Adaptive Capacity, Collaboration, and Adaptive Governance: The Galapagos small-scale fishing sector

By

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AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see the Statement of Contributions section included in this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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STATEMENT OF CONTRIBUTIONS

I am the sole author of Chapter 1 and Chapter 5 of this dissertation. The remaining chapters of this dissertation consist of three manuscripts written for publication. Chapter 2 was co-authored with Dr. Johanna Wandel, Dr. Jeremy Pittman and Dr. Peter Deadman. Chapter 3 and Chapter 4 were co-authored with Dr. Jeremy Pittman, Dr. Mauricio Castrejón and Dr. Peter Deadman. Chapter 2, Chapter 3 and Chapter 4 information has been included below.

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ABSTRACT

Over the last decades, employing adaptive capacity and vulnerability terms to indicate forms of achieving more sustainable goals, particularly in the management of natural resources, has become increasingly frequent. While this has led to a boost in policy-making discourses and guidelines for governing complex social-ecological systems, it is essential to recognize that the broad and indistinct use of such concepts has given rise to multiple interpretations, forms of application, and, therefore, diverse policy-making solutions. Considering that the realities of complex social-ecological systems are place-specific, this dissertation provides some clarifications on vulnerability and adaptive capacity. It suggests strategies and actions that might help practitioners and policymakers to interpret and operationalize the terms, enabling them to move from conceptualizations to practice in distinct contexts, as well as build adaptive capacity and enhance the resilience of complex social–ecological systems.

This dissertation highlights that bolstering the capacity of a system of interest to adapt depends partly on its ability to explore location-specific conditions that enable it to anticipate and respond proactively to diverse shocks, recover and take advantage of new opportunities (Folke et al. 2002b; Engle 2011; Whitney et al. 2017; Cinner et al. 2018). This capacity depends primarily on factors such as the system's technological, behavioural, financial, institutional, and informational resources (Adger 2003b; Burton 2003; Smit and Wandel 2006). This dissertation recognizes that an analysis of the forms of governance and collaboration networks, as well as their linkages, is critical in determining adaptive capacity and resilience when addressing the vulnerabilities of a social–ecological system in the short and long term (Wandel and Marchildon 2010; Pittman et al. 2015). Therefore, it explores ways of building adaptive capacity and enhancing common-pool resource governance's resilience in light of diverse, adverse, internal and external drivers of change, such as climate change, novel pandemics, and institutional fragmentations, using qualitative and social network approaches.

Today, many multidimensional issues cross human-made administrative and political borders, making it increasingly difficult to govern common-pool resources such as small-scale fisheries. Addressing

countless simultaneous and sudden social-ecological interactions requires the collaboration, support and involvement of actors and stakeholders from various areas, geographical scales, and administrative levels. The adverse effects of COVID-19 and climate change are likely the most recent and perhaps the most explicit and vivid examples worldwide of how sudden external drivers of change can rapidly affect livelihoods and alter the socio-economic dynamics in complex social–ecological systems from one day to another, pushing them into more profound social and economic crisis. Thus, a society that might face the adverse effects of new drivers of change derived from novel pandemics, climate change, or globalization requires approaches and strategies that will enable decision-makers and policymakers to act during unexpected and rapid changes. In this regard, this dissertation examines polycentric approaches to governance, including linkages (partnerships) spanning multiple scales and levels, from global to local, that rely on formal and informal networks to create the correct links at the correct time to face climate-related factors of change and non-climate-related drivers of change that generate vulnerability in complex social–ecological systems.

Since governance often represents the different structures by which societies share power and are platforms to define collective and individual actions (Kooiman 2003a; Lautze et al. 2011), this dissertation explores the Galapagos small-scale fishing governance system, a crucial socio-economic sector for diverse coastal communities and food security in the Galapagos Islands. This archipelago is widely recognized in conservation for incorporating the islands that inspired Darwin's theory of evolution but whose high levels of endemism have indirectly hampered research efforts to focus mainly on the biophysical features of the islands and disregarded social sciences as forms of building adaptive capacity. My doctoral research examines forms of addressing context-specific vulnerabilities and building adaptive capacity through a social science perspective to fill this gap. In doing so, this dissertation aims to 1) assess how vulnerability assessments and decision-making planning tools can be applied to increase adaptive capacity at the local scale in the face of multiple drivers of change; 2) explore the role of collaboration and social networks in building adaptive capacity in the Galapagos small-scale fishing sector; 3) improve the collaboration network of the Galapagos small-scale governance system in light of multiple drivers of change.

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DEDICATION

I dedicate my doctoral research to my beloved family and the coastal communities of Ecuador and the Galapagos Islands.

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LIST OF ABBREVIATIONS

AC	Adaptive Co-management
AF	Adaptation Fund
AP	Adaptation Pathway
BURs	Biennial Update Reports
CCIAV	Climate Change Impacts, Adaptation and Vulnerability
CDF	Charles Darwin Foundation
CDRS	Charles Darwin Research Station
COP	Conference of Parties
COVID-19	Coronavirus Disease of 2019
CEDENMA	Ecuadorian Committee for the Defense of Nature and the Environment
ENSO	El Niño-Southern Oscillation
ERGMs	Exponential Random Graph Models
GCM	Galapagos Co-management System
COPROPAG	Galapagos Artisanal Fisheries Production Cooperative
GMR	Galapagos Marine Reserve
GNPS	Galapagos National Park
DPNG	Galapagos National Park Directorate
GSL	Galapagos Special Law
CGREG	Galapagos Special Regime Governing Council
GCM	Global Circulation Models
GEF	Global Environmental Facility
GOF	Goodness-of-fit
GCF	Green Climate Fund
GHG	Greenhouse Gas Scenarios
GIS	Geographic Information System
COPAHISA	Horizontes de Isabela Fishing Cooperative
IUU	Illegal, Undeclared and Unregulated Fishing
IPCC	Intergovernmental Panel on Climate Change
IMA	Inter-institutional Management Authority
NAPs	National Adaptations Plans
NAPAs	National Adaptation Programmes of Action
NDCs	Nationally Determined Contributions
NGO	Non-Governmental Organization
INP	National Fisheries Institute

PA	Paris Agreement
PCR	Polymerase Chain Reaction
PMB	Participative Management Board
ASOARMAPESBAY	Pelican Bay Dock Fishing Shipowners Association
COPESAN	San Cristobal Fishing Cooperative
COPESPROMAR	Seafood Fishing Cooperative
SNA	Social Network Analysis
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

The varying conceptualizations of the terms vulnerability and adaptive capacity inherited by numerous disciplines, including natural hazards, food security, public health, and environmental change, among other fields, have given rise to multiple ways of using these terms in practice at local levels (Vallury et al. 2022). Despite the popularity of these concepts in policy-making arenas, it is necessary to recognize that their ambiguity has often given rise to multiple interpretations and means of seeking solutions to address problems (Gallopín 2006; Engle 2011). Often, intended actions and strategies designed to improve social-ecological systems' adaptive capacity do not strengthen the coping range (adaptive capacity threshold) of such social-ecological systems but instead foster maladaptation and inequalities since they disregard the actual vulnerabilities and contexts of each social-ecological system (Nagoda and Nightingale 2017; Thomas et al. 2019). These research gaps highlight the need for more explicit descriptions, tools and strategies that guide scholars and policymakers to interpret such concepts and build adaptive capacity from a context-specific perspective.

Over the last few decades, much emphasis has been placed on the influence of collaborative forms of governance on building adaptive capacity in a system of analysis and its role in making it more resilient towards internal and external shocks (Armitage and Plummer 2010a; Cinner et al. 2018; Johnson et al. 2020). However, it has been recognized that more explicit descriptions of how collaborative governance systems can address societal issues and be platforms to foster adaptive capacity, particularly in the Galapagos small-scale fishing governance system, are required. The governance of complex social-ecological systems such as the Galapagos small-scale fishing system is a challenging endeavour since the interactions of human and ecological systems are continually changing and are full of uncertainties. Today, social–ecological dimensions demonstrate that the Anthropocene might be entering a new phase of evolution characterized by rapid changes, making it challenging to govern common-pool resources such as small-scale fisheries (Lubell and Morrison 2021). The effects of the COVID-19 pandemic are the most recent example of how rapid changes can affect the resilience, the wellbeing of marine-dependent systems and the capacity of governance systems to react. The adverse consequences of unexpected and rapid changes, such as the ones triggered by the COVID-19 pandemic, clarify that rigid governance systems involving a few actors and stakeholders often delegated by laws are usually unable to cope with complex socio–ecological problems.

Building on the discussions that Dietz et al. (2003) initiated on the "struggle to govern the commons", effective forms of governance are required to evolve. In this context, in response to the limitations of centralized, top-down governance and the increasing demands on natural resources, users and communities need to be part of environmental management decisions that affect their livelihoods. Co-management strategies have proven to be effective forms of co-producing knowledge, clarifying access, and sharing rights and responsibilities between local communities, e.g., fishery local communities and governments (Andrachuk et al. 2019). However, experiences from different co-management processes demonstrate that the social–ecological dimensions spanning complex social–ecological systems go beyond the spatial, temporal, and functional scale of co-management, with wicked problems such as climate change, pandemics, and invasive species crossing human-made boundaries and different political and administrative jurisdictions (Berkes et al. 2003; Armitage et al. 2007).

Today, covering the spatial, temporal, and functional scales spanning complex social–ecological systems is challenging (Bergsten et al. 2019; Lubell and Morrison 2021). However, a significant initial step to approximate such scales is to reveal how actors and stakeholders interact and collaborate within governance systems. The use of network approaches is beneficial in this regard, as they enable the identification of (among other things) particular network configurations (e.g., a tendency toward homophily in governance systems); the presence of critical actors, including influential actors; well-connected actors; and actors and stakeholders that are displaced from decision-making structures. Notably, a broader view of specific governance network interactions provides critical information on whether collaborative links should be improved, kept, or created. Moreover, it facilitates the inclusion and spread of various determinants of adaptive capacity—including skills, financial support, social memory, technology, and local priorities—from the public and private sectors at different scales and levels (Armitage et al. 2017b; Fried et al. 2022).

In several places, such as Latin America, governance systems tend to hold on to biases from previous institutions that are marked by contradictions, different views, vested interests, and power relations between the private and public sectors, which give rise to a series of challenges for governance systems and institutions (Lemos and Agrawal 2006; Gupta et al. 2010; Mudaliar 2020). Therefore, this dissertation highlights the need to understand linkages in governance networks to develop a broader view of how governance system structures operate, encouraging discussions on possible deliberate transformations and governance structure arrangements that could produce more sustainable outcomes. The results of this dissertation may serve to consolidate the first steps of the Galapagos co-management governance system toward an adaptive co-management form of governance. Often known as learning by doing, adaptive co-management is an emerging form of governing complex social–ecological systems that enables an expansion of the scope of governance while considering the value of polycentrism and subsidiarity.

Polycentric systems comprise multiple autonomous decision-making centres that operate at multiple geographical scales and levels (Stephan et al. 2019; Carlisle and Gruby 2019; Acton et al. 2021; Lubell and Morrison 2021). Contrary to top-down governance approaches, polycentric systems promote independence among organizations rather than the hierarchical structure of management, which could facilitate an approximation with social–ecological dimension scales. Considering that there is no true co-management if it does not share power and devolve participation rights to those whose livelihoods might be affected (Armitage et al. 2007; Morrison et al. 2019; Mudaliar 2020), the principle of subsidiarity suggests that decisions should consider the lowest possible level of governance, which means that decision-making structures should include those whose livelihoods might be affected by the decision-making (Armitage et al. 2011). In this regard, the principle prioritizes making decisions as close as possible to the local levels, which is a vital element to consider when incorporating local priorities and social memory into decisions.

This dissertation is the first study in the related literature that uses network research approaches to illustrate how the participants in the Galapagos small-scale fishing governances system interact. Following Kooiman's (2003b) definition of governance, we understood governance as the interactions in which public and private actors aim at solving societal problems and creating societal opportunities. Governance networks comprise diverse actors from diverse sectors, often with opposing views and interests, including public and private actors such as governmental organizations, NGOs, research institutes, fishing cooperatives, and other multi-level organizations (Mitchell 2019; Johnson et al. 2020; Blythe et al. 2022). Therefore, understanding how governance systems interact is significant in the production of sustainable outcomes. The theoretical framework of this doctoral research may enable the formulation of policy actions planned strategically according to the governance system's needs and specific governance network configurations (Bodin et al. 2022). Moreover, decision-makers might formulate and deliver more effective decisions if they know how a governance network behaves. The outcomes of this dissertation reveal a series of network configurations and the positions of several critical actors within the Galapagos small-scale fishing governance network that may contribute to the selection of collaborative partners, the better and more rapid diffusion of information, and therefore, the construction of adaptive capacity and the enhancement of resilience in the sector.

1.2 THEORETICAL FRAMEWORK

My research draws on insights from vulnerability, adaptive capacity, governance fit, and collaborative governance to guide the theoretical frameworks employed in this dissertation. Although these concepts often have been treated separately, I show throughout this dissertation that these terms are closely linked and are concepts to bear in mind, particularly during periods of abrupt change. The theoretical framework of this doctoral research offers diverse forms and methods, mainly using governance as a platform to make deliberate changes that positively influence the direction of the coping range in complex social-ecological systems. Today, social-ecological systems face shocks of multiple and simultaneous adverse place-specific internal and external drivers of change that often exceed the capacity of the system of interest to cope (Lubell and Morrison 2021; Fried et al. 2022). In that regard, I drew on Smit and Pilifisova (2003) to show that if decisions and strategies address the actual causes that generate vulnerability, they can change and influence the state of complex social-ecological systems in such a way that facilitates the construction of adaptive capacity. In this context, I argue that if intended measures and strategies do not address the actual causes of vulnerability regardless of their genesis, they might amount to being isolated efforts. Therefore, they do not contribute to strengthening the coping range of complex social-ecological systems and build hardly any adaptive capacity because they do not move in the same direction as the actual vulnerabilities.

1.2.1 VULNERABILITY AND ADAPTIVE CAPACITY

While the term "vulnerability" has been used effectively to describe states of susceptibility to harm (Adger 2006), it is necessary to recognize that because this term has been derived from different schools of thought, there is ambiguity in its use. This has led to various forms of understanding of vulnerability, thus leaving room for subjective assessments and confusion (Klein and Möhner 2011; Stadelmann et al. 2015; Ferreira 2017). Acknowledging that vulnerability is a context-specific concept that requires cultural-specific investigations is crucial in adopting measures and strategies in complex social-ecological systems. As such, I contend that the different social-ecological dimensions of each system change from place to place, even at short distances, which means that factors that build adaptive capacity in one location might increase vulnerability, foster maladaptation and exacerbate existing vulnerabilities in other systems – see Chapter 2. Adopting vulnerability as a location-specific term contributes to an understanding of vulnerability, adaptive capacity and the coping range of analysis. In this context, I argue that if we aim to strengthen the coping capacity of a system of interest, efforts should initially focus on understanding the system's root causes of vulnerability to impact, to influence it positively. Otherwise, any intended actions and assessments will not be effective in building sufficient adaptive capacity (Downing 2003).

While “adaptive capacity” is a concurrent term in policymaking and public policy discourses, particularly in resource and environmental management, there is still a lack of guidance in the literature on how to use the concept and how it can be used a platform to move from theory to practice. Frequently, adaptive capacity have served to describe means to offset adverse factors of change in systems of analysis in the diverse literature on resource and environmental management, and sustainability science (Holling 1973; Adger 2000; McCarthy et al. 2001; Brooks 2003; Wisner et al. 2004; Gallopín 2006). However, it is necessary to recognize that conceptualizations of adaptive capacity are sometimes overly broad, thereby leaving room for confusion and subjective assessment when delivering place-specific measures and policy decisions. Often adaptive capacity conceptualization treats adaptive capacity as a general property of all social-ecological systems (see discussion in Lade et al., (2020), ignoring specific policy-economic circumstances at each system of concern (Biesbroek et al. 2017). There are unique context-specific and location-specific factors that either bolster or hamper building adaptive capacity (Ford and Smit 2004; Smit and Wandel 2006; Ford et al. 2008). Factors that build adaptive capacity in one place might reinforce inequalities and marginalization in another. This dissertation refers to adaptive capacity as the context-specific conditions that allow a system of interest to anticipate and respond proactively to diverse shocks, reduce the adverse consequences, recover and take advantage of new opportunities (Folke et al. 2002b; Engle 2011; Whitney et al. 2017; Cinner et al. 2018). Therefore, the more adaptive capacity accumulates a system of interest, the greater the likelihood that the system will adapt and be resilient to diverse drivers of change (Folke et al. 2005; Adger et al. 2011; Lemos et al. 2013).

Building adaptive capacity in social-ecological systems greatly depends on the management capacity of governance systems to understand and address the underlying internal and external exposures that render a social-ecological system vulnerable (Smit and Wandel 2006; Ford et al. 2010). To explain this, I build on the work by Smit and Pilifisova (2003), who describe how the coping range of a system of interest (e.g. an artisanal fishing system or a coastal community) reflects its adaptive capacity, which can fluctuate either negatively or positively over time according to context-specific circumstances. On the one hand, some context-specific internal shocks (e.g., political instability, poverty, lack of institutional representation, vested interests, monopolies) and place-specific external shocks (e.g., resulting from climate change, pandemics, globalization, unreported and unregulated fishing in areas beyond national jurisdiction) can potentially affect a system of analysis, altering its thresholds negatively (see red dotted line of Fig. 1.1). However, on the other hand, it is crucial to bear in mind that the direction of a system's coping range can fluctuate positively if intended actions and measures achieve the desired aim of tackling external place-specific and internal context-specific drivers of change that render a system of analysis vulnerable (see blue dotted line of Fig. 1.1). For instance, through tools and strategies that we consider might be used according to social-ecological realities and conditions to achieve actual transformative measures aimed at building resilient social-ecological systems if efforts center on reducing the underlying causes of vulnerability – see Chapter 2.

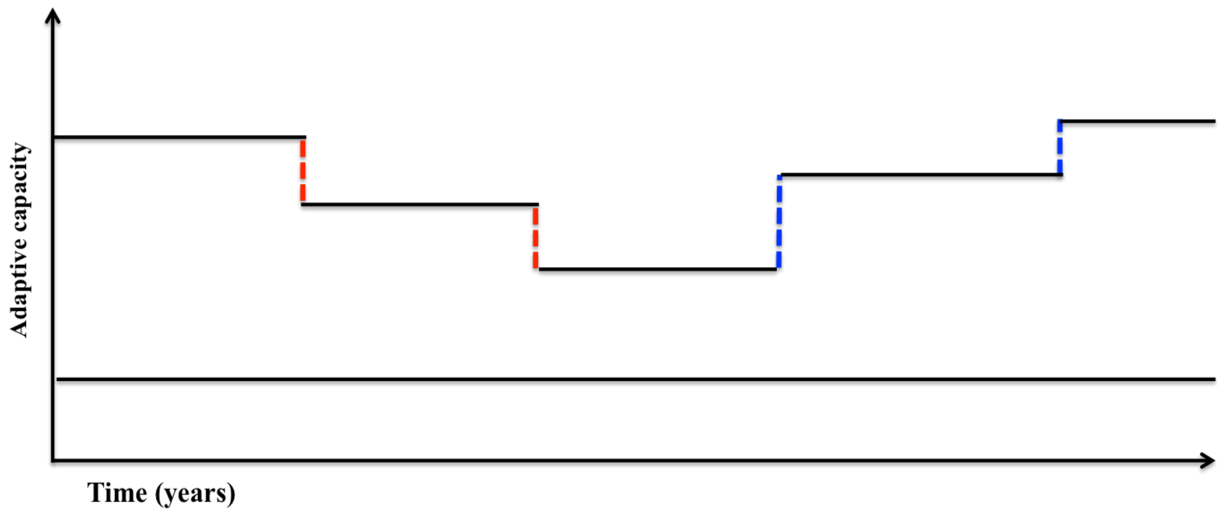

Figure 1.1 Coping range of a system of concern (based on Smit and Pilifosova (2003) and Smit and Wandel (2006).

The black line indicates the coping range of a system of concern. The red dotted line indicates factors that decrease the adaptive capacity in a system, such as poverty, climate change, illegal international fishing or overpopulation. The blue dotted line indicates tools and strategies that might contribute to building adaptive capacity in a system in context-specific settings. See in that regard discussions on: "collaborative forms of governance" (in Armitage et al., (2009); "mainstreaming plus" (in Ayers, (2014) regarding incorporating specific drivers of change into development policies; "adaptation pathways" (in Barnett et al., (2014), regarding "triggers" [adaptation tipping points] at local scales to deal with location-specific risks; "scenario planning" (in Star et al., (2016), which, if they rely on context-specific factors that create vulnerability, are powerful planning tools that might guide practitioners to deal with uncertainty from context-specific perspectives with long planning horizons.

1.2.2 ADAPTIVE CAPACITY AND GOVERNANCE

Building on the discussions that Armitage and Plummer (2010a) and Kooiman (2003b) initiated on "adaptive capacity and governance," the ability to enhance a system of interest's adaptive capacity is often dependent on, and directly related to, those in charge of decision-making processes and structures. Generally speaking, governance often represents the interactions and structures that define power, responsibilities and how decisions are taken across sectors and administrative levels in common-pool resources (Kooiman 2003a; Lockwood et al. 2010; Bennett and Satterfield 2018). The latter has led increasingly to the recognition that understanding the role of governance, institutions, actors, and networks contributes to the capacity of a system of interest to anticipate, prepare, and respond to various adverse shocks and, therefore, to build adaptive and resilient social-ecological systems (Engle and Lemos 2010; Plummer and Armitage 2010; Engle 2011; Armitage et al. 2017b; Blythe et al. 2022). Considering that bolstering the capacity to adapt of a social-ecological system signifies reductions in vulnerability to internal and external climate and non-climate drivers of change, the identification and involvement of all those whose actions determine the state and future of a system of concern is increasingly needed and has been explored insufficiently in Latin America and the Caribbean. Collaborative approaches to dealing with societal problems are not new in the literature, particularly in the public policy and administration arena; however, recognizing that the scope to address current wicked problems has expanded, there is significant demand for a multilevel approach—from local to global—that considers different decision-making networks and political channels as part of the analysis (Wandel and Marchildon 2010; Mubaya and Mafongoya 2017). Following Fisher et al.'s (2011) definition of organizations as bodies such as government departments, autonomous regulatory bodies and non-government organizations, this dissertation posits that the analysis of the role of state and non-state organizations across sectors, geographical scales and administrative levels, their interactions, positions and attributes within a governance network, should become a cornerstone in building adaptive capacity[1] (Pahl-Wostl 2009; Plummer and Armitage 2010). Building on the concept of fit, explored initially by Young (2002), I argue in this dissertation that enhancing the capacity to adapt of a social-ecological system of interest from a governance view depends on the alignment and coordination among actors to prevent a misfit between the social-ecological dimensions, social values and needs, and the scope of governance of a system of concern, which, in practical terms, have direct implications on reducing vulnerability (Kalikoski et al. 2002; Folke et al. 2007; Ishihara et al. 2021). Despite coordinating actions between actors and stakeholders, often fraught with the challenge of different perceptions of the problems, goals, levels of power, and operational procedures, the employment of social network analysis perspectives, as both concept and method, is a powerful and promising tool to reveal the interactions and behaviours within governance systems (Janssen et al. 2005; Treml et al. 2015; Bodin et al. 2016; Pittman and Armitage 2017a; Scott and Ulibarri 2019). In that sense, representing a wide diversity of actors within a governance system as "nodes" and their interactions as "ties" through social network analysis approaches provides insights into network properties that can foster deliberate transformations through multilevel and sectoral coordination mechanisms (Alexander et al. 2015; Bodin et al. 2019), a persistent challenge in science-policy arenas. By building on prominent political and public administration theories, including the ecology of games (Lubell 2013), collaborative governance regime (Emerson et al. 2012), institutional collective action (Feiock 2013), and the polycentrism insights initially discussed by Vincent Ostrom et al. (1961) and further studied by Elinor Ostrom (2010), this dissertation posits that uncovering complex governance interactions provides opportunities to plan strategically to approximate as closely as possible the scale of governance with social-ecological interactions, social values and needs of a system of concern. As such, I argue that engaging in a deliberate planning process reduces the likelihood of surprises and prevents a potential social-ecological misfit in light of multiple location-specific drivers of change that are often recognized as wicked problems – see Chapters 3 and 4.

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[1] Notably, Institutions were treated interchangeably as organizations in this doctoral research to align the terminology to the research context despite often being defined as formal and informal rules and norms that shape societal actions in the literature (e.g. constitution, contracts, traditions).

1.2.3 NETWORK GOVERNANCE AND COLLABORATIVE GOVERNANCE

Although the notion of governance is well known and broadly explored in the public administration literature and public and political discussions, governance is a broad concept that spans diverse governance streams. Among the different governance concepts and theories (e.g., collective action, interactive governance theory, governmentality, evolutionary governance theory, among others) (Partelow et al. 2020), network governance and collaborative governance are core concepts in the development of this doctoral research considering that their features help to analyze how a governance network tend to behave and to reflect how information diffuses across such governance network (Partelow et al. 2020). While there is a tendency to use network governance and collaborative governance interchangeably in the literature, it is worthwhile for this doctoral research to recognize that they have both differences and similarities. On the one hand, network governance, rooted in corporatism, state theory, policy networks and public resource allocation, is understood as the form of governing wherein formal and informal institutions work together to co-implement and co-deliver public goods and services (Isett et al. 2011; Partelow et al. 2020; Wang and Ran 2021). On the other hand, collaborative governance, rooted in classical liberalism and civic republicanism, is understood in a broad sense as a governing arrangement wherein public entities engage directly with non-state stakeholders in collective actions and consensus-oriented decision-making aimed at formulating and implementing public policy, public programs and assets (Ansell and Gash 2008; Avoyan et al. 2017; Wang and Ran 2021). While both network governance and collaborative governance tend to share the same essence, one key consideration is that network governance tends to remain informal and implicit, focusing more on relationships, whereas collaborative governance tends to be more self-serving and explicit, focusing more on formal strategies and arrangements with an individual group of actors in order to address a particular problem (Ansell and Gash 2008; Wang and Ran 2021). Among the concepts' features significant to this doctoral research, five are worth bearing in mind. First, both research streams differ from a traditional top-down form of government, highlighting the engagement of non-state stakeholders and the need for cross-sectoral collaboration in decision-making processes and problem-solving in light of increasingly dynamic societal concerns (Kapucu and Hu 2020; Wang and Ran 2021). Second, both research streams tend to share insights with prominent governance theories such as interactive governance, which, according to Kooiman (2003a), emphasizes interactions between public and private stakeholders to solve societal problems and create opportunities. Third, network and collaborative governance present challenges in their implementation and consolidation: both, by their natures, involve numerous actors who often hold different backgrounds, interests, viewpoints, vested interests, levels of power and aspirations, thus hampering participants' autonomy, communication channels and abilities to achieve common goals (Kapucu and Hu 2020). Fourth, resource dependence, trust, leadership, power and performance are common and central themes across both strains of the literature. Fifth, network governance tends to focus more on network properties (e.g. network formation), while collaborative governance tends to focus on sharing (e.g. sharing information) (Wang and Ran 2021). Considering the rapid changes and uncertainty experienced in complex social-ecological systems driven by complex drivers of change, such as the COVID-19 pandemic and climate change, it is crucial to untangle the structure of governance systems and how they tend to operate in order to cope with and anticipate adverse outcomes more effectively. In this doctoral research, network and collaborative governance research streams are focal points in addressing the multiple societal problems spanning the Galapagos small-scale fishing governance system more effectively; this choice of focal points is strategically driven by the acknowledgment that no single actor has the capacity, resources and knowledge to solve multiple complex socio-ecological problems individually (see Chapters 3 and 4).

1.3 METHOLOGICAL APPROACH

Researcher positionality influences the way that researchers collect, analyze and produce knowledge, likely leading to biased outcomes and further inequalities (Muhammad et al. 2015). Accordingly, I present the following positionality statement: The choice of what to research, the methods used and the analysis undertaken in this doctoral research are openly influenced by my view on the management of natural resources and ideology. These factors inform my approach to place-based research, particularly in complex socio-ecological systems such as small-scale fisheries, where unexpected changes and simultaneous drivers of change produce multiple conflicts and disputes. Through my academic and professional experience, I have witnessed and experienced the position of climate change scholars and negotiators on climate change and development issues. Notably, my identity as a young researcher with a strong interest in vulnerability, adaptive capacity, and governance derives from—and has been greatly influenced by—my participation in Ecuador's discussions and policymaking discourses on climate change as a scholar and governmental official. Indeed, my past experiences as a geographer, scholar and government official in Ecuador as well as the limitations imposed by the COVID-19 pandemic have been significant factors that delineated how this doctoral research was carried out. Importantly, as I am mindful of each socio-ecological system's specific features and socio-ecological interactions, I am aware of the crucial role of local people and their knowledge to support context-specific investigations such as the one that I undertook in this doctoral research. In the case of this dissertation, I do not possess such knowledge, as I am from outside of the local communities.

Following Creswell (2009), the research described in this dissertation followed a mixed-method approach to meet the study's objectives (i.e., an investigation where the researcher collected, analyzed data and integrated outcomes in a single study by incorporating both qualitative and quantitative methods to address the research problems) (Creswell 2009; Doyle et al. 2009). Of the different strands of mixed methods (e.g., triangulation design, exploratory design and explanatory design), an embedded design was used in this research. An embedded design is a research design where qualitative and quantitative data are collected and analyzed simultaneously (Doyle et al. 2009). In this approach, first described by Caracelli and Greene (1997), one type of data plays a supportive role (Creswell 2009; Doyle et al. 2009). The approach fits the research questions of this dissertation since its design began qualitatively and then increasingly emphasized quantitative methods (Creswell 2009).

Conceived in the late 1980s as a method to improve data accuracy and obtain a complete picture of data, philosophical discussions deem mixed-method research a third research paradigm that transcends the ontological and epistemological divisions between qualitative research (also called interpretivism and constructivist philosophy) and quantitative research (also called positivist philosophy) (Baskarada and Koronios 2018; Shan 2022). Contrary to the orientations and philosophical positions of qualitative and quantitative purists, who often debate whether a given research approach is valid or not, this doctoral dissertation treats mixed-method research as a complement to combine the strengths of both qualitative and quantitative approaches (Johnson and Onwuegbuzie 2004; Morgan 2007). The paradigm wars between qualitative and quantitative research have been the subject of intense criticism in the social sciences; qualitative researchers claim that quantitative research approaches do not capture participants' dynamics, while quantitative researchers point out that qualitative research approaches lack the rigidity of a scientific method. Nevertheless, it is imperative to point out that, today, hardly any research question can be answered using a single research method (Osborne 2008; Doyle et al. 2009; Feilzer 2010). Philosophically, the mixed-method research of this doctoral dissertation fits into pragmatism (also called instrumentalism), a position rooted in American pragmatism—see the discussion in Shan (2022), Feilzer (2010), and Tebes (2012)—to promote non-purist approaches, particularly in a time characterized by complex and rapid changes requiring non-purist positions. Linked to mixed methods research by Rosseman and Wilson (1985) and others such as Morgan (2007), Osborne (2008), and Johnson (2004), pragmatism suggests that a phenomenon is best understood if it is analyzed from diverse perspectives. As such, considering the increasingly complex problems in the social sciences, pragmatism is understood in this dissertation according to John Dewey's pragmatic theory as a philosophical position and valid research design that does not limit the researchers' choices to select their methods and procedures of research, in contrast to the limitations often imposed by the dichotomy between positivism and constructivism (Tebes 2012; Shan 2022).

I first explored in the literature, particularly in the climate change realm, how the different interpretations of vulnerability can give rise to diverse forms, scales of applying the term and problem-solution measures. By drawing on this analysis, I suggested that actions and strategies intended to enhance the adaptive capacity of a system of concern need to start with an assessment of the system's vulnerability to location-specific multiple drivers of change (Smit and Pilifosova 2003). Next, I proposed a set of short- and long-term actions and strategies linked to decisions and articles under the United Nations Framework Convention on Climate Change (UNFCCC), particularly within the context of developing countries, which, if aimed at addressing the actual causes of vulnerability, can have a long-lasting effect on reducing exposure and improving resilience and adaptive capacity.

It is crucial to keep in mind that reducing vulnerability and building adaptive capacity in complex social-ecological systems is often dependent on the effectiveness of collaboration networks to find proper solutions according to the context and nature of the problems. As such, I drew on a governance network approach by using descriptive statistics and exponential random graph models (ERGMs) to uncover significant network collaboration attributes of several multilevel organizations that play a role in managing the Galapagos small-scale fishing governance system. Since there had not been any previous research on the small-scale fishing governance system network of the Galapagos Islands, it was necessary to create a list of actors frequently associated with managing the Galapagos Islands' small-scale fishing sector. Therefore, on the one hand, I adopted a nominalist approach to make an initial list of actors associated with small-scale fishing in the Galapagos Islands by exploring the sector's history, management, and institutional interactions from past publications, including academic papers and governmental documentation. On the other hand, I followed a snowball approach in which I asked research participants from our initial list of actors to suggest any other organizations and agencies (nodes) at different scales and levels to be included, and their further interactions (ties), to produce a final list of actors. This methodological rationale enabled me to explore, on the one hand, the network formation in the Galapagos small-scale fishing governance system, the tendencies toward specific governance network formations, and the network positions of significant players in the governance system, while, on the other hand, it enabled me to suggest ways of enhancing the collaboration system in light of diverse and simultaneous drivers of change in the governance system.

1.3 PURPOSE AND OBJECTIVES

This doctoral research aims to contribute to building adaptive capacity in light of multiple drivers of change, particularly by exploring the governance of the Galapagos small-scale fishery. In this context, the following objectives guided this research:

Objective 1: To assess how vulnerability assessments and decision-making planning tools can be applied to increase adaptive capacity at the local scale in the face of multiple drivers of change (Chapter 2).

Objective 2: To explore the role of collaborative governance network for building adaptive capacity in the Galapagos small-scale fishing sector (Chapter 3).

Objective 3: To strengthen the collaboration network of the Galapagos small-scale fishery governance system in light of multiple drivers of change (Chapter 4)

1.4 STRUCTURE

This dissertation follows a manuscript format. Chapters submitted to the research journal keep their original structure.

The first chapter offers an introduction to the dissertation. The second chapter describes how different epistemological viewpoints and schools of thought can lead to varying interpretations of vulnerability. Considering that this has implications for the forms of delivering solutions to problems and measures and assessments, this chapter clarifies the use of the term vulnerability and how it can contribute to building adaptive capacity through various decision-making planning tools. The chapter addresses objective one, drawing on the following research question:

How can vulnerability assessments and decision-making planning tools be applied to increase adaptive capacity at the local scale in the face of multiple drivers of change?

The third chapter explores how collaborative approaches may serve as platforms to build adaptive capacity in complex social-ecological systems. Specifically, the chapter explores the collaborative governance system of Galapagos small-scale fisheries using a social network analysis approach based on descriptive statistics and ERGMs. This chapter addresses objective two, drawing on the following research questions:

How do the collaborative ties in the Galapagos small-scale fishing governance system interact?
Which small-scale fishery sector-related organizations frequently interact in the Galapagos small-scale fishing governance system (central nodes)?
Which small-scale fishery sector-related organizations could help connect groups within the Galapagos small-scale fishing governance system (bridging nodes)?
What type of organizational ties links the Galapagos small-scale fishery governance system?
How often do organizations collaborate within the Galapagos small-scale fishery governance system?
Do organizations and agencies tend to reciprocate institutional links in the Galapagos small-scale fishing governance system?
Is there a tendency towards homophily in the network?
Do organizations and agencies from the public sector tend to send or receive more organizational links than others in the Galapagos small-scale fishing governance system?
Do organizations and agencies from the local level tend to send or receive more organizational links than others in the Galapagos small-scale fishing governance system?

The fourth chapter explores the evolution of polycentric governance in the Galapagos small-scale fishing sector, the preferential attachments of new nodes within the Galapagos small-scale fishery governance system network, and the propensity of cross-sectoral reciprocity and cross-sectoral open triad formation by using descriptive statistics and ERGMs. This chapter addresses objective three, drawing on the following research questions:

Is there a tendency toward open triad network configurations in the Galapagos small-scale fishing governance system?
Which non-small-scale fishery sector-related organizations could contribute to the Galapagos small-scale fishing governance system?
Which organizations and agencies are closer to all nodes in the network of the Galapagos small-scale fishing governance system?
Which organizations and agencies are closer to important nodes compared to others in the network of the Galapagos small-scale fishing governance system?

The fifth chapter provides the contributions, limitations, and suggestions for future work from this doctoral dissertation.

1.5 EMPIRICAL CONTEXT

The Galapagos Islands are an archipelago located in the Pacific Ocean, 1240 kilometres (km) from Ecuador's mainland (Figs. 3.2 and 4.5). These volcanic islands are a biodiversity hotspot with high levels of endemism. They are best known for being one of the first places recognized as a World Heritage Site by UNESCO in 1978 and as the natural laboratory that inspired Charles Darwin's theory of evolution in 1859. The Galapagos Islands are one of Ecuador's 24 provinces (Sampedro et al. 2018; Claudino-Sales 2019). However, they have historically been treated differently from Ecuador's mainland provinces. They have benefited from special protection by the Ecuadorian Government following the creation of the Galapagos National Park in 1959 and the introduction of the Galapagos Special Law (GSL) in 1998, which provide special treatment and environmental protection to both terrestrial and marine areas of the Galapagos archipelago (Garcia Ferrari et al. 2021). The Galapagos Marine Reserve (GMR) spans 198,000 km^2, protecting the Galapagos marine life from international fishing activities following the addition of 60,000 km^2 to the GMR in 2022. Today, it creates a corridor that links the marine reserves of Colombia, Costa Rica, and Panama, making it one of the most extensive marine reserves protected worldwide.

Biodiversity in the Galapagos Islands is one of their distinctive biophysical features, derived primarily from its unique geographic position on Earth. The Galapagos Islands sit in three different ocean currents (the Humboldt Current, Panama Current, and Equatorial Undercurrent), creating a mixture of warm and cold and nutrient-rich waters across the archipelago (Baine et al. 2007; Claudino-Sales 2019; Cavole et al. 2020). The Galapagos Islands comprise 13 major islands, six medium-sized islands, and 107 small islands (Villacis and Carrillo 2013). Currently, four islands are inhabited: Isabela Island, Santa Cruz Island, San Cristobal Island, and Floreana Island (Fig. 4.5). Significantly, the Galapagos is the only province in Ecuador that operates differently from Ecuador's mainland hierarchical governance. Instead, the Galapagos Islands are subject to a participatory governance system following the adoption of the GSL in 1998. The GSL led to the establishment of the GMR and implementation of the Galapagos co-management system (GCM) to further protect the archipelago's biological and ecological systems in the face of existing conflicts over natural resources among both terrestrial and marine stakeholders (Viteri and Chávez, 2007; Castrejón et al., 2014; Barragán, 2015). The GSL established a total ban on industrial fishing in the islands (Cerutti-Pereyra et al. 2020). Since then, only artisanal fishery operations in specific areas have been permitted, and only residents affiliated with artisanal cooperatives can obtain fishing permits (Garcia Ferrari et al., 2021).

While the creation of the GSL and adoption of the Galapagos co-management governance system marked a significant shift from a top-down to a bottom-up approach to the management of the GMR (Heylings and Bravo, 2007), the operational system of the Galapagos governance has faced intense criticism and public concern, which has led to modifications to the initial GSL governance structure that are discussed further in Chapter 4. The 2008 national constitution reform introduced a new management authority in the Galapagos, giving the control and constitutional power over decision-making regarding natural resources, migration, and permanent residence to the Galapagos Special Regime Governing Council (Spanish acronym CGREG), and leading to the reform of the 1998 GSL in

2015 (Garcia Ferrari et al., 2021). Significantly, decades after adopting the first GSL in 1998 and its subsequent reform in 2015, a new version of GSL is under discussion that includes reforms and mechanisms for citizen participation, which have created intense public debate surrounding the appropriateness of these reforms for the Galapagos governance system operation. Therefore, until the new governance structure is defined, the future of the Galapagos co-management governance system remains uncertain.

Commercial fishing activities in the Galapagos Islands date back to the end of the 18th century, when whalers from Britain and North America began exploiting three main marine mammals: sperm whales (*Physeter macrocephalus*), fur seals (*Arctocephalus galapagoensis*), and Galapagos sea lions (*Zalophus wollebaeki*; Castrejón et al., 2014). The commercial exploitation of fishery resources in the Galapagos has created different social and ecological conflicts, the most relevant being the boom-and-bust exploitation of the sea cucumber (*Isostichopus fuscus*) between the 1980s and early 2000s (Castrejón et al., 2014). The sea cucumber boom in the Galapagos represents a cornerstone that significantly bolstered fishing activities in the archipelago, triggering interest from many people, both native to the Galapagos and on the Ecuadorian mainland, in fishing activities (Bremner and Perez, 2002). The lucrative growth of the fishing industry in the Galapagos Islands due to Galapagos sea cucumber exploitation led to the significant migration of fishers from the Ecuadorian mainland, who, in collaboration with Asian exporters, led to political, conservation, and social strife on the islands (Bremner and Perez 2002; Castrejón et al. 2014).

Conflicts between stakeholders, authorities, and commercial interests across the archipelago have prompted the creation and establishment of various governmental, non-governmental, and scientific organizations in the Galapagos for management, conservation, or commercial reasons (Castrejón et al., 2014). Today, primarily, the government governs the GMR. The administration and control of natural resources fall mainly under the CGREG and the Galapagos National Park Directorate (Spanish acronym DPNG). Currently, five artisanal fishing cooperatives are operating in the Galapagos Islands, known by their Spanish acronyms COPROPAG, COPESPROMAR, COPESAN, COPAHISA, and

ASOARMAPESBAY (see Chapter 3). Traditionally, the ecological and biodiversity value of the Galapagos Islands has attracted the attention of numerous international and scientific organizations interested in the conservation of the islands. Therefore, diverse private research organizations act to preserve the archipelago, including the Charles Darwin Foundation, which has operated in the archipelago since the 1960s (Castrejón et al. 2014).

I selected the Galapagos small-scale fishing sector as an empirical case of study for the following reasons: 1) while Galapagos Marine biology has been the focus of intensive investigations in the literature, the social science perspective remains largely unexplored; 2) it represents a significant source of income and is a key sector for food security and socio-economic stability in the Galapagos Islands; 3) its adaptive capacity building from a governance context is largely unexplored in the archipelago; and 4) while all decisions regarding the control and management of marine resources in the Galapagos Islands arise from a governance system regime, a governance network perspective on the Galapagos small-scale fishing governance system is absent from the literature.

1.6 MULTIPLE DRIVERS OF CHANGE

The biophysical and socio-economic conditions on the Galapagos Islands have been gradually changing through time, resulting from exposure to the extreme environmental and climatic changes the Galapagos Islands face. Following Nelson et al. (2006) and Carpenter et al. (2006), throughout this doctoral research, I refer to drivers of change in response to diverse climate-related and non-climate-related shocks that may cause harm to the concerned system. In this context, present-day illegal fishing, climate change, and the COVID-19 pandemic are the main drivers of change affecting the Galapagos small-scale fishery system.

The Galapagos Islands is a global environmental hotspot experiencing intense adverse effects from climate-related change. Notably, it experiences dynamic oceanographic variations (Salinas-de-León et al. 2020) that originate from the confluence of warm and cold oceanic currents, making it vulnerable to climatic variation due to factors such as the periodicity of the El Niño-Southern Oscillation (ENSO and La Niña effects (Escobar-Camacho et al. 2021). During extreme La Niña events, the Galapagos Islands can experience intense cooler and drier conditions, affecting the water security of the agricultural sector and the population settled in urban areas of the Islands (Mateus and Quiroga 2022). During extreme ENSO events, the archipelago can experience anomalous increases in sea surface temperature and intense rainfall. Warmer water is less nutrient-enriched than the cold water that often surrounds the Galapagos Islands and disrupts both Galapagos marine and terrestrial ecosystems (Sachs and Ladd 2010). Prior ENSO events in the Galapagos have tended to occur every two to seven years, and serve as a proxy for understanding the adverse consequences of climate-related factors affecting the archipelago and how these might become more frequent and challenging in longer events (Philander and Fedorov 2003; Palacios et al. 2009). During intense El Niño events in 1975–1976, 1982–1983, 1993–1984, and 1997–1998, marine and terrestrial ecosystems, including some emblematic species, suffered detrimental effects across the islands (Escobar-Camacho et al. 2021; Alava et al. 2022). For example, during the 1982–1983 and 1997–1998 El Niño events, population decline was observed in endemic Galapagos penguins (*Spheniscus mendiculus*; ~78%), Galapagos fur seals (*Arctocephalus galapagoensis*; ~ 60%), and Galapagos sea-lions (*Zalophus wollebaeki*; ~35%; (Edgar et al. 2010). Moreover, mass migration of giant tortoises (*Geochelone nigra*), increased mortality of marine iguanas, nesting failure among brown pelicans and blue-footed boobies, increases in pathogens, parasites, and invasive species, and habitat alterations (e.g., black rats are better adapted for wet conditions) were also observed (Palacios et al. 2009; Trueman et al. 2011). Significant climate change-related concerns have been raised by the scientific community considering the cascade of indirect effects that ENSO events can trigger in the archipelago's primary economic sectors (i.e. tourism, fishing, and agriculture) if they become more frequent and intense as a consequence of climate change. The Galapagos Islands' land surface temperature has risen by 0.6°C since the early 1980s (Paltán et al. 2021). Therefore, should the amount of greenhouse gases in the atmosphere continue to increase and global commitments to restrict the global temperature rise fail, it is expected that the oceanography and climate of the Galapagos Islands will change. According to climate projections, we expect hotter conditions in the Galapagos Islands in the future (Paltán et al. 2021), accompanied by prolonged and more extreme El Niño events before the end of the century. Under this scenario, the archipelago's marine and terrestrial ecosystems and economic sectors may suffer detrimental effects that exacerbate the current conditions of this fragile socio-ecological system. These effects may include challenges with conservation strategies and management, protection of native and endemic species, food security, control of invasive species, biodiversity conservation, and diverse other socio-economic circumstances.

The 2019 COVID-19 pandemic is a new driver of change in the Galapagos Islands and perhaps the most vivid example of how external shocks might impact the daily wellbeing and socio-economic stability of all economic sectors in the Galapagos Islands. Despite the geographical isolation of the Galapagos Islands, initially considered a natural biophysical shield to protect the islands from the spread of COVID-19, the adverse impacts of this pandemic rapidly affected its population of around 30,000 people leading to the worst socio-economic situation ever experienced on the archipelago. The restrictions imposed to limit the spread of the virus by national and local authorities, such as the closure of national borders, the introduction of national curfews and polymerase chain reaction (PCR) testing to enter Ecuador and the archipelago, and the natural fear of travelling as a means to avoid the contagion, quickly disrupted supply chains and decreased the number of visitors to the Galapagos Islands dramatically. It was estimated that the number of visitors to the archipelago decreased from 271,238 in 2019 to 72,519 in 2020, which represents a decrease of 73% in one year (DPNG 2021; Burbano et al. 2022). This drop destabilized and collapsed the entire Galapagos economy (approximately 70% of the economy) due to its over-dependence on tourism (Garcia Ferrari et al. 2021; Mateus and Quiroga 2022). Since March 2020, COVID-19 variants have impacted the archipelago's tourism sector and primary sources of income, prompting a cascade of adverse consequences on the other sectors in the Galapagos, including the fishing and conservation sectors. The collapse of the local economy due to the failure of the tourism sector, representing 65.5% of the Galapagos' Gross domestic product (GDP), led to the cessation of fishers' product sales in mainland Ecuador and international markets, making them entirely dependent on an already weak local economy and triggering severe economic losses for the sector (Viteri Mejía et al. 2022). Evidence shows, for instance, that in the initial months of the pandemic, fishers could not afford fishing vessel operations, among various circumstances, because fisheries prices decreased between 28.6% and 44.0 % from one day to another due to the close link between the sector with the tourism sector, which represents 70% of the total demand for fish (Viteri Mejía et al. 2022). Furthermore, as Garcia Ferrari et al. (2021) demonstrated, the adverse effects of the COVID-19 variants threatened to reverse progress on conservation achieved over the years. Stakeholders from the tourism sector demanded the lifting of restrictions to direct international travel to the Galapagos Islands, contradicting biosecurity hazard measures in place in the Galapagos regulations to control invasive species. As such, commercial international flights whose final destination is the Galapagos Islands have traditionally been required to land in Quito and Guayaquil first. Similarly, the fishing sector demanded the use of long lines in the GMR, contradicting previous conservation efforts to protect species in the islands (Garcia Ferrari et al. 2021).

Year after year, international fishing fleets, the vast majority of them from Asia, threaten the Marine resources of the Galapagos Islands. The Galapagos Islands possess one of the most significant sharks biomass worldwide (Alava and Paladines 2017). However, the dearth of available resources and technology to monitor illegal international fishing vessels has made this activity one of the main adverse drivers of change in the archipelago (Alava and Paladines 2017). The Galapagos Islands are subject to intense international fishing pressure, driven primarily by the prolonged and historic demand of the Chinese market for Galapagos marine resources (Carr et al. 2013). Figures show that of the 40 shark species registered in the GMR, around 30 are frequently caught by fishers illegally (Jacquet et al. 2008). For example, in 2017 the Ecuadorian Navy caught a Chinese vessel carrying 300 tons of fish and 6000 sharks, including threatened shark species such as the thresher (*Alopias pelagicus*), scalloped hammerhead (*Sphyrna lewini*), and silky (*Carcharhinus falciformis*), within the GMR protected area (Alava and Paladines 2017). Similarly, in 2020 the Ecuadorian Navy issued a warning that approximately 260 vessels, the vast majority belonging to the Chinese, were located at the edge of Ecuador's exclusive economic zone around the Galapagos Islands. This event triggered intense social demands and strife on the Ecuadorian mainland and in the Galapagos Islands, where citizens demanded further control actions against illegal international fishing. The social and political pressure resulting from the social concern exerted during that time led indirectly to the expansion of the GMR to include 60,000 km^2 of new territory in 2022.

CHAPTER 2: CLIMATE-CHANGE VULNERABILITY AND DECISION-MAKING PLANNING TOOLS IN THE FACE OF MULTIPLE DRIVERS OF CHANGE: INSIGHTS INTENDED TO ENHANCE ADAPTIVE CAPACITY AT THE LOCAL SCALE.

We must be aware of the setbacks that the interpretation of the term 'vulnerability' and the expression 'particularly vulnerable' have brought to the international funding regimes and decision-making structures. In this paper, we see vulnerability as a crucial piece of evidence, a prerequisite or a starting point for understanding the underlying sources of the vulnerability of a system of concern and avoiding misinterpretation in adopting and delivering actions and planning strategies intended to enhance adaptive capacity at the local scale. This paper (1) reviews the concept of "vulnerability" in climate change interventions and (2) integrates vulnerability with planning tools intended to enhance adaptive capacity locally in different timeframes. We link this analysis to core articles and decisions on climate change adaptation and capacity building under the United Nations Framework Convention on Climate Change (UNFCCC) and Conference of Parties (COP) from developing countries' perspectives.

2.1 INTRODUCTION

The concept of vulnerability is relevant to research in several disciplinary fields, including areas such as natural hazards, food security, public health, and environmental change, for describing states of susceptibility to harm (Blaikie et al. 1994; Cutter 1996; Adger 2006; Smit and Wandel 2006). However, the treatment of the term vulnerability has been notoriously ambiguous, particularly in climate change interventions. In the literature on climate change, different epistemological orientations have influenced the widespread use of the term, giving rise to varying interpretations of vulnerability and forms of understanding and approaching it (Kelly and Adger 2000a; Füssel 2007; Klein and Möhner 2011). This paper helps policymakers and decision-makers interpret the term vulnerability more closely and integrate vulnerability into decision-making planning tools intended to build adaptive capacity locally, considering different timeframes and realities of developing countries.

This paper highlights that in a world full of constant and rapid changes, there is a pressing need to bolster the capacity of complex social-ecological systems to anticipate and respond to diverse adverse climate change-related exposure and non-climate-related stresses (Folke et al. 2002b; Engle 2011; Whitney et al. 2017; Cinner et al. 2018). Therefore, we argue against climate-change interventions (e.g., funding from UNFCCC/COP procedures) and decision-making structures focusing specifically on climate change while disregarding underlying causes of vulnerability that render a socio-ecological system vulnerable. The risk in such a scenario is that subsequent responses will be insufficient to bolster the capacity of such systems to adapt at a local scale (Eriksen et al. 2021).

2.2 METHODOLOGY

First, we conducted a systematic review of the literature on climate change vulnerability emerging from different schools of thought from 2000 to 2022. We used the Google Scholar search engine and Science Direct research databases to search for a significant representation of the available literature. We performed our literature search in four steps: question definition, search, search protocol and analysis. Step 1 was framed on the following question: how does the climate change literature consider vulnerability? Step 2 centred on identifying studies using the following keywords: climate change vulnerability, vulnerability assessments, and climate change adaptation. This search generated 501 returns that included these keywords in their title, keywords or abstracts. In Step 3, we decided which articles to read according to predefined search criteria. In particular, we included papers that (1) were peer-reviewed papers in academic journals (2) were published in English and (3) referred explicitly to the literature on climate change impacts, adaptation and vulnerability (CCIAV). This selection process produced a list of 140 articles. Step 4 involved reading the titles, abstracts and keywords of the articles to determine if the papers collected should be part of the review. This process filtered down the papers to 80 papers to be analyzed. Once the papers were collected and filtered, we used the qualitative data-analysis software NVivo (released March 2020) (QSR International Pty Ltd. 2020) to code them inductively. The codes were developed using the categories noted in (3) in the data methodology section. Caceres carried out Steps 1 and 2, and Caceres, Pittman, Wandel and Deadman carried out Steps 3 and 4. Secondly, we identified a series of decision-making planning tools that might be integrated with vulnerability to enhance local adaptive capacity in different timeframes given the tools' features and capabilities. These tools emerged from the authors' deliberation based on their professional experiences and expertise.

2.3 VULNERABILITY TO CLIMATE CHANGE

Frequently, researchers define the term "vulnerability" as the "susceptibility of a system to adverse effects" or its "capacity to be wounded" (Turner et al. 2003; Ford and Smit 2004; Füssel 2007). However, the conceptualization of vulnerability in climate-change studies depends on the lens through which it is viewed and assessed (Ford and Smit 2004; Eakin and Luers 2006; Füssel 2007). The word "vulnerability" means different things in different discourses (O'Brien et al. 2004, 2007; Füssel 2010). Therefore, the term's ambiguity has led to its indistinct use and triggered numerous diagnoses and cures regarding the climate-change problem (O' Brien et al. 2004), influenced, among various circumstances, by theories on lack of entitlements and natural hazards (Turner et al. 2003; Adger 2006; Füssel and Klein 2006).

2.3.1 Vulnerability viewed through climate-change impact assessments

Often, climate change has been understood and conceived as a scientific and technical problem in the scientific community. The risk-hazard research tradition has influenced assessments of climate change and continues to do so. This research tradition describes the hazard of a system of analysis as a dose-response relationship between an external hazard and its consequences for the system (Adger 2006; Füssel 2007; Tonmoy et al. 2014). This approach represents the classic conceptualization of vulnerability in engineering science, focusing on the physical elements of exposure and hazard impacts in terms of magnitude, rapidity of onset, duration, and frequency (Schröter et al. 2005; Füssel 2007; McLaughlin and Dietz 2008; Shitangsu 2014). This view represents the most basic form in which climate-change discussions treat climate-change impacts at the onset of the problem, through the use of climate model projections. That is, an individual does not react at all and does not adopt any adaptation measures. Adaptation to climate change was a defeatist option that climate-change negotiators and the scientific community at the time did not accept (Pielke et al. 2007; Schipper et al. 2020). Therefore, climate-change assessments focused exclusively on the impacts of climate change, external factors of change in a system of analysis (Thomas et al. 2019).

As a result of a robust mitigation-oriented view, much of the discussion surrounding vulnerability has relied on “climate-change impact assessments,” through the use of greenhouse gas (GHG) scenarios and climate models derived from global circulation models (GCM) (Downing 2003; O’Brien et al. 2004; Ford et al. 2010). This linear interpretation of vulnerability has given rise to one group of vulnerability assessments of climate change, which the risk-hazard school of thought influences. It projects potential future conditions and assumes adaptations to estimate damages, ignoring internal characteristics that vary from place to place. The underlying point of this view is that it considers vulnerability as the residual impacts of climate change after speculating upon some adaptation measures (Dessai et al. 2004; Brooks et al. 2005; Smit and Wandel 2006; Eakin and Luers 2006; Prno et al. 2011). Commonly, this interpretation of vulnerability follows a sequence of steps beginning with GHG scenarios and climate projections, to estimate possible future impacts quantitatively, monetarily, or in terms of biophysical change. Then, it assumes some adaptation options aimed at reducing the adverse effects of climate change. Vulnerability is the last stage of this series of analyses (the end state of a system of interest) (Smit and Pilifosova 2003; O’ Brien et al. 2004). In other words, vulnerability is the result of the projected net impacts of climate change on a system, offset by assuming adaptation options. Under this view of vulnerability autonomous adaptation options are undertaken in response to experiencing some climate-condition changes—i.e., one individual adopts some standalone adaptation options in response to experiencing some changing conditions in the environment. Essentially, the main focus and starting point of this view of vulnerability is the stimulus, i.e., the net impacts of climate change derived from climate-change scenarios (Brooks 2003; Smit and Pilifosova 2003). This linear way of thinking represents the classical approach to vulnerability, inherited from the initial Intergovernmental Panel on Climate Change (IPCC) guidelines to assess vulnerability (Burton et al. 2002; Thomas et al. 2019). Therefore, this approach has been particularly important in comprehending the potential impacts of climate change and raising public and political awareness of the adverse effects of climate change (Ford and Smit 2004; Cardona 2004).

Influenced by climate-change negotiations, the "first generation of vulnerability assessments" has been used for purposes such as meeting Article 2 of the UNFCCC. This Article calls on countries to reduce their greenhouse gas emissions to avoid dangerous anthropogenic interference in the climate system. It aims to convey the seriousness of climate change, particularly when referring to the phrase "dangerous interference" (Smit et al. 2000; Burton et al. 2002), and to meet decision 11/CP.1, which divided adaptation work into three stages. Stage 1 was to carry out impact assessments to identify possible impacts of climate change and potentially vulnerable countries and regions (Adger et al. 2003; Burton 2003). In this context, the first-generation vulnerability assessments, which the literature also calls impact assessments (Smit and Pilifosova 2003), outcome vulnerability assessments (O'Brien et al. 2007), top-down approaches (Dessai and Hulme 2004), endpoint assessments (Kelly and Adger 2000a), or biophysical vulnerability assessments (Brooks 2003), have played a significant role not only in meeting the objectives of the UNFCCC and resolutions under its auspices but also in generating the first IPCC reports, the first National Communications on Climate Change, the first Biennial Update Reports (BURs), and early research efforts in this field.

With this background, we note that climate-change vulnerability assessments have given considerable attention to the mismatch between the scale of GCMs and the local scale (Fowler et al. 2007). The use of climate models and scenarios derived from GCM, through statistical analysis and historical data, forecasts the potential effects of climate change on different scales. This linear form of approaching vulnerability becomes one diagnosis, rather than a way of identifying specific and actual factors of vulnerability in systems of concern. By no means does this signify that such model projections have not aided climate-change vulnerability discussions. But the underlying sources of current and future vulnerability, such as economic crises, pandemics, and political instability factors, are impossible to predict and project, even with the most advanced model.

2.3.2 Vulnerability viewed through climate-change vulnerability assessments

In contrast to impact assessments, climate change alone does not determine decision-making in current climate-change vulnerability studies. The "social constructivism" school of thought, also called "political economy" and "political ecology" by some researchers, has influenced contemporary climate-change vulnerability assessments. The rationale of this research tradition is that pre-existing conditions (internal factors) (e.g. unequal access to resources, marginalization, power relations, socioeconomic and political factors, political, economic, and structural problems) also determine the state of a system of analysis (Turner et al. 2003; Ford and Smit 2004; Schröter et al. 2005; Füssel and Klein 2006; Füssel 2007; Tonmoy et al. 2014; Pearse 2016; Arifeen and Eriksen 2019; Mikulewicz 2020; Scoville-Simonds et al. 2020; Eriksen et al. 2021).

This interpretation of vulnerability incorporates human dimensions and food-security studies have widely used it to explain the implications of both physical and socioeconomic circumstances in unfolding famines (Downing 2003; Füssel 2005). This rationale draws on the "wounded soldier perspective", in which pre-existing pressures (existing wound), rather than the effects of future external factors alone (future attacks), determine vulnerability (Kelly and Adger 2000b). The etymological foundations of this analogy link "vulnerability" with the Latin *vulnerabilis*, describing the state of an injured soldier on a battlefield, implying an army already at risk and vulnerable, regardless of a future attack (Kelly and Adger 2000a). This view of vulnerability contends that both climate and non-climate factors, not just external factors, can harm a system of analysis (Tschakert et al. 2013; Thomas et al. 2019; Eriksen et al. 2021). From this perspective, vulnerability is the starting point of the analysis, rather than a sequence of steps. It is the result of the interaction of multidimensional factors, including both internal conditions (e.g., social, political, economic, environmental, institutional, demographic) and external conditions (e.g., climatic and market conditions) (Kelly and Adger 2000b; Smit and Pilifosova 2003; O' Brien et al. 2004; Ford et al. 2006a, b; Eakin and Luers 2006; Räsänen et al. 2016; Constable 2017; Thomas et al. 2019).

This generation of climate-change vulnerability assessments is one of the applications used for meeting Article 4.4 of the UNFCCC, which commits developed countries to assist developing countries (particularly those most vulnerable to the adverse effects of climate change) in meeting the costs of adaptation. The lack of specificity of Article 4.8 of the UNFCCC (i.e., potentially sensitive places) has appeared, from the perspective of developing countries, as an opportunity to get international funds and, from the developed countries' perspective, as a way to identify vulnerable locations for assigning resources. Commonly referred to as "second-generation vulnerability assessments," the literature variously identifies these as vulnerability assessments (Smit and Pilifosova 2003), contextual vulnerability assessments (O'Brien et al. 2007), bottom-up approaches (Dessai and Hulme 2004), starting-point assessments (Kelly and Adger 2000a), and social vulnerability assessments (Brooks 2003). This generation of climate-change vulnerability assessments has played and does play a significant role in the development of recent IPCC Assessment Reports, contemporary National Communications on Climate Change Reports, Biennial Update Reports, National Adaptation Programmes of Action (NAPAs), National Adaptations Plans (NAPs), Nationally Determined Contributions (NDCs), and current research efforts in the b field.

2.4 EMBRACING CONTEXTUAL VULNERABILITY INTERVENTIONS

Although numerous vulnerability interventions have attempted to measure vulnerability across different sectors of interest, remembering that it is a theoretical concept and unmeasurable is crucial (Adger 2006). The term "vulnerability" reflects a dynamic state, not an outcome. Therefore, we refer to vulnerability more accurately in terms of assessment than measurements (Leichenko and O'Brien 2002; Downing 2003; Hinkel 2011; Nguyen et al. 2016). The term "vulnerability" refers to particularly vulnerable situations (Brooks 2003). This means that it does not presume variables. It seeks to identify empirically the different conditions that pose risks in one system of analysis regardless their geneses (Belliveau et al. 2006; Fazey et al. 2010; Ford et al. 2010; Hopkins 2015; McCubbin et al. 2015).

Any system of concern involves different social, environmental, cultural, and political conditions, which can vary significantly from place to place, regardless of their closeness (Turner et al. 2003; Ford et al. 2008; Nightingale 2017). Therefore, the root causes of vulnerability and possible adaptation measures are context-specific and location-specific. Decisive action in one place might lead to maladaptation or reinforce power relationships in another (Eriksen et al. 2015, 2021; Antwi-Agyei et al. 2018; Work et al. 2019). This implies that the ability of vulnerability assessments to capture the climate-society dynamics of a particular system of concern decreases as distance increases (Thomas et al. 2019). Assuming a relation of behaviours and features across locations will inevitably lead to wrong decisions. Therefore, if vulnerability interventions aim at extrapolating outcomes from nearby areas, they will not capture the specific variables and the dynamics that make people vulnerable (Atteridge and Remling 2018). Mindful of such constraints, many scholars in this context employ ethnographic techniques such as semistructured interviews, focus groups, participant observation, walking transects, seasonal calendars, climate diaries, and hazard mapping, considering the local experience from the beginning of the research to prevent inconsistencies and biased outcomes (Schröter et al. 2005; Belliveau et al. 2006; Brook et al. 2006; van Aalst et al. 2008; Ford et al. 2008; Pearce et al. 2009; Fazey et al. 2010; Hopkins 2015; McCubbin et al. 2015).

2.5 VULNERABILITY AND DECISION-MAKING PLANNING TOOLS

Bearing in mind that within a new architecture of climate governance under the Paris Agreement (PA), the global adaptation goal centres on enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development (see Article 7 of PA). We argue that if we integrate the planning tools and strategies (described below) to address the specific underlying sources of vulnerability in a system of interest, these strategies serve as means to enhance adaptive capacity at a local scale.

2.5.1 No-regrets adaptation options

Political instability often influences systems of analysis, particularly in developing countries where political positions are variable in the short term, and political disputes might render previous decisions invalid. Although it is not considered to be transformational or the best option for strengthening the capacity of a system to adapt, the "no-regrets" adaptation option is a method worth mentioning for decision-making in such a scenario. This approach involves actions thought wise regardless of climate change, which, if implemented, improve the adaptive capacity of a system of analysis in light of climate-change effects. Significantly, no-regret actions can reduce the "adaptation deficit"—also called "development deficit" and "wounded soldier" (i.e., reduce poverty, diminish gender inequity, protect water resources, and enhance the public health system), underlying issues and sources of vulnerability in developing countries usually identified after carrying out vulnerability assessments.

2.5.2 Climate-Change Mainstreaming

Often, climate change and development concerns have been dealt with separately, creating a gap between development agendas and local realities (Smucker et al. 2015; Adam 2015). Evidence shows that adaptation strategies are linked to different societal concerns and factors of vulnerability, usually stemming from underdevelopment, including such social demands as combatting poverty, public health and food security, and education (Smit and Pilifosova 2003; Agrawala 2004; Milman and Arsano 2014; Ayers et al. 2014). Therefore, analyzing climate change and development separately not only increases vulnerability but also has the potential to generate ineffective responses to tackling the underlying factors that make people vulnerable (maladaptation) (Antwi-Agyei et al. 2018). There is broad agreement that current problems, such as climate change or novel pandemics such as the 2019 novel coronavirus or COVID-19, can potentially worsen present socioeconomic factors and needs that make people vulnerable, a priori. Therefore, development is and has been the primary concern (see decision 2/CP.17; (2011), and the best form of adaptation is in places that still face issues related to underdevelopment (e.g., lack of the most basic services, including electricity, water supply, and sanitation) (Milman and Arsano 2014; Robinson 2019; Schipper et al. 2020). Actions to build adaptive capacity are connected to measures to reduce poverty and other socioeconomic problems (promote development) (Abrahams and Carr 2017; Robinson 2019; Braunschweiger and Pütz 2021; Kundo et al. 2021). Mainstreaming adaptation into development enables formulating long-lasting actions across various sectors, by including climate-change issues and development priorities (underlying drivers of vulnerability) together. Therefore, separating progress and responses to climate change makes no sense, bearing in mind that Article 4.1(f) of the UNFCCC call countries to include climate change adaptation into their development programs and that the majority of international financial cooperation destines to support development in developing countries (Smit and Pilifosova 2003; Milman and Arsano 2014; Ayers et al. 2014).

This method of creating policy coherence allows the inclusion of climate-vulnerability concerns in ongoing decision-making structures at various scales, and eliminates unnecessary double efforts and conflicts between priorities and strategies (Agrawala 2004; Ayers et al. 2014; Rauken et al. 2015). For example, initiating such development programs as climate-smart agriculture indirectly encourages concrete adaptation actions and monitoring processes. Using the Pru District in Ghana as an empirical case, Ahenkan et al. (2021) show that through Mobile Weather Alert Messaging training, farmers can learn to use their mobiles phones to obtain daily weather forecasts. This gives them insight into when to plant their crops and when not to, thus increasing their productivity.

In the agriculture sector, a vital area for many developing countries, mainstreaming allows the inclusion of development and climate-change concerns in decision-making policies (e.g. through subsidies). Mainstreaming influences farmers to choose crop varieties better adapted to drier or more saline conditions, considering the prospect of damages and losses. The cost of a sudden reduction in agricultural production could be devastating for a local community (e.g. Galapagos Islands local communities in Ecuador, where climate change dimensions are not fully integrated into policy planning), in terms of economic or food security, for both the short and the long term. These unexpected events not only create environmental damage but also exacerbate poverty and other social problems, due to the high dependency of countries considered vulnerable to climate change on climate-dependent sectors (e.g., agriculture and livestock, fisheries, tourism). In that regard, the incorporation of adaptation into development policies in the agriculture sector, through the implementation of subsidies for seed tolerant of drier conditions instead of other seeds, could decrease damages and losses from drought. We must bear in mind that Article 8 of the PA formalizes Loss and

Damage within the climate regime. This Article calls on countries to avert, minimize and address loss and damage associated with the adverse effects of climate change in vulnerable developing countries (see, also, decision 2/CP.19 regarding the Warsaw International Mechanism for Loss and Damage; (2013).

Therefore, mainstreaming is a vital planning tool for creating a coherent umbrella of policies to bridge adaptation and ongoing development efforts across different sectors and levels (horizontally and vertically). Given that the causes of vulnerability of one system of analysis are context-specific, mainstreaming is an approach that contributes to ensuring that development efforts aim at reducing the root causes of vulnerability and, therefore, achieve actual tangible adaptation measures aimed at building adaptive capacity. This mainstreaming has been referred to as "mainstreaming plus," a vulnerability-based focus rather than a technology-based view, known as a "mainstreaming minimum" (Ayers et al. 2014). Mainstreaming plus aims at incorporating specific drivers of the vulnerability of a system of analysis into ongoing decisions on development in short and medium time frames, particularly significant in countries characterized by political instability, where the political will and direction can change on short notice (or none).

2.5.3 Adaptation Pathways

Similarly, we deem “adaptation pathways” (AP) to be another planning approach, the features of which might contribute to the adaptive capacity of socio-ecological systems at a local scale if they incorporate specific drivers of the vulnerability into the analysis. Following the analogy that Mitchell (2019) uses, any road will take one to a destination if one is unsure about where to go. AP provides different pathways, each of which uses different strategies, to achieve a common desired future (Haasnoot et al. 2019). Central to AP is the identification of tipping points (Haasnoot et al. 2013, 2019). To achieve this, possible trajectories are set, which can change direction depending on defined tipping points (Wise et al. 2014; Barnett et al. 2014). Using the language of Haasnoot et al. (2013), in a manner similar to a metro map, the AP presents different alternative routes to get to the same desired point in the future. If an action no longer meets one specific criterion (tipping point or terminal station), a new action becomes necessary (transfer to a new station or a new action); therefore, decision-makers can change to an AP (Haasnoot et al. 2013). The exact date of a tipping point is not rigid; it might be reached within 30, 40, or 50 years, or more, which enables decision-makers to adjust measures as events unfold (Haasnoot et al. 2013). Developed initially in infrastructure projects, to recognize the influence of sea-level rise (Thames 2100 Project/The Thames Barrier), the AP approach helped decision-makers to identify a set of possible adaptation pathways (or, in Haasnoot et al.'s language, different routes), each with specific measures and thresholds (or, using Haasnoot et al.'s language, terminal stations). Decision-makers can switch directions (or, using Haasnoot et al.'s words, transfer to a new station) if tipping points are reached, depending on the water-level rise to keep the risk low (Ranger et al. 2013). We argue that this approach is significant in systems at the local level, with the capacity to positively transform common-pool resources management. For example, if the desired future is to avoid saltwater intrusion in a common-pool livelihood (an underlying factor of vulnerability identified in a vulnerability assessment), and one path encounters difficulties impossible to overcome (tipping points such as sea level rising 1 meter), decision-makers can switch from that route to another (e.g., a path on which the tipping point is a sea-level rise of 2 meters) to achieve the same desired future (Fig. 2.1) (Wise et al. 2014; Barnett et al. 2014). An example of the adoption of adaptation pathways for sea-level rise is the Delta Programme in the Netherlands. This is a low-lying, country prone to flooding, and the implementation of an adaptation path approach has enabled decision-makers to incorporate uncertainty pertaining to the future by considering climatic and social developments in decision-making structures (Bloemen et al. 2019). The Delta Programme applies different measures across different time frames, with the aim of protecting the country in case of extreme weather events and providing sufficient freshwater until 2050 and 2100 (Restemeyer et al. 2017; Bloemen et al. 2019).

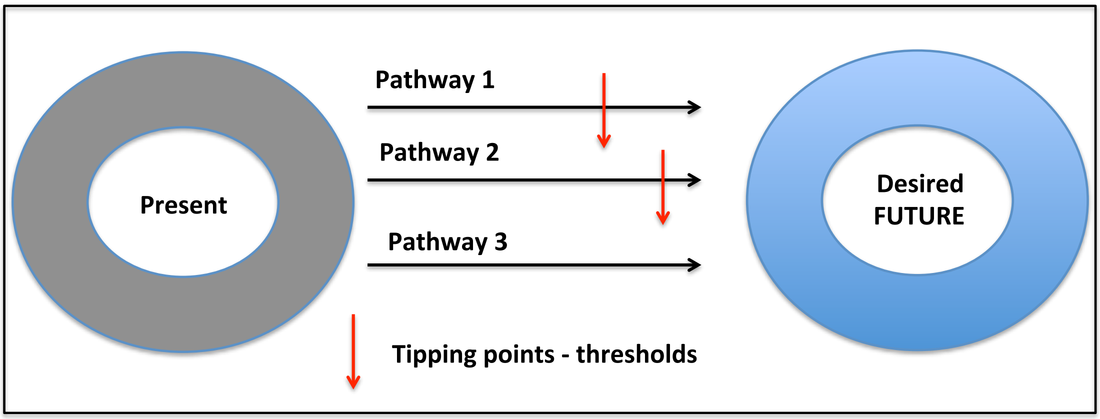


Figure 2.1 Adaptation Pathways.

2.5.4 Scenario Planning

Similarly, we deem "Scenario Planning" (SP) to be another planning approach, the features of which might contribute to the adaptive capacity of socio-ecological systems at a local scale if they incorporate specific drivers of the vulnerability into the analysis. SP enables the incorporation of uncertainty about future conditions into decisions, in extended time frames (Rounsevell and Metzger 2010; Star et al. 2016). Initially developed for military and business purposes and explored in depth by the Royal Dutch Shell oil company for strategic planning (a "what if" planning approach) (Schoemaker and A. J. M. van der Heijden 2006; Rounsevell and Metzger 2010; Star et al. 2016), SP is an approach that identifies specific drivers of vulnerability to explore how they might unfold in the future (Haasnoot et al. 2013; Wise et al. 2014). SP provides an approach that enables the exploration of a suite of multiple long-term possible futures, to devise possible actions ahead of time and respond through time as different conditions unfold, rather than doing so immediately (Cairns et al. 2013; Haasnoot et al. 2013; Wise et al. 2014). Significantly, SP provides a framework that entertains a vision of multiple potential futures, allowing us to think more about anticipatory measures than reactive ones and providing a foundation for discussions of policy development and adaptive strategies (Rounsevell and Metzger 2010; Star et al. 2016). SP has often been used primarily for large-scale strategic business planning, where the underlying causes of change are relatively well known and can be selected by following broad categories. Examples include the STEEP approach— Social, Technological, Economic, Environmental, and Policy Governance, developed by Metzger et al. (2010) and shown in Rounsevell and Metzger (2010)—or the drivers used to show Shared socioeconomic pathways (SSPs), discussed by O'Neill et al. (2014). Yet, we believe that SP has the potential to enable decision-makers to assess the implications of context-specific factors of vulnerability so that a system seeks a desirable future and avoids adverse ones (Fig. 2.2) (Rounsevell and Metzger 2010; Haasnoot et al. 2013; Wise et al. 2014).

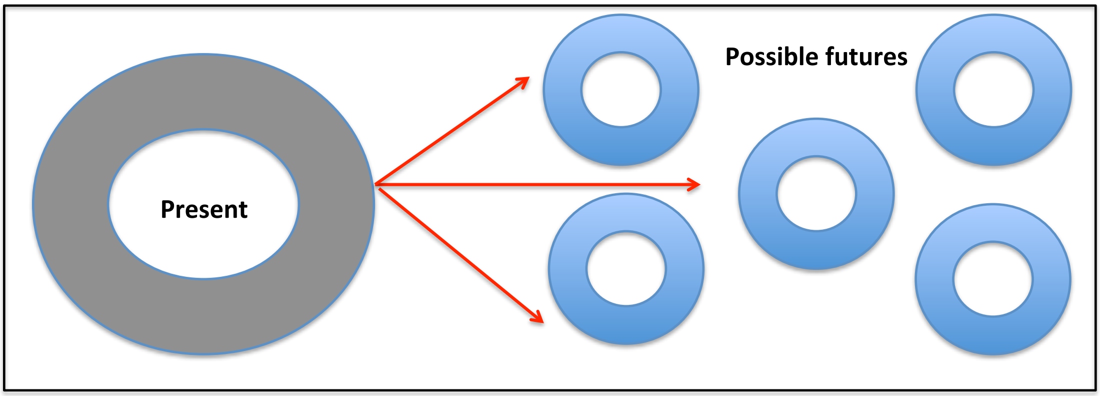


Figure 2.2 Scenario Planning

2.5.5 Collaborative Governance

Bolstering the capacity of a system to adapt at the local scale requires addressing the multiple sources of vulnerability, affecting various sectors alike (e.g., agriculture, health, energy, tourism, and food security) (Bullock et al. 2022). Today, the extent of sources of vulnerability can affect various livelihoods and alter the socio-economic dynamics of different productive sectors together. As observed, for example, in the Galapagos Islands in Ecuador, where climate change, in combination with the adverse impacts of COVID-19, has affected the archipelago's tourism sector, prompting a cascade of negative consequences on the other sectors in the islands—including fishing and conservation (Escobar-Camacho et al. 2021; Viteri Mejía et al. 2022; Cáceres et al. 2022).

Contrary to the conceptualization of government that refers to elected people at different levels or to the various governmental institutions responsible for delivering goods and services to people in a society, governance facilitates multilevel participation beyond the state, involving in decision-making the public sector, the private sector, and civil society, from local to broader scales (Kooiman 2003a; Mitchell 2019). Following Kooiman's (2003b) work, governance involves the totality of interactions, in which the whole range of institutions, networks, and linkages that are part of decision-making processes, including formal and informal actors, public and private actors, nongovernmental organizations (NGOs), communities, interest groups, and corporations, participate in solving societal problems and in creating societal opportunities (Kooiman 2003a; Lemos and Agrawal 2006; Keskitalo 2009; Armitage et al. 2009; Plummer and Armitage 2010; Mitchell 2019).

How governments and local users address societal problems is crucial in responding to vulnerability factors (Thomas et al. 2019). Actors formulate innovative solutions on many geographical and administrative scales, such as within local communities and cities, at subnational levels, and among business sectors, advocacy groups, and private companies, which generates different niches of knowledge and expertise (Ostrom 2010; Tran et al. 2020). Participants in collaborative governance have the advantage of learning from others, especially from local knowledge (Ostrom 2010; Bullock et al. 2022). Power differences and marginalization usually result in some voices not being heard (Nagoda and Nightingale 2017; Nightingale 2017; Mitchell 2019), typically crucial actors at a local level (e.g., Indigenous communities) who possess critical knowledge for solving shared problems and from whom there is much to learn (Klenk et al. 2017; Zurba et al. 2018; Artelle et al. 2019). Local and Indigenous knowledge plays a significant role in collaborative governance because they are on the front lines of change and know first-hand the dynamics that make a particular place vulnerable (Zurba et al. 2018; Mehta et al. 2019; Eriksen et al. 2021; Bullock et al. 2022). Referred to as social memory by some authors (Folke 2006; Armitage et al. 2007; Thomas et al. 2019), local and Indigenous communities possess unique knowledge and experience, acquired over generations of occupying traditional territories and witnessing and adapting to various socioeconomic and environmental changes (Naess 2013; Bullock et al. 2020).

Local and Indigenous peoples have a close relationship with their environment that allows them to see and feel what the scientific community or decision-making structures usually cannot capture (Zurba et al. 2018; Bullock et al. 2020, 2022). This relationship with the environment has enabled them to have linkages in multiple sectors, including farming, fisheries, tourism, and forestry (Nilsson et al. 2012; Leonard et al. 2013; Ford et al. 2020; Bullock et al. 2022). Therefore, in a collaborative-governance context, making local and Indigenous people agents of change and part of decision-making and collaborative processes, in light of various changing conditions, not only improves the understanding of the nature of the local vulnerability but also enables bolstering the capacity of a system to adapt by increasing joint compliance and knowledge flow through institutions and governance systems, in light of uncertainty, change, and surprise (Folke et al. 2005; Bullock et al. 2020). Consistent with Article 7.5 of PA (2015), the latter considerations are central features in building adaptive capacity at a local scale. In particular, if we keep in mind double-loop learning, change that points to correcting errors by adjusting behaviours and attitudes rather than correcting mistakes by adjusting resource management strategies and actions, e.g., modifying harvesting techniques (single-loop learning) (Armitage et al. 2007, 2008).

Among the different strands of collaborative decision-making (e.g., participatory appraisal and integrated conservation), co-management has been one of the leading management strategies that formalize linkages among local resource users (e.g. Indigenous peoples) and governments to share management rights and responsibilities (Armitage et al. 2007). Usually defined as a power-sharing approach, co-management gives rise to cross-sectoral interactions (Fig. 2.3). Therefore, collaborative and power-sharing links across sectors under a co-management context, including partnerships with Indigenous groups, allow the understanding of local vulnerability and traditional values, the development of shared actions, redistribution of rights and responsibilities, and a co-production of knowledge, adding fundamental considerations to reduce vulnerability and bolster the governance systems capacity to adapt at the local level (Armitage et al. 2007, 2011; Plummer and Armitage 2007; Plummer 2013; Andrachuk et al. 2019; Zurba et al. 2022).

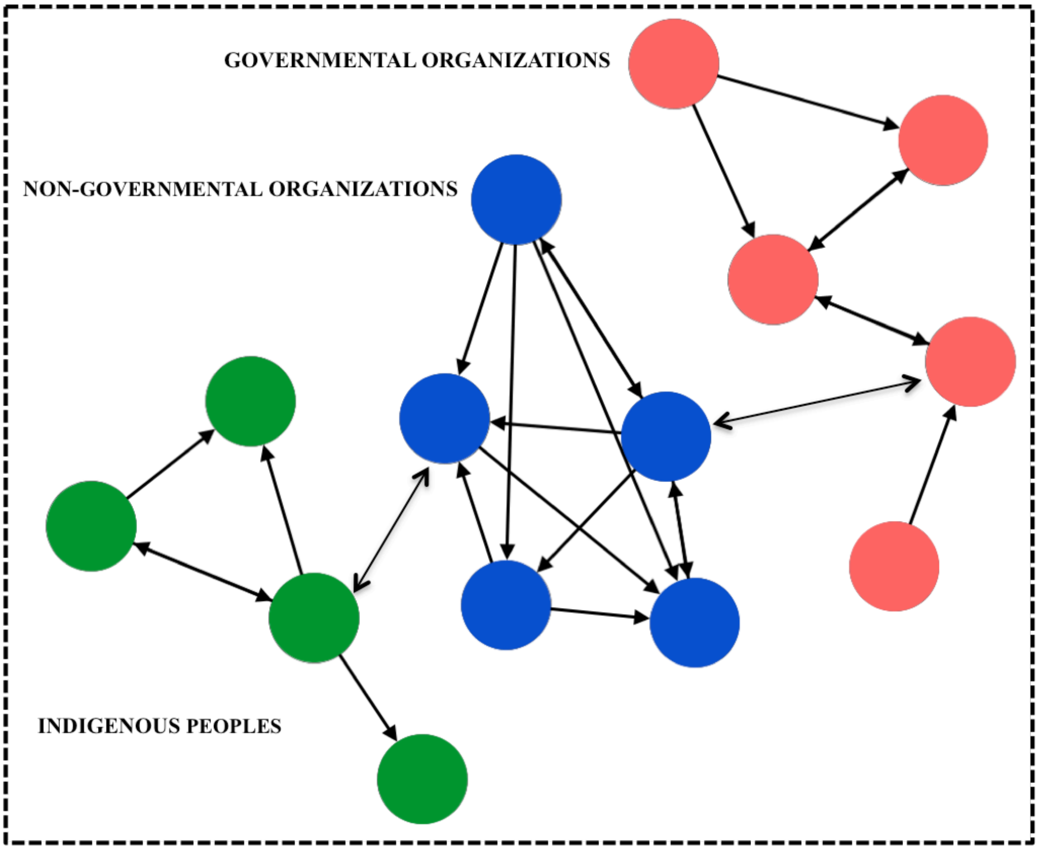


Figure 2.3 Co-management.

The black dotted line indicates the management scope of the system of concern. Nodes indicate stakeholders. Links represent ties among stakeholders.

2.6 CONCLUSION

In this paper, we highlight that we live in a world of constant change, where multiple factors of change that generate vulnerability coincide, such as pandemics, climate change, globalization, and economic crises, among other political and societal concerns. This demands approaches capable of dealing with current drivers of vulnerability but also requires strategies that enable us to plan in the face of uncertainty regarding future developments and climate change (Mehta et al. 2019). This paper critically reviews the concept of vulnerability, focusing on the climate change literature. Our review shows that the interpretation and conception that one gives to vulnerability can influence how decision-making solutions and adaptation measures are proposed and adopted. We caution that if intended actions and strategies do not address the underlying drivers of change that render a system of concern vulnerable, they can hardly build adaptive capacity, or even worse, they might reinforce the vulnerability in the system.

It is significant to recognize that planners often assume that interventions occur in environments with political stability, frequently conceived from a purely technical view disregarding each system's political contexts and realities (Eriksen et al. 2015). Accordingly, here, we see vulnerability as a crucial piece of evidence in understanding and identifying the nature of problems of a system of analysis without assuming responses (Thomas & Warner, 2019). In this context, this paper incorporates vulnerability with planning tools, which serve as means to enhance adaptive capacity locally if they address context-specific realities. In doing so, intervention planners and implementers could support ongoing developing agendas and links across sectors under co-management contexts.

Further, it is important to bear in mind that climate change is one of the multiple complex problems that can make a system of concern vulnerable (Westerhoff and Smit 2008; Hopkins 2015; Bennett et al. 2016; Kuhl et al. 2020; Eriksen et al. 2021). This is particularly important to highlight if we keep in mind that the cost of adaptation continues to rise, therefore increasing the adaptation finance gap and the need to prioritize raising funds for the most vulnerable groups beyond climate change alone. As such, we contend that the insights presented in this paper may help policymakers and decision-makers to interpret more closely what the expression 'particularly vulnerable' means, enabling them, among other things, to 1) reduce confusion in undertaking vulnerability assessments, 2) improve decision-making planning, 3) foster adaptive capacity, 4) guide international funding regimes in allocating adaptation resources and 5) support requests in developing countries for adaptation funds and the submission of commitments under UNFCCC and COP decisions.

CHAPTER 3: THE GALAPAGOS SMALL-SCALE FISHING SECTOR COLLABORATIVE GOVERNANCE NETWORK: STRUCTURE, FEATURES AND INSIGHTS TO BOLSTER ITS ADAPTIVE CAPACITY.

Collaborative forms of governance have a key role in building adaptive capacity in small-scale fishery systems. However, governance systems' structures and features are usually ignored, reducing opportunities to improve collaboration among multiple actors to cope with adverse drivers of change and enlarge trust in decision-making. This study used a social network analysis approach based on descriptive statistics and exponential random graph models (ERGMs) to examine specific network patterns and configurations that may bolster collaboration links and the capacity to adapt in the Galapagos small-scale fishery governance system. To this end, we evaluated the Galapagos small-scale fishery governance system to 1) identify central and bridging organizations, 2) explore the organizational links and link frequencies, and 3) test hypotheses about the governance system structure using a building block approach. Our findings suggest a cross-level and cross-sectoral interaction between various organizations in the Galapagos small-scale fishery system. We identified central and well-positioned actors and network configurations whose interactions might be fundamental to strengthening the small-scale fishing sector's collaboration links and adaptive capacity to face future crises caused by novel pandemics, climate change or other anthropogenic and climate drivers of change.

3.1 INTRODUCTION

Small-scale fisheries are complex socio-ecological systems that evolve according to human behaviours and attitudes, environmental and development conditions, and other circumstances. An increasing number of natural and human-induced drivers of change, such as climate change, globalization, novel global pandemics such as COVID-19, illegal fishing, economic crises, and overexploitation of resources, are causing unprecedented consequences throughout small-scale fisheries in Latin America and the Caribbean, pushing them into socio-economic situations never experienced before (Lopes et al. 2019; Escobar-Camacho et al. 2021; Gianelli et al. 2021; Truchet et al. 2021; Viteri Mejía et al.

2022). The dynamics and interactions of small-scale fishery systems are continually changing, particularly during a period where multiple drivers of change coincide (DeWitte et al. 2017; Kuhl et al. 2020; Lubell and Morrison 2021). This reality triggers various rapid and transboundary management problems derived from different origins charged with uncertainty and complexity, forcing governance systems to explore ways of coping with unexpected drivers of change and building adaptive capacity (Blythe et al. 2022).

Drivers of change affecting the Galapagos small-scale fishery system are various and interdependent in complex ways (Escobar-Camacho et al. 2021; Fried et al. 2022; Viteri Mejía et al. 2022). The adverse effects of the COVID-19 pandemic that has pushed the Galapagos small-scale fishing sector into the worst ever socio-economic situation experienced in the history of this archipelago, climate variability and illegal fishing are vivid examples of how unexpected and complex socio-ecological independencies can challenge the Galapagos governance system adaptive capacity and suddenly affect people's wellbeing and livelihoods. Therefore, this paper contends that those organizations responding to the simultaneous transboundary problems faced by the Galapagos small-scale fishing sector need to build an enabling environment to act during periods of change (Armitage et al. 2015; Christensen et al. 2016).

Although connecting organizations from different sectors and administrative levels - often with opposing views and interests - is challenging (Mcallister et al. 2017; Baird et al. 2019; Mudaliar 2020), building an enabling environment to address socio-ecological problems spanning the Galapagos small-scale fishing sector requires an initial understanding of how governance systems involving actors who often hold different backgrounds, gender, interests, race, viewpoints, and aspirations from various sectors, scales, and levels tend to interact and collaborate. Disregarding the latter might limit the cross-sectoral and cross-level interactions required to deliver and make decision-making structures operational and, therefore, strengthen the adaptive capacity of the fishery sector (Lubell & Morrison, 2021). In this context, this study aims to explore the Galapagos small-scale fishing sector collaborative network using a social network analysis approach, an analytical framework that serves to represent, capture, and unveil relationships and interdependencies in social and ecological environments (Borgatti et al. 2009; Ingold et al. 2018; Sayles et al. 2019).

Our social network analysis is based on descriptive statistics, including centrality measures, a statistical and graph theory approach that captures individuals' connectedness, positions and influence according to their features and interactions in a given network, and exponential random graph models (ERGMs), a statistical approach for assessing if specific network configurations are more prevalent or not in a network than would occur by chance alone according to the presence or absence of links among actors, actors' attributes, and network parameters in an observed network (Landherr et al. 2010; Shumate and Palazzolo 2010; Bodin and Tengö 2012; Lusher et al. 2012; Bodin et al. 2014; Guerrero et al. 2015; Kininmonth et al. 2015; Das et al. 2018; Pittman and Armitage 2019). We followed this approach in the Galapagos small-scale fishery governance system to 1) identify central and bridging organizations, 2) explore organizational links and link frequencies, and 3) test hypotheses about the governance system structure using a building block approach (Fig. 3.2). In doing so, we addressed the following research questions:

1. How do the collaborative ties in the Galapagos small-scale fishing governance system interact?
2. Which small-scale fishery sector-related organizations frequently interact in the Galapagos small-scale fishing governance system (central nodes)?
3. Which small-scale fishery sector-related organizations could help connect groups within the Galapagos small-scale fishing governance system (bridging nodes)?
4. What type of organizational ties links the Galapagos small-scale fishery governance system?
5. How often do organizations collaborate within the Galapagos small-scale fishery governance system?
6. Do organizations tend to reciprocate organizational links in the Galapagos small-scale fishing governance system?
7. Is there a tendency towards homophily in the network?

8. Do organizations from the public sector tend to send or receive more organizational links than others in the Galapagos small-scale fishing governance system?
9. Do organizations from the local level tend to send or receive more organizational links than others in the Galapagos small-scale fishing governance system?

To explore these network configurations, we use the term “nodes” to refer to those organizations (public institutions, private sector, civil society, and society in general, that develop policies, plans, and projects) connected to the Galapagos small-scale fishery sector through different links or ties, represented by actions of collaboration, coordination, communication, and work among organizations. At the same time, we used the term “connectivity” to refer to the links or ties of one organization to other organizations. We used both terms to describe the Galapagos small-scale fishery governance system as a governance network. Such knowledge could be used by decision-makers, among other things, for planning actions strategically and revealing options for enhancing the fishery sector's adaptive capacity and collaboration between governmental organizations, artisanal fishing cooperatives, fishers, and civil society to cope with adverse drivers of change and build trust in the decision-making process. E.g., to facilitate and accelerate the provisions of support and the delivery of mitigation measures in times of crisis and the diffusion of crucial information and knowledge in the governance system.

3.1.1 Collaborative network configurations of governance systems and adaptive capacity

Among the diverse factors contributing to building adaptive capacity, including financial support, technology, and local knowledge, an understanding of collaborative network configurations of governance systems is increasingly a factor to be considered in building adaptive capacity in small-scale fisheries (Adger 2003a; Berkes 2010; Barnes et al. 2017; Cinner et al. 2018; Levy and Lubell 2018; Fried et al. 2022; Blythe et al. 2022). They may offer possible solutions to build an enabling environment to act during periods of change through participation, connectivity, and experimentation across actors, sectors, scales, and levels (Guerrero et al. 2015; Bodin 2017), opportunities for communication (Barnes et al. 2019), the creation of social learning (Bodin 2017; Thi Hong Phuong et al. 2017; Suškevičs et al. 2019; Bullock et al. 2022), trust-building (Mcallister et al. 2017; Bodin et al. 2020), the co-production of knowledge (Crona and Bodin 2006; Kowalski and Jenkins 2015; Zurba et al. 2022), institutional building (Berkes 2009; Armitage et al. 2009), and conflict resolution (Hahn et al. 2006), among other central elements for building adaptive capacity in socio-ecological systems, such as the Galapagos small-scale fishery system.

Here, we define the term "adaptive capacity" as the conditions that enable a system of interest to anticipate and respond proactively to diverse shocks, reduce the adverse consequences, recover and take advantage of new opportunities (Folke et al. 2002b; Engle 2011; Whitney et al. 2017; Cinner et al. 2018). Furthermore, we define "governance," according to Kooiman (2003b), as the interactions in which public and private actors' participation aim at solving societal problems and building societal opportunities to conceptualize the study of governance systems structures and their features as conditions necessary to bolster collaboration and the capacity of complex socio-ecological systems to adapt (Folke et al. 2005; Pahl-Wostl 2009; Gupta et al. 2010; Armitage and Plummer 2010a; Emerson and Gerlak 2015).

3.2 RESEARCH CONTEXT

Our study focuses on the small-scale fishery sector from the Galapagos Marine Reserve (GMR), Ecuador. In this multiple-use marine protected area, research efforts have often centred mainly on biological and ecological perspectives over human and social dimensions, ignoring the role of existing collaborative approaches in building adaptive capacity (Watkins 2008; González et al. 2008; Quiroga 2013; Barragán Paladines and Chuenpagdee 2015). The Galapagos Islands, known for being the natural laboratory in Charles Darwin's research on the theory of evolution and one of the first sites to be inscribed on the UNESCO World Heritage List in 1978, are located 1240 km off the Ecuadorian coastline (Fig. 3.1). Tourism is the primary economic sector in the archipelago, which hosted approximately 271,238 tourists before the COVID-19 pandemic (DPNG 2021). The exponential growth of tourism has encouraged immigration and human population growth in Galapagos. As a result, about 30,000 residents live in the Galapagos Province (Alava et al. 2022). Large-scale fishing was prohibited in 1998 when the GMR was created. Since then, local small-scale fishers were allocated exclusive access rights to Galapagos fishery resources (Castrejón et al. 2014).

The Galapagos small-scale fishery sector plays an essential role in the economy and food security of the Galapagos Islands, being a food supplier for the local population, hotels, and vessels operating in Galapagos (Barragán P. 2015; Cavole et al. 2020). Today, 1100 fishers are registered in the Galapagos National Park fishing record, of which approximately 400 are active fishers (Burbano and Meredith 2020). Despite Although the fishing sector has been significant in the development of the Galapagos since the occupation of the islands, the Galapagos marine exploration has brought different social and ecological conflicts that have led to the establishment of diverse public and private organizations at various geographical and jurisdictional scales and levels (Castrejón et al. 2014). The expansion of the spiny lobster fishery, the Chinese market's growing demand for shark fins, the collapse of the sea cucumber (*Isostichopus fuscus*) fishery in the 1980s and 1990s, together with the adoption of the so-called Galapagos Special Law (GSL), that led to the Marine Reserve (GMR) and the Galapagos co-management system (GCM) creation, to protect both terrestrial and marine ecosystems of the islands through a legal framework in 1998, and efforts to preserve the category of UNESCO World Heritage Site, eventually prompted the establishment and presence of various governmental, scientific and non-governmental organizations, for either management and control, conservation reasons or commercial ends in Galapagos (Castrejón et al. 2014).

Today, five artisanal fishing cooperatives operate in the Galapagos Islands, known by their Spanish acronyms COPROPAG, COPESPROMAR, COPESAN, COPAHISA and ASOARMAPESBAY. Artisanal fishing cooperatives target more than 68 marine species, including sailfin grouper (*Mycteroperca olfax*), locally known as "bacalao"; camotillo (*Paralabrax albomaculatus*); brujo (*Pontinus clemens*); red spiny lobster (*Panulirus penicillatus*); green spiny lobster (*P. gracilis*), and slipper lobster (*Scyllarides astori*). Several governmental organizations have influenced the management of the GMR, mainly the Galapagos National Park Directorate (Spanish acronym DPNG) and the Galapagos Special Regime Governing Council (Spanish acronym CGREG). The latter governmental organization with constitutional powers and authority to control Galapagos natural resources and decision-making in general in the archipelago granted by a reform of the 1998 GSL when the 2008 National Constitution reform (Ecuador's supreme law), which is deemed a novel normative framework in Latin America and the Caribbean by incorporating the rights of nature in human-nature relationships into Ecuador's national legislation, created a new management authority for the Galapagos (Garcia Ferrari et al. 2021). Furthermore, diverse private organizations, non-governmental organizations (NGOs), and research organizations have played a significant role in the assessment and management of Galapagos small-scale fisheries, such as the Charles Darwin Foundation (CDF), which has served as a scientific adviser for the Ecuadorian Government since the 1960s (Castrejón et al. 2014).

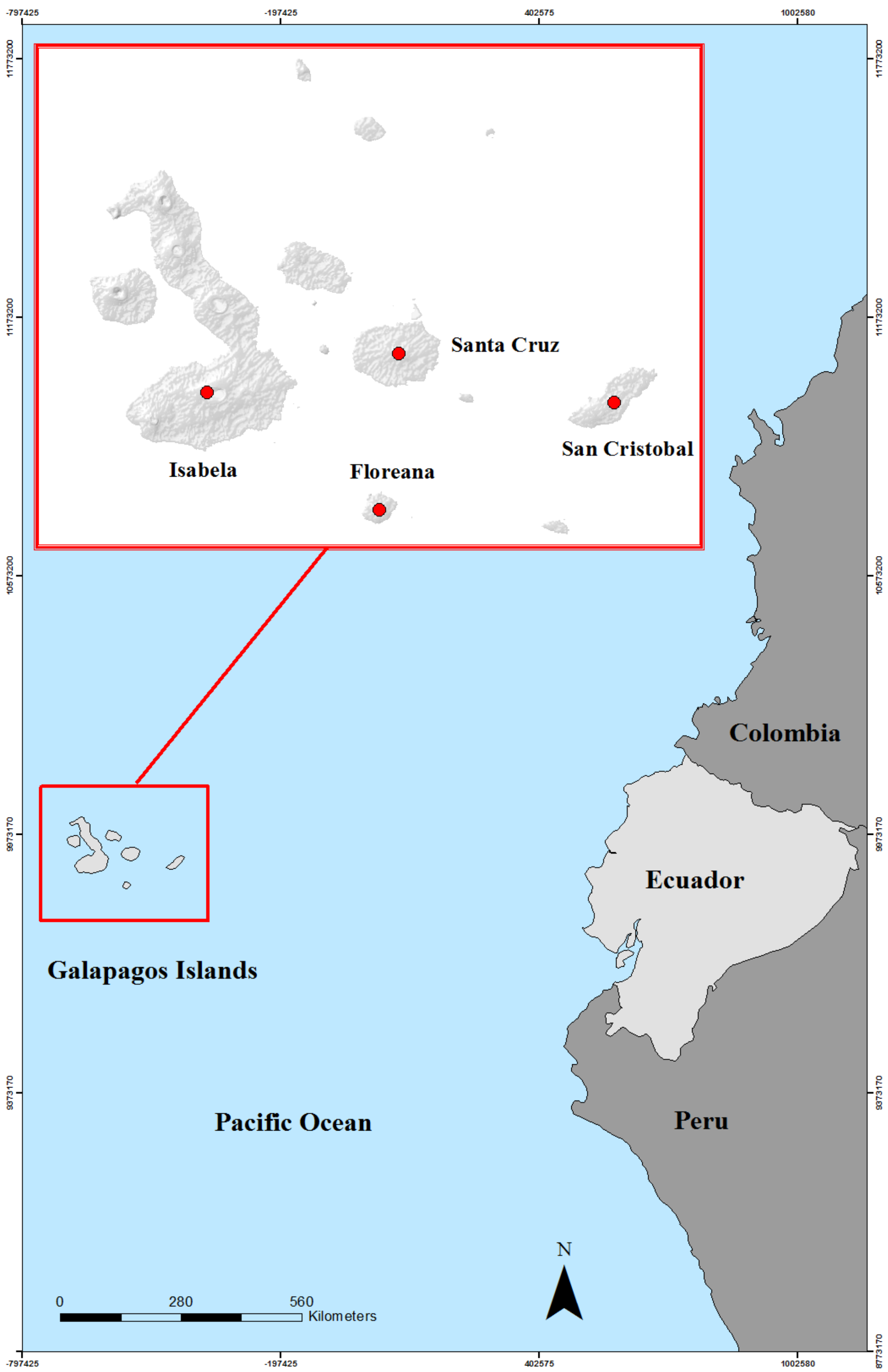


Figure 3.1 Location map.
Red square indicates the Galapagos Islands. While red circles indicate inhabited Islands.

3.3 METHODS

3.3.1 Data Collection

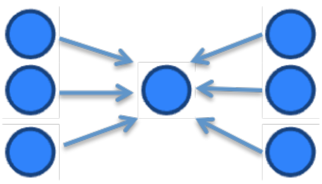
The data collection coincided with the COVID-19 pandemic. Therefore, we limited face-to-face research involving human participants. First, we created an online survey using Qualtrics software, version 7.2020 (Copyright © [2020] Qualtrics). The survey served to input a series of open- and closed-ended questions on the organizations' connectivity to other organizations involved with assessing and managing the Galapagos small-scale fisheries sector and store the answers of respondents of our study in the same database. Then, we undertook an extensive literature review to examine the history, management, and interactions in the Galapagos small-scale fishery system. Through this review, we created a list of public and private organizations frequently associated with assessing and managing the Galapagos small-scale fishery sector (in pre-COVID-19 pandemic conditions on the Galapagos Islands), including fishery cooperatives, governmental organizations, NGOs, private organizations, municipal and parish governments, and academic and research organizations. We used this list to interview representatives and officials of these organizations (n = 38).

We reached out the representatives and officials of public and private organizations (n = 38) via Zoom Video Communications Inc. (Zoom version 5.0.5) (n = 5), phone calls (n = 6), and emails by sending the links of our online survey to the individuals' institutional email addresses) (n = 27). We read to the representatives and officials the open-and closed-ended questions that we input in our Qualtrics survey during phone and Zoom interview calls, and we input their answers into the database. Responses from the links sent to the individuals' institutional email addresses were stored automatically in the Qualtrics database when respondents opened and completed the open- and closed-ended questions of the online survey. We obtained verbal consent from the participants at the beginning of each interview on Zoom and phone call. Informed consent was obtained from the study participants, who were contacted through their institutional email addresses when they opened the online survey. The study data were collected between June 2020 and November 2020. This study received ethics approval from our university's research ethics committee (ORE #41927).

Representatives from the public and private organizations were asked to identify from the list: (a) the organizations they coordinate, communicate, or work with regarding management and organization of the Galapagos small-scale fisheries sector, (b) how often the interviewee's organization collaborates with the selected organizations - frequently, occasionally or rarely - (c) what organizational ties link the interviewee's organization with selected organizations—information exchange (e.g., regarding observations of environmental change, coral reef condition, invasive species, water quality), management (e.g., mandatory organization and coordination of illegal fishing, monitoring, or user conflicts), or collaboration (e.g., joint projects, technical expertise, finances, or human resources) (see, the organizational ties approach we based on in (c) in Alexander et al. (2017), and (d) the level and sector of the interviewee's organization (local, national or international) / (public or private) (see Appendix 1). We followed a snowball approach to conduct the interviews. Therefore, the respondents were asked to suggest other organizations or groups (not listed in our list) with which they coordinate, collaborate, communicate, or work regarding the management and organization of the small-scale fishing sector's activities. To ensure interviewees feel comfortable discussing their opinions, maintain openness in responses and avoid biased responses, respondents were told the identities of organizations in the network's figures of the study would be confidential.

3.3.2 Data Analysis

We drew on a set of social network techniques to illustrate and elucidate the interactions of the Galapagos small-scale fishing governance system proposed in the study. We used Gephi network visualization 0.9.2 software (Bastian et al. 2009): 1) to explore central and bridging organizations within the Galapagos small-scale fishery governance system by employing centrality measures (in-degree centrality, i.e., nodes receiving more links than others in the network and betweenness centrality, i.e., nodes often on the shortest paths between nodes in the network), respectively and 2) to explore the frequency and organizational links of the Galapagos small-scale fishery governance system as (frequent, occasional, or rare) / (information exchange, management, or collaboration) [indicated in (b) and (c) in the data collection section]. We used ERGMs (p* models) in the PNet software (Wang et al. 2009): 3) to test hypotheses about the governance structure of the Galapagos small-scale fishery governance system using a building block approach. The building blocks shown in Fig. 3.2 represent well-defined network patterns linked to specific governance concerns (hypotheses) (Milo et al. 2002), which help to disclose how frequent they are in a more extensive network of analysis (Bodin and Tengö 2012).

Building blocks	Hypotheses	Governance processes
	**Hypothesis 1:** Do organizations tend to reciprocate institutional links in the Galapagos small-scale fishing governance system?	**Reciprocity effects:** Mutual interaction between organizations (A ↔ B). From a governance perspective, mutual interaction between actors represents network structures that facilitate sharing information, expertise, resources, and common objectives in a governance network and provides the baseline for the evolution of collaboration links in a governance network.
	**Hypothesis 2:** Do organizations tend to direct organizational links to a popular node in the Galapagos small-scale fishing governance system?	**Popularity effects:** Propensity in which links tend to direct to popular organizations in the network. From a collaborative governance perspective, popularity effects may facilitate coordination, the flow and spread of information within the network.
	**Hypothesis 3:** Do organizations from the public sector tend to send more organizational links compared to others in the Galapagos small-scale fishing governance system?	**Sender effects:** Propensity to send more links than others due to actors' attributes. From a governance perspective, tendencies to send more organizational links from the public sector than other economic sectors illustrate network configurations in which the public sector plays a predominant role in the management and organization of the governance system.
	**Hypothesis 4:** Do organizations from the public sector tend to receive more organizational links compared to others in the Galapagos small-scale fishing governance system?	**Receiver effects:** Propensity to receive more links than others due to actors' attributes. From a governance perspective, a tendency in which organizations from the public sector tend to receive more organizational links than others illustrates an active involvement of the public sector in the governance network.
	**Hypothesis 5:** Do organizations from the public sector tend to have organizational links with actors from the same sector in the Galapagos small-scale fishing governance system?	**Homophily:** Propensity to be attracted to those with similar network features. From a governance perspective, homophily based on the public sector illustrates network configurations that often represent obstacles for cross-level communication and collaboration as they hamper interactions across administrative levels.

	**Hypothesis 6:** Do organizations from the local level tend to send more organizational links than others in the Galapagos small-scale fishing governance system?	**Sender effects:** Propensity to send more links than others due to actors' attributes. From a governance perspective, a tendency to send more organizational links than others from the local level illustrates network configurations in which local priorities, social memory, local knowledge and experience from the local level organizations probably circulate in the governance network.
	**Hypothesis 7:** Do organizations from the local level tend to receive more organizational links than others in the Galapagos small-scale fishing governance system?	**Receiver effects:** Propensity to receive more links than others due to actors' attributes. From a governance perspective, a tendency in which organizations from the local levels tend to receive more organizational links than others illustrates network configurations in which local-level organizations contribute and are considered in the management and organization of activities in the governance network.
	**Hypothesis 8:** Do organizations from the local level tend to have organizational links with actors from the same level in the Galapagos small-scale fishing governance system?	**Homophily:** Propensity to be attracted to those with similar network features. From a governance perspective, homophily based on local levels illustrates network configurations that often represent obstacles for cross-level communication and collaboration across administrative as they limit horizontal and vertical linkages between the government and local resource users.

Figure 3.2 Building blocks and their associated hypotheses used to explore the Galapagos small-scale fishery governance network system.

Given the importance of actors' interactions across levels and sectors for sustainable socio-ecological governance systems, we devised a series of hypotheses we deem significant to unveil within the Galapagos small-scale fishery governance system by employing a building block approach. ERGMs provide a platform where the hypotheses can be statistically examined (Lusher et al. 2012). Building blocks associated with hypotheses 1 and 2: blue nodes represent organizations within the Galapagos small-scale fishery governance. Building blocks associated with hypotheses 3 to 5: red nodes represent organizations from the public sector, and blue nodes represent organizations from the private sector in the network. Building blocks associated with hypotheses 6 to 8: green nodes represent organizations from the local level, and yellow nodes represent non-local level nodes in the network. See also the discussions regarding "building blocks," also called "motifs" in Milo et al. (2002) and their use in theoretical frameworks presented in Barnes et al. (2019); Bodin et al. (2014); Bodin and Tengö (2012); Guerrero et al. (2015); Kininmonth et al. (2015) and Pittman and Armitage (2017b)).

To estimate the presence of the building blocks presented in Fig. 3.2 in the Galapagos small-scale governance network, we first created an adjacency matrix from the interviewees' responses stored on Qualtrics (i.e. a matrix of zeros and ones that indicates if nodes are connected (1) or not (0) (Koskinen and Daraganova 2012). In this matrix, using the representatives' and officials' answers [noted in (a) in the data collection section], a value of 1 indicated the existence of a link, and a value of 0 indicated the absence of a link. Furthermore, we created two attribute matrices according to the nodes' attributes from the interviewees' responses [noted in (d) in the data collection section], i.e. a matrix that indicates the presence (1) or not (0) of an attribute of a node (Lusher and Robins 2012a). In the first matrix, the public sector nodes were set as 1, and the non-public sector nodes were set as 0. In the second matrix, local level nodes were set as 1, and the non-local level nodes as 0.

Using the matrices described above and setting structural and actor attribute parameters, we tested the hypotheses shown in Fig. 3.2, Table 3.2 in the Galapagos small-scale fishery governance network. We ran two models on PNet software. We combined attribute parameters and structural parameters in our models to include actors' attribute effects in the models (exogenous processes). We tested the fit by assessing if our model parameters converged (t-statistic < 0.1) and had a good fit (goodness-of-fit (GOF) < 0.1 (Table 3.2) (Robins and Lusher 2012).

3.4 RESULTS

We divide the results into two parts. First, we present the Galapagos small-scale fishing governance system network, the network's central and bridging organizations, and the frequency and organizational links of the network through descriptive statistics. Second, we present the Galapagos small-scale fishing governance system network after testing hypotheses about the governance system structure using a building block approach through ERGMs.

3.4.1 Descriptive statistics results

Our results show that our interviewees identified 257 organizational links - comprised of 43 public and private organizations at various levels and scales - connected to the Galapagos' small-scale fishery sector (Fig. 3.3) through management, exchange of information and collaboration. Often, the organizations link to others through more than one organizational tie (Fig. 3.4, Table 3.1). Of these 257 links, 101 associations were frequent, 123 were occasional, and 33 were rare (Fig. 3.5, Table 3.1). Although visually, the network initially appeared centralized (i.e., the network is organized around a central node), our results indicate that diverse organizations with high in-degree centrality were present in the network (i.e., nodes receiving more institutional links than others in the network, which means influential nodes in the network, considered by us as central nodes) (Fig. 3.3). These were: the governmental organizations GO02 and GO01, the fishing cooperative FC01, the governmental organization GO03, and the fishing cooperatives FC02, FC03 and FC04, respectively. Our analysis of betweenness centrality indicated that actors with high betweenness values were present in the network (i.e., nodes often on the shortest paths between nodes in the network, meaning well-positioned nodes, deemed by us to be bridging nodes. These were: the governmental organization GO01, the non-governmental organization NGO01, the municipal government MG01, the fishing cooperatives FC02 and FC01, and the governmental organizations GO04 and GO02, respectively (Fig. 3.6).

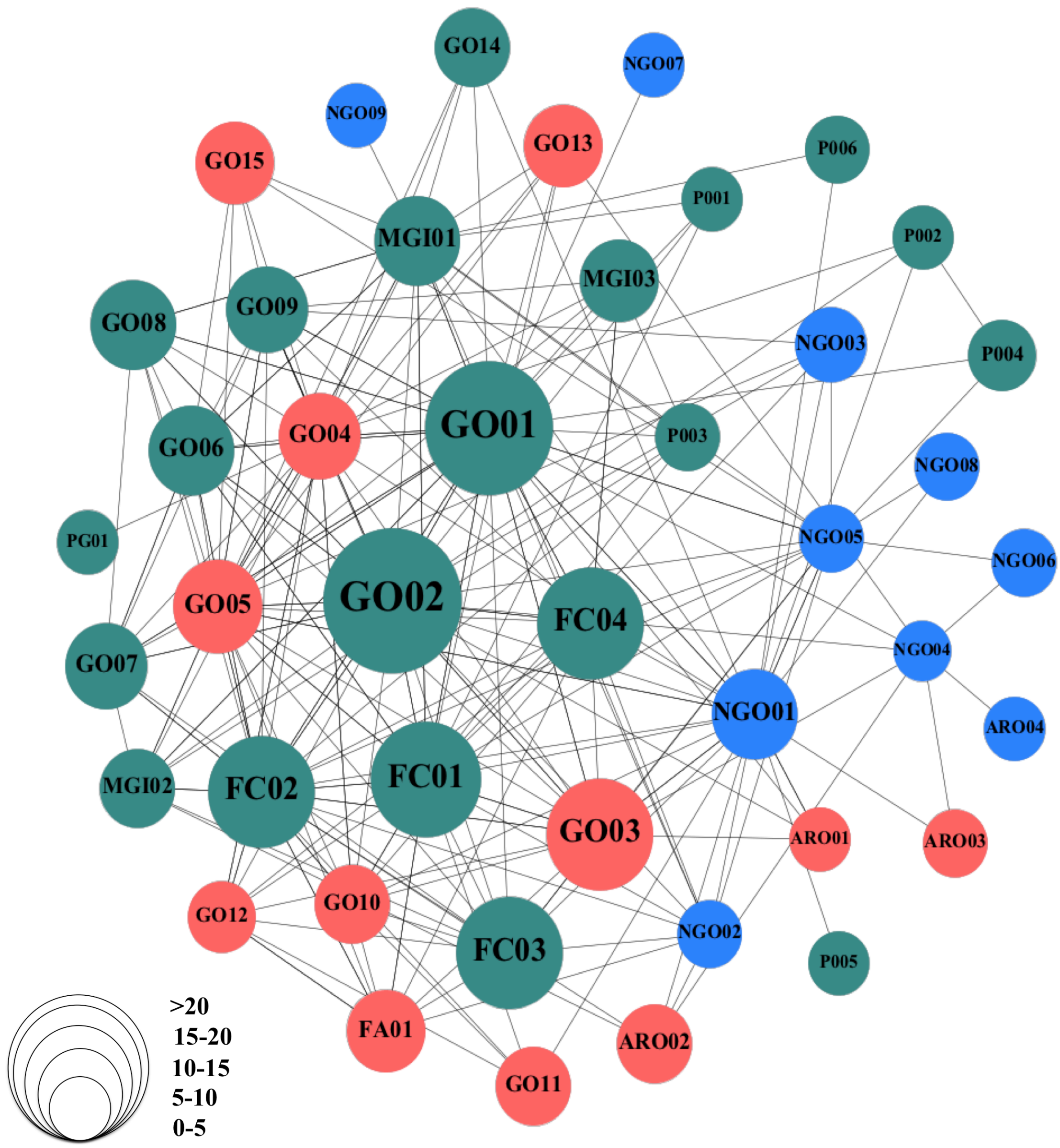


Figure 3.3 Central organizations of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations within the Galapagos small-scale fishery sector (GO = governmental organization, PO = private organization, FA = fishery association, NGO = non-governmental organization, MG = municipal government, PG = parish government, ARO = academic and research organization). Node size indicates in-degree centrality. As the nodes' dimension increases, it means that those nodes receive more organizational links than others in the network, defined by us as central nodes. Node colour indicates level (green nodes = local level, red nodes = national level, blue nodes international level). Links indicate ties between organizations linked with the Galapagos small-scale fishery sector.

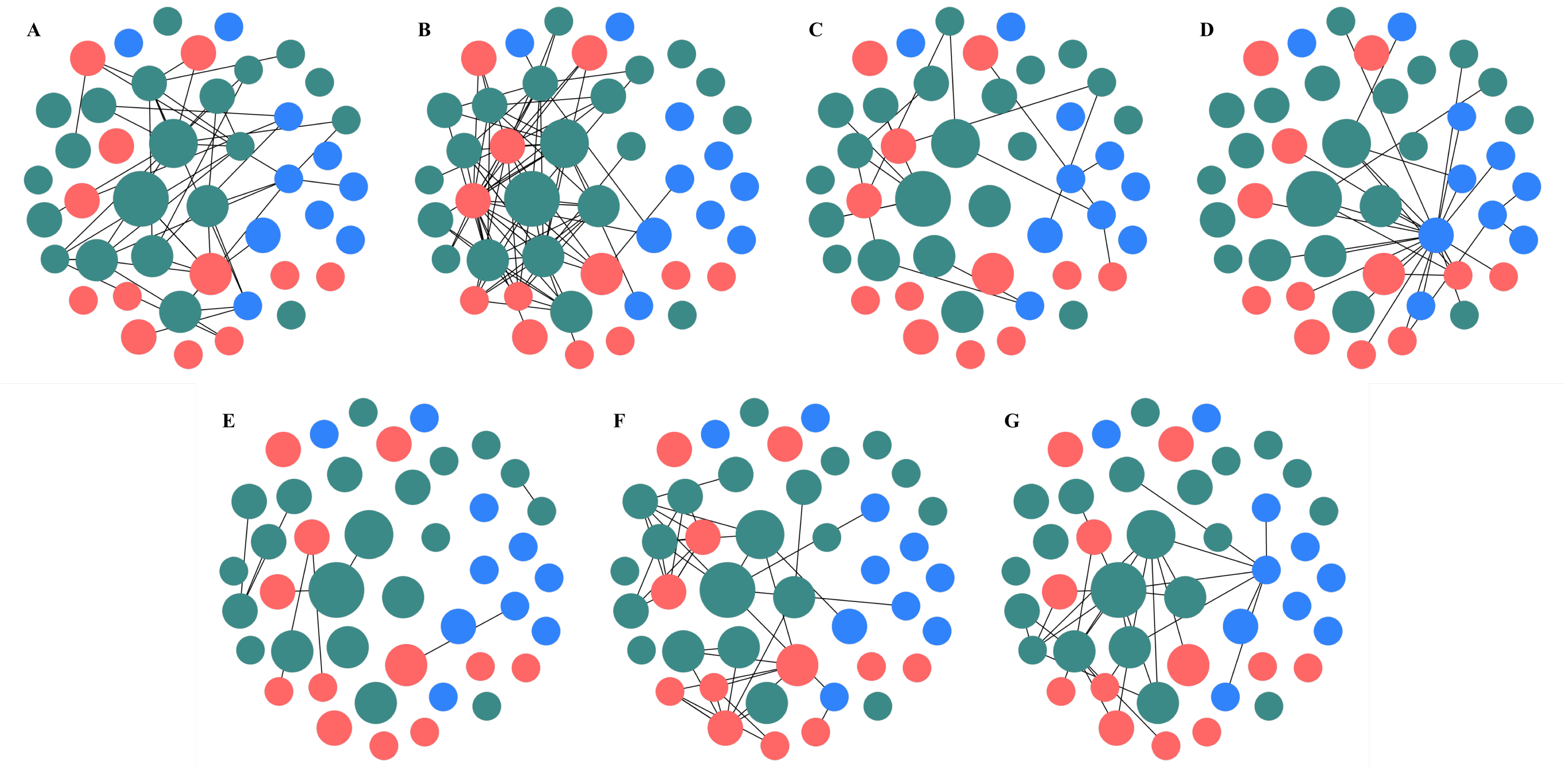


Figure 3.4 Type of organizational ties of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations within the Galapagos small-scale fishery governance system shown in Fig. 3.3. Node colour indicates the level (green nodes = local level, red nodes = national level, blue nodes = international level). As the nodes' dimension increases, those nodes possess higher in-degree values than others in the network (see, Fig. 3.3). Links indicate the organizational ties between organizations within the governance system. 3.4A indicates links due to collaboration. 3.4B indicates links due to management. 3.4C indicates links due to information exchange. 3.4D indicates links due to information exchange and collaboration. 3.4E indicates links due to information exchange and management. 3.4F links due to information exchange, management and collaboration and 3.4G indicates links due to management and collaboration.

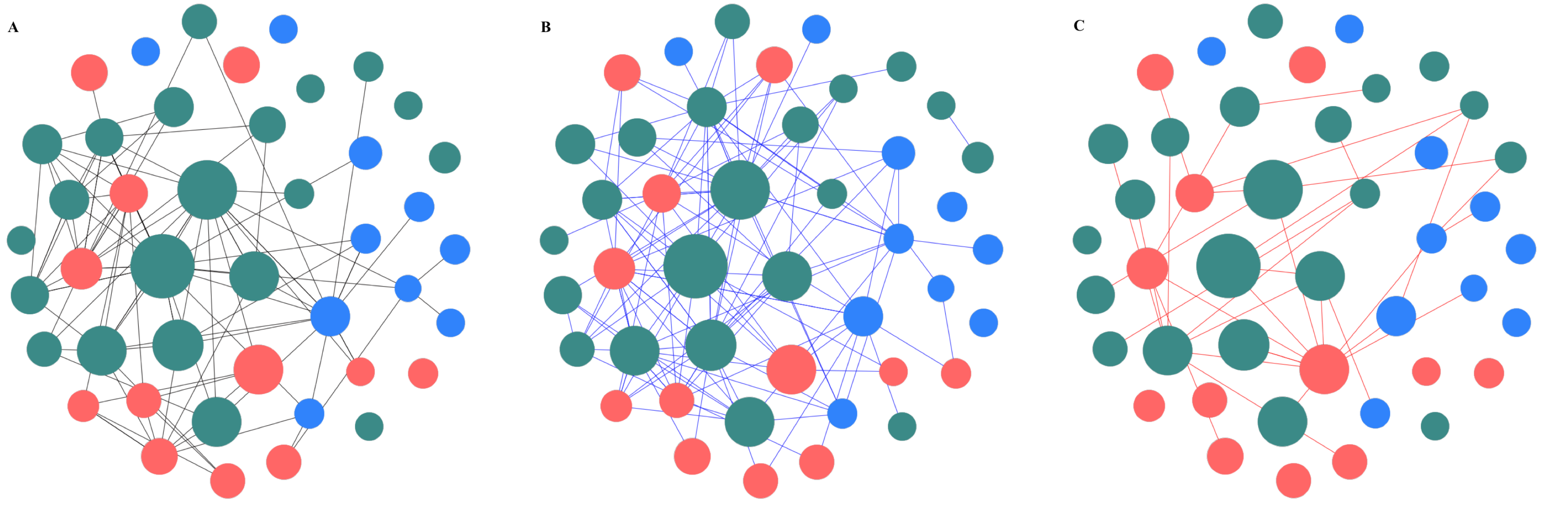


Figure 3.5 Frequency of organizational ties of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations within the Galapagos small-scale fishery governance system shown in Fig. 3.3. Node colour indicates the level (green nodes = local level, red nodes = national level, blue nodes = international level). As the nodes' dimension increases, those nodes possess higher in-degree values than others in the network (see, Fig. 3.3). The link colour indicates the frequency of organizational links between organizations linked with the Galapagos small-scale fishery sector. Black links in 3.5A represent frequent organizational links. Blue links in 3.5B represent occasional organizational links. Red links in 3.5C represent rare organizational links.

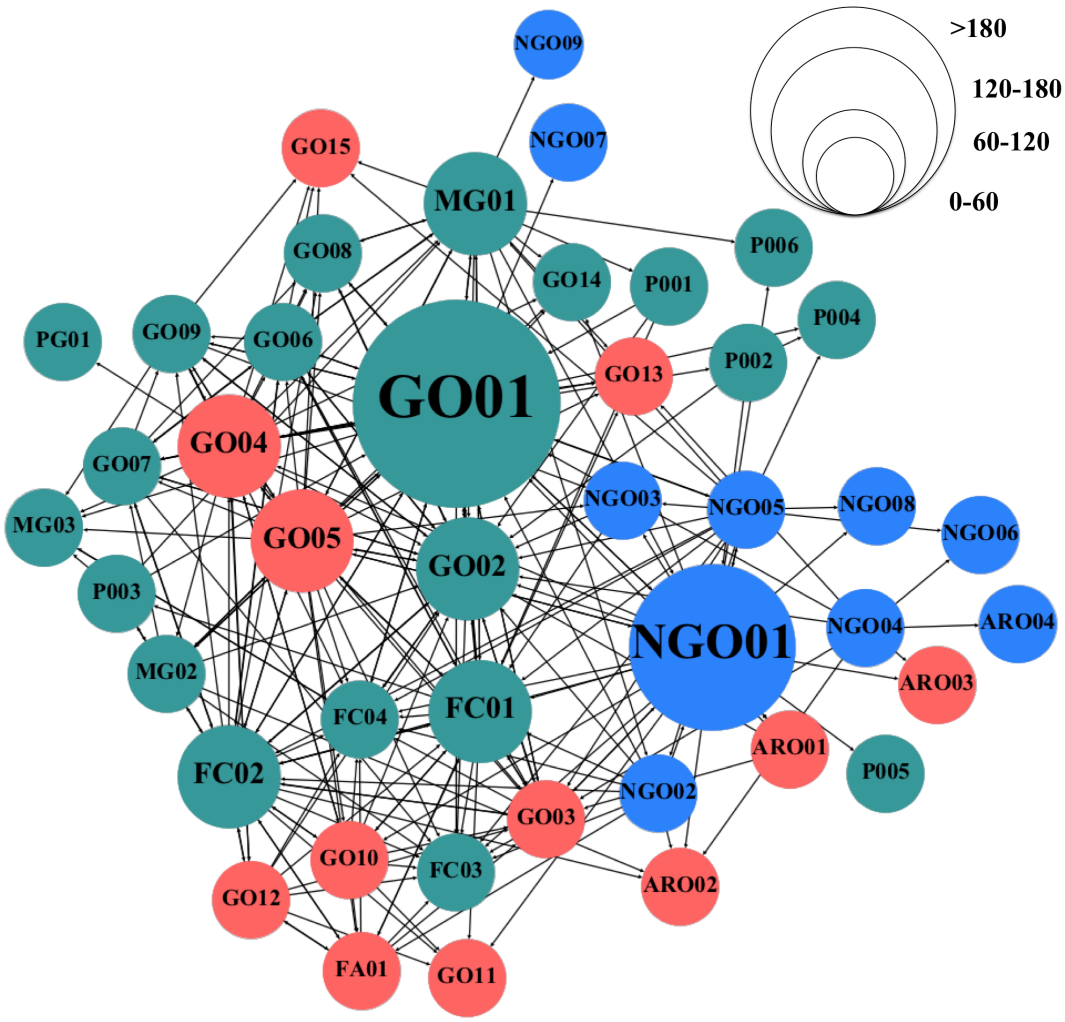


Figure 3.6 Bridging organizations of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations within the Galapagos small-scale fishery sector (GO = governmental organization, PO = private organization, FA = fishery association, NGO = non-governmental organization, MG = municipal government, PG = parish government, ARO = academic and research organization). Links indicate the connections between organizations within the governance system. Node size indicates betweenness centrality. As nodes' dimension increases, it means that those nodes are often on the shortest paths between nodes in the network, defined by us as bridging nodes. Node colour indicates the level (green nodes = local level, red nodes = national level, blue nodes = international level).

Statistic	Value
Number of nodes	43
Number of links	257
Number of frequent organizational links	101
Number of occasional organizational links	123
Number of rarely organizational links	33
Number of nodes from the public sector	21
Number of nodes from the private sector	22
Number of nodes from the local level	21
Number of nodes from the national level	12
Number of nodes from the international level	10
Percentage of links due to information exchange	7.0
Percentage of links due to management	31.91
Percentage of links due to collaboration	17.9
Percentage of links due to information exchange, management and collaboration	15.56
Percentage of links due to information exchange and management	3.5
Percentage of links due to information exchange and collaboration	12.06
Percentage of links due to management and collaboration	12.06

Table 3.1 Overall network statistics description of the Galapagos small-scale fishery governance system.

For interpretation purposes, the table breaks down the links and relationships between 43 organizations within the Galapagos small-scale fishery governance system network (a directed network, i.e. a governance system network in which all links do not necessarily have to be reciprocal). There are organizations connected to others through more than one organizational tie in the network.

3.4.2 ERGMs results

Our results indicated that the reciprocity between organizations was positive and statistically significant, suggesting that organizations are likely to reciprocate organizational links (hypothesis 1; Fig. 3.2, Table 3.2). The AinS parameter (popularity) is positive and statistically significant, indicating a propensity for popular organizations in the network, which relates to the in-degree distribution of the network (hypothesis 2; Fig. 3.2, Table 3.2). Estimates based on node attributes indicated that the public sector and local level did not influence the formation of associations. We did not find evidence of homophily based on the nodes' attributes, either by the influence of the economic sector (public sector) or based on the local level concerning the organizations' choice of partners to manage the activities of the Galapagos' artisanal fishery sector (hypothesis 5 and 8; Fig. 3.2, Table 3.2). There is a positive and significant sender effect based on the public sector attribute, indicating a tendency for public-sector organizations to send more organizational links, compared to others in the network (hypothesis 3; Fig. 3.2, Table 3.2). We found no strong evidence that local organizations tend to send more organizational links than others in the network (hypothesis 6; Fig. 3.2, Table 3.2). Additionally, we found no strong evidence that organizations from the public sector or local levels tend to receive more organizational links than others in the network (hypothesis 4 and 7; Fig. 3.2, Table 3.2). All the parameters we used converged (t-statistic < 0.1) and had a good fit (goodness-of-fit (GOF) < 0.1) (Table 3.2).

Hypothesis	Parameter (PNet names)	Estimate	Standard error (ER)	T-statistics	Goodness-of-fit (GOF)
Model 1:					
-	Arc	-5.56	0.37	0.02*	-0.07
Hypothesis 1	Reciprocity	1.95	0.23	0.003*	-0.03
Hypothesis 2	AinS	1.69	0.21	0.01*	-0.07
Hypothesis 3	Sender (public sector)	0.66	0.23	0.09*	0.02
Hypothesis 4	Receiver (public sector)	-0.14	0.20	-0.04	-0.10
Hypothesis 5	Interaction/ Homophily (public sector)	0.19	0.25	0.01	-0.004
Model 2:					
-	Arc	-2.46	0.15	0.09*	0.04
Hypothesis 1	Reciprocity	2.01	0.24	0.04*	0.04
Hypothesis 6	Sender (local level)	0.23	0.22	0.09	0.06
Hypothesis 7	Receiver (local level)	0.20	0.21	0.05	0.05
Hypothesis 8	Interaction/ Homophily (local level)	0.21	0.26	0.05	0.05

Table 3.2 ERGM results.

A t-statistic < 0.1 indicates a converged model. GOF indicates how well the model captured features of the data. GOF < 0.1 indicates a good fit. * Indicates a significant parameter. Positive or negative values indicate more or less than the network configuration, respectively. Arc parameter ($A \rightarrow B$) provides the baseline for the occurrence of associations (Lusher and Robins 2012b; Robins and Lusher 2012).

5.1 DISCUSSION

Our results suggest that organizations within the Galapagos small-scale fishing governance system network tend to interact frequently and occasionally (Fig. 3.5, Table 3.1) through diverse organizational links emerging from the exchange of information, management, and collaboration (Fig. 3.4, Table 3.1). Notably, our outcomes indicate that the organizations within the network often link to others through one or more interdependent tasks at once. Linkages associated with a) management, b) collaboration, c) information exchange, management and collaboration, d) information exchange and collaboration, and e) management and collaboration were the most prominent linkages in the network (Fig. 3.4, Table 3.1). These outcomes are interesting characteristics of collaborative governance if we consider that the likelihood of effectiveness increases when governance actors collaborate and address various interdependent tasks (Bodin et al. 2022). Therefore, if the network features shown in Figs. 3.4 and 3.5, Table 3.1, are seen and agreed upon more strategically between organizations according to their nature and needs and are activated when social-ecological interactions and social concerns unfold; they are valuable benchmarks to align strategies, coordinate solutions, and harmonize policy-making processes in the sector, particularly in times of abrupt changes. This capacity is referred to in the literature as "sleeping nodes and links" (Janssen et al. 2005). Organizational links should strategically align more closely with the sector's social-ecological interactions and societal needs than with actors' institutional objectives and affiliations often delegated by law as the GSL does. Addressing the adverse location-specific drivers of change that define the state of social-ecological systems (Wisner et al. 2004; Smit and Wandel 2006) depends in part on the effectiveness of governance systems to reconfigure, adapt to change and approximate as closely as possible their management scale with the social-ecological interdependencies scale (Folke et al. 2007; Kininmonth et al. 2015; Pittman and Armitage 2017a). Therefore, exploring the network interdependencies and patterns of collaborative networks shown in Figs. 3.4 and 3.5, Table 3.1 more strategically would also enable devising novel governance arrangements and updating joint efforts to bolster the capacity to adapt in the sector.

Our ERGM's outcomes suggest a positive and significant tendency of organizations to reciprocate links (hypothesis 1; Fig. 3.2, Table 3.2). We consider this an essential feature in the Galapagos small-scale fishery collaborative network, as mutual organizational links between organizations within governance systems play a significant role in sharing information, expertise, resources, objectives, and collaborative network links' evolution. Governance systems' adaptive capacity largely depends on their capacity to act collectively (Baldwin et al. 2018; Johnson et al. 2020). Therefore, positive reciprocal effects in the network (A $\leftrightarrow$ B) can potentially lead to the incorporation of a new third collaboration party (C) in reciprocal organizational links, giving rise to new strategic collaborative alliances in the sector. This means, in other words, that a collaboration partner of my partner is likely to become my collaboration partner (Pittman and Armitage 2017a), making reciprocal action an essential condition for improving the Galapagos collaborative network. As such, it would address complex collective-action problems of the sector and include organizations and stakeholder groups, e.g. Galapagos fishing communities from Santa Cruz, Isabela, San Cristobal and Floreana Islands. These communities have been fishing or diving for over seventy years (Cavole et al. 2020). Therefore, they, men who undertake fishing activities on the sea and women on land, know the local vulnerabilities and priorities beforehand and possess critical local knowledge, e.g., regarding climate shifts and variability (e.g. due to factors such as the periodicity of the El Niño-Southern Oscillation (ENSO and La Niña effects), adverse effects of climatic cycles on marine species, and specific socio-ecological relationships between fishers and marine species caught during warm and cold seasons (Cavole et al. 2020). These types of knowledge systems, which involve knowledge sharing between multiple types of actors across levels, have been shown to improve the capacity to deal with climate stress and other stressors in other socio-ecological systems in Latin America and other regions as well (Sievanen 2014; Andrachuk and Armitage 2015; Silvano and Begossi 2016; Alexander et al. 2016; Quist 2019; Charles et al. 2020; Gianelli et al. 2021).

The results indicate a positive effect but nonsignificant for homophily and receiver effects, suggesting no solid statistical evidence of homophily (hypotheses 5 and 8; Fig. 3.2, Table 3.2) and receiver effects (hypotheses 4 and 7; Fig. 3.2, Table 3.2) based on the nodes' attributes, either by the influence of the economic sector (public) or based on the local level regarding the organizations' choice of partners to manage the activities of the Galapagos small-scale fishery sector. These outcomes can be perceived as an interesting feature for cooperation and building adaptive capacity in the Galapagos fishery sector if one considers the value of cross-level and cross-sectoral interaction (Ostrom 2010; Carlisle and Gruby 2019) and the principle of subsidiarity (Marshall 2008) when managing common interests. Effective responses to rapid and transboundary multidimensional changes require the interaction of various actors at different levels – from the local to the international – in which all decision-making structures must take action within their mandates in a coordinated way to strategically cope with the effects of multidimensional problems facing socio-ecological systems (Armitage et al. 2007; Bixler et al. 2016). Acknowledging that local fishing communities have a close link with their environment – i.e. a link that allows them to capture what often cannot be perceived by the scientific community and decision-making structures – and that the subsidiarity principle ensures that decisions are made as close as possible to those whose livelihoods might be affected by decision-making, are crucial in adaptive capacity building.

Although we found no strong evidence that organizations from the local levels tend to send more organizational links than others in the network (hypothesis 6; Fig. 3.2, Table 3.2), outcomes concerning sender effects suggest that organizations from the public sector are more likely to send organizational links than others in the Galapagos small-scale fishery sector (hypothesis 3; Fig. 3.2, Table 3.2). This, from our view, may be interpreted to mean that the public sector plays a predominant role in defining management and organization in the Galapagos small-scale fisheries sector, reflecting the Galapagos' reality closely if we consider the dominant role that central and local governmental institutions have played historically in the policy implementation and coordination in the sector. These latter considerations may be explained by the control and constitutional power over decision-making granted by law by law (e.g., through the GSL) to the public sector in the Galapagos governance system operation, which, from our viewpoint, has reinforced recentralization processes and power imbalances in the fishing sector and the archipelago in general.

Our results also suggest tendencies for centralization (in-degree distributions) in the Galapagos small-scale fishing sector network (hypothesis 2; Fig. 3.2, Table 3.2). This means that some actors have a popular position in a social network, which increases their influence and impact on the Galapagos governance system. Organizations and stakeholders involved in governance system structures can provide incentives to both ease changing conditions and increase them (Armitage et al. 2011). Thus, probably, bridging organizations (e.g., CDF) can potentially become significant catalysers and intermediaries that connect actors and groups at different geographical and jurisdictional scales and levels in the network, contributing to enhancing collaborative governance networks in times of abrupt and sudden changes. On the one hand, improved connectivity and collaboration between central nodes (e.g., CGREG, DPNG, COPROPAG, COPESPROMAR, COPESAN, and COPAHISA) might provide platforms in the network to foster participation and knowledge sharing that account for local priorities and social memory. On the other hand, improved connectivity and collaboration among such nodes in the network can provide platforms for building trust and social capital that might alleviate the frequent tensions and disputes associated with the management of Galapagos small-scale fisheries. These considerations are particularly important to bear in mind since according to our experience; the level of trust and empathy among these relevant groups of stakeholders is determinant in the willingness to collaborate on issues of mutual interest. Therefore, amid contemporary moments of crisis resulting from the COVID-19 pandemic, which has severely hit the socio-economic stability of the sector, it is necessary to rethink the collaborative relationship between these stakeholder groups. The latter considerations are significant to remember since current or new drivers of change (e.g., probably deriving from climate change), in the short or long run, could foreseeably impact the tourism sector again due to its dependency on global dynamics. In consequence, the flow of tourists could be interrupted, indirectly affecting the stability and adaptive capacity of the fishery sector once more. Therefore, the Galapagos fishing sector requires detailed proactive responses and management strategies to ensure its sustainability without a direct dependence on the tourism sector, which likely will reactivate as the COVID-19 pandemic's adverse effects cease.

It is critical to recognize that managing complex social-ecological systems involving a few actors is a challenging, if not impossible, endeavour (Lubell 2015; Fried et al. 2022; Blythe et al. 2022). This is particularly true in rigid co-management systems where actors are often stipulated and defined by policies and laws, limiting connectivity, flexibility, and experimentation across sectors, levels, and scales. Therefore, the initial idea of governance systems management based solely on collaboration (co-management concept) should be expanded in scope. This approach echoes the adaptive co-management approaches proposed by other research (Dietz et al. 2003; Folke et al. 2005; Armitage et al. 2009; Clark and Clarke 2011). The multiple socio-ecological interactions that exist in small-scale fisheries in the Galapagos require cooperation and experimentation (i.e., learning by doing) that take place in different decision-making centres. Therefore, central organizations (e.g., CGREG, DPNG) and bridging organizations in the network (e.g., CDF) that operate at local, national, and international levels and possess connections to governmental organizations, NGOs, funding organizations, and local resource-users play a significant role in this regard.

Bolstering the capacity of a socio-ecological system at the local scale to adapt is highly dependent on correcting errors by adjusting attitudes and behaviours; i.e., adjusting errors through values and policies (double-loop learning); or by building social capital rather than changing individual resource management strategies and actions; i.e., correcting mistakes from routines (single-loop learning) (Armitage et al. 2008). An example of the latter approach would be repetitive conflicts in the sector between conservationists and local fishers regarding the prohibition of certain fishing gears (e.g. the longlining ban, a constant driver of controversy and disputes in the Galapagos fishing sector dating back to the implementation of the GMR in 1998) (Cerutti-Pereyra et al. 2020). Central organizations (e.g., CGREG, DPNG, COPROPAG, COPESPROMAR, COPESAN, and COPAHISA) and bridging nodes (e.g., CDF) occupy important positions in the network, making them significant actors in creating synergies among stakeholders in the network. Therefore, in our view, their influential positions in the network might enable them to provide leadership and vision necessary among the stakeholders to elucidate and foster best practices within the network, helping to shape transitions from single-loop learning to double-loop learning in the sector (Folke et al. 2005; Hahn et al. 2006; Bodin and Crona 2009; Berardo and Scholz 2010; Armitage et al. 2017a; Blythe et al. 2022).

Finally, it is important to be aware that linking diverse actors and distributing responsibilities across geographical scales and administrative levels often poses one of the most significant challenges in managing common-pool resources such as the Galapagos small-scale fishery system (Wyborn 2014; Mudliar and O'Brien 2021). Therefore, bridging and central nodes can contribute to having a more densely clustered collaboration network, serving as channels for communication and intermediaries to connect separated organizations across geographical scales and management levels in a governance system (Olsson et al. 2006; Berdej and Armitage 2016). In this scenario, the effect of central and bridging nodes in the network might go beyond merely bridging together stakeholders and exchanging information and goals in the network. Central nodes, particularly those with influence and constitutional authority in decision-making processes granted by the GSL (e.g., CGREG, DPNG), play a significant role in building an environment to bolster the capacity of the fishery sector to adapt in light of multiple societal concerns, stakeholders' needs and expectations in the sector (Olsson et al. 2007; Acton et al. 2021; Ishihara et al. 2021).

6.1 CONCLUSIONS

To our knowledge, this paper is the first study in the Galapagos Islands that aims at studying the collaborative governance system of the Galapagos small-scale fishery using a social network approach. The results presented in this paper highlight that the use of social network approaches through network statistics approaches and ERGMs are valuable tools when analysing collaborative processes through social network analysis from place-specific perspectives. We argue that if the aim is to strengthen governance systems, both network statistics approaches and ERGMs enable decision-makers to make decisions. On the one hand, network statistics allow decision-makers to make initial decisions by understanding critical actors in the network, existing collaboration frequency and organizational links that occur in a network. On the other hand, ERGMs allow decision-makers to undertake more profound investigations by understanding more specific interdependencies occurring in a network by incorporating structural and attribute variables in the analysis, enabling a further explanation of a social network configuration and the formation of links.

Our results suggest that various organizations from different sectors and levels interact in the Galapagos small-scale fishing sector network. Therefore, considering the value of social network approaches in adaptive capacity research on socio-ecological systems, we suggest this paper may guide future theoretical frameworks that strengthen the Galapagos small-scale fishing sector collaborative governance network. We recognize the need to align the Galapagos small-scale fishery governance system presented in this study with the collaboration links, relationships and interdependencies formed during the COVID-19 pandemic in the sector. The unprecedented nature of the coronavirus variants must have accelerated the creation of collaboration links in the sector. Thus, we argue that the experience gained in responding to the COVID-19 pandemic would allow the formulation of additional inputs for enhancing the Galapagos small-scale fishing governance system network and the sector's scientific development from collaboration and social network analysis, in addition to opening further discussions on the governance system's capacity to align management with the complex social-ecological interactions occurring in the sector.

This is the first attempt to elucidate the governance configuration of the Galapagos small-scale fishing system. As a result, additional research is needed to broaden the scope of our findings through empirical studies when the COVID-19 pandemic allows it. We emphasize the importance of investigating the role of power and trust in the network, which was not addressed in our investigation. Identifying central and bridging organizations and testing further hypotheses based on the role of power and trust among network organizations would be a significant step forward in understanding how the Galapagos small-scale fishery governance network works. For example, we propose conducting empirical research to identify the organizations that concentrate power and authority in the Galapagos governance network, as well as the trust relationships between such organizations. Additional research in these areas would help to strengthen collaboration links and the capacity for adaptation in the Galapagos small-scale fishery governance system.

CHAPTER 4: THE EVOLUTION OF POLYCENTRIC GOVERNANCE IN THE GALAPAGOS SMALL-SCALE FISHING SECTOR.

Addressing the multiple anthropogenic and non-anthropogenic factors affecting small-scale fisheries requires collaboration from diverse regions, geographical scales, and administrative levels in order to prevent a potential misfit between governance systems and the socio-ecological problems they address. While connecting actors and stakeholders is challenging, as they often hold opposing perceptions and goals, unveiling the network configurations of governance systems remains one effective way to explore collaborative alliances in light of the diverse drivers of change present in small-scale fishery systems. This study employed descriptive statistics, exponential random graph models (ERGMs), and qualitative data analysis to explore preferential attachments of new nodes to well-positioned nodes within the Galapagos small-scale fishery governance system network and the propensity of cross-sectoral reciprocity and cross-sectoral open triads formation in the network. Our findings identified significant players and network configurations that might be essential in the collaboration diffusion and robustness of the Galapagos small-scale fishery sector governance system.

4.1 INTRODUCTION

Today, small-scale fishing governance systems face different challenges in formulating strategies capable of addressing multiple problems. We live in an increasingly interconnected world, where problems in a social-ecological system originate in numerous and simultaneous interactions and exposures from local and global scales (Ostrom 2012; Barnes et al. 2017; Berkes 2017). The effects of global and local dynamics at present – characterized by high uncertainty, complexity and unexpected changes – make social-ecological transformations and uncertainty an inevitable occurrence in small-scale fisheries systems. Consequently, aligning small-scale fishery governance systems with the social-ecological dimensions they are meant to address also becomes challenging (Rijke et al. 2012; Lubell and Morrison 2021).

Small-scale fishery governance systems should consider spatial scale (i.e., capacity to match a social-ecological system's geographical extent), temporal scale (i.e., capacity to act on time), and functional scale (i.e., capacity to match a social-ecological system's functional dynamics and interactions); recognizing this is crucial when dealing with complex social-ecological systems (Young 2002; Cumming et al. 2006; Galaz et al. 2008; Wandel and Marchildon 2010; Bodin and Tengö 2012; Bodin et al. 2014; Epstein et al. 2015). However, it is necessary to recognize that the management scale of those governance systems encompasses multiple types of fit simultaneously to span a socio-ecological system's scope in the face of change (Pittman and Armitage 2017a; Bergsten et al. 2019; Ishihara et al. 2021). Today, the management capacity of governance systems depends not only on its ability to fit with environmental and ecological concerns but also on its ability to fit with various societal problems and stakeholders' expectations (Acton et al. 2021; Ishihara et al. 2021). Global sustainability challenges (Lubell and Morrison 2021) pressure governance systems to align as much as possible with the spatial, temporal, and functional dimensions of the system (e.g., with the interactions between marine species and fishers' actions). Moreover, unexpected socio-economic and environmental changes and needs can emerge in socio-ecological systems (e.g., due to the adverse impacts of novel pandemics such as 2019 novel coronavirus or COVID-19, climate change, or unreported fishing); this has broadened the management scope of social-ecological governance systems and the need to address "the problem of fit" more closely (Galaz et al. 2008; Rijke et al. 2012; Fried et al. 2022).

How society responds to the evolving conditions through collaborative approaches is an essential component of addressing the problem of fit in small-scale fishery governance systems (Armitage and Plummer 2010b; Alexander et al. 2017). By recognizing this, this paper aims to improve the Galapagos small-scale fishery collaboration network and the notion of governance fit within the Galapagos small-scale fishery sector by considering attributes stemming from institutional fit, adaptive co-management, polycentrism and subsidiarity (summarized in Fig. 4.1). Here, we offer a methodological approach that draws on social network analysis (SNA) and qualitative data analysis. This novel research approach enables analysts to represent, capture and unveil relationships and interdependencies in social and ecological environments; we thus employ it to examine specific network patterns and configurations that may strengthen the collaborative links of Galapagos small-scale fishery governance system.

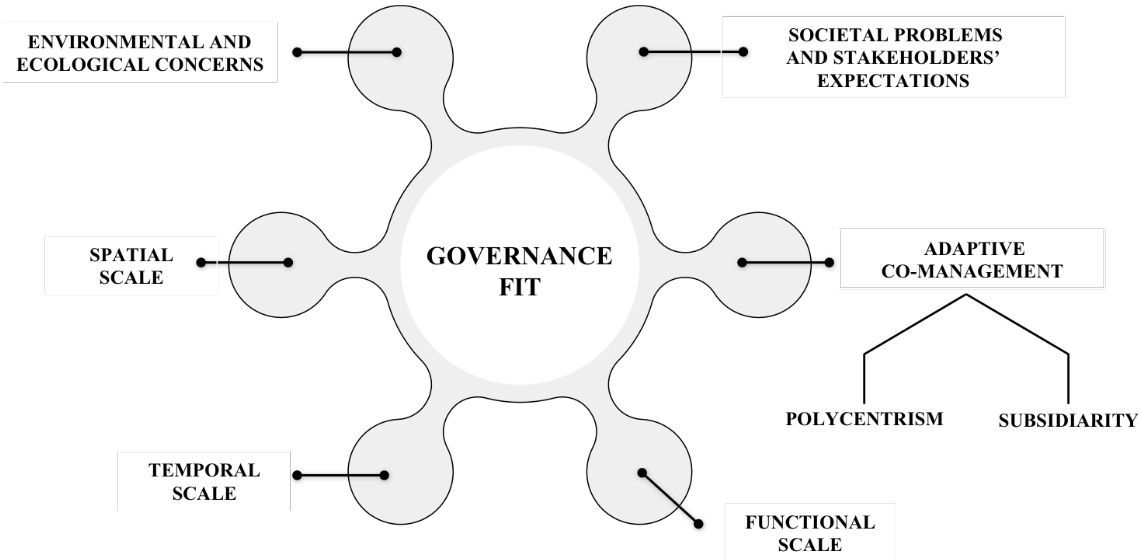


Figure 4.1 Governance fit.

We explore in this study the preferential attachment of nodes (i.e., the likelihood of adding collaborative ties to well-positioned nodes) in the Galapagos small-scale fishery governance network. In doing so, we employ descriptive statistics (centrality measures), estimate the propensity toward reciprocity and open triad formation (as explained in Fig. 4.2) across sectors using exponential random graph models (ERGMs), and analyze interviews. Throughout the paper, we use nodes, referring to those organizations and agencies connected to the Galapagos' small-scale fishery governance network and those organizations that may be part of the collaborative network of Galapagos small-scale fishery governance in the future. At the same time, we refer to links/ties to the organizations' connectivity in terms of other organizations and agencies.

In this paper, we argue that institutions and agencies may be able to more wisely discern how to choose and create collaboration partners based on the nodes' positions, features and needs, rather than leaving it to chance or to policies and laws to define collaboration ties. This implies that organizational ties in a governance system network can become more dynamic, moving from delegated organizational links to organizational ties where actors can make choices regarding the partners with whom they collaborate. Our theoretical framework might guide practitioners as to the spread and allocation of elements needed in social–ecological governance systems networks, such as governmental and international support, including financial aid, economic incentives and subsidies, technology, data exchange, and co-production of knowledge, along with other determinants and instruments deemed significant in building robust collaborative networks.

The theoretical approach of this paper provides stakeholders with a broader image of where collaboration links might have a more extensive influence on collaboration diffusion in a network. It offers stakeholders a platform for evaluating whether collaboration alliances need to be created, enhanced or reformulated. Stakeholders may analyze whether or not it is necessary to create mutual links (A ↔ B) (Fig. 4.2a) or include a third collaboration party C into an existing A–B collaboration. If so, the inclusion of a new collaboration partner would lead to an open triadic (Fig. 4.2b) or a triadic closed organizational network configuration (Fig. 4.2c), where organizations involved can benefit and strengthen each other by sharing organizational goals and resources.

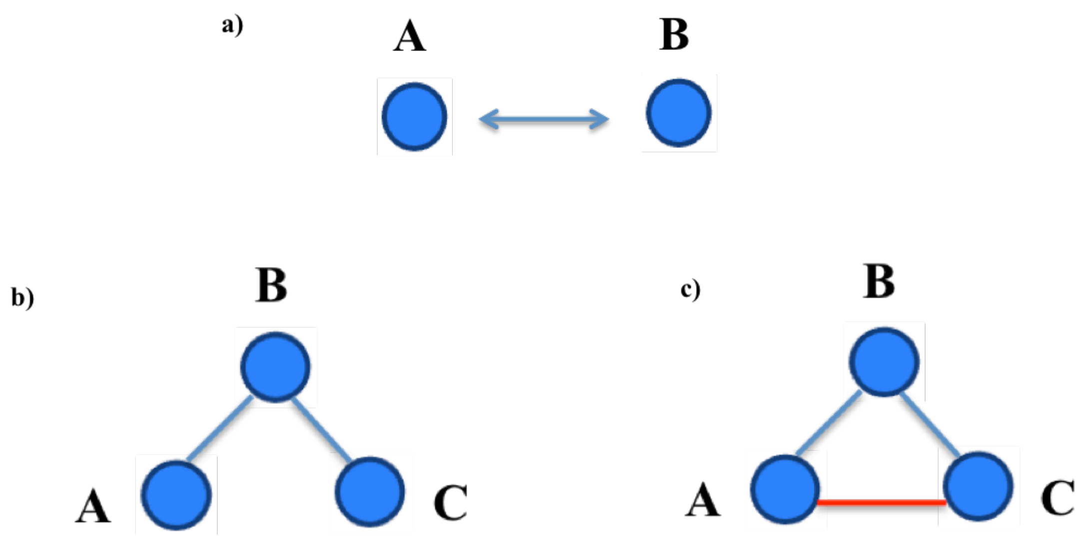


Figure 4.2 a) Reciprocity, b) Open triads, c) Closed triads.

Figure 4.2a: If there are mutual interactions between organizations and agencies (A ↔ B) in a governance structure, such organizations and agencies are likely share efforts, such as financial resources, technicians, knowledge, and data. They also serve as baseline for the formation of open or closed triadic network configurations, implying further diffusion and propagation of collective efforts.

This often starts when organizations and agencies create an initial organizational link and reciprocate organizational ties (A ↔ B). Fig. 4.2b: If collaboration connections A–B and B–C exist, it is likely that a new organizational link A–C would be formed (red line in Fig. 4.1c), giving rise to a triadic closure configuration. The analysis of open triads enables us to indicate the likelihood of partners of partners to become collaboration partners, which implies that the A–B and B–C collaboration ties might be transmitted to A–C in a governance system structure (Lomi and Pallotti 2012; Pittman and Armitage 2017a).

4.2 PATHS TOWARDS COLLABORATION AND POLYCENTRIC LINKS IN GALAPAGOS

Although the conservation of Galapagos marine resources was not a priority at the time, institutional ties to protect these resources date back to the 1960s, when the Charles Darwin Research Station (CDRS), the first international research organization in the Islands, and the Galapagos National Park (GNPS), the first governmental organization for conservation purposes in Galapagos, were created and signed the first collaboration agreement to foster research and conservation in the Galapagos (Castrejón et al. 2014). This agreement marked a turning point for the development of Galapagos fishery science by giving rise to a series of institutional links in the Galapagos, which were initiated when the GNPS and the CDRS requested that US Peace Corps volunteer Jerry Wellington explore coastal intertidal and subtidal ecosystems of Galapagos in the 1970s (Reck 2014). Wellington's outcomes highlighting the marine biodiversity and endemism of the Galapagos served to consolidate the first official inter-institutional cooperation agreement between the CDRS and the National Fisheries Institute (Spanish acronym: INP) in 1976, joined a year later by the University of Guayaquil, in order to explore the Galapagos fishery resources state in terms of abundance and distribution (Castrejón et al. 2014). This effort gave rise to the first triadic network configuration involving reciprocated ties in the Galapagos small-scale fishery sector network (A↔B; B↔C; C↔A), represented by the red links in Fig. 4.3a (i.e. network configurations that narrow and facilitate collaboration in networks).

Galapagos marine resources have been subjected to fishery exploitation since the late 18th century (Castrejón et al. 2014). British and North American whalers and sealers pioneered commercial exploitation in the archipelago. Sperm whales (*Physeter macrocephalus*), fur seals (*Arctocephalus galapagoensis*), and Galapagos sea lions (*Zalophus wollebaeki*) were the primary targets species

(Castrejón et al. 2014). Notably, the demands of the Asian market for shark fins, together with the sea cucumber (*Isostichopus fuscus*) capture in the 1980s and later collapse in the 1990s in close collaboration between Asian intermediaries with Galapagos local fishers and fishers from coastal provinces of Ecuador; prompted great interest in the management, conservation and commercialization of marine resources in the Galapagos (Castrejón et al. 2014). As a result, between the 1980s and 1990s, the number of immigrants from Ecuador's mainland, small-scale fishing fleets, and tourists on the islands increased significantly, giving rise to the establishment and interests of diverse scientific institutions, governmental and non-governmental bodies, and various local fishing cooperatives (Castrejón et al. 2014), as well as diverse legal provisions, institutional arrangements and strategies, shaping changes from a top-down command control form of governance to one with more polycentric links in the Galapagos.

The completion of the management plan of the Galapagos Marine Reserve (Spanish acronym: PMRMG) by the so-called Grupo Nucleo in 1994, the preparation process and later adoption of the so-called Galapagos Special Law (GSL) in 1998, that led to the Marine Reserve (GMR) establishment and the Galapagos co-management system (GCM) implementation (Castrejón et al. 2014), as well as the 2007 inclusion of the Galapagos Islands into the list of endangered World Heritage Sites by UNESCO (Morrison et al. 2020b), marked significant milestones in constructing governance environments with more polycentric links by prompting diverse ties between national public and private international and local organizations and agencies.

Significantly, the GCM, administered mainly from the governmental side, gave rise to delegated institutional ties (Fig. 4.3b) under two management bodies: the so-called Participative Management Board (PMB), formed by representatives from the GNPS, the small-scale fishery (elected among the Galapagos Fishing Cooperatives), the Galapagos Chamber of Tourism, the CDRS and naturalist guides to represent the local level; and the so-called Inter-institutional Management Authority (IMA), formed by representatives from three ministries based on Ecuador's mainland (Ministry of Environment, Ministry of Defense and Ministry of Foreign Trade, Industrialization, Fisheries and

Tourism), representatives of local sectors (the small-scale fishery sector and the Galapagos Chamber of Tourism) and the Ecuadorian Committee for the Defense of Nature and the Environment (Spanish acronym: CEDENMA) to represent a higher level of the decision-making process and decide if there was no consensus among the representatives of the PMB at the local level. Under the IMA structure, CDRS acted as a technical advisor and the GNPS as a technical secretariat for the Ministry of Environment (Denkinger et al. 2014; Barragán P. 2015).

Since the reform of the GSL in 2015, the Galapagos co-governance has been changing its original governance structure. With GSL reforms, the PMB and the IMA were repealed, giving rise to new delegated organizational links—formed by, and run primarily from, the governmental side—to lead decision-making processes. Today, the GSL is being amended, giving rise to discussions to consolidate a new consultative governance scheme, whose operational legal framework remains unclear and inactive. Therefore, collaboration and organizational ties in the Galapagos small-scale fishery sector, involving actors from diverse administrative levels and scales, continue to change due to changes on the governance structure and the creation of new management tools, including the management plans of the Galapagos National Park Directorate (Spanish acronym: DPNG) and the Galapagos Special Regime Governing Council (Spanish acronym: CGREG).

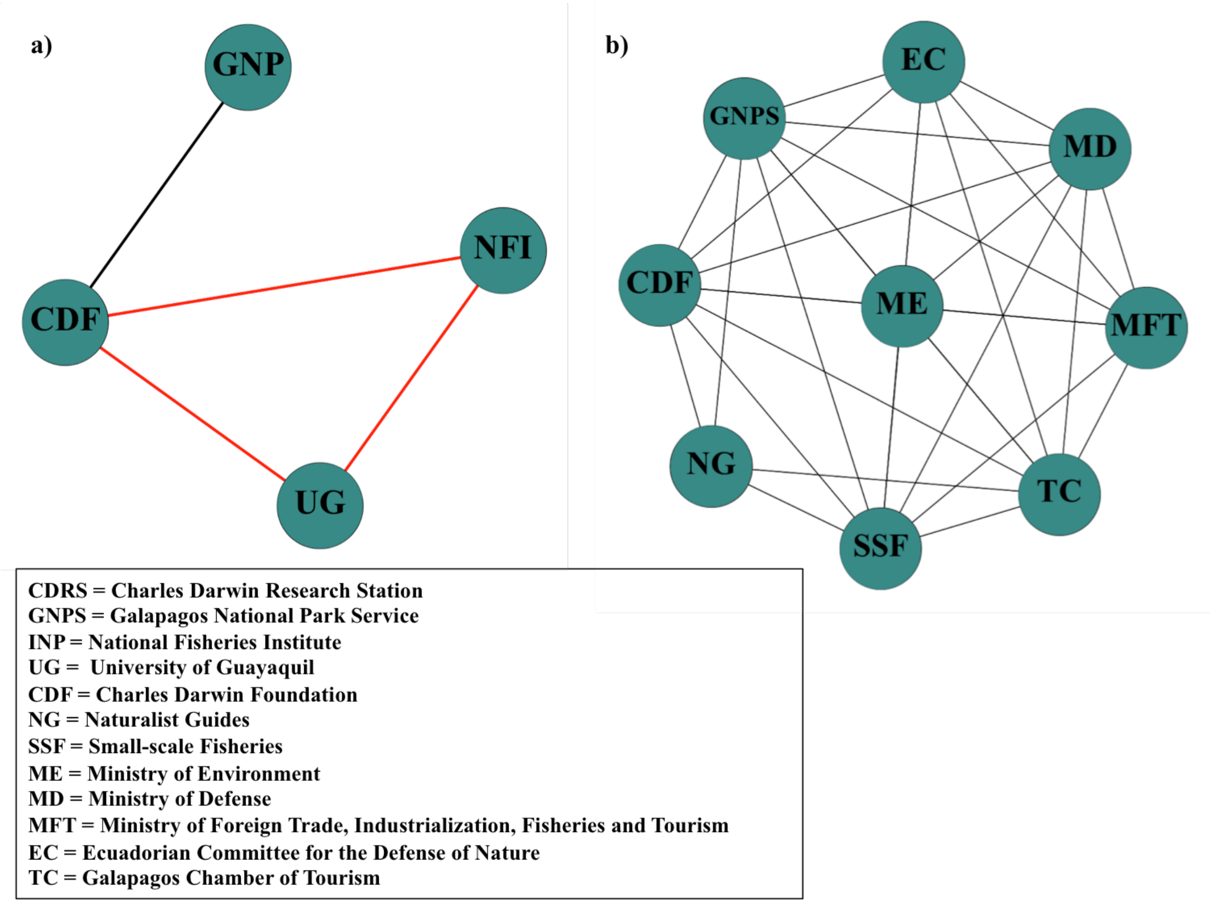


Figure 4.3 (a) Polycentricity onset in the 1960s, (b) Delegated Polycentricity in the 1990s.

Nodes indicate organizations and agencies. Ties represent the organizational connections between organizations and agencies. The red ties of Fig. 4.3a show the first triadic network configuration involving reciprocated ties in the Galapagos small-scale fishery network, as described above. Note: Despite the vital role that Asian intermediaries played in the development of the Galapagos sea cucumber fishery, they were not recognized as a sector or actor in the Galápagos fishery system; therefore, they were not members of the PMB. This gave rise to two parallel management systems: the GCM, and the system formed by Asian intermediaries who, in partnership with local fishers, set up clandestine camps to catch and process sea cucumbers. See also the discussions regarding evolving polycentric governance of the Great Barrier Reef in Morrison (2017) who initially coined the term delegated polycentricity, and the role of Asian intermediaries in the exploitation of Galapagos sea cucumbers in Castrejon and Defeo (2015).

4.3 MOVING BEYOND CO-MANAGEMENT

Although co-management has undoubtedly been a significant approach in response to the limitations of centralized, top-down governance, as well as the increasing demands of natural resource users and local communities to be part of the decision-making processes that affect their livelihoods, it is essential to note that the social-ecological interactions that span the small-scale fisheries systems are more complex and dynamic than the way that co-management literature initially considered them. The human and ecological environments of small-scale fisheries change day to day; this is due to significant problems that create multiple socio-ecological interactions beyond the co-management scope as a category of institutional arrangements to share power and responsibility between the government and local resource users (Berkes et al. 2003; Armitage et al. 2007). Today, we have witnessed closely that we live in a new era of the Anthropocene (Hughes et al. 2017; Morrison et al. 2020a; Lubell and Morrison 2021). The uncertain behaviour of complex social-ecological interactions has broadened the small-scale fisheries governance scale. The incomplete transition toward the new Galapagos governance system established by the new GSL, in combination with the adverse impacts of the COVID-19, climate change and illegal, undeclared and unregulated (IUU) fishing by national and international fleets, makes evident the need to explore other governance forms and further organizational links at diverse geographical and administrative levels, from local to international beyond the Galapagos Marine Reserve protected area and the DPNG jurisdiction that enable to align the Galapagos small-scale fishery governance system as much as possible with the extent, timing and functional diversity of social-ecological systems interactions and prevent a misfit.

Achieving an approximation to such socio-ecological fit requires strategic approaches that support the cooperation and interaction of diverse public and private actors from various jurisdictional levels and geographical scales in order to ensure more sustainable outcomes (Folke et al. 2002a; Olsson et al. 2007; Clark and Clarke 2011). Adaptive co-management (AC) is an emerging approach for common-pool resources management that enables the delivery of responses to social-ecological changes operating on multiple scales and levels, guided by subsidiarity principles and polycentricism (Folke et al. 2005; Ostrom 2010; Plummer et al. 2017; Carlisle and Gruby 2019). The subsidiarity principle implies that actions should be taken at the lowest practical level of governance, which in complex social-ecological systems ensures that decisions are made as near as possible to those whose livelihoods might be affected by decision-making structures (Marshall 2008). Significantly, the subsidiarity principle—sometimes referred to as "good governance"—provides an important platform for taking into account the proper stakeholders and local priorities; disregarding these considerations could reinforce the current status quo, which often reflects political economic inequalities and vested interests (Armitage et al. 2007, 2012). Different from monocentric forms of governance characterized by hierarchical governance structures (e.g. driven by a governmental authority or private monopoly) (Mitchell 2019; Morrison et al. 2019) (Fig. 4.4a), polycentric systems of governance imply the presence of multiple semi-autonomous nodes in decision-making processes (Stephan et al. 2019; Carlisle and Gruby 2019; Mudliar and O'Brien 2021), a central feature in complex social-ecological systems for facilitating linkages (i.e. partnerships; Fig. 4.4b) that span broad geographical scales and administrative levels in order to act as close as possible to social-ecological interactions and the underlying causes of vulnerability (Folke et al. 2005; Ostrom 2010; Plummer et al. 2017).

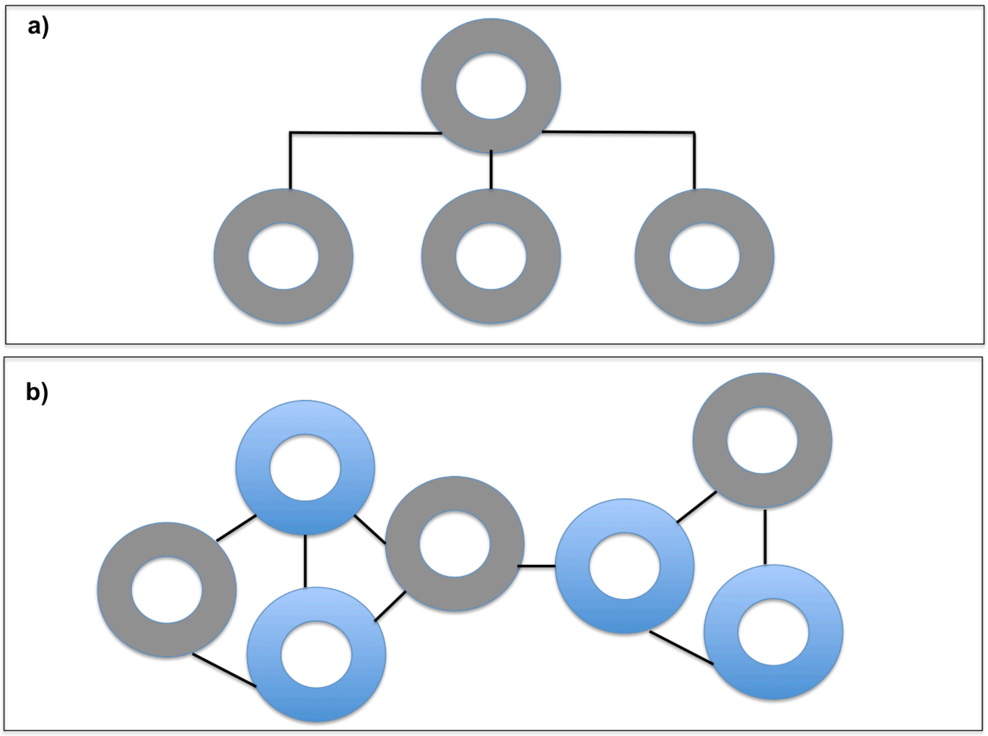


Figure 4.4 (a) Monocentric forms of governance, (b) Polycentric forms of governance.

Nodes indicate organizations and agencies in a governance structure. Ties indicate the organizational links between organizations and agencies. The grey nodes in 4.4a represent either governmental organizations (e.g. in a common-pool resource governance system with a strong presence of the government over decisions) or private organizations (e.g. in a monopoly). Node colour in 4.4b indicates the economic sector (blue nodes = private sector organizations and agencies; grey nodes = public sector organizations and agencies). This implies cross-sectoral interaction between different organizations regardless of their economic sector and administrative level. Furthermore, it is important to point out that while the existence of multiple semi-autonomous decision centers might be enough to deem a governance arrangement as polycentric, it does not mean that there will be enough coordination among such centers to ensure that a system acts as a polycentric governance system, see discussion in Carlisle and Gruby (2019) and Mudaliar (2020). The latter consideration is particularly important in terms of the influence of power in the management of common-pool resources. Power dynamics are pivotal to defining polycentric systems and coordination among decision-making centers (Mudaliar 2020). Without the actual intention to share power, cross-sectoral and cross-level interactions are challenging to achieve, keeping a system from functioning as one polycentric governance system (Morrison et al. 2019; Mudaliar 2020). At the same time, it is essential to bear in mind that an unclear distribution of responsibilities among decision-making centers in polycentric systems may give rise to confusion and functional and geographical overlaps between higher and lower administrative levels, also hindering the polycentric governance system (Wyborn 2014; Mudliar and O'Brien 2021).

Much of the criticism placed on common-pool resources governance systems has emerged because, among some reasons and deficiencies, they tend to suggest panacea/blueprint solutions for all types of problems (i.e. fixed standard universal solutions for various issues, see discussion in Ostrom (2007) and Ostrom and Cox (2010). The complexity that embraces small-scale fishery social-ecological systems' interactions demands management strategies and policies should be viewed as place-specific experiments that can be revised, adapted and changed as different social-ecological circumstances demand (Folke et al. 2002a, 2005; Armitage et al. 2008). AC is an evolving framework that provides elements to be learned via experimentation and learning from joint actions on broad geographical scales and administrative levels (i.e. learn by doing) (Armitage et al. 2007, 2009; Ostrom 2010). AC provides platforms that allow the participation of various stakeholders from local to broader non-local organizations and actors – possessing different sorts of resources such as social memory, financial resources, knowledge and data, among other adaptive capacity determinants, which can be activated when needed to navigate the dynamic nature (non-linear relationship) of interconnected socio-ecological dimensions (complex systems thinking) to deal more appropriately with uncertainty and rapid changes of small-scale fishery social-ecological systems (Mitchell 2002; Armitage et al. 2007; Plummer and Armitage 2010; Rijke et al. 2012).

4.4 CASE STUDY

Our case study focuses on the Galapagos small-scale fishery sector, a crucial socio-economic sector in the biodiversity hotspot that inspired Darwin's theory of evolution, located 1,200 km off the Ecuadorian coastline (Fig. 4.5). We focus our study on this sector considering that it plays a significant role in providing seafood to approximately 30,000 residents and 271,000 tourists who arrive annually in the Galapagos (in pre-COVID 19 conditions), making it a crucial sector for the food security of the archipelago. The case study of the Galapagos small-scale fishery sector serves to highlights today's need for governance systems to deal with the unforeseen trans-boundary social-ecological interactions (e.g. due to the effects of COVID-19) present in complex socio-ecological systems. These have affected diverse fishing communities in the islands due to the linkage of the fishery sector with the tourism sector. Fishing communities are seafood suppliers assisting the development of tourism, the main livelihood and source of income in the Galapagos. In this context, an approximate reduction of 73% in visitors to the Galapagos as a result of measures designed to reduce the spread of the COVID-19 virus and the number of people infected directly affected the socio-economic situation of the Galapagos small-scale fishing sector. The measures, which included the prohibition of all national and international tourist arrivals in the archipelago during the early months of the pandemic, and a subsequent mandatory negative polymerase chain reaction (PCR) test for entry into Ecuador and the Galapagos, led to the number of visitors to the Galapagos dropping from 271,238 visitors in 2019 to 72,519 in 2020 (DPNG 2021).

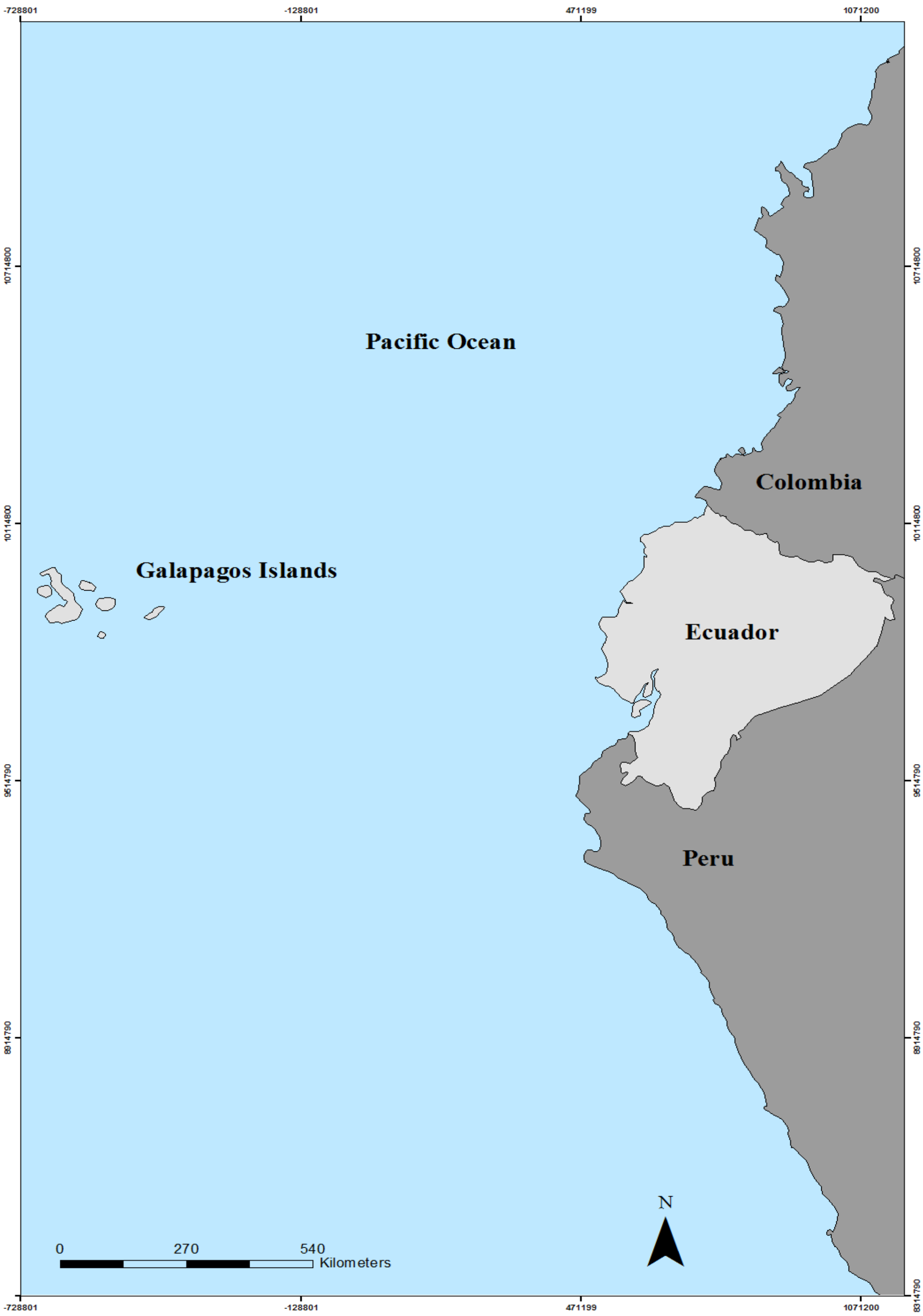


Figure 4.5 Location map.

4.5 METHODS

4.5.1 Data Collection

The study used various methods to collect data, since data collection coincided with the COVID-19 pandemic, which limited human contact. We explored the history and institutional interactions in the Galapagos through a review of previous studies on marine and conservation science development in the Galapagos (n = 41), including peer-reviewed journal articles, policy documents, organizational records and institutional publications from the government and the private sector. To this end, we used Google and Google Scholar to search the following keywords: Galapagos governance, Galapagos small-scale fishery, Galapagos collaborative arrangements and governance, and Galapagos co-management. We also used the reference list of relevant peer-reviewed papers about the development of marine and conservation science in the Galapagos as a guide to decide which articles to read. The review enabled us to examine organizations from different geographical scales and administrative levels and create a list of nodes that traditionally do not possess significant links within the Galapagos small-scale fishery governance system network (n = 28). However, they operate directly and indirectly in the Galapagos conservation and marine development areas (in normal conditions - pre-COVID-19). We used this list and the Galapagos small-scale fishery collaboration network of the work by Caceres et al. (Unpublished results) — a network comprised of 43 organizations and agencies connected through 257 organizational links — to a) suggest a preferential attachment of nodes from our list into the Galapagos small-scale fishery sector collaboration network presented by Caceres et al. (Unpublished results), b) explore cross-sectoral reciprocity configurations and cross-sectoral, open-triad configurations in the Galapagos small-scale fishery sector collaboration network presented by Caceres et al. (Unpublished results) and c) interview representatives and officials (n = 12) of diverse local and international public and private institutions and agencies that do not have significant ties to the Galapagos small-scale fishery sector network presented by Caceres et al. (Unpublished results).

Representatives and officials noted in c) were presented with a series of open and closed questions. They were asked (1) how the respondent's organization might collaborate in the Galapagos small-scale sector if there were institutional arrangements in place (e.g., financial resources, technical and scientific knowledge, local knowledge acquired over time, data and information, equipment and technology, infrastructure, or monitoring of illegal fishing or research projects), and (2) about the administrative level (local, national or international) and economic sector (public or private) of their organizations. A Qualtrics software, Version 6.2020 of Qualtrics (Copyright © [2020] Qualtrics) was used to create our study questions (in Spanish), send personalized links to the individuals' institutional email address and store respondent's answers. Informed consent was obtained via an initial question in the Qualtrics survey. We collected the data of the study between June 2020 and December 2020. We kept the survey open from September 10 to December 18, 2020. This study received ethics clearance (ORE #41927) from our university's research ethics system.

4.5.2 Data Analysis

Representatives' and officials' answers [noted in (1) in the data collection section] were translated from Spanish to English, and transcribed and coded using the qualitative data-analysis software NVivo (released March 2020) (QSR International Pty Ltd. 2020). The coding procedure, undertaken by the study's corresponding author, was both deductive and inductive. The codes were developed using categories from the question [noted in (1) in the data collection section]. We used Gephi network visualization 0.9.2 software (Bastian et al. 2009) to suggest the preferential attachment of nodes [indicated in a) in the data collection section] using centrality measures, degree centrality, eigenvector centrality, and closeness centrality. We used PNet software (Wang et al. 2009) to examine the propensity of reciprocity cross-sectoral formation and cross-sectoral open triads formation in the network [indicated in b) in the data collection section]. For this purpose, we developed a series of hypotheses using a building blocks (motifs) approach (i.e. network configurations representing specific network patterns in an observed network), representing basic network configurations we deem significant preconditions to facilitate network collaboration within governance systems (Fig. 4.6) (see more regarding "building blocks," in Milo et al. (2002) and their application in various studies in

Berardo and Scholz (2010); Chadès et al. (2011); Matti and Sandström (2011); Bodin and Nohrstedt (2016); Dee et al. (2017); Mcallister et al. (2017); Levy and Lubell (2018) and Matous and Wang (2019).

To capture the propensity toward the network configurations/ building blocks shown in Fig. 4.6, we used one asymmetric adjacency matrix (i.e. a value assignation of zeros and ones according to the presence or not of ties between nodes in the network) and two attribute matrices (i.e. a value assignation of zeros and ones according to the presence or not of nodes' attributes). In the adjacency matrix, organizational links in the Galapagos small-scale governance system network were set as 1, and the absence of the organizational relations was set as 0. In the first attribute matrix, public-sector nodes were assigned as 1, and private-sector nodes were assigned as 0. In the second attribute matrix, private-sector nodes were established as 1, and public-sector nodes were established as 0. We used these matrices and the parameters presented in Fig. 4.6 to run two models on PNet software (see also Table 4.2). We tested whether the parameters converged at t-statistic < 0.1 and had a good fit at goodness-of-fit (GOF) < 0.1 (Robins and Lusher 2012).

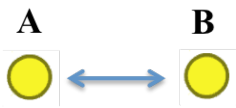
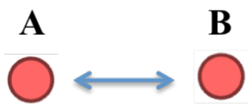
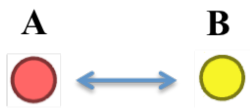
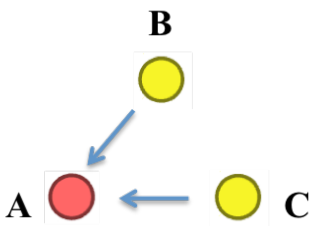
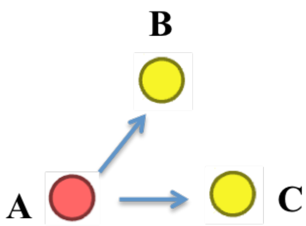
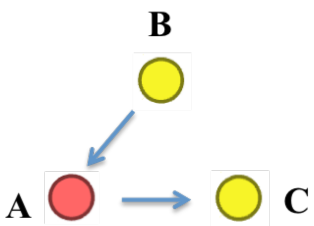
Parameters with Binary Attributes	**Hypotheses**
	Hypothesis 1: Mutual ties between nodes from the public sector - [Attr]-Interaction- reciprocity parameter.
	Hypothesis 2: Mutual ties between nodes from the private sector - [Attr]-Interaction- reciprocity parameter.
	Hypothesis 3: Mutual ties between nodes from the private and public sector- [Attr]-Activity- reciprocity parameter.
	Hypothesis 4: Open triad formation involving nodes from the public and private sector - [Attr]-in-2-star parameter.
	Hypothesis 5: Open triad formation involving nodes from the public and private sector - [Attr]-out-2-star parameter.
	Hypothesis 6: Open triad formation involving nodes from the public and private sector - [Attr]-2-path parameter.

Figure 4.6 Building blocks/ hypotheses used when estimating cross-sectoral reciprocity and open triad network configurations of the Galapagos small-scale fishing governance system.

ERGMs are a class of statistical models that enable capturing the presence or absence of specific network configurations in a social network. ERGMs provide a platform to statistically examine the propensity of building blocks in a more extensive network (Bodin and Tengö 2012). Pink nodes represent organizations and agencies from the private sector, and yellow nodes represent organizations and agencies from the public sector in the network.

4.6 RESULTS

4.6.1 Descriptive statistics results

Our descriptive statistical analysis identified actors whose position and centrality values within the network can contribute to and influence collaboration diffusion in the Galapagos small-scale fishery sector (e.g. CGREG, DPNG, fishing cooperatives, Charles Darwin Foundation (CDF). Our centrality analysis indicated that various actors with high centrality (i.e., nodes' that sent and received more collaboration ties compared to others in the network) were present in the network (Fig. 4.7, Table 4.1). Specifically, these were: the governmental organizations GO01 and GO02, the fishing cooperative FC02, the governmental organization GO05, the fishing cooperative FC01, the international non-governmental organization NGO01, the governmental organization GO04, the municipal government MG01, the governmental organizations GO03 and GO06 and the international non-governmental organization NGO05, respectively (see Fig. 4.7; Table 4.1).

Our analysis showed various actors with higher eigenvector centrality values compared to others in the network (i.e., nodes' importance based on their connections to influential nodes in the Galapagos small-scale fishery governance system, in other words the value of well-connected friends) (Fig. 4.8, Table 4.1). Specifically, these were: the governmental organizations GO01 and GO02, the fishing cooperatives FC04, FC03, FC01 and FC02, the governmental organizations GO03, GO05, GO06, GO08, GO09 and GO07, respectively (see Fig. 4.8, Table 4.1).

Our closeness centrality analysis indicated various actors with higher closeness centrality values than other organizations and agencies in the Galapagos small-scale fishing governance system network (i.e., nodes' importance based on their closeness to all nodes in the network) (Fig. 4.9, Table 4.1). Specifically, these were: the governmental organizations GO01 and GO05, the international non-governmental organizations NGO01 and NGO05, the governmental organization GO04, the fishing cooperative FC02, the municipal government MG01, the fishing cooperative FC01, the governmental organization GO06 and the international non-governmental organization NGO02, respectively (see Fig. 4.9, Table 4.1).

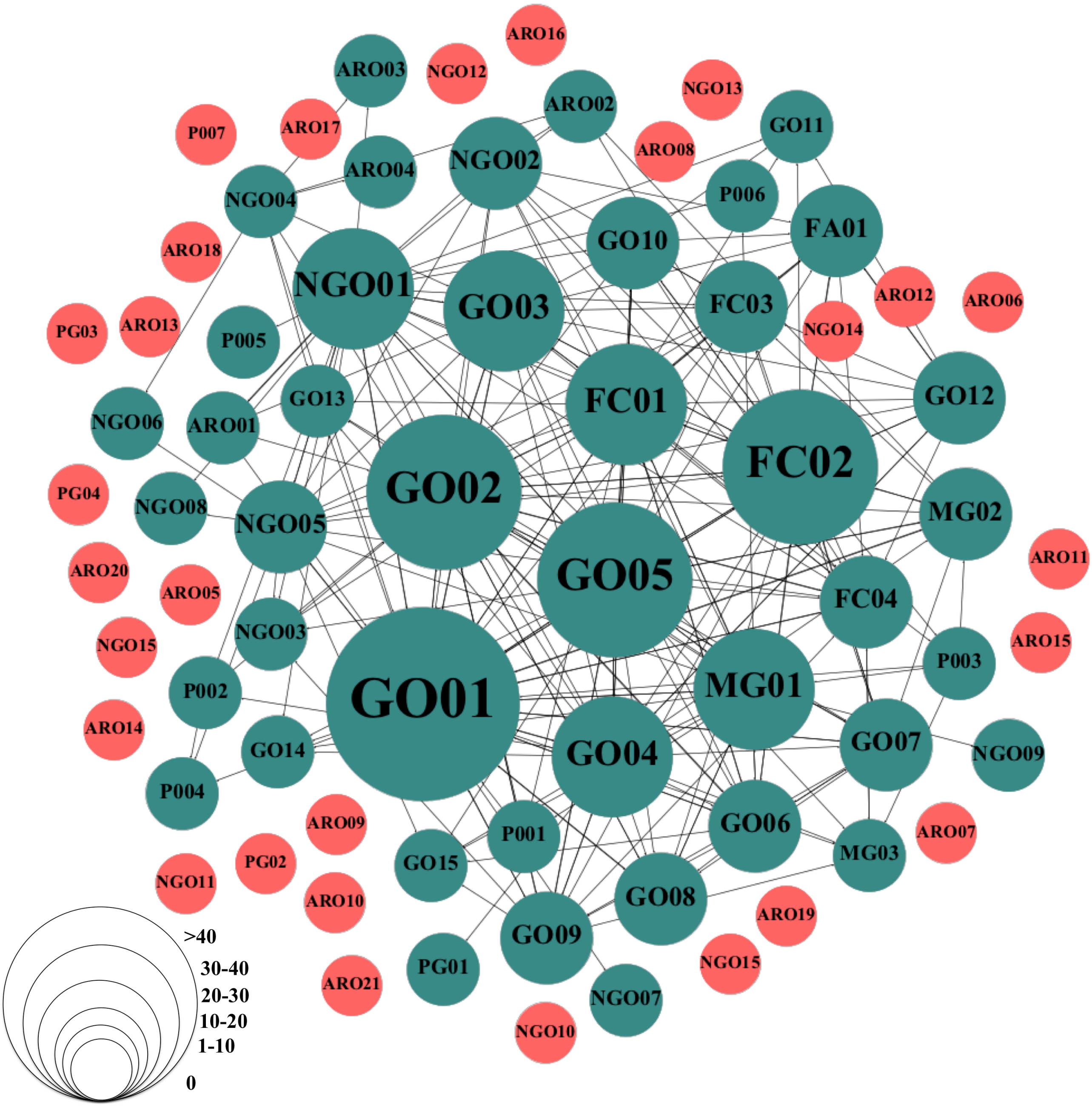


Figure 4.7 Degree centrality of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations and agencies (GO = governmental organization, PO = private organization, FA = fishery association, NGO = non-governmental organization, MG = municipal government, PG = parish government, ARO = academic and research organization). Ties indicate the organizational links between organizations and agencies. Green nodes indicate nodes connected to the Galapagos small-scale fishery network. Pink nodes indicate organizations and agencies that traditionally do not have significant organizational links with the Galapagos small-scale fishery governance system network. Node size indicates degree centrality, meaning that as the size increases, they send and receive more organizational links than others in the network, making them important players in this fishery governance network, as most of the links pass through them.

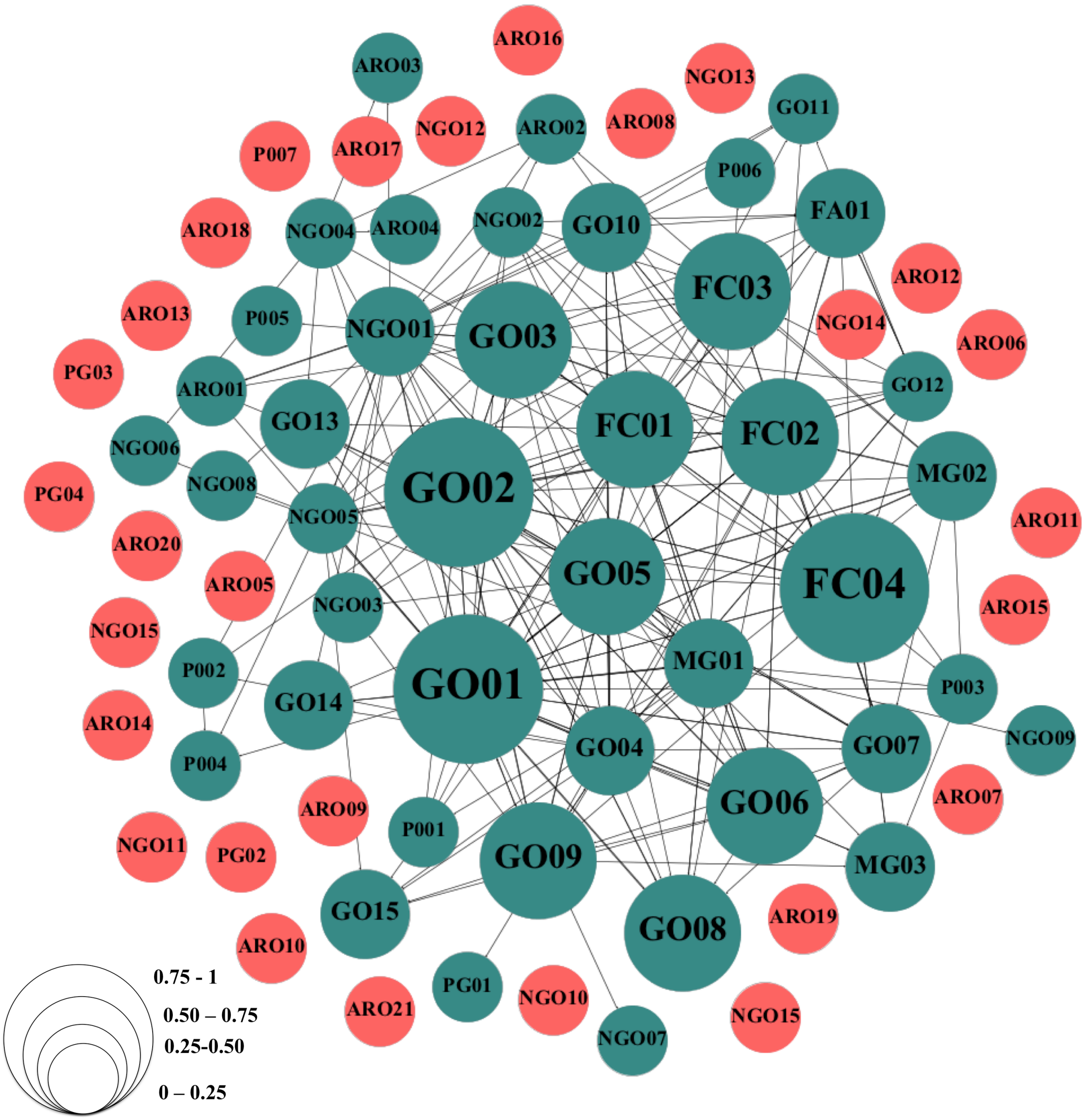


Figure 4.8 Eigenvector centrality of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations and agencies (GO = governmental organization, PO = private organization, FA = fishery association, NGO = non-governmental organization, MG = municipal government, PG = parish government, ARO = academic and research organization). Ties indicate the organizational links between organizations and agencies. Green nodes indicate those nodes connected to the Galapagos small-scale fishery network. Pink nodes indicate nodes that traditionally do not possess significant organizational links in the Galapagos small-scale fishery governance system network. Node size indicates eigenvector centrality, which signifies that, as a node's size increases, it is deemed more important in the network based on its connections to important players in the fishery governance system. Larger nodes are thus influential players in the network, able to reach important organizations and agencies and diffuse critical information and knowledge in the Galapagos small-scale fishery network.

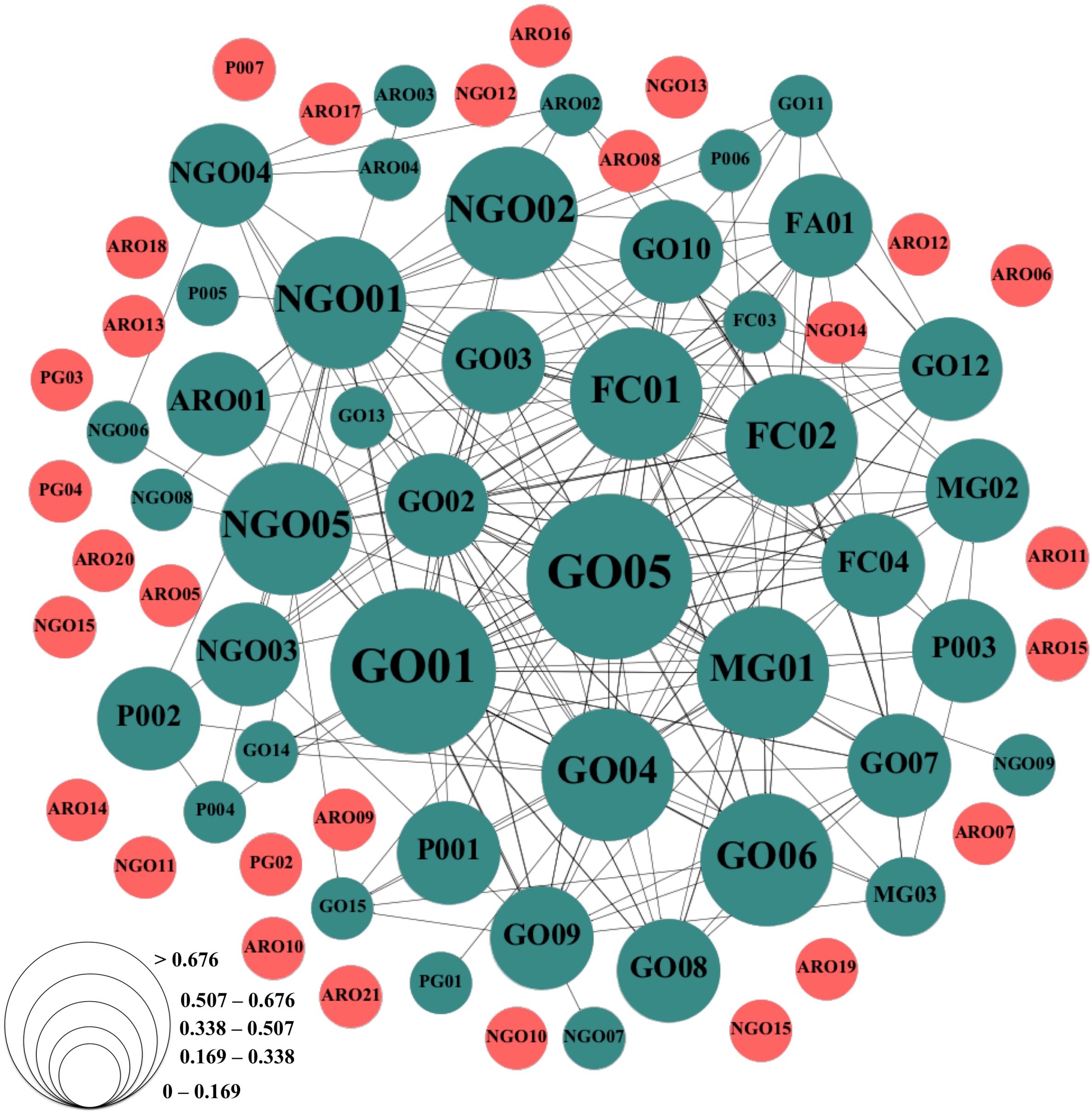


Figure 4.9 Closeness centrality of the Galapagos small-scale fishery governance network.

Nodes indicate the organizations and agencies (GO = governmental organization, PO = private organization, FA = fishery association, NGO = non-governmental organization, MG = municipal government, PG = parish government, ARO = academic and research organization). Ties indicate the organizational links between organizations and agencies. Green nodes indicate those nodes connected to the Galapagos small-scale fishery network. Pink nodes indicate nodes that traditionally do not possess significant organizational links in the Galapagos small-scale fishery governance system network. Node size indicates closeness centrality, which signifies that as a node's size increases, it is deemed important based on its closeness to all nodes in the network. This makes more central nodes significant players in the network for dispersing knowledge or information faster than others, due to their closeness to all nodes in the Galapagos small-scale fishery governance system network.

Actor	Level	Sector	Degree Centrality	Eigenvector centrality	Closeness centrality
GO01	Local	Public	**41**	**0.946958**	**0.677966**
GO02	Local	Public	**34**	**1**	**0.5**
GO03	National	Public	**21**	**0.688491**	**0.5**
GO04	National	Public	**25**	0.393516	**0.588235**
GO05	National	Public	**31**	**0.593424**	**0.677966**
GO06	Local	Public	**18**	**0.58451**	**0.519481**
GO07	Local	Public	14	**0.499183**	0.47619
GO08	Local	Public	11	**0.568119**	0.43956
GO09	Local	Public	15	**0.519037**	0.47619
GO10	National	Public	14	0.30492	0.470588
GO11	National	Public	5	0.248856	0
GO12	National	Public	12	0.155603	0.470588
GO13	National	Public	6	0.341234	0
GO14	Local	Public	5	0.298025	0
GO15	National	Public	6	0.292194	0
P001	Local	Private	4	0.049082	0.43956
P002	Local	Private	4	0.043318	0.430108
P003	Local	Private	6	0.159707	0.454545
P004	Local	Private	3	0.125825	0
P005	Local	Private	1	0.037381	0
P006	Local	Private	2	0.086462	0
FC01	Local	Private	**29**	**0.719052**	**0.547945**
FC02	Local	Private	**33**	**0.731034**	**0.571429**
FC03	Local	Private	14	**0.748158**	0
FC04	Local	Private	**17**	**0.756154**	0.416667
FA01	National	Private	12	0.284361	0.434783
NGO01	International	Private	**28**	0.329197	**0.645161**
NGO02	International	Private	11	0.065363	**0.519481**
NGO03	International	Private	6	0.174079	0.373832
NGO04	International	Private	8	0	0.456522
NGO05	International	Private	**17**	0.14111	**0.597015**
NGO06	International	Private	2	0.017383	0
NGO07	International	Private	1	0.10373	0
NGO08	International	Private	2	0.053662	0

NGO09	International	Private	1	0.049082	0
MG01	Local	Public	**22**	0.449672	**0.571429**
MG02	Local	Public	12	0.309859	0.47619
MG03	Local	Public	7	0.368432	0.296296
PG01	Local	Public	1	0.043318	0
ARO01	National	Public	5	0.037381	0.465116
ARO02	National	Private	5	0.161212	0
ARO03	National	Public	2	0.038482	0
ARO04	International	Private	1	0.001102	0

Table 4.1 Descriptive statistics of the Galapagos small-scale fishery sector.
Numbers in bold indicate higher centrality values.

4.6.2 ERGMs results

In terms of cross-sectoral reciprocity configuration formations, we found no strong evidence that nodes from the private sector tended to reciprocate organizational links between them (Hypothesis 2, Table 4.2). However, we found a positive and significant propensity of nodes from the public sector to reciprocate organizational links between them (Hypothesis 1, Table 4.2). Significantly, we found a positive and significant propensity of nodes from the private sector and the public to return ties (Hypothesis 3, Table 4.2); this was notable considering the value of multi-sectoral links in decision-making structures of common-pool resource-governance systems. Estimates on cross-sectoral open triad formation were positive and significant (Table 4.2). Our results showed a positive and significant effect based on [Attr]-in-2-star (Hypothesis 4, Table 4.2), [Attr]-out-2-star (Hypothesis 5), and [Attr]-2-path (Hypothesis 6, Table 4.2) parameters. We believe this signified cross-sectoral collaboration diffusion and likely diffusion of diverse determinants of adaptive capacity in the network (such as knowledge, technology, data, and expertise) needed to address diverse multidimensional internal and external factors of change that might affect the present and future stability of the sector.

Hypothesis	Parameter (Pnet names)	Estimate	Standard error (ER)	T-statistics	Goodness-of-fit (GOF)
Model 1:					
-	Arc	-1.35	0.22	-0.03*	-0.09
-	A2P-T	-0.07	0.03	-0.07*	-0.12
Hypothesis 1	[Attr]-Interaction-reciprocity (Public sector)	1.01	0.15	0.06*	-0.01
Model 2:					
-	Arc	-1.90	0.13	-0.05*	-0.17
Hypothesis 2	[Attr]-Interaction-reciprocity (Private sector)	-0.66	0.52	0.005	-0.07
Hypothesis 3	[Attr]-Activity-reciprocity (Private ↔ Public sector)	1.43	0.27	0.06*	-0.05
Hypothesis 4	[Attr]-in-2-star	0.08	0.01	0.08*	-0.08
Hypothesis 5	[Attr]-out-2-star	0.06	0.02	-0.01*	-0.05
Hypothesis 6	[Attr]-2-path	-0.07	0.02	0.003*	-0.12

Table 4.2 ERGM results.

A t-statistic < 0.1 indicates a converged hypothesis. GOF < 0.1 indicates a good fit. * Indicates a significant parameter.

4.6.3 Qualitative data analysis

Effective collaborative responses to diverse simultaneous drivers of change necessitate embracing a social-ecological perspective that involves different sorts of information, skills, and stakeholders at different geographical scales and administrative levels. Recognizing this is significant if we aim to improve the governance capacity to anticipate and adjust to simultaneous drivers of change, particularly in this era of constant change and evolution (Smit and Pilifosova 2003; Smit and Wandel

2006; Armitage et al. 2017b). Our results show that diverse organizations and agencies from various geographical and administrative levels, with no significant collaboration ties within the Galapagos small-scale fishery governance system, might collaborate with the Galapagos small-scale fishery system through diverse forms:

> *Our collaboration in the management of the artisanal fishing sector could be carried out through technical support and donation of equipment to strengthen the infrastructure they have and improve marketing strategies for their products. PG02* node of Figs. 4.7-4.9, Level: Local, Sector: Public.

> *We might stimulate the consumption of local fishery products in the tourism sector and to report incidents or non-regulated vessels within the Galapagos Marine Reserve.* GO15 node of Figs. 4.7-4.9, Level: National, Sector: Public.

> *We can deliver specific projects that can provide information for decision-making.* NGO15 node of Figs. 4.7-4.9, Level: International, Sector: Private.

> *We constantly make reports of the guided visits, and we can provide information about the management of the fishing sector in the places of visit.* P005 node of Figs. 4.7-4.9, Level: Local, Sector: Private.

Using the language employed by Dietz et al. (2003), it is important to note that governance systems should be viewed as a co-evolutionary race. While the existing Galapagos small-scale fishery sector collaborative network provides a significant umbrella to deal with multiple drivers of change, incorporating new actors at different geographical scales and administrative levels into the current Galapagos small-scale fishery collaborative network might lead to exploring further external cooperation links. The following quotes from interviewees are significant in that regard:

We have projects related to fisheries in other parts of the world whose experience and information could be made available to local actors. NGO07 node of Figs. 4.7-4.9, Level: International, Sector: Private.

We have research groups at both the University of Malaga and the Spanish Institute of Oceanography based in Fuengirola (Malaga) with experience in fisheries. ARO10 node of Figs. 4.7-4.9, Level: International, Sector: Private.

We are a multidisciplinary research center that brings together researchers from different universities in Ecuador and the world. Our alliances with academia are very important in developing knowledge, information gathering, and training that contribute to sustainability. ARO04 node of Figs. 4.7-4.9, Level: International, Sector: Private.

We could sign an Inter-institutional Cooperation Agreement with the fishing sector to finance projects of interest. PG01 node of Figs. 4.7-4.9, Level: Local, Sector: Public.

In adaptive co-management, continuous learning is crucial in approximating a governance system as close as possible to one desired functional state. From a governance perspective, learning refers to the process of detecting and correcting errors to achieve better outcomes over time (Mitchell 2019). In this context, the literature of social-ecological systems often differentiates between different types of learning include single-loop learning (i.e. correcting mistakes by adjusting resource management strategies and actions), double-loop learning (i.e. correcting errors by adjusting behaviours and attitudes) and triple-loop learning (i.e. addressing conflicts by designing or revising governance norms and protocols to produce significant changes in governance) (Armitage et al. 2008). Managing complex social-ecological systems largely depends on moving from scattered and individual learning processes to collective learning, transitioning from single-loop learning to double-loop and triple-loop learning. The following quotes from interviewees are significant in that regard:

We are an educational entity; our collaboration would be clearly linked to education. We have previously linked the children of fishers in educational programs such as the Sea Turtle Monitoring Program. NGO08 node of Figs. 4.7-4.9, Level: International, Sector: Private.

As has been done in previous years, our collaboration would be oriented to training and workshops for the socio-organizational consolidation of the fishing cooperatives and the organization and strengthening their legal scope. NGO15 node of Figs. 4.7-4.9, Level: International, Sector: Private.

With the above in mind, a crucial development in social-ecological systems lies in the question of who is learning and from whom (Armitage et al. 2008). It is important to recognize that the scientific community and rigid governance structures have often viewed scientific production as the only way of solving problems. However, learning at the local scale is crucial to addressing uncertainty and the changing local conditions that generate vulnerability. Local actors possess particular knowledge and experience acquired over the years, which if it is aligned to the right actors, might potentially strengthen the Galapagos small-scale fishery collaborative network. The following quotes from interviewees are significant in that regard:

Marketing in conjunction with the fishing sector as part of a macro project to collect food products that involve the rural sector. We could contribute with local knowledge acquired overtime to motivate youth to get involved in the fishing sector. PG04 node of Figs. 4.7-4.9, Level: Local, Sector: Public.

They could count on our group of local volunteers to be part of the participatory processes. P006 node of Figs. 4.7-4.9, Level: Local, Sector: Private.

4.7 DISCUSSION

Our research suggests that understanding the structures of governance systems is a significant contributor to creating synergies among stakeholders to achieve collective outcomes that lead to more robust social-ecological systems in light of multiple adverse drivers of change. Governance systems often represent the different structures by which societies shape collective actions (Tortajada 2010; Lockwood et al. 2010). Bearing this in mind, our research indicates that addressing the extent of the effects of unprecedented and simultaneous drivers of change (such as climate change, novel pandemics, illegal marine fishing, invasive species, among other wicked problems) demands a deeper understanding by those involved in governance systems (Morrison et al. 2020a; Lubell and Morrison 2021). These must have a clear grasp of the governance actors, with their interactions and network configurations between different sectors, geographical scales and administrative levels (Baird et al. 2016; Kanwar et al. 2016; Bergsten et al. 2019). In this context, we argue that actors within the Galapagos small-scale fishing governance system network may create strategic alliances to deal with external and internal drivers of change and enhance the governance system fit. This will be possible if they explore further organizational ties and network configurations across sectors and geographical scales, and keep track of the organizations' positions and features in the existing small-scale fishing governance network. Approximating as closely as possible the governance scale of the Galapagos small-scale fishing sector with the extension of the multiple social-ecological interactions in the Galapagos (fit) by including a few delegated organizations and organizational links designated by law is challenging, if not impossible to achieve (Bodin 2017; Fried et al. 2022). Managing and controlling wicked problems spanning the Galapagos small-scale sector, such as climate change or the introduction of rapid mitigation measures to address novel pandemics, requires the collective effort of diverse organizations and agencies beyond state and national boundaries.

Our results show that understanding certain degrees of network distribution can provide valuable information for strengthening the Galapagos small-scale fishery collaborative network. It could provide additional pathways for the diffusion of determinants of adaptive capacity, along with better coordination and collaboration among actors within the fishing governance network. Our descriptive statistics suggest that various organizations and agencies occupy important positions within this network. Our centrality analysis indicates that certain organizations and agencies send and receive more organizational links than others in the network (Fig. 4.7, Table 4.1). We deem it important to unveil these nodes in the governance network considering that these organizations and agencies probably control decisions in this network. Therefore, if we aim to incorporate new collaboration links into the existing network, it is necessary to recognize the organizations and agencies possessing the authority and power to make changes to approximate the management of governance systems with socio-ecological interactions and operationalize transitions to adaptive co-management forms of governance.

Our results also point to various organizations and agencies have higher eigenvector centrality values than others in the Galapagos small-scale fishing governance system network (Fig. 4.8, Table 4.1). We consider this an important feature to recognize if we aim at aligning new actors with diverse technological, behavioural, financial, institutional, and informational resources, among other determinants of adaptive capacity, with said network. We argue that these organizations and agencies are influential and well-positioned, not so much for the number of organizational links that they send and receive, but because of their connections to organizations and agencies with higher centrality values than others in the Galapagos small-scale fishing governance system. This means that these organizations and agencies may serve as channels of communication to reach other organizations and agencies often in charge of the decision-making structures of the governance network, facilitating the creation of links between external stakeholders and decision-making actors. We claim that this access might lead to governance arrangements and the formation of new organizational links that facilitate the connection between local priorities and international, regional and national levels of management.

Our outcomes also indicate that diverse organizations and agencies within the Galapagos small-scale fishing governance system network have higher closeness values than others (Fig. 4.9, Table 4.1). We argue that this is a good sign for collaboration and the diffusion and incorporation of adaptive capacity determinants into the network, as these organizations and agencies are closer to any others in the network. From a governance perspective, reaching all other actors more rapidly implies that the incorporation and diffusion of ideas, financial resources and technical solutions might occur more quickly and more efficiently in the network. This is significant considering that approximating a governance fit partially depends on the capacity of governance systems to act in time (Cumming et al. 2006; Epstein et al. 2015; Alexander et al. 2017). Recognizing that the capacity of governance systems to achieve such a fit has been gradually reduced due to the growing human and ecological interactions spanning governance systems is needed in managing common-pool resources like the Galapagos small-scale fisheries. Recently this has been evidenced more explicitly as governance systems have been struggling with measures and strategies to limit the spread of the COVID-19 virus and cope with the associated socio-economic and public health fallout. Therefore, evaluating organizations and agencies closer to all in the network might signify acting faster in crisis and delivering rapid responses in the Galapagos small-scale fishing governance system network.

Although we found no strong evidence of mutual interaction between organizations and agencies from the private sector (hypothesis 2), our ERGM outcomes suggest a propensity towards a cross-sectoral interaction network among various organizations and agencies in the Galapagos small-scale fishery system. We found evidence of this propensity towards mutual interaction among nodes of the public sector (hypothesis 1), and a significant, positive propensity of nodes from the private and public sectors to form organizational links in the Galapagos small-scale fishing governance system network (hypothesis 3). The latter, from our perspective, may be seen as a significant feature of analysis, bearing in mind the need for cross-sectoral interactions to deliver adequate policy-making solutions in the sector. We further noted positive and significant effects towards cross-sectoral open triadic network configurations (hypotheses 4, 5, and 6). We argue that the prevalence of these configurations in the network can be interpreted as a good sign for the evolution of cross-sectoral collaboration relationships within the Galapagos small-scale fishing governance system network. It is likely that the prevalence of a reciprocal relationship (A ↔ B) might further be developed into either an open triadic or a closed triadic network configuration. The propensity towards open triadic configurations might potentially lead to closed triad configurations if organizations and agencies deem that the participation of a third party (C) could contribute to the achievement of common institutional goals and collective actions for governing a shared natural resource, through more densely clustered relations of collaboration.

According to our qualitative data analysis, diverse organizations, and agencies with no strong presence in the Galapagos small-scale fishing governance system may collaborate within the network through various means. This includes contributions in the form of technical assistance, equipment, information and training capabilities, and local fisheries knowledge. The willingness to collaborate is speculative, and our observations in this regard ignore the role of power and the level of trust required among organizations and agencies to cement collaborative partnerships. However, we argue that these results demonstrate that additional alliances and collaboration may emerge in the network, transforming it into a more densely clustered collaboration network. Well-positioned organizations and agencies in the network, such as CGREG, DPNG, fishing cooperatives, and CDF, can play an important role in creating a more collaborative network because they possess ties to other governmental organizations, NGOs, funding, academic and research institutions, and local resource users.

4.8 LIMITATIONS AND FUTURE DIRECTIONS

Our study coincided with the Coronavirus disease 2019 (COVID-19) pandemic, restricting nearly all in-person interactions; as a result, reaching organizations' representatives and officials to be included in the study was a challenging endeavour. Therefore, in the future there remains room for this paper's outcomes to be expanded in scope. This can be accomplished by integrating other organizations and agencies at diverse geographical scales into our analysis, as well as administrative levels and organizational links that this study may have missed. Furthermore, this paper may serve as a guide for future theoretical frameworks geared towards exploring further network configurations of the Galapagos small-scale fishery governance system. For example, there is clearly a need to examine the propensity towards triadic network configurations (i.e., interactions and links between the three nodes

A, B and C) and investigate further hypotheses considering actors' attributes (e.g., hypotheses regarding trust between nodes, a central feature that drives stakeholders to engage in collaboration and choose collaboration partners) (Turner et al. 2016; Baldwin et al. 2018; Bodin et al. 2020; Lubell and Morrison 2021). Further, while we deem polycentric governance arrangements attractive to create and deliver solutions to the various socio-ecological problems affecting the Galapagos small-scale fishing sector, we also recognize that understanding the manifestations of power and its influences is critical to fostering collaboration among multiple actors within the Galapagos small-scale fishing governance system. Conflicts usually emerge in polycentric governance arrangements because of conflict of interest and resource access inequality, increasing polarisation among stakeholders and obstacles to forming collaborative partnerships between higher and lower administrative levels (Mudaliar 2020; Mudliar and O'Brien 2021). Therefore, we suggest that future investigations evaluate the role of power dynamics in the governance of the Galapagos small-scale fishery system, which is an aspect that our research does not address. By no means the inclusion of multiple organizations and agencies across various administrative levels and geographical scales will be sufficient to enhance collaboration and functionality within the Galapagos small-scale fishing governance system (Biddle and Baehler 2019). Additional research efforts are needed to unveil the power dimensions of the Galapagos small-scale fishing governance system. The transition to a new Galapagos governance system regime, which is currently being amended, will most likely redistribute responsibilities and decision-making power, potentially leading to recentralization pathways and monocentric governance arrangements. Thus, we suggest exploring the power dynamics of the Galapagos small-scale fishing governance system based on the typology of power proposed by Morrison et al. (2019). These authors define three dimensions of power: power by design, pragmatic power and framing power. Based on this research approach, it will be possible to elucidate the concentration of power within the Galapagos small-scale fishing governance system network. Such knowledge is fundamental for improving the collaborative ties in the Galapagos small-scale fishing governance system, marking a critical step in addressing the complex socio-ecological problems that hinder the sustainable development of the Galapagos small-scale fisheries.

4.9 CONCLUSIONS

Since Elinor Ostrom's publications, there has been a significant rise of scientific interest in polycentrism in the literature on complex social-ecological systems. However, to our knowledge, the number of studies in the Galapagos Islands aimed at improving marine resource management of complex social-ecological systems, considering social-network approaches and polycentric governance arrangements, is still limited. Addressing simultaneous wicked problems, such as public health, socio-economic, environmental, institutional and climate issues, requires a multi-level approach across different scales. This study, therefore, proposes that the Galapagos small-scale fishing governance system should explore more polycentric approaches to governance, including linkages (partnerships) spanning multiple scales and levels, from global to local, relying on formal and informal networks. More polycentric ties in the sector might contribute to creating the correct links at the right time in light of multiple drivers of change (Olsson et al. 2007; Carlisle and Gruby 2019; Lubell and Morrison 2021). Complex social-ecological systems, like the Galapagos small-scale fishing sector, need to embrace a social-ecological perspective involving different sorts of information, skills, and stakeholders, at different scales and levels. This would enable the sector to approximate as closely as possible the governance scope required to handle the multiple social-ecological dynamics in the archipelago and prevent a misfit. By no means are we suggesting that the state should cede control over marine resources in the Galapagos. We do, however, consider that the multiple social-ecological interactions that comprise the sector require the cooperation and collaboration of multi-scale and multi-level organizations to deal with the multiple drivers of change, particularly in these current times of constant change und uncertainty. Without question, the adverse effects of the COVID-19 pandemic on the social-economic situation of the Galapagos population, together with the difficulties controlling illegal international fishing within the Galapagos Marine Reserve protected area, highlight the need to create an adaptive capacity based on a polycentric governance network. Systems with high adaptive capacity are those most capable of reconfiguring themselves when subjected to shocks (Folke et al. 2005). Therefore, this paper might guide practitioners and decision-makers to explore further organizational links and network configurations, allowing for the development of collaboration strategies to cope with the various multidimensional problems faced by the Galapagos small-scale fishing system.

We contend that the gauging of nodes' positions, features, and needs can enable actors within governance systems to better discern among collaborative partnerships from which to choose, rather than relying on chance or policies and laws to define collaboration ties. In our view, this argument contributes to the discussion analyzing polycentric arrangements by implying that, rather than being arbitrarily forced to adjust to polycentric structures, actors can do so voluntarily because it helps them to consolidate strategic alliances considering mutual goals and concerns (Stephan et al. 2019; Lubell and Morrison 2021). Notably, we argue that the insights presented in this study contribute to elucidating the notion of institutional fit, initially explored by Young (2002). It is significant to consolidate the idea that the concept of fit in common-pool resources depends on governance systems' ability to fit in with environmental and ecological concerns, but also on their ability to fit in with various global sustainability challenges and stakeholder expectations (Acton et al. 2021; Ishihara et al. 2021; Lubell and Morrison 2021). Finally, we see our research as a timely study that might open discussions in the ongoing reformulation of the GSL—bearing in mind that the distribution of functions and power in the Galapagos Islands centers around the guidelines and policy decisions established under the GSL. COVID-19 is a new driver of change in the Galapagos that has led to the archipelago's worst-ever socioeconomic scenario and the need to explore new ways to address various issues beyond environmental and ecological concerns. In this context, we consider the insights presented in our study to have usefully introduced governance-related insights hardly explored among the related public and political discussions in the Galapagos.

CHAPTER 5: CONCLUSION

This final chapter aims to reflect on the outcomes and insights gained from this study. In this dissertation, I argue that decision-makers and a diverse range of stakeholders from different sectors increasingly use vulnerability and adaptive capacity as emerging concepts to describe ways of achieving more sustainable outcomes. This makes it increasingly necessary to refine the descriptions of these concepts, and to provide tools and strategies that facilitate the use of these concepts in practice. Today, the adverse effects of socio-ecological problems, such as the COVID-19 pandemic, have highlighted the need for more effective instruments and strategies to address exposures (vulnerabilities) and to build adaptive capacity and resilient systems. In this dissertation, I have given considerable attention to governance network analysis approaches of complex social-ecological systems as a powerful tool in that regard. They are particularly significant because the scope of governance spans different cornerstones of decision-making process systems, including networks of influence, laws, regulations, institutions, and interactions between the public and private sector, which means that the capacity to make transformative changes often relies on changes in governance (Kooiman 2003a; Rogers and Hall 2003). In that regard, the three manuscripts presented as part of this study provide novel and significant insights into the development of studies of complex social-ecological systems, particularly as seen through a governance lens as a tool and strategy for bolstering the capacity for adaptation in common-pool resources such as small-scale fishery systems.

5.1 SUMMARY OF THE WORK

Recognizing that a lack of clear interpretations of vulnerability and adaptive capacity concepts might lead to ill-policy-making solutions is a fundamental principle of this study. Therefore, this dissertation aimed to facilitate a more precise understanding and application of vulnerability and adaptive capacity terms in policy-making discourses and decision-making. In this regard, this doctoral research shows diverse forms of building adaptive capacity by considering the causes that generate vulnerability in complex social-ecological systems. In this dissertation, I focused on the Galapagos small-scale fishing governance system as an empirical case to illustrate forms of strengthening the adaptive capacity of complex social-ecological systems. My doctoral research used a social network approach to explore tendencies toward specific network configurations and the positions of critical players in the Galapagos small-scale fishing governance system by using ERGMs and descriptive statistics. The approach employed in this dissertation could provide scholars and policymakers with avenues to operationalize adaptive capacity in complex social-ecological systems such as the Galapagos small-scale fishing sector. Significantly, as it is imperative in current times to find a form of effective management to address contemporary problems, this dissertation may serve as a platform to strengthen, create new, or reformulate collaborative ties within the Galapagos small-scale fishing governance system. This consideration is significant to remember considering that the adverse consequences of the COVID-19 variants and climate variability are not likely to decrease in the short term in Galapagos (Escobar-Camacho et al. 2021; Viteri Mejía et al. 2022; Cáceres et al. 2022). Notably, the outcomes of this dissertation may be helpful to prompt discussions on transitions toward an adaptive co-management form in the Galapagos Islands.

The objectives of this dissertation were:

Objective 1: To assess how vulnerability assessments and decision-making planning tools can be applied to increase adaptive capacity at the local scale in the face of multiple drivers of change (Chapter 2).

Objective 2: To explore the role of collaborative governance network for building adaptive capacity in the Galapagos small-scale fishing sector (Chapter 3).

Objective 3: To strengthen the collaborative network of the Galapagos small-scale fishery governance system in light of multiple drivers of change (Chapter 4).

This doctoral research addressed these objectives by conducting literature reviews and gathering data from the case study of the Galapagos Islands located in Ecuador. I addressed the first objective of this dissertation by carrying out an in-depth review of the literature on climate change vulnerability. This analysis allowed me to explore how climate change vulnerability has been assessed by looking at the methods and conceptual frameworks commonly employed to evaluate vulnerability, as well as several of the planning efforts intended to reduce vulnerability and increase the adaptive capacity of a system of analysis. This is important to highlight, considering the existence of different frameworks ranging from the political sphere to equity and responsibility considerations that make it a challenge to reach agreements. It is important to bear in mind that unclear interpretations of vulnerability can lead to the reinforcement of an existing vulnerability, create new vulnerabilities, or merely redistribute vulnerability (Eriksen et al. 2021), hampering the ability of a system of concern to strengthen its capacity to adapt. Chapter 2 offers a straightforward interpretation of vulnerability and adaptive capacity, to guide stakeholders and decision-makers and to facilitate pathways to move from theory, political discourse, and aspiration through to practice. I believe the latter point is a significant one to highlight in developing countries, particularly in real cases like the Galapagos Islands. The archipelago is one of the biodiversity hotspots in the world. Therefore, a clear grasp of the adaptive capacity and vulnerability dimensions is significant, on the one hand to deliver adequate policy-making solutions and on the other hand to seek financial resources to support projects (e.g. under the Green Climate Fund (GCF), Global Environmental Facility (GEF), or the Adaptation Fund (AF).

I argue against climate change interventions and decision-making structures that focus specifically on climate change while at the same time disregarding underlying non-climate-related drivers of change that render a socio-ecological system vulnerable. The risk in this scenario is that subsequent responses will be insufficient to bolster the capacity of such systems to adapt at a local scale, and funding support will not get to those in vulnerable situations. Climate change interventions sometimes face setbacks in addressing place-specific socio-political considerations—among other circumstances—because they tend to assume vulnerability and vulnerable systems through predetermined indicators (Eriksen et al., 2021). Therefore, a recognition that climate change interventions may need to be reformulated, particularly regarding finance and planning, is increasingly required. Often, climate change interventions are derived from top-down projects that delegate actors and consultancies at national and international levels to undertake adaptation and define vulnerability at the local scale. However, the design of interventions often makes them unable to capture specific local contexts; thus, there is a risk that in reality they might disempower and further marginalize vulnerable people, exacerbating local vulnerability (Thomas and Warner 2019; Eriksen et al. 2021).

The insights presented in Chapter 2 contribute to embracing that without a clear understanding of the scope of the vulnerability, 1) it is challenging to reach tangible outcomes that bolster the ability of a system of concern to adapt, and 2) it is hard to interpret the expression "particularly vulnerable," which is an argument frequently used in political discourse and climate and development funding. Chapter 2 provides forms of employing vulnerability assessments to build adaptive capacity through various strategies while considering different timeframes and contexts at the local scale. I linked these forms of adaptive capacity building with articles under the UNFCCC and Conference of Parties (COP), which may serve policymakers and climate change negotiators in the elaboration of countries' commitments under the UNFCCC, such as the National Communications on Climate Change and Nationally Determined Contributions (NDCs).

In line with the objectives of this doctoral research, in Chapter 3, I explored the collaborative ties of the Galapagos small-scale fishing governance system. Considering that it is significant to understand how governance actors interact to know the state of a governance system to formulate possible collaborative arrangements, I identified several organizations on diverse scales and levels that interact within the Galapagos small-scale fishing sector (in pre-COVID-19 pandemic conditions) through literature reviews of past studies on marine resources in the Islands. The identification of these actors allowed me to interview numerous representatives and officials, who were asked to identify the organizations they coordinate, communicate, or work with regarding the management and organization of the Galapagos small-scale fisheries sector, as well as how often the interviewee's organization collaborates with the selected organizations and what organizational ties link the interviewee's organization with the selected organizations. These interviews provided a foundation for understanding how the Galapagos small-scale fishery sector interacts through social network approaches. I combined descriptive statistical analysis (in-degree centrality and betweenness centrality) and ERGMs to identify critical players in the network and test the propensity to some specific governance processes statistically within the Galapagos small-scale fishery governance system. From the descriptive statistical analysis, I concluded that organizations within the Galapagos small-scale fishing governance system network tend to interact frequently and occasionally through diverse, interdependent tasks that emerge from exchanging information, management, and collaboration. I deem these network configurations significant features of collaborative governance if we remember that the effectiveness increases when actors that collaborate address various interdependent tasks (Bodin et al. 2022). Therefore, these network configurations might be significant for the sector's future if they are restructured and agreed upon more strategically between organizations according to their nature and needs and activated when social-ecological interactions and concerns in the system unfold. This consideration is an aspect to remember, particularly today (in the midst of the COVID-19 pandemic), that we know that the organizational links in pre-COVID-19 pandemic conditions in the sector were ineffective under conditions of urgency and uncertainty. Furthermore, I concluded that central organizations (e.g., CGREG, DPNG, COPROPAG, COPESPROMAR, COPESAN, and COPAHISA) and bridging nodes (e.g., CDF) occupy critical positions in the network. Bridging nodes are an important feature to highlight if we consider that their relationships in the GMR management have historically been conflictive due to socio-economic and political reasons and interests. Power disputes and dissatisfaction between fishers, governmental organizations of control, and conservationist ONGs have been a constant limitation for achieving practical participatory approaches in the archipelago. I therefore believe there are two considerations to highlight in this regard: 1) building trust processes and connectivity between such nodes is necessary for alleviating constant tensions and disputes in the sector—without connectivity, it would be challenging to bolster the capacity of the fishery sector to adapt in light of multiple drivers of change; and 2) without the actual intention to share power, cross-sectoral and cross-level interactions will be challenging to achieve in the sector, keeping the system from functioning as one polycentric governance system (Morrison et al. 2019; Mudaliar 2020).

Chapter 3 also sought to test a series of hypotheses about the governance structure of the Galapagos Islands' small-scale fishery governance system using a building block approach. My results suggest tendencies for centralization (in-degree distributions) in the Galapagos Islands' small-scale fishing sector network. This is a significant feature of analysis if one considers that well-positioned actors with power and influence may facilitate coordination of the flow and spread of information within the network (Andrachuk et al. 2019). From the governance hypotheses, I believe it is important to highlight that my results indicated that 1) reciprocity between organizations was positive and statistically significant, suggesting that organizations are likely to reciprocate organizational links; and 2) there was non-solid evidence of homophily based on the nodes' attributes, either by the influence of the economic sector (public sector) or based on the local level concerning the organizations' choice of partners to manage the activities of the Galapagos Islands' artisanal fishery sector. These latter considerations are important to keep in mind for cooperation and building adaptive capacity in the Galapagos Islands' fishery sector if one considers a) the value of cross-level and cross-sectoral interaction (Ostrom 2010; Carlisle and Gruby 2019) and the principle of subsidiarity (Marshall 2008) when managing common interests; and b) the multi-level cooperation required to deliver appropriate policy solutions, solve societal problems, and create opportunities (Kooiman 2003b; Lubell and Morrison 2021). As expected, Chapter 3 outcomes suggest that organizations from the public sector are more likely to send organizational links than others in the Galapagos small-scale fishery sector, which reflects the Galapagos' reality closely if we consider the GLS has historically granted constitutional powers and authority to specific governmental organizations to act in the archipelago.

Addressing super wicked problems affecting the Galapagos small-scale fishery sector, such as climate change, a global pandemic, illegal fishing, or global market changes, requires a collaborative governance approach and adaptive co-management to prevent a governance misfit (Baird et al. 2016). Hence, in Chapter 4 of this dissertation, I explored how to improve the Galapagos small-scale fishery collaboration network and the notion of governance fit within the Galapagos small-scale fishery sector by considering attributes stemming from institutional fit, adaptive co-management, polycentrism and subsidiarity. To this end, I examined several organizations and agencies on different geographical scales and administrative levels that traditionally do not have frequent connections within the Galapagos small-scale fishing network but that operate directly and indirectly in the Galapagos conservation and marine development areas due to the nature of the organizations (in normal conditions, pre-COVID-19). I interviewed various representatives and officials from this list on how their organizations may contribute within the Galapagos small-scale fishing network in light of multiple drivers of change affecting the sector (e.g., with financial resources, technical and scientific knowledge, local knowledge acquired over time, data and information, equipment and technology, infrastructure, the monitoring of illegal fishing, or research projects in the Galapagos). Furthermore, I used centrality measures such as degree centrality, eigenvector centrality, closeness centrality, and ERGMs such as the propensity of cross-sectoral reciprocity formation and cross-sectoral open triad formation in the network, to identify essential features for the collaborative development of the Galapagos small-scale fishing governance network. The theoretical approach used to address this objective enabled the identification of actors and network structures that may serve as platforms that facilitate the spread of adaptive capacity determinants, collaborator selection, the inclusion of new actors within the governance network, and pathways toward adaptive co-management in the sector. From this analysis, it is significant to point out that well-positioned organizations in the network, such as CGREG, DPNG, fishing cooperatives, and CDF, might play an essential role in creating a more collaborative network, as they possess ties to other governmental organizations, NGOs, funding, academic and research institutions, and local resource users. The complexity of socio-ecological problems affecting the Galapagos fisheries sector requires cross-sectoral interactions and the appropriate actor collaborations over interdependent tasks beyond the CGREG and DPNG jurisdictions. Distributing specific tasks strategically beyond actors possessing constitutional powers and authority to act in the archipelago might increase the effectiveness of addressing complex socio-ecological challenges spanning the Galapagos small-scale fishing governance system (Bodin et al. 2022). These aspects are important to highlight now that the adverse effects of COVID_19, the lack of good medical facilities to face crises, water availability in both the urban and rural areas, illegal fishing, and climate variability have amplified the need for distributing governance tasks to address the diverse socio-ecological challenges of the fishing sector and the archipelago in general.

Chapter 4 contributes to elucidating and interpreting ideas on governance fit more closely in current times. On the one hand, it is imperative to point out that gauging the positions, features, and needs of nodes can enable actors within governance systems to make wise choices among collaborative partnerships, rather than rely on chance, policies, and laws to define collaborative ties. On the other hand, it should be noted that many of the issues facing the Galapagos Islands' small-scale fishery governance system arise due to the diverse socio-ecological dimensions and interdependencies spanning the sector, making it challenging to address them effectively. Therefore, this chapter highlights the finding that approximating a governance fit as closely as possible in the Galapagos Islands' small-scale fishery governance system depends not only on its ability to fit ecological and environmental concerns but also on underlying realities and stakeholders' needs, values, and world views in the sector. These considerations are important to discuss now that the GSL is being amended. New reforms will become operative soon, which are likely to determine the functioning of the governance structure for many years.

5.2 METHODOLOGICAL CONTRIBUTIONS

Complex social-ecological systems such as the Galapagos small-scale fishing sector are complex and interconnected, making them subjects of analysis. Therefore, this dissertation remarks that vulnerability and adaptive capacity interventions should be context-specifically. Otherwise, intended actions and strategies might reinforce, redistribute or generate new vulnerabilities (Eriksen et al., 2021). In delivering solutions, it is important to recognize, on the one hand, that factors that generate vulnerability change as geographic distance increases and, on the other hand, that the determinants that strengthen the coping range of one system of analysis might diminish the coping capacity of others. It is significant to bear in mind that the literature on climate change, in particular, illustrates diverse forms of building adaptive capacity (e.g., through technology, financial resources, skills, infrastructure, and information). However, it is necessary to point out that the literature concentrates more on the availability of resources (Jones et al. 2011) than on cultural-specific forms of building adaptive capacity. The latter is an aspect to discuss, considering that actions and strategies that do not address factors that render a system vulnerable—regardless of their genesis—could hardly influence the coping range of a system of interest, leading to unfruitful efforts that might reinforce vulnerability rather than undermine it. This dissertation highlighted that developing vulnerability assessments is an initial step to understanding the causes of vulnerability and building adaptive capacity and resilient complex social-ecological systems. This dissertation contributes to clarifying what "particularly vulnerable" means, which is needed when formulating assessments such as national reports under the UNFCCC and using the term "vulnerability" in policy-making discourses. Further, this dissertation presents decision-making and planning tools, which, if centred on addressing the causes of vulnerability that affect the system, can strengthen its capacity to adapt. These strategies and planning actions could be implemented in different timeframes, such as in the short and long term, and according to diverse capacities, particularly in the context of developing countries. Therefore, linking the actual dimensions of vulnerability and the planning tools presented in this Chapter, contributes to redefine traditional planning approaches often utilized to work on climate change vulnerability.

Chapter 2 is a timely review considering that the Paris Agreement (PA) requires the measurement of progress on adaptation (Eriksen et al., 2021), which might be challenging for some signatory countries of the PA. Chapter 2 provides insights that might shed light on further discussions in planning, implementation, and funding for climate change interventions. The insights presented in this chapter open spaces for reflection and lead us to consider, for example, whether intended actions and planning tools help to tackle the actual causes of vulnerability and build adaptive capacity. Who decides and defines what is deemed particularly vulnerable, and under what criteria? Who is in charge of climate change interventions? Are the designated organizations, in the end, those that decide and determine the vulnerability to realize projects from the top down? Who are vulnerable and why? Do climate change interventions help to enhance the coping range of a system or concern? Are local people's knowledge, world views, priorities, aspirations, and values (e.g. from Indigenous peoples or coastal communities) part of the design of climate change interventions in practice? These considerations, which are explored in Chapter 2, are significant and should be borne in mind in order to expand the notion of vulnerability and to strengthen the capacity of a system to adapt in current times.

The Galapagos small-scale fishing sector involves multiple perspectives and domains, including interactions among endangered and endemic species, fishers, fishing cooperatives, government authorities, and private conservation organizations. Therefore, as governance systems are often vehicles that determine the use of marine resources, practices employed, and access to marine resources, unveiling governance networks is needed to strengthen the capacity of the Galapagos' small-scale fishing sector to adapt. The methodological frameworks of this dissertation led us to reveal how actors within the Galapagos small-scale fishing governance system interact and how frequently they do so, as well as the nature of their institutional relationships. This doctoral dissertation's methodological framework might foster future discussions on whether the organizations and agencies involved in the Galapagos Islands' small-scale fishing governance system are satisfied with their current collaborative partners. For example, decision-makers and stakeholders might consider whether existing collaborative partnerships are efficient, whether they are worth the time and cost spent on them, or if it is wiser to seek other collaborative alliances. This consideration is a significant one to bear in mind in the context of the Galapagos Islands if one considers that maintaining collaborative links involves costs and the availability of financial resources (Newig et al. 2017), which are often lacking in a system from developing countries to cope with multiple adverse drivers of change.

The methodological framework applied in this dissertation provides avenues through which organizations can decide whether their collaborative partners are appropriate, or whether they want to move on and explore new collaborative partners. Embracing a governance network approach where organizations can decide to keep or change their collaborative relationships is important in approximating the scale of governance to the scale of social-ecological dimensions as closely as possible. Therefore, the methodological frameworks of this dissertation might eventually guide decision-makers in the Galapagos small-scale fishery governance system to reach a desirable social-ecological fit, after a series of network collaboration movements.

Addressing wicked problems in complex social-ecological systems is more concerned with collaboration, interaction, and experimentation than with pre-structured rules and pre-defined interactions among organizations according to regulations and legislation. The latter consideration is significant to bear in mind and discuss, considering that the guidelines of the GLS—which historically have defined both power and control to steer decision-making processes in the archipelago to specific organizations—are being amended and will soon become operational. Therefore, there is a risk that the new GSL and a new consultative governance scheme will likely distribute power and responsibilities among specific and selected organizations, fostering recentralization processes and monocentric governance arrangements that might magnify power imbalances. This dissertation highlights that governance systems should avoid the imposition of fixed organizational links and adopt a collaborative approach across levels, scales, and jurisdictions (Kooiman 2003a; Lockwood et al. 2010). In this context, the methodological frameworks of this dissertation provide practitioners and policymakers with platforms to explore further polycentric links within the Galapagos small-scale fishing governance system. In the Galapagos Islands, it has been challenging to address the problem of illegal fishing, the adverse consequences of novel pandemics such as COVID-19, the effects of climate change, the decline in water availability, invasive species and other wicked problems (Alava et al. 2022). Thus, the methodological frameworks employed in this dissertation offer tools to formulate governance arrangements by identifying new, popular, and well-positioned actors, as well as analyzing propensities toward specific network configurations, which include homophily, reciprocity, sender and receiver effects, cross-sectoral reciprocity formation, and cross-sectoral open triad formation. Considering that much of the effectiveness of governance systems depends on the type of collaborative partners selected, the methodological approaches used in this dissertation might serve to explore further collaborative links in the Galapagos small-scale fishing governance network and foster discussions on appropriate ways to add adaptive capacity determinants and diffuse critical information faster and more efficiently in the network.

A feature that needs to be highlighted is that, to the author's knowledge, this is the first study exploring open triad network configurations in the literature on the governance of common-pool resources. This is new contribution in the literature serves in terms of collaboration when it comes to the evolution of collaborative ties in a governance network. In particular, if we keep in mind that the analysis of open triads enables us to indicate the likelihood of partners of partners to become collaboration partners, which implies that the A–B and B–C collaboration ties might be transmitted to A–C in a governance system structure (Lomi and Pallotti 2012; Pittman and Armitage 2017a).

Also, another feature that needs to be highlighted is that this doctoral research coincided with the impositions resulting from the COVID-19 pandemic, which stopped all research projects in all scientific fields worldwide. As such, I believe that the methodological approach used in this dissertation contributes to the literature by illustrating methods for overcoming face-to-face research restrictions imposed by new drivers of change, such as the COVID-19 pandemic. My methodological approach might help future research efforts to continue even if they coincide with societal challenges that limit face-to-face research, such as those the scientific community and the rest of the world experienced during the COVID-19 pandemic.

5.3 THEORERICAL CONTRIBUTIONS

Consistent with Chung Tiam Fook (2017), this dissertation contributes to the literature on adaptive capacity and vulnerability by offering locally-driven alternatives to tackle structural causes of vulnerability and enhance adaptive capacity. While adaptive capacity and vulnerability have gained considerable attention for coping with various wicked problems, primarily in the public and political spheres, I argue there are still critics and uncertainty about what adaptive capacity and vulnerability mean and how such terms should be applied. A failure to consider the implications of such concepts can produce inequitable outcomes that reinforce the status quo in complex social-ecological systems such as the Galapagos small-scale fishery system (Buggy and McNamara 2016; Karlsson et al. 2018). In response to this challenge, this doctoral research contributes to developing these concepts by providing further explanations and strategies within the environmental decision-making and public and political discourses. By recognizing the need for measures and designs tailored to fit each system of interest, and by suggesting appropriate and applicable ways of building adaptive capacity and enhancing the resilience of those systems, the Galapagos Islands' small-scale fishing governance case presents ways of bolstering the ability of the system to adapt from a local network governance perspective. These contributions address some concerns voiced by Brand (2006) and Carpenter et al. (2001) regarding the need for approaches that enable the operationalization and application of resilience. Notably, this dissertation contributes to broadening the notion of institutional fit explored initially by Young (2002). Consistent with Ishihara (2021), this dissertation holds that fit encompasses multiple types of fit simultaneously, to span the actual scope of social-ecological systems. The concept of fit depends on which societal problems need to be addressed. On the one hand, the idea of fit might signify a spatial, temporal and functional fit between fishers' actions and marine species interactions. However, on the other hand, the concept of fit might also mean the spatial, temporal and functional fit between co-management decision-making structures and fishers' and societal needs, or the spatial, temporal and functional fit between co-management decision-making structures and invasive or endangered species. Consistent with Kooiman (2003b), responses to multiple complex societal concerns require approaches that involve previously uninvolved partners. Therefore, this doctoral research consolidates the idea that if governance network structures are left static, achieving a desirable social-ecological fit will be challenging in light of multiple drivers of change. It is therefore imperative to bear in mind that institutions and stakeholders involved in governance system structures can provide incentives to both ameliorate changing conditions and influence incremental changes in vulnerability (Armitage et al. 2011). As such, governance network structures should become more dynamic and move in the same direction as multiple exposures (vulnerabilities). This dissertation contributes to the theoretical debate of fit, by suggesting that addressing multiple types of fit in a social-ecological system may require moving, removing or adding nodes and ties strategically within the governance network of a system of concern. Strategic network actions in decision-making structures can signify more sustainable outcomes (Bodin et al. 2022). As such, the theoretical approaches used in this dissertation contribute to the literature on Galapagos conservation science from a social science perspective, by suggesting ways of addressing multiple wicked problems that affect the Galapagos small-scale fishing sector, such as concerns about public health, illegal international fishing, and climate change. This has been achieved by adopting participatory and collaborative network approaches and solving-problem perspectives that are often ignored in the context of the Galapagos Islands. These considerations are particularly important to keep in mind to evaluate and improve how actors with the Galapagos small-scale fishery governance system react and prepare to act in times of change.

5.4 EMPIRICAL CONTRIBUTIONS

The different cross-sectoral problems spanning the Galapagos' small-scale fishing sector increasingly press the Galapagos management authorities to devise collaborative strategies to cope with them. This doctoral research examined how actors from different sectors interact within the Galapagos Islands' small-scale fishing governance system, using for the first time a social network analysis. To the authors' knowledge of Chapter 3 and chapter 4, this doctoral research represents the first study in Ecuador and one of the first in Latin America and the Caribbean that test these hypotheses about a governance system structure. Following Kooiman's (2003a) description of institutions as those setting the normative foundations for governance processes, an initial understanding of the Galapagos Islands' small-scale fishing governance network is critical for studying the structure and operation of the Galapagos governance system in greater depth. Based on the identification of the most relevant and well-positioned actors in the network, this doctoral research described the basic configuration of this governance network. This knowledge might contribute to developing platforms for collaboration among various stakeholders, which will help improve Galapagos small-scale fisheries' governance in light of multiple complex societal challenges.

This research contributes to the literature on adaptive capacity and vulnerability in Latin America and the Caribbean. It advances the scientific understanding of the influence of governance, still in its infancy, as an effective means to construct adaptive capacity by addressing context-specific vulnerabilities. Significantly, to my knowledge, this is the first study in the Galapagos Islands that aims at building adaptive capacity by considering collaboration networks. Bearing in mind that the success of marine protected areas is frequently dependent on the form of governance applied to manage them, this research is the first to bring polycentrism and adaptive co-management insights into governance discussions in the Galapagos Islands. Following Olsson's metaphor (2006) of shooting the rapids for transformational change in social-ecological systems, the governance network, actors' positions, ties and network attributes of the Galapagos small scale-fishing sector presented in this study have the potential to create channels and prepare the system to navigate transitions toward adaptive governance. The lack of platforms for collaboration between actors and sectors to address such multiple wicked problems is a major gap in the governance system of the Galapagos Islands. As such, this study contributes guidelines to connect individuals, organizations and agencies from multiple sectors and levels to navigate periods of transformation and align the Galapagos governance system as closely as possible to the multiple exposures and societal needs of the system.

Further, it is necessary to point out that the Galápagos Islands governance scheme does not just address the interactions of one sector, such as fishing, it simultaneously addresses other sectors (e.g., tourism) and other socio-ecological concerns (e.g., the effects of COVID-19 and climate change). Therefore, this dissertation introduces governance-related insights that have hardly been explored in public, and political discussions in Ecuador, which might contribute to having a more holistic form of governance in light of multiple and simultaneous severe problems that exist in the archipelago. Finally, a significant implication of this research is that it indirectly supports the scientific decision to add 60,000 km^2 to the GMR; an argument frequently used by those who were opposed to expanding the GMR was that its expansion lacked scientific evidence.

5.5 CHALLENGES AND RECOMMENDATIONS

While this dissertation investigated the organizational interactions among diverse public and private organizations in the Galapagos small-scale governance system, it is necessary to note that these links derive from organizational interactions in pre-COVID-19 pandemic conditions. The effects of COVID-19 pushed the Galapagos population into the worst socio-economic situation in their history.

Therefore, new institutional ties might have emerged within the governance network that this dissertation missed. The need to stop the spread of the adverse consequences of the COVID-19 pandemic forced public and private organizations to seek cooperation within the Islands and Ecuador's continental region, strengthening institutional interactions and collaborations. For example, international NGOs (e.g. CDF) and Galapagos management authorities (e.g. CGREG and DPNG created collaboration links to obtain vaccines and polymerase chain reaction (PCR) tests for the Galapagos Province. The latter reflects closely the role that the central nodes presented in this doctoral research play in the policy implementation and coordination in the sector.

Further, it is worth mentioning that it was intended for this dissertation to involve conducting interviews and focus groups, including with the artisanal fishers in Santa Cruz Island, Isabela Island, and San Cristobal Island, which would have enabled us to explore the interactions among fishers and specific marine species captured by the different fishing fleets that operate across the Islands as well. The COVID-19 pandemic's limitations regarding working on-site and having human contact, however, forced us to focus only on institutions and agencies linked with the Galapagos small-scale sector. Therefore, this study might have had a more significant impact and greater participation if it had not coincided with the COVID-19 pandemic.

This dissertation provides the following recommendations to enhance the Galapagos small-scale fishing governance system:

Problem-solving wicked problems spanning governance systems require coordination among a broad range of multi-level actors and the inclusion of diverse skills, expertise, knowledge, and resources. However, how the Galapagos small-scale governance system operates today might be insufficient to address the social-ecological dimensions spanning the Galapagos small-scale sector. The adverse consequences of super wicked problems such as COVID-19, climate change and illegal fishing require novel governance approaches. Hence, this dissertation suggests exploring further polycentric links that enable a transition toward adaptive co-management governance. It implies shifting government control toward more open participation and collaboration of non-state actors and stakeholders in decision-making structures. Embracing adaptive co-management in the Galapagos Islands would allow approximating as much as possible the governance scope scale to the scale of the social-ecological dimensions of the Galapagos small-scale fishing sector and prevent a potential misfit.

Among the main drivers leading to a mismatch between governance systems and socio-ecological dimensions is a vague understanding of the existing interdependencies and relationships (ties) between social and ecological systems (Bodin et al. 2016; Barnes et al. 2019; Fried et al. 2022). Therefore, I recommend exploring the connections between social nodes (e.g., fishers, organisms of control, and fishing cooperatives) and ecological nodes (i.e., marine species caught in the sector). This analysis would facilitate the formulation of inputs to prevent the collapse of essential fisheries in the Galapagos Islands such as what occurred with the collapse of sea cucumber (*Isostichopus fuscus*) fishery in the 1980s and 1990s. In this context, I suggest exploring the relationships among social nodes and the ecological nodes of critical marine species, such as the locally known bacalao (*Mycteroperca olfax*), camotillo (*Paralabrax albomaculatus*), brujo (*Pontinus clemens*), red spiny lobster (*Panulirus penicillatus*), and green spiny lobster (*Panulirus gracilis*), to ensure the Galapagos' food security and fishers' economic and social stability. Disregarding the relationships between the governance system and ecological systems might lead to the population of marine species declining and, consequently, socio-economic problems for fishers and further conflicts between organisms of control and the fishing sector arising in the future. Therefore, I suggest embracing a social-ecological perspective that considers the interactions between social nodes and ecological nodes to govern artisanal Galapagos fisheries. This would allow decision-makers to adapt and formulate policies according to social-ecological interactions rather than institutional affiliations. In the same line of investigation, furthermore, I suggest exploring the collaboration ties of the Galapagos small-scale fishing governance system based on the work proposed by Bodin et al. (2022). These authors define a novel network-centric method for emergency responses. Based on this research approach, it will be possible to elaborate further hypotheses for collaborative responses to societal and environmental challenges within the Galapagos small-scale fishing governance system.

Governance systems evolve, shifting patterns in collaborative partnerships (Lubell 2015). Therefore, I suggest keeping track of actors' positions and attributes and exploring further network configurations within the Galapagos small-scale fishing governance system. I recommend updating the Galapagos small-scale fishing governance system's collaborative ties, considering links created during COVID-19 pandemic conditions. Further, I suggest exploring closed triadic network configurations and the relationships of trust among governance actors in the network. Analyzing these network structures and governance actors' attributes would help decision-makers to approximate desirable network collaboration states to greater compliance and legitimacy. Considering the latter, I recommend designing an online platform for the Galapagos small-scale governance network. This platform would facilitate visualizing and updating the Galapagos small-scale fishing governance network so that decisions and new collaborative links can be made that strengthen the governance network by addressing any problems that arise.

Finally, although this doctoral research provides important governance insights that might contribute to the GMR functionality, there are still significant gaps to address. I suggest exploring the role of power and trust in the Galápagos Islands' small-scale fishing governance system network. Common-pool resources like the Galápagos Islands' small-scale fishery sector involve self-interested motivations. This dissertation illustrates how the GSL has shaped several polycentric arrangements emerging from complex socio-political settings in the Galápagos Islands' small-scale fishing sector. Therefore, understanding the power dimensions is particularly important in addressing complex socio-ecological problems and bolstering the capacity of the Galápagos Islands' small-scale fishery sector to adapt. Future theoretical frameworks might use the ones used in this doctoral research as a starting point to explore organizations that concentrate power and the level of trust among them, supported with empirical work when the COVID-19 conditions allow.

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Appendix 1. Interview Guide Questions

Interview date: ______________________________

Organization name: ______________________________

Interviewee (Code #): ______________________________

Is it your organization?

a) Local
b) National
c) International

Is this organization?

a) Public
b) Private

From the list of institutions handed to you, which organizations or groups do you coordinate, speak or work with about the management and organization of activities of the artisanal fisheries sector of Galapagos?

How often does your organization collaborate with the selected organization?

a) Frequently
b) Occasionally
c) Rarely

What type of organizational ties do you consider that exist with the selected organization?

a) Information exchange (e.g., regarding observations of environmental change, coral reef condition, invasive species, water quality).
b) Management (e.g., mandatory organization and coordination of illegal fishing, monitoring, or user conflicts).
c) Collaboration (e.g., joint projects, technical expertise, finances, or human resources).

Could you suggest other organizations or groups (not listed in our list) with which your organization coordinate, communicate, or work regarding the management and organization of the small-scale fishing sector's activities? If so,

How often does your organization collaborate with this organization?

a) Frequently
b) Occasionally
c) Rarely

What type of organizational ties do you consider that exist with this organization?

a) Information exchange (e.g., regarding observations of environmental change, coral reef condition, invasive species, water quality).
b) Management (e.g., mandatory organization and coordination of illegal fishing, monitoring, or user conflicts).
c) Collaboration (e.g., joint projects, technical expertise, finances, or human resources).

Appendix 2. Interview Guide Questions

Interview date: ____

Organization name: ____

Interviewee (Code #): ____

Is it your organization?

a) Local
b) National
c) International

Is this organization?

a) Public
b) Private

How does your organization could collaborate in the Galapagos small-scale sector if there were institutional arrangements in place?

a) Financial resources
b) Technical and scientific knowledge
c) Local knowledge acquired over time
d) Data and information
e) Equipment and technology
f) Monitoring of illegal fishing
g) Research projects

If an option was selected, could you explain your answer, please?