Analyzing the Santa María Bay through the Social-Ecological System Framework

Identifying leverage points for sustainability in La Reforma, Sinaloa

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LUCSUS
Lund University Centre for Sustainability Studies

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Abstract: 262 words

Small-scale fisheries are highly important in terms of economic productivity and environmental relevance in Mexico's Northwest. The Santa María Bay (SMB), in Sinaloa, México, is the largest bay in the state and is highly productive in terms of fishing and the economic activities derived from it. It is also home to endemic species and the region's largest mangrove wetland. It faces environmental and social threats and the communities that rely on the common-pool resource are vulnerable. La Reforma, one of the four small-scale finishing communities in the bay, is the focus of this case study. In this community a local NGO – SUCEDE – works toward sustainability in the Santa María Bay.

This thesis' objective is to study and analyze the Santa María Bay as a social-ecological system to find leverage points to increase the system's sustainability through SUCEDE's work. I collect qualitative data by conducting 6 semi-structured interviews. I analyze my data by applying common-pool resource (CPR) theory and the social-ecological systems framework (SESF) as an analytical tool to find the most relevant variables in the system. I explain the implications of the variables' interactions and outcomes and, focusing on the most relevant ones, I look for leverage points that can improve said them and advance sustainable development in the SMB.

I find three of SUCEDE's existing projects that have high likelihood of improving the SES's negative outcomes and propose two new interventions that can further advance socio-economic and sustainability. This study shows SUCEDE can increase a community's likelihood to organize towards socio-economic and ecological sustainability by intervening where change is most efficient.

Key words: Socio-ecological system, Socio-Ecological Systems Framework, Santa María Bay, small-scale fisheries, common-pool resources, leverage points.

Word count (thesis):11,627

Note to the reader:

Horrible things make international headlines about my home state of Sinaloa. While many of them are true, Sinaloa is also home of beautiful beaches, rich valleys and majestic peaks. With this thesis I hope to make a piece of work that speaks about some of the positive aspects I find that make proud of being a Sinaloense.

Figure 1. La Reforma (Source: Author, Feb 26, 2020)

Acknowledgements

What a ride, finishing a masters in the middle of a global pandemic.

To start with, I want to acknowledge that it was thanks to the support from the CONACYT-Sinaloa scholarship that I got the privilege of completing this program. Also, thanks to the Swedish International Center for Local Democracy (ICLD), whose support helped me carry out the fieldwork for this thesis project.

Many people helped me in this process. Firstly, thank you to everyone in La Reforma who received me so warmly and taught me so much; especially to Rubén, Astrid and Beto.

Torsten, thanks for pushing me over the finish line with your great guidance. You were right, it doesn't get easier if you wait to hand-in in the fall! And Marisol, thank you for your help and positive support. I couldn't have finished without your help.

To my partner from afar, Kat, thanks for all the fun encouragement. We can finally go ride our bikes!

To all my friends who encouraged me while I struggled; thank you from the bottom of my heart. Especially to my family, who have never failed to cheer me on when I feel like I'm in over my head. I wasn't the most pleasant to have around during lockdown, but you can't not love me! Thanks for always believing in me. And Agus, thanks for being my number one supporter and thesis-fuel-baker throughout this whole process (even if it seemed like I didn't want your help).

I never thought I could learn and grow so much… Then, LUMES changed my life forever. To my LUMES family, now scattered all over the globe: you will forever have the most special place in my heart, you are the most amazingly diverse people I've had the privilege to learn from. Thank you for broadening my perspective and for filling me with hope for a better world.

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List of Abbreviations

CCPC	Consejo cívico de Participación Ciudadana (Civic Council for Citizen Participation)
CPR(s)	Common-pool resource(s)
CONAGUA	Comisión Nacional del Agua (National Water Commission)
CONEVAL	Consejo Nacional de Evaluación de la Política de Desarrollo Social (National Council for the Evaluation of Social Development Policy)
NGO(s)	Non-governmental organization(s)
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Acuacultura de México (Mexico's Agriculture, Animal Husbandry, Rural Development, Fishing and Aquaculture Department)
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales de México (Mexico's Environment and Natural Resources Department)
SES(s)	Social-ecological system(s)
SESF	Social-ecological system framework
SMB	Santa María Bay
SUCEDE	Sociedad en Acción de Sinaloa (Sinaloa Community in Action)

1. Introduction

1.1 The challenges of small-scale fisheries and La Reforma

Fisheries are complex social-ecological systems which make up the main source of livelihood for more than 50 million people in the world (Finkbeiner & Basurto, 2015; FAO, 2018). Around 90% of the worlds' fisheries are considered small-scale fisheries, defined by the FAO (FAO, 2004, p.3) as a "…dynamic and evolving sub-sector of fisheries employing labor-intensive harvesting, processing and distribution technologies to exploit marine and inland water fishery resources".

Fishery systems are the object of global concern. Fish yields are declining in the world's fisheries; the number of fisheries beyond maximum sustainable yields keeps rising with an alarming 94% of all stocks are either overfished or at capacity (FAO, 2018). Changes in land use and the impacts of climate change – like shifts in precipitation and freshwater availability, habitat degradation and ocean acidification –exert further stress on the world's fishery systems (Daw, Adger, Brown, & Badjeck, 2009; Robert W. Kates & Parris, 2003).

Around the world, small-scale fishing-dependent communities often fall at low living standards despite fruitful economic production and growth at national levels that result from fishing activities (FAO, 2018).

Such is the case for La Reforma; a small-scale fishery in the state of Sinaloa along the Pacific coast in Northwestern Mexico. La Reforma is located in the Santa María Bay (SMB) – the case study area of my thesis. In La Reforma, fishing has been the most important economic activity since the first known settlements were started back in the early 1910s (Amezcua, Madrid Vera, & Aguirre Villaseñor, 2006; García Rodríguez et al., 2017). It has been a productive fishing community within a very productive bay, reporting an average yearly shrimp catch valued at 315 million pesos (14 million USD) between 2010 and 2014 (adjusting for inflation) (SAGARPA, 2017). Nonetheless, Reformenses[1] find themselves in a lock-in situation: despite a prolific main economic activity, welfare, social indicators and living conditions in La Reforma have not improved. Further, García Rodríguez et al. (2017) highlight that the

[1] Reformenses: how inhabitants or natives of La Reforma are called

current population growth rate is bringing “urban” issues, such as alcohol and drug consumption, and housing scarcity to La Reforma.

The Santa María Bay is undergoing ecological and social transformation that increases the vulnerability of its local population and decreases the resilience of the ecosystem. There is illegal and underreported catching of its main resource, shrimp, as well as fish, crab and shark. Changes in freshwater inflows, increases in salinity, and loss of mangroves and marine wetland areas affect marine flora and fauna. According to the National Water Commission (CONAGUA) the SMB is the seventh most polluted coastal lagoon in the state – from a total of 33, and in the area surrounding La Reforma, there are high concentrations of organic and fecal matter that negatively affect water quality (García Rodríguez et al., 2017; Villa Castro, 2019).

1.2 SUCEDE’s interventions in La Reforma

SUCEDE (*Sociedad en Acción de Sinaloa* - translates to: Sinaloa Community in Action) is a local NGO that started work in La Reforma in 2017 (Bien Informado, 2018a, 2018d). Their work is aimed at protecting and restoring the SMB and the community in La Reforma through “educating the population in more conscious resource-use practices, the protection of marine species, respect for the periods of closure and custody of the bay and its surroundings” (Bien Informado, 2019a, para. 6). SUCEDE’s objective is to promote the sustainable development through enhancing people’s capabilities to take part in more resource-conscious activities and more easily transition towards climate change adaptation and mitigation strategies (Bien Informado, 2019a).

SUCEDE’s work in La Reforma ranges from social strengthening dynamics, workshops for alternative livelihood opportunities for women and English lessons for kids, to environmental restoration efforts such as an oyster reef restoration initiative and mangrove protection campaigns (Bien Informado, 2018a). Hence, their work targets social and environmental issues in La Reforma and the SMB. Further, SUCEDE’s aims align with the improvement of the contradicting conditions of social stagnation and environmental threats within a prolific fishery described above.

La Reforma exemplifies a common issue in many small-scale fisheries: previously abundant resources that decrease due to fragile socioeconomic realities, and thus increase environmental vulnerability. SUCEDE’s work can potentially put in motion the systemic change needed to foster a more socially and ecologically sustainable environment in La Reforma and the SMB.

1.3 Research objectives

The aim of my thesis is to contribute to SUCEDE's work towards social and environmental sustainability in La Reforma. I do so by studying and analyzing the Santa María Bay as a socio-ecological system. By applying Common-Pool Resource theory, I use the Social-Ecological System Framework (SESF) as an analytical tool to look into the system's variables, their interactions and outcomes, and to identify leverage points for potential improvement.

To answer said objectives and aims I will answer the following research questions:

1- *How is the Santa María Bay characterized as a social-ecological system?*
2- *What are the outcomes of the subsystem's interactions in the social-ecological system?*
3- *What are the potential leverage points by which SUCEDE can help improve social and ecological sustainability in La Reforma and the SMB?*

1.4 Relevance and contribution to the field of sustainability science

This case study contributes to sustainability science by bridging CPR theory with practice through applying a sustainability science framework – the SESF. By applying this framework to a specific case study I am analyzing the "fundamental character of interactions between nature and society… to guide those interactions along more sustainable trajectories" (Kates et al., 2001, p.641), which is the core of this scientific field. By incorporating the NGO's interventions I am steering this study into transformational sustainability research, looking for actionable knowledge for the sustainable development of the SMB (Wiek, Ness, Schweizer-Ries, Brand, & Farioli, 2012).

2. Background

In this section I set the context of my study site and the problem around it by delving deeper into the issues presented in the previous section. I start by providing context about the state of Sinaloa, its socioeconomic situation, and fishing as an economic activity. Then I move on to the SMB and La Reforma, to describe the context in regard to the fishery, the environmental system and its relevance, and the social issues in the area. I finish by presenting SUCEDE and their work in the area.

2.1 Sinaloa

Figure 2. Location of the state of Sinaloa along the Pacific coast and the Occidental Mountain Range in the northwest of Mexico (Source: Author, 2020 with data from INEGI 2015).

Sinaloa is a state in Northwestern Mexico that is bordered to the east by the Occidental Sierra Madre Range and to the west with the Pacific Ocean, as seen in Figure 2. Sinaloa has a population of 2.9 million people (2.4% of total national population) and contributes roughly 2% to Mexico's national GDP (INEGI, 2015b). The most important economic activities are agriculture, fishing, livestock commerce and industry; Sinaloa is recognized nationally for being the top food producer in Mexico (INEGI, 2015b). In terms of fishing, Sinaloa is the country's main fishery producer in terms of value; it

makes up 30% of the national total, and it is the second state in terms of net production, contributing to 19.36% of the national total production (Bien Informado, 2018a; SAGARPA, 2017). The value of Sinaloa's seafood catch has grown in recent years, from 3.5 billion pesos ($258 million USD) in 2009 to 9 billion pesos ($489 million USD) in 2017 (SAGARPA, 2017).

Sinaloa has some deficiencies in other social and economic aspects. The state's population living below the poverty line has increased by approximately 29,000 people every year since 2010; from 36.7% of population in 2010 to 39.4% in 2014 (Fuentes, 2016). While the rest of the Mexico become less unequal – the Gini coefficient decreased by 5.9% at a national level – Sinaloa has become more unequal. Inequality in Sinaloa has increased by 4.3%, with the Gini coefficient going from 0.428 to 0.446, from 2016 to 2018 respectively (CONEVAL, 2020). Inequality represents income (wealth) distribution amongst Sinaloa's population and the most disadvantaged part of the population is not receiving the economic benefits from the prolific fishing and food-producing industry in the state (CONEVAL, 2020).

Despite being the most important food producer in Mexico, 29% of Sinaloa's population was still food insecure[2] in 2015 (Fuentes, 2016). According to CONEVAL, the state's population lacking access to food increased 1.8% from 2008 to 2018 (CONEVAL, 2020).

2.2 Santa María Bay

The bay is a lagoon-estuarine system on the Pacific coast, in the center-north region of the state, along the Gulf of California (Amezcua et al., 2006). It stretches across three municipalities: Guasave, Navolato and Angostura (Acosta Velázquez & Vázquez Lule, 2009). It covers an area of 95,500 hectares and is of high environmental importance (CONANP, 2012; García Rodríguez et al., 2017).

[2] People whose access to nutritious and sufficient food is not stable, according to guidelines set by federal authorities at CONEVAL

Figure 3. Location of the Santa María Bay. The official area of the bay is highlighted in yellow in the lower left corner. (Source: Author, 2020 with data from INEGI 2015).

The SMB is the most important mangrove wetland of its kind in Mexico's northwest and the largest wetland in Sinaloa, shown in orange in Figure 3 (Acosta Velázquez & Vázquez Lule, 2009; CONANP, 2012). It encompasses natural protected areas – 82% of the mangrove area is categorized as "important area for bird conservation", 60% of the mangrove area is a Ramsar site which deems the wetland of international relevance for conservation, and 13% of the mangrove area is a National Protected Area placing the outmost important protection level at a federal level in Mexico (Acosta Velázquez & Vázquez Lule, 2009).

The bay has rich biodiversity: the most significant fauna is the blue-footed booby (*Sula nebouxii),* the laughing seagull (*Leucophaeus atricilla*), the American oystercatcher (*Haematopus pillates),* as well as the olive ridley sea turtle (*Lepidochelys olivacea*) and the California sea lion (*Zalophus californianus)* (Acosta Velázquez & Vázquez Lule, 2009; Bien Informado, 2018b). In terms of flora, four species of endangered mangrove can be found (*Rhizophora mangle, Avicennia germinans, Laguncularia*

racemosa and *Conocarpus erectus)* categorized as endangered by Mexico's Environment and Natural Resources Department (SEMARNAT) (Acosta Velázquez & Vázquez Lule, 2009).

2.3 La Reforma

The focus of my research is La Reforma, a fishing community in the municipality of Angostura, Sinaloa. This settlement is the largest settlement within the four small-scale fishery communities in the SMB (see Figure 3) (Bien Informado, 2019). As of 2015 – the last official census – it has a population of 6,846 inhabitants (INEGI, 2015a).

Salinity conditions in La Reforma, which are modified due to freshwater inflow to the estuaries, make for an optimal environment for abundance of shrimp (García Rodríguez et al., 2017) as well as crab, mullet and dogfish that support the local fishery (García Rodríguez et al., 2017).

Overfishing, illegal fishing, and under-reporting of harvesting, are among the causes of resource depletion in the community (García Rodríguez et al., 2017; Villa Castro, 2019a) but SAGARPA ranks Sinaloa as the number 1 fishery and aquaculture production state in Mexico (SAGARPA, 2017).
Water quality in La Reforma's coast is not optimal. Recent water-quality studies conducted by Ramírez López and Sánchez Rodríguez (2017) confirm the presence of ammonium, nitrites and phosphorous nutrients. The bay also has low levels of dissolved oxygen, high organic matter concentration (Ramírez López & Sánchez Rodríguez, 2017), all of which are characteristics of low water quality. Fishermen attest to this by reporting higher fish mortality attributed to high organic matter presence, large algae blooms and general eutrophication in water in La Reforma (García Rodríguez et al., 2017; Villa Castro, 2019a).

The socioeconomic indicators: education, school attainment, teenage pregnancies, and housing, in La Reforma underline a lack of economic development. La Reforma has one primary school, where according to the 2019 standardized PLANEA test; 46% and 66% of students scored in the lowest bracket for achievement in language and math, respectively (INEE, 2018). Dropouts are caused mainly by young people getting married, pregnancies in young girls, and young men deciding to venture into fishing, or leaving La Reforma, instead of staying in school (Villa Castro, 2019).

Most housing in La Reforma lacks access to some basic service; less than 30% of households have proper sewage systems or electricity, and still 28% of them are not built with durable materials and

are highly vulnerable to flooding (from a total of 5597 houses registered in 2015) (García Rodríguez et al., 2017).

Although there is no available data about food insecurity at a local level, at the municipal level, 25.5% Angostura's population was reported to be food insecure in 2010 (CONEVAL, 2010). Assuming that data for La Reforma is similar to municipal statistics; these figures are particularly relevant given that it is a community where fishing resources exist. Here, food scarcity represents a lack of access to good sources of food which at the same time can points to a larger social issue.

2.4 SUCEDE in La Reforma

SUCEDE's director, Ruben Rojo, is the local high school principal. He has been playing an important role within the community since his arrival in La Reforma back in 2015, before joining SUCEDE. SUCEDE has been working in the community with the mission of increasing environmental awareness among Reformenses (Bien Informado, 2019b), as well as developing concrete environmental restoration projects, specifically an oyster bank to improve the Bay's water quality standards (Villa Castro, 2019). They organize workshops with Reformenses to raise environmental awareness and educate them on the negative impacts human activities can have on the SMB, highlighting the importance of its conservation in the face of climate change (Bien Informado, 2019b).

In terms of environmental-conservation interventions, SUCEDE has undertaken mangrove reforestation actions in Altamura island – the barrier island that separates SMB from the Gulf of California as seen in Figure 3. These mangrove forests are a key habitat for migratory and native birds (Bien Informado, 2018d).

Furthermore, SUCEDE plans to tackle water quality issues by replenishing areas in the SMB with oysters. This project stared in 2018 and is in its initial stages, it aims to counteract eutrophication through nutrient-sequestration. Several studies point to oyster beds (and other bivalve shells) as effective bio-filters, as estimates calculate they can remove nitrogen, phosphorus, carbon and other nutrient-pollutants and significantly enhance water quality at a rate up to 10 liters of water per hour, removing pollutants by assimilating them into their shells and tissues (Higgins, Stephenson, & Brown, 2011; Kellogg, Cornwell, Owens, & Paynter, 2013).

As a small, local level NGO they face challenges and have opportunities for improvement in achieving their goal of promoting sustainability in the SMB; both of which are uncovered and discussed further in this thesis.

3. Theoretical and conceptual framework

In this section, I describe the theoretical and conceptual frameworks I followed to answer my research questions. I start by describing Common-Pool Resource Theory (CPR), followed by the Social-Ecological Systems Framework (SESF), which I use as a conceptual and analytical tool.

3.1 Common-pool resource theory

In 1968, Garrett Hardin explained that when multiple users share a common unregulated resource, each user acts on their own best interest and the resource results being depleted: a situation known as "the tragedy of the commons" (Schlager, 2004). Hardin proposed control and privatization of the commons as the solution to the dilemma (Heenehan et al., 2015). Since then, scholars – amongst them, Elinor Ostrom – have found hundreds of cases in which users successfully cooperated and developed rules to limit and coordinate the use of common pool resources, without resorting to Hardin's notions of control (Schlager, 2004). From here, Common-Pool Resource Theory emerged as a field of study, centered around the successful human use of CPRs, cooperation and user's abilities to coordinate and successfully govern the commons. It has since become the base for a very important field of environmental management (Schlager, 2004). It is often applied to analyze the usage of extractive forms of natural resources such as fisheries (Heenehan et al., 2015).

Ostrom argues that CPR dilemmas occur when individual actors fail to coordinate their actions and consequently these actions bring negative outcomes to the rest of the actors (Schlager, 2004). Positive outcomes can be achieved if all actors work within rules and limitations that benefit all resource-appropriators. CPR theory helps identify conditions under which users are likely to cooperate towards successful governing arrangements (Schlager, 2004) and self-organization for long-term cooperation around CPR (Ostrom, 1990). Ostrom's (1990) theory highlights eight principles by which long-term cooperation is more (or less) likely to happen. In more recent work deriving from CPR theory, Ostrom modified and incorporated these attributes into the Social-Ecological Systems Framework (SESF) (Heenehan et al., 2015; Ostrom, 2009). She highlights ten variables from the SESF that affect the likelihood of users to engage in collective action to organize in the use of CPR: size of the resource system, productivity of the system, predictability of system dynamics, resource unit mobility, number or users, leadership, norms/social capital, knowledge of the SES, importance of the resource to users, and collective action rules (Ostrom, 2009).

3.2 Social-Ecological System Framework

Linking proper, sustainable CPR use with economic development, has to be done recognizing the complex interconnections between the ecological aspect of resource-use, socioeconomic concerns and local involvement (Young, 1999). The SESF, developed by Ostrom (Ostrom, 2007) and further elaborated on by McGinnis and Ostrom (2014), is "…a tool to confront interdisciplinary puzzles that bridges the gap between social and ecological research" (Manfredo, Rechkemmer, Duke, & Vaske, 2014, p.xxii). It can help analyze information from different fields in an organized and integrative way (McGinnis & Ostrom, 2014) which "treats the social and ecological systems in almost equal depth" (Binder, Hinkel, Bots, & Pahl-Wostl, 2013, p.12).

The framework aims to identify the components that make up each **variable** and the interactions amongst them. The first-tier variables, also called subsystems, are: Resource Systems (RS), Actors (A), Resource Units (RU), and Governance Systems (GS); these result in social-ecological Interactions (I) and Outcomes (O) (McGinnis & Ostrom, 2014). The framework explains the way resource users are influenced by various forms and levels of governance and it is applicable at different scales (McGinnis & Ostrom, 2014). As seen in Figure 4, the SESF clearly shows links between the variables, drawing a path to follow the direction of influence between them. Furthermore, it shows that the 'action' happens in the center subsystem 'Focal Action Situations', where "inputs are transformed by the actions of multiple actors into outcomes" (McGinnis & Ostrom, 2014, Fig.2). This makes the SESF a great conceptual and analytical tool by which to apply the CPR theory to complex systems with related subsystems and variables, as happens in the SMB.

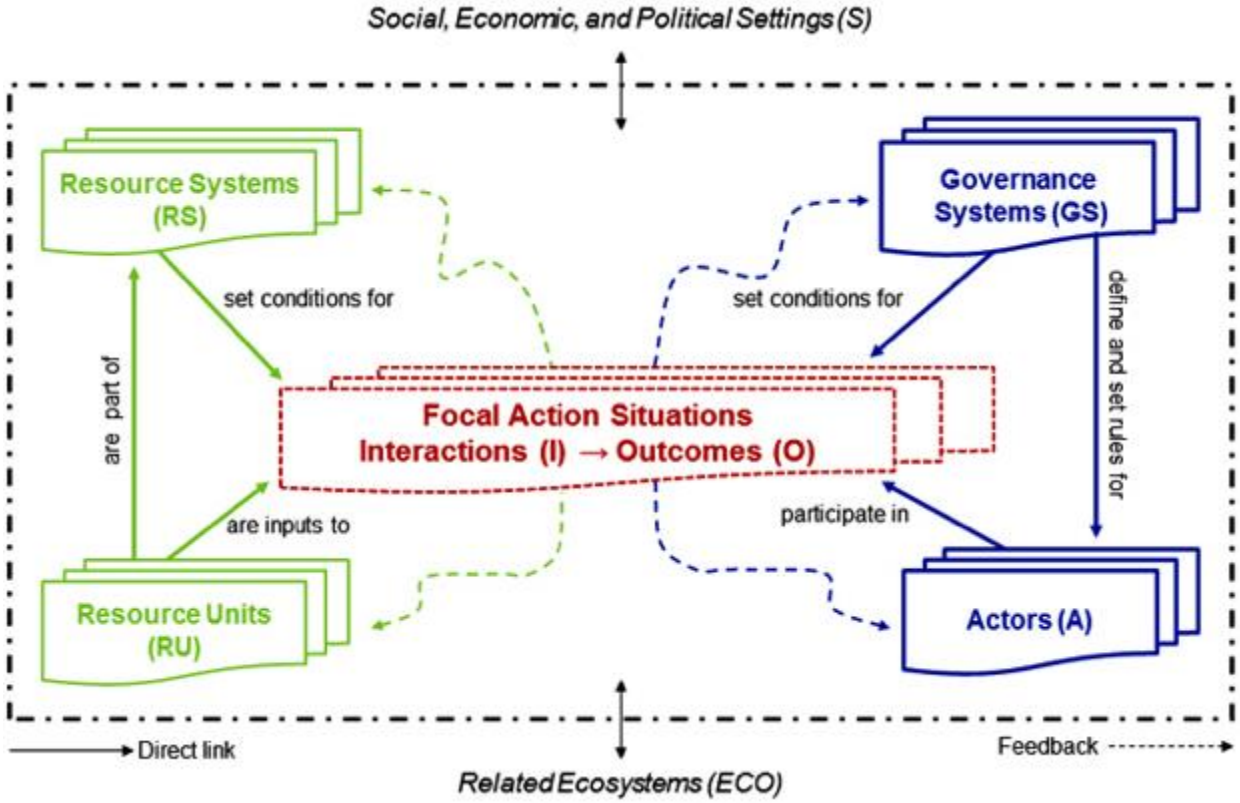

Figure 4. Revised social-ecological system framework (McGinnis & Ostrom, 2014).

The aforementioned subsystems are made up of second-tier variables (McGinnis & Ostrom, 2014), McGinnis & Ostrom's full list of second-tier variables can be found in Appendix A. Different authors have added third-tier variables when they deemed more specific description of the variables was needed (Delgado-Serrano, 2015). Lower tier variables may be more or less relevant depending on the SES in question; so they may be used, or not, in accordance to the particular SES.

I apply the theoretical and conceptual frameworks described here to this study of the Santa María Bay. As mentioned in section 3.1, Ostrom (2009) identified the ten key variables that affect the likelihood of actors' organizing towards more sustainable resource-use. These ten variables – referred to in this thesis from now on as 'Ostrom's key variables' – have a central role in my research as a bridge between the theoretical and conceptual frameworks by which I guide my research, data collection and analysis. My interview-guiding questions were based on the SESF variables with a special focus on Ostrom's (2009) key variables, since they highlight the element of self-organization for cooperation in CPR systems.

Both the ecological and the social dimensions of CPR management need to be considered in decisions towards sustainability (Folke, Hahn, Olsson, & Norberg, 2005). Therefore, the SESF is an appropriate tool to deal with the system's complexity and I will be applying it to characterize the social-ecological dynamics in the SMB, and through this analysis answer my research questions. Furthermore, I acknowledge this framework's limitations in its lack of direction for its implementation and thus the difficulty to apply it operationally (Binder et al., 2013; Delgado-Serrano & Ramos, 2015). The flexibility in its implementation though allows me adapt it for my case study.

4. Methods

In this section, I describe the design and methodology that I put together and followed to answer my research questions and analyze my qualitative data.

4.1 Research design

My research design is based on the case study of the SMB; the nature of a case study is to be "concerned with the complexity and particular nature of the case in question" (Bryman, 2016, p.66). I found this to be the research design most suited to answering my research questions, and it was flexible enough to deal with the particularities of the SMB and the community of La Reforma.

I take a relativist ontological position with a constructivist approach to my research; by which I recognize that reality is socially constructed (Bryman, 2016) in this specific case, by my interviewees' accounts. My research follows an abductive line of reasoning; departing from observation with the purpose of creating a broader understanding, looking for plausible explanations for social (in this case social-ecological) phenomena (Given, 2008) and taking into consideration the social perspectives of my informants as unit of analysis (Bryman, 2016). My informants' and my own understandings, interpretations and inferences of reality are central to my study.

Additionally, I draw on grounded theory to generate concepts derived from my data in an iterative way, also related to constructivism (Bryman, 2016) going back and forth from the collected data to CPR theory in the analysis – detailed in section 4.4.

4.2 Research method

I used a mixed methods approach for this case study in order to collect the relevant qualitative data to inform my SES analysis. First, I started with a literature review in preparation for field work by which to inform myself on my case study. I researched similar academic publications covering fisheries in the Gulf of California, systems thinking, social-ecological systems and the socio-ecological system framework, as well as grey literature relevant to Sinaloa and the SMB. This form of data collection was initially intended to inform my introduction and background sections. However, as part of the iterative process, information from grey literature and local newspapers also informed my analysis and results where data collected from interviews was not sufficient. I also conducted non participatory observations and semi-structured interviews, which are described in detail bellow in section 4.3. Using

varied data collection methods helped increase the validity of my research and the depth of my analysis by information triangulation (Bryman, 2016).

4.3 Fieldwork - data collection

As the first step to the data collection phase, I made contact with Rubén Rojo from SUCEDE in November, 2019. He agreed to function as my gatekeeper, letting me work in close contact with SUCEDE, introducing me to the community in La Reforma and helping me conduct my research. After our initial conversations I proceeded to plan my field work for data collection. My fieldwork lasted a total of 11 days; divided in five field visits as described below in Table 1.

4.3.1 Non-participant observation

In an initial stage of my data collection, I conducted non-participant observations, a type of observation in which the observer does not directly interact with the participants (Bryman, 2016; Given, 2008). I chose to conduct it as a first approach not because I was not able to make contact with people in La Reforma, but because I wanted an easier transition into the community. Initially, I spent time adjusting by going on observation walks, drawing from ethnography (Bryman, 2016), to find my way around and get acclimated to the place. I remained in my role as non-participant observant as much as possible and limited note and picture taking in this stage. I collected my observations, impressions, and thoughts in a field journal (example of the journal on Appendix B). The observation days in the field helped me determine my interview subjects and informed my interview guides. I got to know the place, the surroundings, and to feel at ease within the community before I proceeded to asking questions. I then established contact with relevant individuals to interview. In Table1 below I describe my field visits, date and location, and a brief description of the main activity undertaken in each of them.

4.3.2 Semi-structured interviews

In a second phase of data collection, I conducted in-person semi-structured interviews with key informants (Table 1). My sampling method was both purposive and by snowball sampling (Bryman, 2016) in order to select interview subjects that would provide relevant, information-heavy data. Following the information trail, together with advice from the gatekeeper and the locals, I selected interviewees according to the snowball sampling technique (Bryman, 2016), focused on recruiting subjects based on their knowledge and involvement in fishing and La Reforma's society.

CPR theory and the SESF were useful when conducting fieldwork; they helped guide my focus while observing and interviewing, narrowing-in on the relevant information about the SESF subsystems and Ostrom's key variables, as well as directing my interview-guiding questions (found in Appendix C). The interviews were conducted during 5 field visits carried out throughout the months of February and March (Table 1), except for the ones done through phone and Zoom. In all instances, both in-face and virtual, audio was recorded with the interviewees' knowledge and authorization for later analysis.

This phase of data collection was interrupted by the COVID-19 pandemic and, when resumed, the communication channel had to be over the phone and via Zoom, as described in Table 1.

Table 1. Field-work, interviews and interviewee description table.

	Description	Location	Date	Interviewee ID	Interview date and Interviewee Description
0	First meeting with SUCEDE staff (gatekeeper).	Culiacán, Sinaloa.	February 10, 2020	No	
1	First field visit, alone walk for non-participant observation. Interview with Interviewee 1.	La Reforma, Sinaloa.	February 18-19, 2020	Interviewee 1	February 18, 2020 SUCEDE member closely integrated in La Reforma and in the fishing community.
2	Field visit #2, more observation and observation walk.	La Reforma, Sinaloa	February 25-26, 2020	-	
3	Field visit #3, bay excursion with fishermen and SUCEDE.	La Reforma, Sinaloa and Santa María Bay	March 3-4, 2020	-	
4	Field visit #4. Visited the shore and the docks. Talked to Interviewee 2.	La Reforma, Sinaloa.	March 10-12, 2020	Interviewee 2	March 11, 2020 La Reforma local, born and raised. Member of a fishing cooperative
5	Last field visit #5 (before COVID). Visited the local school. Talked to interviewees 3 &4.	La Reforma, Sinaloa	March 18-19, 2020	Interviewee 3	March 18, 2020 La Reforma local, born and raised. Indirectly but very closely related to fishing activities, member of the CCPC. Active member of society and the communities education.
				Interviewee 4	March 19, 2020 La Reforma local, born and raised. Indirectly but closely related to fishing activities, member of the CCPC and active member of society.
6	Zoom interview with SUEDE member	Zoom call	May 6, 2020	Interviewee 5	May 6, 2020 SUCEDE member.
7	Phone interview with Reformense	Phone interview	August 2, 2020	Interviewee 6	August 2, 2020 La Reforma local, born and raised. Head of a fishing cooperative.

4.3.3 Limitations and ethical considerations

Considering my ontological and epistemological positioning, I remained reflective of the implications of socio-cultural differences between myself and Reformenses; values, biases, and methods, and the implications they could have (Bryman, 2016). I presented myself as a student and was transparent about my research and its objective, especially it not being a prescriptive work (i.e. CPR management strategies or sustainable harvesting models) and the use of the information gathered, as well as the interviewees' anonymity. Since my approach was established through Ruben Rojo – the gatekeeper – I also disclosed that I was independent from SUCEDE and their projects. Social-distancing measures due to the COVID-19 pandemic interrupted my fieldwork and the last interviews were done by Zoom and phone, this alternative data-gathering method has other limitations that can affect the level at which the interviewee opens up (Bryman, 2016), I addressed this as best as possible.

4.4 Data analysis

My theoretical and conceptual frameworks guided my data analysis in the following way. Tackling the SESF's limitations mentioned in section 3.3, I take McGinnis and Ostrom second-tier variables (with special focus on Ostrom's key variables for CPR cooperation (2009)) and add Delgado-Serrano & Ramos' (2015) third-tier variables whenever another level of specificity is suitable. Then, for more clarity for the analysis, I categorized the original subsystems into: Ecological subsystems, Social Subsystems, Context-setting subsystems and Action situation subsystems. The latter subsystem (Action situation subsystem) encompasses the interactions and outcomes from the relations between the SES's variables. Within it is the core of my study; where I analyze my interviewee's accounts to identify the SESF variables, their interactions and outcomes and potential leverage points by which SUCEDE can potentially improve sustainability in the system.

To carry out the data analysis, I did thematic analysis of my interview transcripts by extracting core themes that can be "distinguished both between and within transcripts" (Bryman, 2016 p.13). I adapted the use of the thematic analysis to work well with the 'themes' I sought to identify in my data. I took each SES subsystem, considering each second and third-tier variable within them, as a theme: Governance system (GS), Actors (A), Resource System (RS), Resource Units (RU), Interactions (I), Outcomes (O), Related Ecosystems (ECO) and Social, Economic and Political Setting (S). Furthermore,

I added a final theme to encompass the Opportunities I investigate for the second phase of my analysis, adding up to 9 total themes.

The theme coding was done on Scrivener, a text management software that allowed me to manipulate data and operationalize a coding method by which I created tags for each theme. In Scrivener, I could handle and manipulate the excerpts from each of the 9 themes and each transcription independently, or in combination, by theme for a better analysis of my interviewees' accounts.

5. Results and Analysis

This section presents the results from my data collection and its analysis. I organized them in two sections, one building on the other, in order to answer my research questions.

5.1 La Reforma as a Social-Ecological System

Here are the main findings from my data collection, organized according to the SESF. As previously stated in section 3.3, I describe the SESF's most adequate second and third-tier variables from McGinnis & Ostrom (2014) and Delgado-Serrano (2015) in order to answer my research question #1: How is the SMB characterized as a SES?

I define each variable according to my interviewees' accounts and, following the nature of the SESF, the bulk of my analysis in this section is focused on the last subsystem: Action Situation Subsystem.

5.1.1 Context-setting Subsystem

Related Ecosystems (ECO)

This subsystem describes how the SMB connects and relates to surrounding systems (Delgado Serrano, 2015). The most relevant accounts by Interviewee 4 related to this are of pollution and water inflows (ECO2 & ECO3) in which chemicals, runoff from agriculture, and "pollution in general" enters through the mangrove areas and flows into the bay, damaging its ecological state (personal communication, March 19, 2020).

Social Economic and Political Settings (S)

As stated in section 2.3, La Reforma is a small community with a population (S2a) of 6,846. The adjacent communities in the SMB have a total combined population of 3,873 people (INEGI, 2015a) adding up to a total of 10,719 in the rural communities within the SMB. Population is growing in the area, despite out migration (S2e) to agricultural or larger settlements in search for temporary employment during closed season (Interviewee 3, personal communication, March 3, 2020). Reformenses are a relevant social presence in the Bay and the largest group of fishing cooperatives are from La Reforma (Interviewee 3, personal communication, March 3, 2020).

Global and local markets have influenced (S5b) the SES mostly in terms of price and sales volume. Shrimp from La Reforma is exported (mainly to the United States, France, and Vietnam), sold nationally, and consumed locally (SAGARPA, 2017).

5.1.2 Social Subsystem

Actors

This subsystem describes the actors involved in the SES. As stated by McGinnis & Ostrom (2014) it is important to consider third parties who are not direct users of the resource in question. Hence, the second-tier variable Relevant Actors (A1) subdivides into those who directly use the resource (A1a) and those who are not directly harvesting (Indirect Actors A1b), processing or consuming the resource but that, according to McGinnis & Ostrom (2014), Delgado-Serrano (2015) and my research, are important to be considered.

Fishing is the main economic activity in La Reforma and the SMB (A8), and there is full awareness of it as stated by Interviewees 2, 3 and 5.

"Not all of us are fishermen but we all live off fishing. Schools, businesses, everything we have in the community revolves around fishing. If you come [to La Reforma] in May or June, businesses are paused because of the shrimp fishing ban. Everything that there is here, revolves around fishing; direct or indirectly." (Interviewee 3, personal communication, March 3, 2020).

The most relevant direct users in the SMB (A4) are fishermen who work directly extracting the resource. In this study, I consider the small-scale fishing cooperatives as the most important direct actors (A1a1). According to Interviewees 1, 4 and 6 (personal communication, 2020) there are 9 fishing cooperatives in La Reforma and 17 in the SMB; which makes La Reforma the community with the most cooperatives in the SMB. Members of this group work together and collaborate (A6a) to benefit the whole cooperative. Interviewee 6 (personal communication, Aug 2, 2020) informed that some cooperative-members "coordinate and go fishing daily on several boats and they stay out, 'parked' camping, while one boat brings back the catch so that the rest can save fuel and cut costs down for everyone" exemplifying the collaborative behavior from cooperative fishers.

There are also illegal fishermen locally referred to as 'free fishermen' (A1a) who fish without resource-extraction permits; their presence and activities in the bay brings challenges for collaboration with the rest of the community's fishermen. Interviewee 4 (personal communication, March 19, 2020) stated that free fishermen often come from neighboring communities and cities (A2a Demographic

attribute). Interviewee 6 added they often have private sponsors, have more financial resources and better equipment than cooperative fishermen (Socio economic attributes A2) which often causes conflict between the two groups (personal communication, August 2, 2020).

Another indirect actor (A1b) that concerns this study is SUCEDE, which could also fall under the NGO second-tier variable from the Governance System subsystem, but I consider it an indirect actor, since it is key for my study. Similarly, the Civil Council for Citizen Participation is also important as an indirect actor; it is further described in the Governance System subsystem.

Additionally, aquaculture farms are present in the surrounding are of the SMB which, for the purpose of my study, I categorize as direct actors (A1a), even if they do not directly harvest the resource in question (shrimp). However, the farms are an important part of the SES and directly contribute to the Ecological subsystem's condition (described below in 5.1.3) and Interactions resulting from that. Furthermore, 'Del Pacifico Seafoods' is an American seafood processing company involved in the SES, considered as an indirect actor (A1b). The cooperatives and free fishermen supply them with shrimp catch and they process it (mainly freezing and packaging) for export to the United States (Interviewee 1, personal communication, Feb 18, 2020).

Actors demonstrate knowledge about the SES (A7) by referring to their awareness of the importance of the resource, acting on that awareness, changing their harvesting practices, and human-nature relationships (A7a & A7e), as stated by Interviewee 3:

"Things have changed in recent years, how fishermen take care of nature. They used to go and leave behind all their trash. Now they come back with it, they don't leave it out at sea because they have realized it affects the fish and the shrimp… So many of them [the fishermen] have realized these actions benefit themselves in terms of how good the catch is" (personal communication, March 18, 2020).

Small-scale fishers in the SMB use artisanal technology (A9): small boats with single outboard propeller engines, they occasionally attach sails and use cast-nets called 'tarrayas', trawl nets and seines to catch shrimp with within the bay area with mesh no smaller than 3cm (Interviewee 4, personal communication, March 19, 2020). Cooperative members go out to fish and 'park' camping in small islands in the bay, a technique used by fishermen in the region for generations in order to make efficient use of time and fuel (Interviewee 3, personal communication, March 18, 2020).

Governance System

As described by Delgado-Serrano & Ramos (2015) this subsystem describes "the processes through which decisions on SES management are made, implemented, reformed and reinforced" and here I describe the variables that best fulfill this purpose for the SBM.

The government organizations (GS1a) present in the SMB are various and operate at different levels. The federal government is represented through the INAPESCA and CONAPESCA, national-level governmental institutions that branch out of the federal Agriculture and Rural Development Department (SAGARPA). They are responsible for granting fishing and resource use and extraction permits, delimiting fishing protection areas, closed and open seasons (Interviewee 1, personal communication, Feb 18, 2020), which are examples of constitutional rules (GS7). Use-permits granted by federal authorities operate as property-right regulations (GS4): allowing cooperative members to extract resources for commercial purposes within the SMB area. The shrimp closed season starts in late April or early May and lasts until mid-September. Normally dictated by a species-size analysis by CONAPESCA, this year the dates were decided arbitrarily after the federal government cut funds to this monitoring device (Interviewee 6, personal communication, Aug 2, 2020).

The state government's involvement in the SES is through the Sustainable Development State Department of Sinaloa. According to Interviewee 1 (personal communication, Feb 18, 2020) they have been in contact with the local government and SUCEDE, planning to deploy programs to certify 'clean beaches' and they also support SUCEDE's projects in the SMB by pledging to help their projects with donations.

The Civil Council for Citizen Participation (CCPC) is a communitarian organization in La Reforma (GS1b). It is an independent council, made up of volunteers who are voted in by the community, they represent Reformenses before municipal authorities and take on social and cultural responsibilities and activities (Interviewee 2, personal communication, March 2, 2020). This shows the strong social and community network (GS3a &GS3b) and strengthens community cooperation. Fishing cooperatives support the Civil Council's activities when needed: "When we have needed to use heavy machinery to fix our gravel roads the cooperatives give us fuel, lend us a hand and donate money so we can do it. We do things together" (Interviewee 2, personal communication, March 2, 2020) and they work towards the betterment of the community's social aspects, together.

Beyond constitutional rules, cooperatives in this SES follow collective-action rules (GS6) about resource use and management defined at a local level by the resource users themselves (Delgado-Serrano & Ramos, 2015). An example of such is the agreement to not fish during moon quarters:

"They have their own internal agreements; some are based on the lunar phases. When the moon is in quarters, they don't go to fish… No one can forbid it but they know the catch won't be good in those moon phases. So they fish for 10 days straight but they rest when the moon's in its quarters. No laws say they can't go, it's not a law; they just know by experience and they agreed." (Interviewee 3, personal communication, March 18, 2020).

Monitoring and sanctioning processes (GS8) are undertaken by the federal authorities. CONAPESCA (federal fishing regulator) has teams that monitor the validity of use-permits and audit cooperatives to ensure fishing net mesh measurements and equipment are within allowed standards. Fines are applied upon the rule breakers or with expired permits, which progressively increase in severity if not abided (Interviewees 4 &6, personal communication, 2020).

Cooperatives in La Reforma put together a 'surveillance commission' with members of each cooperative, with "inspectors who go out to check and bring order, and watch" against free fishermen who do not abide regulations (Interviewee 6, personal communication, Aug 2, 2020). Further, they have established the agreement to punish, amongst themselves (GS6), whoever uses nets mesh smaller than 3cm or technologies outside the norm, regardless of authorities' involvement. The corresponding sanction being the forfeit of their boat's engine (Interviewee 6, personal communication, Aug 2, 2020).

5.1.3 Ecological Subsystem

Resource Units

For the scope of this study, shrimp is regarded as the main resource unit. Crab, oysters, other mollusks, shark and other species of fish are also caught in the bay, although in smaller quantities or out in open waters (Interviewee 4, personal communication, 2020); and shrimp is the most important resource extracted from the bay; placing the SMB among the top shrimp producers in the country (Interviewee 1, personal communication, Feb 18, 2020).

The reproductive cycle of shrimp is closely related to the lagoon-estuary ecosystem; in late spring shrimp 'release the larvae' and it enters the bay around June with the winds and currents (RU1). The larvae move up to the freshwater inflows and mangroves, where they find organic matter to consume and mature (Interviewee 6, personal communication, Aug 2, 2020).

The value of shrimp depends on the size of the catch, the bigger the shrimp the higher its market value. Nevertheless, its net value has fluctuated over the years (RU4) (Interviewee 6, personal communication, Aug 2, 2020). According to Interviewee 4, in past seasons the market price was so low that fishing was not profitable; but it has been on the rise since its last low. Furthermore, it was directly affected by the number of active fishermen in the bay and depends on the buyers; Del Pacifico buys at the highest price, regardless of the catch-size (Interviewee 4, personal communication, March 19, 2020).

The temporal distribution varies throughout the season, which stretches from September through March (RU7). The daily catch is bigger early in the season; with stories of catches short of a ton (800 to 900kg) close to open waters, and by the end of the season the catch can range around 100 to 200 kg or even less (RU7) (Interviewee 4, personal communication, March 19, 2020).

Resource systems

The SMB delimits the boundaries of this social-ecological system (RS2a) as seen in Figure 3. It measures approximately 95,000 hectares (RS3) and is delimited to the south by the Yameto peninsula and to the north by the end of the Altamura Island, which also separates the bay from the Gulf of California (Interviewee 1, personal communication, Feb 18, 2020).

In terms of boundaries of CPR extraction (RS2c), cooperatives have the internal rule to not fish near the mangroves to allow for reproduction of younger shrimp and other important species (Interviewee 6, personal communication, Aug 2, 2020).

According to Interviewee 1, there were oyster banks in the SMB before, but they were depleted by poorly managed CPR extraction, which led to an imbalance and increase of water pollution in the bay (RS6 & RS6b) (personal communication, Feb 18, 2020). The presence of shrimp farms (RS4) also introduces an excess of nutrients into the water and causes eutrophication, which in turn causes "everything to be in danger except for shrimp, which thrives with the excess of nutrients, but the

system is [off balance], people don't believe it but it will 'burst'" (Interviewee 1, Feb 18, personal communication, 2020).

The productivity of the SMB (RS5) is a recurrent controversial topic. Reformenses claim they catch less shrimp than fishermen did in past generations; and that "there are more cooperatives with more members extracting resources from the bay, there are more outside influences changing the bay" (Interviewee 3, personal communication, March 18, 2020), potentially referring to the shrimp farms and wastewater pollution that negatively affects production and biodiversity in the SMB. "Before, seasons were always good, if people went out to fish, they fished. Now, in recent years, there have been bad seasons, where people go out and do not even earn enough to pay for fuel, much less for food" (Interviewee 3, personal communication, Feb 18, 2020).

5.1.4 Action Situations Subsystem

This subsystem is "where all the action takes place as inputs are transformed by the actions of multiple actors into outcomes" (McGinnis & Ostrom, 2014, p.n.d.). Here I focus the analysis of the system's variables and my interviewee's accounts with complementary information when necessary.

Interactions

Where interviewee accounts show most evidence of Conflict (I4) is between cooperative and free fishermen; with the involvement of free fishermen in the SMB (Interviewee 4 & 6, personal communication, 2020). "They exceed us, they fish and sell in our area without belonging to any cooperative, they go around us and sell without 'registering' their harvest with anyone and without permits" (Interviewee 6, personal communication, Aug 2, 2020).

Additionally, free fishermen use un-regulated technology – using torches to illuminate the water at night and attract more and larger shrimp, which in turn can result in cooperative members obtaining smaller catches. Cooperative leaders organized and spoke to the buyer who bought the illicitly caught shrimp (Interviewee 3, personal communication, March 18, 2020). Judging by the cumulative accounts around this conflict, this approach did not result in lessening the conflict. This account testifies to the lack of law enforcement (GS7) by government authorities (GS1). This also exerts pressure on the shrimp resource (I1). Federal and state authorities should set the conditions for better interactions between Actors and the Ecological Subsystem; legal restrictions and regulations exist in the SMB, but

their enforcement is weak (Irlbeck, 2002). By better enforcing existing constitutional rules, free fishermen's illegal extraction of resources from the SMB could start to decrease, thus improving the cooperative fishermen's harvests as well as the Bay's productivity (RS5).

The SMB's Productivity (RS5) sets the condition for its Harvesting levels (I1); they are directly linked and, as explained before in the Social Subsystem, the harvest levels are perceived to have declined over time in the SMB.

There are discrepancies around harvesting levels and productivity (I1 & RS5). Fishermen state that harvests have decreased (Interviewee 3, 4 & 6, personal communication, 2020). According to (García Rodríguez et al., 2017) Reformenses state that the causes of the seasonal harvest fluctuations are pollution, an increase in cooperative fishers (due to migration from nearby communities) and free fishermen's illegal catch (I1b). A local newspaper reported "senior fishermen tell stories of catching 20 tons of shrimp per boat per season, and sometimes even 800 to 1000 kg in a single day. Now in more recent seasons, boats do not make it to a ton in a whole season" (Bien Informado, 2019a). By contrast, SAGARPA data shows contradicting figures. Shrimp extraction from small scale fisheries in the State of Sinaloa had a compound average growth rate of 7.5% from 2008 to 2017; period during which the population registered with small-scale fishery permits in the state has increased only by 0.7% (SAGARAPA, 2017). Further supporting this, State level data shows that the number of registered shrimp boats increased steadily for two decades from 1988 to 2008 but have had a decrease of 3.5% since then (from 2009 to 2017) (SAGARPA, 2017).

The government's failure at enforcing the rule of law, and their lack of supervision (GS1) mentioned above, fuels political mistrust and doubts about the government's agency. These negative interactions result in self-organizing activities (I7) based on collective-action rules described in the governance sub-system (GS6). These are not directly a resource-related activity per se, but they relate directly to the resource system's conservation and quality. Monitoring rounds (I9) carried out by the 'surveillance commission' and the self-imposed agreed upon bans (e.g. no fishing during moon quarters) and sanctions are examples of self-organizing activities by cooperative members. The Civil Council for Civic Participation also undertakes this kind of self-organized activities in which different actors participate (Partnership and Cooperation I8c); such as beach clean-ups and road paving that bring together fishermen and community volunteers (Interviewee 2, personal communication, March 11, 2020). This

example of community action towards positive CPR management results from the overlap of Ostrom's key variables for self-organization (2009).

In terms of information sharing (I2), results show a disconnect between direct and indirect actors (A1a & A1b) – this is a significant flaw in the information sharing interaction amongst them. Interviewees 1, 2 & 5 have close contact with SUCEDE (A1b) and they appear to have an idea of what the community needs and wants. On the other hand, Interviewees not related to SUCEDE (Interviewee 3, 4 & 6, personal communication, 2020) do not have information about the NGO's involvement and their projects relating to the bay. This shows that information is not 'well' shared.

"I don't know what [SUCEDE] is about; I know there's something about oysters but I haven't heard about any invitation to learn about any projects, who is doing them, where, or who is involved, the purpose and impact… I am in the dark about it." (Interviewee 3, personal communication, March 18, 2020).

This in turn may affect how SUCEDE designs its restoration initiatives, who they communicate, connect with, and involve in the process. SUCEDE could benefit from establishing better communication that lead to closer collaboration; this is further discussed in section 5.2.

There are interactions between SUCEDE and the state government (A1b & GS2). Interviewee 1 explained network activities (I8) that the Sustainable Development department has pledged to financially help SUCEDE deploy its programs. As an NGO with limited resources, this is beneficial for SUCEDE's work, although the fruits of this collaboration are yet to be seen. Confirmed by Interviewee 1 (personal communication, Feb 18, 2020) and García Rodríguez et al. (2017), Reformenses state their mistrust in the government. The networking between SUCEDE and the state authorities can work as a bridge to foster better governance relationships between the state and the community, this possibility is also discussed in section 5.2.

Outcomes

Interactions amongst all the aforementioned subsystems and variables result in dynamic processes (Delgado-Serrano & Ramos, 2015). In this section I answer research question #2 by presenting the outcomes of said interactions, and how they affect the SES.

The two main outcomes are in relation to the Socio-economic performance (O1) and Ecological performance (O2) measures.

According to the sum of my interviewees' accounts; the SMB has poor socio-economic measures (O1) caused by the interlinked factors of: (i) fishing as the main economic activity and source of income, (ii) closed season exerting economic pressure on the community, and (iii) the variability and unpredictability of incomes for fishermen and the rest of the community (Interviewee 2, 3 & 5, personal communication, 2020). These variables cause a negative impact on the socio-economical sustainability (O1b), making the whole community vulnerable to the socio-economic stagnation referred to in sections 2.3 and 2.4.

The outcomes of the SES's subsystems show that that ecological performance (O2) is poor and fragile in the SMB. In terms of Environmental unsustainability (O2a) the bay has below standard water quality and needs restoration (Interviewee 1, personal communication, Feb 18, 2020). Furthermore, vegetation in the islands where fishermen 'park' suffers from clearing and logging, and mangroves are deforested, although "not suffering as much logging as before" when they were sometimes cleared to build ponds to promote shrimp larvae growth (Interviewee 4, personal communication, March 18, 2020) (Blitch, 2018).

Additionally, water quality in La Reforma's coast is not optimal. Recent water-quality studies conducted by Ramírez López & Sánchez Rodríguez (2017) confirm the presence of ammonium, nitrites and phosphorous nutrients. The bay also has low levels of dissolved oxygen, and high organic matter concentration (Ramírez López & Sánchez Rodríguez, 2017), all of which point to low water quality. This accounts are further corroborated by García Rodríguez et al. (2017) and Irlbeck (2002), who state that the SMB presents high concentrations of pollutants, nutrients, organic, and fecal matter that negatively affect water quality.

One of the possible causes of these pollution impacts links back to the context-setting subsystem: The demographic trends of migration and growing communities (S2) bring larger numbers of people into the SMB area. These phenomena are caused and accelerated by growing population and economic activities in the surrounding areas (Bien Informado, 2019b) which results in increased pressure on the ecosystem and negatively affects ecological performance (O2).

I identified a positive ecological performance outcome (O2). SUCEDE's presence within La Reforma's community comes at play in the positive impact of this environmental sustainability variable. SUCEDE (GS2), with its environmental education, the cooperative members in Cooperation and self-organizing activities (I7) resulted in the increase of Knowledge of the SES (A7) and Mental models related to SES management (A7e) and this interaction's positive outcome as Interviewee 4 states:

"I personally didn't think about the importance of nature before. Now I think of what harms nature, before I just thought of what I could get out of it; from fishing, from cutting mangrove… They are habits we have that come from before [generations back], but now when you see things [differently], you realize your actions can harm nature and you can be better" (Interviewee 4, personal communication, March 19, 2020).

Table 2. Second and third-tier variables found in the SMB with Ostrom's key variables for self-organization found highlighted in yellow.

Subsystem	First-tier variables	Second-tier variables	Third-tier variables
Context-setting subsystem	Social, economic, and political settings (S)	Demographic trends (S2)	S2a. Number of inhabitants
			S2e. Migration trends
		Market incentives (S5)	S5b. Influence of global/local markets
	Related ecosystems (ECO)	Pollution patterns (ECO2)	
		Flows into the focal SES (ECO3)	
Social subsystem	Actors (A)	Relevant actors (A1)	A1a. Direct users
			A1b. Indirect users
		Socio-economic attributes (A2)	A2a. Demographic attributes
		Location (A4)	
		Norms/social capital (A6)	A6a. Traditional forms of collaboration
		Knowledge of SES mental models (A7)	A7a. Local knowledge on the SES
			A7e. Mental models related to SES management of conservation and human nature relationships
		Importance of resources (A8)	
		Technologies available (A9)	
	Governance system (GS)	Government organizations (GS1)	GS1a. State organizations
			GS1b. Communitarian organizations
		NGOs (GS2)	
		Network structure (GS3)	GS3a. Social networks
			GS3b. Community networks
		Property-rights systems (GS4)	GS4c. Subtractability
		Collective-choice rules (GS6)	
		Constitutional rules (GS7)	
		Monitoring and sanctioning processes (GS8)	
Ecological subsystem	Resource system (RS)	Clarity of system boundaries (RS2)	RS2a. Natural boundaries
			RS2c. Extraction access and property boundaries
		Size (RS3)	
		Human constructed facilities (RS4)	
		Productivity of system (RS5)	
		Equilibrium properties (RS6)	RS6b. External impacts and system responses
	Resource units (RU)	Resource unit mobility (RU1)	
		Resource value (RU4)	RU4a. Market value
		Spatial and temporal distribution (RU7)	
Action situation subsystem	Interactions (I)	Harvesting levels (I1)	I1a. Harvesting levels and effects on SES
			I1b. Free-Riding
		Information sharing (I2)	
		Conflicts (I4)	
		Self-organizing activities (I7)	
		Networking activities (I8)	
		Monitoring activities (I9)	
	Outcomes (O)	Socio-economic performance measures (O1)	O1b. Socio-economical sustainability
		Ecological performance measures (O2)	O2a. Environmental sustainability
			O2b. Pressure on resources
			O2c. Natural habitat condition
			O2e. Environmental quality

Table 2 above summarizes the variables second and third-tier variable found from each subsystem. The cells highlighted in yellow are Ostrom's key variables for self-organization (Ostrom, 2009).

5.2 Opportunities within the SES

After characterizing the SMB as a SES in section 5.1, to achieve different outcomes in the system the interactions amongst subsystems and variables have to change – that is the nature of systems. This can be achieved by identifying and acting on leverage points – "places in the system where a small change could lead to a large shift" (Meadows, 2009, p.145). In this section, I will dive into the main opportunities identified by which SUCEDE can intervene in the SES to obtain better Outcomes and answer research question #3.

Leverage points for sustainability are found where Ostrom's key variables (2009) match the SESF variables found, shown in Table 3 below. It is in this overlap where SUCEDE can most efficiently integrate and adapt its current projects, and create new ones to fill the gaps. Ostrom's key variables from CPR theory about resource and resource-users "should not be considered either necessary nor sufficient" for collective action, or collaboration; they are related to the likelihood of engaging in collective action for better CPR management (Schlager, 2004, p.153). Therefore, I added another SES variable marked below with an asterisk.

Table 3. Variables identified in the SES that match Ostrom's key variables for self-organization.

Subsystem	First-tier variables	Ostrom's second-tier key variables	Third-tier variables
Social subsystem	Actors (A)	Relevant actors (A1)	A1a. Direct users
			A1b. Indirect users
		Leadership and entrepreneurship (*A5)	
		Norms/social capital (A6)	A6a. Traditional forms of collaboration
		Knowledge of SES mental models (A7)	A7a. Local knowledge on the SES
			A7e. Mental models related to SES management of conservation and human nature relationships
		Importance of resources (A8)	
	Governance system (GS)	Collective-choice rules (GS6)	
Ecological subsystem	Resource system (RS)	Size (RS3)	
		Productivity of system (RS5)	
	Resource units (RU)	Resource unit mobility (RU1)	

As my findings suggest, with seven of Ostrom's key variables, the SES has potential to self-organize and cooperate for more sustainable CPR use in the SMB. Here I demonstrate and discuss how SUCEDE can be a catalyst for self-organization and help advance sustainability in the SMB. I do so by integrating SUCEDE's current and potential actions into McGinnis & Ostrom's SESF figure (2014) to graphically show where these leverage points can influence the system.

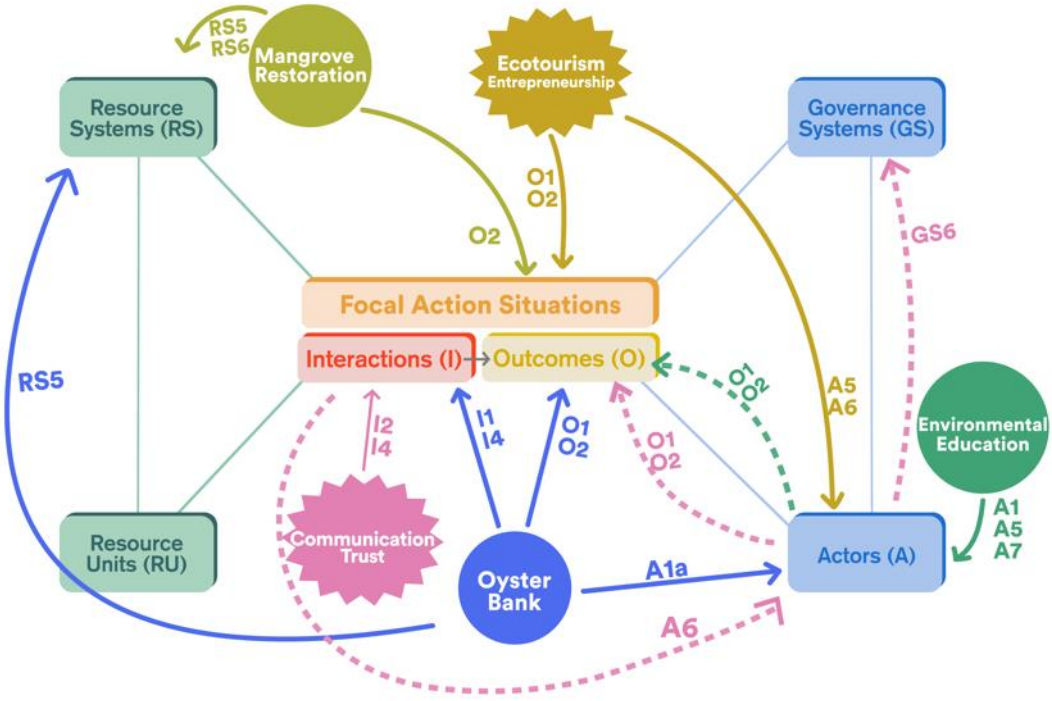

Figure 5. Social-ecological system framework integrating SUCEDE's leverage points. The bubbles represent the leverage points: solid bubbles represent SUCEDE's current projects and the pointy bubbles represent the proposed interventions. The arrows point at the SES variables they each influence and they specify which second and third-tier variables they tackle specifically. Solid lines indicate direct influence and dashed lines indicate feedbacks. (Source: Author, 2020).

In this figure McGinnis & Ostrom's diagram is simplified and I add SUCEDE's interventions; the current ones with a solid bubble and the proposed ones with a textured edge. I indicate the variable that each intervention is influencing with a solid line, and the feedbacks with a dotted line.

5.2.1 SUCEDE's current projects as leverage points

SUCEDE undertakes environmental education efforts in La Reforma that involve direct and indirect actors (A1) and increase knowledge of SES (A7) as shown in Figure 5. Considering the added variable of leadership (*A5), this education initiative promotes the emergence of leader figures and positively impacts CPR management decisions (Delgado serrano, 2015). Leadership can spread knowledge further into the social subsystem (Finkbeiner & Basurto, 2015) as actors with awareness of the impact of their actions on the SES are more likely to act and organize (Ostrom, 2009) to preserve it and better manage CPR (Schlager, 2004) as was already confirmed by Interviewee's 4 account. Improvement in this leverage point can lead to an increase of positive ecological performance outcomes (O2).

Mangrove reforestation actions directly impact the negative ecological outcomes (O2) mentioned in section 5.1.4 through the improvement of the Resource system by reducing mangrove loss. This interactions also enhance equilibrium properties (RS6) and, most importantly, the SES productivity (RS5) as shown above in Figure 5.

A study in small-scale fishery communities in Centla, Mexico, found that high levels of self-organization facilitate CPR conservation and mitigate CPR conflicts; that community members needed to increase their knowledge about the SES complexity and its balance in order to achieve it (Manuel, Wendi, & Emilio, 2013). This supports my study's claims that increasing knowledge by SUCEDE's environmental education efforts can lead to better CPR management and less conflict.

SUCEDE's oyster bank project is their most ambitious initiative. The NGO will define an aquaculture zone close to La Reforma, process the required aquaculture permits with the corresponding authorities, then form a group and provide them with alternative means of employment (Interviewee 5, personal communication, 2020). They plan to recruit free fishermen (A1a) to form this group – to stir them away from illicit fishing (I4) into aquaculture in the oyster bank (Interviewee 1, personal communication, Feb 18, 2020). If successful, this would create new sources of income and reduce pressure on the ecosystem by improving water quality thanks to the mollusks' filtering nature (described in 2.4). This will ameliorate the system's socio-economic and ecologic performance measures respectively (O1 & O2).

Before moving forward, I am aware of the need to be critical about SUCEDE and, as stated by Schlager (2004) to properly implement insights from CPR theory is to avoid making heroic assumptions about communities' needs and capacities. Therefore, I will discuss where SUCEDE should correct and improve various aspects.

5.2.2 Proposed interventions by SUCEDE as leverage points

Communication and trust

For starters, there is a need to increase the efficiency of information flows (I2). This is hindering the NGO's potential; results show that locals are unaware of the organization's projects and, in turn, SUCEDE ignores its potential involvement in community conflicts (I4). SUCEDE engages with free fishermen in the oyster bank project as mentioned above. By this interaction they may be, inadvertently, legitimizing free fishermen before the cooperatives and the community with whom

they already clash. To build trust with the whole community, they should be mindful of these implications of their involvement.

My results show mistrust from Reformenses towards government authorities (Interviewee 1, personal communication, Feb 18, 2020) (García Rodríguez et al., 2017). This is an opportunity – outside of Ostrom's key variables – to improve socio-economic sustainability through strengthening governance systems. Scholars state there is "considerable opportunity in increasing small-scale fisher representation and participation in governance" (Finkbeiner & Basurto, 2015, p.438).

As a 2014 study about NGO's involvement in small-scale fisheries in Mexico found: NGOs work as bridging organizations and add value to management processes by fostering collaboration, generating and sharing information, agreements, collective-rules, etc. (Espinosa-Romero, Rodriguez, Weaver, Villanueva-Aznar, & Torre, 2014). They found that NGO's in the Gulf of California have shifted focus from environmental conservation to socio-economic and ecological objectives and that their involvement in small-scale fishery communities helps build stronger networks and expand local capabilities. They found that building trust between resource users and the NGOs was arduous and slow, but the benefits of mutual trust are major. Additionally, trust increases social capital (A6) and groups with higher social capital respect each other more and are more likely to uphold the agreements they make between them (Ostrom, 2009) – this feeds back to the actor's interactions with the rest of the ecological subsystem in how they keep follow rules of CPR use. Thus, this is suggested in my study as a leverage point, as shown in Figure 5.

Building on this, SUCEDE could be better engaged with Reformenses to increase their trust towards the NGO. They then can act as a facilitator between Reformenses and government authorities to foster better relations built on trust. If locals' trust towards SUCEDE and towards the authorities increases, they may partake in local governance processes, with effects in collective-choice and constitutional rulemaking (GS6) as shown by the dashed feedback line from Actors to Governance systems in Figure 5.

Rules that actors are involved in creating are more likely to be adopted (Ostrom, 2009) and user-participation in problem and conflict-solving increases the likelihood of community cooperation (Schlager, 2004) and more positive socio-economic and ecological outcomes (O1 & O2). By building trust in the community SUCEDE can also facilitate conflict resolution between cooperatives and free

fishermen, lessening the negative impacts of the latter actors on the first, and on the state of the CPR, the SES and its productivity. It can be done by providing clarity about their role and objectives and a transparent agenda (Espinosa-Romero et al., 2014) with the rest of the community to avoid unwanted collateral conflict.

Ecotourism entrepreneurship

Ecotourism can be an entrepreneurial alternative (*A5) to boost local economy (O1) during closed season and promote economic diversification (O1) without exerting additional pressure on the ecosystem (O2). There already are ”one or two” ecotourism groups in the area (Interviewees 1, 4 & 6, personal communication, 2020) but efforts can be expanded to meet the community's needs for more diverse economic activities (García Rodríguez et al., 2017). SUCEDE can use this leverage point to help those interested and develop skill-building workshops to expand people's capabilities and aid in the design of strategies to protect the natural environment amidst this new activity. Having previously built better relations and trust, Reformenses can design strategies to attract tourists during the closed season to promote economic activity during this time.

Knowledge resources and support from NGO's can be particularly important in developing new skills in local leaders (A5). As trust between governments and society increases, there will likely be an increased influence from NGOs in the creation of support institutions and interactions that further support sustainable development for better outcomes (Finkbeiner & Basurto, 2015).

Looking beyond

This analysis through the social-ecological systems framework, as all systems, is a simplification of reality (Meadows, 2009). SUCEDE's interventions are depicted in Figure 5 as separate bubbles but they are part of SUCEDE – an actor in the community – and therefore should technically be part of the Actors box. However, for explanatory and graphic purposes I chose to show them as external interventions acting independently.

Governance systems can either facilitate or destroy local level governance in SES (Ostrom 2009), and same can be said about NGO's interventions in systems. Finding leverage points for intervention to promote self-organization and collective action, without exerting excessive control, and doing it in an appropriate way is what a successful social-economic intervention should aspire to; what SUCEDE should aspire to.

Looking beyond the SESF, governance institutions in the SMB need improvement. The community should look into adapting better methods for governance that could benefit the fishery and the community. Multi-level co-management as a governance alternative is appearing often in scholarly articles as a solution to dilemmas around CPR, particularly in small-scale fisheries (Finkbeiner & Basurto, 2015; Manuel et al., 2013). That being said, any deeper intervention in the governance system will benefit from a stronger and better equipped social-ecological system; which is the aim of SUCEDE's work.

Reflecting on the length of this case study, it first looks at issues of common-pool resource use and social aspects around the management of a small-scale fishery. Looking at my interviewee's accounts it is evident that this study, the analysis through the lens of the SESF and broader CPR theory, and my personal analysis is not enough to detangle the depth and complexity of the system at full length. However, the characterization of the SMB by this method and the breakdown of the system's complexity's implications helps motivate further research into social interventions in social-ecological systems and small-scale fisheries.

6. Conclusion

This case study of the small-scale fishery of La Reforma through the Social-Ecological System Framework shows how complex interconnections arise in a relatively small community that depends on a common-pool resource in the Santa María Bay. In my analysis, I identified 34 of the 57 SESF's second-tier variables McGinnis & Ostrom (2014), and 7 of 10 Ostrom's key variables for collaboration (Ostrom, 2009). My findings suggest, that with seven of Ostrom's key variables for organization to manage a CPR, the SES has high potential to self-organize and cooperate for sustainable long-term use of its common-pool resource.

The implications of the SES's interactions around CPRs are not straightforward. The main Outcomes of the subsystems' interactions found in my study are of socio-economic and ecological character, and both show unfavorable measures. Socio-economic outcomes show high social and economic vulnerability due to high pressure during closed fishing seasons since most of the community depends on fishing shrimp as their primary source of income. On the other hand, ecological outcomes present both negative and positive aspects. The main negative ecological outcome was the poor water quality, which negatively affects shrimp harvests and SMB ecosystem at large. The positive outcome was change in behavior by community members who, thanks to increasing environmental awareness efforts from SUCEDE, have changed their behavior towards the ecological subsystem.

Informed by CPR theory, my results show that interventions from the local NGO, SUCEDE, are very likely to positively affect the SES. The main leverage points found by which the NGO can exert positive change are SUCEDE's three existing initiatives: (i) environmental education programs, (ii) mangrove reforestation actions and (iii) an oyster bank project. Two potential leverage points for exerting systemic change were found: increasing communication and mutual trust between the NGO, the community, and the authorities; and expanding ecotourism alternatives in the Bay. The fist aims at increasing social capital, and the latter at diversifying sources of income in the community, relieving economic pressure during closed fishing seasons. I suggest that these leverage points, with the purpose of stirring the SES into more sustainable socio-economic and ecologic ways for the fishery to manage its CPR; can reduce economic vulnerability and increase the system's flexibility in the face of bigger challenges, while at the same time it help hinder CPR scarcity and ecosystem degradation.

My SES study of the SMB and La Reforma is relevant to the broader perspective of small-scale fisheries and CPR theory because it provides answers to sustainability questions of socio-ecological systems,

CPR management and the potential for positive social interventions in small-scale fisheries. It shows NGOs can help communities increase the likelihood of moving towards self-organization and collaboration for sustainable use of CPRs by intervening where change is most efficient – leverage points. The SESF helps identify leverage points by which NGOs can work with existing variables towards improving negative outcomes in the system. In this case; those leverage points were found where the existing SESF variables matched with Ostrom's key variables for self-organization. This study also shows how, in a broader sense, NGOs can help incentivize more efficient social initiatives, and by this promote more sustainable development for CPR management.

7. Bibliography

Acosta Velázquez, J., & Vázquez Lule, A. D. (2009). Caracterización del sitio de manglar Santa María - La Reforma. In *Sitios de manglar con relevancia biológica y con necesidades de rehabilitación ecológica.* Ciudad de México.

Amezcua, F., Madrid Vera, J., & Aguirre Villaseñor, H. (2006). Effect of the artisanal shrimp fishery on the ichthyofauna in the coastal lagoon of Santa María la Reforma, southeastern Gulf of California. *Ciencias Marinas*, *32*(1 B), 97–109. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-33645522240&partnerID=40&md5=ffbb5f8324f63356834390997c948c1e

Bien Informado. (2018a, February). Restauran personas, familias y comunidad. *Revista Bien Informado*. Retrieved from https://yobieninformado.com/restauran-personas-familias-y-comunidad/

Bien Informado. (2018b, November). Migran buscando vida. *Revista Bien Informado*. Retrieved from https://yobieninformado.com/migran-buscando-vida/

Bien Informado. (2019). La pesca en la Bahía Santa María: SUCEDE busca la restauración de la bahía y el cuidado de sus pobladores. *Revista Bien Informado*. Retrieved from https://yobieninformado.com/la-pesca-en-la-bahia-santa-maria/

Binder, C. R., Hinkel, J., Bots, P. W. G., & Pahl-Wostl, C. (2013). Comparison of frameworks for analyzing social-ecological systems. *Ecology and Society*, *18*(4). https://doi.org/10.5751/ES-05551-180426

Blitch, S. (2018). *Field Work Report: Field Notes and Thoughts from Initial Trip to Bahía Santa María/La Reforma*.

Bryman, A. (2016). *Social research methods.* (Fifth edit). Retrieved from http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=cat07147a&AN=lub.4718593&site=eds-live&scope=site

Comisión Nacional de Áreas Naturales Protegidas (CONANP). (2012). *Estudio previo justificativo para el establecimiento del área natural protegida con la categoría de Área de Protección de Flora y Fauna - Bahía de Santa María, Sinaloa*. Sinaloa, México.

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). (2010). *Informe Anual Sobre La Situación de Pobreza y Rezago Social - Angostura, Sinaloa*.

Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL). (2020). *Informe de Pobreza y Evaluación 2020. Sinaloa*. Ciudad de México.

Daw, T., Adger, W. N., Brown, K., & Badjeck, M.-C. (2009). Climate change and capture fisheries: potential impacts, adaptation and mitigation. *Climate Change Implications for Fisheries and*

Aquaculture, 107–151. https://doi.org/FAO Fisheries and Aquaculture Technical paper No. 530

Delgado-Serrano, M. del M., & Ramos, P. A. (2015). Making Ostrom's framework applicable to characterise social ecological systems at the local level. *International Journal of the Commons*, *9*(2), 808–830. https://doi.org/10.18352/ijc.567

Espinosa-Romero, M. J., Rodriguez, L. F., Weaver, A. H., Villanueva-Aznar, C., & Torre, J. (2014). The changing role of NGOs in Mexican small-scale fisheries: From environmental conservation to multi-scale governance. *Marine Policy*, *50*(PA), 290–299. https://doi.org/10.1016/j.marpol.2014.07.005

Finkbeiner, E. M., & Basurto, X. (2015). Re-defining co-management to facilitate small-scale fisheries reform: An illustration from northwest Mexico. *Marine Policy*, *51*, 433–441. https://doi.org/10.1016/j.marpol.2014.10.010

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive Governance of Social-Ecological Systems. *Annual Review of Environment and Resources*, *30*(1), 441–473. https://doi.org/10.1146/annurev.energy.30.050504.144511

Food and Agriculture Organization of the United Nations (FAO). (2018). Small-scale fishers and communities. Retrieved April 12, 2020, from Food and Agriculture Organization of the United Nations: Fisheries and Aquaculture Department website: http://www.fao.org/fishery/ssf/people/en

Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific (FAO/RAP/FIPL). (2004). *A research agenda for small-scale fisheries*. Retrieved from http://www.fao.org/3/a-ae534e.pdf

Fuentes, M. L. (2016, May 17). México social: Sinaloa, entre la pobreza y la violencia. *Excelsior*. Retrieved from https://www.excelsior.com.mx/nacional/2016/05/17/1093094

García Rodríguez, O. B., Cortés Aguilar, S., Félix Puga, A. R., Mendoza Ontiveros, L. R., Armenta Rodríguez, A. U., & Obeso Santo, J. E. (2017). *Diagnóstico Sociocultural - Sindicatura La Reforma, Municipio de Angostura, Sinaloa.*

Given, L. (2008). *The SAGE Encyclopedia of Qualitative Research Methods*. https://doi.org/10.4135/9781412963909 NV - 0

Heenehan, H., Basurto, X., Bejder, L., Tyne, J., Higham, J. E. S., & Johnston, D. W. (2015). Using Ostrom's common-pool resource theory to build toward an integrated ecosystem-based sustainable cetacean tourism system in Hawai`i. *Journal of Sustainable Tourism*, *23*(4), 536–556. https://doi.org/10.1080/09669582.2014.986490

Higgins, C. B., Stephenson, K., & Brown, B. L. (2011). Nutrient Bioassimilation Capacity of Aquacultured

Oysters: Quantification of an Ecosystem Service. *Journal of Environmental Quality*, *40*(1), 271–277. https://doi.org/10.2134/jeq2010.0203

Instituto Nacional de Geografía e Informatica (INEGI). (2015a). México en cifras - La Reforma, Angostura, Sinaloa. Retrieved April 28, 2020, from https://www.inegi.org.mx/app/areasgeograficas/?ag=25

Instituto Nacional de Geografía e Informatica (INEGI). (2015b). México en cifras - Sinaloa. Retrieved April 28, 2020, from https://www.inegi.org.mx/app/areasgeograficas/?ag=25

Instituto Nacional para la Evaluación de la Educación (INEE). (2018). *Reporte La Reforma Plan Nacional para la Evaluación de los Aprendizajes (PLANEA)*. Retrieved from http://planea.sep.gob.mx/content/general/docs/2018/PlaneaDocumentoRector18.pdf

Irlbeck, M. J. (2002). *Mocorito River Basin And Santa Maria Bay Sinaloa, Mexico*.

Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., … Svedin, U. (2001, April 27). Environment and development: Sustainability science. *Science*, Vol. 292, pp. 641–642. https://doi.org/10.1126/science.1059386

Kates, Robert W., & Parris, T. M. (2003). Long-term trends and a sustainability transition. *Proceedings of the National Academy of Sciences of the United States of America*, *100*(14), 8062–8067. https://doi.org/10.1073/pnas.1231331100

Kellogg, M. L., Cornwell, J. C., Owens, M. S., & Paynter, K. T. (2013). Denitrification and nutrient assimilation on a restored oyster reef. *Marine Ecology Progress Series*, *480*, 1–19. https://doi.org/10.3354/meps10331

Manfredo, M. J., Rechkemmer, A., Duke, E. A., & Vaske, J. J. (2014). *Understanding Society and Natural Resources: Forging New Strands of Integration Across the Social Sciences*. Retrieved from http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=cat07147a&AN=lub.5807231&site=eds-live&scope=site

Manuel, M. C., Wendi, A. F., & Emilio, I. D. (2013). Common pool resources dilemmas in tropical inland small-scale fisheries. *Ocean and Coastal Management*, *82*, 119–126. https://doi.org/10.1016/j.ocecoaman.2013.06.004

McGinnis, M. D., & Ostrom, E. (2014). Social-ecological system framework: Initial changes and continuing challenges. *Ecology and Society*, *19*(2). https://doi.org/10.5751/ES-06387-190230

Meadows, D. H. (2009). *Thinking in systems: A Primer.* (D. Wright, Ed.). Retrieved from http://ludwig.lub.lu.se/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=cat07147a&AN=lub.1859694&site=eds-live&scope=site

Morzaria-Luna, H. N., Turk-Boyer, P., & Moreno-Baez, M. (2014). Social indicators of vulnerability for

fishing communities in the Northern Gulf of California, Mexico: Implications for climate change. *Marine Policy*, *45*, 182–193. https://doi.org/10.1016/j.marpol.2013.10.013

Ostrom, E. (1990). *Governing the commons the evolution of institutions for collective action*.

Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(39), 15181–15187. https://doi.org/10.1073/pnas.0702288104

Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, *325*(July), 419–422. https://doi.org/10.5055/jem.2013.0130

Ramírez López, J. A., & Sánchez Rodríguez, M. Á. (2017). *Informe de Resultados de la Calidad De Agua Zona De La Bahía Santa María La Reforma*. Mazatlán Sinaloa.

Schlager, E. (2004). *Common-Pool Resource Theory* (R. F. Durant, D. J. Fiorino, & R. O'Leary, Eds.). In (pp. 145–175). Retrieved from http://hdl.handle.net/10535/5648

Secretaría de Agricultura Ganadería Desarrollo Rural Pesca y Alimentación (SAGARPA). (2017). *Anuario Estadístico de Acuacultura y Pesca Publicación 2017*. Retrieved from https://www.gob.mx/conapesca/documentos/anuario-estadistico-de-acuacultura-y-pesca

Villa Castro, B. (2019, April 9). Angostura registra un alto índice de ausentismo en las escuelas. *El Debate Sinaloa*. Retrieved from https://www.debate.com.mx/sinaloa/guamuchil/Angostura-registra-un-alto-indice-de-ausentismo-en-las-escuelas-20190408-0079.html

Wiek, A., Ness, B., Schweizer-Ries, P., Brand, F. S., & Farioli, F. (2012). From complex systems analysis to transformational change: A comparative appraisal of sustainability science projects. *Sustainability Science*, *7*(SUPPL. 1), 5–24. https://doi.org/10.1007/s11625-011-0148-y

Young, E. H. (1999). Balancing Conservation with Development in Small-Scale Fisheries: Is Ecotourism an Empty Promise? *Human Ecology*, *27*(4), 581–620. Retrieved from https://link.springer.com/article/10.1023/A:1018744011286

8. Appendices

8.1 Appendix A. SESF first and second-tier variables

Source: Adapted from McGinnis & Ostrom 2014

First-tier variables	Second-tier variables
Social, economic, and political settings (S)	S1 – Economic development
	S2 – Demographic trends
	S3 – Political stability
	S4 – Other governance systems
	S5 – Markets
	S6 – Media organizations
	S7 – Technology
Resource systems (RS)	RS1 – Sector (e.g., water, forests, pasture, fish)
	RS2 – Clarity of system boundaries
	RS3 – Size of resource system
	RS4 – Human-constructed facilities
	RS5 – Productivity of system
	RS6 – Equilibrium properties
	RS7 – Predictability of system dynamics
	RS8 – Storage characteristics
	RS9 – Location
Governance systems (GS)	GS1 – Government organizations
	GS2 – Nongovernment organizations
	GS3 – Network structure
	GS4 – Property-rights systems
	GS5 – Operational-choice rules
	GS6 – Collective-choice rules
	GS7 – Constitutional-choice rules
	GS8 – Monitoring and sanctioning rules
Resource units (RU)	RU1 – Resource unit mobility
	RU2 – Growth or replacement rate
	RU3 – Interaction among resource units
	RU4 – Economic value
	RU5 – Number of units
	RU6 – Distinctive characteristics
	RU7 – Spatial and temporal distribution
Actors (A)	A1 – Number of relevant actors
	A2 – Socioeconomic attributes
	A3 – History or past experiences
	A4 – Location
	A5 – Leadership/entrepreneurship
	A6 – Norms (trust-reciprocity)/social capital
	A7 – Knowledge of SES/mental models
	A8 – Importance of resource (dependence)
	A9 – Technologies available
Action situations: Interactions (I) → Outcomes (O)	I1 – Harvesting
	I2 – Information sharing I3
	– Deliberation processes I4
	– Conflicts
	I5 – Investment activities
	I6 – Lobbying activities
	I7 – Self-organizing activities
	I8 – Networking activities
	I9 – Monitoring activities
	I10 – Evaluative activities
	O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability)
	O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)
	O3 – Externalities to other SESs
Related ecosystems (ECO)	ECO1 – Climate patterns
	ECO2 – Pollution patterns
	ECO3 – Flows into and out of focal SES

8.2 Appendix B. Field-work journal

Examples of two entries in field-work journal for February 18th and 25-26th, 2020.

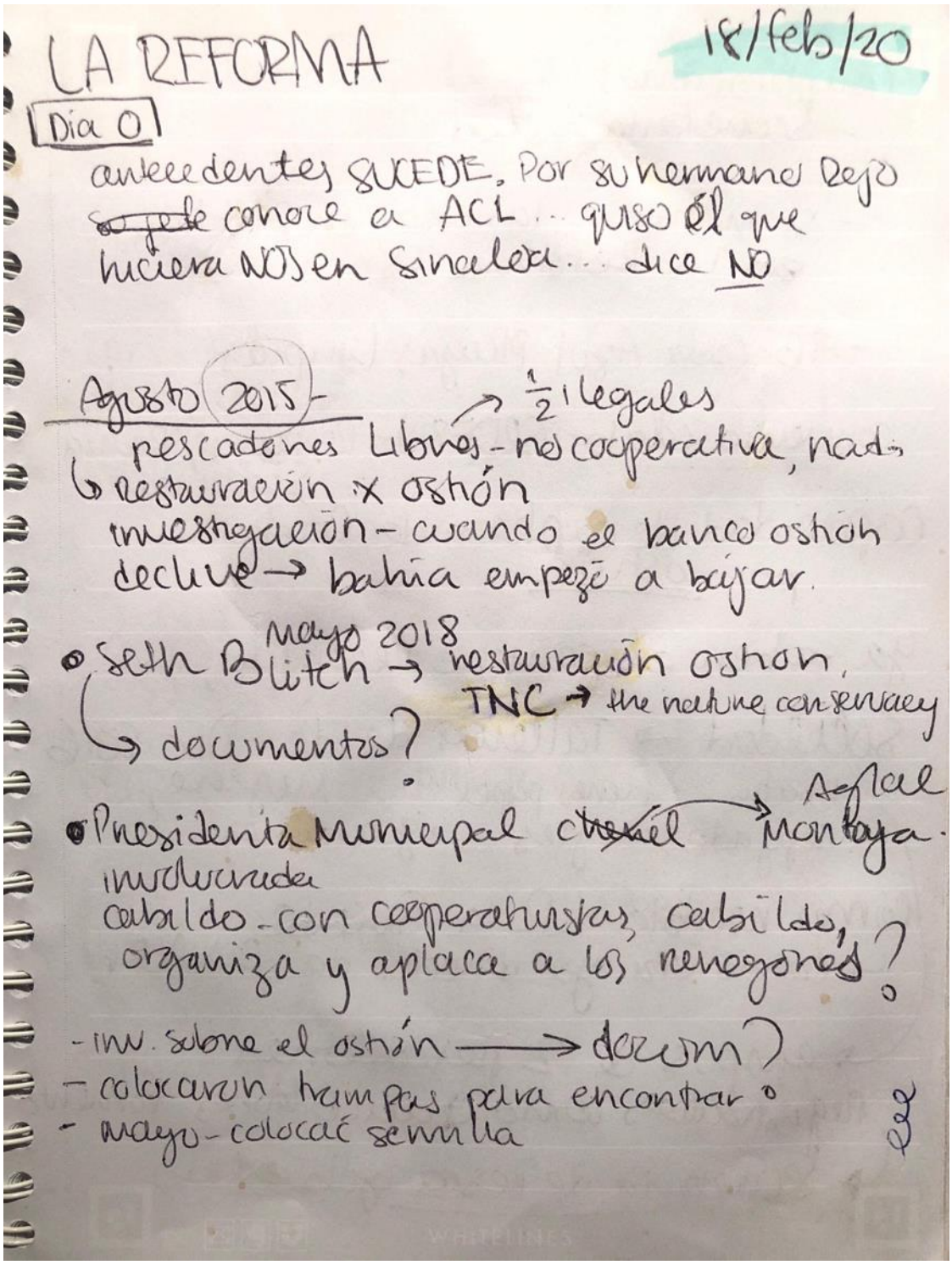

Figure B1. Fieldwork journal notes (Source: Author, 18 Feb, 2020)

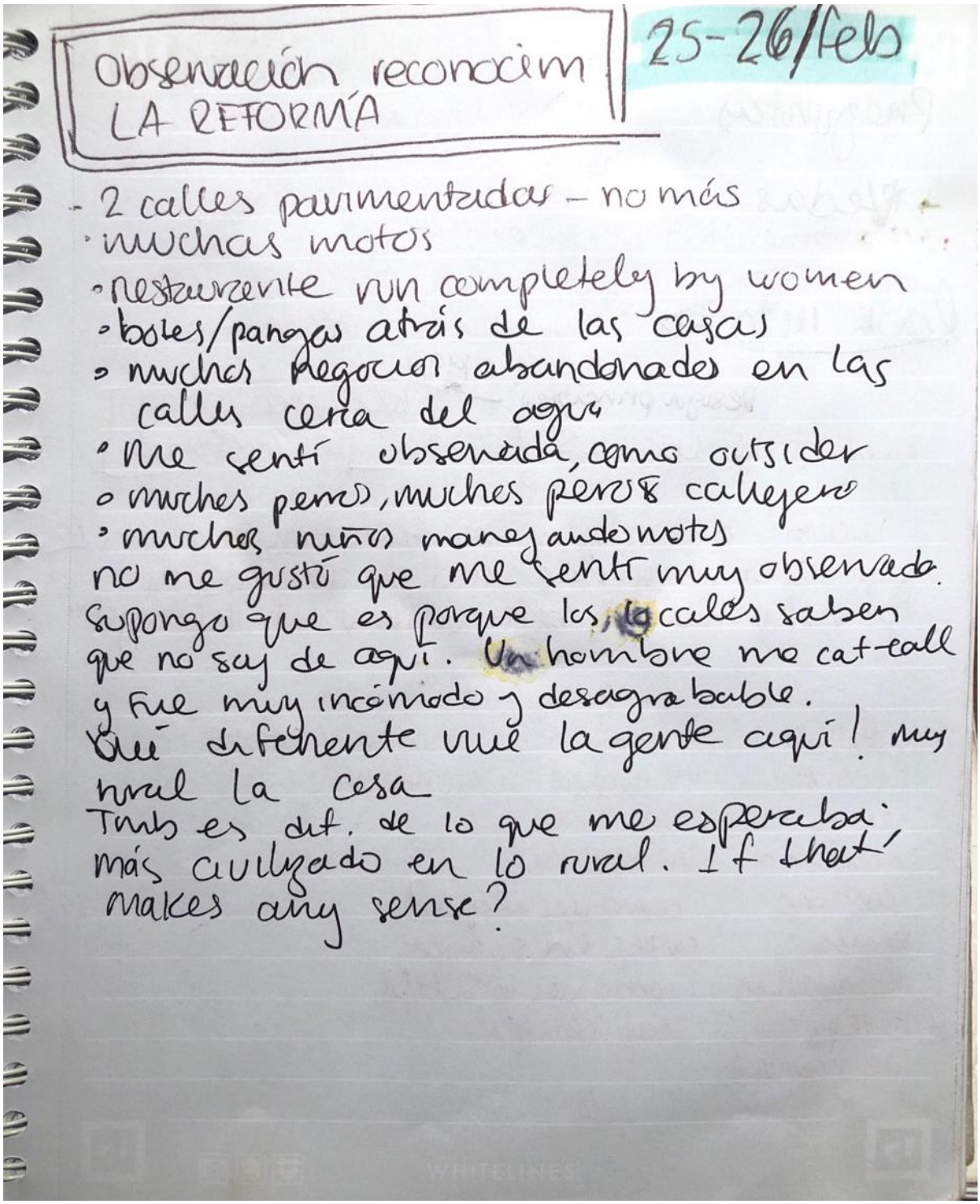

Figure B2. Fieldwork journal notes (Source: Author, 25-26 Feb, 2020)

8.3 Appendix C. Interview Guide

Introducción

Hola, soy Alina Breceda. Gracias por acceder a verme y platicar conmigo hoy. Soy estudiante de maestría y estas preguntas son para el estudio de mi tesis.

Es un estudio en el que voy a aplicar una manera de ordenar la información sobre sistemas de medio ambiente y sociedad, donde el recurso viene del medio ambiente y la comunidad lo usa, que es la pesca en este caso. Quiero saber sobre el recurso, sobre las reglas alrededor del recurso, sobre cómo se organiza la gente que usa el recurso, que pues en este caso son los pescadores, también sobre las reglas de monitoreo (si hay o no), y sobre sanciones e incumplimientos, también como se resuelven conflictos entre los que usan el recurso y también con la autoridad y otros agentes como SUCEDE, porque ya es otro jugador adentro de sistema.

Su nombre y datos serán anónimos y el audio de la entrevista sólo lo escucharé yo para propósitos de mi estudio.

Variables SESF	Preguntas
Sistema de recurso **RESOURCE SYSTEM (RS)**	Quiénes están autorizados para pescar? Cuántos son? Qué extraen – especies principales Cómo lo extraen – métodos de pesca Tiempos de pesca Límites geográficos Productividad de la bahía Predictibilidad del recurso pesquero y la temporada de pesca
Unidades de recurso pesquero **RESOURCE UNITS (RU)**	Qué recurso pescan en la Bahía Santa María? Qué especies? Cómo ha percibido usted el valor de la pesca, como se vende el recurso…
Sistema de gobenanza **(GS)**	**About rules – appropriation rules and provision rules w/ local conditions:** Reglas de uso: restricciones de tiempo, lugar, tecnología, cantidad. Están relacionadas a las condiciones locales y a las reglas de provisión sobre trabajo, materiales y dinero. Cómo están diseñadas las reglas? Las siguen? Cuando son las vedas? Las respetan? Hay diferencias en las reglas/leyes sobre cómo se hacen las cosas aquí y en otras bahías? SUCEDE – cómo lo ven? Consejo Cívico de participación ciudadana
	Collective-choice agreements (GS6): Pueden ustedes influir o aportar en las reglas/leyes que se imponen para la pesca? Consejo cívico de participación ciudadana – tiene influencia sobre cómo se hacen las cosas en LR? (tal vez no leyes pero sí en las normas sociales?) **Estrategias de monitoreo (GS8):** Saben quien rompe las reglas y quien no? Quien anda pescando ilegalmente o reporta de menos? Hay alguien que tenga más ese papel de andar checando o de mitotero? Cómo monitorean que la gente no pesque en veda? Pueden ustedes influir o aportar en las reglas/leyes que se imponen para la pesca?

	Consejo cívico de participación ciudadana – tiene influencia sobre cómo se hacen las cosas en LR? (tal vez no leyes pero sí en las normas sociales?)
	Estrategias de monitoreo (GS8) Saben quien rompe las reglas y quien no? Quien anda pescando ilegalmente o reporta de menos? Hay alguien que tenga más ese papel de andar checando o de mitotero? Cómo monitorean que la gente no pesque en veda? **Sobre las sanciones (GS8)** A quien se sorprende rompiendo las reglas, qué le pasa? Cuando los chachan pasándose de vivos, se les aplica sanción? Si sí, de qué depende la severidad de las sanciones? Quién aplica las sanciones? Hay sanciones sociales? Como que, sea el quemado y ya nadie quiera tener relación con él o algo similar?
Mecanismos de resolución de conflicto (I4)	Hay conflictos entre los pescadores? Cómo se resuelven los conflictos? Cómo se llevan entre los pescadores? Se ayudan mutuamente? Cómo? Hay conflictos con las autoridades e instituciones? Hay conflictos con SUCEDE? CONSEJO – el consejo ha podido aportar en algo a que la sociedad se lleve mejor? A que resuelva conflictos de mejor manera? Quienes son miembros del consejo? Cómo se llevan los miembros con los no miembros?
Organización (I7)	Los locales están incluidos en la toma de decisiones? De qué manera? El consejo? Cooperativas? Instituciones propias? El consejo cívico – lo veo como una muy buena manera en que se dio un proceso democrático en la reforma Usted está en el consejo?
Actores y usuarios del recurso	Cuántos pescadores hay pescando en la bahía? Cree usted que la gente conoce la importancia del recurso? Que me dice de liderazgo entre los pescadores y demás usurarios del recurso Conoce el proyecto de SUCEDE? Cómo lo percibe? Cómo se relaciona con la sociedad? Cómo ve usted que se relacione la comunidad con la pesca? Con la bahía y el medio ambiente?

8.4 Appendix D. Field work photos

Figure D1. La Reforma sign (Source: Author, Feb 18, 2020)

Figure D2. SUCEDE office (Source: Author, Feb 18, 2020)

Figure D3. Helping SUCEDE make oyster beds (Source: Author, Feb 25, 2020)

Figure D4. Example of oyster “traps” (Source: Author, Feb 25, 2020)

Figure D5. Excursion to the bay (Source: Author, March 3, 2020)

Figure D6. Excursion to the bay. Local fishermen depicted (Source: Author, March 3, 2020)

Figure D7. La Reforma street (Source: Author, March 18, 2020)