

ADAPTIVE CAPACITY FOR SOCIAL AND ENVIRONMENTAL
CHANGE: THE ROLE OF NETWORKS IN CHILE'S SMALL-SCALE
FISHERIES

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Adaptive capacity for social and environmental change: the role of networks in Chile's small-scale fisheries

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Dedicated to Grace, Aurora,
Estela and Teodoro.

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Abstract

World's small-scale fisheries face permanent and increasing external changes and shocks that challenge their viability and potential as an engine of human sustainable development. It is broadly assumed and expected, in scientific and political discourses, that small-scale fishers and their communities have the capacity to adapt to current and future social and ecological changes. While social networks and social capital have been regarded as key components of adaptive capacity in small-scale fisheries, there is little empirical understanding of how they operate and of their effectiveness in the context of multiple and overlapping perturbations. This thesis examines the role of social networks and social capital in explaining the performance and responses of fisher organizations and communities to the implementation of a resource co-management policy (e.g. a slow-paced process of change), to the varied impacts of an abrupt coastal disaster (e.g. an earthquake and tsunami), and to the interaction of both slow and fast processes of change. The unexpected occurrence of a disaster during the development of the research was taken as an opportunity to study adaptive capacity under different conditions, and to carry on longitudinal and comparative analyses.

The thesis consists of five papers that analyze the successes and failures of small-scale fisher organizations in the central-south of Chile in adapting and responding to the *Management and Exploitation Areas for Benthic Resources* system and to the massive February 2010 earthquake and tsunami. Paper I explores the levels of linking and bridging social capital among fisher organizations in Valparaiso and Bio-Bío regions, and their correlation with co-management performance variables; this paper, along with Marín and Berkes (2010), also represents the baseline for some of the successive papers. Paper II describes the material devastation of existing small-scale fishing capacity caused by the tsunami, and identifies the factors associated with immediate evacuation responses (i.e. including bonding social capital) that explain high levels of survival among fishing communities in the O'Higgins, Maule and the Bio-Bío regions. Paper III investigates how the interplay between internal (i.e. pre and post-disaster linking social capital) and external factors (i.e. levels of damage and geographical isolation) can help explain differences in post-disaster recovery trajectories of fisher organizations in the Bio-Bío region. Paper IV assesses whether and how co-management governance networks changed in the Bio-Bío as a consequence of tsunami impacts, as compared to the non-impacted case of Valparaiso. Paper V investigates the particular case of permanent earthquake-driven ecosystem transformations in a coastal wetland in Bio-Bío region, the associated impacts on ecosystem services and human well-being, and the livelihood responses implemented by fishing and non-fishing resource user groups.

The results reinforce the general hypothesis about the positive role of social networks and social capital as vehicles for accessing and mobilizing valuable resources and information to achieve collective goals, and as expressions of adaptive capacity in small-scale fisheries. In the context of fisheries co-management, higher levels of linking and bridging social capital were found among the most successful organizations. This finding implies greater adaptive capacity to the complexities of the policy and the overall functioning of the co-management system. In the context of short-term post-disaster responses, bonding social capital within fishing communities - along with other socio-cultural assets - was found to be a central trigger of immediate and effective tsunami evacuation, which indicates well-established adaptive capacity to extreme and unexpected coastal hazards and disasters. In the mid and long-term, higher levels of linking social capital appeared as a critical requirement for optimal post-disaster recovery trajectories of fisher organizations, reflecting the importance of cross-scale networks of support to overcome the impacts of disasters and to explore opportunities for innovation.

This thesis shows that developing broad and strong social networks and building social capital are necessary conditions of small-scale fisher organizations and coastal communities' response and adaptive capacities in the face of policy changes and the effects of environmental disasters. However, the study also indicates that they are not sufficient in and of themselves which, suggests a careful and nuanced consideration of social networks and social capital as potential answers to the challenges and problems affecting small-scale fisheries. Thus,, it is important to: 1) differentiate the types of social capital (e.g. bonding, bridging and linking) as potentially relevant for some expected outcomes (i.e. not for all/any outcomes); 2) consider the extent to which the expected benefits of social networks/capital depend on external factors (i.e. contingent value); 3) take into consideration that social capital/networks can change over time as a consequence of and/or in response to internal and external processes and shocks (i.e. the temporal dimension of social capital); 4) treat social capital/networks as descriptive, bounded concepts about the social reality (i.e. not normative), which illuminate not only the positions of the better connected and most advantaged actors within a system, but also the less integrated and more vulnerable actors within a system. Social networks and social capital provide small-scale fishing communities with adaptive capacity to cope with change, but ultimately the achievement of long-term sustainability is highly dependent on their levels of vulnerability and to the magnitude of the external perturbations.

Key words: artisanal, benthic, Chile, coastal areas, collaborative management, disasters, ecosystem services, hazards, livelihoods, post-disaster, QCA, recovery, TURFs.

Resumen

En todo el mundo, las pesquerías de pequeña escala enfrentan permanentes y crecientes cambios y presiones externas que desafían su viabilidad y potencialidad como motor de desarrollo humano sustentable. Comúnmente, en el discurso científico y político, se asume y espera que los pescadores de pequeña escala y sus comunidades tengan la capacidad de adaptarse a los actuales y futuros cambios sociales y ambientales. Si bien las redes sociales y el capital social han sido considerados como elementos centrales en la capacidad adaptativa en estas pesquerías, existe un limitado conocimiento sobre cómo éstos operan y sobre su efectividad en el contexto de perturbaciones múltiples y simultáneas. Esta tesis examina el rol que cumplen las redes sociales y el capital social en explicar el desempeño y las respuestas de las organizaciones y comunidades de pescadores ante la implementación de una política de co-manejo de recursos (es decir, un proceso lento de cambio), ante los diversos impactos de un desastre costero imprevisto (es decir, un terremoto y tsunami), y ante la interacción de ambos factores. La ocurrencia inesperada de un desastre durante el desarrollo de la investigación fue tomada como una oportunidad de estudiar las capacidades adaptativas bajo diferentes condiciones, y de desarrollar análisis longitudinales y comparativos.

La tesis se compone de cinco artículos que abordan los éxitos y fracasos de organizaciones de pescadores artesanales en el centro-sur de Chile en su esfuerzo por adaptarse y responder al sistema de *Áreas de Manejo y Explotación de Recursos Bentónicos* y al gran terremoto y tsunami de Febrero de 2010. El Paper I explora los niveles de capital social de puente y escalera en organizaciones de pescadores en las regiones de Valparaíso y Bio-Bío, y su correlación con variables de desempeño en el co-manejo de recursos; este artículo, junto con Marín y Berkes (2010), representan también la línea base para algunos de los artículos siguientes. El Paper II describe la devastación material en la capacidad pesquera instalada como causa del tsunami, e identifica los factores de respuesta y evacuación inmediata (entre ellos el capital social de unión) que explican altos niveles de supervivencia entre las comunidades pesquero-costeras en las regiones de O'Higgins, Maule y Bio-Bío. El Paper III investiga cómo la interacción entre determinantes internos (es decir, capital social de escalera pre y post desastre) y externos (es decir, niveles de daño material y aislamiento geográfica) pueden ayudar a explicar las diferencias en las trayectorias de recuperación de las organizaciones de pescadores en la región del Bio-Bío después del tsunami. El Paper IV evalúa los cambios en las redes de gobernanza de co-manejo en el Bio-Bío como consecuencia de los impactos del desastre, en comparación con la región de Valparaíso que no sufrió impactos. El Paper V investiga el caso particular de las transformaciones ecosistémicas permanentes, causadas por el terremoto, en un humedal costero en el Bio-Bío, los impactos asociados sobre los servicios del ecosistema y el bienestar humano, y las respuestas y adaptaciones en los medios de vida implementadas por parte de grupos costeros de pescadores y no pescadores.

Los resultados refuerzan la hipótesis general acerca del rol positivo que cumplen las redes sociales y el capital social como vehículos del acceso y movilización de valiosos recursos e información para la consecución de metas colectivas, y como expresiones de capacidad adaptativa en la pesca artesanal de pequeña escala. En el contexto del co-manejo pesquero, altos niveles de capital social de puente y escalera son un atributo de las organizaciones más exitosas. Este hallazgo implica la existencia de mayor capacidad adaptativa ante las complejidades de esta política y el funcionamiento general del sistema de co-manejo. En el contexto de las respuestas de corto plazo frente a un desastre, se encontró que el capital social de unión – junto con otros atributos socio-culturales – representa un determinante central en la efectiva respuesta y evacuación inmediata, lo que indica la existencia de capacidad adaptativa arraigada en las comunidades costeras ante

amenazas y desastres extremos e inesperados. En el mediano y largo plazo, altos niveles de capital social de puente fueron identificados como un elemento crítico de las trayectorias más óptimas de recuperación entre organizaciones de pescadores afectadas, reflejando la importancia de las redes de apoyo (que conectan diversas escalas) para superar los impactos de un desastre y explorar oportunidades de innovación.

Esta tesis muestra que desarrollar redes sociales amplias y fuertes, y construir capital social, son condiciones necesarias para ampliar las capacidad adaptativas y de respuesta de las organizaciones y comunidades de la pequeña pesca artesanal de cara a cambios en las políticas pesqueras y los efectos de los desastres ambientales. No obstante, el estudio también indica que estas no son suficientes por sí mismas, y sugiere una cuidadosa y matizada consideración de las redes y el capital social como respuestas posibles a los problemas y desafíos que aquejan a las pesquerías de pequeña escala. En este sentido, es importante: 1) diferenciar los tipos de capital social (es decir, de unión, puente y escalera) como potencialmente relevantes para ciertos resultados esperados (y no para todos o cualesquiera); 2) considerar hasta qué punto los beneficios esperados de las redes sociales y el capital social dependen de factores externos (es decir, su valor contingente); 3) tomar en consideración que las redes y el capital social pueden cambiar en el tiempo como consecuencia de procesos y fenómenos internos y externos (es decir, su dimensión temporal); 4) tratar las redes y el capital social como conceptos descriptivos respecto de la realidad social (es decir, no normativos), que iluminan no solo la posición de los actores más aventajados, sino también la de los menos integrados y más vulnerables dentro de un sistema. Las redes y el capital social proveen a las comunidades de pescadores artesanales de pequeña escala de capacidad adaptativa para enfrentar cambios sociales y ambientales, pero – en última instancia – el logro de la sustentabilidad de largo plazo es altamente dependiente de los niveles de vulnerabilidad y de la magnitud de las perturbaciones externas que el sector deba enfrentar.

Palabras clave: *Análisis Cualitativo Comparativo, artesanal, bentónico, Chile, desastres, manejo colaborativo, medios de vida, peligros, post desastre, recuperación, servicios ecosistémicos, zonas costeras.*

Sammanfattning

Världens småskaliga fiske står inför bestående och ökande yttre förändringar och chocker. Det här något som hotar deras livskraftighet och potential för mänsklig hållbar utveckling. I vetenskapliga och politiska diskurser så förväntas småskaligt fiske och fiskesamhällen generellt ha stor kapacitet att anpassas till nuvarande och framtida sociala och ekologiska förändringar. Sociala nätverk och socialt kapital har ansetts vara nyckelkomponenter för det småskaliga fiskets adaptiva kapacitet. Det finns dock lite empirisk förståelse för hur det småskaliga fisket fungerar och dess effektivitet vid multipla och överlappande perturbationer. Den här avhandlingen undersöker rollen av sociala nätverk och socialt kapital för att förklara hur fiskeorganisationer och fiskesamhällen svarar på implementeringen av en samförvaltningspolicy (t.ex. en långsam förändringsprocess) samt på en plötslig kustnära katastrof (t.ex. en jordbävning eller tsunami) och även på interaktionen mellan långsamma och snabba processer. Den oväntade uppkomsten av en katastrof under forskningen öppnade upp möjligheter för att studera adaptiv kapacitet under olika förhållanden och för att utföra jämförande analyser över tid.

Avhandlingen består av fem artiklar, som analyserar framgångar och misslyckanden, inom småskaliga fiskeorganisationer i den syd centrala delen av Chile, vad gäller deras anpassning och svar på förvaltning, *Management and Exploitation Areas for Benthic Resources system* och på den massiva jordbävning och tsunami som inträffade i februari 2010. Artikel I undersöker nivån av sammanlänkat och överbryggande socialt kapital mellan fiskeorganisationer i regionerna Valpariso och Bio-Bío samt deras korrelation med samförvaltningsvariabler. Denna artikel, tillsammans med Marín och Berkes (2010), är också en grund för några av de följande artiklarna. Artikel II beskriver den materiella ödeläggelse som drabbade det småskaliga fiskets kapacitet till följd av tsunamin och identifierar faktorer som är associerade med omedelbara evakueringsåtgärder (dvs. inkluderat sammanbindande socialt kapital) och som förklarar varför så många överlevde i fiskesamhällen runt regionerna O'Higgins, Maule och Bio-Bío. Artikel III utreder hur samspelet mellan interna- (dvs. sammanlänkade sociala kapital före och efter katastrofen) och externa faktorer (dvs. skadenivåer och geografisk isolering) kan hjälpa till för att förklara varför fiskeorganisationerna i Bio-Bío regionen återhämtats olika efter katastrofen. Artikel IV utvärderar, om och i så fall hur, det styrande samförvaltningsnätverket förändrades i Bio-Bío som en konsekvens av tsunamin, och i förhållande till det icke katastrofdrabbade Valpariso. Artikel V undersöker det specifika fall av ekologisk transformation i kustnära våtmarker i Bio-Bío regionen. Transformationen skedde till följd av en jordbävning och artikeln undersöker vidare hur ekosystemtjänsterna och det mänskliga välbefinnandet påverkades av detta, dessutom undersöks de livsuppehållsbaserade åtgärderna som implementerades av fiskare och andra grupper naturresursanvändare.

Resultaten stödjer den generella hypotesen av att sociala nätverk och socialt kapital är positiva drivkrafter när det kommer till att samla och mobilisera värdefulla resurser och information i syftet av att uppnå ett gemensamma mål, samt också som uttryck av adaptiv kapacitet i småskaligt fiske. I kontexten av samförvaltning av fiske hittades högt sammanlänkande och överbryggande socialt kapital hos de mest framgångsrika fiskeorganisationerna. Detta resultat betyder hög adaptiv kapacitet mot policys och samförvaltningssystemet. I kontexten av kortsiktiga åtgärder efter katastrofen, var socialt kapital inom fiskesamhällena, tillsammans med andra socio-kulturella tillgångar, en central trigger av direkta och effektiva tsunami evakueringar. Detta indikerar en väl etablerad adaptiv kapacitet mot extrema och oväntade händelser och katastrofer i kustområdena. På längre sikt var högt socialt kapital en nödvändig förutsättning för en optimal utveckling av fiskeorganisationerna efter katastrofen. Resultatet

visar på vikten av nätverk som verkar över olika nivåer för att kunna överkomma katastrofers påverkan och hitta innovationsmöjligheter.

Den här avhandlingen visar att utveckling av breda och starka sociala nätverk och byggandet av socialt kapital är nödvändiga förutsättningar för småskaliga fiskeorganisationers och kustsamhällens anpassning till policy och effekter av miljökatastrofer. Avhandlingen indikerar dock att socialt nätverk och socialt kapital inte är tillräckliga i sig själva, utan måste ses som potentiella åtgärder på utmaningar och problem som påverkar småskaligt fiske. Det är således viktigt att: 1) differentiera de olika typerna av socialt kapital (t.ex. sammanbindande, överbyggande och sammanlänkande) som potentiellt relevanta för några förväntade utfall (dvs. inte för alla/något utfall); 2) beakta till vilken grad den förväntade nyttan av sociala nätverk/kapital är beroende av externa faktorer (dvs. villkorat värde); 3) ta hänsyn till att socialt kapital/nätverk kan förändras över tid som en konsekvens av och/eller i svar på interna och externa processer och chocker (dvs. den temporala dimensionen av socialt kapital); 4) behandla socialt kapital/nätverk som deskriptiva, sammanbindande koncept om den sociala verkligheten (dvs. inte normativt), vilket inte bara belyser positionen av de mer sammanlänkade och mest fördelaktiga aktörer, utan också av de mindre interagerade och mer sårbara aktörer inom ett system. Sociala nätverk och socialt kapital bygger adaptiv kapacitet inom småskaliga fiskesamhällen och ökar deras förmåga att hantera förändringar. Men med det sagt, så bör det framhållas att långsiktig hållbar utveckling framförallt beror på magnituden av extern påverkan och förändringar.

Nyckelord: *hantverksmässig, havsbotten, Chile, kustområden, samförvaltning, katastrofer, ekosystem tjänster, risker, livsuppehållen, efter katastrof, QCA, återhämtning, välbefinnande.*

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List of papers

- I. Marín, A., Gelcich, S., Castilla, J.C., Berkes, F. (2012). Exploring social capital in Chile's coastal benthic comanagement system using a network approach. *Ecology and Society*, 17(1), 13.
- II. Marín, A., Gelcich, S., Araya, G., Olea, G., Espíndola, M., Castilla, J. C. (2010). The 2010 tsunami in Chile: Devastation and survival of coastal small-scale fishing communities. *Marine Policy*, 34(6), 1381-1384.
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My contribution to the papers included in the thesis is as follows:

- | | |
|-------------------|---|
| I, II, III, IV, V | Conceptualized and actively co-developed the idea; designed data collection instruments; responsible for most of the fieldwork and supervised assistants collecting field data; responsible for data processing and analysis and led the writing and submissions. |
| V | Involved in the overall project design and coordinated the participation/consultation process with local and regional stakeholders. |

Other publications of relevance to the thesis

- VI. Marín, A., Berkes, F. (2010). Network approach for understanding small-scale fisheries governance: The case of the Chilean coastal co-management system. *Marine Policy*, 34(5), 851-858.
- VII. Oyanedel, R., Marín, A., Castilla, J. C., Gelcich, S. (2015). Establishing marine protected areas through bottom-up processes: insights from two contrasting initiatives in Chile. *Aquatic Conservation: Marine and Freshwater Ecosystems*. In press.

Abbreviations

MEABR	Management and Exploitation Areas for Benthic Resources
SSF	Small-scale fisheries
TAC	Total Allowable Catch

Introduction

Small-scale fisheries (hereafter SSF) and associated ways of life have a great social, economic and ecological importance in most parts of the world. The sector is the source of livelihood for hundreds of millions of rural people and they provide a significant boost to national and local economies (FAO 2007; Andrew et al. 2007). Around half of the world's fish production is provided by SSF, playing a key role for nutrition and food security in a context of a growing world population. In terms of environmental performance, there is growing consensus about the potential contribution of SSF practices for the conservation of marine ecosystems and their resources (Pauly et al. 2002; Johnson 2006). SSF have also been suggested to be a valuable repository for local and traditional ecological knowledge about the oceans and coastal areas that can inform and guide sustainable management options (Berkes 2003; Andrew et al. 2007). For these and other reasons, SSF have been considered a powerful engine for human sustainable development for many social groups in a diverse number of countries around the world (Berkes et al. 200; Weeratunge et al. 2014; FAO 2015).

Despite the positive contribution of SSF to society they are often vulnerable to multiple shocks and perturbations. In many areas, SSF are already suffering the consequences of global threats on marine ecosystems (Daw et al. 2009; Allison et al. 2009). Studies have highlighted the persistent over-exploitation of marine resources (e.g. due to unsuccessful regulations and the widespread use of advanced catch and processing technology) and, emerging climate and other environmental changes (e.g. driven either by unsustainable development patterns or by natural forces) that are dramatically altering the capacity of the oceans to secure fish and other benefits for the society (Pauly et al., 2002; Andrew et al. 2007; Boonstra et al. 2015). In addition, SSF face a number of more specific social and environmental shocks and disturbances. Coastal resource users often find themselves in conflicts over resources with larger industrial fleets (Pomeroy et al. 2007), and have to contend with high volatility of prices in global markets (Andrew et al. 2007; Kittinger et al. 2013), well-intentioned but problematic fishery, conservation and development policies (Lewins 2004; Bene et al. 2010), and more frequent and extreme coastal disasters (Adger et al. 2005; Régnier et al. 2008). Poverty, high dependence on resources, and inattention from governments often form the backdrop against which SSF have to cope and adjust to these multiple external challenges (McGoodwin 1990). Adversity, uncertainty and vulnerability describe compounded and multiscale challenges that threaten coastal and fishing communities' survival, resource management capacity and livelihoods (Pomeroy et al. 2006; Régnier et al. 2008).

The circumstances of many SSF described above, characterize the challenges the sector faces to adapt to survive, especially in the light of large external social and ecological shocks and perturbations. Adaptation, in general, is “a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity” (Smit and Wandel 2006; p. 282). But social adaptation is not easily achievable. In practice, not all members of a social system are equally equipped to adapt and respond to multiple, and usually unexpected, changes and the associated threats and opportunities. The concept of adaptive capacity has been widely used to describe the unequal possibilities and capabilities of actors to respond and adapt to social and environmental change. For McClanahan and coauthors (2008) adaptive capacity is the “potential to cope with perturbations and take advantage of new opportunities, whether due to climate impacts (IPCC 2007), conservation interventions, or other changes to the social-ecological system” (p. 53-54). Similarly, Adger (2006; p. 270) defines adaptive capacity as “the ability of a system to evolve in order to accommodate environmental hazards or policy change and to ex-

pand the range of variability with which it can cope”. In my own words and drawing on this previous work, adaptive capacity is: a measure of how well or how poorly actors, within a given system, perform in different domains to sustain their livelihoods under changing contexts.

There is an ongoing debate among scholars and practitioners about the limitations and potential of adaptive capacity in resource dependent communities to cope with current challenges. Some authors have pointed out that some social groups, despite having the capacities, may – deliberately or not - refuse to change and adapt (Diamond 2005). Other studies have questioned the actual results of adaptive responses. Communities may have the capacity to adapt, but their actions may not go in the right direction/be overly focused on the short-term (e.g. exhausting the ecosystem they depend on; see Boonstra and Hanh 2014) or their efforts may be insufficient (e.g. due to the extent of shocks; see Kates et al. 2012). This thesis adds to this body of work by examining the (mal)adaptive responses of fishing communities in Chile after the 2010 tsunami to understand how and if they contribute or not to increasing sustainability and reducing future vulnerability to perturbations. From another point of view, authors have explored the multiple sources and factors of enhanced/reduced adaptive capacity in natural resource users in both general and fishing communities in particular. These include financial and technological (Tompkins and Adger 2004; Badjeck et al. 2010); productive (Allison & Ellis 2001; Kraan 2009); institutional (Ostrom 2003; Folke et al. 2005; Armitage 2005); cultural and cognitive (Marshall and Marshall 2007; Van Holt 2012; Boonstra and Hanh 2014), and socio-relational/network (Pelling and High 2005; Bodin et al. 2006; Ernstson et al. 2008) dimensions of adaptive capacity.

This thesis consists of five papers that address adaptive capacity in Chilean SSF in response to social and environmental change. Following Adger’s (2006) definition presented above, adaptive capacity is studied in the context of policy changes and environmental hazards. Two significant drivers of change are considered, namely: 1) the implementation of a co-management policy in 1997 (i.e. *Management and Exploitation Areas for Benthic Resources*; see Castilla 1994); 2) and the occurrence of a massive earthquake and tsunami in 2010 (Madariaga et al. 2010). More concretely, the papers address the adaptive capacity of fisher organizations and communities’ to cope with and respond to the consequences of these change processes. In the first case, it is about the capacity to assimilate and succeed within the new governance system; in the second case, it refers to the capacity to survive, respond to and recover from the impacts of the disaster. The thesis also investigates contexts in which these two drivers interact. The unforeseen disaster, which occurred during the early stages of this research (see Box I), provided an opportunity for the empirical assessment of adaptive capacity with a longitudinal perspective (Box III).

A central theme in this work is the empirical examination of social networks (i.e. the explanatory variable) as hypothesized source of fisher organizations and communities’ adaptive capacity. Social networks, and the social capital they give rise to, have been considered the “glue”, “lubricant” and “pipelines” that mobilize information and resources - within and across scales - on which people and groups rely to develop (Woolcock 1998; Krishna 2002) and adapt to change (Pelling and High 2005; Bodin and Crona 2008; Ernstson et al. 2008). There has been growing interest in the use of social network analysis (Scott 2012) in the study of natural resource governance systems (Bodin and Prell 2011) and of socio-environmental disasters and hazards (Aldrich 2012). However, these two strands have so far developed separately and there are few empirical studies that systematically investigate the role of social networks and social capital in the interplay between social and environmental changes.

The thesis hopes to span this gap and asks: What is the role of social networks/social capital for adaptive capacity of SSF organizations to respond to major changes in marine resource governance and to the impacts of coastal disasters?

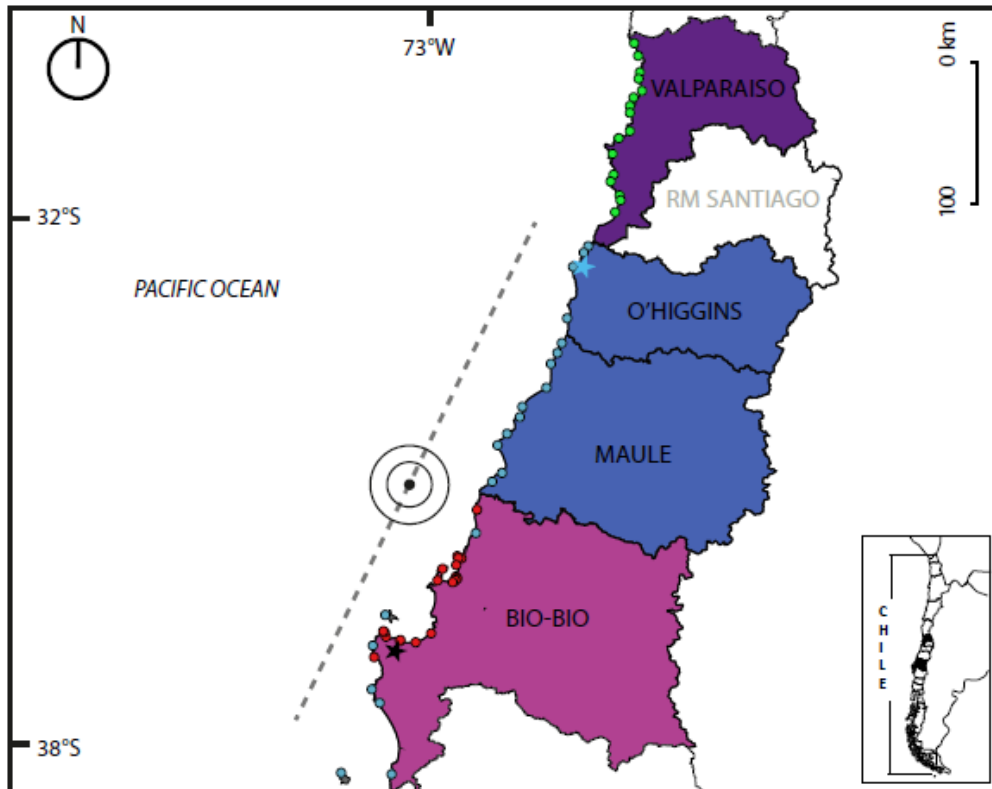


Figure 1: Map of central-south of Chile and the coastal zone under study. Circles represent the caletas/organizations covered; stars indicate specific case studies; concentric circles show the earthquake epicenter and the dotted line marks the zones with the highest tsunami impacts.

The specific research questions addressed in the papers are the following:

- Paper I: What is the role of bridging (i.e. between organizations) and linking (i.e. cross-scale) social capital for fisher organizations' ability to cope and adapt to the changing policy landscape? (see next section for an elaboration on the different types of social capital)
- Paper II: How do fishing communities survive and respond to a tsunami event in the short term? How important are primary social relationships (vs. institutionalized/ formal measures) in fishing communities immediate survival and response to a tsunami?
- Paper III: How can we understand and predict fisher organizations mid to long-term post-disaster recovery trajectories? How do internal (linking social capital) and external factors (levels of damage and isolation) interplay and determine fisheries livelihoods recovery?
- Paper IV: What was the impact of the tsunami on small-scale fishery co-management networks? Are there structural changes (actors, positions and functions) that suggest adaptations in the overall governance network?
- Paper V: How are disaster-driven biophysical changes perceived and assessed by coastal communities, and what are the impacts of those changes on human wellbeing? And how do people adapt their livelihood strategies to the new conditions?

By exploring these questions, the aim of the thesis is to contribute to the sustainability science literature by advancing empirically-based understanding of what contributes to fishing communities ability to confront social and environmental changes; and also to inform the design of future relevant empirical studies as well as more equitable and effective fishery development policies in Chile and elsewhere.

BOX I: Adaptive and iterative research design

The results of this thesis are a reflection of the changing and adaptive nature of SSF described in the literature. The study began with a focus on understanding varied levels of performance of fisher organizations participating in a relatively recently implemented and promising co-management policy. At that time, the overall research context looked apparently stable and the future development of the sector could have been foreseen as a linear process. But this was not the case. A major earthquake and tsunami in 2010 marked the lives and livelihood activities of more than half of my study subjects, in one of the two original study regions. Thousands of coastal dwellers and fishers suddenly confronted the many faces of disaster, including immediate evacuation and survival, mid-term recovery of fishing capacity, and long-term redevelopment of fisheries livelihoods. In some cases, adaptation to permanent ecosystem transformations and resource loss was also necessary. In addition to the disaster, broader political and institutional changes modified the post-disaster policy arena and eventually reshaped the governance of SSF and co-management. In that scenario, maintaining a narrow focus on the study of co-management became extremely unfeasible.

In response to the moving reality under study, and with the support and encouragement of my colleagues and friends Juan C. Castilla and Stafan Gelcich, my research changed as well. Without having a very clear road map at the beginning, the disaster was taken as a unique opportunity to advance my research and making a contribution to the literature and to decision-making. And the focus shifted towards documenting and understanding post-disaster responses and adaptations in coastal communities and fisher organizations, and whenever possible, looking at the factors that help explain varied levels of performance in the face of the disaster and its consequences. In reaction to the 2010 earthquake and tsunami, and driven by a firm interest in the sustainability of SSF, the result of my research is a thesis that addresses interconnected issues of fisheries livelihoods, resource management, post-disaster response and recovery, abrupt ecosystem change and governance in SSF and coastal social-ecological systems. The concept of adaptive capacity provides the overarching theme of the research and the emphasis on social networks/social capital as key vehicles of adaptive capacity represents my particular approach to the concept.

This type of research approach, in which the researcher's goals, questions and methods are revised and negotiated in line with experiences and interactions with others, has been termed adaptive or iterative research (O'Reilly 2012; Yin 2013). Whereas such approaches are more frequent in qualitative and ethnographic traditions, this thesis is an unintended example of an adaptive/iterative research design using mixed methods and techniques.

Theoretical and conceptual background

Social networks as adaptive capacity

The socio-relational approach adopted in this thesis, namely the use of social networks and social capital concepts and methods, has shown great potential as an integrative perspective for the study of human-nature relations. In recent years, natural resource management scholars have paid increasing attention to network approaches to explore which network structural patterns would enhance social capital and support sustainable management governance systems and how they would do so (Bodin et al. 2006; Bodin and Crona 2008; Prell et al. 2009). In turn, in the disaster literature, Social Network Analysis (SNA) and social capital have become attractive lenses for researchers and practitioners alike to understand and enhance community resilience and response capacity (Varda 2008; Magsino 2009; Aldrich 2012). In addition, social networks/capital have been considered key factors that feed into adaptive capacity in social-ecological systems and enable them to respond to global environmental change and associated disasters and hazards (Pelling and High 2005; Adger 2003).

SNA is the formal study of social relationships. The core idea is that individuals, groups, and organizations interact and form relatively stable social structures or networks (Scott 2012). “A social network is a set of actors (or points, or nodes, or agents) that may have relationships (or edges, or ties) with one another. Networks can have few or many actors, and one or more kinds of relations between pairs of actors” (Hanneman and Riddle 2005, no page). The study of social networks has been motivated by the argument that the various positions occupied by actors within the social structure are related to their access to valuable information and resources. Hence, human action and development is closely associated with the mobilization of opportunities along these networks. The analysis of social networks proceeds by rigorously describing the patterns of social relations using formal methods and metrics, such as density, centrality, and subgroups (Wasserman and Faust 1994). This approach allows for the assessment of whether network characteristics and/or the positions of individuals in the network are correlated or cause certain outcomes of interest (Scott 2012). In complement, the analysis can also seek to explain the formation of a given network structure and how networks change over time (Lusher et al. 2012; Snijders 2005).

Social capital is a broad and contested concept that broadly captures a group or an individual’s ability to act and make use of various types of resources through the existence of social relations, shared norms and mutual trust (Coleman 1988; Krishna 2002). Despite the diversity of definitions of social capital, social networks are a key component in all of them and provide common ground for the empirical study of social capital (Borgatti et al. 1998; Bodin and Crona 2009). The network approach to social capital emphasizes the resources embedded in the social structure that are differentially accessed and/or mobilized in purposive actions by social actors (Lin 2001; Bodin and Crona 2008). Higher levels of social capital have been correlated with multiple desirable societal outcomes, such as improved public health, enhanced economic development, and more sustainable management of natural resources (Krishna 2002; Pretty 2003; Szreter and Woolcock 2004, Gutiérrez et al. 2011). More recently, studies have also stressed social networks and social capital as critical engines for long-term post-disaster recovery (Pelling and High 2005; Munasinghe 2007; Aldrich 2012). However, social capital is not only about explaining success

and good performance. Because of the nature of the social structure, and because actors present different disposition and capacities to establish social relations with others, social capital is unequally distributed in society (Lin 2001; Van der Gaag and Webber 2008). Social capital is a relative measure that also describes the condition of less advantaged actors and their low level of accomplishment, and informs possible pathways to improvement. Many authors have warned about the sometimes negative consequences of social capital inequalities (Portes and Landolt 2000), for instance when used by the elites to reinforce their privileges and to exclude others (Murphy 2007).

The concept of social capital has been operationalized as a multidirectional phenomenon that includes bonding, bridging and linking relationships (Woolcock 2001; Woolcock and Sweetser 2002). That is, social relationships among actors at different levels of social organization are distinct and, because they channel different resources, they play different roles:

- Bonding social capital is formed by strong ties, for instance based on kinship, ethnicity or neighborhood, among relatively homogeneous individuals within the same community or group. These relationships are important for people's identity and to strengthen common purposes (OECD 2001). It has been termed the social "glue", on which individuals rely to "get by" in daily life (Narayan 1999);
- Bridging social capital consists of more distant, weaker and more diverse ties than in bonding, but still consists of relations amongst communities and groups at the same level of social organization. Bridging social capital represents a relevant resource in making the mobilization of opportunities possible (Granovetter 1973). Relying on bridging linkages, some sort of social lubricant, people and groups manage to achieve their goals and to "go ahead" together (Narayan 1999). These linkages constitute horizontal networks of civic engagement that help participants to act collectively to produce impacts on community productivity and well-being;
- Linking social capital refers to weak but often formal relations between local groups and actors in higher levels of political, economic or social hierarchy. It includes the ability of local communities and groups to engage with the state and external agencies either to influence their policies or to access useful resources and information (Woolcock 2001; Woolcock and Sweetser 2002). In a sense, linking social capital is mostly about power negotiations and economic exchange networks. The literature has also referred to linking relationships as cross-scale interactions or linkages (Cash et al. 2006) and the "pipelines" to external resources and information (Aldrich 2012).

Adaptive capacity: between vulnerability and resilience

The thesis necessarily touches upon the broader concepts of social resilience and vulnerability, which have long framed the debate on change in the human – nature relationship (Smit and Wandel 2006). Vulnerability refers to the exposure of a person, group or social system to risk (Blaikie et al. 2004; Adger 2006), and reflects the likelihood to be damaged, which varies in time and space, and among different social groups (Cutter et al. 2003). The vulnerability approach highlights external or contextual factors that determine the exposure of a system to perturbations and its potential to respond and recover. Resilience, by contrast, refers broadly to the capacity of systems to absorb recurrent disturbances while retaining essential structures, processes, identity and feedbacks (Walker et al. 2004; Adger et al. 2005). In the face of policy change, disasters or other threats, the social resilience approach focuses on the internal or intrinsic factors of systems that lead to more or less capacity to self-organize, learn from experience and adapt to change.

The distinction between vulnerability and social resilience highlighted here resembles the old debate in the social sciences between “structure” and “agency” (Giddens 1996). Ultimately, a broad open question of this research is whether small-scale fisheries have the internal capacities (e.g. social capital) to respond to increasingly adverse conditions or if their coping strategies are determined and limited by structural constraints (Bohle 2001). However, despite their differences, resilience and vulnerability have been increasingly regarded as complementary concepts. Integrative approaches to the study of disasters and in sustainability science attempt to understand how internal capacities and external conditions interact in order to simultaneously determine processes and outcomes after major shocks (Cutter et al. 2003; Turner et al. 2003; Adger 2006; Berkes 2007; Turner 2010).

The adaptive capacity notion has been proposed as a powerful conceptual approach to bridge the divide between social resilience and vulnerability thinking (Dalziell and McManus 2004; Engle 2011). Adaptive capacity is held by actors inside the system and can be autonomously enhanced by them, but their effectiveness in terms of broadening peoples’ opportunities and producing desirable outcomes is ultimately determined by contextual factors that are beyond actors’ control. Likewise, the socio-relational approach described above has been defined as a merger between agency and structure perspectives (Bodin and Prell 2011). The assumption is that actors express their agency by engaging with others, creating larger networks or structures where they become embedded, which in turn determines their possibilities for action. By operationalizing adaptive capacity as social networks/capital (Pelling and High 2005; Adger 2003), my research contributes with case-based studies to the debate and theoretical development about interplaying resilience and vulnerability of coastal social-ecological systems.

Ecosystem services and human well-being

Ecosystem services are the multiple benefits people obtain from nature (MA 2005). The ES framework developed by the Millennium Ecosystem Assessment is a conceptual model aimed at understanding the consequences of ecosystem change for human well-being and to inform decision-making processes for sustainability (Carpenter et al. 2006, 2012). The framework highlights the mutual interactions and dependencies between society and ecosystems. The multiple dimensions of human well-being are considered to be heavily dependent on the availability of various types of ecosystem services. In practice, studies have highlighted that the wellbeing and livelihoods of different social groups rely on the access to specific natural resources and services that are meaningful to, and sometimes co-produced by, them (Daw et al. 2011; Andersson et al. 2014). In turn, the availability and access to resources can be determined by direct and indirect social, economic, political and environmental drivers of change.

This framework has been applied in many studies to assess social-ecological conditions at a given moment in the history of a place where gradual changes occur (Raudsepp-Hearne et al. 2010, Palomo et al. 2011, Tuvendal and Elmqvist 2011). However, few studies have used the ES framework to assess change after abrupt transformations in social-ecological systems (Troell et al. 2005) related to natural disasters. In this research, Paper V explores the applicability of this framework to describe and analyze the case of rapid and permanent disaster-driven ecosystem transformations and the consequences on coastal people’s well-being and livelihoods.

Research setting – social and environmental change in Chilean small-scale fisheries

This research develops a socio-relational approach to investigate adaptive capacity in Chilean SSF in the face of social and environmental change. In concrete, the thesis considers two different drivers of change, namely the implementation of a fisheries co-management policy and a coastal disaster, and their interrelation.

SSF experiences constant changes in policies regulating the access and exploitation of resources and promoting the conservation of marine ecosystems. In many cases, these solutions become new challenges and problems. Platteau (1989) argues that many fishery modernization programs have, in effect, undermined small-scale fisheries due to limited understanding of fishing livelihoods. In the same vein, Lewins (2004) states: “well-meaning policy interventions have so often failed to produce change because the social and political realities faced by the poor are rarely understood or considered” (p. 44). Because policies and regulations represent key drivers of social change, and potential threats to social resilience, a number of studies have investigated fishers’ abilities to cope and adapt to them (Marshall 2007; Gelcich et al. 2006).

In this study, the driver of social change addressed is the implementation in 1997 of a national policy for SSF called; *Management and Exploitation Areas for Benthic Resources* (hereafter MEABR; Box II) that radically transformed the previous open-access regime into a co-managed fishery (Gelcich et al. 2010). Co-management or collaborative management of common-pool natural resources consists in the sharing of responsibility and power between a group of individuals and the state with respect to the use and exploitation of the benefits of seas, forests, or agricultural land (Berkes et al. 1991). In the Chilean context, after a deep overfishing crisis in the late 1980s (Castilla 2000), the MEABR system allowed long-term recovery of coastal ecosystems and the stabilization of resource stocks that are key for the livelihoods of SSF (Gelcich et al. 2010).

The transformation in fisheries governance described above has been accompanied by the slow-paced and unwieldy transit of traditional fishers into a more modern type of activity. And this process has been rife with challenges, opportunities and threats to fishers at the regional and local levels. The MEABR system: 1) drove the union and blending of different user groups (i.e. fishers, divers and gleaners), through the creation of previously non-existent organizations and the formalization of leadership structures (Castilla and Payne 1994); 2) demanded the establishment of more permanent and complex relationships between fishers, the state, marine scientists/technicians, and multiple other public and private actors (Marín and Berkes 2010); 3) regulated and rationalized the relationship between fishers and the sea, through the definition of exclusive property rights and the introduction of management plans (Bernal et al. 1999).

In practice, fisher organizations along Chile’s coasts have shown different degrees of assimilation and adaptation to the complexities involved in MEABR. Various factors have been assessed as possible determinants of MEABR success or failure, including economic and technical (SUBPESCA 2004), biophysical (Thiel et al. 2007), and leadership and organizational aspects (Schumann 2007). Some studies have referred to the importance of networks and social capital in the performance and adaptation of the MEABR co-management system (Gelcich et al. 2006; Schumann 2010), while few have attempted to empirically measure them (Rosas et al. 2014). Certainly, the diversity of actors involved in the functioning of MEABR (Marín and Berkes 2010), and

the importance of knowledge, information and other resources for Chile's fisheries governance (Gelcich et al. 2007; Mondaca-Schachermayer et al. 2011; Aburto et al. 2014) suggests that social networks play a key role in fishers' success and adaptation to co-management. This thesis represents the first systematic effort to empirically investigate this role.

Box II: Management and Exploitation Areas for Benthic Resources

This administration measure involves the devolution or allocation (by the state) of territorial user rights to formally established and registered fisher organizations, namely unions, associations or cooperatives. After applying for an available area and proposing a management plan, prepared by hired fishery consultants, organizations become responsible for sustainably managing and exploiting the benthic marine resources (e.g. mollusks, seaweed, and crustaceans) within their specific parcels. Fishery authorities retain control and enforcement roles in MEABR functioning, mainly by means of the annual or biannual assessment of follow-up stocks reports, also prepared by consultants, and through assigning a total allowable catch (TAC) for each target species. The design, piloting, and launching of this system responded to a deep overexploitation crisis in the late 1980s with negative social, economic and ecological impacts.

Based on preliminary social, economic, and environmental outcomes, which were judged to be positive, the MEABR system has become well-known as a promising model of natural resources management (Hilborn et al. 2005; Castilla and Gelcich 2006; Gelcich et al. 2010). In addition, co-management areas have been considered as potential building-blocks for a national-scale marine conservation network, along with other conservation mechanisms (Castilla and Gelcich 2006). Nonetheless, various studies have also revealed several shortcomings of the system. For instance, Meltzoff and co-authors (2002) identified the problem of competing visions of stakeholders. The fishers have productivity objectives, whereas the state and biologists hold conservation objectives. Gelcich and co-authors (2006) identified the failure of the policy to integrate and respect existing local and traditional management institutions. Also Castilla and Gelcich (2006), González and co-authors (2006), and Schumann (2007) reported unsatisfactory economic outcomes from managed harvests.

Currently, the MEABR system includes more than 700 areas (Gelcich et al. 2010), but it is highly dynamic in terms of active users and their associated MEABRs. According to official registers (SUBPESCA 2010), new areas are being permanently proposed to the State by fisher organizations, a reflection of a growing demand. A number of MEABRs become formally inactive every year due to the non-compliance of legal requirements. Other MEABRs are voluntarily returned to the authority, presumably due to unsatisfactory results. In 2010, a number of adjustments were introduced in the MEABR regulation set in response to ongoing challenges of co-management. Certainly, the good functioning and performance of particular MEABRs cannot be taken for granted. Co-management is likely to change over time and the capacity of fisher organizations is constantly put to the test. In this thesis, the MEABR represents the frame and setting that define a particular coastal social-ecological system under study.

In addition to changes in policy landscapes, SSF continually have to cope with environmental changes (i.e. driven either by natural or human-induced factors) that affect their livelihoods and/or threaten coastal settlements. The driver of environmental change relevant for this thesis is the February 27th magnitude 8.8 earthquake and the associated tsunami that stroke central-south of Chile (Figure 1). Due to climate and other global environmental changes, more frequent and severe disasters like these¹ are forecasted for the 21st century. In coastal zones, disasters tend to have dramatic consequences for fishers and their communities, including sudden threats to lives and to fishing livelihoods (Adger et al. 2005; Costanza and Farley 2007; Smith 2013). Disasters not only alter ecosystems on which people rely, but they can also destroy infrastructure and technology used to exploit and manage those ecosystems (Miller et al. 2006; Palermo et al. 2013; Mimura et al. 2011). Poverty and high dependence on diminishing natural resources frequently imply a constrained ability to respond and recover among small-scale fishing communities, which makes them one of the most vulnerable groups to coastal disasters and other shocks (Pomeroy et al. 2006). In practice, coastal fisheries and communities manage to cope with and recover from catastrophic shocks in the long-term, but show uneven response capacities. While some groups are able to react quickly and adapt to the new conditions, many have a hard time trying to normalize their lives and risk losing their livelihoods or moving towards unsustainable practices such as overfishing (Pomeroy et al. 2006; Santha 2015).

In the Chilean case, fishing communities are increasingly and unrelentingly exposed to multiple coastal hazards, including severe marine storms, alluvium and landslides, and tsunamis. The 2010 earthquake (i.e. the sixth largest instrumentally recorded) and tsunami has been one of the most devastating events in Chile since 1960. The disaster had severe social and economic consequences, especially for the SSF sector and fishing “caletas” (i.e. coves and villages) all along 600 km’s of coastline and in the Juan Fernández island (Ernst et al. 2010; Dengler et al. 2012). This thesis contributes to a better understanding of the impacts of coastal disasters on coastal dwellers and of the resilience and adaptive capacity of people in the short, mid, and long term in a context of high vulnerability.

When catastrophes strike resource dependent communities, mutual effects between the impacts of the disaster and other ongoing social and environmental drivers can be expected. For small-scale fisheries, recovering from abrupt devastating events normally implies the compound challenge of not only recovering what was lost, but also addressing old and persistent problems, vulnerabilities and slow-paced changes and uncertainties (Pomeroy et al. 2006; Régnier et al. 2008). Authors have broadly explored the interplay between external perturbations and collaborative natural resource management systems. Collaborative management has been considered to increase users' resilience to environmental change and other hazards (Adger et al. 2005; Tompkins and Adger 2004). In addition, co-management arrangements have been regarded as potentially adaptive to multiple social and ecological dynamics and uncertainties (Armitage et al. 2009). But few studies have empirically tested these hypotheses in the context of real case co-management systems affected by large-scale external perturbations. This thesis makes a contribution in filling this gap in the literature, first by investigating whether, and under which conditions, co-management related social capital of SSF organizations can help explain post-disaster recovery; and second, by assessing if, and to what extent, co-management governance networks change or adapt in response to a disaster.

¹ Even though earthquakes have long been considered natural phenomena triggered solely by geological forces (which excludes them from the category of global environmental and climate changes), recent studies have found correlations and interactions between atmospheric, hydrological and geological events (McGuire 2012; Scafetta and Mazzarella 2015). This evidence suggests that earthquakes and tsunamis are likely to increase along with planetary temperatures and other environmental changes.

Study design and scope

The papers cover various temporal and spatial scales in the investigation of adaptive capacity of SSF to social and environmental change. As shown in Figure 1, from a broad perspective, the thesis spans from pre to post-disaster phases. This implies the availability of baseline studies (Paper I; also Marín and Berkes 2010) and the inclusion of longitudinal analyses of social networks/capital (Paper III and IV; Box III). The studies carried on after the disaster represent short, mid and long-term assessments of disaster-driven adaptation processes (Papers II-V).

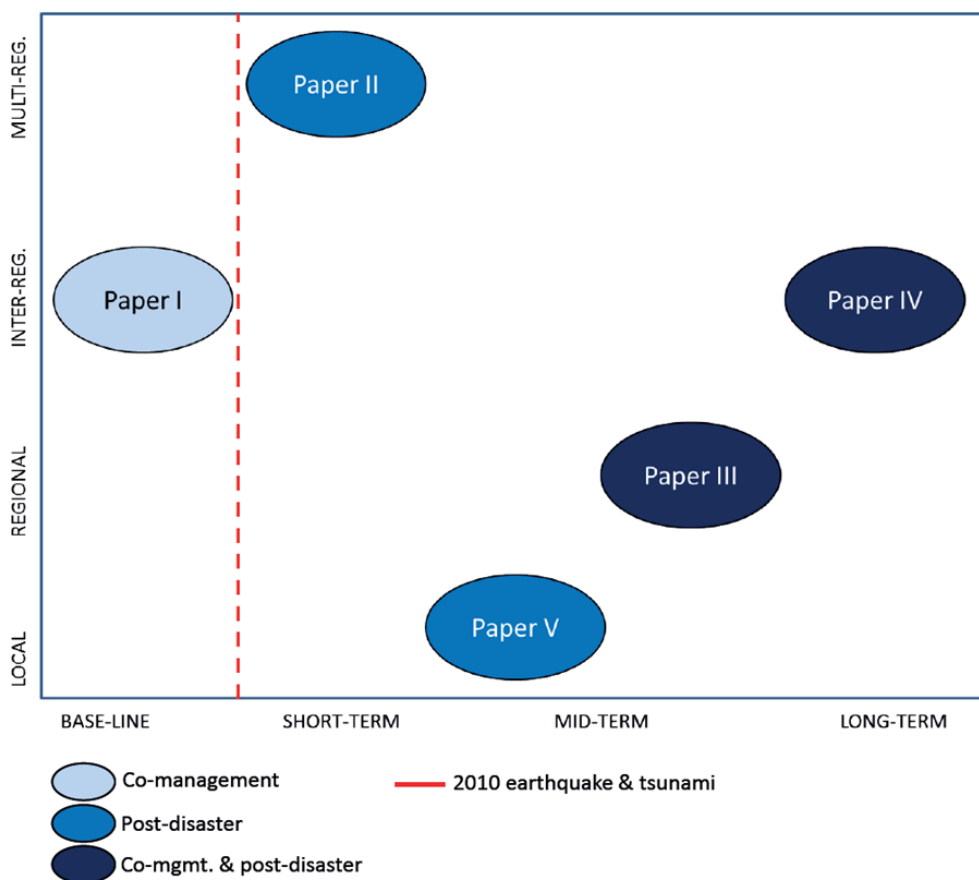


Figure 2: Scope of the thesis. Administrative/spatial and temporal scales, and the adaptation focus that the different papers cover.

The figure also describes the spatial scales covered in the papers. The thesis includes one multi-regional assessment (Paper II), two inter-regional comparisons (Paper I and IV), one intra-regional analysis (Paper III), and one in-depth local case study (Paper V).

In terms of the units of analysis, the papers focus mainly on fisher organizations, namely formally constituted unions, cooperatives and associations comprised of fishers, divers, seaweed gleaners, and also on coastal fishing and non-fishing communities, such as fishers' families and small/medium scale farmer households.

BOX III: The temporal dimension in adaptive capacity research

Timescales are of great importance when studying adaptive capacity to social and environmental change. Shocks and their associated consequences are dynamic and vary over time (Smit and Wandel 2006); similarly, most social adaptations do not occur instantaneously (Brooks et al. 2005; Engle 2011). Therefore, the relationship between adaptive capacity, resilience and vulnerability depends crucially on the timescales of the changes and the adaptations with which we are concerned. Pierson (2003) notes that drivers of change in social-ecological systems can be very fast (e.g. a tornado), and have immediate effects on societies (e.g. damage on housing), but they can also be linked to slow and long-term social processes (e.g. reconstruction). Other drivers that take long time to be manifested (e.g. an earthquake), which can produce abrupt effects on the landscape (e.g. regime shifts and loss of habitats/resources) requiring both mid and long-term social adaptations (e.g. livelihood diversification).

The papers in this thesis have different internal rationales regarding the time horizon of the drivers of change and of the associated adaptations and responses. Below, I summarize the causes and consequences addressed in this thesis, and illustrate the interplaying timescale in each paper (based on Pierson 2003).

Paper	Drivers (Adaptation to what?)	Responses (Adaptation as...)
I	Co-management policy implementation	Levels of co-management performance
II	The tsunami	Disaster responses and evacuation
III	Devastation of fishing vessels, equipment and infrastructure	Recovery of fishing activities and livelihoods
IV	Disaster impacts on the fishery and co-management	Changes in co-management governance networks
V	Coseismic coastal uplift and wetland hydrological regime shift	Intensification, diversification and innovation in livelihood portfolios

		Time horizon of responses	
		Short	Long
Time horizon of drivers	Short	II*	III V
	Long	--	I IV

Legend: * although the earthquake and tsunami is classified here as an abrupt event affecting coastal communities, it could also be considered a long-term cause. There are long-term geological processes that explain the sudden occurrence of earthquakes; also, these coastal disasters, which strike with low periodicity, become -in the long-term- part of peoples' social memory and local ecological knowledge as explored in Paper II.

Methodological and analytical approaches

Mixed methods and tools

The methods used to conduct fieldwork and collect and analyze data are mixed. That is, information was collected combining qualitative and quantitative research tools (Creswell 2003). The aim of using qualitative methods was to learn at the grass-roots level how the individuals describe their problems, the actions and solutions they implement, and the networks within which they operate. Participatory and Rapid Rural Appraisal techniques (Chambers 1994), such as in-depth interviews, workshops, and observation were employed. My informants were fishers, fishers' representatives, scientists, consultants, and public sector officials. The qualitative information they provided plays an important role in the research process, both during the exploratory stages (e.g. to gain a preliminary understanding of the research context and inform subsequent decisions), during the analyses (e.g. with descriptive and comparative purposes), and during the interpretation/discussion of results (e.g. to support making sense of results obtained from quantitative data and analyses).

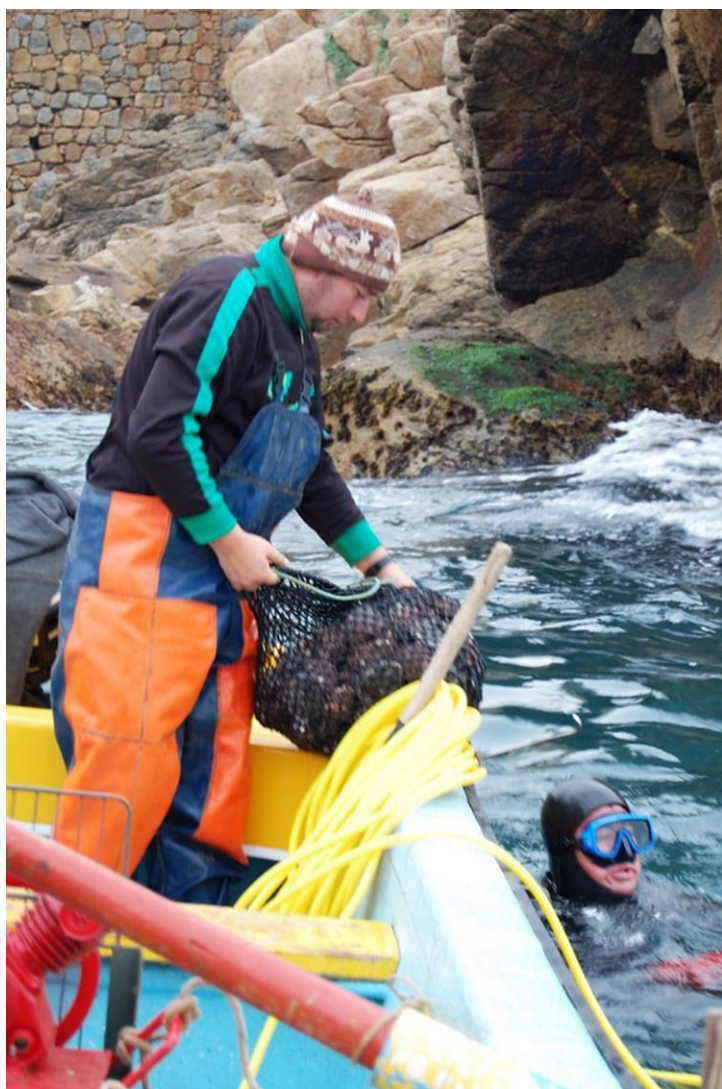
Semi-structured questionnaires (Creswell 2003) were also applied in order to have a broad and representative collection of informants from the fisher organizations and to obtain quantitative data, which allows for more generalizable conclusions. Questionnaires are particularly useful for the analysis of social networks (see below), for instance to systematically register existing and meaningful relationships among actors – by using a list or roster of pre-defined actors – and to prioritize these relationships – to express their strength. Questionnaires can also include closed questions or predetermined choices for answers. The use of Likert Scales of response, for instance, can be useful for numerically expressing different levels of a variable, such as increasing or decreasing trends in the availability of ecosystem services or the extent of damage suffered after a disaster.

Social network analysis

SNA is both a theoretical approach to social life (as outlined above) and a set of concepts and analytical tools to describe and analyze underlying social structures. A social network basically consists of actors, such as individuals, organizations or countries, which may or may not be linked to each other on the basis of one or more relationships, for instance communication, exchange of materials, or support. In addition to conventional actor attribute data used in social sciences (e.g. gender, age and profession from actors A, B, and C), SNA requires socio-relational data (Scott 2012). Relational data refers to the relationships that tie social actors together (e.g. A and B are brothers, and both are acquaintances of C; but B also trades with C), which can be measured and expressed in multiple ways to account for their presence or absence (e.g. binary data), their valence (e.g. positive or negative), and their strength (e.g. frequency or perceived relevance). Relational data are stored and analyzed in a quantitative fashion, using matrices that allow calculation of network measures, such as centrality and density for example, and graph representations (Hanneman and Riddle 2005). In these graphs or sociograms, actors are com-

monly represented as nodes, using for instance circles or squares, and relationships as lines between them.

There are two broad ways or modes to approach the study of social networks. A complete network design is one where an entire set of actors (e.g. “n”) of the same type and the relationships linking these actors together are studied. These networks are mostly based on one-mode and square matrices (e.g. $n \times n$). By contrast, an ego-centered network design focuses on the study of the relationships between actors in one set (e.g. egos or focal actors; “n”) and actors in another set (e.g. alters; “m”). In this case, only egos are interrogated about their relationships with alters, and the resulting relational matrices are rectangular (e.g. $n \times m$). When the set “m” consists of events or actors intrinsically different from actors in set “n” (e.g. individuals vs. associations) then the networks are called two-mode networks. In essence, the difference between one and two-mode designs lies largely in the likelihood of defining network boundaries – that are relevant for the study and delimit actor sets –, and the information and resources available to access and cover either some or all of the actors. In this thesis, I adopt an ego-centered approach to investigate the relationships between fisher organizations (i.e. egos) and co-management counterparts (i.e. alters). Since the latter consist of abstract social roles and categories (e.g. fishery state agencies, universities, and the municipality), as opposed to concrete fisher organizations, I conceive this as a two-mode network design. In paper VII (Oyanedel et al. 2015; not included in this thesis), I have also gained experience in the design and analysis of complete one-mode networks in the context of multi-stakeholder coastal conservation initiatives in Chile.



Harvest time in a MEABR. Hookah diving for ‘Loco’ (*Concholepas concholepas*) in Montemar, Valparaiso Region.

Qualitative comparative analysis

In Paper III, I performed data analysis using Qualitative Comparative Analysis (QCA; Ragin 2008). This is an analytical approach and a set of research tools that allows combining comprehensive within-case analysis and formalized cross-case comparisons (Legewie 2013). QCA aims to identify different causal conditions or pathways leading to a given outcome (Ragin 2008; Schneider and Wagemann 2012). It is based on set-theory and operates on membership scores of cases in sets that correspond to the different conditions (independent variables) and the outcome to be explained (dependent variable). Membership in sets can be conceived as dichotomous and expressed with values 1= member and 0= non-member, for which crisp set QCA is applied. In this study, due to the nature of the problem and the kind of data we collected, fuzzy-set QCA (fsQCA) was used. The fsQCA analytical is suitable for studying phenomena where variables present different levels (e.g. amount of damage) and cases tend to be partial members in sets (e.g. closer to a good performance than to failure), hence membership scores between 0 and 1 can be assigned (Ragin 2008). QCA is particularly appropriate to systematically analyze social-ecological problems where different pathways can lead to the same result (i.e. *equifinality*), where the effect of one factor on an outcome can only be understood together with other factors (i.e. *conjunctural causation*), and where the causes of the presence of an outcome are not necessarily the same as those of its absence (i.e. *asymmetry*).



Fieldwork. Caleta Horcón, Valparaíso Region.

Data sets and data analysis software

Overall, the thesis is based on the application of ca. 309 semi-structured questionnaires and more than 50 semi-structured interviews and 10 workshops/focus groups. The analysis of collected data would be impossible without the use of specialized computer software packages. In this thesis, data processing and analyses were performed in UCINET 6 (Borgatti et al. 2002), Net-Draw 2.135 (Borgatti 2002), QCA version 1.1-3 (Dusa and Thiem 2014), SigmaPlot version 13.0, and MS Excel. Some of the maps included in the papers were done in Quantum GIS (2013).

Summary of papers

Paper I: Exploring social capital in Chile's coastal benthic co-management system using a network approach.

This paper studies the role of bridging and linking social capital for fisher organizations' ability to adapt to and succeed in the MEABR co-management system. The research is based on semi-structured questionnaires applied to 38 fisher leaders and five fishery authority representatives in the Valparaiso and Bio-Bío regions. Bridging and linking social capital levels are expressed as compound indices – based on the egocentric network degree centrality measure - to integrate valence, strength, and other qualities of organizations' co-management networks. Performance in co-management is conceived as a multidimensional variable including seven indicators that refer to aspects of management capacity, social integration, and livelihood diversification. The analysis explores similarities and differences in social capital among fisher organizations and regions, and possible effects of social capital levels on co-management performance. To examine possible effects of combined linking and bridging social capital, four fisher organizations' social capital groups were analyzed and compared.

Results show that the best performing fisher organizations are those with higher levels of linking and bridging social capital. Positive and strong correlations exist between linking social capital levels and co-management success indicators, such as the current performance scale, the number of value-adding enterprises and the “star caleta” indicator. Importantly, fisher organizations considered to manage resources successfully, on a consistent basis, presented high levels of linking social capital, irrespective of variability in bridging social capital.

Drawing on a network approach, the study provides critical insights for improving coastal resource management. Our findings shed lights on actors' differences in co-management performance, highlighting the importance of linking social capital of fisher organizations in adapting to policy change. The research also raises questions about the less evident role of bridging social capital in Chile's co-management, whether related horizontal networks among fisher organizations represent an unused potential and under which condition it could be realized, for instance, for collective action and coastal stewardship.

Paper II: The 2010 tsunami in Chile: Devastation and survival of coastal small-scale fishing communities.

This paper reports the direct impacts of the 2010 tsunami on fishing communities, their small-scale fishing capacity and associated livelihoods along approximately 600 km of coastline in central-south of Chile. The study draws, first, on more than 80 semi-structured interviews with fisher leaders from 59 coastal fishing villages, carried on one

week after the tsunami in the O'Higgins, Maule, and Bio-Bío regions, to learn about human and material damages. Later on, 41 of those leaders were surveyed (personally or telephonically) to collect data and perceptions on key factors of fishing communities' evacuation and survival.

Results estimate and describe the massive devastation of the small-scale fishing capacity (e.g. vessels, gear and equipment, and caleta infrastructure) and the livelihoods of more than 24,000 fisher households in the impacted areas. Importantly, the study shows that despite the magnitude of the catastrophe, the absence of official warnings, and the failure of telecommunication systems only 8 fisher victims were reported out of a total death toll of more than 170. This outstanding response and survival capacity is explained by the existence of tacit local ecological knowledge, bonding social capital, and the right assessment of natural warnings. The timely activation of these latent sociocultural assets in the face of an abrupt threatening shock suggests the existence of a natural hazard subculture among coastal fishing communities. Contrastingly, most casualties corresponded to tourists coming from inland and urban areas who lacked the knowledge and the adaptive capacity to cope with a tsunami.

In the short term, this study provided valuable information for SSF national leaders and authorities to negotiate financial aid and to design recovery programs. In the long term, our findings highlight the value of social capital and local knowledge in hazard preparedness and responsiveness, and stress the need to integrate contextual and behavioural approaches in disaster management and rehabilitation policies.

Paper III: Social capital in post-disaster recovery trajectories: insights from a longitudinal study of tsunami-impacted small-scale fisher organizations in Chile.

The study assesses the factors explaining varied post-tsunami recovery trajectories of fisher organizations involved in the MEABR system in the Bio-Bío region, with a particular interest in understanding the contribution of linking social capital to fishers' mid/long term responses and adaptations to the disaster impacts. Disaster research has looked for singular factors explaining post-disaster recoveries, frequently focusing either on communities' internal capacities or on external constraints. This research investigates whether and how the interplay between internal and external factors – namely pre/post social capital, and levels damage and isolation, respectively – can better explain post-disaster performance. The analysis draws on data collected by means of a semi-structured questionnaire applied to 21 fisher organizations' leaders in Bio-Bío, before and after the disaster; also on interviews with five regional fishery authority representatives after the tsunami. Post-disaster trajectories (i.e. the variable to be explained), are expressed as a five-category scale that reflects different trends in collectively performed productive activities in relation to resources use, management and commercialization. As of the explanatory variables: 1) Pre and post-disaster linking social capital are studied in the context of co-management, based on facilitating relationships organizations possess with actors at regional and national levels, and measured as organizations' degree centrality; 2) Levels of damage capture the degree of material destruction of organizations' vessels, gear, and infrastructure; 3) and levels of isolation express the geographical distance between the place where fishers operate and main regional urban centers. Qualitative comparative analysis (QCA) approach was used to assess how the concurrency of these four factors helps explain how fisher organizations have responded.

Results show that the level of linking social capital is critical in determining post-disaster trajectories such that maintained or increasing levels of social capital is indispensable for positive trajectories to occur, while a common denominator for less desirable post-disaster recovery trajectories is a low or reduced level of social capital. External factors are also relevant in determining recovery trajectories. Thus the capacity of local users to steer better responses through their social networks is important but should not be overestimated. Concurrent factors, such as the amount of damage and geographical isolation can amplify or reduce the importance of supportive and collaborative relationships.

The findings highlight what makes a difference for fishing communities in the aftermath of coastal disasters, and can inform the design of more equitable, effective and efficient responses and policies. In addition, the study suggests that social capital developed for the purpose of co-management of natural resources can actually improve fishers' adaptive capacity and stimulate post-disaster livelihoods recovery.

Paper IV: Impact of disasters on co-management governance networks: insights from a longitudinal analysis of Chilean small-scale fisheries.

The research explores the adaptability of co-management networks in response to the consequences of and challenges posed by the 2010 coastal disaster. The analyses draw on pre and post-disaster data about facilitating and hindering relationships to co-management in 21 fisher organizations in Bio-Bío region, as compared to 16 non-impacted organizations in Valparaíso region. Recent studies have explored which kinds of network structures better accommodate deliberate adaptive management to deal with uncertainty and change. However, there is little understanding of how co-management networks change or adapt in response to abrupt social and ecological perturbations. We specifically look at emergent patterns in network composition (i.e. number and strength of ties), cohesion (i.e. density, centralization and fragmentation), and actors' positions (i.e. in and out-degree centrality) that might indicate adaptive changes in co-management governance networks associated to the disaster.

Our findings indicate that, despite an overall decrease of density, the co-management network in Bio-Bío after the disaster is formed by stronger relationships (i.e. higher levels of trust), is less centralized than could be expected as compared to control, and is less fragmented. The study shows how, in response to the tsunami and associated challenges, the network has evolved according to new priorities, needs and demands. These emergent patterns can change the distribution of information and resources throughout the network, affecting overall conditions and development opportunities for different actors.

Based on other studies, we can speculate that the changes observed reflect an increase in the capacity of the Bio-Bío governance network to respond and adapt to forthcoming environmental changes and other hazards. The policy challenge, in Chile and elsewhere, is to be open to integrate and support post-disaster emerging relationships in decision-making, in order to secure equitable access to key resources and information and to enhance the long-term sustainability of co-management.

Paper V: Ecosystem Services and Abrupt Transformations in a Coastal Wetland Social-Ecological System: Tubul-Raqui after the 2010 Earthquake in Chile.

The study describes and analyzes the social and ecological impacts of a ~1.6 meter uplift in the coastal Tubul-Raqui wetland, driven by the 8.8 magnitude earthquake in Chile, and the associated (mal)adaptive livelihood responses by adjacent fishing and non-fishing communities. The research focuses on understanding changes and responses from the perspective of the resource users, and is based on eight workshops with fisher and neighbor organizations and 154 surveys applied to local dwellers all around the wetland. Using the ecosystem services framework we (1) identify and prioritize ecosystem services people rely on; (2) assess changes in the availability of services and human well-being before and after the earthquake; (3) investigated post-disaster social adaptations and responses; and (4) explored users' interests and visions about possible future social-ecological pathways.

Results show spatially diversified effects of the uplift on ecosystem services, both negative and positive, representing threats and opportunities for different user groups around the wetland. The total loss of the cultivated seaweed "pelillo" is associated with the most manifest reduction in perceptions of well-being among coastal users. Adaptive capacity triggered by pre-existing livelihood portfolios generated intensification in the exploitation of less impacted or enhanced ecosystem services which could be reducing resilience. The study highlights that two years after the transformation there is little attempt to create untried, new beginnings in the Tubul-Raqui wetland from which user groups could evolve to a more innovative livelihood and resource management system after the shift. Although visions about the future are not homogeneous among users, common interests regarding the conservation of key services are shared.

The analysis of abrupt transformations through an ecosystem services approach provides a powerful framework for the study of environmental change and associated impacts on local communities. Importantly, the study presents a case of coastal communities that seem to have the capacities to cope with abrupt changes and increased vulnerability. However, in Tubul-Raqui, the resulting responses may not be adaptive or sustainable in the long-term.

Synthesis of results and discussion

What is the role of social networks/social capital for adaptive capacity of SSF organizations to respond to major changes in marine resource governance and to the impacts of coastal disasters?

Social networks and social capital have been regarded as key conditions for social resilience and adaptive capacity of natural resource users in the face of unprecedented global environmental change (Pelling and High 2005; Adger 2003). The results of this thesis reinforce the general hypothesis about the positive role of social networks and social capital as vehicles for accessing and mobilizing valuable resources and information to achieve collective goals, and as expressions of adaptive capacity in small-scale fisheries.

In the context of fisheries co-management, higher levels of linking and bridging social capital were found among the most successful organizations, which imply greater capacities to adapt to the complexities of policy-change and the overall functioning of the co-management system. In the context of short-term post-disaster responses, bonding social capital within fishing communities - along with other socio-cultural assets - was found to be a central trigger of immediate and effective tsunami evacuation, which indicates well-established adaptive capacity to extreme and unexpected coastal hazards and disasters. In the mid and long-term, higher levels of linking social capital appeared as a fundamental condition for more desirable post-disaster recovery trajectories of fisher organizations, reflecting the importance of cross-scale networks of support to overcome the impacts of disasters and to explore innovative opportunities.

This thesis shows that knitting broad and strong social networks and building social capital are necessary conditions of small-scale fisher organizations and coastal communities' response and adaptive capacity in the face of policy changes and the effects of environmental disasters. This finding is consistent with the idea of social resilience and the existence of internal capabilities that allow "communities to absorb external changes and stresses while maintaining the sustainability of their livelihoods" (Adger et al. 2002, p. 358). However, the study also indicates that they are not sufficient by themselves and suggests a careful and nuanced approach to the study of social networks and social capital as potential answers to the challenges and problems affecting small-scale fisheries.

Findings indicate that it is crucial, first, to differentiate the types of social capital (e.g. bonding, bridging and linking) as potentially relevant for some specific outcomes (i.e. not for all/any outcomes). On the one hand, each type of social capital refers to relationships within and across system boundaries and scales of organization, which enable the flow of different resources and information that are functional to particular goals. For instance, linking social capital can be important to obtain support from distant and powerful actors to co-manage natural resources, but it is less likely to help in responding to and surviving sudden hazards that disable communication systems. Hence, the different types of social capital are context-specific and connected to particular outcomes. However, one may hypothesize that the overall role of networks on complex and dynamic social-ecological processes emerges from bonding, bridging and linking relationships simultaneously. In this vein, Grafton (2005) discussed how the three types of social capital can be linked with different dimensions of fisheries co-management governance in the face of change and uncertainty. However, most case studies, including this thesis, have covered one or, at most, two social capital types (Bodin and Crona 2008; Ramírez-Sánchez and Pinkerton 2009).

Further empirical evidence to test such hypothesis will be necessary, for instance, to explore how the three types work together and how interdependent to each other they are in enhancing or reducing resources users' adaptive capacity.

On the other hand, while social capital and networks were found to be correlated and even to predict social and economic adaptations – expressed as co-management performance, evacuation and survival and post-disaster recovery – it is less clear what their effect is on ecological conditions of coastal areas on which fishers depend. We know that social capital is important for coastal communities' current livelihoods, but we cannot draw conclusions yet regarding the long-term conservation of ecosystems under exploitation. For the case of co-managed areas, other authors have reported higher species diversity within MEABR than in open-access zones (Gelcich et al. 2012) and have also found correlations between social and organizational characteristics and some benthic ecosystems health indicators (Gelcich et al. 2010). The studies in this thesis include qualitative and indirect estimations of the state of resources and ecosystems (i.e. number of target species, management capacity, and post-disaster livelihood strategies). However, more robust and accurate ecological data will be necessary to fill this gap and to complement our findings.

Second, the findings of this research highlight the fact that the expected benefits of social networks/capital depend to a great extent on external factors. This is consistent with the idea of social capital as having a contingent value (Burt 1997). In particular, high levels of linking social capital were found to explain fisher organizations' mid/long-term adaptive capacity, even under contexts of high geographical isolation or high disaster impacts. However, our findings do not support the conclusion that social capital can lead to more desirable outcomes at any degree of vulnerability, for instance in cases of both high isolation and high devastation. There are reasons to think that the positive paybacks from large and diverse supportive networks can be incremental until certain limit in which adaptive capacity are surpassed by contextual constraints. Better understanding of such limits is particularly relevant in a context of increased uncertainty associated with global environmental change.

Third, the thesis pinpoints the importance of taking into consideration that social capital/networks can change over time as a consequence of and/or in response to internal and external processes and shocks. In the research, my findings show that fisher organizations' linking social capital changed between the pre and post disaster phases, and that those changes help explain recovery trajectories. Whereas maintained and increased social capital leads to enhanced adaptive capacity, reduced social capital is associated with reduced or maladaptive capacity. Similarly, a longstanding history of disasters can shape coastal people's culture and knowledge systems, making them better prepared to respond to unexpected threatening events. These insights underline the pertinence of focusing more on the temporal dimension of social capital (i.e. social capital when?). Also, they raise questions about the role and capacity of fisher leaders in building and maintaining social capital, and about which natural resource and development policies foster more supportive and collaborative environments. Importantly, insufficient attention to the temporal variations of social capital can undermine the positive contribution of social capital to adaptive capacity and enhance the vulnerability of certain groups to social and environmental change.

Fourth, the work underlines the treatment of social capital/networks as relative concepts about the social reality (i.e. not normative), which illuminate not only the positions of the better connected and most advantaged actors within a system, but also of its less integrated and more vulnerable actors. Whether assessed in a cross-sectional or longitudinal way, social capital studies have a high probability to describe evolving landscapes of social inequity. Social capital has been defined as a metaphor about the relative advantage of some individuals and actors over others (Burt 2000). While usually the use of social capital in research and policy discourses is being criticized for presenting and fostering an idealized image of social life, the network approach to social capital is of a more analytical kind. In this thesis, the social capital approach helps to characterize the winners, namely those with improved capacity to recover, innovate and diversify,

and the losers, namely those with reduced coping capacities and increased levels of exposure in the face of social and environmental change. Else, it highlights underlying mechanisms that can be modified and reshaped to create more resilient and less vulnerable coastal social-ecological systems.

To what extent do small-scale fisheries have the internal capacities to respond to increasingly adverse conditions or are their coping strategies determined and limited by structural constraints?

The potentials and limitations of social networks/capital as sources of adaptive capacity in small-scale fisheries relate directly to the debate between resilience and vulnerability approaches to understand dynamic society-nature interactions. In this thesis, some risks associated with over-emphasizing these two perspectives must be pointed out. By only looking at the resilience of a given social-ecological system, and putting high expectations on social capital and adaptive capacity of actors (i.e. their agency), recovery and development policies may fall into some kind of *laissez faire*. If people are supposed to have enough of the right capacities to confront and overcome different shocks, then the role and responsibility of the state and the rest of the society in supporting small-scale and traditional livelihood systems could be completely minimized, entrusting their fate to their autonomous performance in the market. On the contrary, by only looking at the vulnerability of local users, and justifying their unfavorable performance and conditions based on external determinants (i.e. structural constraints), post-disaster and development programs may be influenced by paternalistic visions. If communities are considered to lack the capacities to respond to adversity and get ahead, then the only way to overcome permanent threats is by being subject of state and external intervention, undermining individual and collective capacities to organize and innovate.

Various authors have highlighted the need to move towards more integrated theoretical frameworks, which give proper weight to the role of human agency, structural constraints and the environment in the production of more/less sustainable futures (Turner et al. 2003; Adger 2006; McLaughlin and Dietz 2008). A reasonable approach that is supported by the findings of this thesis is to view resource users neither as passive “observers” of their vulnerability nor as fully autonomous agents of their resilience, but a combination of both. Ultimately, the consolidation of SSF as a sustainable engine of human development, in a context of increasing social and environmental complexity and uncertainty, will be neither determined by levels of resilience nor of vulnerability, but by the interplay of both.

Such an integrative vision is attuned with a socio-relational approach to adaptive capacity. Social network analysis and the network approach to social capital emphasize the existence of resources and information that are potentially accessible for actors by means of their relationships with others situated at different social, economic and political levels. The underlying idea is that, ultimately, social networks/capital are not intrinsic/internal nor extrinsic/external attributes of the system of concern. Social networks tend to bridge and cross multiple scales, connecting multiple actors that are sources and recipients of resources and information, both within and across system boundaries. Thereby, networks have the potential to simultaneously increase levels of resilience and reduce levels of vulnerability. Bohle (2001) refers to the idea of coping resources or “assets” that are accessible and potentially under the control of people, which contribute to mitigating their vulnerability and strengthening their resilience towards multiple social and ecological threats. This thesis supports the idea that vulnerable resource user communities – who are likely to lack financial and political power - can ultimately rely on their social networks of mutual trust, shared norms and reciprocity to expand their opportunities to adapt and secure more sustainable livelihoods in the face of growing and unprecedented social and environmental changes.

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