishers

Fishers —Do not fish→ Juveniles —Benefits→ Fish stock

Juveniles —Do not buy→ Intermediaries

f) LaPa6

Fishers —Do not fish— Juveniles —Benefit— Commercialization

g) LaPa7

Harvest ←Benefits— Fish stock

SEPESCA —Enacts→ No take areas and closed seasons —Preserve→ Fish stock

Fishers —Enact→ No take areas and closed seasons

Fishers —Preserve→ Fish stock

Fishers —Do not fish→ Fish with roe —Benefits→ Fish stock

Fishers —Do not fish→ Juveniles —Benefits→ Fish stock

7

h) LaPa8

Fig. A3.2. Individual mental models of eight members of La Palma fishing cooperative

a) LuCa01
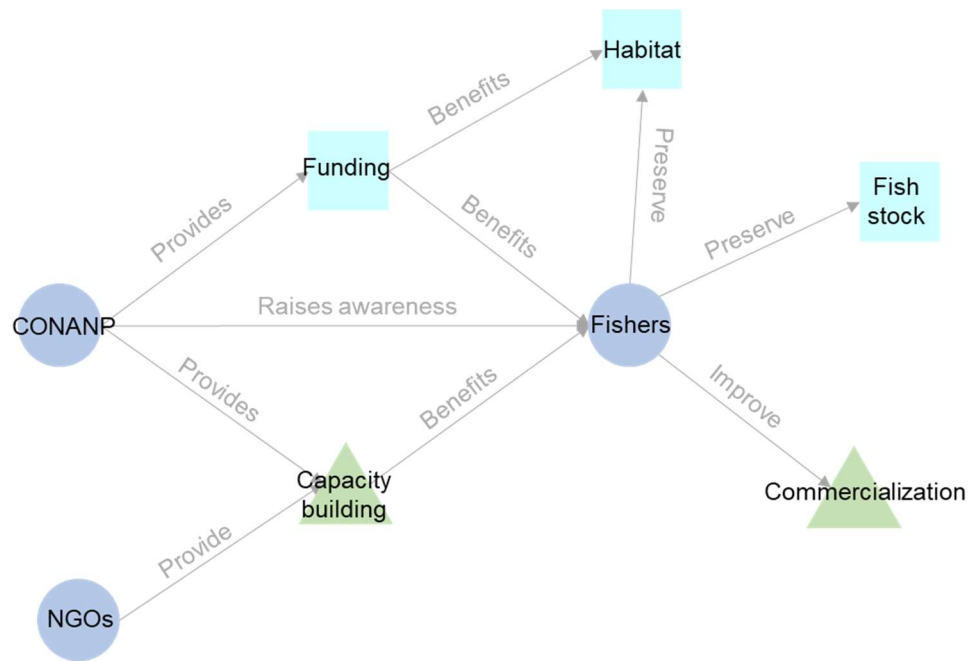
b) LuCa02
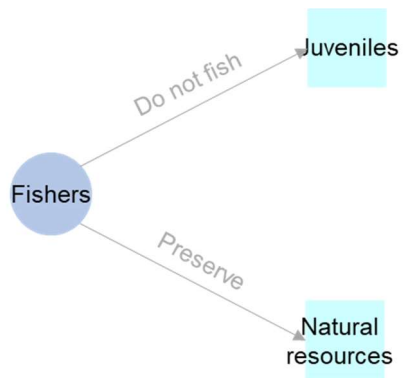
c) LuCa03
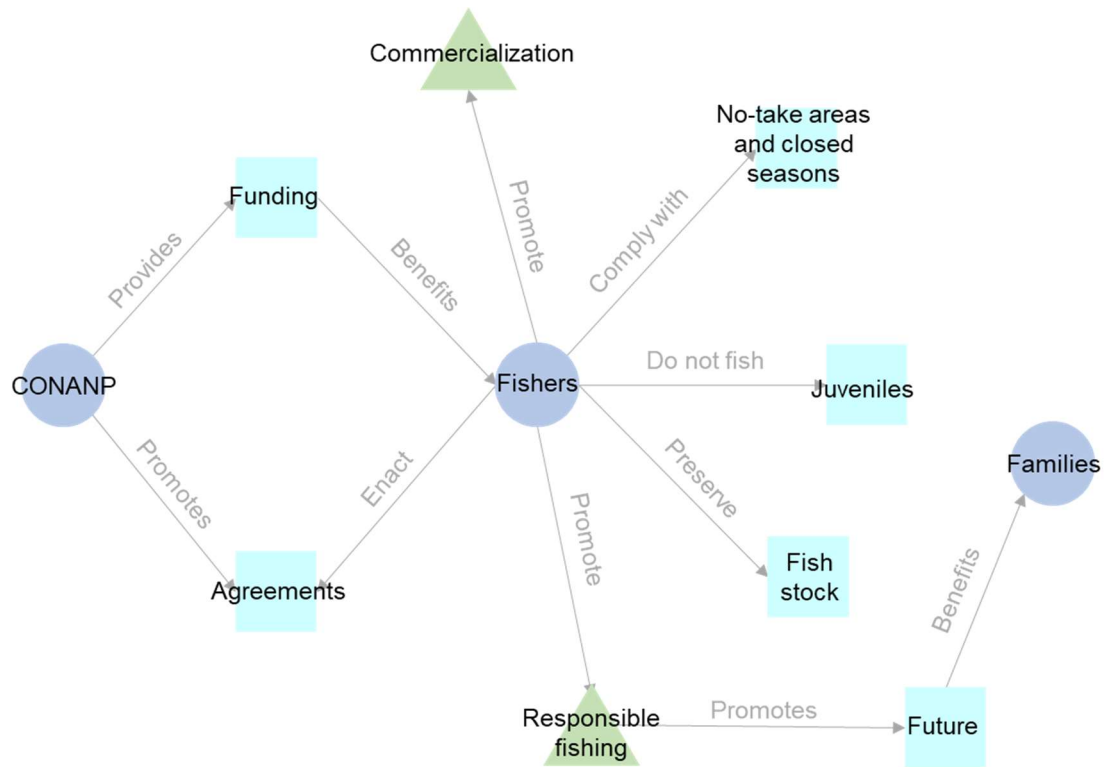
d) LuCa04
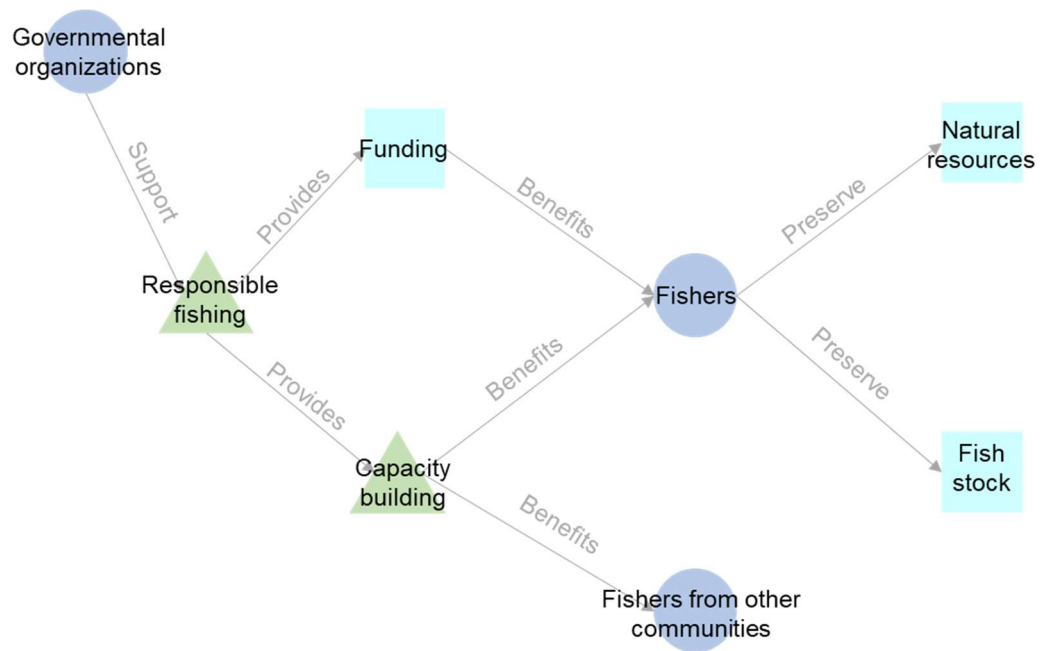
e) LuCa05
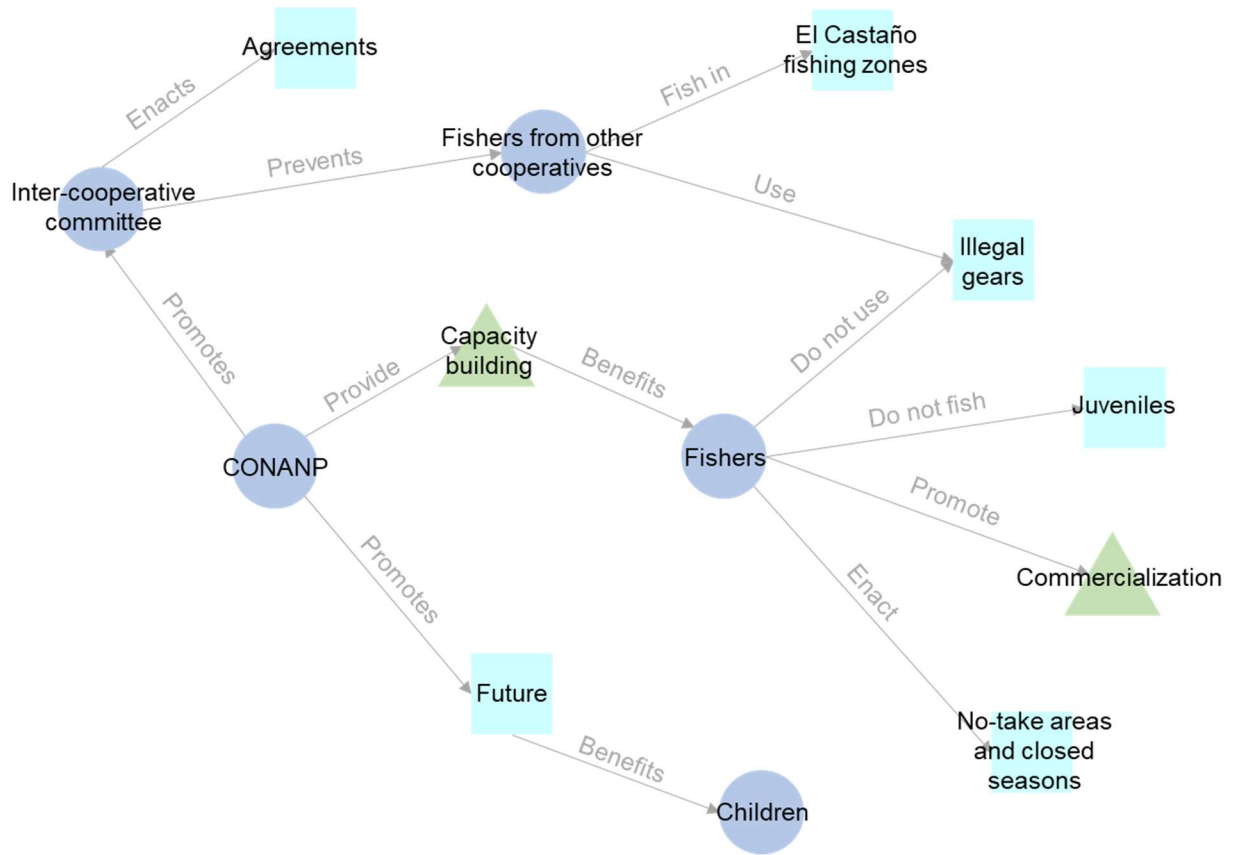
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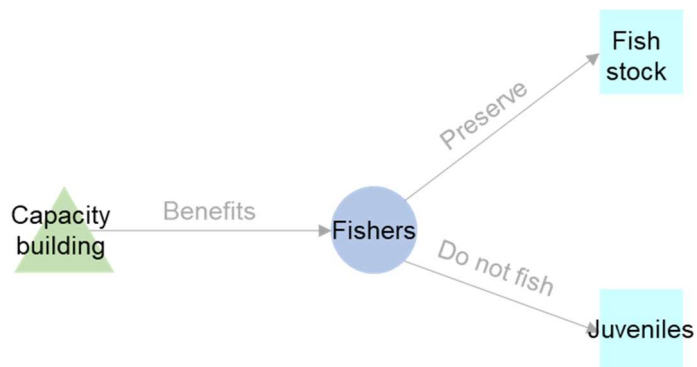
g) LuCa07
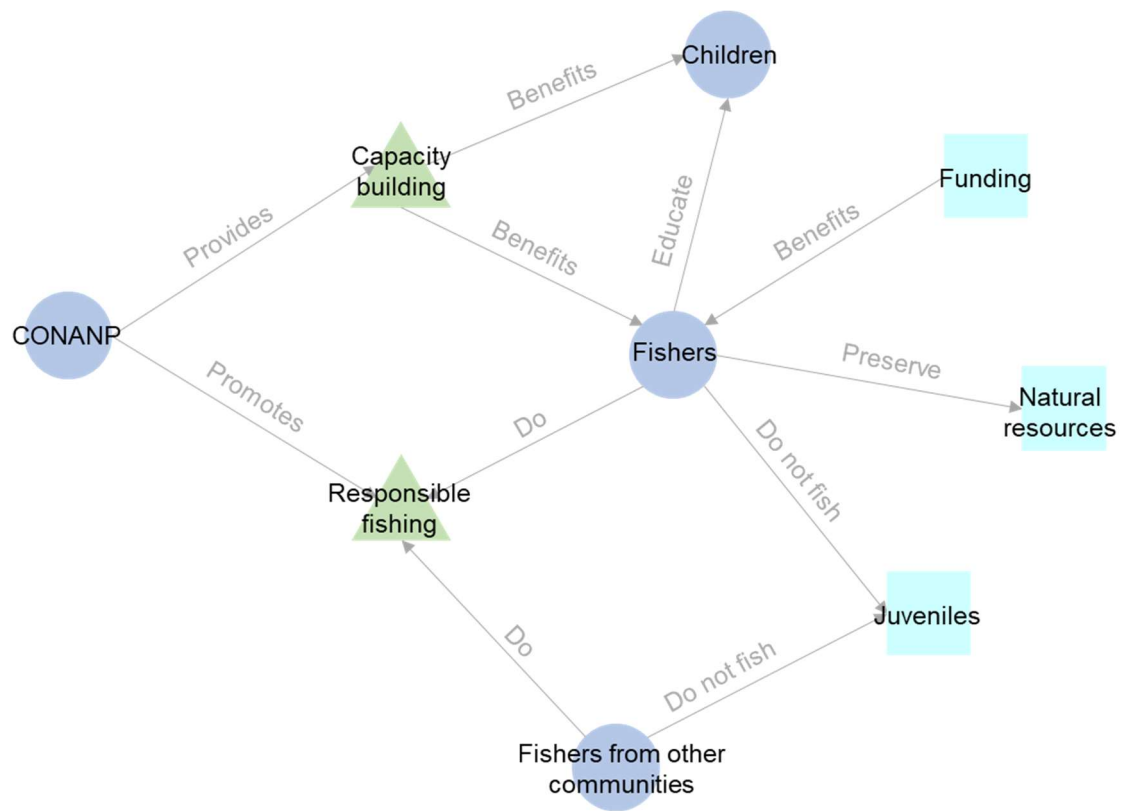
h) LuCa08
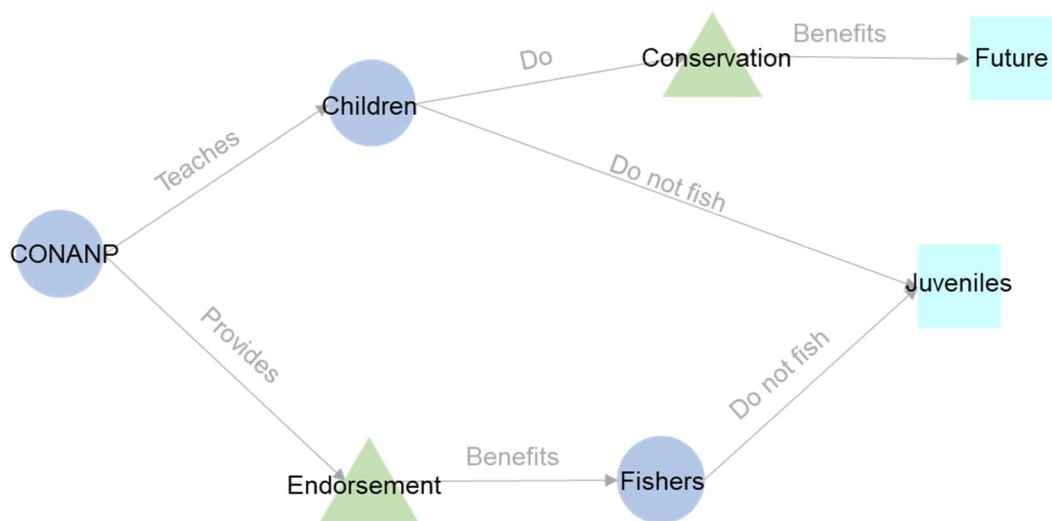
i) LuCa09
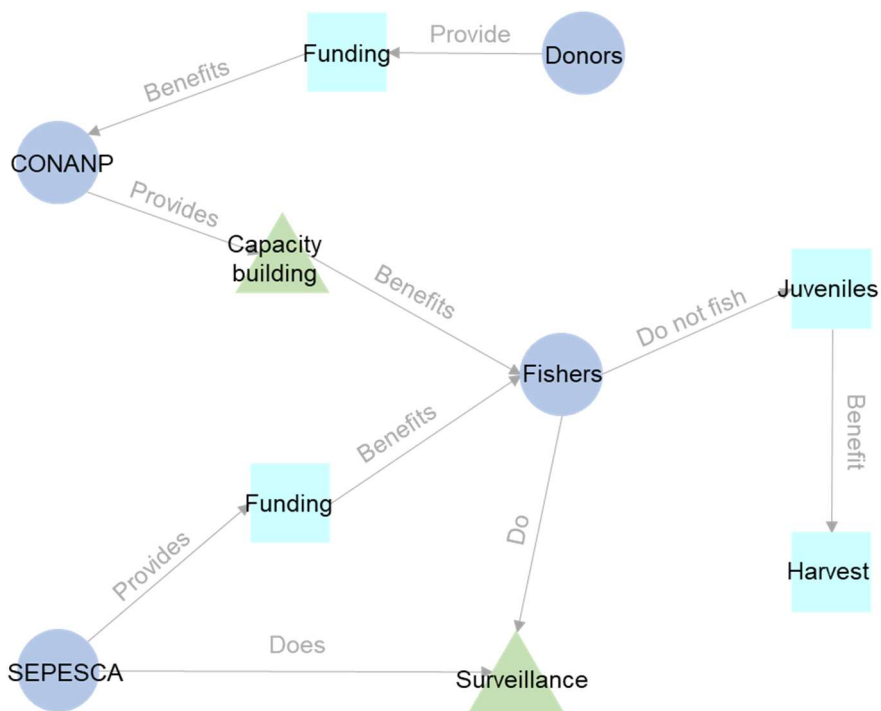
j) LuCa10 (Coop5)
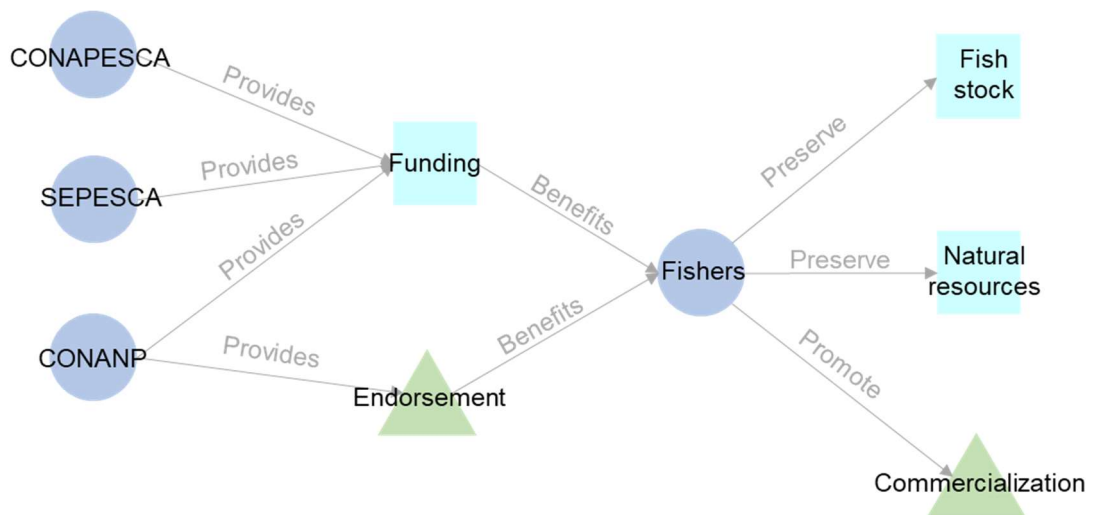
k) LuCa11
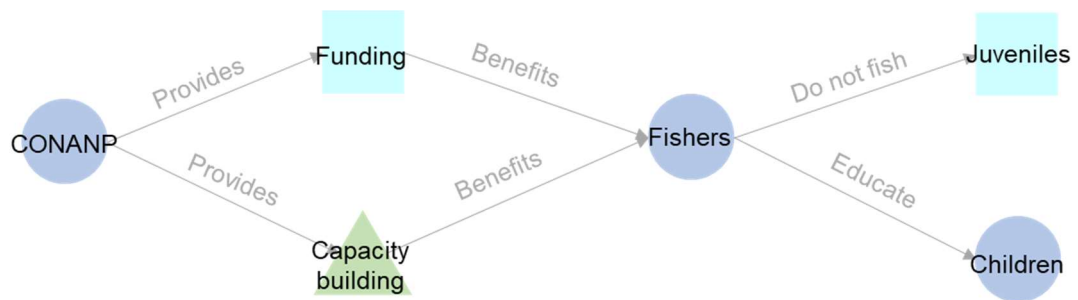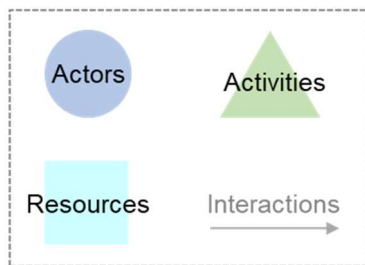
Fig. A3.3. Individual mental models of eleven members of Luchadores del Castaño fishing cooperative
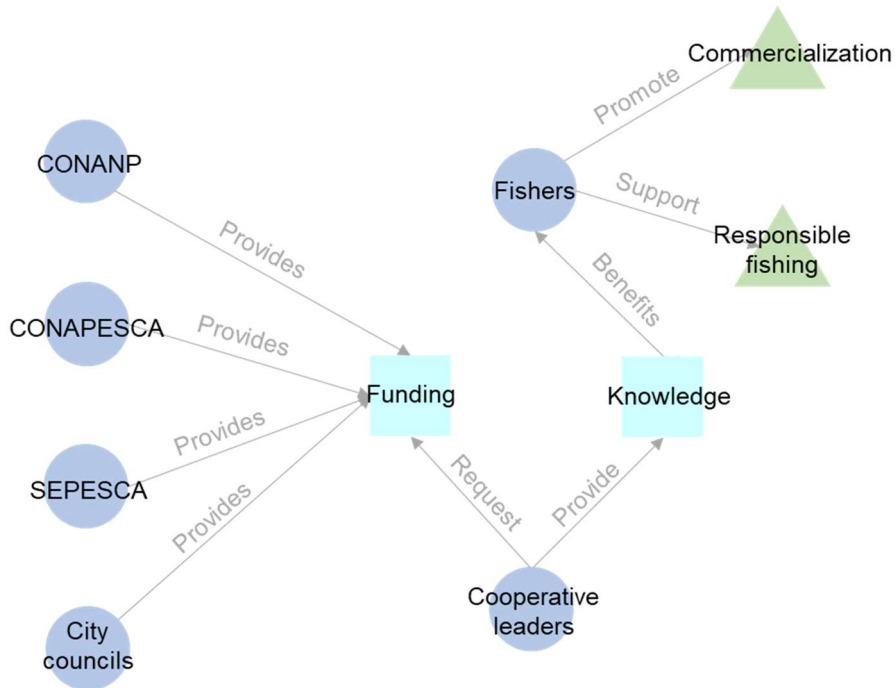
a) Gov1
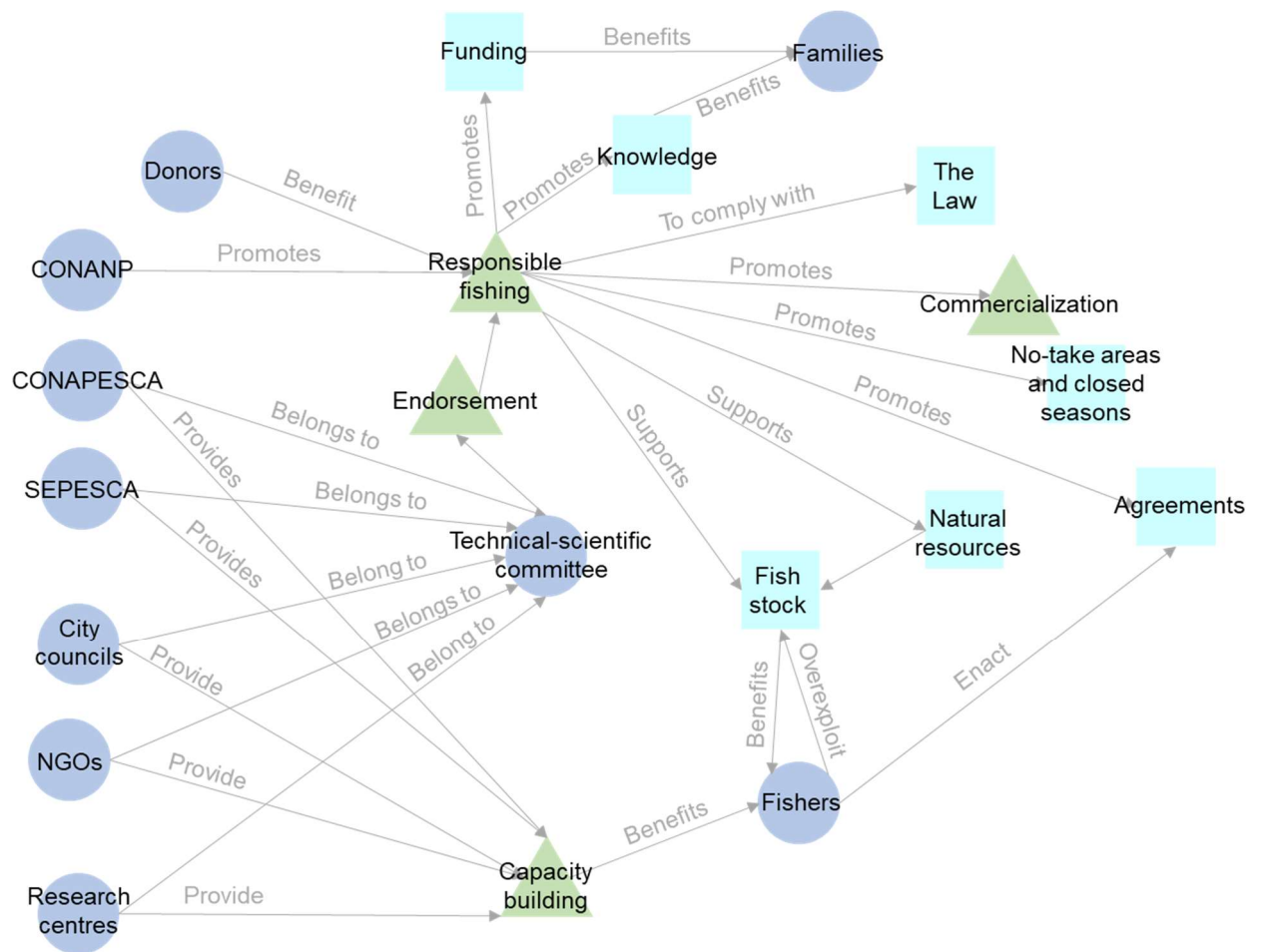
b) Gov2
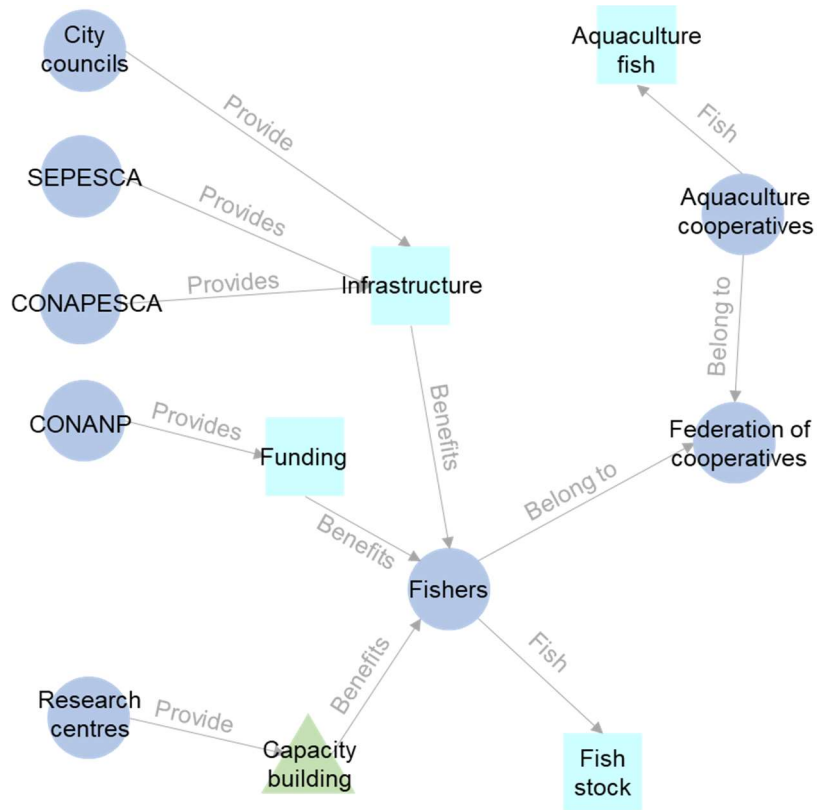
c) Gov3
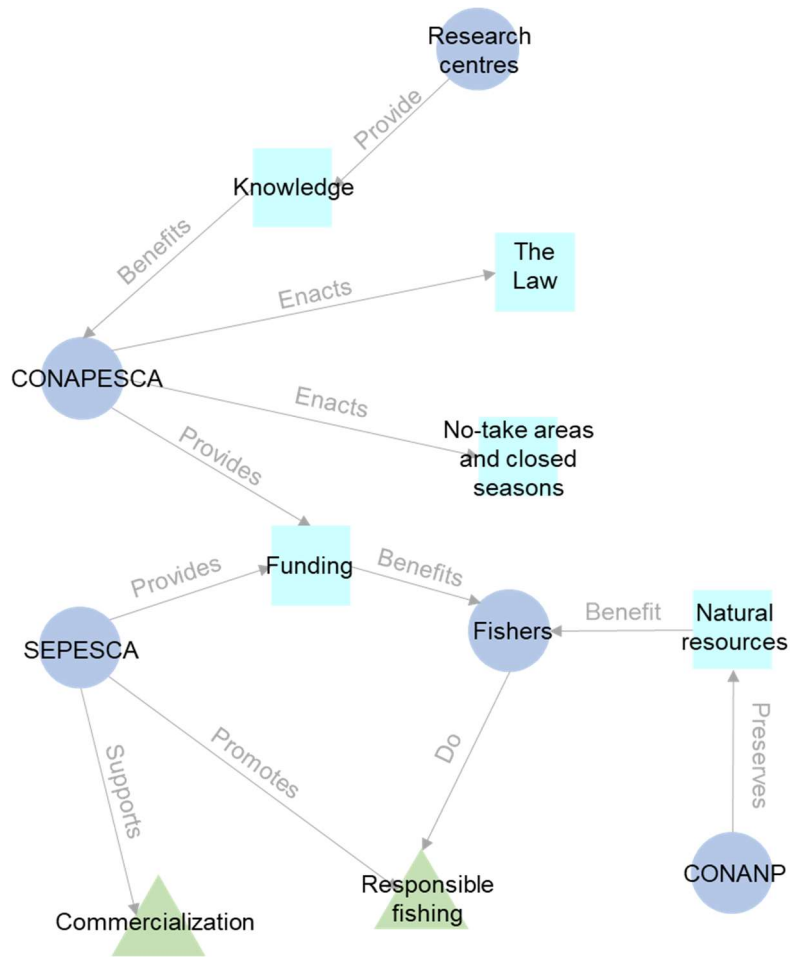
d) Gov4

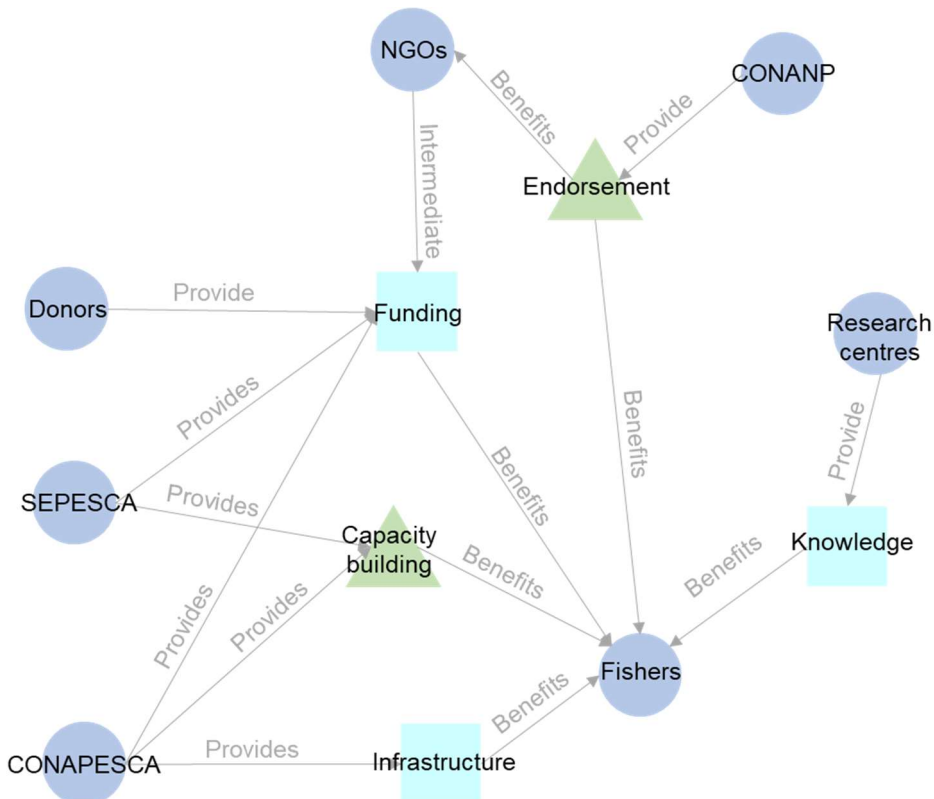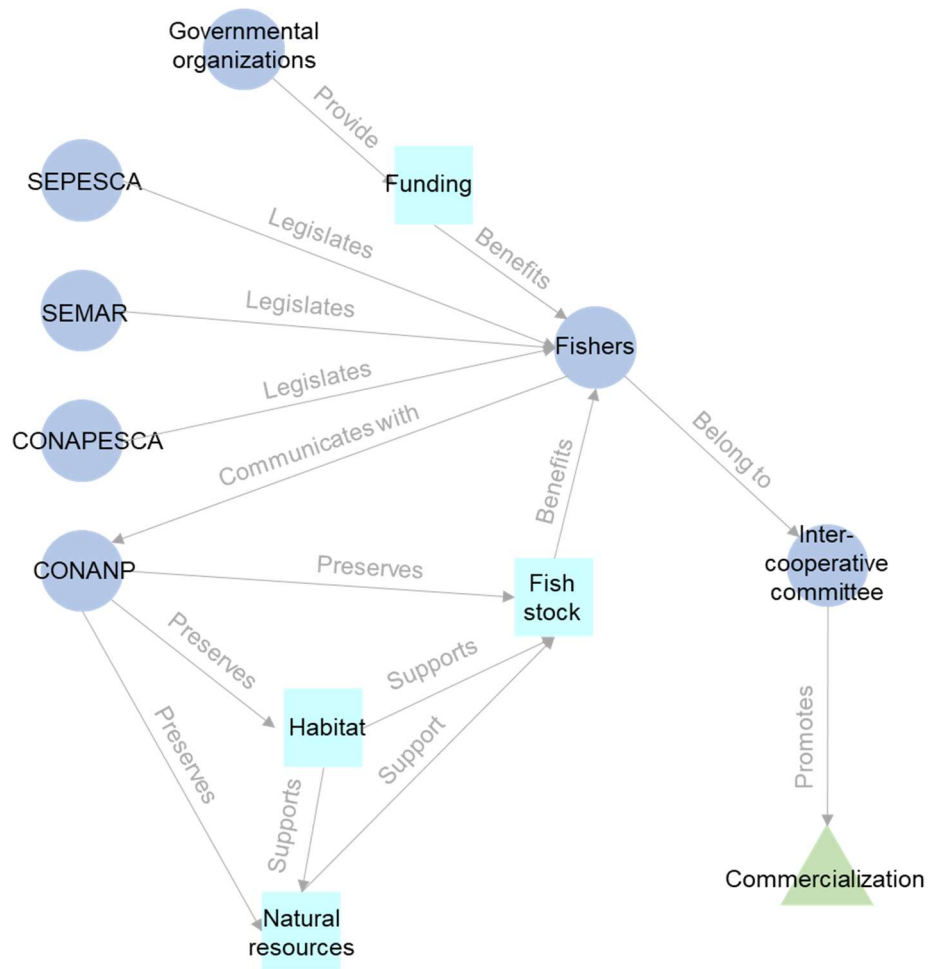**Fig. A3.4.** Individual mental models of four government agencies' representatives
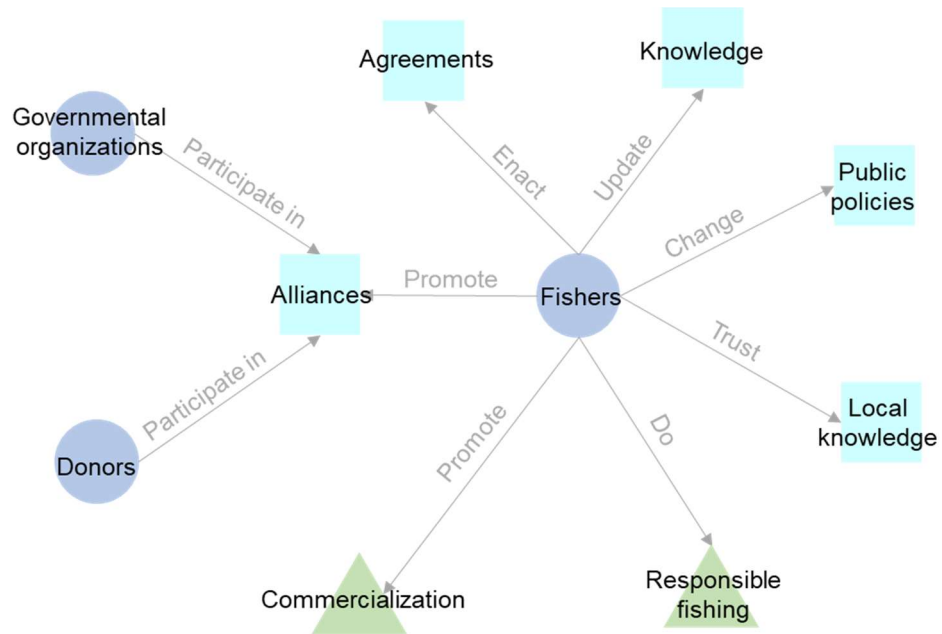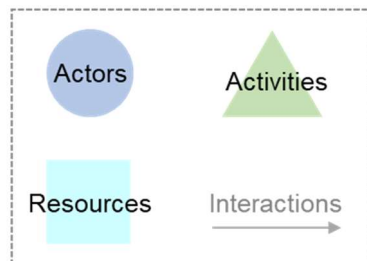
a) NGO1

b) NGO2

c) NGO3

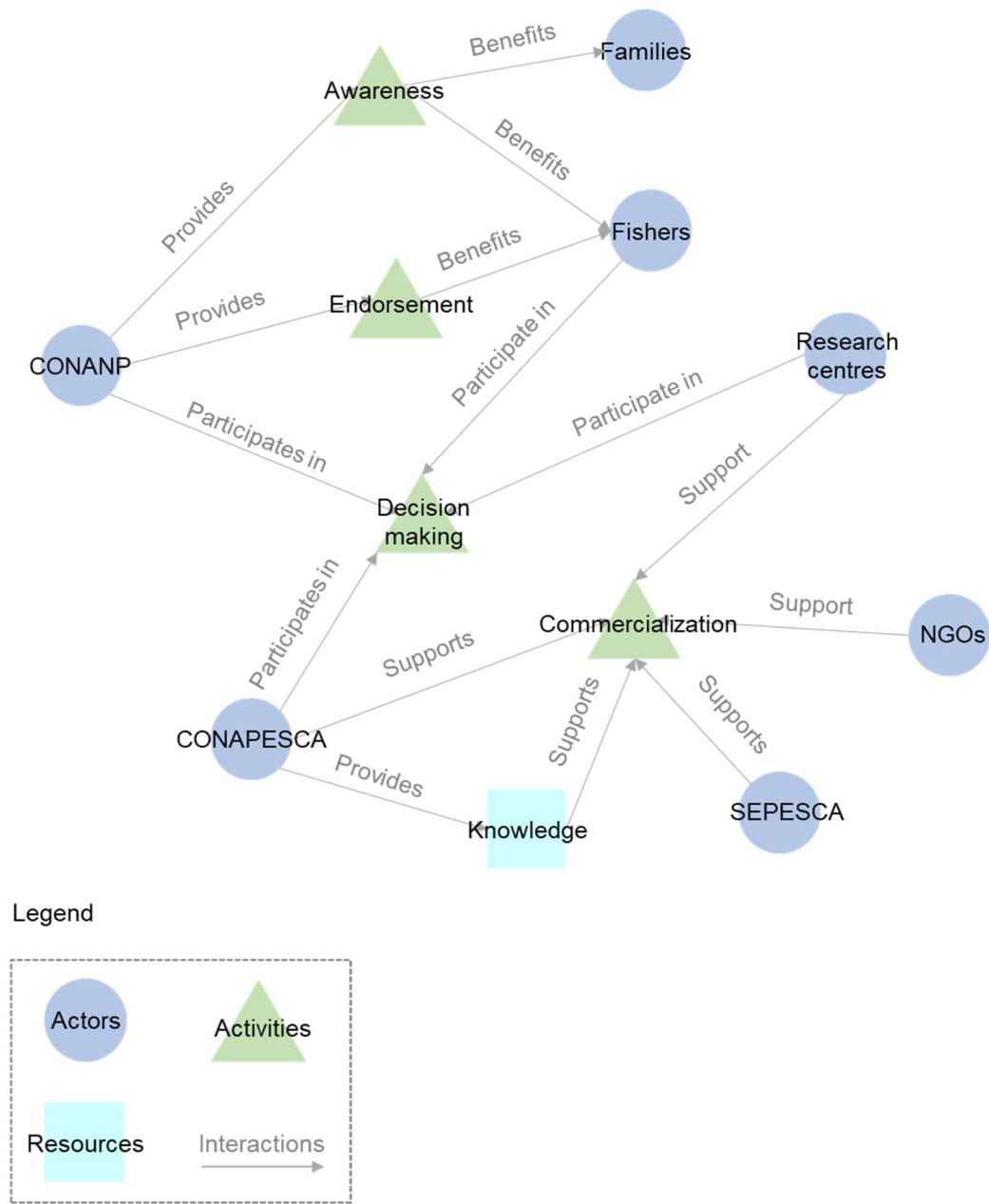**Fig. A3.5.** Individual mental models of three NGOs' representatives

Fig. A3.6. Individual mental model of a research centre's representative