UNDERSTANDING ADAPTATION AND SOCIAL-ECOLOGICAL CHANGE

IN CHILEAN COASTAL COMMUNITIES

by

Jordan Tam

B.A., The University of British Columbia, 2005
M.A., The University of British Columbia, 2010

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Abstract

In recent decades, attempts have been made to integrate social and ecological dimensions of change into understandings of resource sustainability, yet challenges persist. Complex dynamics in social-ecological systems fuel these challenges, rendering it difficult to anticipate and address problems arising from development or environmental change. This dissertation examines the ability of common-pool resource (CPR) theories to address and realize sustainable management. Traditionally, CPR systems have been understood as a set of design principles for managing resources, especially single-resource regimes wherein local drivers of change are known. However, most CPR settings are embedded in complex systems and affected by drivers at global to local scales. This recognition has led many scholars to champion adaptation as the way forward, but significant confusion remains over key concepts, including adaptive capacity. Focusing on Chile’s small-scale fishers and divers, I explore how user adaptations and sociocultural shifts in response to globalization can threaten the resilience of Chile’s celebrated territorial user rights regime. I develop a typology of user motivations, and explain how these intersect with user adaptations and expand our ability to create more robust management. By studying the concrete adaptation behaviours of marine users, I also demonstrate how adaptive capacity is a proactive process and behaviour-specific, contrary to assessment methods that emphasize generalizability. Similarly, by measuring social learning as the propensity of individuals to attend to social information, I show how social learning may not be uniformly positive (and may even be negative) for social-ecological outcomes, counter to expectations in contemporary resource literatures. Finally, it is generally assumed that common understanding of resource dynamics will improve the kinds of collective action that ensures the success of
CPRs. Results suggest that other variables may be more important (e.g., migrant population), and the positive role of common understanding requires further testing using clear measures. Overall, the results of this dissertation suggest a need to attend to, and account for, a broader set of potentially significant social and psychological variables. Adopting a more precise and critical eye regarding human factors, as endeavoured in this study, may help the science of social-ecological sustainability progress more capably and effectively.
Preface

This research was made possible by the contributions of many individuals. As a whole, this dissertation draws from two separate surveys designed and administered in Chile in 2013. This work was approved by UBC’s Behavioural Research Ethics Board (certificate number: H12-03130).

I designed the research and the instruments. Overall, however, Drs. Kai Chan and Terre Satterfield contributed throughout the dissertation process and were consulted regularly to improve the problem-framing, general research design, and instrument design; their advice has been indispensable. I also received valuable feedback and advice in aspects of the survey design. I designed the core of each survey. These were refined with the help of Drs. Terre Satterfield, Kai Chan, Stefan Gelcich, and Timothy Waring. Dr. Stefan Gelcich was key in providing numerous reviews of both survey instruments as the in-country host for my research, and also helped scope and orient the fieldwork. Dr. Timothy Waring provided instrumental guidance in the design of the ‘social learning game’ that is the core of Chapter 4.

Administration of the survey was conducted by me, along with a number of assistants including: Camila Vargas; Javiera Espinosa; Matías Guerrero; Marcelo Galvez; Maria Ignacia; and Andres Jacques. The aforementioned assistants also helped translate the survey and the results from English to Spanish, and vice versa, and Antonia Perez and Jennifer Romero Valpreda provided additional help with translation.
I conducted the analysis for every chapter, but received advice and direction from my committee throughout. I also received R programming support and assistance from Gerald Singh and Caitlin Millar, especially in the lasso regression and t-test analyses in Chapter 5.

I wrote the vast majority of this dissertation. However, I received invaluable contributions, comments, and reviews throughout from my committee: Drs. Terre Satterfield, Kai Chan, Stefan Gelcich, and Timothy Waring. Chapters 1 and 7 aside, all chapters were written with the intent of publication, however, none have been published at present.
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Chapter 1: Introduction

No man ever steps in the same river twice, for it is not the same river and he is not the same man – Heraclitus

1.1 The challenge of elucidating and adapting to change at multiple social scales

People depend on marine ecosystems to satisfy a great diversity of needs. Fishing is the principal livelihood of millions of people worldwide, while seafood represents the major source of protein for one billion of the world’s population (WRI, 1999). Ecosystems are furthermore crucial for the wellbeing of people in many more ways, from the tangible to the intangible (such as our spiritual and mental wellness), yet continue to be degraded at a rapid pace.

Finding solutions to challenges posed by environmental and natural resource sustainability continue to be elusive and difficult to achieve, in part, because they are sought in settings of constant social and ecological change. Resolving patterns of change and how persistent and oftentimes unpredictable shifts in social and ecological system states can be accounted for and accommodated (i.e., adaptation), and their implications for resource management in practice, are all major themes in contemporary sustainability science scholarship. While it is difficult to pinpoint the genesis of this intellectual trend, certainly part of the interest is attributable to well-publicized and shocking failures in resource management that held as a core assumption stable and simplified models of ecosystems (e.g., Atlantic cod fishery collapse), and have likely contributed to the embrace of more dynamic conceptualizations of social-ecological systems.
(SESs). Global scale changes as a result of human actions, including climate change and globalization, may have also contributed to this shift in interest.

In the above vein, this research aims to investigate how resource users and management institutions (i.e., rules and norms) adapt in response to change, and the implications for people and natural resources. Specifically, I ask how community-based resource management and resources users will fare in the face of globalization, and whether the ability of users to adapt is uniform or different across different changes. I also ask what leads to the tendency of people to learn from one another or hold similar perceptions, and whether learning and shared views are positive for resource management and social adaptation.

The inclusion and more serious consideration of people (e.g., resource users), both as a factor affecting environmental sustainability outcomes, and the need to improve the human condition itself as an outcome, is a second major theme of modern sustainability discourse. Blaming people for the deteriorating state of the natural environment is, of course, not new academic or rhetorical territory. Rather, the ‘human dimensions’ (e.g., psychological processes, social interactions, governance, culture) have become accepted as a crucial aspect of the sustainability puzzle. Some of what constitutes ‘serious consideration’ in more recent resource scholarship is attention to people as part of—rather than apart from—ecosystems, where complex feedbacks exist within social-ecological systems, and as more than rational actors and consumers of ecosystem goods and services, to encompass a wider set of social structures and variables.
Interest in topics of change, adaptation to change, and human factors as related to environmental sustainability (and their linkages) have, together, led to a burgeoning of interdisciplinary work and collaboration between several major intellectual lineages. Among them are the linked literatures of resilience and adaptive co-management, common-pool resource management, and vulnerability. However, the degree to which human behaviour and dynamics are considered in different literatures varies. Uptake of these themes has also been apparent in environmental management frameworks, such as in ecosystem-based management (EBM; McLeod & Leslie, 2009) and conservation planning (e.g., Ban et al., 2013).

In particular, research on the concept of resilience has placed much greater emphasis on observing social and ecological systems as a whole, rather than only as parts, and drawn attention to dynamic interactions. At its core, the resilience perspective is based on the idea of linked social and ecological systems as complex with adaptive components (Levin, 1998) and is characterized by self-organization, feedbacks, and interactions (Folke, 2006). Resilience itself is defined as the ability of a system to absorb and buffer perturbations while maintaining essentially the same functions, processes, and identity (Berkes, Colding, & Folke, 2003; Folke, 2006; Walker et al., 2006).

Resilience researchers have done much to illuminate and put human interactions with nature in a systems perspective with attention to thresholds, feedbacks, and change over time (e.g., the adaptive cycle). Such a view is in stark contrast to the perspective on social and ecological systems that has traditionally informed and dominated natural resource management which assumed a single equilibrium and predictable linear relationships, and thus validated extraction
policies such as those based on maximum sustainable yield (Berkes et al., 2003; Holling, Gunderson, & Ludwig, 2002). However, resilience is a field that emerged and is informed primarily by ecology. The need for greater emphasis on social considerations and their integration has been recognized (Walker, Holling, Carpenter, & Kinzig, 2004).

At the heart of resilience is a heuristic model of change called the ‘adaptive renewal cycle’ which describes a four step sequence that hypothetically characterizes change in ecological and social systems at any given scale (Holling, 2001). These four steps are exploitation (r phase), conservation (K phase), release (Ω phase), and reorganization (α phase). Moving from the Ω phase to the α phase is the so-called ‘back loop’ of the adaptive cycle. According to Berkes et al. (2003), the back loop is the location in the adaptive cycle where the innovation and novelty essential to adaptation can be generated. Often the back loop is viewed as being triggered by a crisis, opening a ‘window of opportunity’ to change.

In addition to the ability of a system to buffer disturbance, the degree to which a system is able to reorganize and adapt over time is also proposed as crucial to resilience (Folke, 2006). It has only been relatively recently that high resilience has been distinguished as a potentially negative property, as in cases where an undesirable state is maintained and difficult to change (Walker et al., 2006). In addition to adaptability—the ability to learn and adjust to maintain the system in the desired state—a second type of change is critical to the state of a SES. This change is known as transformability, which is the ability to change the fundamentals of a system to shift to an entirely new type of system (Walker et al., 2004). In the resilience framework, then, sustainability is the maintenance of a high capacity for adaptation to remain
in desired states and the ability to undergo controlled transformation while preventing unintended shifts into other regimes or transformations. In other words, maintaining resilience at a high level allows the system to buffer and adapt to change while maintaining its essential features and functions.

While conceptual advances made by resilience researchers have helped to question certain assumptions about social-ecological interactions (e.g., linearity) and expanded thinking on SES dynamics, in some respects, resilience scholarship is empirically weak. Considerably more evidence has been amassed supporting the idea of resilience in ecological systems compared to social systems, while evidence of resilience dynamics in coupled social-ecological systems is virtually absent except in a handful of qualitative case studies (e.g., Kristianstad, Sweden; Everglades, USA; Mae Nam Ping Basin; Thailand; Olsson et al., 2006). As a result, resilience as applied to more social dimensions, such as social learning (i.e., the transmission of knowledge between individuals and groups) and social adaptive capacity (see pg. 79 for definition), lack operational clarity and nuance for explaining social change, and resilience research has had little real impact on management itself in advising policy processes.

Another prominent stream of research that has tried to address social-ecological relationships and their persistence is the work on common pool resource (CPR; i.e., resources where use by one party means the loss of use by another party, and where exclusion is difficult) systems and the institutions that appear to be correlated with long-lasting resource management regimes. The work of Elinor Ostrom and colleagues on common pool resources is arguably most famous for debunking the “Tragedy of the Commons” proposition (Dietz, Ostrom, & Stern, 2003;
Hardin, 1968), in which self-interested individuals in a commons inevitably degrade the environment absent privatization or central government ownership. Instead, through a substantial set of empirical case studies, Ostrom and colleagues have demonstrated many examples of successful and long-lasting self-organized resource management in the absence of either privatization or central ownership, and the importance of institutions (Ostrom, 1990). One result from this work that has often been cited are the eight ‘design principles’ (e.g., graduated sanctions, conflict-resolution mechanisms, etc.) commonly found in successfully managed commons (Cox, Arnold, & Villamayor-Tomas, 2010; Ostrom, 1990).

In comparison to the study of resilience, much more emphasis and attention has been paid to the human variables in research on collective action (i.e., coordination and cooperation in groups) in common property regimes for common-pool resource management. In particular, work on common property highlights governance and institutional arrangements with implications for natural resource extraction (Imperial, 1999), but also recognizes that governance occurs in contexts that are often marked by conflict between stakeholders, who share different values, and where power differences are inherent (Dietz et al., 2003).

Whereas human considerations are front and centre in explorations of common property systems, research in this field has traditionally given little attention to multiple scales and feedbacks beyond the immediate system. Rather, investigated systems tended to be isolated and small-scale single resource domains for the obvious reason of interpretability. More recently, there has been an expansion of both methods (beyond case-studies) and scope to gain greater insight on common-pool resource systems as comprising intertwined social and
ecological dimensions, such as the use of experimental methods (Janssen, Holahan, Lee, & Ostrom, 2010). A social-ecological systems perspective has also found favour among CPR researchers with efforts to systematically understand the factors that are associated with successful management being sought through ‘diagnostic’ frameworks that explicitly incorporate feedbacks, multiple scales, and ecosystem components (Basurto & Ostrom, 2009; Ostrom, 2007).

The strength of the CPR field is in understanding the importance of institutions. Though the design principles for ensuring sustainable common-pool resources are compelling, they are built on a foundation that does not necessarily account for the complexities and challenges of the modern world. The case studies that are the basis of the conclusions of CPR research have tended to be narrow in scope, with small, homogeneous single resource systems as the primary object of study. Conversely, reality on the ground or at sea is significantly different than these idealized types. In the modern era of the Anthropocene it is an inescapable fact that social-ecological systems are often not so easily circumscribed.

Furthermore, neither the SES analytical framework nor the list of design principles is sufficiently nuanced to be used for planning management actions in specific contexts. That is not to take away, however, from the ground-breaking influence the design principles in particular have had on improving understanding of common-pool resource systems and spurring continued research (e.g., Cox et al., 2010). Nonetheless, there is for instance, little knowledge of when particular design principles are important or not, why they sometimes fail or are sometimes successful, and how they arise and are implemented (see Cox et al., 2010 for a similar set of
identified criticisms). However, attending to interactions and temporal variability has led researchers to examine the different kinds of interactions between various components of the social system and recognize that institutions can become well adapted to certain kinds of variability over time, but these adaptations can also make them vulnerable to certain changes (Anderies, Janssen, & Ostrom, 2004; Janssen, Anderies, & Ostrom, 2007). As an example, Janssen et al. (2007) point to Gaddi shepherds in India, whose movements over the landscape are highly adapted to the terrain and patterns of rainfall, mediated through associated social networks and norms that ensure timely access to agricultural lands. However, these tailored informal institutional arrangements are very susceptible to changes, such as the formalization of land privatization that have created barriers to access.

As with the study of common-pool resource governance, consideration of vulnerability research for social systems is substantially greater than found in the resilience literature, likely as a product of differing epistemologies. One origin of the vulnerability concept is research on natural hazards, although different scholars have considered other fields to be major developers of the concept, including political and human ecology, and even resilience (Adger, 2006; Eakin & Luers, 2006).

Vulnerability research as a whole explicitly incorporates human beings and how they differ. Power differentials, history, culture, governance institutions, political process, economics, livelihoods, social networks, demographic considerations and much more are critical to vulnerability and vulnerability scholarship. Also key are human beliefs, values, perceptions, and knowledge (Adger, 2006; Miller et al., 2010) that can determine how vulnerable people are and
how they might adapt to different hazards. On the other hand, ecological factors in vulnerability are considered to a much lesser degree (Adger, 2006; Miller et al., 2010).

In particular, vulnerability research observes that exposure, sensitivity, and adaptive capacity are all dependent on the social context of the target of concern (Adger, 2006; Eakin & Luers, 2006). Exposure relates to the probability and extent of contact with a hazard; sensitivity to the extent of impacts caused by the stressor; and adaptive capacity to the ability to cope and mitigate the impact of a hazard and recover from the impacts (Adger, 2006; Brooks, Adger, & Mick Kelly, 2005; Eakin & Luers, 2006; Miller et al., 2010; Smit & Wandel, 2006). However, others have considered exposure to be separate from vulnerability (Gallopín, 2006).

Importantly, most researchers consider vulnerability to be, in large part, a function of a person or group’s ability to access and mobilize capital (of all kinds), mediated by social institutions and governance structures that interact with a particular stressor and, as such, is highly context specific (Adger, 2006; Smit & Wandel, 2006).

While vulnerability is recognized as dynamic, many past assessment methods have taken snapshot “single-stressor-single-outcome” approaches (Eakin & Luers, 2006, p. 380). Fortunately, more recent investigations have aimed to fill this void by explicitly addressing multiple stressors over time (e.g., McDowell & Hess, 2012; O’Brien et al., 2004; Tschakert, 2007). Nonetheless, research continues to be needed on a number of fronts, including how vulnerability may translate from one scale to another, the importance of ecosystem conditions for determining vulnerability, and how vulnerability changes over time (Adger, 2006). Many methods of assessment also often operate under linear assumptions (Brooks et al., 2005; Eakin
& Luers, 2006) and attention to dynamic feedbacks between social and ecological domains is often neglected (Miller et al., 2010). In general, vulnerability research often takes a short view of history that focuses on social actors rather than systems (Miller et al., 2010). The absence of a general theory of vulnerability has been seen as the greatest barrier in the field (Eakin & Luers, 2006).

While practical and theoretical efforts to date are laudable, a number of key issues, some of which are touched on briefly above, continue to obstruct progress in elucidating how humans interact and adapt with the environment to affect the sustainability of resources, and how social-ecological systems change through time. Some of these issues can be broadly classified as follows: 1) confusion over major concepts and conflation between their precedents and outcomes; 2) lack of systematic and detailed methods that allow for complementary investigations; 3) deficiency of operationalization, and thus measures and data adequate for statistical inquiries; and 4) the proliferation of assumptions and, as yet (despite advances), a relatively narrow contemplation of human behaviours and psychologies than what is possible.

In sum, even though social systems and their dynamics are recognized as key intervention points for managing social-ecological system resilience and sustainability, and significant insights have been offered on the critical differences between social and ecological systems, these have not been adequately elaborated. The challenge is to take the differences between ecological and social systems seriously and understand the implications.

Despite the aforementioned advances in theory, management in practice, and in particular marine management as will be discussed here, is a story of both successes and failures. For
instance, within popular ecosystem-based management (EBM) frameworks, there are three key elements: that connections between people and the environment are important and can be linked through the concept of ecosystem services; that human impacts are additive and possibly synergistic (i.e., cumulative), and so management and policies must be integrated across sectors, organizations and stakeholders; and that there exist multiple objectives and trade-offs between objectives (McLeod & Leslie, 2009; Rosenberg & McLeod, 2005). EBM is also grounded in the concept of resilience, uses a holistic perspective of people as part of ecosystems, and emphasises cross-scale interactions and the need for adaptive management (McLeod & Leslie, 2009). To realize EBM, the use of diverse management tools to cope with uncertainty, spatial planning to organize the activities of multiple sectors, matching governance to ecosystems scales, and attending to human goals and influence on systems have been suggested (Ruckelshaus, Klinger, Knowlton, & DeMaster, 2008).

From the track record of EBM in practice, however, it is clear that consistent success in application remains a challenge (Murawski, 2007). A recent study of fisheries in 33 countries revealed that only two countries (Norway and USA) achieved an overall EBM score at a ‘good’ level (7/10 or above on a performance score), with about half failing (4/10 or less) based on their adherence to EBM principles, performance on indicators of EBM success (e.g., social, economic and cultural context of fishery is incorporated, knowledge is adequate), and following recommended steps for the implementation of EBM (e.g., identify stakeholder community, design performance assessment and review processes; Pitcher, Kalikoski, Short, Varkey, & Pramod, 2009).
Failure in management implementation, not just of EBM, is a major theme of current marine literature. Indeed, the record of MPA is also unfortunately blotted with failures both biological and social. In a study of MPAs in Southeast Asia, Christie (2004) describes cases of biological success (i.e., halting ecosystem degradation) while being ‘social failures’ (e.g., mistrust and reduced stakeholder support). In another study, an analysis of 56 marine reserves in the Western Indian Ocean, Caribbean and the Philippines demonstrated that impacts on fish biomass depended on the region and social factors (e.g., compliance), with some social factors showing opposite effects (e.g., population density being negatively related to biomass in the Caribbean while positive in the Western Indian Ocean; Pollnac et al., 2010). Elsewhere, among co-managed fisheries (aggregated social, economic and ecological), success appears to be related to the presence of varied combinations of nineteen co-management (i.e., management in partnership between local communities and governments) attributes depending on location, fishery type, and level of development, with a minimum threshold of eight being present (Gutierrez, Hilborn, & Defeo, 2011). In another review, significant differences were found in successful resource management (in terms of ecology) among ‘progressive’ small-scale fisheries despite high social organization (McClanahan, Castilla, White, & Defeo, 2009).

The evidence presented begs the question: why are some management efforts more successful than others? One key aspect is likely people (e.g., Charles & Wilson, 2009; Fulton, Smith, Smith, & Van Putten, 2011). People are acknowledged as a key part of management as reflected in the following statement: “...ultimately [in EBM] we are managing people’s influences on ecosystems, not ecosystem themselves” (McLeod & Leslie, 2009, p. 5). Accordingly, a great deal of attention has been directed to the human issues of governance (Christie & White, 2007;
Mahon, Fanning, & McConney, 2009) and institutional design (Ostrom, 1990), human impacts and benefits of marine policy or protection (Mascia, Claus, & Naidoo, 2010), and the dynamics and responses of people as features of linked to social-ecological systems (McClanahan et al., 2009; Pollnac et al., 2010). Despite this, seeing marine ecosystems as involving people and taking that view and the implications seriously is still a relatively new development (McLeod & Leslie, 2009).

As argued by Charles and Wilson (2009), at least in the case of marine protected areas (MPAs), planning and management must take into account the ‘bigger picture’. That is, all such efforts are situated within a broader context of society, politics, and regulatory frameworks that exist in other sectors (hence the need for cross-sectoral integration and attention to cumulative impacts as advocated in EBM; McLeod & Leslie, 2009). Furthermore, governance arrangements that include institutional design and coordination, and issues of decision-making power and processes are critical (Charles & Wilson, 2009). It is within this overarching understanding of the influential role of human society that scholars have sought to identify the specifics that lead to better management design, implementation, and impacts (both ecological and social).

Ultimately, how will people behave? The success of any management scheme or policy presumably hinges on how people will behave in response (Fulton et al., 2011), for instance whether people will act cooperatively, comply, accept management processes and outcomes, or even be willing to participate and share knowledge. People’s individual behaviours, when viewed externally (and in isolation) can appear irrational, but can often be understood from their point of view and thus anticipated (Fulton et al., 2011). Understanding behaviour can help
improve management but remains a significant gap (Ban et al., 2012) that requires that we pay attention to many of the factors elaborated above, such as local ecological contexts and cultures (McClanahan et al., 2009).

Data-intensive analytical work has revealed that many social factors previously hypothesized to matter for management outcomes do appear important. For example, Gutierrez et al. (2011) found that the influence of co-management variables depended on the social-ecological context and the target resource, and that leadership, social capital, limits on extraction, and enforcement all affected management success. An analysis of 34 conservation initiatives by Kenward et al. (2011) found that ‘knowledge leadership’ (or knowledge sharing) and monitoring had a strong positive association with ecosystem service provision, sustainable resource use, and the conservation of biodiversity, whereas the presence of tools used to regulate resource use was negatively associated with the provision of services but positively with biodiversity conservation. Evidence of from MPAs in the Philippines found that the availability of alternative incomes, monitoring, participation, and training all contribute positively to success (Pollnac & Seara, 2010). Population and population density appear to have negative effects, but these appear to depend on region, as is the case with compliance on ecological outcomes, which is in turn affected by monitoring and participation (Christie et al., 2009; Mascia, 2003; Pollnac & Seara, 2010) for more evidence on perceived fairness of enforcement, cross-institutional linkages, conflict, capacity and participation). In sum, human dimensions are interactive and complex with positive or negative influences depending on context.
It is clear that attention to social systems and human factors are essential for the design and implementation of management and to assess the impacts of management in marine areas. While the marine management literature contains an abundance of knowledge of what needs improving, there is relatively little concrete detail on how improvements should be made in any particular system. However, given the importance of human behaviour, it would be beneficial to have a more accurate and nuanced view of human behaviour.

1.1.1 Problem statement and research goals

Given the many challenges identified above, the problem is that management on the ‘ground’ is massively complex, characterized by multiple impacts and actors, and feedbacks and interactions between and within scales and social and ecological system components. Yet, managers absolutely require concrete predictive and diagnostic guidelines and tools. This research thus aims to clarify and empirically examine some of this complexity, by characterizing and elaborating on social concepts that are frequently used in natural resource literatures, and processes of change in response to drivers from global to local scales (e.g., deriving from globalization and development such as international market pressures, demographic changes, and infrastructure expansions), especially as they relate to the sustainability of common-pool resources and their governance. To this end, I ask the following four research questions that will be tackled in subsequent chapters in a case study of Chilean artisanal fisheries:

1. How is social change, driven by globalization and development, likely to challenge community-based resource management regimes, such as co-management for common-pool resources, and what can be done?
2. How valid is a generalized concept of social adaptive capacity as opposed to a more specific understanding of what factors facilitate or hinder different kinds of adaptation?

3. How is social learning different from its hypothesized precedents and outcomes, and how is social learning manifested at different social scales?

4. How can common understanding of resource dynamics be operationalized and how is it linked to collective action for common-pool resource?

By answering the above research questions, the present research aims to generate insights that both aid managerial decision-making in realms of natural resource management and fill gaps in our understanding of social-ecological dynamics through a better understanding of the social dimension.

The principal objectives of this research can thus be stated as follows: to 1) more precisely define and clarify for operational purposes some of the major concepts used in resource management literatures (i.e., adaptive capacity, social learning, and common understanding); 2) begin to operationalize and adapt or create new measures that are replicable and easy to administer, and are suitable for quantitative investigation and prognostic quantitative analysis where possible; and 3) expand the set of human psychological and social dimensions under consideration, and demonstrate how they may be important for social-ecological outcomes.
1.2 Why Chile’s artisanal fishing communities?

As a consequence of human activities in and around the ocean environment, ecosystems experience cumulative anthropogenic effects with impacts to ecosystem function and quality. These ecosystem impacts have implications for the ability of the oceans to provide for people. Thus, over the long-term, the critical question of sustaining human well-being is inseparable from maintaining productive and healthy ecosystems. As such, the theories raised previously are highly pertinent with implications relevant for the well-being of people around the world.

These above research questions are addressed in the context of artisanal fisheries in Chile and their governance, which includes the territorial user rights fishery (TURF) system, which provides a unique opportunity wherein the characteristics of the resources being harvested and the macro-level (national) institutional constraints can be held relatively consistent and thus affords the opportunity to study variation in behaviour and local institutional structure as a symptom of community socio-cultural, ecological, and economic contexts (and vice versa). In addition, the problems confronting marine managers in Chile are reflective of the difficulties encountered in the management of ocean resources worldwide. There exist disputes over territorial rights between fishers (Gelcich, Edwards-Jones, Kaiser, & Watson, 2005), conflicting cross-sectoral interests such as between forestry and artisanal fishers (Holt et al., 2012), disputes between conservation and development as in Patagonia and hydroelectric dams (Sáenz-Arroyo, Roberts, Torre, Cariño-Olvera, & Enríquez-Andrade, 2005), and as anywhere, challenges associated with meeting the needs of multiple stakeholder groups.
Fishing unions/syndicates under the TURF system are currently engaged in the harvest and extraction of many marine species, including kelp, shellfish, and finfish, though the types of species targeted and their abundance differs between sites. In the case of Chile, sites may be bound geographically by ‘caleta’ or cove, within which one or more unions may fish a mix of TURF designated areas and open access areas. The active participation of local marine users in TURF management is, additionally, fundamental to maintaining protected stocks, in contrast to contexts where fishers are too numerous, as is typical of many industrialized fisheries. It is this richness in exploitable species, the diversity in local institutional systems, and the importance of local user participation for social-ecological sustainability that make the Chilean case study of great interest. The Chilean co-management regime is furthermore highly regarded in the CPR literature and well studied.

For one specific fishery, significant changes in the past ten years have been observed in the harvesting of kelp, which has traditionally involved their collection (of castoff) and drying from the intertidal zone. However, due to increased demand and prices on world markets for alginic acid (e.g., for food and pharmaceutical purposes) and the rise of abalone aquaculture in Chile that requires kelp as feed, kelp extraction has grown rapidly and harvest has expanded to include the purposeful extraction of kelp from the subtidal, which may lead to significant ecological impacts, as kelp is a key habitat provider.

Over the past decade, the kelp fishery has become firmly established in the northern part of Chile and the fishery appears to be spreading south. The unfolding change in the kelp fishery represents only one among many other simultaneous changes affecting artisanal fishing
communities, and offers a unique chance to research adaptive capacity in ‘real-time’ and to examine coupled social-ecological responses.

Figure 1. Map showing nine research sites (i.e., caletas), indicated by grey markers, and their locations in Region V relative to Santiago and Valparaiso. Map data is provided by Google (2016).

The central region of Chile (Region V), which borders Santiago, is also a logistically sensible choice for research. Research has already been done in this area and its proximity to major urban centres and specifically the Pontificia Universidad Católica de Chile ensures accessible academic support. Furthermore, fishing continues to be an important source of livelihood for the closely situated fisher communities on the coast of Region V. In combination with good
road infrastructure, this ensures the inclusion of a greater number of communities in the study given the available resources, while macro-level ecological settings are held relatively consistent.

1.3 Structure of the dissertation

This dissertation comprises seven chapters, the core of which is found in Chapters 2 to 6, with each core chapter to be submitted to a refereed academic journal. As such, the core chapters exhibit some redundancy, primarily in the methodological descriptions of when, where, and how data was collected. Some redundancy may also be found in the introduction of each chapter; however, each focuses on a unique problem and different solutions. The central thread of the dissertation is the in-depth examination of the social dimensions of adaptation at multiple scales, including individuals, communities, and management institutions. In addition, throughout, I venture to operationalize, measure, and clarify key social concepts linked to adaptation, and thus social-ecological outcomes.

Using data and observations from Chile’s artisanal fishing communities engaged in a national co-management system for benthic resources, Chapters 2 and 3 address the first research question by raising the possibility that changes wrought by globalization and economic development have the potential to derail community-based management of common-pool resources. Chapter 2 builds the case that the quantity, speed, and scale of changes from globalization and development are likely to be disruptive to local management efforts while remaining outside the jurisdiction or ability of communities to control them. At the same time, the effects of globalization and development can interact directly and indirectly with the
diverse motivations of local users, resulting in a loss of participation in co-management efforts and primary extraction. I then propose that explicit attention to user motivations and desires may provide a means to tailor policy in ways that can help preserve user engagement, while mitigating against the undermining, usurping, or reprioritizing of motivations that support social-ecological sustainability.

Chapter 3 looks specifically at how demographic and intergenerational cultural shifts in opportunities, expectations, and desires may lead to a dearth of recruitment of new marine users. I provide evidence that the existing population of artisanal fishers is already skewed toward older individuals with a lack of newcomers, while the desire of current users to pass on the tradition of fishing to the next generation is strikingly low. The consequences of a lack of recruitment for the persistence of a large network of local management and marine stewards are considered. I propose some possible solutions to move users up the supply chain and to recruit and retain new marine users, as well as highlight a budding opportunity to reform artisanal fishing to focus on a smaller and more highly trained workforce with a greater capacity for innovation and navigating change.

Whereas Chapters 2 and 3 primarily explore what large-scale change might mean for local systems, Chapter 4 drills down to the level of the individual and dissects the concept of ‘adaptive capacity’, a key idea in both resilience and vulnerability literatures. While generally construed as the ability to manage and cope with change, adaptive capacity in many ways remains ill-defined and poorly conceptualized. In this fourth chapter, I empirically test the validity of a generalized model of adaptive capacity by looking at the factors that are linked
with adaptation behaviours. More precisely, I examine adaptations made by marine users in terms of their principal species harvested, type of gear used, and sources of income. I conclude that adaptive capacity may better be understood as specific to the kind of adaptation, given what enables each type of adaptation appears to differ.

Chapter 5 seeks to clarify and investigate another major concept that is popularly associated with greater capacities to deal with change and positive outcomes in social-ecological sustainability: social learning. Social learning has received an inordinate amount of attention given its as-yet nebulous conceptualization across diverse fields. This chapter details my attempt to define and operationalize social learning by integrating theory and methods from the field of cultural evolution. The result is a measure of individuals’ propensity to seek social information to inform personal decision-making. Furthermore, statistical tests at the individual and community scale between the newly developed measure of social learning and various social variables appear to be counterintuitive in the context of the expectation of sustainability science, but well-aligned with cultural evolutionary theory.

As with the preceding two chapters, Chapter 6 centers on the operationalization, measurement, and testing of a conventional assumption and concept in the adaptive co-management and common-pool resource literatures regarding the importance of common understanding among stakeholders for collective action. Drawing from methods in anthropology, I measure the consistency of people’s beliefs about local environmental dynamics as compared to their peers and calculate community-averaged scores of common understanding. Through comparisons across artisanal fishing communities, my findings suggest
that contrary to the above assumption, common understanding may not be an essential
ingredient for collective action, but is rather secondary to other factors.

The dissertation concludes with Chapter 7, which highlights the contribution of this research
program to the broader scholarship on common-pool resources, adaptive capacity, and social-
ecological systems. This is followed by thoughts on the limitations of the dissertation as a whole
and future directions that may be taken in light of the research conducted here.
Chapter 2: Common-pool resource institutions in a developing and globalized world: The case of Chilean artisanal fishers and their motivations

2.1 Introduction

A key challenge to the sustainability of common-pool resources (CPRs), such as forests and fisheries, has always been managing the self-interest (and threat of free-riding) of individual users. While individual overharvesting and selfish strategies are not the sole barriers to sustainable CPRs, economic and ecologically focused investigations in particular have traditionally limited their scope in this manner, while case studies on CPRs in general tend to be isolated or highly circumscribed communities with a focus on single resources. Increasingly, conceptualizing CPR systems as distinct and clearly bounded, with self-interest representing the principal risk, cannot be assumed to be the reality.

Although narrowly targeted investigations of CPRs are necessary in the face of great complexity, narrow project scopes omit threats equal to that of self-interest, such as climate change, pollution, invasive species, and more. Growing interest in ecosystem-based management (EBM), social-ecological system perspectives, and resilience theory reflects

1 The following chapter is based on the contributions (i.e., discussions, methodological refinement, revisions, and editing) of Drs. Terre Satterfield, Kai Chan, Stefan Gelcich, and Timothy Waring.
increasing appreciation for such complexity (Berkes et al., 2003; McLeod & Leslie, 2009; Ostrom, 2009).

The intertwining of local realities with global drivers through globalization only serves to increase complexity through the growing number of pathways by which events from afar can influence the proximate. One consequence of these linkages is the mushrooming of factors and changes that can influence the success and persistence of community-scale institutions and governance, but cannot always be anticipated or tracked. In addition to the number of avenues by which global forces can overwhelm the local, community-scale institutions and management can be relatively slow to adapt in the face of global economic markets and the fluctuations of supply and demand (Berkes et al., 2006).

Furthermore, a fundamental aspect of human psychology and behaviour that receives little attention in CPR literatures is the diversity of motivations that drive individual and community behaviours, including motivations that relate directly to collective action and stewardship. Especially in cases where CPRs are managed at the community-level or in partnership with governments (as in co-management), continued and authentic engagement by locals is critical. Yet, the (non-monetary) motivations for resource users to engage or disengage are little explored. The shortcomings of the CPR literature as they pertain to the challenges of globalization and diverse motivations are elaborated below (in Section 2.2).

This paper addresses the potential negative impacts of globalization and development on community-based resource institutions and the nexus of globalization and local user motivations. While globalization and user motivations may appear to be two distinct topics, we
suggest that global forces and development have the potential to alter the (balance of) motivations of users to participate in the extraction, management, and governance of local resources through the introduction of new opportunities and direct threats to the resource base.

We raise the question and examine whether ongoing reliance on local institutions and management is likely to fail due to the influences of globalization and socio-economic development. We examine how community-based CPR management may become threatened by globalization and development (social and economic) directly, through markets; and indirectly, through interactions with the diverse monetary and non-monetary motivations of Chilean artisanal fishers and divers. We do so through a case study of the adaptive pathways of nine Chilean artisanal fishing groups.

Specifically, we examine the following questions: Is a focus on building community interest in local resources a viable way to ensure fruitful human and environmental outcomes in a globalizing and developing world? Can a focus on building user capacities and livelihoods, and fitting institutions to user-desired adaptive pathways, produce more resilient management systems? One line of thought is that institutions and policy can attempt to build or engage other motivations that may benefit CPRs, such as individuals’ sense of place, competency, identity, community, tradition, and stewardship, that may be less vulnerable in the face of market changes than monetary self-interest.

First, a brief overview of the CPR management literature is provided, with particular attention to gaps in research on motivations and globalization and development. Next, the Chilean
artisanal fishing context is described. An exploration of specific challenges posed by globalization and development and their interactions with user motivations follows (Figure 2); this constitutes our results section. Each results subsection begins with a description of a challenge (laid out in Figure 2), which is then illustrated with data from the Chilean case study, drawing from quantitative and qualitative survey conducted with Chilean artisanal fishers and divers in January and March of 2013. From the case study, we draw insights and lessons to inform how CPR institutions and governance may be adapted to the conditions of globalization and development. This manuscript concludes with a discussion of conceptual guidelines for rethinking CPR institutions and policy under globalization and development, and ways in which motivations might become an integral part of the solution.

2.2 Literature review: Enduring challenges to the logic of institutions and common-pool resources

Solving CPR problems involves two distinct elements: restricting access and creating incentives (usually by assigning individual rights to, or shares of, the resource) for users to invest in the resource instead of overexploiting it. Limiting access alone can fail if the resource users compete for shares... unless incentives or regulations prevent overexploitation. (Ostrom, Burger, Field, Norgaard, & Policansky, 1999, p. 279)

In the field of CPRs, institutions are sets of rules that guide the behaviour of resource users. Some are formalized and encoded in law. Other institutions are informal and perhaps even spoken, such as rules pertaining to sharing newfound fishing grounds. Institutions, often addressing resource rights (broadly conceived, though primarily pertaining to extraction), are
frequently invoked as the most significant tool of resource managers. They are also widely acknowledged in the academic literature as a critical piece of the sustainable resource puzzle (Imperial, 1999; Ostrom, 1990; Ostrom et al., 1999).

The field of CPR research is anchored by the seminal work of Elinor Ostrom and colleagues, which provides a definitive refutation to the ‘Tragedy of the Commons’ hypothesis, following Garrett Hardin’s assertion that self-interested individuals will tend to degrade the environment (absent privatization or ownership by central governments; Hardin, 1968). Ostrom’s insights and empirical observations showed that long-term sustainable management of resources is possible through self-organization at a local scale, especially given the presence of certain institutions (Ostrom, 1990); rules that dictate access to resources, sanctions, and ‘management rights’ (Mascia & Claus, 2009) among others.

The enormous case study literature on common-pool resource management also highlights the diversity of solutions to collective action dilemmas, and emphasises that local solutions can be found (Ostrom, 1990). From this empirical work, Ostrom distilled eight design features (Cox et al., 2010; E. Ostrom, 1990) commonly found in successfully managed CPRs (e.g., graduated sanctions and conflict-resolution mechanisms). Common-pool resource research has since expanded to include methods beyond case study analysis, such as modeling and experimentation (e.g., Anderies et al., 2011; Janssen et al., 2010), and has also spawned a popular integrated framework for assessing CPR interactions (i.e., the social-ecological systems framework; Ostrom, 2009).
It is clear that good institutional design can have a significant and positive impact on the sustainability of natural resources while bad design or fit can have the opposite effect (e.g., Gelcich, Edwards-Jones, Kaiser, & Castilla, 2006). However, CPR theory remains challenged in the following ways.

2.2.1 Motivations beyond the self-interested and monetary

First, the limitations of rational choice assumptions are well recognized (e.g., Ostrom, 2011); however, much CPR theory still defaults to a logic of people as rational agents operating principally on the balance of calculated costs and benefits (e.g., Basurto & Ostrom, 2009). This is true to the extent that CPR theory assumes that cooperation can be fostered and maintained if the rules around resource extraction and access are designed to subsume self-interest under the interests of the group (and so assumed self-interests held in check). It is rarely questioned whether 1) deriving incomes from primary resources is the most dominant livelihood (or will remain dominant), and 2) whether users are principally motivated to remain or continue extracting in a system, or whether other motivations exist. That users want to remain primary extractors may become less true under globalization and development (explained below).

Assuming that people’s preferences are static may also be unethical if institutions inadvertently inhibit users from satisfying those preferences (e.g., exiting fishing if desired).

In reality, people have multiple preferences and motivations that exist simultaneously (as we will show). Additionally, motivations are not static, but gain and lose priority with time and experience as contexts and circumstances change. Although a model of human preference
based on assumptions of self-interest and monetary values has been extremely productive for CPR research and elsewhere, as with all assumptions, important insights are inevitably obscured.

That multiple motivations exist simultaneously is notable for the management of CPRs under globalization and development for the following points that have received little consideration:

- Many motivations can be satisfied by domains outside the resource base and can be non-monetory yet have implications for management objectives. These are easily overlooked if a near-sighted focus on monetary self-interest is employed.
- Money is a powerful incentive but not necessarily the most powerful, stable, or constant motivator. Recognizing other motivations can open the door to the creation of more long-lasting and resilient institutions by targeting equal or more important motivations, which might in turn help our understanding of why some institutions fail.
- A greater appreciation for a larger suite of motivations makes available a more comprehensive toolkit to manage CPRs.
- Attending to the actual motivations and behaviours of resource users and their interaction with local to global drivers makes it possible to consciously and purposely align user desires with those of sustainable management.
- Unrecognized motivations can lead to the repurposing of institutions to unexpected ends. Examining diverse motivations can help anticipate changes in, and the efficacy of, institutions.
A narrow focus on users’ motivations to derive a living from resource extraction may be symptomatic of institutional theory’s primary concern with resource conservation and fostering collective action toward that end. Scholars and practitioners have instead increasingly recognized the moral imperative and the instrumental benefits of considering the broader human condition of what constitutes a good life (Allison et al., 2012; Coulthard, Johnson, & McGregor, 2011). However, positive human and social outcomes are often implicitly equated with ecological sustainability without accounting for other ways in which institutions can facilitate or hinder user efforts to improve their welfare (e.g., poverty traps; Cinner, 2009; J.E. Cinner, 2011).

### 2.2.2 The speed of change

In addition to potential interactions between motivations and globalization that may detract from the efficacy of CPR institutions, the relative speed of changes across scales is also problematic. In their 2006 Science article, Berkes et al. (2006) highlight the problem of globalization and growing difficulties in designing institutions that can appropriately address the impact of global economics on local incentives to sustain natural resources. They argue that globalization opens and facilitates access to markets at a pace beyond the ability of existing institutions to adjust, compelling fishers to switch and expand fishing grounds and species (that are often open access). Berkes et al. (2006) recommend the “[replacement of] destructive incentives with a resource rights framework that mobilizes environmental stewardship, i.e., one that builds the self-interested, conserving feedback that comes from attachment to place” (p. 1558). Despite the passing of a decade, this topic has been addressed only sparingly, and even
less so empirically, but has begun to garner more attention (Anderies & Janssen, 2011; Crona, Van Holt, Petersson, Daw, & Buchary, 2015).

In the meantime, CPR literature’s current treatment of change has been focused elsewhere, such as ensuring and designing robust institutions that will persevere through change. Less attention has been on the process of institutional evolution, or how institutions can adapt and transform with changing conditions. However, as CPR scholarship has become more interdisciplinary, change and surprise are increasingly recognized (Anderies & Janssen, 2011; Liu et al., 2007). This is especially so in the promising development of adaptive co-management, where institution building and governance are viewed as evolutionary and collaborative processes based on trust, purposeful experimentation, and deliberation (e.g., Armitage et al., 2009).

Despite these developments, there are high hopes and even asymmetric attention placed on ‘getting the institutions right’, so as to lead to sustainable resource management. For instance, as suggested by adaptive management and adaptive co-management literatures, a solution in the case of CPRs is to increase the sensitivity of management actions to ecological signals to facilitate timely responses (Olsson et al., 2006; Olsson, Folke, & Berkes, 2004). The philosophy behind adaptive co-management is to engage local users in the process of management directly as the most proximate and responsive agents to resource relevant changes (Moller, Berkes, Lyver, & Kislalioglu, 2004). However, adaptive co-management is critically dependent on the desire of users to be engaged, which may be less likely as opportunities and pressure to exit the
resource sector altogether grows from the impacts of globalization and development (Anderies & Janssen, 2011).

To borrow a phrase from author Thomas Friedman, as the world becomes flatter and economic development continues apace, new pressures and opportunities manifesting at the local scale will appear, presenting persistent challenges to local efforts at resource management. We assert that solutions to regional environmental challenges cannot require that local stakeholders be sequestered from development (and associated opportunities that become available).

While the Chilean artisanal fishing system embodies many of the institutional features recommended by CPR theory and adaptive co-management, there are reasons to believe that global change (and its local manifestations) may threaten how well they function in the future.

### 2.3 The Chilean context

Unlike the context of many CPR case studies, the Chilean artisanal fishing sector is multi-gear and multi-species, for which there is a patchwork of formal and informal institutions. In Chile, as elsewhere, the artisanal fishing industry is a source of employment for many thousands, and is spread across the entire coastline of the country. Artisanal fishing and diving are also encountering rapid environmental, social, and economic changes. The problems confronting marine managers in Chile are reflective of the difficulties encountered in the management of ocean resources worldwide. There exist disputes over territorial rights between fishers (Gelcich et al., 2005), conflicting cross-sectoral interests such as between forestry and artisanal fishers.
(Holt et al., 2012), disputes between conservation and development as in Patagonia and hydroelectric dams (Sáenz-Arroyo et al., 2005), and as anywhere, challenges associated with meeting the needs of multiple stakeholder groups.

Artisanal fishers in Chile can be differentiated between small-scale and mid-scale; both are subject to closures and quotas for certain species but have also been granted exclusive access to fishing grounds within five nautical-miles of the coast (Gelcich et al., 2010). However, the very small-scale fisher (using boats under twelve metres) faces significant competition with industrial and especially mid-sized vessels for the same stocks for pelagic resources.

Among the multiple laws that govern the extraction of marine resources by artisanal fishers in Chile is the well recognized and prominent Management and Exploitation Areas for Benthic Resources (MEABR) system (Juan C. Castilla & Fernandez, 1998). Under the MEABR, territorial user rights fisheries (TURFs) exist for various benthic organisms. The MEABR system consists of a strong framework of institutions that assign exclusive harvesting rights to organized groups of fishers (or ‘syndicates’ or ‘caletas’) to specific species and areas of seabed.

The MEABR system’s genesis can be traced to the rise and fall of the ‘loco’ (a gastropod, Concholepas concholepas) fishery (Gelcich et al., 2010). Following marked political upheaval and market liberalization, loco quickly became a high-value export as ersatz abalone. Being an open-access resource, loco stocks quickly befell the classic ‘Tragedy of the Commons’ (Hardin, 1968) of overharvesting, leading to a population crash in the late 1980s and early 1990s. It was then in the mid-1990s that the MEABR framework was implemented to prevent further loss of the loco. Harvest of loco was made illegal in all areas except for in designated TURF areas and
only by recognized and licensed groups. This policy effectively incentivized groups to sustainably manage, and protect loco populations from outsiders, for collective profit. At a national scale, loco populations appear to be recovering and the system itself is held in high regard internationally by policymakers, non-governmental organizations, and development organizations (e.g., Moreno & Revenga, 2014).

While recently introduced processes for determining science-based quotas (Gelcich, 2014) and the MEABR system have been hailed for promoting more sustainable fisheries, these may still be considered “resource-protection policies” (Marshall & Marshall, 2007) that largely omit human considerations. Furthermore, it is questionable how well these policies are working at the local scale. Although loco populations seem stable, TURF areas are not free from poaching, and the five-mile boundary is not always respected. Furthermore, as Chile’s domestic and export economies have continued to grow (World Bank, 2014), the effects of globalization and development are beginning to threaten the future viability of MEABRs as currently conceived, as well as artisanal fishing as a livelihood.

2.4 Methods: Surveying across fishing communities in coastal Chile

For this study, data on Chilean fishers were collected through two in-person surveys between January and March 2013. One hundred people participated in the first survey (henceforth ‘S1’ in this chapter) and 122 people participated in the second survey (henceforth ‘S2’ in this chapter). Surveys were conducted in nine Chilean communities along 200km of coast in Region V (directly west of Santiago), spanning from Los Molles in the north to Algarrobo in the south.
Participants were recruited on syndicate-operated beaches where fishers conduct a variety of activities including landing their catch, administration, small business, and seafood processing. In each case, the syndicate president was first approached, both to receive permission and to gain help informing syndicate members of our work. Convenience sampling was used.

Participants were recruited at the landing areas in each caleta. Caleta memberships ranged in size from 76 (Los Molles) members to 188 (Pichicuy), and were situated in rural as well as more urban areas. In total approximately eleven percent (conservatively) of the total population of fishers from the nine communities were surveyed.

Members were asked to participate and were given time to consider their participation if they did not wish to do so immediately. The research team consisted of two to three research assistants (Chileans) as well as the primary author. We visited each caleta over sequential days between. Only individuals 19 years of age and over were allowed to participate. The results and data reported in this paper are only a subset of that obtained through the survey instruments. Where data from the surveys is reported and noted below, they are accompanied by a brief synopsis of the questions used and the data’s analysis.
2.5 Results: Challenges for community-based management in a globalized world and the case of Chile

Figure 2. Diagram of simplified pathways of influence (P1-P10) between global drivers and development affecting the sustainability of CPR systems and institutions. Blue arrows and boxes (P1-P4) capture globalized market forces impacting community-based economic logics for engagement. Path five, also in blue, represents knowledge exchange that can affect extraction efficiency and efficacy. Red arrows and boxes (paths P7-P10) depict the interactions of globalization and development with user motivations affecting CPR management. Path six (the dashed red box) represents the diversity of motivations that exist among users and are described in-text. Pathways of impact are not mutually exclusive and may interact.
To recap, we believe that globalization and development can impact the success of local institutions and management in two major ways not yet fully appreciated in the CPR literature (Anderies & Janssen, 2011): first, in terms of the speed and scale of changes placing additional pressure on local management systems; and second, the interaction of these changes with diverse user motivations that may detract from management objectives and local participation. Thus, we argue for greater consideration of local-to-global drivers of demand for CPR products and labour, and the simultaneous consideration of globalization and development in the context of monetary and non-material motivations. We illustrate our arguments in the sequence of ten simplified pathways of influence (Figure 2) using data from the Chilean artisanal fishery context.

First, as seen in Figure 2, we examine how the changes of globalization can outpace local institutions. Whereas Berkes et al. (2006) address the problem of global demand causing changes to local sources of supply; our point is to expand to also include demand (and opportunities) for labour and implications for local participation, upon which community-based CPR management depends. Below, we show how globalization, in addition, can have local impacts via unrelated industries (e.g. mining) and non-market changes, such as technological advances and socio-demographic shifts (P1 to P5 in Figure 2).

Second, new opportunities and impacts on resources of concern (often beyond the jurisdiction or control of local institutions) can usurp, undermine, and lead to the reprioritization of motivations for local investment in resource maintenance and stewardship (P6 to P10 in Figure 2).
2.5.1 The speed and scale of change

As people and communities become increasingly linked to one another through communications and market supply chains, changes in one corner of the globe can be felt acutely across the world in very short timeframes. Even if changes can be anticipated, which may be increasingly difficult given increased complexity, there is often no means at the local level to influence the drivers of those changes directly. By their nature, local institutions and governance are limited in their possible responses.

2.5.1.1 Globalized markets

Integration into the global economy can be a boon for income streams but also expose primary resource users to the whims of new markets and demand (P1). Access to new markets and demand often coincide with price fluctuations and (P2) diversion of engagement (and human resources) when supplying alternative markets or changing livelihoods is judged more beneficial (P3), with potential impacts to the local ecosystems on which CPRs depend (P4).

In terms of P1 and P2, rapid oscillations or unexpected drops in the price or demand of community-managed resources can prove difficult for local institutions. For instance, as recorded in official government statistics (see left graph in Figure 3; SERNAPESCA, 2011, 2014; SUBPESCA, 2013) and elsewhere (Gallardo Fernández & Friman, 2011), the price of loco has a history of instability. In fact, Chile’s MEABR system was first implemented to combat the overexploitation of loco caused by access gained to overseas markets, resulting in a rush to supply international demand.
Competition from other corners of the globe also becomes relevant for local communities, in forms such as diverted demand to alternative products or new supplies (Anderies & Janssen, 2011). With development and exposure to more choices and options to satisfy people’s wants, consumer demands can also change. In recent years, the profitability and demand for loco has been challenged by the growth and production of abalone through aquaculture. This is evinced in official government records of declining and increasing loco and red abalone harvest, respectively (see Figure 3, right graph). Abalone is a highly prized species, especially in Asia, and a primary competitor to loco in terms of market share. The production of abalone has been on the rise, with new aquaculture ventures in Chile and elsewhere, increasing their availability, and diverting demand from loco.

Figure 3. Fluctuating prices of loco (in 2011 US dollars) generated from official Chilean government statistics for both the landing price (on the beach) and its export value between 2000 and 2013 (left graph). Growth in Chilean abalone landings and decreasing landings of loco between 2004 and 2014 are also shown (right graph).

Despite the intimate connection between MEABR institutions and globalization, the MEABR system may not be well-geared to respond to declines in the price and demand for loco, which can threaten the viability of management areas. The drive of users to invest, maintain, and
respect the institutions may wane. Even in the event that prices are relatively stable, profits derived from continued extraction and investment in loco may not be worthwhile if outpaced by the cost of living, profitability, or the relative security of other resources and livelihoods (P2 and P3).

Our speculation that market competition and price fluctuations may lead to declines in user participation is borne out in survey results indicative of faltering interest in the conservation of loco. This may be observed in S1 data on monitoring activities in management areas; a key means by which caletas battle against poaching. When participants \((n = 99)\) were asked how monitoring activities for loco had changed in the past year, both in terms of their own behaviour and that of their colleagues (using categorical responses options), a net decrease in monitoring activities was observed (Figure 4). At the same time, 44.10% of respondents answered that they had illegally extracted loco in open access areas when queried. The response pattern indicates that loco is still an economically valued species.

Fernández and Friman (2011) similarly observed that fluctuations in global market prices could negatively affect conservation goals when they fail to fulfill users’ livelihood objectives:

*Our results show that MAs’ [management areas’] economic benefits are connected to fluctuations on the global market. Adapting to changing world market prices then becomes paramount. TURFs’ main goal is ecological conservation, but achieving this seems to depend on meeting fishers’ livelihoods; failure to do so likely results in failure to meet conservation objectives. A serious weakness of the Chilean TURFs system is that it*
does not pay enough attention to fishers’ livelihoods or to the global market context. (p. 433)

While it is not certain, there may well be a price threshold for loco, below which investment in the MEABR is no longer worthwhile given its costs. It may also be possible that the relationship between loco prices and engagement is non-linear, such that engagement does not decline appreciably until a ‘tipping point’ is reached.

Figure 4. The number of S1 participants providing various answers to two separate questions: How loco monitoring activities of caleta colleagues have changed in the past year on the left, and how personal loco monitoring behaviours have changed over the past year on the right. A net decrease in monitoring can be observed in the case of both community and personal anti-poaching activities.
The appearance of new markets can also affect the persistence of local institutions in other ways (e.g., ‘spillover effects’, Crona et al., 2016). Demand for kelp used for abalone feed has grown alongside abalone aquaculture. Kelp has also become a prominent Chilean export due to its value in the production of alginic acid that has many applications, from food processing to cosmetics. At present, kelp, like loco in the 1970s, is an open access resource that is unregulated except for within some MEABRs. Harvesting can occur anywhere without limit.

Importantly, the harvest of new species, especially in abundance, can cause collateral ecological damage. Kelp forests form a key habitat for many species, including many finfish and shellfish such as loco (Almanza, Buschmann, Hernández-González, & Henríquez, 2012; Vásquez, 2008; Vásquez, Piaget, & Vega, 2012; Villegas, Laudien, Sielfeld, & Arntz, 2008). The Chilean example thus suggests that new markets can also impact species indirectly, affecting already managed species, and so the efficacy of local institutions (P4 in Figure 2; Crona et al., 2015). The emerging reef fish and squid fisheries are similarly unregulated. At the time of this study, kelp, reef fish, and squid were open access. In contrast to kelp and squid, reef fish is predominantly a local market product.

In all three cases (i.e., of kelp, squid, and reef fish), the rise in demand has been rapid, with demonstrable effects in community marine extraction. Survey results in Figure 5 demonstrate this; that is, changes in principal species targeted by S2 participants between 2008 and 2013 (see Chapter 4). The results demonstrate the increased targeting of squid, reef fish, and kelp over that time period.
As with the historic loco boom, if demand continues to rise for these species and appropriate institutions are not implemented in time, it is possible for overharvesting to become a problem, and was a noted concern among S1 and S2 fishers. On the other hand, if prices cannot be sustained, or fluctuate, institutions can become redundant and onerous (without the necessary benefits from their upkeep; e.g., Gallardo Fernández & Friman, 2011).

Figure 5. Among 75 S2 ‘adapters’ (out of 122 participants) who made changes to the species they principally extracted, squid, conger eel, reef fish, shellfish, or kelp was mentioned 60 times (in total) as being the original targeted species (grey bars). In terms new or added species (black bars), 27 people began targeting squid and 22 began targeting conger eel. Sixteen, 15, and 14 people also began extracting reef fish, shellfish, and kelp respectively.

Although the rise and fall of demand and prices for resources are the most obvious pathways by which globalization can outpace local management and institutions, the diversion of human
resources away from CPR systems and managed species also has the potential to be problematic. The MEABR system has yet to confront the reality of increasing employment opportunities created by the global economic recovery and growth of the Chilean economy, which may enable fishers to transition to additional or replacement sources of income, in effect drawing people away from the fishing profession (to be discussed in more detail later on).

In addition, economic development nationally in Chile (World Bank, 2014; fuelled in part by global demand for Chilean exports) has led to greater consumer spending, such as in domestic tourism (World Travel and Tourism Council, 2015), as well as greater demands on infrastructure, and production of goods and primary resource extraction. As a consequence, there may be a greater number of impacts on local marine resources (P4 that may affect P3) than before from direct and indirect sources such as coastal development, forestry (Holt et al., 2012), refineries, tourism, and others (that will require monitoring, e.g., Navarrete, Gelcich, & Castilla, 2010).

2.5.1.2 Global transmission and dissemination of knowledge

Globalization is facilitated by the ability to communicate and transmit knowledge nearly instantaneously over large distances, at historically low costs (P5 in Figure 2). The internet, mobile technologies, advances in transport technology, and the proliferation of trade networks have made it faster and easier than ever to transfer knowledge and goods. These features of modernity have changed the lives of small-scale artisanal fishers: for instance, by improving their physical safety and financial stability, as well as fishing efficacy and efficiency.
Global knowledge and technology transfer are well illustrated by fishers’ changing gear. When S2 participants (N = 122) were asked whether they had changed or adopted new gear between 2008 and 2013, a conversion from traditional wooden boats to fibreglass was apparent (6.56% of all participants; note that in general, only a minority of individuals own boats). The adoption of ‘trasmalla’ fishing nets (conservatively 18.85% of S2 participants; also known as ‘tres telas’) and ‘totas’ (or jigs/lures) for catching squid were also frequently mentioned (approximately 10.00% of S2 participants switched to or gained new squid extraction equipment). In the case of the trasmalla, some fishers reported learning of the net and how it is made and used from neighbouring caletas and caletas further north in the country, while others traced the origin of the nets to Peru and Spain.

Less ambiguous is the transfer of squid jig technology and use. In many cases, surveyed fishers reported that the specialized hooks were brought from Asia to the caletas (specifically by the Japanese or Koreans). Furthermore, knowledge of the squid jig and trasmalla net, their availability, and know-how in terms of use and construction diffused through the social network of fishers and divers established by the MEABR structure. For instance, the jigs were bought by the syndicates and then sold or provided to local fishers at a subsidized price. In turn, fishers supply their catch to Asian buyers and markets.

The appearance of squid jigs and trasmalla, as well as other types of fishing gear (e.g., GPS and echosounders) has increased the efficiency of fishers in terms of effort, as well as the ability to target particular species or harvest more en masse. For instance, among surveyed fishers, trasmalla nets have begun to replace longline and other forms of net that are more size-
selective and less efficient (in total catch per unit effort). The globalization of knowledge and technology can thus threaten resource management institutions and organizations, and even be facilitated by CPR institutions.

2.5.2 Undermining, overriding, and shifting motivations for stewardship and collective action

2.5.2.1 Multiple motivations and needs: Beyond economic self-interest

Globalization and development has and will continue to bring about many changes that affect the day-to-day lives of artisanal fishers. Understanding how motivations—monetary and non-monetary—interact with these changes is an essential to anticipate responses: for instance, whether users will continue to maintain resources or even engage in primary extraction as a livelihood.

In the context of the MEABR system, there is evidence that economics and self-interest are not the only motives under the consideration of resource users (P6 in Figure 2). When S1 fishers were asked directly what they considered most essential for their quality of life, and to rank these needs by importance, the diversity of motivations and needs quickly became evident (Figure 6). When these responses were coded, categorized, and counted, health was the most frequent need, followed by work and then income. Health was also frequently ranked first, while work and income were frequently ranked second or third when mentioned.
Figure 6. Needs mentioned by S1 participants \( n = 98 \) as being necessary for their quality of life by rank. In total 198 needs were identified, with health, work, and income being the three most frequently acknowledged.

2.5.2.2 Usurping motivations directed at stewardship and collective action

Without a doubt, money can be a powerful motivator. Less appreciated is that money is a means, and when the same ends can be met in ways that are equally or more satisfactory, the power of monetary instruments may dissipate. This is evident when monetary motivations are usurped toward other ends. The same may occur for other non-monetary motivations as well.
This too is notable in survey results. The vast majority of the needs identified by participants in Figure 6 can be satisfied by domains other than fishing (including income and work), or are not directly related to occupations. Additionally, Figure 7 shows that S2 participants acknowledged diversifying their income streams when asked whether they had added or switched to any new income sources between 2008 and 2013 (n = 58). Especially high (relative to other professions) was the number of respondents devoting some or the majority of their time to construction, going hand-in-hand with greater economic development in the country. Not represented in Figure 7 are the fishers and divers that have left the profession completely, but were not interviewed. Although a limitation of this study, there was clear anecdotal evidence from informal conversations with fishers and divers that many individuals had already left the fishing profession to satisfy their needs and goals.
Figure 7. Fifty-eight S2 participants (out of $N = 122$) acknowledged diversifying or changing their principal income sources (grey bars) between 2008 and 2013. Among these 58 ‘adapters’, construction was the most common new source of income and was identified by 26 individuals. The most common primary income source prior to switching or adding new income sources (original; black bars) was fishing or diving, and was identified by 52 of the adapters.

When a diversity of better (according to individual preferences and desires) livelihood and employment alternatives exist (as may become increasingly available under globalization and development), single motivations may not be reliably relied upon to foster stewardship. This may be especially true when the security or income from resource extraction is not keeping
pace with the alternatives, as appears to be the reality for Chile’s small-scale artisanal marine
users (as incomes are dropping; Crona et al., 2015).

It is also possible that concern for resources may decline as alternative livelihoods become
available (and reliance on marine resources wane). Reduced reliance on the resource base for
incomes may reduce personal stakes in resources’ well-being, perhaps with a concomitant
decline in the quantity and “quality” of collective action participation.

Monitoring data presented previously (Figure 4) and S1 responses regarding poaching may
evince such a case (Figure 8 below) of declines in the quality and quantity of collective action. In
the case of poaching, S1 (n = 99) participants were asked their level of approval or disapproval
of a hypothetical colleague’s poaching activities (higher numbers indicating stronger approval
and ‘1’ indicating strong disapproval). As Figure 8 shows, poaching is looked upon favourably, or
is at least tacitly approved, by some users.
Figure 8. Responses from S1 participants ($n = 99$) to each of two hypothetical scenarios in which they were asked to indicate their level of approval or disapproval from one to seven (x-axis); seven being the strongest approval and one being the strongest disapproval. Participants were asked to consider ‘Jorge’ a colleague in the caleta, and to provide a judgment in a case of poaching (left) and whistleblowing (right). The y-axis is the number of respondents.

Additionally, both income diversification and declining numbers of fishers can be problematic if it leads to an absence of stewards who would otherwise be well-placed to protect and monitor resource and ecosystem changes. The exit of small-scale artisanal fishers can also leave a void that could be filled by less efficient (i.e., more polluting and fuel consumptive) and less sustainable fishing fleets, such as industrial ships and operations (Jacquet & Pauly, 2008). Domestic demand for seafood may also lose access to more sustainable and local sources. Another knock-on effect of the diversion of small-scale fishers into other professions is that
other livelihoods may themselves be more harmful for resource sustainability (e.g., industrial factories and fleets).

Overlooking the range of motivations that exist can lead to surprises that could have been anticipated, such as the appropriating of institutions for ends not originally intended (P8 in Figure 2) that may or may not align with resource management objectives. For example, discussions with S1 and S2 fishers in Region V revealed that in some instances, management areas under the MEABR system had been left fallow, held only as a legal bargaining chip to be used to argue for compensation in disputes over industrial contamination (also see Gelcich et al., 2005). In other cases, applications for MEABR areas were made with the sole purpose of obtaining exclusive beach access to take advantage of growing tourism-based opportunities. Furthermore, other studies recorded instances where existing management areas were sometimes used to achieve greater rights and access to resources beyond those legally designated (Aburto et al., 2013). Such creative repurposing of institutions can detract from the system’s planned goals.

2.5.2.3 Damaging the foundations that satisfy existing motivations

While motivations can be redirected from participation in common pool resource institutions by new opportunities, participation can also be lost when a thing that is satisfying an existing motivation is damaged or compromised. For example, where a motive of monetary self-interest is currently satisfied by, and is the basis of, CPRs’ management, price declines that result in unfulfilled monetary motivations can lead to non-participation. A range of motivations, in fact, may function to support stewardship (Greiner, Patterson, & Miller, 2009) and participation in
occupations (Pollnac & Poggie, 2008) and collective action institutions, such as the motivation to maintain relationships with peers or place. Thus, when the social fabric of a community or valued aspects of place are eroded or altered, participation may falter.

Multiple motivations may also be undermined simultaneously. When multiple motivations that (perhaps unknowingly) support engagement with CPRs are negatively affected or not longer satisfied, the likelihood of disengagement may increase. When S2 participants were asked why they had diversified or switched their primary income source away from marine extraction between 2008 and 2013, a range of reasons were provided, including economic and non-economic (Figure 9). Globalization and development can be problematic if they introduce more avenues in which places, communities, markets, and resources that satisfy existing motivations can be adversely altered.
Figure 9. Among 52 income adapters who made changes to their primary income sources between 2008 and
2013 (n = 58), 82 reasons were provided for doing so. The most mentioned reason was economic, followed by
decreases in catch, and bad sea conditions. Note: The ‘Desire’ category captures miscellaneous personal
inclinations.

An illustrative example of how motivations matter and why undermining their foundations is of
concern for CPR engagement is captured by three caletas studied as part of this research. The
trio of caletas—Ventanas, Horcon, and El Manzano—are sited on Quintero Bay, where
worldwide and domestic demand for metals and energy have led to the build-up of refineries
and power plants on the bay’s shore. Artisanal fishers and divers in the area reported that these
industries have contaminated the bay with heavy metals and altered water temperatures to the
detriment of marine resources and shellfish in particular. Industrial development also appears
to have impacted the aesthetic, environmental, demographic, and social relational characteristics of place, as well as the prices that can be commanded for local seafood, and the region’s viability as a tourist destination.

An exodus of fishers from Quintero Bay might be expected given the concentration of heavy industry and its negative implications for marine resources. Indeed, the situation in Ventanas appears to meet those expectations, and the caleta is relatively devoid of active marine resource users. Although it would be reasonable to assume that the impacts of industry would be similar across communities in a single bay, attending to motivations satisfied by the bay (and subsequently undermined) would have suggested uneven impacts and responses unique to each community’s context. A mere two kilometers away from Ventanas is the syndicate of Horcon, which continues to persist with relatively large numbers of active fishers and fishing as a dominant livelihood. During interviews, participants from these two communities suggested that this difference in numbers lies in their respective identities and thus motivations. Where Horcon has traditionally been devoted primarily to fishing, Ventanas was historically a diving union and identified as such (a similar finding is reflected in Gelcich, Edwards-Jones, Kaiser, & Watson, 2005). While fishing was also previously practiced in Ventanas and is still viable (as demonstrated by Horcon), rather than shift extraction more toward fishing, many Ventanas members have left or changed livelihoods entirely away from primary extraction.
2.5.2.4 The absence and reprioritization of motivations for stewardship and collective action

While exogenous social, economic, and ecological contexts can change through globalization and development, endogenous changes in personal values and priorities might also be expected and may similarly lead to disengagement from resource livelihoods and collective action. For example, changes in the socio-economic setting, such as rising income inequality or professional opportunities of higher social status, may lead to the loss or reprioritization of motivations for stewardship and collective action.

As seen in Figure 6, not all motivations and needs hold equal rank. Moreover, priorities can change over time with shifts in social norms and preferences, as exposure to other lifestyles, standards of living, and cultures become more widespread and accessible. These may alter the economic and social ideals of individuals: for example, what people believe possible and appropriate in terms of security and wealth, and definitions of success and desire for status.

There is evidence that, at least in Chile’s Region V, entry by younger generations into the artisanal fishing profession is far short of replacement (see Chapter 3), and appears indicative of cultural shifts in motivations. Data from S2 suggest not only that social and economic ideals have changed for youth, but also within the generation of current fishers; a decisive majority of S2 fishers did not want a future of artisanal fishing for their children, despite their high job attachment and view of the profession as a familial tradition (Chapter 3).
When asked why they did not desire the same livelihood for their children, many S2 fishers stated that they hoped their offspring would obtain formal education, and find employment and futures in other industries with greater social status, economic prospects, and less physical labour, and that their children were motivated by the same. Some of the interviewed fishers also mentioned that they are witnessing Chilean prosperity grow around them, but not for them.

There are likely many reasons why the next generation of fishers and divers are failing to materialize. Yet, it is clear that where motivations such as obligations to tradition, affinity for the occupation and the ocean, and a desire to stay close to family and home were once enough to ensure replacement, such motivations are no longer sufficient. As the Chilean economy continues to expand and the wealth of opportunities and of fellow citizens grows, fishers are likely to feel less attached to the status quo, or inclined to forge ahead with business as usual.

Ultimately, motivations important to stewardship and participation may wax and wane, and lead individuals and communities to undertake behaviours that may be negative or positive for resource sustainability (e.g., Steins & Edwards, 1999). The key for managers and policymaker is to try and anticipate how user behaviours may change, and understand why and how those behaviours beneficial for resources and livelihoods can be encouraged, while mitigating those that are counterproductive to management aims without limiting the adaptation of users.
2.6 Discussion: Conceptual guidelines for integrating motivations in institutions and policy for a globalized and developing world

A core challenge for common pool resource institutions is adaptation to change that is increasingly prevalent, rapid, and complex (Liu et al., 2007). We have shown some ways in which local institutions may be derailed or rendered ineffective in the face of rising pressures from globalization and development through their interaction with motivations. Thus far, CPR and associated literatures have inadequately addressed the challenge of change epitomized by globalization and development (Anderies & Janssen, 2011), where some changes may be beneficial or harmful for the sustainability of resources or human wellbeing.

There is a need to reorient institutional thinking to the reality that some multi-scalar pressures are greater than can be surmounted by community-based management alone. Pressures that also demand an expansion of the role of local institutions beyond controlling access and rights, and assumptions that the most relevant objectives of users are to exploit resources and remain primary extractors. In light of the results presented above, we recommend greater attention to potential user adaptations by explicitly considering the actual motivations and needs of individuals and communities, developing complementary policies and institutions, and diversifying ways in which users and others can become engaged in resource stewardship (e.g., Gelcich & Donlan, 2015).

Integrating motivations means anticipating how socio-ecological changes may be taken advantage of, recognized, or perceived (as desirable or not). Distinguishing the consequences of user behaviours and their drivers can be valuable for management by identifying points of
leverage toward desired outcomes; encouraging those that align with management objectives, and finding beneficial or benign outlets for those that do not. In doing so, institutions and social policy may simultaneously enable and facilitate user adaptive efforts.

2.6.1 Suggestions and possibilities for rethinking motivations in CPR theory and practice

Reflecting on the observations and results presented above, what follows are proposed guidelines that can be included in the institutional planning process that may help clarify user motivations and their potential impacts, and mitigate the possibility of CPR institutions being rendered ineffectual by globalization and development. The guidelines outlined here are meant to be iterative and may be nonlinear. The following can be embedded into, or used alongside, other diagnostic, planning, and analytical frameworks such as ecosystem-based management (McLeod & Leslie, 2009), adaptive co-management (Olsson et al., 2004), or development frameworks such as the sustainable livelihoods approach (Allison & Ellis, 2001), among others.

2.6.1.1 Better address and understand user motivations and behaviours

In addition to the identification of users (or stakeholders) as a first step, we recommend the direct exploration of motivations and how these may manifest in existing and planned behaviours. It is important to identify the reasons for people’s behaviours as potential courses of action may be different if people are choosing not to participate because of issues of procedural justice, cost barriers (e.g., MAEBR consultation costs; Gelcich, Godoy, & Castilla, 2009; Schumann, 2010), or simply changing desires (e.g., to be fishers).
Once a portrait of motivations and (potential) associated behaviours has been constructed, whether these behaviours align with resource management objectives, albeit with some uncertainty, may be explored. For instance, a number of S2 fishers suggested that harvesting kelp was either something they had started doing or would begin to do if prices were higher or if the work became easier (i.e., barriers). Several individuals who had started harvesting kelp suggested they were seeking income stability in addition to gross income (i.e., motivations). Understanding how kelp extraction may be triggered by factors of economic stability and ease of extraction may allow managers to anticipate growth in exploitation and the potential impacts to kelp ecosystems and related resources.

**2.6.1.2 Aligning institutions and user adaptation pathways**

Identifying a suite of behaviours and motivations and their potential interactions with social-ecological contexts to impact local management objectives may provide a means to investigate and develop complementary institutions and policy (e.g., Gelcich et al., 2015; Gelcich & Donlan, 2015).

For behaviours that are more likely to have a positive impact on management objectives, efforts can be undertaken to facilitate them. For example, across both surveys, Chilean fishers commonly expressed a desire to transition into businesses based in tourism, seafood sales, or restaurants. Providing assistance through permitting and licensing processes, consultation on sustainable business practices, planning, and training, mentorship, and other programs may be helpful.
Simultaneously, it may be necessary to create alternatives to satisfy motivations and associated behaviours that run counter to management objectives. For instance, many surveyed fishers reported adopting the highly efficient ‘trasmalla’ net, but also concern that the net was harmful for the long-term sustainability of conger eel. In fact, some fishers explicitly stated avoiding adopting the net for reasons of sustainability, while others were conflicted by the necessity of maintaining a livelihood. Fishers’ concerns over the potential adverse effects of using the trasmalla net suggests that they may be willing to move away from destructive technologies if alternative gear can be developed or found. Managers may also target the satisfaction of economic motivations directly such as by exploring value-added products to raise incomes.

2.6.1.3 Employing and fostering a variety of motivations toward stewardship and collective action

Alongside self-interest and monetary motivations, it is suggested that institutions engage a variety of other motivations, especially those that are endogenous and intrinsic rather than instrumental. Furthermore, institutional systems that rely on a single dominant motivation are likely to be more vulnerable, analogous to an investment portfolio consisting of a solitary stock. Rather, bringing to bear a number of complementary motivations to the cause of resource conservation and collective action such as tradition, family, identity, belonging, and love of place and occupation, and even stewardship itself as a motivation may help to create a more resilient system.

Many methods may be used to employ other motivations, including building of social capital through co-management efforts. Additionally, education can be used to establish links between
personal health and healthy ecosystems, while broader marketing may help raise the status of
the profession and pride in local fishing. Tracing and celebrating history of place and building
new traditions may also create a stronger link with the surrounding communities.

An additional means to safeguard against the reprioritization of stewardship and collective
action motivations may be to satisfy other coexistent needs. As previously shown, people may
hold multiple motivations at any given time; ensuring that these motivations are satisfied may
help mitigate the possibility of their taking priority to motivate large changes in livelihood
approaches. Doing so will most likely require the coordination of other institutions and policies,
such as for healthcare, education, infrastructure, and others.

2.6.1.4  Diversifying avenues of local investment

In addition to expanding the motivations that are leveraged by institutions, it is also
recommended that the means by which users can invest in a system be diversified. For
example, as has been noted and recommended by fishers, additional species could be
protected under the MEABR framework (Castilla & Gelcich, 2008). Helping users to find ways to
diversify the species they exploit might also accomplish the similar goal of hedging against
fluctuations of abundance and price in a single species. Growing local businesses and industries
that also depend on the well-being of marine ecosystems is another potential route to generate
user stewardship and participation.

In the caleta of Ventanas, users identify principally as divers rather than fishers. Ironically, many
of these divers have abandoned the livelihood to take up employment in the very industrial
plants that contaminated the shellfish resources upon which they once depended. In these cases, exploring other means to employ divers in shellfish aquaculture or tourist diving operations may be favourable. However, due to contamination of Quintero Bay as a whole, it is clear that any solution must be part of a larger suite of changes and broader strategies.

2.6.1.5 Conserving and enhancing the current foundations of motivations

Whatever the relevant motivations that underpin participation in collective action and stewardship, institutions and policies can be more attentive to conserving and enhancing their foundations. For example, although many fishers and divers are highly attached to their profession and enjoy the work and freedom that it affords, primary extraction was reported by surveyed fishers as increasingly financially insufficient to support their families. Furthermore, the developing social context is such that artisanal fishers are observing people increasingly employed in positions of higher social status. Social comparison may threaten the profession itself as an attractive option for current and future generations; raising the profile of fishers as important and sustainable providers of local seafood (in much the same way as promoting local producers and farmer’s markets) may be beneficial.

2.6.1.6 Looking beyond community-based institutions

Where community-based CPR institutions cannot be feasibly or adequately adapted to changing motivations and socio-ecological conditions, some degree of privatization or centralization may become more favourable alternatives. Opening the decision space so that options beyond community-based management may be fruitful.
Regardless of the degree of centralization, due to the speed and complexity of globalization and development, many changes constitute surprises, and how people will respond cannot always be accurately anticipated. It is for this reason, among others, that local users are valuable as participants and experts in governance and policy development wherever possible, as they are the most directly tied to resources and thus able to signal trends and change both in the system (e.g., Moller et al., 2004) and in terms of behaviours.

Ultimately, while some user and local ownership of common pool resource management and governance is desirable, it is almost inevitable that larger-scale organizations will need to be involved, given the complexity of global and national change (Gelcich, 2014; Gelcich et al., 2015). To monitor trends in social-ecological context and formulate viable solutions, cross-scale linkages will need to be made between institutions, sectors, policies, and organizations (Gelcich, 2014).

2.7 Conclusion

We have endeavoured to show that community-based management of CPRs faces considerable challenges or are in need of significant modification under conditions of rapid globalization and development. This is especially so if relying too narrowly or heavily on institutions based on self-interested monetary motivations. It has also been an objective of this paper to show the value of explicitly investigating, rather than assuming, what people desire and how they aim to achieve their needs. Recognizing the existence of multiple motivations, which guide individual and community behaviours, opens the door to constructing more creative, resilient, and effective resource management systems.
In essence, we conclude that the pressures of globalization and development will often be greater than can be surmounted by local management alone. However, paying attention to user desires, and developing complementary policy and institutions, as well as facilitating social-ecological changes, rather than resisting them, may be promising.
Chapter 3: Gone fishing? Intergenerational cultural shifts can undermine social-ecological systems

3.1 ‘Slow’ social and cultural change and common property regimes

Many issues of resource sustainability pertain to environmental goods, where extraction and use are difficult to regulate and are also susceptible to overexploitation, and for which common property regimes have been frequently suggested as a solution (E. Ostrom, 1990). The viability of common property systems hinges on the collective desire to maintain resources, and a willingness to bear costs in time, energy, and money toward the development and enforcement of norms and regulations. However, little attention has been paid to how collective desires to maintain resources may be eroded.

The implementation of common property systems and their maintenance depends on the right mix of incentives and the interest of local users to self-organize and invest in the system. Yet, the crucial role of intergenerational change (‘slow’ or social variables) in determining the resilience of common property regimes is often missed, despite calls in social-ecological systems theory for their consideration (e.g., Walker, Carpenter, Rockstrom, Crépin, & Peterson, 2012). Instead, the preponderance of attention is on ‘fast’ ecological variables and their direct effects on the sustainability of natural resources.

2 The following chapter is based on the contributions (i.e., discussions, methodological refinement, revisions, and editing) of Drs. Kai Chan, Terre Satterfield, and Stefan Gelcich.
In commons problems, examples of ‘slow’ variables are intergenerational shifts in education levels, employment opportunities and expectations, changing notions of ‘success’, altered motivations, and rural-to-urban migrations. Critically, the aforementioned demographic and cultural changes could lead to a lack of recruitment of new fishers. Ironically, although research on common-property has considered in great detail the livelihood diversification of fishers (Allison & Ellis, 2001; Brugère, Holvoet, & Allison, 2008; Kronen, Vunisea, Magron, & McArdle, 2010) and recruitment of marine species (e.g., Aburto & Stotz, 2013; Almanza, Buschmann, Hernández-González, & Henríquez, 2012), relatively little attention has been paid to the recruitment of new marine users.

In this paper, using a well-known example of a successful common property system, we show that a creeping crisis for co-managed common property systems exists in demographic shifts, changes in the social status of livelihoods, and the employment aspirations of users. These types of social and cultural changes are common in economic development (Brugère et al., 2008), and can pose policy challenges in many nations and sectors, and thus are likely to apply to a broad class of common property systems.

3.2 Social and cultural change in the context of Chile’s territorial user rights fishery

One of the best-known and highly-regarded common property regimes in the world for fisheries resources is the Territorial User Rights Fishery (TURF) system in Chile. As a national co-management governance regime for benthic resources, it has the rare honour of being widely hailed as a success (e.g., Moreno & Revenga, 2014).
As recounted by Gelcich et al. (2010), the current Chilean institutional and governance system emerged in a void where open-access extraction of marine resources (in particular the economically valuable mollusc *Concholepas concholepas*, or ‘loco’, which competes with abalone in international markets) and roving harvesters reigned. Due to the confluence of political crisis, plummeting resource stocks, and innovative collaborations between fishers and scientists, a new regime of governance was ushered in, which has since delivered (in aggregate) stabilized stocks (San Martín, Parma, & Orensanz, 2010). At the same time, fishers have become environmental stewards, more species have been added to those protected under the system, and fishers have been able to maintain their livelihoods and diversify (Gelcich et al., 2010).

Thus, on the face, the TURF system appears to be well-managed from a linked social-ecological point of view.

Closer examination, however, suggests that slow socio-cultural changes may come to threaten the resilience of the system. A recent investigation conducted by the authors appears to reveal a lack of desire among the current generation of fishers to see their fishing traditions carried
forward by their kin (Figure 10), as well as a distinct aging population structure (Figure 11).

The survey, conducted in March 2013 in small-scale artisanal fishing associations engaged in the TURF program, revealed that 59% of respondents ($N = 116$) agreed or strongly agreed that artisanal fisheries did not have a future; many of whom identified industrial fishing and exploitation (58%), the decline of marine resources (45%), government policies counter to artisanal fishing interests (43%), and industrial development and pollution (13%) as contributors. Importantly, 14% identified the lack of entry by young fishers. While 37% ($n = 43$) of the survey sample did perceive a future for artisanal fishing, 28% of these nonetheless acknowledged a lack of youth recruitment or an overall decline in the number of fishers engaged in the profession. A total of 19% of all respondents perceived a decline in engagement of fishers young and old.
Furthermore, 95% of fishers surveyed did not want their children to be involved in the profession, in comparison to a much smaller percentage of respondents who perceived a general decline in participation. This discrepancy signals a potential lag in recognition among fishers of the problem of disengagement and how widely personal desires for the next generation are shared among peers. Among these participants, 40% expressed a desire for their children to seek education, find careers as professionals, or seek alternative opportunities and higher paying jobs with security. The difficulty, labour, and sacrifice required in fishing (49%), the decline of marine resources (28%), a lack of profitability (23%), the instability and lack of security (13%), and the perception that fishing is dangerous and risky (13%) were also provided by fishers as reasons for wanting their children in livelihoods other than fishing.

![Belief that artisanal fisheries will not exist in the future](chart1.png) ![Desire children to be artisanal fishers](chart2.png)

Figure 10. The number of artisanal fishers ($N = 116$) indicating agreement or disagreement about the future existence of Chile’s artisanal fishing industry (left) and their desire to pass on the occupation to their children (right).
The myriad difficulties perceived to be associated with marine harvesting suggests that current fishers may also contemplate leaving the sector, a finding also borne out in the same survey. A significant minority of surveyed fishers (42%) had either decreased (39%) their fishing effort in the past five years or stopped entirely (3%; note that those who stopped would generally have been missed by the survey), and relatively fewer who started (2%) or increased their fishing effort (29%). Although these numbers may simply represent a diversification of livelihoods among existing fishers, they may nonetheless mean a reduced investment in local management efforts. Yet this divestment among current fishers seems minor in comparison to the changes on the horizon.

In addition to the decline in participation and the poor prognosis of artisanal fishing futures, evidence suggests a distinct lack of newcomers into the sector. This is evinced by the age distribution of respondents surveyed (Figure 11) as well as anecdotal confirmation from the fishers of a distinct absence of young fishers to replace them. Most fishers are middle-aged or older, with very low representation by the younger generation. Out of 184 respondents (across two surveys with artisanal fishers conducted in 2013), only 11% were below the age of 40, and 20% between the ages of 20 and 45. In contrast, respondents averaged 18.38 (SD = 7.93, N = 182) years when they started fishing and 28.23 (SD = 10.32, N = 175) years when they joined their respective fishing organizations. Median age of males for Chile is 32.5 (Central Intelligence Agency, 2013) compared to 54 in this sample.

Far from unique, similar experiences have been documented in fishing communities worldwide. A recorded dearth of interest among youth to participate in fisheries was found in a recent
study in Newfoundland, Canada (Power, Norman, & Dupré, 2014). In Quebec, Canada, the number of people employed as fishers is expected to shrink at a rate of 0.4% in a period of four years (2013 to 2017; Government of Canada, 2014) and is similarly overrepresented by older individuals, with 55.7% over 45. Furthermore, when compared to other occupations in Quebec, 41.4% are over 45 years of age.

Figure 11. Shown is the age structure of Chile’s artisanal fishers surveyed \( (N = 184) \) over two studies in 2013. The loss of artisanal fishers could result in greater exploitation of nearshore marine resources by industrial fleets, with potentially negative implications for regional and domestic food security or sovereignty.

A similar story can also be found in parts of Europe and Asia. Drawing from 2006 Taiwanese government statistics, Liu et al. (2011) report that, “the average age of [Taiwanese] fishermen in offshore and coastal fisheries was between 50-59 and 40-49, respectively, and over half of purse-seine operators in mackerel fisheries (57.1%) were over 60 years of age” (p. 520). The
trend of aging fishers is also noted in Japan (e.g., Akamine, 2005), and among OECD countries (OECD, 2007) such as Norway (Hovelsrud, Dannevig, West, & Amundsen, 2010). Retention of young fishers is furthermore appears to be an issue in some fishing sectors in Scotland (Scottish Government, 2014).

Coupled with poor expectations and aging populations, as well as the rising costs of maintaining Chile’s TURFs (Gelcich et al., 2009; Schumann, 2010), it is perhaps no surprise that as of 2015, over a third of approximately 850 licensed TURFs are either inactive or abandoned (Gelcich et al., submitted). However there is wide variation between regions, partially attributable to the varying capacities of communities (such as between rural and urban areas) to access funding and other services (Mondaca-Schachermayer et al., 2011; Zúñiga, Ramírez, & Valdebenito, 2010). Many fishing associations depend on subsidies to cover the continued operation of TURFs (Moreno & Revenga, 2014).

### 3.3 Management implications

In the realm of common pool natural resource management, the effects of ‘slow’ socio-cultural change have not received much attention, and examples of solutions are lacking. In parts of the world, shifts away from the fishing profession are being addressed: for instance, via initiatives of the European Union Fisheries Area Network aimed at recruiting the young and unemployed by providing training and mentorship (Fisheries area network, 2015). However, such efforts are piecemeal and limited.
A common thread in the academic literature is that socio-economic factors that lead to the diversification of livelihoods or transitions away from primary resource extraction are generally positive for resource sustainability (e.g., Allison & Ellis, 2001; Cinner, Folke, Daw, & Hicks, 2011). Such a perspective fails to appreciate the contributions that common property regimes like TURFs can deliver toward sustainability at larger scales.

In Chile, the potential attrition of active TURFs due to a lack of recruitment and retention of investment by participants may mean the loss of direct and regular stewards and monitors of environmental change over large expanses of sea against poaching and pollution. The loss of a strong network of community-based common property may also remove a source of sustainable seafood for locals (and diverting demand to less sustainable and distant sources; Jacquet & Pauly, 2008), and a source of connection between consumers and the sea. Such a network also functions as a valuable testing ground for adaptive management and learning (Walters & Holling, 1990). In addition, retaining fishers in small-scale fishery activities can mean the diversion of human resources away from less sustainable activities such as industrial fishing and poaching. Retention and recruitment may also help maintain social memory and local ecological knowledge (Folke, 2006).

### 3.3.1 I’d rather be fishing: Potential solutions

For common property regimes in marine settings, solutions may be particularly elusive because ‘slow’ socio-cultural changes can operate at multiple scales and are likely to manifest in unique ways in different localities. At the same time, their impacts may have implications for management of resources at larger spatial scales, such as the erosion of management and
institutional networks. Thus, it is important to try and anticipate how local (dis)engagement may be tied to ecological conditions (e.g., seasonal availability of resources) as well as drivers at regional and global scales (e.g., export demands).

While contributing to the current decline of interest in fishing (through enhanced alternatives), the rapid rise of educational levels and technological savvy in Chile also represent opportunities to secure common property regimes (such as that suggested by Gelcich & Donlan, 2015). More education and diverse experiences can mean a greater capacity to confront the challenges identified by the current generation as barriers to more resilient and sustainable fisheries, including the ability to navigate complex bureaucratic, political, scientific, and social challenges and innovate in these spaces.

While perhaps not sufficient for ‘replacement’ (and highlighting the inherent uncertainty in anticipating cultural change), there is anecdotal evidence since the 2013 survey that at least some educated children of marine users are returning to fishing communities, due a shortage of positions in the professional job market. Thus, an opportunity may exist to re-forge the existing common property system into one that is focused on a smaller but more highly educated and trained workforce, with a greater capacity to innovate, creating a stronger and more resilient, diversified system. Whether such a workforce can be harnessed to benefit natural resources management, and how this may be accomplished is a hypothesis worth testing (e.g., Gelcich & Donlan, 2015).

Importantly, ascertaining and attending to the motivations that govern the (non-)participation of current users and potential fishers in common property organizations can be the means of
opening a dialogue and suite of possible solutions. For example, while it is important to consider economic conditions as a motivator (supporting the need for access to credit, business training, and income potential), the reasons provided by fishers included increased access and desire for education and alternative livelihoods that may have more security, opportunities for advancement, and prestige.

The extensive literature on worker motivation (which can contribute to job retention, satisfaction, and performance) has furthermore shown that variability in tasks, feelings of competence (e.g., via a good match in a person’s skills and job tasks), the ability to exert autonomy and control, opportunities to learn, social interaction, and perceptions of contributing to a ‘greater good’ can all powerfully influence job engagement (e.g., Barrick, Mount, & Li, 2013; Latham & Pinder, 2005; Ramlall, 2004; Rosso, Dekas, & Wrzesniewski, 2010).

Findings such as these can help guide initiatives to attract newcomers and retain veterans in marine harvesting and value-added professions such as in processing and related sales.

Of the fishing organizations and fishers surveyed, some have begun taking steps to diversify and innovate their businesses beyond harvesting, including through tourism, fish mongering, restaurants, and aquaculture. Such business endeavours (relative to harvesting) may better enhance worker motivations described above, such as through increased task variability, greater social interaction, and opportunities for autonomy. However, these efforts tend to be dispersed and disconnected, where more direct investment, coordination, and purposeful development of value-added endeavours and human resources may help foster the mechanisms that generate motivations to engage in the artisanal fishing industry.
Common property institutions will have to adapt to and accommodate changing contexts and circumstances, whether economic, environmental, social, or otherwise. As has been highlighted previously, there are no panaceas (Ostrom, Janssen, & Anderies, 2007), and governance regimes too may be forced to shift with the culture in which they are embedded, while being sensitive to local realities and motivations.
Chapter 4: Who’s adapting to what? General and specific adaptive capacities

4.1 Introduction

Adaptive capacity (AC) is most frequently framed as a set of properties that grants systems the ability to adjust to change (Allen & Holling, 2010; Engle, 2011; Gallopín, 2006). This paper aims to advance research on adaptive capacity by investigating three challenges to how we examine adaptive capacity as promoted in resilience and social-ecological systems literatures.

First, adaptive capacity is most often conceptualized and examined as a general trait and suite of features. Despite this, adaptive capacity has been applied to specific ‘hazards’ such as climate change, but rarely across multiple hazards and stressors (although multi-stressor perspectives are growing, e.g., McDowell & Hess, 2012; O’Brien et al., 2004; Tschakert, 2007). A focus on specific hazards, however, may overlook the possibility that the properties that lead to successful adaptation differ depending on the stressor as well as the adaptive actions required. For instance, the conditions and factors that may be useful in confronting disease are different than for economic shocks. If this is the case, a ‘generic’ view of adaptive capacity may be invalid. The tendency to think about adaptive capacity as general may also help to explain the dearth of research on individual-level adaptive capacity. Adaptive capacity has mostly been

3 The following chapter is based on the contributions (i.e., discussions, methodological refinement, revisions, and editing) of Drs. Stefan Gelcich, Kai Chan, Terre Satterfield, and Timothy Waring.
applied to social-ecological systems, nations, and communities, yet it is the actions of
individuals in response to their environment that give rise to adaptivity at larger scales.

Second, concentration on scales larger than the individual also ignores individual psychologies
that may be fundamental for understanding AC. For instance, social learning is often
hypothesized as a component of adaptive capacity (Fazey et al., 2007; Carl Folke, Colding, &
Berkes, 2003; Claudia Pahl-Wostl, 2009; Pelling, High, Dearing, & Smith, 2008), yet social
learning behaviours have clear links to psychology (such as the cognitive bases of conformism,
content biases, and preferential learning from certain teachers; e.g., Mesoudi, 2009; Rendell et
al., 2011). In addition, perceptions, preferences, and attitudes toward risk are all acknowledged
as important aspects of AC (Adger et al., 2009; Grothmann & Patt, 2005), yet most research on
these variables as they pertain to AC has been theoretical. Less investigation has been statistical
with clear operationalization of psychological properties that are assumed to be critical for
adaptive capacity.

Finally, adaptive capacity is frequently described as latent: that adaptive capacity is resident
and dormant until need arises (Engle, 2011; Lockwood, Raymond, Oczkowski, & Morrison,
2015). As a consequence, many studies have approached the measurement of adaptive
capacity using a set of a priori determined properties (Engle, 2011) whose presence is indicative
of high adaptive capacity and whose absence is evidence of deficiency (while rarely specifying
the relative importance of these properties). This notion of latency, however, ignores the
dynamic and active role people play in shaping their future and every day circumstances in
minor and major ways (e.g., by seeking out new opportunities).
In this article, we question whether a generalized or generic view of adaptive capacity is complete. We hypothesize that capacities are not identical for all changes and may in fact be maladaptive for some. Additionally, although factors such as those linked with poverty (e.g., low education and low financial capital) are frequently associated with decreased adaptive capacity (e.g., Adger & Vincent, 2005; Brooks & Adger, 2005; Yohe & Tol, 2002), generalizing these across scales, actors, and stressors obscures complexity at finer scales that are critical for management. For example, even at the scale of communities and households, there is a need to be explicit about what is affecting whom.

In this research, individuals’ behaviours are the focus of our investigation rather than a single stressor or hazard, as we intend to test the extent to which AC is the same or different across challenges and stressors. This focus is opposite to most adaptive capacity research. Recognizing the dynamic and active nature of adaptation, as well as the complex environment in which lives are lived, we conduct this research with artisanal marine users (fishers and divers) from nine fishing associations in Region V of Chile, along approximately 200 km of coastline. Chile’s Region V artisanal fishers are found in a rapidly changing context, at the center of expanding towns, cities, and associated industry, where adaptation to change is ever-present and critical to wellbeing.

4.2 Chilean artisanal fishing and economic development

Chile’s Region V includes the country’s largest city and capital, Metropolitan Santiago, as well as Chile’s second largest municipality by population, Valparaíso (including Viña del Mar). As such, social and economic networks are extensive between rural and urban regions of the coastline,
and are also characterized by significant urban and industrial development. Areas of Region V are well known as popular domestic tourist destinations, and the country’s recent economic growth (World Bank, 2014) has generated greater demand for properties and amenities in the area. Industrial development has also expanded (United Nations Industrial Development Organization, 2015) to meet the needs of growing domestic and international consumer demands.

Chilean artisanal fishing is both a major source of employment and producer of seafood equal to the industrial fleet (and in some measures greater) despite the use of small vessels (Moreno & Revenga, 2014; SERNAPECSA, 2011). However, artisanal fishing can be divided into two distinct classes: the mid-sized artisanal fleet and the small-scale which are differentiated by boat size, and where the former dominates artisanal catch quotas (Gelcich et al., 2010).

Organizationally, many small-scale fishers are members of fishing associations called syndicates (or colloquially known as caletas) as well as being participants in Chile’s Management and Exploitation Areas for Benthic Resources (MEABR) system; membership in a syndicate is a prerequisite for participation. To date, over eight hundred exclusive (community) licenses to areas of the seabed and the species within them have been assigned (Gelcich et al., submitted) to approximately 300 associations (SUBPESCA, 2013).

The protection of Concholepas concholepas, or ‘loco’, a high-value gastropod was a catalyst for the development and institutional structure of the MEABR (Gelcich et al., 2010). As one of their primary goals, the syndicates and the MEABRs endeavour to ensure economic and social security for their members through risk spreading and cost and benefit sharing, as well as the
securing of resources for exclusive access. As will be elaborated further on, syndicates may also be an important contributor to adaptation actions over and above the welfare and economic functions they provide.

Despite their importance, small-scale artisanal fishers are often economically and politically marginalized (Mondaca-Schachermayer et al., 2011; Orensanz et al., 2005), and they may be especially susceptible to certain impacts of social and environmental change. Among these impacts are declines in the abundance and health of fishing stocks, earthquakes, challenging oceanographic and weather conditions, pollution, market fluctuations and competition, and changing demographics. Many such changes demand that fishers undertake adaptive behaviours to maintain their livelihoods and/or wellbeing, and that of their family and community. At the same time, these same changes can also create new opportunities that fishers may wish to exploit provided they have the means to do so. Thus, the day-to-day of Chile’s small-scale artisanal fishers is characterized by many simultaneous changes that constantly require the mobilization of their adaptive capacities.

4.3 Hypotheses

In contrast to the existing adaptive capacity literature that largely promotes a general and latent view of the concept (Engle, 2011; Moser, 2010), we hypothesize that the factors that grant adaptive capacity and adaptability will differ by behaviour. Moreover, different adaptive actions may be aided or obstructed by different factors. In addition, different individuals may undertake different adaptation actions to address specific challenges, such that there is no single suite of factors that may constitute the capacity to adapt. We investigate the
psychological and demographic properties associated with individual fishers’ adaptations in terms of fishing gear, primary species exploited, and means of livelihood. We further examine self-reported reasons for adapting, and the factors that assist or hinder adaptability. Properties that appear general are distinguished from those that are specific and their implications for policy are elaborated.

4.4 Theorizing adaptive capacity

Conceptually, AC is most closely linked with the distinct but overlapping fields of resilience and vulnerability (Engle, 2011; Gallopín, 2006; Smit & Wandel, 2006). In both cases, AC concerns the ability and willingness to confront or address change (by recovering from and/or mitigating impacts) as well as plan and prepare for changes that have yet to occur. In short, adaptive capacity is the ability to adjust to and shape change. In the context of vulnerability, this is sometimes translated as the ability to reduce sensitivity and exposure to hazards, whereas in resilience it is the means to increase resilience to maintain desirable states and decrease resilience to escape undesirable states (Engle, 2011).

Adaptive capacity is also largely considered an implicitly positive property (Engle, 2011). Nonetheless, beyond this core agreement, there is continued debate about definitions, and alignment with other concepts and their conceptual relationships (Engle, 2011; Gallopín, 2006; Nelson, Adger, & Brown, 2007). Another distinction between the treatment of AC from the resilience and vulnerability perspectives is the relative treatment of ecological versus social aspects. However, in this manuscript we focus exclusively on social adaptive capacity.
Within the resilience literature, ideas of adaptability and adaptive capacity have generally taken on a flavour of holism that is characteristic of the resilience literature (focusing on system-level dynamics), epitomized by its characterization of adaptive capacity as a general and system-level feature. In resilience scholarship, the tendency to focus on larger social scales has led to a lack of specificity and operationalization of adaptive capacity. For instance, terms such as learning, thresholds, and basins of attraction are often invoked in relation to AC (Allen & Holling, 2010; Fazey et al., 2007; Walker et al., 2006) but their interactions are rarely, if ever, defined in ways that can be measured or directly observed.

Although closely linked with resilience, vulnerability research gave rise to the concept of adaptive capacity separately and in parallel (Engle, 2011). In contrast to resilience however, vulnerability research is rooted in the social sciences, and because of its ties with disaster and natural hazards research, largely attends to the ‘here-and-now’ and is much more focused on human actors.

In further contrast to resilience, much more work has been done to operationalize aspects of adaptive capacity in terms of assessment and measurement. However, assessment and theoretical frameworks regarding adaptive capacity as related to vulnerability tend to emphasise access to capital (i.e., human, natural, physical, financial, and social) as a means to mitigate and recover from the impact of stressors (Brooks & Adger, 2005; Brown et al., 2010; Lockwood et al., 2015; Raymond & Cleary, 2013; Smit & Wandel, 2006), which is perhaps a limiting view. For instance, mere access does not describe how capitals will be used (if at all), whether there are path dependencies, whether there is willingness to adapt, or what
combination of capitals matter, etc. As linked to the intellectual lineage of vulnerability, AC also tends to be applied to specific and acute hazards (Brooks & Adger, 2005), with less attention paid to slower and more persistent stressors that may nonetheless require adaptation.

4.4.1 Components of adaptive capacity

Despite differences in the philosophy and approaches between resilience and vulnerability in characterizing AC, a relatively cohesive set of factors have emerged as being linked to high adaptive capacity; these are listed below.

The commonly theorized components of AC listed in Table 1 is not comprehensive; rather the purpose here is to highlight the shared meta-categories that consistently appear linked to AC, as reviewed and implemented here and by others (e.g., Bennett, Dearden, Murray, & Kadfak, 2014; Brooks & Adger, 2005; Engle, 2011; Engle & Lemos, 2010; Folke et al., 2003; Gupta et al., 2010; Lockwood et al., 2015; McClanahan et al., 2008). One will note that while Table 1 loosely follows the conventional ‘capitals’ categories, they are modified and revised.

Table 1. Previously hypothesized components of adaptive capacity and independent variables measured in this research.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Example subcomponents</th>
<th>Measured variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information and learning</td>
<td>• Access to and creation of information</td>
<td>Game cost (social learning)</td>
</tr>
<tr>
<td></td>
<td>• Innovation and exploration</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td>• Knowledge and skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ability to learn and reorganize</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Social learning</td>
<td></td>
</tr>
<tr>
<td>Perceptions</td>
<td>• Understanding of stressors, beliefs and</td>
<td>Foresight</td>
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### Categories and Example Subcomponents

<table>
<thead>
<tr>
<th>Categories</th>
<th>Example subcomponents</th>
<th>Measured variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>and cognition</td>
<td>• Flexibility and anticipatory thinking</td>
<td>Risk perceptions</td>
</tr>
<tr>
<td></td>
<td>• Risk perceptions</td>
<td>(monetary/general)</td>
</tr>
<tr>
<td></td>
<td>• Knowledge of impacts and behaviour</td>
<td>Future fishing</td>
</tr>
<tr>
<td></td>
<td>• Locus of control</td>
<td>Occupational attachment</td>
</tr>
<tr>
<td>Social relations</td>
<td>• Customs, norms and cultural constraints</td>
<td>Not included</td>
</tr>
<tr>
<td></td>
<td>• Social capital</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Leadership</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Trust</td>
<td></td>
</tr>
<tr>
<td>Governance</td>
<td>• Representation (political and power)</td>
<td>Not included</td>
</tr>
<tr>
<td></td>
<td>• Institutions, entitlements, and governance</td>
<td></td>
</tr>
<tr>
<td>Economic wealth and</td>
<td>• Access to technologies</td>
<td>Income</td>
</tr>
<tr>
<td>asset base</td>
<td>• Infrastructure</td>
<td>Age</td>
</tr>
<tr>
<td></td>
<td>• Livelihood alternatives</td>
<td>Perceived opportunities</td>
</tr>
</tbody>
</table>

The above highlighted components are intuitively appealing as elements that may determine adaptation. But it is also the case that their relative importance is not well understood, especially between stressors and contexts. Furthermore, though these components can apply to households, communities, and organizations, they can also characterize individuals, a scale that rarely receives attention (with some exceptions, e.g., Grothmann & Patt, 2005; Lockwood et al., 2015; Patt & Schröter, 2008). Yet, the distinction between social scales, stressors, and contexts are likely critical in determining what leads to the ability to adapt or not.
4.4.2 General versus specific adaptive capacities

Understanding why adaptive capacity research is focused on general versus specific types is key. To date, the majority of evaluative efforts have tended to concentrate on adaptive capacity in the face of single stressors. Less appreciated is that even ‘single’ stressors (e.g., climate change; Brooks & Adger, 2005) can have more than one impact, each impact with just as many or more potential responses requiring different capacities. This oversight is similarly unaddressed in theoretical work on AC, which often discusses adaptive capacity as uniformly applicable and positive without distinguishing the contexts in which this may or may not be true (Engle, 2011). As a consequence, the extent to which multiple stressors may be simultaneously affecting a population has been under-examined. Although some research has begun to study the issue of multiple stressors (Bennett et al., 2014; McDowell & Hess, 2012; Tschakert, 2007), for the most part, larger suites of stressors and associated impacts have been conveniently ignored, likely for pragmatic reasons in conducting research.

While we are not the first to note the need to distinguish general adaptive capacity from the specific (Adger & Vincent, 2005; Lemos et al., 2013; Smit, Burton, Klein, & Wandel, 2000), there still appears to be an unstated assumption that the presence of more components of adaptive capacity equates to more positive outcomes. But this can only be true if all AC is general. More likely, factors that enhance AC for some adaptations may actually hinder others, while undertaking any one adaptation may also preclude others because of opportunity costs, path dependencies, and so forth. Rather, identifying the when, where, and ‘for what’ of adaptive capacity is essential (Brooks & Adger, 2005). Nonetheless, it may be correct that some elements
of AC are more universally positive than others. For instance, greater incomes and education may be important for many adaptive actions (at least a national level), however, more formal investigation is required (Adger & Vincent, 2005).

The need to identify, then, when certain traits or factors enhance adaptivity is sharpened when considering that the same factors that promote adaptation may promote maladaptation under some conditions (Barnett & O’Neill, 2010). For example, it has been hypothesized that high job attachment can be good for a system’s resilience, but it can also lead to an unwillingness to change livelihoods when conditions demand, which can be bad for individuals and communities (also see poverty traps and social-ecological traps; Cinner, 2011). Similarly, the capacity to build infrastructure to weather regular coastal flooding can increase the vulnerability of coastal communities to rare but larger flood events (Freudenburg, Gramling, Laska, & Erikson, 2008).

In addition, components of AC that increase adaptivity to one stressor may not apply to other stressors (Brooks & Adger, 2005), or may increase the ability to adapt to one aspect of a single stressor and not others. Taking climate change as a single stressor example, having high capacity to adapt to increased vector-borne diseases brought on by changing temperatures does not mean that an equally high capacity exists to confront coastal flooding in the same area. Similarly, adaptivity at one scale can be maladaptive at other scales (e.g., short-term vs. long-term, local vs. regional). A general view of adaptive capacity fails to capture these nuances.
4.4.3 Psychology and individual adaptive capacity

The need for a specific account of adaptive capacity is perhaps clearest when contemplating the challenges and means of adaptation of individuals. However, the adaptive capacity literature has predominantly focused on larger social scales, such as systems (social, economic, ecological, or their combination), nations, communities, and institutions and organizations. The omission of the individual scale in adaptive capacity research is problematic because the behaviours and perceptions of individuals directly affect larger scale phenomena and adaptive capacities, and can also help inform those adaptation efforts.

Although larger social structures do change over time, they are often portrayed as having agency (as if they were sentient entities in their own right). It is easy to forget that these structures do not have intention, but rather they are driven by the collective behaviours of individuals. Thus certain institutional and system features may facilitate adaptation they themselves do not adapt per se; their persistence is a by-product of adaptation at smaller scales. Neglecting the individual provides an incomplete picture of adaptive capacity, and there is furthermore great uncertainty in the translation of indicators from one scale to another (Vincent, 2007).

Frequently, households or communities, and even countries are described as relatively well or poorly adapted or having high or low capacity. However, this ignores that even within households, some individuals may be more equipped to adapt than others (e.g., between men and women or adults and children; Adger & Brown, 2009). For instance, to say a household has high adaptive capacity assumes that power dynamics within the household are irrelevant and
that prospects are equivalent among household members through adaptation. Considering AC at aggregate scales ignores that one entity’s adaptation may come at the expense of another’s (e.g., the persistence of a community requiring the sacrifice and acceptance of losses on the part of some of its members).

Although it may be easy to agree that having high adaptive capacity to adapt to harmful hazards such as climate impacts, disease, and other stressors is a good thing, a critical element of the equation is what constitutes a desirable adaptation. It simply cannot be assumed that the ends and means that people desire are homogeneous. What is high adaptive capacity in the face of hurricanes for a resident who wishes to stay compared to another who is willing to leave the storm zone? High adaptive capacity in this scenario is almost certainly different for their respective desired ends and priorities.

The willingness to undertake certain actions and what is deemed desirable are questions of psychology. This willingness, among other psychological aspects, can contribute greatly to determining adaptive capacity (Bichard & Kazmierczak, 2011; Spence, Poortinga, Butler, & Pidgeon, 2011). Despite some recognition that psychology has a role to play in adaptation, for instance in confronting flooding and the adoption of farming practices resistant to climate change (Grothmann & Patt, 2005; Marshall, Park, Adger, Brown, & Howden, 2012), psychologies are often left unmeasured and/or loosely defined and conceptualized. How people transmit, use, and collect information (Leiserowitz, 2006), perceptions of adaptation alternatives and their consequences (Patt & Schröter, 2008), and perceived risks associated
with a hazard (Spence et al., 2011) are all governed in part by psychological processes, all of which may be critical to determining adaptation outcomes.

4.4.4 Latent or active adaptive capacity

Given the above, it appears clear that assuming the presence of pre-determined features as equivalent to high adaptive capacity or that their absence is a sign of low adaptive capacity is inadequate. Additionally, adhering to a pre-determined set of features may be unnecessarily limiting and overlook other factors that may be highly relevant depending on the context. Moreover, the adaptive capacity literature has tended to focus on mitigation and recovery alone; that is simply surviving, rather than a more expansive view of adaptation that includes flourishing.

A latent view may also omit people’s active efforts to seek and create opportunities, and is at odds with definitions of adaptive capacity that include the ability to take advantage of opportunities (Gallopín, 2006). How they do so, and what opportunities people observe in their environment can also be important for adaptation outcomes (e.g., McDowell & Hess, 2012). Thus, also missed may be the associated reasons people choose to undertake certain actions or not, and the factors that may serve to inhibit or facilitate their achievement, dimensions that can be critical for informing policy and decision-makers.

Consideration of individual and active perspectives inescapably leads to a more specific and complete view of adaptive capacity. To these ends, and to address the above gaps, we collected individual self-reports of behaviours in the context of artisanal fishing. We investigated the
factors (the adaptive capacities) that allowed people to undertake particular actions (adaptations). By focusing on individuals and their recent behaviours we are able to parse the conditions to which people are responding, their rationale for their behaviours, and how different behaviours may be used to address single stressors or vice versa, all of which would be lost in a ‘checklist’ approach to AC at larger-scales.

In adopting a more active view of adaptation, we also explored the types of opportunities participants have observed and the potential traits and factors that may have led people to seek adaptation opportunities at all. We concentrate on three concrete behaviours and reveal multiple facilitating and hindering variables for those behaviours. We identify how adaptive capacities are similar and/or different for different behaviours, with a particular focus on psychology. We show how different courses of action are being used to address diverse suites of problems, with implications for adaptive capacity at larger scales.

4.5 Methodology

In order to better understand individual-level adaptive capacity, we surveyed artisanal fishers in a set of communities on the Chilean coast. To understand adaptive capacity as it might be applied to a range of adaptation actions (i.e., adding or switching fishing gear, income sources, and targeted species), we asked questions about adaptation behaviours, motivations, opportunities, and the factors that assisted or prevented the adaptation behaviours. In our analysis, we code these various behaviours as adaptations (our dependent variables), and ask how these relate to a suite of independent variables (potential components of adaptive capacity) through a series of questions about demographics, knowledge sharing, risk
propensity, and occupational attachment, among others. By determining the degree to which these potential components of AC contribute (or not) to adaptation behaviours, we attempt to assess the extent to which each component is relevant to specific forms of adaptation. In the sections below, we explain in detail our data collection methods, how we scored each of the dependent variables (adaptations), independent variables (components of AC), and how we analyzed these together.

4.5.1 Data collection

Data were collected through in-person surveys during March 2013. Surveys were conducted in nine Chilean communities along 200 km of coast in Region V (directly west of Santiago), spanning from the community of Los Molles in the north to Algarrobo in the south. In total 122 people were surveyed.

Participants were recruited on syndicate-operated beaches where fishers conduct a variety of activities including landing their catch, administration, small business, and seafood processing. In each case, the syndicate president was first approached, both to receive permission and to gain help informing syndicate members of our work. In terms of membership, the caletas ranged in size from 76 members (Los Molles) to 188 (Pichicuy), and were situated in rural as well as more urban areas. In total approximately eleven percent of the total population of fishers from the nine communities was surveyed (although the percentage is likely slightly higher as the official statistics include non-surveyed organizations within the same communities).
Convenience sampling was used. Members were asked to participate and were given time to consider their participation if they did not wish to do so immediately. The research team consisted of two to three Chilean research assistants as well as the author. We visited each caleta over sequential days. Only individuals 19 years of age and over were allowed to participate. No honorarium or payment was made for participation in the survey itself, however a small monetary payment was possible for playing a game that was part of the survey (to be described further below).

The results and data reported in this paper are only a subset of that obtained through the survey instrument.

4.5.2 Dependent variables

As previously discussed, this study focused on three concrete behaviours related to artisanal fishing. We asked participants whether they had switched to, or added to, the species principally targeted through fishing, gear used, and source of income, each over the past five years. All switches and additions were considered adaptations, while the individual was considered an adapter for a specific behaviour. Those who had neither switched nor made additions were considered non-adapters for a specific behaviour. Thus it is possible for the same individual to be considered an adapter in terms of fishing gear, a non-adapter for income, and an adapter as related to targeted species, or any combination thereof.

For each of the three behaviours, using open-ended questions, we asked adapters why they had made a change, and the factors that helped them to undertake the adaptation and those
that hindered them. In addition, we asked all participants to list opportunities they had observed but were unable to take, and for each, describe what would have helped them to seize these opportunities and why they were unable to do so. These qualitative data were coded thematically (i.e., assigned a qualitative descriptor of one or two words to capture the dominant ideas of a statement). There was no limit to the number of codes that could be assigned to a participant’s responses. However, while the same code may be applied to different responses made by a participant, duplicate codes are never assigned to a single response. Codes were then treated as count data, with ratios calculated for each code relative to all codes assigned within each question.

4.5.3 Independent variables

To help explain adapters from non-adapters, and how capacities may differ between behaviours, we included a set of predictor variables. The predictor variables are a subset of those theorized in the literature to be linked to adaptive capacity. The independent variables chosen for this study emphasize individual psychological factors in particular. To reduce the number of predictor variables in the final analysis, some questions were combined to form indices (this is described in detail in the analysis section below). In total, there were 23 predictor variables measured, although this number was reduced to 17 in the analysis as detailed below.
4.5.3.1 Demographics

We measured three demographic variables: age, education, and income. Participants were asked their precise age. For education, respondents were asked to indicate their highest level of study from grade one to twelve; post-secondary training was coded as thirteen. For income, we asked participants how much they earned in an average month in Chilean pesos.

4.5.3.2 Social learning

We measured one social learning variable. Knowledge access and sharing (and the linked concept of innovation) are often hypothesized as central to adaptive capacity (Fazey et al., 2007; Pelling et al., 2008). Social learning especially has been tied to adaptive capacity (e.g., Lebel, Grothmann, & Siebenhüner, 2010), despite many and varied definitions. As social learning pertains to adaptive capacity, little progress has been made in its empirical measurement and its conceptualization remains rather abstract (Reed et al., 2010).

In this study, social learning was measured using a card game involving choices and linked payoffs to quantify people’s propensity to seek information from others (for a monetary cost) to inform their game decisions. This measure was adapted from (Efferson et al., 2007), and its development is detailed elsewhere (Chapter 4 of this dissertation). The amount of money spent in the game is interpreted as the inclination to learn socially, with higher amounts indicating greater inclination for social learning.
4.5.3.3 Anticipatory thinking and foresight

We measured three foresight and anticipatory thinking variables (adapted from Marshall et al., 2012). As has been discussed elsewhere, adaptation can be reactionary or anticipatory, with the latter assumed to lead to better and desired outcomes (Brooks & Adger, 2005; Smit et al., 2000). We measured the degree to which people plan and think ahead using three, five-point Likert scale questions (from strongly disagree to strongly agree, coded one and five respectively). The questions were framed in terms of fishing to facilitate responses. Responses to the questions were not highly correlated and were not transformed into an index.

A. If the abundance of marine resources declines, you just wait and hope things will change for the best

B. You do not really believe in long-term planning – things are too uncertain

C. You do not think ahead and plan for changes that might occur in the quantity and quality of marine resources

4.5.3.4 Perceived opportunities

We measured three variables pertaining to the degree to which people observe or are monitoring for opportunities adapted from Marshall et al.'s (2012) conceptualization of perceived risks associated with change. Adaptive capacity is described not only as the ability to cope and recover, but also the ability to take advantage and seek opportunities (Gallopín, 2006; Parry, 2007). However, doing so requires the perception of an opportunity in the first place.

A. You have many options available to you other than being a fisher/diver/collector
B. All changes bring opportunities, they only need to be recognized

C. If the quality and quantity of marine resources declines, there is little you can do to respond

4.5.3.5 Occupational attachment

We measured four occupational attachment variables adapted from (Marshall et al., 2012). Job attachment has been variously stated as critical for sustainability and important for adaptation actions with regard to resources (Marshall et al., 2012; Pollnac & Poggie, 2008; Pollnac & Poggie, 2006). In this study we asked participants to evaluate the degree to which they are attached to marine extraction as a livelihood, using four, five-point Likert scale questions. Two of these ‘A’ and ‘C’ (the latter being reverse coded) were retained and combined following PCA analysis.

A. Working in the ocean (fishing/diving/collecting) is what you love doing the most

B. Being a fisherman/diver/collector is a lifestyle– it is not just your job

C. You would happily consider another occupation other than fishing/diving/collecting if the need arose

D. If needed, you are prepared to completely change the way you fish/extract to stay a fisherman/diver/collector

4.5.3.6 Risk perceptions

We measured two risk perception variables. Risk perceptions influence much human behaviour, and scholarship in this field has shown that risk perceptions can be both general and domain specific (Weber, Blais, & Betz, 2002). The amount of perceived risk associated with a stressor or
a means of adaptation can affect whether an individual takes action. We measure general and monetary risk perceptions adapted from Dohmen et al. (2005). Participants were asked: “How do you see yourself? Are you generally a person who is fully prepared/willing to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: ‘unwilling to take risks’ and the value 10 means ‘fully prepared/willing to take risks’”.

4.5.3.7 Locus of control

We measured five ‘locus of control’ variables. Whether people perceive consequences of their actions for resources has been recognized as important for adaptive capacity (e.g., McClanahan et al., 2008). Also important is whether people have control over barriers to adaptation (Moser & Ekstrom, 2010). However, whether people feel as though they have control over their circumstance has been generally overlooked in adaptive capacity literature. In psychology, this is known as locus of control.

Here we measure whether people believe what occurs in their life is a matter of chance and circumstance or personal control using five, five-point Likert scale questions adapted from Mueller and Thomas (2001).

A. To a great extent you feel that life is out of your control

C. When you get what you want, it is usually because of luck

D. When you get what you want, it is usually because you worked hard for it

E. Whether or not you are successful in life depends mostly on your abilities

F. You feel that what happens in your life is mostly determined by people in powerful
Using PCA we combined questions ‘A’ and ‘C’ and separately combined ‘D’, ‘E’, and ‘F’ into two measures of locus of control. Questions ‘A’ and ‘C’ captures the extent people believe life is uncontrollable and governed by luck whereas questions D-F captures the amount people believe that life is controlled by oneself as opposed to others.

4.5.3.8 Future of fishing

We measured two variables regarding fishers’ belief in the future of their industry. Related to anticipatory thinking and occupational attachment, and as suggested by Coulthard, Johnson, and McGregor (2011), whether people believed there is a future for their profession may affect how people behave relative to ecosystems. We thus asked participants to answer on a five-point Likert scale the degree to which they agreed with the following statements:

A. In Chile, artisanal fishing will not exist in the future

B. You want your children and family to be involved in artisanal fishing and diving

4.6 Analysis

In cases where data was missing for certain participants, they were removed, leading to the retention of $N = 113-115$ subjects in the analysis of each dependent variable. The principal software packages used in the analysis were SPSS 17.0, R 3.2.1 (R Core Team, 2015) and associated packages ‘randomForest’ (Liaw & Wiener, 2002) and ‘varSelRF’ (Diaz-Uriarte, 2014), as well as Microsoft Excel 2010.
As previously described, the behavioural dependent variables were treated as binary. Predictor variables were largely treated as continuous, and measured through Likert-scale questions with the exception of demographic and social learning variables. Reasons why people undertook an adaptation, and the facilitating and hindering factors, as well as the observed opportunities provided in open-ended questioning were coded into common themes and then treated as count data; these were not used in multivariate analyses.

The central analysis of this study was conducted in three main stages using random forests (Breiman, 2001; see below), with the primary goal of uncovering the most important predictors that constitute the capacities relevant to different adaptation actions. The analysis also aimed to determine the relative importance of the most important predictors. The goal was not to develop a generalizable and predictive model of adaptive capacity and adaptation. Random forest analysis was chosen rather than linear regression analysis as it requires fewer assumptions and is more powerful in the face of small sample sizes and many predictors.

4.6.1 Random forests

Random forests (Breiman, 2001) are collections of classification trees. Classification trees take raw data, identify patterns from those observations, and create rules that can then be used to predict new data. Broadly speaking, classification trees determine how to ‘best’ split the data (in this case, according to reductions in Gini impurity, which is the likelihood of misclassifying a case at a node if randomly selected from the classes in that node), given certain predictors (Liaw & Wiener, 2002). For instance, to determine whether fruits are mangoes or oranges, a classification tree might determine from a suite of measurements across mangoes and oranges...
that among the predictors, weight, water content, and acidity are the best criteria for
identification. Such a classification tree might determine that weight provides the best filter for
the first split (reducing the variability maximally within each of the resulting sub-groups), where
anything over half-a-pound is more likely to be a mango and anything under is more likely an
orange. From there, further filters are applied until the value of parsing the data further is
marginal. At each split, the data is separated in two based on some ‘optimal’ point to reduce
variability in the response variable, even where predictors are continuous. In our case, the
predictors (independent data, components of AC) are used to predict/identify whether an
individual was an adapter or not (the dependent variable).

Classification trees are prized for their ease of application, interpretability, and flexibility, but
are disadvantaged by their tendency to overfit data, which can result in inconsistency. Random
forests seek to address these shortcomings by constructing and aggregating over many trees
(for which each split reduces the variability considerably but often not optimally; if optimal
splits were required, there would frequently be a single resulting tree). Specifically, within a
forest, each tree is constructed using a sample bootstrapped with replacement from the total
dataset. Approximately one-third of the data is left out in the construction of each tree (called
‘out-of-bag’ or OOB). At each point where a split is to be made, the filter used is selected
among a random subset (the number of which is specified by the researcher) of all available
predictors, and only the best among this subset is chosen. Each tree is grown without limit, that
is, they are exhaustive. A tree then classifies cases not included in the construction of the tree;
this, combined with the true class of each case provides a means to calculate classification error
rates over the entire forest.
4.6.2 Stages of analysis

Step 1 – All predictors (a total of 17; see Table 1) were entered into a general model through randomForest in R (Breiman, 2001) in a model averaging procedure proposed by Genuer, Poggi, and Tuleau-Malot (2010). This procedure involved conducting randomForest fifty times (each with 2000 trees, $ntree$, and sub setting four predictors, $mtry$, at each split) and extracting each predictor’s importance measure. The predictor’s importance measure is determined by the number of times a tree in a forest correctly classifies an out-of-bag case, minus the number of times a tree correctly classifies the same case when the predictor’s value is randomly permuted among the OOB cases, averaged over every tree in the forest.

The importance measures of each predictor in each forest were then averaged over all forests. Predictors that showed an importance value of zero or less—values suggesting that they did not contribute well to the classification of participants into the correct category of behaviour (adapter or not)—were removed from further analysis.

Step 2 – Remaining predictor variables from Step 1 were then entered into a backward elimination process using the varSelRF R package (Diaz-Uriarte, 2014) to select the most important variables for a final model. In this process, remaining variables were entered into sequential random forests (of ten thousand trees, and drawing two variables at random for each split, except for three in the income model), with a pre-specified number of the least important variables removed after each (20%) until the lowest possible total OOB error estimate was achieved (within a given statistical bound of error).
Step 3 – The resulting variable sets extracted in Step 2 were then entered into separate random forests to obtain final OOB error rates and final values of variable importance (Table 2). A predictor’s importance is provided, which is the mean decrease in accuracy score, and is the average difference (over all trees) in the prediction error rate between the OOB data and the error rate after the permuting the value of each predictor variable. The differences are normalized by the standard deviation of the differences.

4.7 Results

4.7.1 Demographics

The sample (N = 122) was almost exclusively male, with only one female surveyed. Participants were generally middle-aged with a mean of 52.78 years (SD = 11.41). Low levels of education were apparent (M = 6.23, SD = 3.03) and incomes (in Chilean pesos) relatively low per month (M = 246,818.18, SD = 128,706.71; a mean of approximately 420 USD/month) though with great variation.
Figure 12. Reasons users mentioned for undertaking adaptation behaviours provided as a percentage of total mentions within each behaviour category. Only reasons that represent at least five percent of reasons provided for any single behaviour are shown. NOTE: Security refers to economic security; Presence and Decline refer most often to key species availability but also abundance more broadly; Species refers to the need to switch equipment to exploit new species.

4.7.2 Reasons for adapting

To understand the dynamic context and diversity of reasons why people underwent adaptation, adapters were asked to provide the reason why they had changed their behaviour. In total, 19 unique codes were assigned among the 344 mentioned (and coded) reasons people provided for engaged in adaptation behaviours (113 for species, 149 for equipment, and 82 for income); eleven of the most mentioned are shown in Figure 12. In many cases, people provided more than one reason for why they engaged in adaptation. With regard to targeted species, 81
people provided at least one reason, and of these, 31 gave more than one reason, with two of them mentioning more than two (i.e., 38.27% provided multiple reasons). For equipment adaptations, 95 people provided at least one reason, 44 of which gave more than one, with ten of them mentioning more than two (i.e., 46.32% provided multiple reasons). For income adaptations, the respective numbers are 61, 17, and four (i.e., 27.87% provided multiple reasons).

The motivations for undertaking each of the behaviours are dominated by a few common reasons and are not mutually exclusive. We summarize the top three reasons for each. For adapting income sources, the major reason is economic (39.02%), followed by declines in species abundances (18.29%), and sea conditions (12.20%). For equipment it is gear efficiency (37.58%), species targeted (21.48%), and labour conditions (11.41%). Finally, for adaptations in principally fished species, it is the decline of targeted species (29.82%), economic (24.78%), and the presence of other potentially more profitable species (12.39%). Among the reasons are perceived opportunities and not simply stressors, such as improvements in gear efficiency or the appearance in abundance of new species.

4.7.3 Adaptation and adaptive capacities: Income sources, target species, and fishing gear

To test the hypothesis that the features that grant adaptive capacity differ between adaptations, random forest was used to assess the importance of predictor variables in determining adaptation actions in terms of income sources, target species, and fishing gear. As can be seen in Figure 13, different reasons were provided for undertaking each kind of
behaviour, and thus it is perhaps unsurprising to find that the predictor variables included in the final models also differ between the different adaptation behaviours.

Table 2. Variable importance values are shown (scaled mean decrease in accuracy) of final model variables each for species, equipment, and income adaptation behaviours. Out-of-bag estimate of error rates denotes the percentage of participants misclassified as either adapting or not adapting by each model.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Scaled Mean Decrease in Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Species</td>
</tr>
<tr>
<td>Age</td>
<td>--</td>
</tr>
<tr>
<td>Monetary risk perception</td>
<td>--</td>
</tr>
<tr>
<td>Perceived opportunity (A): Many options available other than marine extraction</td>
<td>16.91</td>
</tr>
<tr>
<td>Perceived opportunity (C): Little response available in the face of marine resource declines a</td>
<td>27.68</td>
</tr>
<tr>
<td>Social learning: Game cost</td>
<td>--</td>
</tr>
<tr>
<td>Locus of control index (D, E, F): Life is controlled by oneself as opposed to others</td>
<td>44.98</td>
</tr>
</tbody>
</table>

| Out-of-bag Estimate of Error Rate                          | 35.96%  | 47.37%    | 38.26% |

a Refers to a reverse coded variable.

Of the 17 explanatory variables included at the outset of the main analysis, a relatively small set of six was used in final models (Table 2). Of the six, two were shared between behaviours: monetary risk perceptions and the perception of many options available as an alternative to fishing, however, the relative importance of these variables differs across adaptation behaviours. Furthermore, the most important predictor of each adaptation behaviour was not shared by any other adaptation behaviour. For targeted species it is locus of control and in particular perceptions of agency associated with outcomes. With regard to equipment it is age,
and with income sources, it is the measured propensity for social learning. Notably, education and income were not selected for any of the final models. The absence of income as a predictor is particularly interesting in light of economic reasons reported by participants for undertaking adaptation behaviours.

Although few variables were included in the final models, they were able to correctly classify OOB cases more than 60% of the time for species and income. The model for equipment adaptation fared worse, and was only able to predict OOB cases a little over half the time, however the model is fairly good at selecting adapters (60.61% success rate), but poor at identifying non-adapters (41.67% success rate).

Figure 13. The actual and predicted values of whether a respondent adapted or not in terms of targeted species, with reference to the three predictors in the final random forest model. Data points (circles) are semi-transparent, such that lighter circles represent fewer respondents and darker circles represent more. ‘True’
values of adaptation are represented by circles in the top three panels, while circles in the lower three panels show the fraction of times an individual was predicted as an adapter over all trees in the final model, where 1 is adaptation and 0 is non-adaptation. The x-axes are normalized predictor values, where 1 represents strong agreement and 0 is strong disagreement; note that ‘Opp(C)’ is reverse coded. Blue fit lines are added based on simple linear regressions to help illustrate the data and grey shading is the 95% CI of the fit line.

A closer look at each of the final random forest models and the predictors therein are provided by Figures 13, 14, and 15. In each figure, the top panels show the recorded self-reported adaptation behaviours for each species, income, and equipment respectively in relation to the predictors. The lower panels depict the corresponding predictor/response relationship using the predicted values of adaptation based on the final models applied to each individual in the sample (i.e. the number of times an individual was voted as adapting as opposed to not over all trees). The x-axes in Figure 13 to Figure 15 represent each predictor’s (normalized) range, while the y-axis represents the adaptation behaviour where one is adaptation and zero is non-adaptation. It should be noted that all of the ‘Actual’ values for the dependent variable are binary, while values predicted by the model are probabilistic—representing the effects of all the independent variables included in the model—and range from zero to one, explaining the wider confidence intervals in the former.

The actual behavioural data pertaining to target species adaptations and that predicted by the model plotted in Figure 13 both demonstrate that adaptation is most likely when perceived locus of control is low than high. A small negative relationship between perceived alternatives to fishing was also detected, such that those believing there are few options were more likely
to adapt. However, in general, perceiving few options other than fishing explains little of the variation in adaptation behaviours. Lastly, greater perceived available responses to resource declines appear to be associated with more adaptation (note that this predictor is reverse coded).

Figure 14. The actual and predicted values of whether a respondent adapted or not in terms of income sources, with reference to the three predictors in the final random forest model. Data points (circles) are semi-transparent, such that lighter circles represent fewer respondents and darker circles represent more. ‘True’ values of adaptation are represented by circles in the top three panels, while circles in the lower three panels show the fraction of times an individual was predicted as an adapter over all trees in the final model, where 1 is adaptation and 0 is non-adaptation. The x-axes are normalized predictor values, where 1 is strong agreement and 0 is strong disagreement. Blue fit lines are added based on simple linear regressions to help illustrate the data and grey shading is the 95% CI of the fit line.
In terms of income adaptation (Figure 14), greater efforts to learn socially (as measured by the card game) were associated with a greater tendency to make changes in income sources. Perceptions of available alternatives to marine extraction were similarly positively related to income adaptation. Interestingly, greater monetary risk propensity appears to be associated with slightly less income adaptation, although predicted values (lower left panel) suggest that this variable provides little explanation.

In contrast to the minor negative relationship between monetary risk perceptions and income adaptation, a stronger and positive relationship was detected between monetary risk and gear adaptation behaviours (Figure 15). Gear adaptation was also associated with younger rather than older individuals in the final model.

![Figure 15. The actual and predicted values of whether a respondent adapted gear or not, with reference to two predictors in the final random forest model. Data points (circles) are semi-transparent, such that lighter circles](image-url)
represent fewer respondents and darker circles represent more. ‘True’ values of adaptation are represented by circles in the top three panels, while circles in the lower three panels show the fraction of times an individual was predicted as an adapter over all trees in the final model, where 1 is adaptation and 0 is non-adaptation. The x-axes are normalized predictor values, where 1 is strong agreement and 0 is strong disagreement. Blue fit lines are added based on simple linear regressions to help illustrate the data and grey shading is the 95% CI of the fit line.

### 4.7.4 Perceived barriers and facilitators to income, species, and gear adaptation

In addition to the random forest models, adaptation behaviours can be better understood by the qualitative insights provided by participants on the conditions that helped them undertake adaptation or made it more difficult. These data also highlight how the settings in which adaptations occur likely require (and may be assisted by) multiple, specific, adaptive capacities.

In total, 20 unique codes (in 311 assigned) were given to the responses provided by participants pertaining to the conditions that facilitated their adaptation behaviours. Nine of the most common coded facilitating factors and themes are shown in Figure 16. As with the reasons provided for undertaking adaption behaviours (see Section 4.7.2 above), distinct differences can be observed in the factors that facilitate them.

The top three facilitating factors for each of the three behaviours follow. For income it is, in descending order, having social connections (37.17%; which is well aligned with social learning in the multivariate analysis), knowledge or know-how (25.64%), and education (7.69%). For gear adaptations it is also social connections (33.63%), economic factors (29.20%), and the
fishing syndicate (13.27%), with knowledge a close fourth (11.50%). Finally, for adaptations in targeted species it is economic factors (23.14%), equipment (20.66%), and efficiency in gear (9.92%).

Qualitative descriptions of barriers encountered while undertaking the adaptation behaviours in question were similarly coded for dominant themes. In total, 18 unique themes were coded and 178 codes were assigned. For income adaptations, two barriers are tied for the most mentioned and second most mentioned. These are the need to adjust to new working conditions and economic factors (both at 16.67%), followed by physical labour issues and social connections (both at 11.90%). For equipment, it is economic factors (40.68%), and issues of physical labour (18.64%) and knowledge (15.25%). Finally, for species adaptations, the largest barriers were economic (23.38%), physical labour (20.78%), and equipment related (10.39%).
Figure 16. Themes coded for the conditions that assisted in adaptation for each of three behaviours (left) and the conditions that made adaptation more difficult (right). Only codes that represent at least five percent of codes assigned for any single behaviour are shown.

4.7.5 Perceived opportunities

Respondents also mentioned 125 opportunities that they had observed but were unable to take. This list was dominated by a few major categories including: starting and operating new businesses (33.60%; i.e., tourism, restaurants, aquaculture, construction, etc.); the use and purchase of fishing equipment (28.80%); and targeting of alternative and additional species (24.80%). Together, the aforementioned three categories make up 87.20% of opportunities mentioned. The remaining 12.80% include improvements in caleta infrastructure, housing, and regulations to support sustainability, among others.
4.8 Discussion

The results of this study support the argument that adaptive capacity can be specific and not merely general. The random forest models that constitute the central analysis of this study demonstrate that the most important factors contributing to adaptation behaviours (i.e., of targeted species, income sources, and gear) are not the same. Adaptation behaviours with regard to targeted species was most strongly linked to perceptions of having personal control over life’s circumstances. In contrast, gear adaptation behaviours were best explained by age, and income adaptation by the individual propensity for social learning. Only monetary risk perception and the perception of opportunities outside of fishing were shared across any adaptation behaviour (and so may be called ‘general’), however the influences of these predictors appear in opposite directions. For instance, a low propensity to take monetary risks is linked to a greater probability of income adaptation, whereas high monetary-risk propensity is linked with adaptations in gear. In other words, individual adaptive capacities appear to be specific to particular adaptations.

Further supporting the argument for greater attention on specific adaptive capacity, there are different as well as shared reasons for why individuals engaged in each of the adaptation behaviours. The latter suggests that there can be a number of adaptations available for the same stressor, at the same time, certain adaptation behaviours may be undertaken for unique reasons. The (proximate) reasons provided for engaging in one adaptation as opposed to another can be markedly different. For instance, income adaptation centers on economic factors, whereas equipment adaptation is largely linked to issues of gear efficiency, species
targeted in fishing, and physical labour. On the other hand, economic considerations and species declines were provided as common reasons for both income adaptations and adaptations in targeted species.

Similarly, fishers reported unique as well as shared factors and conditions that helped to facilitate or impeded their adaptation behaviours. Having formal education (which did not appear in the final random forest model), adequate knowledge, and social connections are strongly represented among factors facilitating income adaptations. For gear adaptations, facilitating conditions include social connections, support of the syndicates, and economic means. With targeted species, most facilitating factors pertain to the obtainment and access to new equipment.

In comparison, self-reported factors identified as hindering adaptation appear more cohesive across behaviours, although some are still unique. Difficulty obtaining the necessary knowledge, issues pertaining to physical work conditions, and lack of economic means were all prevalent and shared inhibitors among the three adaptations. Conversely, difficulty adjusting to new workplaces and routines, and lack of desired social connections or the presence of inhibitive ones was more distinctive to income adaptation.

Importantly, among the facilitating factors and the reasons for adaptation are features that cannot be appropriately considered stressors; people are not responding solely to negative impacts. Reasons include personal goals and desires, prospects to increase wellbeing through safety and efficiency, and responding to stochastic events such as the appearance of species. In short, opportunities also influence when and how people act and thus adapt. Data on missed
opportunities also highlights the fact that people attend to promising prospects within and beyond fishing, for both personal and collective benefit. Furthermore, even stressors with negative impacts may sometimes become, or give rise to, opportunities should the perception, willingness, and capacities exist to take advantage. For example, rising international markets for abalone not only compete for the demand of C. concholepas managed under the MEABR system, but are also an opportunity for expanding into abalone aquaculture.

The sum of the above findings challenges the assumption that adaptive capacity is latent. A latent view of adaptive capacity has tended to focus on negative stressors with adaptive capacities being dormant until activated by need (Engle, 2011), implying a static unidirectional relationship between stressor to adaptation. Instead, participants in this study are continuously attending to opportunities and proactively making efforts to improve their condition and wellbeing. Furthermore, it appears that fishers are choosing what capacities to apply, how, and when, rather than adapting as matter of course in the face of stressors. Thus, a latent perspective may fail to capture the existence of simultaneous and multitudinous drivers to which people attend, and the diverse adaptation paths and opportunities available to each person. Attending to why people choose to undertake certain actions or not, and what helps or inhibits them can be informative for broader policy development toward adaptation.

Adaptive capacity research has conventionally been fixated on determining the existence of capacities according to pre-determined criteria (Engle, 2011), whereas little has been done to examine actual adaptation behaviours and what make them possible (and a general shortage of ‘real-world’ considerations; Moser, 2010). Rather, the current study suggests that adaptive
capacity is not monolithic, indicating that efforts at enhancing adaptive capacities will likely require careful consideration of stressors and opportunities, as well as associated human perceptions and social and environmental conditions. Promisingly, this means that there are numerous points of possible leverage that decision-makers and managers can attend when seeking to enhance adaptive capacities. These include endogenous considerations, and enabling exogenous facilitating factors while removing barriers, and enhancing the abilities of individuals and communities to seize new opportunities.

Notable from the central analysis is the absence of education and income in the final models, which are fixtures of past adaptive capacity studies (e.g., Brooks & Adger, 2005; Brooks, Neil Adger, & Mick Kelly, 2005; Yohe & Tol, 2002). The absence of income and education as predictors is particularly puzzling in light of participants’ emphasis on economic reasons for undertaking certain adaptations, as well as knowledge and educational conditions for facilitating and inhibiting some adaptation behaviours. Given the diversity of adaptation behaviours and purposes observed, it may be that income aids in some cases while obstructing in others (e.g., risk aversion), while knowledge needs may be specific to a particular adaptation, such that neither the influence of income nor general education materialised.

Psychological components, instead, feature heavily in our three studied behaviours, overriding traditional demographic measures except for the case of age in gear adaptations. Although education and income did not appear in the final models, it may be possible that they are relatively more important for adaptations not covered by this research. Nonetheless, these findings caution against reducing adaptive capacity to demographic variables. It also appears
that a willingness to act, as well as the perception of opportunity and alternatives, is integral to
capacity rather than merely having capital from which to draw.

Our results also suggest that some individuals are better suited to undertake certain actions
given that distinct combinations of factors contribute to different capacities for change. Thus,
building adaptive capacity at larger scales inherently creates winners and losers and addressing
capacity as a uniform trait ignores certain trade-offs and issues of equity (and require us to ask
who is adapting to what; Smit et al., 2000). Instead, much research overlooks individual and
behavioural level differences in adaptive capacity and treats households, communities, and
even larger social groups as homogeneous.

In many respects, this study is preliminary. A vast space remains for the exploration of adaptive
capacity as a research and management concept (e.g., Moser, 2010). This research focuses on a
narrow set of adaptation behaviours specifically in artisanal fishing in one region of Chile.
Whether the results of this study is generalizable, even among artisanal fishers in other regions
of Chile is open to research.

The operationalization of adaptation in this research also has drawbacks. Efforts made by
individuals to preserve the status quo (e.g., continue fishing the same species with the same
gear in the face of change) are not captured as adapters. In a sense, finding the means to
continue as usual requires adaptation of a specific kind. A small sample size and many
predictors also limit this research, and was the reason why model averaging procedures and
random forest was chosen for analysis. However, to maximize the use of the dataset, no test
set of data was kept separate to further examine the success of the final models.
4.9 Conclusion

Adaptive capacity is a fundamental aspect of resilience and vulnerability, and a burgeoning topic in resource management and governance. At its core, the concept attempts to capture the ability of an entity to change and weather change. Despite the obvious value of adaptive capacity as a subject of research, there continue to be major gaps and confusion that prevent the development of concrete actions to build capacity (Adger & Vincent, 2005; Engle, 2011; Moser, 2010; Vincent, 2007), or even identify where a dearth exists.

As previously described, we identified three gaps in adaptive capacity scholarship. Foremost is the need to distinguish between general and specific forms. This need is especially apparent when considering adaptive capacity at the scale of individuals and between specific behaviours in contrast to the larger-scale investigations that are the norm. Attention to individuals also makes it possible to examine psychological properties (in this study, examples include social learning, locus of control, perception of opportunities, etc.; Table 1) that have been hypothesized as important in adaptive capacity, but have yet to receive serious empirical treatment in all but a few preliminary cases (e.g., risk perception, occupational attachment, etc.; Grothmann & Patt, 2005; Lockwood et al., 2015; Marshall et al., 2012; Patt & Schröter, 2008). Lastly, approaching adaptive capacity as more dynamic, shaped by everyday actions, often with intent, is a clear contrast to the more latent (i.e., unidirectional and inactive) conceptualizations typically proposed.

By investigating three specific behavioural adaptations in the domain of artisanal fishing at the scale of individuals, we provide tangible evidence that a generalized or ‘generic’ concept of
adaptive capacity cannot apply across all situations. This study is also among the few that have operationalized and measured psychological factors that have been linked to adaptive capacity in theory to show their significant role in enabling or preventing adaptation. We also offer evidence that adaptive capacity is more than a dormant feature, but that people actively seek and attend to opportunities and means to adapt and shape their circumstances to their desired ends. In other words, adaptive capacity is far from a passive trait that lends itself to straightforward characterizations.

The results amassed from this research recommend the need to develop new approaches to assess adaptive capacities for defined behaviours, contexts, and stressors. While demonstrating the need to differentiate general and specific adaptive capacities was an expressed aim of this paper, it is not to insinuate that general components do not exist or have value, but rather require defined bounds.

Finally, adaptive capacity is too often deployed in the context of crisis, perhaps owing in part to its origins in natural hazards and vulnerability research. Where a great deal of psychological research addresses illness, the branch of positive psychology was established to focus, in contrast, on the foundations of happiness and wellbeing (Seligman & Csikszentmihalyi, 2000). In the same spirit, we advocate for an expanded application of the concept of adaptive capacity to focus beyond recovery, disturbance, and maintenance of the status quo to include opportunities and thriving, or a ‘proactive capacity’.
Chapter 5: Rethinking and measuring social learning in natural resource management

5.1 Introduction

In general, one of the strongest and most common claims made in regard to social learning broadly is that it is likely to lead to improved social-ecological management and outcomes, for example, by increasing common understanding and identities between stakeholders (e.g., Pelling, High, Dearing, & Smith, 2008), changing environmental attitudes (e.g., Glasser, 2007), and increasing collective action (Reed et al., 2010; Webler, Kastenholz, & Renn, 1995).

Growing attention in the resource management literature on social learning is currently accompanied by a proliferation of diverse definitions at the expense of clarity and operationalization (Cundill & Rodela, 2012; Reed et al., 2010; Rodela, 2011). We perceive opportunities for both methodological and theoretical contributions from the field of cultural evolution (the study of cultural inheritance and composition as a function of learning; Boyd & Richerson, 1988) as it might apply to our understanding of social learning in natural resource management contexts.

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4 The following chapter is based on the contributions (i.e., discussions, methodological refinement, revisions, and editing) of Drs. Timothy Waring, Stefan Gelcich, Terre Satterfield, and Kai Chan, and coding assistance and statistical advice from Gerald Singh and Caitlin Millar.
Social learning is widely recognized as important to natural resource management, although measures are unstandardized and nascent in this field, with a distinct absence of quantitative and objective measures of these constructs (Reed et al., 2010; Rodela, 2011). The lack of quantitative tools in natural resource literatures may be due, in large part, to confusion around the concept and conflation of social learning with other social processes such as collaborative workshops and governance initiatives that may engender learning (Reed et al., 2010).

Furthermore, social learning in the resource realm is often (implicitly and explicitly) thought to be closely associated with factors such as social capital and positive social relations. In other words, learning between individuals and groups should increase when the context is sociable rather than hostile. Much of this wisdom rests on a foundational assumption that learning should occur given the ‘right’ spaces for the ‘right’ people to connect (e.g., Pelling et al., 2008), and little linkage between social scales is made (i.e., individual to community, rather than cross-organizational).

Conversely, the development of metrics of social learning is relatively formalized and well established in psychology and cultural evolution (and an active area of research). These include experimental methods (Mesoudi & Whiten, 2008) as well as field-applicable methods (e.g., Efferson et al., 2007). A major difference of the cultural evolutionary and psychological approach is the careful control of conditions to enable more confident claims that what is being measured as outcomes in fact reflect social learning. We believe that drawing from the rich methodologies in cultural evolution can afford resource scholars greater means to investigate
social learning in the context of sustainability (Boyd & Richerson, 2008; Richerson & Henrich, 2012; Richerson, Boyd, & Paciotti, 2002).

The cultural evolutionary body of work focuses on social learning as an individual behaviour that all people engage in at times, where such learning depends on the type of information and the learning context (Richerson & Boyd, 2005). Learning behaviours can also result in emergent properties at larger scales (Chudek & Henrich, 2011). In addition, social cultural evolutionary theory suggests that social learning is an adaptive behaviour that is costly, and thus should occur most at levels of intermediate disturbance where social or environmental variability is neither so high nor so low that learning from others confers few advantages (Boyd, Richerson, & Henrich, 2011). Much less is made of social variables such as trust and social capital, with only some aspects of learning determined by the teacher (or model). Rather, learning depends more heavily on the qualities of the model(s) (i.e., the people being learned from, for instance their age, gender, and prestige), the frequency of behaviours in a population, and individual experiences such as uncertainty and success (Rendell et al., 2011).

Given the above, we aim to operationalize social learning and create a measurement that is easy to administer and logistically undemanding for field studies. To do so, we adapt a group measure of social learning from the field of cultural evolution (Efferson et al., 2007) to be used with individuals, and test its validity in a resource management context. The measure developed in this study is the propensity of a person to seek information from others (i.e., trait-level social learning), as distinct from an outcome-based measure.
Theoretically, we aim to test whether and how factors such as trust and shared understandings, which are hypothesized to be related to social learning by resource management scholars (Reed et al., 2010) are in fact related. In so doing, we hope to address three major problems in natural resource literatures on social learning. As identified by Reed and colleagues (2010), these are: 1) Understanding what factors lead to social learning; 2) conflation of social learning and its outcomes, such as trust and social capital; and 3) differentiation between social scales of organization. Our chosen research sites are the artisanal fishing communities in Region V of Chile, which is situated slightly northwest of the Chilean capital of Santiago. Our research is at both individual and community scales.

5.2 Methods

Methodologically this paper investigates social learning in a real world context, in the field. We draw upon two separate surveys of 184 individuals from seven artisanal fishing communities, which provided self-reported information on social learning and a variety of factors hypothesized to be associated with social learning, as well as a social learning game. In the sections below, we explain more fully the survey sample and content, the game, how we analyzed the validity of the game in relation to self-reported learning, and the literature-hypothesized relationships between various factors and social learning.

5.2.1 Study site

Chile’s artisanal fishing organizations and institutions offer a unique context in which multiple fishing communities can be found in a relatively small distance, allowing for sampling in more
similar macro-social and ecological environs. Critically, many of the fishing communities are engaged with a national common property governance system for benthic resources through the assignment of territorial user rights to fisher organizations (Castilla & Fernandez, 1998; Gelcich et al., 2010). This co-management regime in effect creates a common future and purpose within groups, as well as a degree of autonomy to tailor local institutions to align with national policies, allowing for differentiation between groups.

As such, we expect unique cultures to emerge from individual communities (e.g., Aburto et al., 2013) allowing for the study of both individual and community variations in the traits of interest, in this case, social learning and other social variables. Chile’s artisanal fishing communities thus represent an ideal test ground for examining the presence and influence of social learning in a quasi-experimental setting.

Fishing as a livelihood also presents an interesting case study to examine social learning because although fishers included in this study are members of organizations with common objectives and have a vested interest in the wellbeing of communally owned resources, high social learning is not a given. Fishers themselves may be loathe to share valuable information with one another, for example regarding new fishing grounds, business ventures, and fishing techniques that are not immediately tied to benthic resources. However, payoffs in sharing may also be great, and repaid in-kind or through other favours. Thus, we expect individual variation in the degree of social learning to be partially independent of the community characteristics.
5.2.2 Data collection

Two separate surveys were administered between January and March 2013 in seven fishing associations (also known as caletas) in Region V of Chile. In sum, 184 unique individuals were surveyed (100 in the first survey and 121 the second). Thirty-seven people responded to both surveys; these individuals were retained for the individual scale analysis. Where answers to certain questions (i.e., demographics) were at risk of being double counted for the 37 repeat respondents, answers from the first survey were omitted. At the community level, all survey respondents were included, with data aggregated and averaged by fishing association. Not all measured variables are included in this study, only those hypothesized to be related to social learning (described, in part, in the section ‘Hypothesized social learning correlates’ below).

5.2.2.1 Demographics

A standard suite of demographic variables was measured including age, number of years of formal education, and income (all treated as continuous). In addition, because of the significance of migration for social learning (Boyd & Richerson, 2009; Boyd & Richerson, 1988a; Henrich & Boyd, 2008; Kameda & Nakanishi, 2002) and the historical migration pattern of fishers along the Chilean coast (Aburto, Thiel, & Stotz, 2009) we also assessed whether a person was born in the local community or not. Other demographic variables related to fishing also include the percentage of income derived from marine extraction, number of years fishing, number of years respondents have been members of the local fishing association, and the average number of days spent fishing per month.
5.2.2.2 Social learning

With the cultural evolutionary understanding that social learning is sought by all individuals at certain times depending on the social and environmental context, social learning (for this study) was operationalized as the propensity of individuals to seek social information to inform their own decision-making. The measure used was a social learning game adapted from the game designed by Efferson et al. (2007), which was originally played in groups, to be played with individuals. The intention of adapting the game for individuals was to create a means to investigate social learning in field settings with fewer logistical requirements. Furthermore, individual playing may mitigate any unaccounted for group effects (e.g., group composition) that can alter responses, in effect turning the game from a state measure to a trait measure.

The game involves two separate decks of cards, one red and one blue, with 30 cards apiece. On the backside of every card is the colour of the deck and on the front is a payoff in Chilean pesos, which players can win by selecting the card. With only the back of the cards showing, the objective of the game is for the respondent to make as much money as possible by selecting one card at a time from either deck across 30 plays (or rounds), leaving 30 cards unselected at game’s end. However, one of the decks always has a higher average payoff than the other. If a player chooses to play the High Payoff (HP) deck exclusively, their end payout is 3760 pesos compared to 2720 if the same strategy is employed with the Low Payoff (LP) deck. All players faced the same pair of payoffs in the same order. For example, in round twelve, all respondents have a choice between a card valued at 50 pesos and another at ten. If a player chooses
optimally (i.e. the highest payoff card in every round) they can earn a maximum of 4130 pesos. Conversely selecting all the lowest payoff cards grosses 2350 pesos.

Two goals guided the game’s payoff design. First, we wanted to encourage players to take the game seriously, thus payoffs were real and kept by participants; expected payoffs were judged to be equivalent to earnings from one hour of fishing work. Second, following Efferson et al. (2007), we drew a random set of 30 numbers from truncated normal distributions for the HP and LP decks as payoffs, with a lower bound of zero and an upper bound of 275 pesos and a mean of 133, and another with an upper bound of 245 pesos and a mean of 103 pesos for the HP and LP decks respectively (both with SD = 57). The decks were organized such that, theoretically, uncertainty over which of the decks was HP was gradually reduced (Figure 17) over successive rounds. Rounds (containing pairs of red and blue cards) from the organized pair of decks were then assigned numbers from 1-30.

The social informational aspect of the game involves the opportunity for participants to learn about what the most successful player (based on winnings in the piloting phase) did in the round just played. The ability to purchase this ‘social’ information begins in the third round, priced at 15 pesos, rising by 15 peso increments each round to a maximum of 420 pesos in the final round (costing 6090 pesos if all social information is purchased). The cost of buying information is subtracted from total payoffs at the end of the game.

To generate the social information, the game was piloted without social information with seven fishers (the range of winnings among pilot players was 2910-3490 ($M = 3204.29$, $SD = 198.48$). However, for each pilot participant, the order of the rounds (originally organized and from 1-
30) was randomized (i.e., put out of sequence). The choices of the most successful of the seven fishers were offered for purchase to all subsequent players. That is, at each round’s end (e.g., round X), a player was offered the opportunity to see the choice of the most successful fisherman ‘A’ in round X. Note that because fisherman A’s choices were made based on rounds in a different (randomized) order, the social information (player A’s choices) does not pertain to the amount of knowledge a subsequent player has access to through their experience of the game, but instead represents the choices of the most successful player in the pilot round. Thus the value of the social information varies between choices, but does so only randomly. We believe this provides a ‘purer’ measure of a person’s propensity to seek social information.

Ultimately the game provides two different metrics of a respondent’s social learning propensity: the amount spent to access social information and the number of times such a purchase was made. The amount spent (Game Cost) may be considered a better metric if we assume that respondents are sensitive to price. Conversely if respondents are not very price sensitive, the buying frequency (Buy Count) may be a better measure. As such, using the Game Cost metric, it is possible for an individual to be considered more of a social learner than another even if they purchased social information fewer times but at higher prices (i.e., later in the game). We use both Game Cost and Buy Count to examine the claims related to social learning in this study.

As this was the first trial of the social learning game, four questions were included in the second survey to test the game’s convergent validity (i.e., that both measures of learning, frequency and amount of purchases, are correlated to measures that should be related, in theory); the
questions assessed self-reported personal knowledge seeking, and knowledge availability and sharing in the community. These were crafted in-line with social learning as conceptualized in the cultural evolution literature. Our hypothesis was that perceptions of information sharing and availability of information worth learning in the communities should be positively correlated with information purchasing frequency and cost.

Figure 17. Average p-values for between group t-tests, assessing whether the high payoff (HP) deck offers higher average payoffs than the low-payoff (LP) deck (left plot) and vice versa (right plot). Ordered values from the game are used, and game choices are simulated over 30 rounds (one iteration). T-tests were conducted after each round using the history of payoffs achieved within each iteration; p-values graphed are averaged for each round over 200 iterations. The p-value serves as a proxy for the theoretical uncertainty of a player that the higher or lower payoff deck can be identified with 95% probability of success. Black dots indicate means. Errors bars represent the p-value 95% CIs.
5.2.2.3 Hypothesized social learning correlates

Factors that have been hypothesized to be related to social learning (as precursors or outcomes) in resource management literatures include improved environmental attitudes (Glasser, 2007), common perception and understanding of environmental dynamics (e.g., Pelling et al., 2008), positive social relations (Pahl-Wostl et al., 2007; Rodela, 2011), greater collective action (Reed et al., 2010; Webler et al., 1995), and higher adaptive capacity (Folke et al., 2003; Pahl-Wostl, 2009; Pelling et al., 2008). As such we include the following measures, which affords us the ability to examine, more critically, claims made in the natural resource management literature between social and cognitive factors, and social learning.

- Environmental attitudes: three questions adapted from the New Ecological Paradigm Measure of pro-environmental worldviews (adapted from Dunlap, Van Liere, Mertig, & Jones, 2000).

- Common understanding: shared perceptions among respondents and their communities were assessed using a 22 question true or false test based on statements regarding local environmental dynamics. These statements were created based on conversations with fishers in the first survey and administered in the second. Using Cultural Consensus Theory methodology (Romney, Weller, & Batchelder, 1986; Weller, 2007), the test allows the computation of a ‘competence score’ – the degree to which respondents answers cohere with those of their peers – for each respondent.
• Positive social relations: many scholars have emphasized that social learning is likely to be associated with enhanced trust, social capital, and strengthened social relations (Cundill & Rodela, 2012; Reed et al., 2010). Thus we include the following: two questions on trust of colleagues and outsiders (adapted from Veenstra, 2002); two questions related to social capital, specifically the perception of a capable leadership and valuing of friendships with colleagues (adapted from Obst, Smith, & Zinkiewicz, 2002); and two questions related to the perceived need to belong to the fishing association (adapted from Leary, Kelly, Cottrell, & Schreindorfer, 2013).

• Locus of control: social learning is frequently associated with adaptive capacity (e.g., McClanahan et al., 2008; Moser & Ekstrom, 2010). An essential component of adaptive capacity is the will and perceived ability to effect change. We included five questions pertaining to locus of control – or the perceived ability to affect personal outcomes and circumstances around fishing adapted from Mueller and Thomas (2001).

• Quality of life: social learning is by and large touted as having an overall positive influence. As a measure to assess one specific manifestation of this claim, we also include a measure of overall wellbeing as depicted by quality of life. This was a single-item measure from 1-10, with ten indicating the most positive rating (World Values Survey Association, 2005).

• Willingness to take risks: Two measures of risk perceptions were included (adapted from Dohmen et al. (2005): one general and the other specific to
monetary risks. Both questions ask the degree to which respondents are willing to take risks on a scale of zero to ten with ten being very willing to take risks.

- Collective action: Lastly, ten measures of collective action are included; five of which pertain to Ostrom’s collective action institutions (Cox et al., 2010; E. Ostrom, 1990), and another five related to social norms related to fishing.

5.2.3 Analysis

Analyses focused on clarifying the factors that lead to social learning and to distinguish it from other social variables at individual and community scales. All analyses were conducted using the statistical packages R 3.2.1. (R Core Team, 2015), R packages ‘hier.part’ (Walsh & MacNally, 2013) and ‘ggplot2’ (Wickham, 2009), SPSS 17.0, Microsoft Excel 2010, and UCINET 6 (Borgatti, Everett, & Freeman, 2002).

Social learning metrics and all predictors were treated as separate (i.e., were not combined into indices) at the individual or community level. This was primarily to maintain comparability between the individual and community scales. One exception is an index created at the community level, which includes selected trust, social capital, and belonging variables. This index is described in more detail further below in the results section. Measures at the community level were composed of the aggregated and averaged individual measures.

Although the full details of Cultural Consensus Theory (which we use to measure common understanding) cannot be described here, we refer the reader to Weller (2007) and (Romney et al. (1986). In short, we transformed 22 true and false questions on environmental dynamics
and change into competence measures for each individual and each community as above (see Chapter 6). Competence is a measure of conformity between an individual’s answers and that of their peers (in the same community), and not of the environmental accuracy of their responses. This analysis was conducted using UCINET 6 (Borgatti et al., 2002).

5.2.3.1 Correlation and hierarchical partitioning analysis

Our analysis consists of three distinct steps. First, we examine whether the game is a valid measure of individual efforts to learn socially. To do so we assess convergence with self-reported personal knowledge seeking behaviours and perceptions of knowledge sharing and knowledge availability in the community.

Second, we test whether there is a statistically significant relationship between our social learning measures and variables hypothesized as outcomes and/or enabling variables at the individual and community level. Because there is significant confusion in regard to causality but more explicit claims related to directionality (generally positive relationships), we use basic bivariate parametric and nonparametric one-tailed correlations (Pearson and Spearman at $p < 0.05$) in the first and second steps.

Finally, to understand the relative importance of significant variables identified in the preceding step, as well as to address multicollinearity among predictors, we utilize a hierarchical variance partitioning procedure (Chevan & Sutherland, 1991). The objective is not to create a generalizable predictive model of social learning but rather a richer description of the factors that co-vary with efforts to learn socially in our context. Through hierarchical partitioning we
examine the independent and joint contribution of significant variables in explaining the variance of behaviours in the game at the individual and community level.

Although methods such as structural equation modeling may be desirable in a case where causality is unclear and much understanding could be gained, we deemed such methods unsuitable due to the small sample size to predictor ratio and the associated risk of unstable results.

5.3 Results

5.3.1 Social learning game descriptive statistics

In general, most players bought some information, and relatively few players purchased none.

In the subsample of individuals who completed both surveys and were retained for the individual scale analyses (n = 37), 10.81% (4/37) bought no information and 5.41% (2/37) bought 26 times out of a possible 28 (even when the cost of information exceeded the maximum payoff of any one card) with an overall mean of 6.70 (SD = 6.62) and a mode of two. On average individuals in the subsample spent 1151.76 pesos (SD = 1463.17) on information with a range of 5850 (from zero to 5850).

By comparison, out of all game players (N = 119), 20.17% (n = 24) did not buy any information and one person bought the maximum of 28 times. The mean number of purchases was 5.12 (SD = 6.05) and a mode of zero. The average spent by all game players was 872.18 pesos (SD = 1365.38) ranging from zero pesos to 6090 pesos (the maximum possible).
Figure 18. The average amount spent (in Chilean pesos) to purchase social information by individuals during the social learning game (left), and the average frequency of social information purchasing behaviours during the game (right) in each of seven artisanal fishing communities. Solid dots represent outliers (beyond 1.5 times the interquartile range from the upper or lower quartile).

For the community level analysis ($N = 7$) a total of 97 respondents were included (omitting two communities in which only the second survey was administered). We found variation between communities in the game behaviours (Figure 18). Overall, residents from Ventanas bought information the most times ($M = 10.60, SD = 9.29$) and spent the most money ($M = 1969.00, SD = 2361.77$) with El Manzano buying the least in terms of frequency ($M = 2.69, SD = 2.75$) and amount ($M = 340.38, SD = 432.34$). Notably, communities that spent more on average also bought more on average with only minor exceptions (Algarrobo and Quintay).
5.3.1.1 Convergent validity of the social learning measure

Social learning game behaviours were positively correlated ($p < .05$) to two measures of perceived knowledge availability and seeking. Specifically, at the individual level, instances of information buying and the amount spent were both moderately positively related to the perception that there were many people in the community from whom they could usefully learn (see Table 3). Buying frequency was also significantly and positively correlated with the perception that colleagues are willing to give advice when asked ($r_s = .28, p = .05$) while game cost was nearly significant ($r_s = .25, p = .06$).

The availability of useful teachers was also positively correlated at the community level, however, only with game cost using a spearman correlation ($r_s = .70, p < .05$). The relationship between buying frequency and the availability of useful teachers was nearly significant ($r_s = .67, p = .05$).

Although the relationship between game cost and the perception that organization members tended to mutually share knowledge was nearly significant ($r_s = .57, p = .09$) at the community level, it never reached significance with any game metric at the community or individual scale. Game behaviour was also not significantly related to personal preferences to learn independently at either social scale.

5.3.2 Social learning at the individual scale

Among the suite of predictors at the individual scale, six variables are significantly related to game behaviours, including: whether a person is a migrant or not; monetary risk perception;
the availability of useful teachers in a community and the willingness of colleagues to provide advice (as detailed above); agreement that behavioural rules for organization members are clearly defined (a basis for collective action); and, agreement that continuation of the status quo is likely to lead to ecological catastrophe (a measure of environmental attitude). All of these are positively related save the last (see Table 3). In contrast to the resource literature, common understanding, social relations as measured by trust, social capital and the need to belong, locus of control, quality of life, and by and large, collective action are unrelated.

Table 3. Individual-level bivariate Pearson and Spearman correlations (1-tailed) between predictors and two metrics of social learning (amount spent, i.e., Game Cost, and buying frequency, i.e., Buy Count). Variables that have p-values greater than .20 across tests are not shown.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Spearman</th>
<th>Pearson</th>
<th>Spearman</th>
<th>Pearson</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Game cost</td>
<td>Game cost</td>
<td>Buy count</td>
<td>Buy count</td>
<td></td>
</tr>
<tr>
<td><strong>rs</strong></td>
<td><strong>p</strong></td>
<td><strong>r</strong></td>
<td><strong>p</strong></td>
<td><strong>r</strong></td>
<td><strong>p</strong></td>
</tr>
<tr>
<td>Age</td>
<td>0.04 0.42</td>
<td>0.11 0.26</td>
<td>0.10 0.28</td>
<td>0.15 0.19</td>
<td>37</td>
</tr>
<tr>
<td>Education</td>
<td>-0.22 0.09</td>
<td>-0.04 0.41</td>
<td>-0.24 0.08</td>
<td>-0.12 0.24</td>
<td>37</td>
</tr>
<tr>
<td>Migrant</td>
<td>0.405 0.01</td>
<td>0.528 0.00</td>
<td>0.394 0.01</td>
<td>0.499 0.00</td>
<td>37</td>
</tr>
<tr>
<td>Income</td>
<td>-0.12 0.23</td>
<td>0.17 0.15</td>
<td>-0.18 0.14</td>
<td>0.05 0.38</td>
<td>37</td>
</tr>
<tr>
<td>% of life as resident</td>
<td>-0.295 0.04</td>
<td>-0.427 0.00</td>
<td>-0.302 0.03</td>
<td>-0.416 0.01</td>
<td>37</td>
</tr>
<tr>
<td>% of life as organization member</td>
<td>-0.13 0.09</td>
<td>-0.09 0.18</td>
<td>-0.16 0.05</td>
<td>-0.12 0.10</td>
<td>115</td>
</tr>
<tr>
<td>Average fishing days/month</td>
<td>0.24 0.08</td>
<td>0.19 0.13</td>
<td>0.18 0.14</td>
<td>0.21 0.11</td>
<td>37</td>
</tr>
<tr>
<td>Locus of control: Luck(^\text{a})</td>
<td>-0.17 0.16</td>
<td>-0.16 0.17</td>
<td>-0.17 0.15</td>
<td>-0.18 0.14</td>
<td>37</td>
</tr>
<tr>
<td>Locus of control: Powerful people(^\text{a})</td>
<td>0.21 0.11</td>
<td>0.19 0.13</td>
<td>0.17 0.16</td>
<td>0.14 0.21</td>
<td>36</td>
</tr>
<tr>
<td>Monetary risk propensity</td>
<td>0.23 0.10</td>
<td><strong>0.295</strong></td>
<td>0.04</td>
<td>0.22 0.10</td>
<td>0.26 0.06</td>
</tr>
<tr>
<td>Quality of life</td>
<td>0.20 0.12</td>
<td>-0.09 0.31</td>
<td>0.22 0.10</td>
<td>-0.03 0.44</td>
<td>37</td>
</tr>
<tr>
<td>Enviro attitude: Ecological catastrophe</td>
<td>-0.23 0.08</td>
<td>-0.303 0.03</td>
<td>-0.25 0.06</td>
<td>-0.318 0.03</td>
<td>37</td>
</tr>
<tr>
<td>Enviro attitude: Humans abuse enviro</td>
<td>0.06 0.36</td>
<td>0.16 0.17</td>
<td>0.06 0.36</td>
<td>0.18 0.15</td>
<td>37</td>
</tr>
<tr>
<td>Belonging: Desire to be accepted</td>
<td>0.22 0.10</td>
<td>0.09 0.29</td>
<td>0.19 0.13</td>
<td>0.09 0.29</td>
<td>37</td>
</tr>
<tr>
<td>Social capital: Org. friendships important</td>
<td>0.02 0.45</td>
<td>-0.18 0.15</td>
<td>0.01 0.48</td>
<td>-0.16 0.18</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Spearman</td>
<td>Pearson</td>
<td>Spearman</td>
<td>Pearson</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------</td>
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<td>-------</td>
</tr>
<tr>
<td></td>
<td>Game cost</td>
<td>Game cost</td>
<td>Buy count</td>
<td>Buy count</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r_s$</td>
<td>$P$</td>
<td>$r$</td>
<td>$P$</td>
<td></td>
</tr>
<tr>
<td>Learning: Many useful teachers</td>
<td>0.345</td>
<td>0.02</td>
<td>0.283</td>
<td>0.04</td>
<td>0.348</td>
</tr>
<tr>
<td>Learning: Willing teachers available</td>
<td>0.25</td>
<td>0.06</td>
<td>0.20</td>
<td>0.12</td>
<td>0.282</td>
</tr>
<tr>
<td>Learning: Prefer individual learning*</td>
<td>-0.14</td>
<td>0.20</td>
<td>-0.18</td>
<td>0.14</td>
<td>-0.12</td>
</tr>
<tr>
<td>Institution: Confident in monitoring</td>
<td>0.07</td>
<td>0.34</td>
<td>0.24</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td>Institution: Clear rules of behaviour</td>
<td>0.21</td>
<td>0.10</td>
<td>0.275</td>
<td>0.05</td>
<td>0.305</td>
</tr>
<tr>
<td>Institutions: Approve of poaching</td>
<td>-0.16</td>
<td>0.17</td>
<td>-0.17</td>
<td>0.15</td>
<td>-0.13</td>
</tr>
<tr>
<td>Institutions: Approve of risk taking</td>
<td>-0.22</td>
<td>0.09</td>
<td>-0.19</td>
<td>0.14</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

* Variable is reverse coded

Among the significant predictors, the status of individual as a migrant showed the strongest correlation to game behaviours, with people originally from the community tending to spend less and buy less information.

That ‘newcomers’ should engage in more learning behaviours in the game is consistent with cultural evolutionary theory that greater uncertainty should result in more social learning (Boyd & Richerson, 2009; Boyd & Richerson, 1988a; Henrich & Boyd, 2008; Kameda & Nakanishi, 2002). In contrast to these results for the subsample, in the full sample of game players, neither game cost ($r = .12, p = .11$ and $r_s = .08, p = .19, N = 118$) nor buying frequency ($r = .11, p = .13$ and $r_s = .07, p = .21, N = 118$) is related to migrant status. In the subsample of individuals, percentage of a respondent’s life spent in the community was negatively correlated with learning in the game. This analysis was not possible in the full sample as the amount of years spent living in the community was only recorded in the first survey. However, the percentage of
a person’s life spent in the local fishing organization was similarly negative correlated with buying frequency ($r_s = -0.16, p = 0.05, N = 115$) and non-significantly negatively correlated with amount spent ($r_s = -0.13, p = 0.09, N = 115$). This relationship was not found in the subsample.

5.3.2.1 Hierarchical partitioning of significant correlates

Hierarchical partitioning revealed that of all six significant game correlates identified above, the majority of the variance in individual game cost was independently explained by the percentage of years lived in the community (36.57%; substituting for the migration variable) followed by the perceived likelihood of ecological catastrophe (19.04%), perception of clear behavioural rules (12.82%), availability of useful teachers (12.37%), monetary risk propensity (14.77%), and finally, the willingness of colleagues to provide advice (4.43%).

These results are consistent with ridge regression analyses using the full complement of predictors (see Appendix A). Of the top five most influential variables identified through ridge regression, three are also selected above (monetary risk, availability of useful teachers, and the relative amount of time lived in the community). The belief that humans are abusing the environment (positive relationship) and the average number of days spent fishing (positive relationship) were not identified by correlational analyses, but were ranked fourth and fifth respectively using in the ridge analysis.
Table 4. Results of hierarchical partitioning at the individual and community scales. Variance in the amount of money spent in the social learning game explained by the independent (I) and joint (J) contributions of predictor variables. Independent and joint contributions given in $r^2$, where the sum of independent contributions totals the $R^2$ of the full model with all predictors. Joint contributions are the portion of variance explained in conjunction with other predictors. The rank of each predictor variable as found through ridge regressions are also provided.

<table>
<thead>
<tr>
<th>Predictors</th>
<th>I</th>
<th>J</th>
<th>Ridge regression rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of life as resident</td>
<td>0.12</td>
<td>0.07</td>
<td>3</td>
</tr>
<tr>
<td>Enviro attitude: Ecological catastrophe</td>
<td>0.06</td>
<td>0.03</td>
<td>10</td>
</tr>
<tr>
<td>Monetary risk propensity</td>
<td>0.05</td>
<td>0.04</td>
<td>1</td>
</tr>
<tr>
<td>Institution: Clear rules of behaviour</td>
<td>0.04</td>
<td>0.03</td>
<td>6</td>
</tr>
<tr>
<td>Learning: Many useful teachers</td>
<td>0.04</td>
<td>0.04</td>
<td>2</td>
</tr>
<tr>
<td>Learning: Willing teachers available</td>
<td>0.01</td>
<td>0.03</td>
<td>25</td>
</tr>
<tr>
<td>Quality of life</td>
<td>0.28</td>
<td>0.67</td>
<td>1</td>
</tr>
<tr>
<td>Institutions: Approve of poaching</td>
<td>0.18</td>
<td>0.56</td>
<td>2</td>
</tr>
<tr>
<td>Social Approval Index</td>
<td>0.12</td>
<td>0.48</td>
<td>5</td>
</tr>
<tr>
<td>Trust: Majority of org. members</td>
<td>0.11</td>
<td>0.31</td>
<td>3</td>
</tr>
<tr>
<td>General risk propensity</td>
<td>0.09</td>
<td>0.38</td>
<td>8</td>
</tr>
<tr>
<td>Average % income from fishing</td>
<td>0.09</td>
<td>0.34</td>
<td>10</td>
</tr>
<tr>
<td>Learning: Many useful teachers</td>
<td>0.07</td>
<td>0.20</td>
<td>13</td>
</tr>
<tr>
<td>Institutions: Approve conformism</td>
<td>0.07</td>
<td>0.25</td>
<td>16</td>
</tr>
</tbody>
</table>

5.3.3 Social learning at the community scale

Bivariate correlations conducted at the community scale revealed a distinctly different picture than at the individual scale. Eight variables were found to be significantly and negatively associated with game behaviours including: The percentage of income derived from fishing activities, general risk propensity, the desire to avoid social disapproval, perceived capable leadership, greater trust in organization members than outsiders, greater quality of life,
approval of peer poaching activity, and approval of peers withholding dissenting opinions (conformism). Perceptions that friendships with organization members were of great significance also neared significance in a negative direction in terms of game cost ($r = - .62, p = .07$) and buy count ($r = - .64, p = .06$). Two variables were positively related: the ability to trust the majority of organization members and the perceived availability of useful teachers.

Table 5. Community-level bivariate Pearson and Spearman correlations (1-tailed) between predictors and two metrics of social learning (amount spent, i.e., game cost, and buying frequency, i.e., buy count). Variables that have p-values greater than .20 across tests are not shown.

<table>
<thead>
<tr>
<th></th>
<th>Spearman</th>
<th>Pearson</th>
<th>Spearman</th>
<th>Pearson</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Game cost</td>
<td>Game cost</td>
<td>Buy count</td>
<td>Buy count</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------</td>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
<td>----</td>
</tr>
<tr>
<td>r_s</td>
<td>p</td>
<td>R</td>
<td>p</td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>Education</td>
<td>0.61</td>
<td>0.07</td>
<td>0.65</td>
<td>0.06</td>
<td>0.64</td>
</tr>
<tr>
<td>% migrants</td>
<td>-0.46</td>
<td>0.15</td>
<td>-0.58</td>
<td>0.09</td>
<td>-0.50</td>
</tr>
<tr>
<td>Average income</td>
<td>0.57</td>
<td>0.09</td>
<td>0.66</td>
<td>0.05</td>
<td>0.43</td>
</tr>
<tr>
<td>Average % income from fishing</td>
<td>-0.43</td>
<td>0.17</td>
<td>-0.66</td>
<td>0.05</td>
<td>-0.57</td>
</tr>
<tr>
<td>Average % of life as resident</td>
<td>-0.36</td>
<td>0.22</td>
<td>-0.44</td>
<td>0.16</td>
<td>-0.39</td>
</tr>
<tr>
<td>Average fishing days/month</td>
<td>-0.43</td>
<td>0.17</td>
<td>-0.55</td>
<td>0.10</td>
<td>-0.39</td>
</tr>
<tr>
<td>Common understanding</td>
<td>-0.32</td>
<td>0.24</td>
<td>-0.55</td>
<td>0.10</td>
<td>-0.36</td>
</tr>
<tr>
<td>General risk propensity</td>
<td>-0.61</td>
<td>0.07</td>
<td>-0.682*</td>
<td>0.05</td>
<td>-0.714*</td>
</tr>
<tr>
<td>Enviro attitude: Ecological catastrophe</td>
<td>-0.50</td>
<td>0.13</td>
<td>-0.41</td>
<td>0.18</td>
<td>-0.39</td>
</tr>
<tr>
<td>Enviro attitude: Humans abuse enviro</td>
<td>-0.64</td>
<td>0.06</td>
<td>-0.49</td>
<td>0.13</td>
<td>-0.57</td>
</tr>
<tr>
<td>Belonging: Avoid disapproval</td>
<td>-.685*</td>
<td>0.05</td>
<td>-.759*</td>
<td>0.02</td>
<td>-0.63</td>
</tr>
<tr>
<td>Belonging: Desire to be accepted</td>
<td>-0.43</td>
<td>0.17</td>
<td>-0.32</td>
<td>0.24</td>
<td>-0.46</td>
</tr>
<tr>
<td>Social capital: Org. friendships important</td>
<td>-.21</td>
<td>0.32</td>
<td>-.62</td>
<td>0.07</td>
<td>-.29</td>
</tr>
<tr>
<td>Social capital: Capable leaders</td>
<td>-0.46</td>
<td>0.15</td>
<td>-.673*</td>
<td>0.05</td>
<td>-0.54</td>
</tr>
<tr>
<td>Trust: Majority of org. members</td>
<td>.750*</td>
<td>0.03</td>
<td>0.65</td>
<td>0.06</td>
<td>0.61</td>
</tr>
<tr>
<td>Trust: Org. members more than non-members</td>
<td>-0.64</td>
<td>0.06</td>
<td>-.764*</td>
<td>0.02</td>
<td>-0.61</td>
</tr>
<tr>
<td>Learning: Mutual knowledge sharing</td>
<td>0.57</td>
<td>0.09</td>
<td>0.50</td>
<td>0.13</td>
<td>0.54</td>
</tr>
<tr>
<td>Learning: Prefer individual learning a</td>
<td>-0.50</td>
<td>0.13</td>
<td>-0.51</td>
<td>0.12</td>
<td>-0.43</td>
</tr>
</tbody>
</table>

* Significant at the .05 level.
Only the variable of useful teachers being available was shared between scales. The percentage of migrants in a community neared a negatively significant relationship with game behaviours in terms of both money spent (\( r = -.58, p = .09 \)), and buying frequency (\( r = -.62, p = .07 \)).

Monetary risk propensity, environmental attitudes, and other collective action institutions did not reach significance.

### 5.3.3.1 Hierarchical partitioning of significant correlates

Significant community level correlates were entered into a hierarchical partitioning procedure. However, the variables of perceived leadership capacity, trust in members more than outsiders, and desire to avoid social disapproval were combined into a Social Approval Index (\( \alpha = .937 \)).
due to issues of entering nine or more predictors simultaneously (Olea, Mateo-Tomás, & de Frutos, 2010).

In terms of independent contributions of predictors to explaining the variance in community game cost, quality of life (27.76%) was largest, followed by approval of poaching behaviours (18.17%), the Social Approval Index (12.28%), trust in the majority of fellow members (11.04%), general risk propensity (8.78%), percentage of income derived from fishing (8.63%), the availability of useful teachers (6.77%), and lastly, approval of withholding dissenting opinion (6.58%).

These results are largely supported by ridge regression analyses when using the full complement of predictors (see Appendix A). Of the top five most influential variables identified using ridge, four were also selected using bivariate correlations (quality of life, poaching approval, trust in colleagues, as well as the Social Approval Index which was fifth). The exception is the community proportion of migrants (ranked fourth, negative direction) that appeared important in ridge regression but not in correlation analysis.

5.4 Discussion

5.4.1 Principal findings

This research is one of the first quantitative investigations into the concept of social learning in a natural resource management context, and perhaps the first that includes multiple social scales. The evidence suggests that as intended, the social learning game provides a simple, replicable, individual level quantitative tool for assessing efforts to learn socially with few
logistical barriers. Although this work is necessarily exploratory given the novelty of the tool, we found that game behaviour was significantly related to measures of knowledge availability and the perceived presence of useful teachers. These results provide convergent validity and add confidence that the game is measuring our conceptualization of social learning.

Although the game developed in this study only provides one measure of a specific aspect and conceptualization of social learning, the results strongly suggest that standing assumptions about social learning within the natural resource management literature warrant more specification, operationalization, and testing. This study’s results are broadly in line with cultural evolutionary theory but are not predicted in most natural resource management scholarship, including counterintuitive relationships between efforts to learn socially and the quality of social relationships. By developing an easily applied and replicable tool, this study furthermore contributes to social learning scholarship by distinguishing the individual effort to learn socially from potential antecedents and outcomes. It should be recognized, however, that there is a long and rich history of scholarship on game theory outside investigations of social learning, including within natural resource management and especially outside the field of sustainability science (e.g., in cultural evolution, economics, psychology, political science).

As noted by Reed et al. (2010), social learning is often associated or conflated with “improved management of social-ecological systems, enhanced trust, adaptive capacity, attitudinal and behavioral change, stakeholder empowerment, strengthening of social networks...” (pp. 2-3). However, these relationships are often assumed and untested, or presumed based on
anecdotal evidence. Furthermore, whether these factors should be linearly related to social learning is unspecified.

For example, it makes intuitive sense that trust in colleagues should increase the degree of knowledge sharing between individuals. However, our results suggest that the relationship is not so straightforward – a sufficient level of trust is necessary between people for social knowledge transfer to occur (as evinced by the positive correlation with trusting the majority of organization members), but that a great deal of trust (the negative correlation of greater trust of peers than outsiders) may negate the need to learn from others. In other words, the act of actively seeking information from others may occur at intermediate levels of trust. This may be because at high levels of trust, sharing may be normative and/or the population is more homogeneous in its knowledge and skills, making efforts to learn socially easier or less beneficial.

5.4.1.1 Social learning in a state of uncertainty: dueling hypotheses?

Similarly, and also surprising in the context of the natural resource management literature is the counterintuitive finding that greater community-level perceptions of capable leadership and the desire to maintain good social relations were also negatively related to game behaviours. Thus while the hypothesis that social learning should be related to trust, social networks, and social capital is supported, they appear in the opposite direction to that hypothesized or theorized in current resource literatures, at least as measured by the game.
While the above findings are counterintuitive in the context of the natural resource literature, they are expected in cultural evolutionary theory. In cultural evolution, social learning is the transmission of (non-genetic) information between people (Boyd & Richerson, 1988b). It is clear from research on social learning in cultural evolution and psychology that learning is not homogeneously engaged by all people at all times. Rather, it depends on trait level differences in psychology such as risk perceptions and tolerance around uncertainty, social and ecological contexts (such as availability of knowledge and teachers and environmental variability), the frequency of behaviours in a group, and the type and difficulty of information being learned, among other factors (Rendell et al., 2011). Critically, efforts to learn from others is an adaptive behaviour (as is individual learning depending on context) with costs (such as time and effort) when pursued, as well as benefits (Boyd et al., 2011). In theory pursuing information from others is most adaptive when, for example, social conditions are novel or unstable, and individual learning is expensive.

Further evidence that supports an uncertainty hypothesis, and not predicted in existing resource literatures, is that efforts to learn socially appear to diminish as the community’s share of income is derived from fishing grows. That is, the more a community depends on fishing for income, the less likely community members are to seek/purchase information (as measured by the game). One might reasonably predict that where communities (and their members) are most engaged in fishing activities, they would also be more likely to be engaged and invested in local resource governance – exactly were the resource literature would suggest social learning to be strongest (Armitage, Marschke, & Plummer, 2008; Leys & Vanclay, 2011). Among our Chilean caletas, this does not appear to be the case. It is possible that while fishers share
common goals in the Chilean MEABR context, fishing is generally a competitive venture, and greater dependence on fishing may mean more competition.

5.4.1.2 Social-ecological outcomes: collective action, adaptive capacity, and understanding

It has been proposed that environmental attitudes should improve in contexts of co-management and learning, such as in the context of Chilean artisanal fisheries where fishing organizations are engaged in co-management and aware of the conservation issues around resources (Armitage et al., 2008; Olsson et al., 2004). In fact, results between environmental attitudes and individual game behaviours were mixed (and not apparent at the group level).

The more that individuals felt he status quo would lead to ecological harm the less they engaged in efforts to learn socially in the game. Although it is unclear why a negative relationship between efforts at social learning and the belief of environmental harm should exist, it is possible that people believe that their fates are sealed and so there is little more to learn (from their peers). It may also be possible that motivation to learn from fellow fishers disappears because such a belief is associated with an intention to exit the system to avoid the consequences of collapse. On the other hand, ridge regression analyses (see Appendix A) identified a relatively strong positive relationship between the individual level belief that people are severely abusing the environment and efforts to learn. Needless to say, more research is necessary to uncover the answer.

Social learning is also thought to have a critical role in creating shared understanding, a key variable thought to be linked to better management outcomes and a primary reason for
interest in social learning (Folke, Hahn, Olsson, & Norberg, 2005; Olsson et al., 2004; Pelling et al., 2008). However, we found that efforts to learn socially as measured by the game was not associated with common understanding, perhaps because fishers in a context of strong common understanding perceive less need to purchase information, as we would expect from cultural evolutionary theory.

Common understanding is also of interest to resource scholars because of its hypothesized link to greater collective action, as is social learning (Reed et al., 2010; Webler et al., 1995). We found that game behaviour was associated with certain types of institutions that are thought to be key to collective action. In particular, more buying behaviour in the game was associated with greater disapproval of poaching and conformity at the community level and greater agreement that there are clear rules of conduct for caleta members.

The above evidence suggests that social learning (as measured by the game) may have benefits for collective action but they may be limited. For instance, a relationship did not manifest in terms of greater participatory engagement in decision-making, confidence in monitoring systems, sanctions, conflict resolution, or norms around reporting unlawful behaviours, sharing of new fishing grounds, or innovation.

Similarly, social learning in resource literatures tends to be associated with adaptive capacity (Folke et al., 2003; Pahl-Wostl, 2009; Pelling et al., 2008). Part of adaptive capacity is the ability of people and communities to direct their future and circumstance (Engle, 2011; Moser, 2010). However, game behaviour was not associated with our measures of locus of control (the sense that people had control over their own life).
Additionally, one might expect that if social learning is generally supposed to engender high adaptive capacity and better social-ecological outcomes, this may manifest in overall improved quality of life. Instead, we found a strong negative relationship between quality of life and our conceptualization of social learning as exhibited in game behaviours at the community level, as a cultural evolutionary interpretation might suggest.

5.4.1.3 Comparing individual to community social learning

We found that social relational factors that dominate at the group scale are absent at the individual level. In fact, only the availability of useful teachers as a predictor was shared across scales. But why should social learning manifest differently at varying scales at all? In accordance with cultural multilevel selection (Waring et al., 2015), in social dilemmas (such as Chilean artisanal fisheries) the interests of individuals and the groups in which they reside are fundamentally at odds. Within groups individuals are in competition with their peers and selection of self-interested behaviours is favoured. However, individual self-interested behaviours do not benefit the group (as they compete with other groups), which favour cooperative behaviours that are individually costly on the part of its members. Thus competition selects for different traits at different social scales; traits transmitted through social learning.

Despite this, the significance of social learning at different social scales is little examined in the natural resource context and thus little has been said about how they might differ. There does appear, however, to be some consistency across scales. Although the manner in which social learning is relevant for collective action are different at each level they are congruous: higher
Learning at the individual scale was associated with agreement that the expected conduct of association members was clear, while at the group level, learning was associated with greater disapproval of poaching and holding back opinions. In other words, learning appears to influence individuals’ understanding of how to behave, and at the same time, the development of norms that can promote social learning (open communication) and behaviour that requires clear rules of conduct and communication as in the case of poaching. Indeed, it has been said that social learning at the individual scale can help to establish social norms at the group scale (Chudek & Henrich, 2011; Richerson & Henrich, 2012).

Also congruent across scales were the demographic variables related to migration. The percentage of one’s life lived in a community as an individual and the percentage of one’s life spent in the fishing organization at the community level both suggest that the longer a person’s tenure in a place, the less learning occurs. Intriguingly, however, at the individual level, a person’s status as a migrant appeared to be linked to more efforts to learn as measured by the game, while at the community level, the greater proportion of migrants making up the community (as identified in ridge analysis) appear to diminish average learning efforts. This difference suggests that individuals in novel situations are motivated to seek information, while at the community scale, many migrants may diminish the value of learning from peers as knowledge may not be as pertinent to local circumstances. A similar pattern which may also be explained by the differential value of information at varying social scales can be observed in terms of the amount of time people dedicate to fishing as individuals (positively related to game behaviours), and the average amount of time people spend fishing in a community (negatively related to game behaviours).
It thus appears that group level characteristics can cause variations in levels of social learning through their impact on individuals by raising it or lowering the average amount. Taking community social relations as an example, though it does not appear to affect whether people as individuals seek information from others, if the overall learning environment is hostile, it may bring down the average amounts of learning possible in the community.

5.4.1.4 Some remaining mysteries

Greater willingness to take monetary risks was, at an individual level, associated with more efforts to learn socially in the game. As the game is a monetary instrument, this makes sense. However, monetary risk at a group level is not related to group levels of learning. Rather, the average willingness to take risks generally was associated with less game buying behaviours at a community scale (but not at the individual).

Using a cultural multilevel selection framework (Waring et al., 2015), these differences might be explained by the different competitive pressures that exist at different social scales. For instance, beyond the game being economically based, within caletas, competition exists between members, for example for fish and business rights and licensing rights. However, livelihood innovations at the individual scale often depend on the willingness to specifically take monetary risks, for instance to buy new fishing technologies or open a business, or forego fishing income, and is thus favoured alongside social learning that may also fuel innovation. On the other hand, monetary risk may not be selected for in the group context of a caleta since organizational money is scarce, spending may be held in check by the need for accountability to members, and money may be pre-allocated.
Furthermore, although fishing associations do compete against one another for resources (not only fish but tourist dollars, government subsidies, etc.), caletas in Region V are often united against common perceived threats, such as industrial fishing, poachers, and government policies they perceive as against their interests. Common threats and competition with industrial fleets, as well as the organization of Region V caletas under a regional umbrella organization, favours learning across artisanal groups and may diminish the need for any one organization to strike out and take risks on their own, or repress actions that may be out of line with the larger regional group.

5.4.2 Implications

The results presented in this manuscript suggest that the portrayal of social learning in the resource management literature may thus far be oversimplified and overly optimistic. In general, social learning is construed as a positive feature that can lead to or facilitate more sustainable social and ecological outcomes. However, this research suggests that the contribution of at least one measure and conceptualization of social learning may be limited or, at times, opposite of what is currently imagined.

While individual efforts to learn socially may contribute to improving some aspects of resource management, such as certain collective action institutions, there is no silver bullet (Ostrom et al., 2007). Our evidence also suggests that some of the current thinking about social learning can be more nuanced and specific, as in the case of trust and strengthened social networks. In other words, there are different types and aspects of social learning, and positive social relations cannot be expected as an assured outcome or principal cause of all kinds of social
learning. Thus social learning as currently conceived in the natural resource management literature may be overly broad, and only a piece of the policy puzzle.

As to the critical question of how to build social learning, the results of this study suggests that, at least to encourage individual willingness to learn socially, some of the critical ingredients may be: (1) the perceived availability of knowledge worth learning and people from whom they can learn; (2) a context that inspires a need for learning (i.e., disturbance); and perhaps, (3) clear social norms of expected behaviours and information sharing. Thus in practice, current proposed strategies for encouraging social learning more broadly may not be far off the mark. Highlighting and connecting people to a diversity of knowledge of various parties and their potential value may be a starting point. Exposing people to new points of view, revising thinking on old problems, highlighting new challenges, and ensuring some rules of engagement may be helpful (e.g., Armitage et al., 2008).

However, if our interpretation of the data is correct and individual efforts to learn socially is diminished in contexts of high social stability, encouraging positive social relationships, as a pathway to social learning, may be somewhat misguided. Though this research does appear to demonstrate that such a strategy may be effective up to a point (for example, by building a base level of trust), the data also encourages resource management scholars and practitioners to attend to the potential non-linear relationship between social learning and social relations.

It should be recognized that social learning (as conceived in this study) operates as a homogenizing force within groups (e.g., Henrich & Boyd, 1998) and also can help reduce social uncertainty, thus potentially contributing to improved social relations. If learning socially in fact

diminishes under conditions of very high social stability because there is little new information to learn due to homogeneity then there are critical implications in terms of the loss in diversity of knowledge, skills, and perspectives. As previously reviewed, past studies have concluded that greater homogeneity within a community of resource users and positive social relations (such as high social capital) can net gains in ecological sustainability and collective action. However, increased homogeneity may be counter to adaptive capacity and adaptive management, which stress innovation and diversity (Folke et al., 2005). Thus, a fine balance must be struck when encouraging knowledge transmission.

5.4.2.1 Implications for future research

This manuscript introduces a new tool for quantitatively measuring one aspect of social learning that can be easily deployed in the field or laboratory. This may aid future research on the topic of social learning and its contribution to resource management by allowing statistical and replicable examination of the causes and effects of the effort to learn socially on outcomes of concern.

Conceptually, this work characterizes social learning as a behaviour in which all people are engaged at certain times, contingent on extrinsic and intrinsic factors. However, some people have a greater or lower tendency than others to seek social information. This is distinctly different from collaboration, workshops, and dialogue (Armitage et al., 2008; Rodela, 2011). While social learning as defined here is without a doubt a part of such social processes, the conceptualization as presented helps to eliminate the conflation between these terms and processes (Reed et al., 2010).
A key insight offered by the social learning game and cultural evolutionary theory for natural resource scholarship is the focus of social learning as a process of adaptation. As opposed to a conceptualization of adaptive capacity as a latent set of attributes or potentials (Engle, 2011), social learning as measured by the game is a measure of an individual’s adaptive response in progress. The game may benefit future research on adaptive capacity where measurement has also been notoriously difficult.

Finally, this research points to the need for greater nuance and specificity when approaching the concept and study of social learning, and to question assumptions that verge on axiomatic, such as the system-wide benefit of greater social learning.

5.4.3 Limitations

In large measure, this research is exploratory and therefore the conclusions of this manuscript must be taken with some caution. The conceptualization of social learning used here is narrow and does not address co-management, participatory governance, networks, or learning that may occur through collaborative events. We also make a major assumption that game behaviour is reflective of social learning in real life. However, because the game is a novel tool and is manufactured, it may not be a valid reflection of how people behave day-to-day. Game behaviours are also a reflection of the payment mechanism as shown by the correlation with monetary risk propensity, and other measures of efforts to learn may or may not yield different results.
Another concern is the low sample sizes. Further to this, there were some different results (e.g., migration) between the subsample and full sample. Thus, it is possible that some of the results presented could be artefacts of a relatively small sample.

Finally, one of the major gaps not addressed by this research is causality – we do not know for example whether the collective institutions are causing social learning or the reverse, or whether they feed back on one another. Our models are also not predictive.

5.5 Conclusion

Despite this study’s limitations, we believe this investigation to be one of the first (if not the first) quantification of claims made in resource literatures about the importance of social learning and its associated factors. If research on social learning in resource sustainability is to progress, the field will require better theories, definitions, and measures, many of which can be drawn from other fields such as cultural evolution and psychology. Furthermore, this study strongly supports the endeavour to uncover the mechanisms of learning rather than focusing on outcomes (Rodela, 2011). These are important omissions; bypassing the mechanics of social learning without adequate theory and metrics hobbles the ability to understand the links between social learning and emergent phenomena in linked social-ecological systems with implications for the practical management of resources.
Chapter 6: Is common understanding key to collective action in common pool resource management? Not in Chile’s caletas

6.1 Introduction

The sustainable management of wild resources is a persistent and pervasive problem the world over, especially in the face of the continued degradation of the natural capital upon which humans depend. Among the most challenging resources for people to manage are those where it is difficult to exclude others and where extraction by one individual inherently means the loss of availability of that resource for another. Such resources are called common pool resources, and it is well recognized that cooperation and coordination among users, that is their ‘collective action’ to care for such resources, can be a critical piece of the sustainability puzzle (E. Ostrom, 1990).

It is generally assumed that people in common pool resource systems are better able to cooperate, coordinate, and find solutions (i.e. engage in collective action) when they share a common understanding of their environmental context and its social-ecological dynamics (e.g., Matta & Alavalapati, 2006; Pelling et al., 2008; Plummer & Fitzgibbon, 2004). However, perhaps due to its intuitive appeal, these assumed benefits of common understanding are rarely

5 The following chapter is based on the contributions (i.e., discussions, methodological refinement, revisions, and editing) of Drs. Terre Satterfield, Kai Chan, Stefan Gelcich, and Timothy Waring.
examined in any critical or disaggregated manner. First, the significance of common understanding for collective action is not well established in quantitative empirical investigations, and the influence of common understanding on collective action over and above other factors is not well articulated; in the second, it is not clear what factors lead to greater shared perceptions.

6.1.1 Common understanding in the natural resources literatures

The assumption that common understanding enables collective action toward sustainable resource management is pervasive across several related literatures, including common pool resource institutions (Ostrom, 2002; Ostrom, Burger, Field, Norgaard, & Polsmansky, 1999), adaptive co-management (e.g., Plummer & Fitzgibbon, 2004), and resilience (e.g., Lebel et al., 2006). Common understanding is also referred to through numerous terms, such as shared understandings, experiences, mental models, visions, and perceptions. At times, common understanding is subsumed (or even assumed as a given) under larger concepts like social capital (e.g., Pelling & High, 2005), or more recently, social learning (e.g., Cundill & Rodela, 2012).

Often, common understanding is used in reference to social-ecological dynamics. Specifically, whether there is a shared perception (among resource users, for instance) of how aspects of the ecosystem are linked to one another and how they change, as well as how human behaviours are linked to environmental change (Ostrom, 2009). Common understanding is also, at times, applied to values, norms and rules (i.e., institutions), problem and solution identification, and also the goals of collective action (Matta & Alavalapati, 2006). In other
words, when common understanding exists among resource users, it means that there is some agreement about how things are, how things might be, and/or how things should be and how to get there.

Evidence for the importance of common understanding is perhaps most readily found in the work of Elinor Ostrom and colleagues on institutions for collective action in the management of common pool resources. Drawing from a rich assemblage of case study research on common pool resource systems, the essential conclusion (among others) is that an absence of common understanding of resource dynamics and norms among users increases the cost of interacting, and thus inhibits the discovery of shared solutions (Ostrom, 2009; Ostrom, 2000; Ostrom et al., 1999).

Despite the wealth of case study research on common pool resource systems that has been used to support the importance of common understanding, there has been little direct, quantified, or statistically robust examination of such a conclusion. This is problematic given the complexity of social-ecological systems and the number of variables that may be relevant to collective action (Ostrom, 2009). Likely, there are multiple dimensions that lead to common understanding, which are currently obscured or conflated. Perhaps common understanding is only important in certain contexts, and perhaps only in the presence of other key attributes.

Concurrent recognition of complexity in natural resource management systems, and the need and difficulty of parsing the effects of different variables, led to the creation of the highly influential Institutional Analysis and Development framework (IAD; McGinnis, 2011; Ostrom, 2011), and its more recent incarnation, the Social-Ecological Systems analytical framework.
(Ostrom, 2009). Both are conceptual tools intended to help distinguish the cause and effect of multitudinous factors. Within each framework, explicit attention is paid to user groups’ common understanding of resource dynamics and norms as an assumed indicator of sustainable outcomes (Ostrom, 2009; Ostrom, 2002; Ostrom et al., 1999). These popular frameworks have since been applied to the analysis of various resource management systems at differing scales (e.g., Fidelman et al., 2012; Fleischman et al., 2010).

A major contribution that has emerged from work on common pool resources is the distillation of a discrete set of institutional features, called ‘design principles’ (Cox et al., 2010), that have been identified as being associated with collective action in many long-sustained systems. As described by (Ostrom, 2002), “These [design] principles work to enhance the shared understanding of participants of the structure of the resource and its appropriators and of the benefits and costs involved in following a set of agreed-upon rules.” (p. 10).

Appropriate institutions are thus hypothesized to induce greater degrees of common understanding in support of collective action. However, in all likelihood, the relationship between the creation of collective action institutions and common understanding is bidirectional, such that the latter also makes self-organization and the formulation or emergence of norms for collective action among a group of users more probable (Ostrom, 2002). For instance, rather than institutions creating common understanding, Berkes (2010) conceptualizes the relationship between shared perceptions and collective action as moving from the establishment of common understanding through discourse, leading to self-organization, which can translate to the creation of institutions and collective action toward the
emergence of adaptive co-management (although he states that these relationships may work in other directions as well).

In the spirit of Berkes and colleagues, the importance of common understanding has also been accepted among scholars of adaptive co-management, as well as in the resilience literature. For example, in their study of a rural Kenyan fishing village, Crona and Bodin (2006) make an explicit assumption that common understanding affects the self-organization of communities to formulate and adhere to resource institutions. That is, common understanding between people is generally deemed as a necessary and beneficial condition that can ease coordination and motivate collective action in co-management (Berkes, 2010; Biggs et al., 2012; Crona & Bodin, 2010; Matta & Alavalapati, 2006; Plummer & Fitzgibbon, 2004). At larger scales, common understanding is also presumed to be important for relationship building between groups and organizations (Imperial, 1999) and positive for adaptive governance (Folke et al., 2005; Olsson et al., 2006).

Discourse within communities and stakeholder participation are popularly offered as means by which common understanding may be achieved, though frequently in only general terms (Beratan, 2007; Berkes, 2010; Reinette Biggs et al., 2012; Jones, Ross, Lynam, Perez, & Leitch, 2000; Louis Lebel et al., 2006). Beratan (2007) offers one of a few more specified arguments, based in cognitive psychology, which posits that iterative discourse and interaction can create common understanding (and trust). Together, these are said to help determine how groups of people will behave, and to be crucial for cooperation in collaborative efforts to manage resources. Also drawing from psychological research, Mosimane, Breen, and Nkhata (2012)
argue that collective action is more likely when common understandings exist, as the latter is a foundation of a collective identity, which can help refocus goals and experiences from the individual to the collective. There appears, then, to be a broad suggestion, if not consensus, across related resource management literatures that common understanding can help to foster collective action vice versa.

More recently, there has been a rapid and growing contemporary scholarship directed at the concept of social capital, and especially social learning. These concepts extend beyond, but also encompass common understanding, as they similarly emphasise the value of (building) common ground within and between groups (Cundill & Rodela, 2012; Lebel, Grothmann, & Siebenhüner, 2010; Plummer & Fitzgibbon, 2004). For instance, Plummer and Fitzgibbon (2004) offer one definition of social learning as “[m]utual gaining of knowledge by actors through sharing values, developing strategies, implementing actions, and reflecting upon feedback” (p. 880). Although the terminology of common understanding has changed over time, it is clear that there is a general consensus that it is a beneficial factor for collective action, while the means to foster common understanding continues to receive widespread interest.

In sum, there is an immense and well-conducted body of case study research that assumes or appears to indirectly support the beneficial link between common understanding and collective action to the benefit of resource sustainability. However, such assumptions and indirect support far outnumber direct, nuanced analysis of this link. There is a need for better understanding of the relative role of common understanding as it explains collective action in and of itself as compared to, or distinct from, other commonly cited social variables. For
instance, how important is common understanding when accounting for variables such as trust and social cohesion? Are all types of common understanding equally important?

In addition, how can common understanding be measured as a discrete driver of collective action versus bundled with a larger set (e.g., social learning)? Untangling the influence of common understanding will require clear operationalization and direct measures where it currently does not exist in the vast majority of research in resource management and governance. It is thus unsurprising to find a gap in the literature of quantitative investigations on this topic, and as a consequence, a gap in knowledge pertaining to common understanding’s influence on collective action as discrete from or in the context of other factors.

### 6.1.2 Research questions and hypotheses

Together, the above concerns raise the basic question: does common understanding enable collective action as compared to other factors when quantitatively examined? Addressing this question leads us to three linked research questions: (1) Is there a statistically significant relationship between community-scale levels of common understanding of resource dynamics and the presence of collective action institutions? (2) What is the influence of common understanding on collective action in comparison to other potentially influential variables? (3) And, regardless, what factors might appear to lead to greater common understanding?

As per questions one and two above, collective action is our dependent variable while common understanding is the principal independent variable of interest. In light of the literature, we would expect there to be a significant positive relationship between common understanding
and the presence of collective action institutions; however, the strength of common understanding vis-à-vis other potentially important variables is an open question. In terms of the third research question, common understanding is the dependent variable, while social and psychological factors previously linked to common understanding in the literature, such as trust, social cohesion, identity, and knowledge transmission (among others) are the independent variables. In light of current scholarship, we would anticipate to find relationships between them.

6.2 Methods

Our analysis consisted of two key steps, based on two surveys of marine users (fishers and divers) from seven Chilean artisanal fishing associations. In the first step, we aimed to determine what contributes to high common understanding at the community scale. In the second step, we analyzed the impacts of common understanding and other predictor variables on variables representing collective action. In terms of collective action, we distinguish between institutions as rules that facilitate collective action, and informal norms of behaviour that may affect collective action and the achievement of sustainable management.

Below we detail the Chilean context, the survey dissemination methods, the various predictor variables, the variable representing common understanding, the variables representing collective action, and the related analyses.
6.2.1 Context: Chilean artisanal fishing

The institutional context of Chilean artisanal fishing communities offers a unique opportunity to test the importance of common understanding. The communities researched are among the hundreds of formalized small-scale fishing communities called syndicates or caletas (the Spanish word for cove) that dot the Chilean coastline. Many of these caletas participate and are partially organized under a national co-management plan for benthic resources (Juan C. Castilla & Fernandez, 1998; Gelcich et al., 2010), in addition to national policies for finfish.

Advantageously, for the purpose of this study, the co-management regime has also afforded these communities a modest degree of autonomy to organize their own members, including forms of sanctioning, membership, participation, and social/organizational structure. In essence, the macro-institutional structure remains consistent while allowing variance to exist at the local scale, setting up a natural quasi-experiment for the effect of community dynamics and variation pertaining to how fisheries are managed. Ultimately, this context enables a unique setting to examine and compare common understanding across communities by treating each community as possessing a unique set of perceptions and beliefs of resource dynamics, around which community members’ agreement can be determined (i.e., level of common understanding).
6.2.2 Community selection

Research sites were chosen to minimize variation in ecological drivers and macro (national and regional) institutional structures, allowing for a more in-depth study of local social factors and their effects on variance between communities.

The study sites were seven communities located in Region V of Chile. These communities are multi-species and multi-gear, occupying both urban and rural spaces, but all are relatively near to major metropolitan centers (Santiago, the capital, as well as the city of Valparaiso) and are thus affected by many human and environmental changes. The seven artisanal fishing communities are located along ~200 km of coastline (or approximately 130 km in a straight line), all of whom are engaged with issues related to collective action and co-management of fisheries resources.

Despite their geographical proximity and macro-institutional similarity, the social context of each community investigated was tangibly different, from the extent of fishing activity to the camaraderie between group members and level of conflict.

6.2.3 Data collection

Data was collected through two separate in-person surveys at two different time intervals (January and March, 2013). In each community, permission to conduct surveys was sought through the caleta president and respondents were recruited in the landing areas for each caleta. Sampling was of convenience with some repeat participants (i.e., individuals who
answered both surveys). Surveys were administered in-person with Chilean research assistants reading the questions and recording the answers.

6.2.4 Survey content

6.2.4.1 Dependent variables

6.2.4.1.1 Common understanding

For the purpose of this study there are two sets of dependent variables of interest: a measure of common understanding, and measures of collective action. The first variable – common understanding – was operationalized using methods from Cultural Consensus Theory (Romney et al., 1986). Cultural Consensus Theory (CCT) has been similarly employed to represent common understanding in studies of natural resources elsewhere (for example see Atran et al., 2002; Grant & Miller, 2004; Miller, Kaneko, Bartram, Marks, & Brewer, 2004). Specifically, through CCT, we assess the consistency of individuals’ understanding within groups (this is described more fully below in the analysis section); that is, how closely individuals’ perceptions of resource dynamics align with that of their group – in this case, the fishing community or caleta to which they belong.

The uniformity of understandings (i.e., common understandings) was determined through a series of true and false questions (Table 6) related to resource dynamics. The questions were crafted based on responses to the first of the above two noted surveys, wherein each participant was asked about local environmental changes and their drivers. It should be stressed that it is not whether people answer ‘factually’ that is of relevance, rather it is the
pattern of agreement among group members. As our investigation is at level of communities, we averaged the consistency score within each community, across individuals, to represent the caleta’s overall level of common understanding. This variable was also later used as a predictor variable.

Table 6. True and false format questions used in the common understanding analysis. Where there are no common english translations for species, the scientific name is provided.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>The ocean is warming due to climate change</td>
</tr>
<tr>
<td>2.</td>
<td>There are more fish inside the management areas than outside</td>
</tr>
<tr>
<td>3.</td>
<td>Chilean abalone eat giant barnacles</td>
</tr>
<tr>
<td>4.</td>
<td>Over the past ten years, the abundance of squid has diminished</td>
</tr>
<tr>
<td>5.</td>
<td>Snoek are found more often in hot water than in cold water</td>
</tr>
<tr>
<td>6.</td>
<td>Hake reproduce during August and September</td>
</tr>
<tr>
<td>7.</td>
<td>Huiro palo (i.e., <em>L. trabeculata</em>) will grow back if you cut it directly above the base</td>
</tr>
<tr>
<td>8.</td>
<td>Piure (i.e., <em>P. chilensis</em>) can move on its own</td>
</tr>
<tr>
<td>9.</td>
<td>Crabs eat small fish</td>
</tr>
<tr>
<td>10.</td>
<td>When there are fewer keyhole limpets there is more red algae</td>
</tr>
<tr>
<td>11.</td>
<td>Flounder live on the soft bottom of the ocean</td>
</tr>
<tr>
<td>12.</td>
<td>Shrimp is the favourite food of the red conger eel</td>
</tr>
<tr>
<td>13.</td>
<td>Huiro palo (i.e., <em>L. trabeculata</em>) provides a good habitat for young fish to live</td>
</tr>
<tr>
<td>14.</td>
<td>It is easier to catch fish during the full moon</td>
</tr>
<tr>
<td>15.</td>
<td>The amount of corvina drum has declined over the last ten years</td>
</tr>
<tr>
<td>16.</td>
<td>Huiro negro (i.e., <em>L. nigrescens</em>) does not grow in areas lower than three meters</td>
</tr>
<tr>
<td>17.</td>
<td>Red sea urchin do not eat algae</td>
</tr>
<tr>
<td>18.</td>
<td>Shellfish and algae compete for habitat</td>
</tr>
<tr>
<td>19.</td>
<td>There are less shellfish inside the management areas than outside</td>
</tr>
<tr>
<td>20.</td>
<td>Vieja (i.e., <em>G. nigra</em>) live in rocky hollows</td>
</tr>
<tr>
<td>21.</td>
<td>Artisanal fishers and divers can easily affect the abundance of marine resources</td>
</tr>
<tr>
<td>22.</td>
<td>Marine areas serve to protect marine resources</td>
</tr>
</tbody>
</table>
6.2.4.1.2 Collective action

The second dependent variable – collective action – was operationalized using a set of nine questions. Five of the questions are focused on Ostrom’s design principles (Cox et al., 2010; Ostrom, 1990). We take Ostrom’s design principles as indicators of collective action based, first, on the substantial body of scholarship of CPR scholars, that suggests at a minimum, that their presence increases the likelihood that collective action exists (whether voluntarily or coerced). However, we acknowledge that the presence of the design principles does not guarantee successful CPR management (Ostrom et al., 2007). Secondly, we assume that the more resource users recognize the existence of institutions (as described by the design principles) and believe they are functioning well, the more likely that collective action exists, as it suggests users are operating by the same rules and find them agreeable.

Due to the nature of the study context and the assumed similarity of macro and regional level institutions, we examined only five of Ostrom’s design principles, those that are most likely to vary between communities. These are: conflict resolution mechanisms; sanctions; effective monitoring; participation in decision-making; and clarity of rules and behaviours. Respondents were asked to rate how much they agreed or disagreed with statements regarding these institutions on a five-point Likert scale. The two design principles not included were the recognition of self-determination and nested enterprises. These were not assessed because communities are likely to be nested to the same degree and operate with a similar amount of self-determination, as they are subject to the same national and regional policies and structures, and so unlikely to vary in these dimensions.
The remaining four questions examine informal norms (Table 7) that may influence collective action. While rules may exist, it is another question whether people would nonetheless be willing to engage in behaviours that would damage/benefit collective action. For example, even if people can participate in decision-making, would they want to? Although sanctions exist against poaching, would people still be willing to take the risk? We thus sought to investigate, in addition, four behaviours we hypothesize to also be important for sustainable resources and collective action through an adapted semantic differential question format (Osgood, May, & Miron, 1975) in which participants were asked to rate their approval or disapproval of a hypothetical peer’s rule flouting behaviour on a scale from one to seven (strongly disapprove to strongly approve, respectively). These questions are of an exploratory nature and are aimed to assess informal norms. We are then able to assess whether common understanding is related to positive appraisals of (formal and informal) institutions theorized to be important for collective action in local resource management.

Table 7. Institutions and norms measured in this study, with the question formats provided. Ostrom’s design principles were measured using five-point Likert scales, with 1 indicating strong disagreement and 5 indicating strong agreement with a statement. Norms were measured using a seven-point scale with 1 indicating strong disapproval and 7 indicating strong approval of a hypothetical community member’s actions.

<table>
<thead>
<tr>
<th>Ostrom’s design principles for CPR institutions</th>
<th>Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation in decision-making</td>
<td>My opinion is taken into account when the rules of my organization are being changed.</td>
</tr>
<tr>
<td>Effective monitoring</td>
<td>I have confidence in the monitoring system for Chilean abalone in the management area of my organization.</td>
</tr>
<tr>
<td>Graduated sanctions</td>
<td>I agree with the system of penalties in my organization for rule violations.</td>
</tr>
<tr>
<td>Ostrom’s design principles for CPR institutions</td>
<td>Statements</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Cheap and easy access to conflict resolution mechanisms</strong></td>
<td>When conflicts arise between members, these are resolved simply.</td>
</tr>
<tr>
<td><strong>(1) Rules regarding appropriation and provision of CPRs and boundaries (2)</strong></td>
<td>The expected behaviour of all members of the organization is clearly defined.</td>
</tr>
<tr>
<td><strong>Recognition of self-determination</strong></td>
<td>Not investigated as assumed relatively uniform</td>
</tr>
<tr>
<td><strong>Nested enterprises</strong></td>
<td>Not investigated as assumed relatively uniform</td>
</tr>
<tr>
<td><strong>Norms</strong></td>
<td>Statements</td>
</tr>
<tr>
<td><strong>Poaching</strong></td>
<td>Jorge illegally harvests Chilean abalone to sustain his household.</td>
</tr>
<tr>
<td><strong>Whistle-blowing (informing on peers)</strong></td>
<td>Jorge knows that the organization has not been reporting all of their catch and alerts the authorities.</td>
</tr>
<tr>
<td><strong>Withholding valuable information</strong></td>
<td>Jorge has discovered a new fishing area, but does not tell anyone else in the organization.</td>
</tr>
<tr>
<td><strong>Conformity</strong></td>
<td>The majority of syndicate members agree with the organization’s plans for the future. Jorge disagrees, but reserves his opinions to himself.</td>
</tr>
</tbody>
</table>

### 6.2.4.2 Independent variables

Independent variables used to understand the link and relative importance of common understanding for collective action were selected from those hypothesized to affect the ability of communities to engage in collective action (see Table 8, and see Appendix B for question wording and sources from which they are adapted). Table 8 also lists the variables used to investigate potential factors that may lead to greater common understanding and were selected from those previously linked to common understanding, but where relationships have been not been strongly established. Most questions required participants to note their level of
agreement or disagreement to a series of statements using a Likert scale from one to five (strongly disagree to strongly agree respectively); those structured otherwise are noted below.

Demographic variables included: the participant’s age (in years); education in years, however all post-secondary education was coded as a 13; whether people were originally from the community or had migrated (coded as ‘1’ and ‘2’ respectively); average income in Chilean pesos per month; years of experience fishing; years as a member of the local union; fishing income as percent of total income; number of years resident in the community; and days spent fishing per month, on average.

Table 8. Explanatory variables used in this study to assess both the relative influence of common understanding for collective action among other variables, as well as what factors may lead to common understanding in the first place.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Respondent’s age, in years</td>
</tr>
<tr>
<td>Education</td>
<td>Number of years of formal education</td>
</tr>
<tr>
<td>Migrant</td>
<td>Whether respondent came from another place, binary</td>
</tr>
<tr>
<td>Income</td>
<td>In average pesos per month</td>
</tr>
<tr>
<td>Years fishing</td>
<td>Number of years respondent has been fishing</td>
</tr>
<tr>
<td>Membership years</td>
<td>Number of years the respondent has been a member of the syndicate</td>
</tr>
<tr>
<td>Fishing income</td>
<td>The percentage of total income derived from fishing</td>
</tr>
<tr>
<td>Years resident</td>
<td>Number of years the respondent has resided in the community</td>
</tr>
<tr>
<td>Days fishing</td>
<td>The average number of days per month the respondent engages in fishing</td>
</tr>
<tr>
<td>Social relations</td>
<td>Composite index of social capital, trust, and need to belong</td>
</tr>
<tr>
<td>Foresight and flexibility</td>
<td>Composite index of respondents’ willingness to think ahead and adjust</td>
</tr>
<tr>
<td>Information sharing</td>
<td>Composite index of available teachers and willingness to seek advice</td>
</tr>
<tr>
<td>Locus of control</td>
<td>Composite index of perceived control over what happens in life</td>
</tr>
<tr>
<td>Environmental worldview</td>
<td>Measurement of pro-environmental orientation</td>
</tr>
<tr>
<td>Occupational attachment</td>
<td>Measurement of desire to be and remain a fisherperson</td>
</tr>
<tr>
<td>Explanatory variables</td>
<td>Definition</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------</td>
</tr>
<tr>
<td><strong>Perceived opportunities</strong></td>
<td>Measure of seeking and perceiving opportunities outside of the fishing profession</td>
</tr>
<tr>
<td><strong>Risk perception</strong></td>
<td>Single measure of willingness to take risks in general</td>
</tr>
<tr>
<td><strong>Quality of life</strong></td>
<td>Single measure of quality of life at present, all thing considered</td>
</tr>
</tbody>
</table>

6.3 Analyses

As common understanding is a group level construct, analyses were undertaken at a community scale, in this case between the seven artisanal fishing groups.

6.3.1 Univariate analyses

6.3.1.1 Dependent variables

Levels of common understanding were computed using UCINET (Borgatti et al., 2002), a program developed for Cultural Consensus analysis. As described in depth elsewhere (Borgatti et al., 2002; Weller, 2007) UCINET determines the ‘culturally correct’ answer for each of the 22 true/false questions in Table 1 for each community, against which the responses of individual community members is assessed and competencies calculated; here we use the covariance method. As detailed by Weller (2007):

*The cultural competence scores are found by factoring an agreement matrix ... The agreement matrix (with observed agreement between individuals i and j in cell row i and column j) can be used to solve for the unknown competence of each individual (the corresponding main diagonal cells row i column i and row j column j) when there are three or more individuals. Cultural competence estimates are provided by a principal axis*
(minimum residual) factoring method that solves for the unknown main diagonal values of the matrix. The competence scores appear as factor loadings on the first factor. (p. 346)

Individual competency scores were then aggregated and averaged within each community to derive a community common understanding score. Greater average competency in a community is understood to represent a greater level of common understanding. Although each question on institutions for collective action was treated as separate dependent variables, responses were similarly aggregated and averaged within each community.

6.3.1.2 Independent variables

Due to the low sample size, where possible and reasonable, a procedure of dimension reduction was undertaken based on Principal Components Analyses (PCA) and Cronbach’s alpha reliability coefficients, preceded by aggregation and averaging. Throughout this process, variables that were thought to be distinct and have distinct effects with regard to the dependent variables were kept separate. In cases where PCA was utilized, only the first factor and its items were retained as an index.

Overall, four indices were created (component variables were aggregated and averaged): 1) an index of the quality of community social relations containing five items related to social capital, trust, and the need to belong (α=.91); 2) an index of foresight and flexibility containing three items related to respondents’ willingness to think proactively and adapt their behaviour (α=.85); 3) an index of information sharing, measuring the degree to which people believe there
are opportunities to learn and their desire to learn from others in the community (α=.90); and, 4) a two-item index of locus of control, or the extent to which people feel in control of their life’s direction and circumstance, rather than being unmanageable or dictated by luck (α=.79).

Remaining explanatory variables (Table 8) were left unaltered and treated as separate variables as the creation of indices was not warranted according to PCA and Cronbach’s reliability analyses. These include questions regarding environmental worldviews, occupational attachment, and the perception of opportunities. Demographic variables were also treated as separate variables, while quality of life and risk perceptions were measured each by single questions and remained standalone variables.

### 6.3.2 Correlation and hierarchical partitioning analyses

The core analysis was conducted in two stages. Due to the limited sample size, we encountered the $p >> n$ problem, where the number of independent variables is much greater than the sample size; even after reducing the number of predictors, a significant number remained and limited the number of appropriate statistical tools. Thus as a first step, 2-tailed bivariate Pearson correlations were conducted with each explanatory variable and each dependent variable. Independent variables with a significant correlation of $p < .05$ were identified and retained. No correction for multiple tests was conducted (e.g., Bonferroni) because the correlations were primarily used as a coarse filter to identify the most influential variables.

While correlation analyses suggest which variables may be influencing one another, we sought to understand the relative importance of predictors as well. Again, our emphasis is not to
produce a generalizable predictive model, but to understand the relative role (if any) of
common understanding related to collective action, as well as those factors that contribute to
common understanding itself. Due to the potential issues of multicollinearity, we chose to
enter all significant predictors from the preceding stage into hierarchical partitioning
procedures (Chevan & Sutherland, 1991) to identify the relative contribution of each predictor
to the variance observed in the dependent variable. This was implemented via the ‘hier.part’ R
package (R Core Team, 2015; Walsh & MacNally, 2013). The output of hierarchical partitioning
includes the individual contribution of each variable to explaining variance, as well as their joint
contribution (the contribution made by the variable in conjunction with the other explanatory
variables in the model). These contributions are given as $R^2$. Furthermore, where hierarchical
partitioning was implemented (when more than one variable was significantly correlated with
the response variable), a randomization procedure (MacNally, 2002) was implemented to
assess their 95% confidence interval (shown as z-scores) – however, note that the utility of such
a procedure is also limited by the small sample size.

6.4 Results

6.4.1 Common understanding

Variance was observed in the common understanding scores of the communities. In ascending
order, Ventanas had the lowest average score (.561), followed by El Manzano (.588), Los Molles
(.590), Papudo (.594), Algarrobo (.617), Quintay (.618), and Horcon the highest (.647), however
the overall range is fairly narrow. The ‘culturally correct’ answers to the true and false
questions were also different between communities. Note that the scores do not follow the
geographic distribution of the communities (e.g., Horcon is the closest community to Ventanas by distance, but the two are most different in their levels of internal common understanding).

6.4.2 Common understanding correlates

Pearson correlations (Table 9) revealed three significant relationships between the explanatory variables and common understanding. Occupational attachment (as measured by the statement that being a fisherman/diver/gleaner is a lifestyle rather than a job; \( r = .81, p = .03 \)) and the social relations index (\( r = .85, p = .02 \)) were positively correlated, while level of formal education was negatively correlated (\( r = -.81, p = .03 \)). In addition, the greater the average number of days spent in marine resource extraction (\( r = .73, p = .06 \)) and locus of control (\( r = .74, p = .06 \)) were both nearly significant in a positive direction.

Table 9. Pearson 2-tailed correlations between community-averaged scores of common understanding and the explanatory variables (\( N=7 \)).

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Correlation coefficient</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enviro worldview: Ecological catastrophe</td>
<td>0.09</td>
<td>0.86</td>
</tr>
<tr>
<td>Enviro worldview: Nature is resilient</td>
<td>0.39</td>
<td>0.38</td>
</tr>
<tr>
<td>Enviro worldview: Humans abuse enviro</td>
<td>0.46</td>
<td>0.31</td>
</tr>
<tr>
<td>Quality of life</td>
<td>0.44</td>
<td>0.32</td>
</tr>
<tr>
<td>Job attachment: Love working in the ocean</td>
<td>-0.52</td>
<td>0.23</td>
</tr>
<tr>
<td>Job attachment: Fishing is a lifestyle not just a job</td>
<td>0.81*</td>
<td>0.03</td>
</tr>
<tr>
<td>Job attachment: Happily consider other jobs a</td>
<td>-0.06</td>
<td>0.91</td>
</tr>
<tr>
<td>Job attachment: Would adapt to stay fishing</td>
<td>-0.19</td>
<td>0.69</td>
</tr>
<tr>
<td>Opportunity: Marine extraction alternatives available</td>
<td>-0.08</td>
<td>0.87</td>
</tr>
<tr>
<td>Opportunity: Change brings opportunity</td>
<td>0.13</td>
<td>0.78</td>
</tr>
<tr>
<td>Opportunity: Little response to resource declines a</td>
<td>0.16</td>
<td>0.73</td>
</tr>
<tr>
<td>Social Relations Index</td>
<td>0.85*</td>
<td>0.02</td>
</tr>
<tr>
<td>Foresight and Flexibility Index</td>
<td>0.45</td>
<td>0.31</td>
</tr>
<tr>
<td>Explanatory variable</td>
<td>Correlation coefficient</td>
<td>Sig. (2-tailed)</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>-------------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Information Sharing Index</td>
<td>-0.14</td>
<td>0.76</td>
</tr>
<tr>
<td>Locus of Control Index</td>
<td>0.74</td>
<td>0.06</td>
</tr>
<tr>
<td>Age</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>Education</td>
<td>-0.81</td>
<td>0.03</td>
</tr>
<tr>
<td>% Migrants</td>
<td>-0.26</td>
<td>0.58</td>
</tr>
<tr>
<td>Income</td>
<td>-0.67</td>
<td>0.10</td>
</tr>
<tr>
<td>Years fishing</td>
<td>0.38</td>
<td>0.40</td>
</tr>
<tr>
<td>Membership years</td>
<td>0.46</td>
<td>0.30</td>
</tr>
<tr>
<td>% Income from fishing</td>
<td>0.64</td>
<td>0.12</td>
</tr>
<tr>
<td>Years resident in community</td>
<td>0.50</td>
<td>0.26</td>
</tr>
<tr>
<td>Average marine extraction days per month</td>
<td>0.73</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*. Correlation is significant at the 0.05 level (2-tailed)

6.4.3 Hierarchical partitioning with common understanding

To assess the relative contribution of job attachment, education, and social relations to common understanding, these variables were entered into a hierarchical partitioning procedure. It was found that of the explained variance, occupational attachment was most important by accounting for 34.26%, and education (33.72%) and social relations (32.02%) coming in second and third respectively not far behind. Overall, each variable was nearly the same in importance. When all three variables are entered into a single model, an $R^2$ (unadjusted) of .936 is obtained. When considering joint contributions (those resulting from the correlation of a predictor with the other predictors), the quality of social relations is the most important predictor with an $R^2$ of .74, followed by levels of formal education at .70, and finally occupational attachment at .63.
Because of the small sample size, we undertook a significance testing procedure by randomizing variable values (1000 runs) as proposed by (MacNally, 2002). We found that, when compared to randomly generated independent contributions, the contributions of occupational attachment, the social relations index, and education to common understanding did not reach statistical significance. See z-scores in Table 10 for results.

Table 10. Results of the hierarchical partitioning (I, J, and I+J) and significance testing procedures (Z-scores) used to assess the relative contribution of variables significantly correlated with common understanding. ‘I’ indicates independent contributions, ‘J’ represents joint contributions, these are provided as $R^2$. The sum of ‘I’s is the unadjusted $R^2$ of the full model including using all three explanatory variables.

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>I</th>
<th>J</th>
<th>I + J</th>
<th>Z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job attachment: Fishing is a lifestyle not just a job</td>
<td>0.32</td>
<td>0.31</td>
<td>0.63</td>
<td>0.98</td>
</tr>
<tr>
<td>Social Relations Index</td>
<td>0.30</td>
<td>0.44</td>
<td>0.74</td>
<td>0.83</td>
</tr>
<tr>
<td>Education</td>
<td>0.32</td>
<td>0.39</td>
<td>0.70</td>
<td>0.84</td>
</tr>
</tbody>
</table>

6.4.4 Collective action institutions

6.4.4.1 Ostrom’s institutions for collective action

Among Ostrom’s institutions for collective action, some variation was observed between communities (Figure 19). Perceived participation in decision-making showed a range of .79 (i.e., no community was more than one point apart) on a five-point scale, with Los Molles being the highest and Papudo being the lowest; in general, the collective action as measured by the design principles was rated highly by all communities. Confidence in monitoring systems for benthic resources showed a wider range with 2.17, Horcon being highest and El Manzano being lowest; in general, there is low confidence in monitoring. There is general agreement with
sanctioning rules with a range of 1.12, with greatest agreement in Horcon and lowest in
Ventanas. Perceptions of simple and effective means of conflict resolution were lowest in
Algarrobo and highest in Horcon, with a range of 1.28 and generally high ratings. Finally,
members in Quintay felt that the rules of conduct for members was clearest, while members
from Algarrobo felt they were the least clear with a range of 1.49; communities generally
agreed that rules were clear.

Figure 19. Community-averaged rating for each measured institution (in shades of red) and norm (in shades of
grey). Note that institutions (red bars) were measured using a scale from 1-5, while norms (grey bars) were
measured using a scale from 1-7.

Of all five of Ostrom’s design principles evaluated, Horcon exhibits the highest (3/5) agreement
or second highest (2/5) agreement that collective action institutions exist and are satisfactory
or effective. In contrast, Algarrobo is last (2/5) or second to last (1/5), three out of five times
(and either third from last or tied for third from last the remaining two times).
Among Ostrom’s design principles, common understanding only statistically and significantly correlated with sanctioning institutions. However, each of the evaluated institutions showed significant correlations with at least one factor.

Sanctioning institutions and conflict resolution were significantly correlated with three variables each. These were entered into hierarchical partitioning procedures. Sanctioning was positively correlated with the perceived locus of control index \((r = .86, p = .01)\), community levels of common understanding \((r = .84, p = .02)\), and perceptions of effective conflict resolution \((r = .78, p = .04)\), accounting for 35.03%, 34.62%, and 30.36% of explained the variance (total model \(R^2\) of 0.878) in agreement with sanctions respectively. The randomization procedure, however, did not find the contributions statistically significant. When considering joint contributions, perceived locus of control was still the most important variable with a total \(R^2\) of .74, with common understanding second at .65, followed by conflict resolution institutions at .61.

The presence of simple and effective conflict resolution mechanisms was positively correlated with acceptable sanctioning rules as noted above, and in addition, to perceived locus of control \((r = .76, p = .05)\) and the perception that there were clear rules and expectations of member behaviours \((r = .88, p = .01)\). The latter explained the most variance (of the full model; unadjusted \(R^2\) of .99) at 49.58%, followed by locus of control (26.33%), and sanctioning institutions (24.09%). Randomization procedures only found clear behavioural rules to be statistically significant explanatory variable. Again, joint contributions appear to be important. When considering joint contributions, rules of appropriate behaviour was still the most
important at .77, followed by agreeable sanctioning mechanisms .61, and then locus of control .57.

For perceptions of participation in decision-making, effective monitoring, and clear rules for behaviour, there was only one significant correlate for each. Perceptions of having a voice in the organization was negatively correlated with willingness to make substantial changes to stay engaged in the profession of marine resource extraction ($r = -.85, p = .02$). Confidence in resource monitoring was negatively correlated with the proportion of migrants in a community ($r = -.80, p = .03$). Perception that there were clear behavioural rules and expectations of members was significantly and positively related to perceptions of adequate conflict resolution mechanisms ($r = 0.88, p = 0.01$).

**6.4.4.2 Norms for collective action**

In terms of norms that have the potential to impact collective action efforts, none were statistically significantly correlated with common understanding. Three of the four measured norms were significantly correlated with at least one predictor, the exception being the approval or disapproval of whistleblowing against the caleta, which was not correlated with any explanatory variable.

A general trend of disapproval was observed for poaching behaviours with a range of 1.73, with members of Quintay most approving of poaching behaviours (4.00; recall that one is strong disapproval and seven strong approval) and Ventanas being the most disapproving (2.43). In general, communities approved of individuals reporting illegal catch activities of peers with a
range of 1.62, with members from Los Molles providing the highest approval (5.07) and Papudo the least (3.45). Nearly all communities disapproved of hiding valued fishing information with a range of 1.40; however, Algarrobo gave the most positive and highest rating at (4.00) and Los Molles the least approving (2.60). Finally, approval of conformist behaviours at the expense of open discourse was the most prominent in Quintay (3.91) and least in Ventanas (1.71) with a range of 2.20, with communities split between approval and disapproval.

In our investigation of informal norms, approval of whistleblowing was not significantly correlated with any of the predictor variables. The approval of withholding valuable fishing information was positively correlated with the number of years people had spent fishing or diving ($r = .82, p = .03$). Approval of poaching behaviours was positively correlated with quality of life ratings ($r = .85, p = .01$) and no other variables.

Finally, approval of conformist behaviours was significantly and positively correlated with four predictors: the willingness to take risks ($r = .84, p = .02$); the amount of options people perceived they had if resources declined ($r = .80, p = .03$); the propensity to plan ahead and be flexible ($r = .90, p = .01$); and the percentage of income derived from marine resource extraction ($r = .87, p = .01$). None of the informal institutional variables were correlated with the design principles using two-tailed Pearson correlations.

Hierarchical partitioning revealed that foresight and flexibility was the most independently important in explaining the total variance (of the full model; unadjusted $R^2$ of 0.93) of the approval of conformist behaviours at 29.57%. Second most important was the percentage of income derived from marine extractive activities (25.01%), willingness to take risks (25.01%),
and lastly job attachment as measured by the willingness to consider other occupations (21.01%). Randomization procedures, however, found that none of the independent contributions were significant. In terms of joint contributions, the order of importance is different, with foresight and flexibility continuing to be the most important \( R^2 \) of 0.82 followed by the percentage of income derived from fishing (0.76), willingness to take risks (0.71), and job attachment (0.64).

Table 11. Results of the hierarchical partitioning (I, J, and I+J) and significance testing procedures (Z-scores) used to assess the relative contribution of variables significantly correlated with the measures institutions for sanctions, conflict resolution and the norm of conformity. ‘I’ indicates independent contributions, ‘J’ represents joint contributions, these are provided as \( R^2 \).

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>I</th>
<th>J</th>
<th>Z-score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sanction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locus of Control Index</td>
<td>0.31</td>
<td>0.44</td>
<td>0.79</td>
</tr>
<tr>
<td>Common understanding</td>
<td>0.30</td>
<td>0.35</td>
<td>0.79</td>
</tr>
<tr>
<td>Conflict resolution</td>
<td>0.27</td>
<td>0.35</td>
<td>0.62</td>
</tr>
<tr>
<td>Clear rules of behaviour</td>
<td>0.49</td>
<td>0.28</td>
<td>2.05*</td>
</tr>
<tr>
<td><strong>Conflict</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locus of Control Index</td>
<td>0.26</td>
<td>0.31</td>
<td>0.59</td>
</tr>
<tr>
<td>Sanctions</td>
<td>0.24</td>
<td>0.37</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Conformity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing income</td>
<td>0.23</td>
<td>0.53</td>
<td>0.40</td>
</tr>
<tr>
<td>Risk perception</td>
<td>0.23</td>
<td>0.48</td>
<td>0.43</td>
</tr>
<tr>
<td>Opportunity: Little response to resource declines</td>
<td>0.20</td>
<td>0.44</td>
<td>0.18</td>
</tr>
<tr>
<td>Foresight and Flexibility Index</td>
<td>0.28</td>
<td>0.54</td>
<td>0.76</td>
</tr>
</tbody>
</table>

6.5 Discussion

6.5.1 Common understanding and collective action institutions

In contrast with the hypothesized link in the literature between collective action and common understanding, our results did not confirm the existence of strong links between common
understanding and collective action, at least in the communities studied. This is demonstrated by the lack of statistically significantly relationships between the institutions investigated and common understanding as measured through CCT. The exception was community levels of agreement with sanctioning institutions, and in the case of sanctions, common understanding was not the most important contributing variable. The most important predictor of community appraisals of sanctions was (in descending order) perceived locus of control, common understanding, and perceptions of effective conflict resolution.

Additionally, in our results, no single factor was exceptionally influential in spurring aspects of collective action. Thus, collective action may be achieved though a number of means, with different forms of collective action uniquely influenced by different factors. For instance, among both formal and informal institutions (i.e., norms), only locus of control was a shared predictor and correlated with perceptions of conflict resolution and sanctioning mechanisms.

If common understanding were important for collective action, we would expect that the community with the highest level of measured common understanding would also exhibit the most highly functioning collective action institutions. By extension, in our study, Horcon would be expected to exhibit the most highly functioning collective action institutions relative to other communities (by having the highest common understanding score), and Ventanas the least. As expected, between all seven communities, Horcon exhibited the highest or second highest rating of its collective action institutions (three times out of five and two times out of five respectively) in terms of their existence, satisfaction, or effectiveness. However, rather than Ventanas displaying the lowest ratings, Algarrobo (which had the third highest common
understanding score) placed last or second to last in three of the five design principles, and placed third from last in the remaining two.

Nonetheless, it was found that, in general, across all communities, residents rated most local collective action institutions highly, including involvement in decision-making, sanctioning rules, conflict resolution mechanisms, and clearly defined rules for behaviour. Participants were relatively more dissatisfied with monitoring systems.

There also appears to be a tendency for institutions to reinforce one another, as appraisals of conflict resolution mechanisms and sanctions were positively correlated; conflict resolution mechanisms were also positively correlated with the perception of clear rules for behaviour. No statistically significant relationship was found between the design principles and informal norms. Thus the perceived existence and effectiveness of rules may be distinct from private moral sentiments (and indeed formal rules may conflict with norms, e.g., Gelcich, Edwards-Jones, Kaiser, & Castilla, 2006).

Although it is not possible to establish causality in any of the apparent relationships between predictors and collective action institutions in this study, despite the small sample of communities, many of our findings make intuitive sense and converge with findings and theory from elsewhere. For example, community members’ confidence in monitoring mechanisms was inversely related to proportions of migrants, congruent with certain expectations that heterogeneity and migrants makes collective action harder to maintain (e.g., Crona & Bodin, 2006; Dasgupta & Beard, 2007; Miguel & Gugerty, 2005; Poteete & Ostrom, 2004). It is also reasonable to expect that the existence of simple means to resolve conflicts should be related
to more effective sanctions and the perception of clear boundaries for behaviour. The evidence also suggests that the longer people have been fishing the more they approve of concealing valuable fishing information, information that would likely be more valuable for novices.

The interpretation of other findings is not as straightforward. For instance, approval of poaching behaviours was positively correlated with quality of life ratings. One possible interpretation is that quality of life is strongly linked with good social relations and that preservation of these relations may lead to lower willingness to condemn peers. Our findings indicate that quality of life is positively correlated with social relations index \( r = .85, p = .02 \), and this interpretation is furthermore corroborated by anecdotal evidence from the president of one community, who stated that it was difficult to conduct monitoring and sanctioning due to the many familial ties within his community.

Also odd was that the more community members were dedicated to remain fishers, the less they felt that they had a voice in community decisions. It is possible that the more people feel attached and dedicated to preserving fishing as their occupation, the greater the desire to be heard, whereas those less dedicated to the profession may hold less of a perceived stake and desire to participate in community decisions, making whatever participation that does exist appear more sufficient.

Finally, assent of conformist tendencies was significantly and positively correlated with four predictors. Communities with members that reported greater flexibility and forward planning, derived more of their income from fishing, and perceived more adaptation options in the face of resource declines were more approving of group conformity. Less clear is the
counterintuitive finding that willingness to take risks in general is positively correlated with approval of conformism; it may be that this relationship is due to chance alone, or perhaps conformism is a by-product of group cohesion, which provides more freedom and security for risk taking in other domains (De Carolis & Saparito, 2006). Finally, in our investigation of informal institutions, approval of whistleblowing was not significantly correlated with any of the predictor variables.

6.5.2 Forging common understanding

Although evidence that common understanding strongly influences collective action was not found in this research, there remains both continued interest and potential benefits for understanding what leads to common understanding (Lebel et al., 2006). However, as previously elaborated, how common understanding can be built (Lynam, De Jong, Sheil, Kusumanto, & Evans, 2007) is only beginning to be explored, but not well understood. Factors such as discourse, trust, networks, knowledge sharing, identity, and others have been linked or equated to common understanding but these relationships are not clear-cut (e.g., Armitage et al., 2008; Crona & Bodin, 2006; Pahl-Wostl et al., 2007; Plummer & FitzGibbon, 2006). Our results suggest that, at a minimum, common understanding can be distinguished from these other constructs and where links have previously been supposed, some are supported whereas in other cases, proof could not be found.

Some of the variables that would reasonably be expected to increase the amount of knowledge cohesion within communities were found correlated to community levels of common understanding. In this case higher levels of common understanding were best explained by a
small set of predictors related to the perception of fishing occupations as a lifestyle (rather than solely as an occupation), less formal education, and better social relations.

It is possible that decreased levels of education may be linked to a greater reliance on peers for information, leading to greater coherence in knowledge, an effect that could be facilitated by better social relations allowing for freer communication and learning (active or passive).

Greater occupational attachment, as suggested by perceptions of fishing as a lifestyle, may also incentivize learning about resource dynamics through peers, or greater active and direct observation through more frequent fishing activities. Although shy of statistical significance ($p = .06$), the number of days per month community members spent on average in marine resource extraction appeared to be positively related to common understanding. The contribution of the aforementioned variables to the variance in common understanding was close to equal. However, the independent contribution of occupational attachment was greatest, followed by education and quality of social relations.

A factor complicating the above interpretation is the non-significant statistical relationship between common understanding and an index of information sharing, which suggests that peer learning is perhaps more unconscious and passive and/or derived from direct experience and exposure with the environment leading to a common coalescence around local ecological realities. Neither possibility supports previous arguments that discourse and stakeholder participation and collaboration are key to achieving common understanding (e.g., Lebel et al., 2006; Plummer & FitzGibbon, 2006).
6.5.3 Limitations

Although support for the role of common understanding in collective action was sparing in this study, alternative definitions as to how to measure common understanding, such as those that extend beyond a ‘resource dynamics’ model may lead to different results. For instance, it may not be common understanding itself that contributes to collective action, but the belief that common understanding exists among peers. Alternatively, it may be a common understanding of one or a few salient risks that is necessary to spur collective action, or simply a shared feeling of risk, even if the understanding of its dynamics differ. It is also possible that common understanding of some other aspect of the local social-ecological system—such as the institutions themselves, their purpose and their function—may be more relevant. None of these possibilities were investigated in this research and remain speculative.

Another possible explanation for the absence of strong relationships between common understanding and collective action is the small amount of variability observed in the former among the communities. This may be especially likely since the communities are all located in Region V, where ecological variation is not as different as would be expected if communities were more spatially dispersed. Region V caletas are also connected through larger organizations of artisanal marine users at the regional level that may facilitate knowledge exchange and thus homogeneity. Unfortunately, it is not possible to verify whether the paucity of variation in common understanding scores is the cause, but it is a plausible explanation.

Furthermore, the current study represents only a small contribution to research on collective action and suffered from a small sample size (N=7 communities), affecting the generalizability
of the study’s results and the power of the statistical effects to detect significant correlations where they may exist (but went undetected). Nonetheless, while questions of statistical power may be raised a possible reason for why more relationships between common understanding and collective action were not found (apart from with sanctioning institutions), the sample and methods used were sufficient to resolve other significant relationships. That other relationships could be found adds confidence to the conclusion that, at a minimum, relationships between collective action and common understanding may be weaker than suggested in the literature, and that other variables may be more influential.

6.6 Conclusion

A principal contribution of this research has been the operationalization of common understanding, allowing for the formal investigation of the commonplace assumption that common understanding is a key ingredient in collective action. Use of cultural consensus methods yielded a lack of evidence that common understanding of ecological dynamics is related to many aspects of collective action, at least in the specific context of collective action for common pool resources in coastal Chile among artisanal fishers. Thus, the null hypothesis with regard to common understanding as a critical component for the manifestation of collective action cannot be rejected.

This research has also demonstrated that a diversity of factors appear to be more strongly related to collective action institutions and norms than common understanding, including demographics, psychologies, and other collective action institutions. This research suggests that emotional and financial investment in the resource base, group composition and their intra-
relations, and the ability and perceived ability to navigate change may be stronger candidates than common understanding in influencing collective action.

Discourse and stakeholder involvement are frequently offered as a means to build common understanding and thus collective action (e.g., Lebel et al., 2006). Results from this study indicate that, at the very least, common understanding may be more easily fostered via other means, and moreover, that attention on common understanding may be misplaced. However, that is not to say that discourse is not beneficial for collective action, rather the contribution of discourse may be through alternative pathways, such as strengthening collective investment in resources, social groups, and psychological resilience. These pathways were not investigated directly in this research and remain open to investigation.

As previously stated, collective action institutions and norms were not found to be reliably or strongly related to a single variable (common understanding or otherwise), supporting the oft-cited statement that there are no panaceas (Ostrom et al., 2007). This suggests that building collective action more likely involves the self-organized and piecemeal evolution of institutions and capacities that are context specific. It remains the task of future research to disentangle the patterns behind collective action that may exist, and their caveats and limitations, just as this study has attempted to do.
Chapter 7: Conclusion

7.1 Overview of the dissertation and summary of contributions

The sustainable management of natural resources is the endeavour to ensure the persistence of the things we care about through time, which itself involves the many challenges of adaptation to change. Uncovering the patterns of change and the ways to confront or (purposively) accede to change is a fundamental thread of modern sustainability science, just as it has been foundational to disciplines (e.g., evolution) and even religions and philosophies (e.g., Taoism) that have come before. Yet, immense obstacles continue to hinder our understanding of adaptation and change in human communities, as well as research efforts and the integration of knowledge across fields of study that might contribute to this understanding.

Among the obstacles to understanding is the need for a more comprehensive picture of how social and ecological systems constitute a whole, part and parcel of portraits of change, wherein the illumination of relevant social dimensions is key. Because people and the structures that they create, both physical and intangible (e.g., beliefs, rules, and systems of governance) are massive controllers of change, having a concrete basis to examine these dimensions is imperative. Yet, such a foundation arguably needs clear and unambiguous definitions of key dimensions that can be operationalized and observed, and a more complete set of important dimensions (i.e., those relatively more or most important). Advancing scholarship on these fronts constitutes the principal objectives of this dissertation. Tremendous advances have been made as concerns our understanding of social-ecological resilience, common-pool resources, and the vulnerability of groups within social-ecological systems;
similarly, we understand better: governance, institutions, adaptive capacity, social learning, and more. And yet many aspects of the elucidation of each of these key ideas remain incomplete.

Problems of sustainability increasingly require interdisciplinary and transdisciplinary collaboration (e.g., Folke, 2006). Drawing knowledge from diverse disciplines and applying them to questions of sustainable social-ecological systems is the source of this dissertation’s major contributions. For instance, human motivations and needs have long been the subject of intense study in the psychological sciences, yet are only sparingly addressed in common-pool resource management scholarship despite their apparent central importance. Adoption of an expanded and more complete and detailed lens of human actors (e.g., in-depth examination of motivations that are often overlooked as in Chapters 2 and 3) provide for insights that might otherwise be missed or obscured.

In the case of globalization and development, channels of impact from the global to local become more apparent, as do potential solutions. Alarms have previously been rung, alerting us to the potential negative effects of globalized markets that incentivize the increased rate, pace, and extent of resource exploitation (Berkes et al., 2006). Similarly, paying explicit attention to motivations helps us understand both where interventions are possible and which are central, and highlights when exploitation might occur, or not. Non-monetary routes (e.g., endogenous changes in personal values and preferences, for instance, to seek higher education), in which exploitation and participation in co-management may evaporate or be
compromised, are also revealed herein, and help to combat the common unstated assumption that primary resource users will remain available and interested.

Whereas rights-based approaches (Mascia & Claus, 2009) and conventional policy instruments often focus on monetary incentives and disincentives to guide behaviours, others have begun to argue that a property rights approach is too narrowly focused on economic concerns where others are pertinent (Allison et al., 2012). In this vein, expanding the scope of considered drivers of human behaviour can help to explain the implications and origins of major cultural shifts (Chapter 3), and to create more resilient management systems through a larger and diversified set of potential tools (Chapter 2), without compromising user desires and opportunities for adaptation.

Critically, in the celebrated Chilean context, without the appropriate policies, user adaptations may threaten the persistence of what is currently considered a highly successful common property and co-management system. Chief among the potential threats are shortages in the recruitment of new marine users and the exit of existing ones as a result of user adaptations. The participation of local users cannot be assumed, and is especially important in co-management systems where there is great dependence on the involvement and participation of local users to maintain the stability and protect natural resources. Large-scale disengagement may also mean a lost opportunity to secure and strengthen a valuable network of monitored and managed coastline and benthic ecosystems. An extensive system of local management may also be fertile territory for adaptive management (Cook, Casagrande, Hope, Groffman, &
Collins, 2004; Walters & Holling, 1990). However, navigating such a change will require understanding why potential users are or are not appearing, and where many causes may exist.

Major cultural and demographic shifts (of the kind suggested in Chapter 3), are the result of the actions of hundreds and thousands of individuals responding to stimuli in their surrounding social-ecological environment. In other words, the ‘system’ includes and is constantly alive with the combined consequence of people wielding their respective capabilities, energies, and resources to adapt (consciously or unconsciously). For obvious reasons, knowing whether a capacity to adapt exists and what constitutes that capacity can be immensely valuable for policy. The idea of adaptive capacity has thus become a vital component of resilience, vulnerability, and common-pool resource literatures. Indeed, it could be argued that adaptability is a unifying theme of these literatures (Engle, 2011). In general, adaptability is portrayed as a positive property (Engle, 2011) and whether attributed to individuals, institutions, societies, ecosystems or social-ecological systems, it invokes the ability to adjust and to create change.

The construct has seen wide application at multiple social and ecological scales. However, social adaptive capacity has rarely been researched among individuals (the focus of Chapter 4) and much of the writing and measurement of adaptive capacity tends to focus on vulnerability (Brooks, Adger, & Mick Kelly, 2005; Nelson, Adger, & Brown, 2007; Vincent, 2007; Yohe & Tol, 2002). In addition, there are many different interpretations of adaptability and adaptive capacity as well as significant confusion about whether the definitions from various fields are congruent or incongruent (Gallopín, 2006), or whether social adaptive capacity is different at
different scales (Engle, 2011; Nelson et al., 2007). Concurrent with this confusion, two of the chief deficiencies pertaining to adaptive capacity are how it can be built and what comprises its constituent parts, and whether general adaptive capacity is a valid conceptualization (particularly for assessment) or whether it should be understood as specific types relevant for different behavioural changes. In Chapter 4, I tackle these issues directly at the level of individual marine users. This includes efforts within Chapter 4 to quantify adaptive capacities.

Where quantification of adaptive capacity has been attempted in past studies, earlier efforts have tended to measure variables selected *a priori* as being associated with the ability to adapt. In the present research, I instead concentrate on three specific classes of behaviour relevant to marine extraction undertaken as responses to various environmental, social, and endogenous factors. Making behaviours the focal point of analysis allows the potential enabling factors (i.e., the components of capacity) to vary, such that it is possible to determine whether they are shared or different across behaviours.

Results presented in Chapter 4 suggest that adaptive capacity, at least in the specific case under study, is more accurately thought of as specific than general, and that variables commonly associated with greater adaptive capacity (such as income and education) cannot simply be assumed to be important. Furthermore, as argued within Chapter 4, the collected evidence also recommends the adoption of a more positive and active conceptualization of adaptive capacity in place of latent and crisis-linked renderings. Rather than adapting as a matter of course, I found that participants were very attentive to opportunities, and proactively making efforts to improve their context and wellbeing. Fishers were shown to be choosing what capacities to
apply, how, and when. For example, different people are using different adaptations in response to the same driver and vice versa, a degree of ‘customization’ by agents not generally recognized in the adaptation literature.

Consequently, there appears to be a case for a different approach to adaptive capacity measurement and assessment, one that makes fewer assumptions of the wide applicability of components across domains. For example, through more in-depth investigations in real-life day-to-day settings (Moser, 2010) involving the actual and multiple actions of people (I acknowledge that behaviours researched in Chapter 4 are self-reported and thus may not be ‘actual’). Among the components of adaptive capacity that have previously been supposed and hypothesized is the equally (if not more) diversely-interpreted concept of social learning (Reed et al., 2010; Rodela, 2011). Social learning has been linked to positive outcomes for adaptive co-management, resilience, and environmental governance, and thus environmental and institutional sustainability. However, the lack of clarity of what social learning is, let alone how it can be fostered, is perhaps surprising given its frequent invocation as vital for adaptation to change and sound management.

Resilience scholars have also stressed a need to develop learning capacities in individuals (Fazey et al., 2007), although it is unclear what that entails or how that can be accomplished. Other scholars have called for the fostering of interstitial ‘shadow spaces’ outside of regular organizational structures where there is autonomy and freedom to be creative with fewer constraints or pressures (Pelling, High, Dearing, & Smith, 2008). Shadow networks that comprise the relations outside formal institutional structures have also been proposed as
places where learning takes place (Olsson et al., 2006; Pahl-Wostl, 2009). Organizations that span different scales, interests, stakeholders and other organizations are also thought to provide a similar function (bridging organizations; Berkes, 2009).

The adaptive co-management literature in particular emphasizes that knowledge generated at different scales and through different social actors has the potential to be fruitfully combined to generate insights for the management of social-ecological systems, as knowledge is likely to be distinct but complementary (Berkes, 2009; see also Folke, Hahn, Olsson, & Norberg, 2005; Olsson, Folke, & Berkes, 2004). Unfortunately, the process of social learning and assertions made regarding the benefit of its presence is seldom critically examined or tested, and frequently appears as a proxy for forging engagement between stakeholders, for example (e.g., Leys & Vanclay, 2011). Fortunately, this is a recognized gap in scholarship (Armitage et al., 2008; Berkes, 2009).

In an effort to clarify the conceptualization of social learning and its correlates, Chapter 5 documents the creation and deployment of a quantitative measure of the propensity of individuals to seek social information to inform personal decision-making. Development of the measure is accomplished by drawing upon the field of cultural evolution (Boyd & Richerson, 1988b), which has not been a source of relied upon scholarship within sustainability or adaptation research (see Waring, 2010 as an exception). Yet, that field has a long history of rigorous research on social learning, with useful and well-established conclusions. By operationalizing, measuring, and identifying the bounds of at least one narrow conception of social learning so inspired by theory in cultural evolution, Chapter 5 contributes to all of the
objectives of this dissertation (as set out in Section 1.1.1): to 1) define and clarify, for operational purposes, major concepts used in resource management literatures; 2) begin to operationalize and adapt or create new measures suitable for quantitative investigation; and 3) expand the set of human psychological and social dimensions under consideration.

The measurement of social learning adapted from another field (specifically, Efferson et al., 2007), inheriting from the much wider intellectual heritage of game theory research and applied here, is perhaps the first of its kind to be used to quantitatively assess the significance of social learning in a resource management context. This evaluation contributes to the understanding of social learning in a number of ways, including separating it from other similar social variables that are often conflated (e.g., trust and improved social relations; Reed et al., 2010), and also introduces the firm theoretical foundation of cultural evolution to issues of resource sustainability, which in turn should become valuable to future investigations. In addition, results from the study show that social learning was not associated with variables and outcomes commonly associated with the concept, including social cohesion and collective action, and where relationships did appear with previously hypothesized variables, they were in the opposite direction of what was expected. By examining both the individual and community scale, Chapter 5 also provides a concrete basis to separate (and link) the importance and effects of social learning between individual and community social scales.

While many scholars advocate bringing together diverse stakeholders in resource contexts for social learning (Armitage et al., 2008), it is well known that the presence of competition or conflict (which characterizes many resource management situations) can thwart cooperation
(Dovidio & Gaertner, 2010). Conversely, the sharing of ideas and the co-production of knowledge is frequently explicitly encouraged for a number of reasons, foremost among them, to build common ground and understanding between and within stakeholder groups on resource dynamics and resource issues, with the assumption that common understanding facilitates collective action.

All three concepts – adaptive capacity, social learning, and common understanding – are each considered in their own respect to be beneficial for social-ecological outcomes and adaptation. At the same time, common understanding, like its companions, would also benefit from operationalization and formal statistical investigation. Measuring common understanding and gauging its importance for collective action in common-pool resource management is the enterprise of the final core chapter.

Using a method developed in anthropology and applied in the setting of Chile’s artisanal fisheries, the routine assumption that common understanding of resource dynamics among stakeholders is beneficial for collective action is put to the test. I find (as described in Chapter 6) little evidence that common understanding (operationalized and measured as the community level consistency of knowledge) is essential for collective action, and was thus unable to reject the null hypothesis.

While there are reasons to believe that the inability to reject the null hypothesis may be a Type II error (as detailed in Chapter 6 and below in the limitations of the dissertation), the findings at minimum suggest that other factors may be more important contributors to collective action and that the role of common understanding merits further study. In Chapter 6 and throughout
the dissertation, additional social and psychological variables were also operationalized and measured, and may also be incorporated in future research.

### 7.2 Potential applications of the research findings

The sum of research presented in this dissertation also offers a few tentative proposals for practical efforts at sustainable resource management and adaptation in contexts akin to the case of Chilean artisanal fisheries or caletas. Overall, the following recommendations follow from the data and analyses of this dissertation (emerging from the stated objectives) and thus coalesce around the perceived need to attend to, and account for, a broader set of potentially significant social and psychological factors with a greater (more precise) apprehension of what they are and how they may be important.

In terms of pragmatic applications, as elaborated in Chapter 2, I make the case for conscious and explicit attention by decision-makers and managers to the motivations of resource users, in the first place, to build a more complete picture and better understanding of how and why people’s behaviours may change in response to the social-ecological setting. Secondly, we also need to improve (or at least not hinder) the adaptive pathways available to users, and to then find alternatives if user desires as misaligned with management objectives. While not all change can be anticipated, I argue that documenting human motivations and their potential implications can help reduce the instances of potential surprises that may in fact be foreseeable. Finally, diligent attention to human motivations can help to expand the toolkit for crafting more robust management regimes (by diversifying the modes of capturing user
engagement and investment) and also retaining and attracting the necessary participation of
users.

On the subject of adaptive capacity, a natural extension from the results of the present
research program is a recommendation for more exacting approaches to building adaptive
capacity. There is a dearth of attention on how different people and different courses of
adaptation have different requirements. As the title of the fourth chapter suggests, asking who
is adapting, and to what, can be powerfully informative (Smit et al., 2000). Such a line of
questioning immediately brings into focus how adaptation (and its intended outcomes) may
diverge or converge. Furthermore, a case can be made from the data that equally important to
understanding individuals’ capacity to adapt are the opportunities perceived (or not) in the
surrounding environment, as well as endogenous and exogenous barriers and facilitating
conditions that may impact the achievement of desired goals (a thread more prevalent in
sustainable livelihood literatures; e.g., Allison & Ellis, 2001). Ultimately, there is little assurance
that a one-size-fits-all attempt to enable adaptation will succeed with uniformly positive
outcomes.

A final prospective application for resource sustainability efforts concerns the frequent
recommendation to share ideas and foster the co-production of knowledge through
stakeholder or organizational linkages and collaboration. While the scope of this study’s
investigations on social learning and common understanding are relatively narrow (a discussion
of limitations is presented in Section 7.3 below), results from both Chapters 5 and 6 urge
caution, and so more tempered and qualified expectations regarding the benefits of common
learning and knowledge. Findings indicate that social learning and common understanding may sometimes be correlated only weakly with collective action.

Social learning as operationalized and conceived in this dissertation (Chapter 5) is theorized by cultural evolution scholars to be a homogenizing force within groups (Henrich & Boyd, 1998), and greater in-group homogeneity may have possible benefits for smoothing and improving relationships between peers. However, the synonymous concepts of innovation, novelty, and re-invention are often described as a crucial part of maintaining resilience, and a source of renewal (Gunderson, 2003). Yet, following Biggs et al. (2010), what leads to novelty is not well understood. Instead, there are, primarily, extremely robust findings in both cultural evolution and social psychology that people are conformists (Hogg, 2010), borne out in empirical and experimental studies such as a bias towards learning or copying from prestigious or older individuals (Joseph Henrich & Henrich, 2010) and majorities (recollecting the classic studies by psychologist Solomon Asch). Social learning may thus act as a barrier to innovation in groups (though accumulation of beneficial innovations over longer timespans is likely to occur beyond the timescales relevant for pressing resource issues; Boyd, Richerson, & Henrich, 2011).

In fact, a whole host of factors might affect the creation of new knowledge, particularly in groups. Groups also tend to have or form cohesive identities with their own norms of appropriate behaviour. The desire of group members to avoid social scorn (Ouwerkerk, Kerr, Gallucci, & Van Lange, 2005) and those that feel strongly about belonging to the group may be less likely to offer innovative ideas or suggestions that may violate those norms (Postmes, Spears, & Cihangir, 2001). There thus appears to be a level of uncertainty around when, what,
and how social learning and knowledge transmission should be encouraged to benefit social-ecological sustainability when outcomes of learning may be at odds (by potentially improving in-group relations while also diminishing innovation). This research nevertheless dissuades an unambiguously sunny perception of social learning for social-ecological governance and outcomes.

While there are good theoretical reasons (and some intuitive ones) for believing that common understanding, perhaps forged by social learning, can facilitate collective action, the results in this dissertation (Chapter 6) again urge tempered expectations. The lack of strong, statistically significant relationships between collective action and common understanding presented above, like all recommendations made in this section, ultimately advises greater qualification and the avoidance of broad generalization. In many cases, the findings of this dissertation instead indicate a need for further research.

7.3 Strengths and limitations of the thesis research and future directions

The strengths of this research program follow from the stated objectives, which were chosen to address perceived shortcomings in the existing adaptive capacity, resilience, co-management, and common-pool resource literatures (and those closely related). Addressing these key deficiencies in knowledge are made possible by the distillation and integration of methods and knowledge developed by a long history of effort and scholarship in diverse fields, including cultural evolution, game theory, psychology, and anthropology. In other words, the strength of this research is based in its interdisciplinary approach, which provides insights and clarification
to critical social constructs that may improve our collective understanding of how to better manage natural resources.

By harnessing insights from other disciplines, the major contributions of this work are broadening the set of relevant and considered social dimensions, clarifying hypothetically important social variables (through operationalization, definition, and measurement), documenting observations at multiple social scales, and offering ‘new’ lenses to approach recognized problems and constructs supported by sound theoretical foundations.

This research, however, also suffers from numerous limitations, which are detailed in each of the core chapters, but will also be summarized and expanded upon here. Perhaps the largest limitation is that of generalizability. By operationalizing concepts such adaptive capacity, social learning, and common understanding, the multitude of other conceptualizations that are available or have been proposed for these concepts are omitted and unaddressed. For example, I did not operationalize or measure social learning as a cognitive change, which would have required different tools, but was outside the scope of social learning as conceptualized. Furthermore, common understanding as measured only applies to resource dynamics and not other forms of shared perceptions (e.g., norms or the purpose of institutions), and adaptive capacity was focused on three specific behaviours; other behaviours were not included and efforts to maintain the status quo were not fully considered. By extension, the conclusions made and the results obtained through this research only apply to the concepts as measured, and do not speak to hypotheses and claims made for other versions of the concept.
The fisher-targeted selection of participants versus a more ideal random sample alongside small sample sizes also limits the generalizability of my findings (although methodological tools and developments may be tested elsewhere). That is, sampling was of convenience, and only targeted artisanal fishers and divers from communities in Region V of Chile. The result is a biased sample (for instance almost no female marine users were captured, and likely busier as well as part-time fishers were missed, as well as individuals who have already left the profession), and findings cannot be generalized to other parts of the world or even, potentially, artisanal fishers and divers in other parts of Chile. This is not to say there are no insights to be gained, rather only that extension of these ideas to other cases should be empirically examined.

Community-scale findings, in addition, are even further constrained by sample size (seven communities), and thus findings at the group level are more susceptible to noise in the data. Issues with low cross-community variance in certain measures (e.g., common understanding in Chapter 6) may have furthermore limited the power to detect real relationships. A major assumption is made in many cases that the aggregate and averaged response of individuals is an adequate proxy at the community scale, which it might not be. The whole might be more than the sum of its part, and the whole might not be adequately representative of those parts. Additionally, despite the likely importance of multi-scale interactions and differences between communities and individuals, no conclusions can be drawn regarding adaptive capacity at organizational (i.e., community) scales as it was not examined, and the influence of common understanding at individual scales was similarly not assessed.
Much of the data used to support the conclusions of this dissertation are also dependent on self-reported behaviours and perceptions. For various reasons self-reports can be inaccurate, for instance due to the desire to please interviewers or to hide information that the respondent considers private or undesirable (Tourangeau & Yan, 2007). Errors of memory or accuracy of recall are also a potential threat.

As many of the questions used are quantitative in nature, the richness of data is naturally limited and questions are subject to misinterpretation. For these latter reasons, surveys were conducted in-person so that confusion over questions could be clarified, and qualitative data were also collected. Another risk, which also pertains to the questions used, comes from the fact that some are adapted to fit the present research context from past published and peer-reviewed studies. Adaptation, as well as translation of these questions into Spanish for administration, means their interpretation or precise wording and intent may have been inadvertently altered, thus affecting the validity of the measure. Measures from questions that were adapted to this context also come with their own methodological histories that support their reliability and validity; new measures created for this research naturally do not have the same history. Results such as those derived from new measures should therefore be taken with this caveat in mind.

Nonetheless, the culmination of the findings, strengths, and weaknesses of this research program does offer several directions and opportunities for future research. Most obvious among them would be the replication of this research in other locations, whether in Chile or elsewhere, and also in other common-pool resource settings.
Development of the social learning measure in Chapter 5 also presents opportunities for further refinement and testing. By all accounts, the social learning game is still in its infancy and much more could be done to assess its validity and reliability. Yet, as perhaps the first introduction of such a tool to the realm of sustainable resource research, many of the hypotheses relating to the significance of social learning can now, to a limited extent, be tested directly.

As the titles of the core chapters imply, I believe that more critical thinking and questioning of major social concepts and constructs is necessary for fruitful research endeavours. In the case of adaptive capacity, there remains considerable intellectual space for understanding what facilitates adaptation in many other contexts, and identifying the properties that are more generally relevant across domains. Similarly, much more research could be conducted on differences and linkages across social scales. In this vein, the present research did not look at ecological conditions and outcomes specifically, and much more could be done to tie social variables such as social learning, adaptive capacity, and motivations (among others) to ecological contexts.

More broadly, this dissertation responds to the need to look at people as multidimensional and more than reactive agents; and to consider individuals and communities as proactively shaping their futures and environment. It is clear that people have many needs and priorities, and priorities can change over time. Deciphering the complex interactions between endogenous drivers and broader societal and environmental structures and changes is a daunting, and likely unending challenge that is also ripe for investigation.
7.4 A new river beckons

In recent decades, repeated calls and admirable attempts have been made to integrate social and ecological dimensions of environmental change into understandings of resource sustainability and management. Adopting a more precise and critical eye regarding human factors may help the science of social-ecological sustainability progress more capably and effectively. This can be accomplished, in particular, by drawing from the extensive work in the social sciences that often remain at the fringes of natural resource investigations, however many puzzles involving the behaviour of people have been contemplated and studied elsewhere. To this larger and enduring objective, this dissertation offers one contribution that I hope will pique the curiosity in passionate minds, and upon which I hope others will build, to support the things that we care for and wish to sustain far into the future.
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Appendices

Appendix A

We used hierarchical partitioning procedures with the primary objective of testing key relationships hypothesized in natural resource management literatures between social learning and other social (i.e. human) variables, and determining their relative importance. As explicitly stated, the objective is not to derive a generalizable predictive model.

Hierarchical partitioning as employed in this study is limited in several ways. First, the variables used in hierarchical partitioning were chosen based on bivariate correlations; this coarse filter did not account for multivariate interactions. Second, although hierarchical partitioning is able to deal well with multicollinearity, it is not ideal where there are few observations and many predictors. Finally, the number of predictors that can be used is limited in statistical packages currently available in R.

Due to issues of multicollinearity and the low ratio of observations to predictors, AIC is also not an ideal choice in this context. On the other hand, the use of ridge regression and LASSO regression are ideally suited to the above issues in that they are multivariate, are able to handle large numbers of predictors with few observations, make no a priori assumptions about variables to include, and is uniquely built to handle multicollinearity. Importantly, however, LASSO regression aggressively ‘discards’ variables as a means to deal with multicollinearity and high numbers of predictors; this does not suit our objectives, as we are not aiming to derive a good predictive model but to understand a relative rank of importance across many related
variables. For this reason, we opt for ridge regression, which penalizes large coefficients and drives predictors toward zero but provides a full output.

Ridge regression was conducted at the individual and community levels using game cost and buy count as dependent variables. All predictors previously described were also included with minor exceptions, specifically the use of the Social Approval Index in community analyses, and the omission of the binary migrant variable in favour of the percentage of a respondent’s life lived in the local community in the individual analyses. The minimum lambda (penalization factor) was chosen for each regression, that is, where lowering lambda does not change the error variance (between full model and null) explained. Only full cases were used for the individual analysis, reducing the sample to 31. All variables were rescaled by dividing by two standard deviations. Results from the ridge regression analyses are summarized in the table below.

<table>
<thead>
<tr>
<th></th>
<th>Community</th>
<th>Individuals (n = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ridge – Game Cost</td>
<td>1092.81</td>
<td>Ridge – Game Cost</td>
</tr>
<tr>
<td>Ridge – Buy Count</td>
<td>6.14</td>
<td>Ridge – Buy Count</td>
</tr>
<tr>
<td>(Intercept)</td>
<td>1054.93</td>
<td>(Intercept)</td>
</tr>
<tr>
<td>Quality of life</td>
<td>-61.66</td>
<td>Monetary risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>propensity</td>
</tr>
<tr>
<td>Approve poaching</td>
<td>-52.68</td>
<td>Many useful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>teachers</td>
</tr>
<tr>
<td>Trust majority</td>
<td>42.07</td>
<td>% years lived</td>
</tr>
<tr>
<td>org. members</td>
<td></td>
<td>in community</td>
</tr>
<tr>
<td>% migrants</td>
<td>-41.96</td>
<td>Attitude: Humans</td>
</tr>
<tr>
<td>Social Relations</td>
<td>-40.89</td>
<td>Clear rules of</td>
</tr>
<tr>
<td>Index</td>
<td></td>
<td>behaviour</td>
</tr>
<tr>
<td>Education</td>
<td>38.24</td>
<td>Avg. fish days/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>month</td>
</tr>
<tr>
<td>Income</td>
<td>37.99</td>
<td>% years lived</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in community</td>
</tr>
<tr>
<td>General risk</td>
<td>-36.83</td>
<td>Charm: Powerful</td>
</tr>
<tr>
<td>propensity</td>
<td></td>
<td>people</td>
</tr>
<tr>
<td>Attitude:</td>
<td>-36.75</td>
<td>Common</td>
</tr>
<tr>
<td>Ecological</td>
<td></td>
<td>understanding</td>
</tr>
<tr>
<td>catastrophe</td>
<td></td>
<td>Avg. fish days/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>month</td>
</tr>
<tr>
<td>% income from</td>
<td>-33.77</td>
<td>Locus: Powerful</td>
</tr>
<tr>
<td>fishing</td>
<td></td>
<td>people</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age</td>
</tr>
</tbody>
</table>

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Appendix B

B.1 Predictor variables

- Social capital (adapted from Obst et al., 2002)
  
D. The friendships I have with organization members is very important to me

E. The leaders of this organization are very capable

- Need to belong (adapted from Leary et al., 2013)

B. I try not to do things that make people avoid me or reject me

C. Being accepted by other members of this organization is very important to me

- Trust (adapted from Veenstra, 2002)

F. I can trust in the majority of people in this organization

G. In general I trust more in my colleagues than people outside this organization

- Flexibility

H. I often assess how things might be in the future and try to influence the future with my daily behaviour

I. I find it stressful when my plans do not work the way I hope and I have to adapt

J. I like surprises, because they are challenging and make me learn new things

- Anticipatory thinking and foresight (adapted from Marshall et al., 2012)

A. If the abundance of marine resources declines, you just wait and hope things will change for the best

B. You do not really believe in long-term planning – things are too uncertain
C. You do not think ahead and plan for changes that might occur in the quantity and quality of marine resources

- Future of fishing
D. In Chile, artisanal fishing will not exist in the future
E. You want your children and family to be involved in artisanal fishing and diving

- Information sharing
H. Members of my organization tend to share their knowledge and give each other advice
I. I prefer to learn on my own instead of asking for help and advice from other
J. There are many people in my organization where I can learn useful things
K. Members of my organization are willing to give advice when asked

- Locus of control (adapted from Mueller and Thomas, 2001)
A. To a great extent you feel that life is out of your control
C. When you get what you want, it is usually because of luck
D. When you get what you want, it is usually because you worked hard for it
E. Whether or not you are successful in life depends mostly on your abilities
F. You feel that what happens in your life is mostly determined by people in powerful positions

- Environmental worldview (adapted from Dunlap, Van Liere, Mertig, & Jones, 2000)
E. If things continue on its present course, we will soon experience a major ecological catastrophe
F. The balance of nature is strong enough to offset the impacts of development in Chile
G. Humans are severely abusing the environment
• Risk perceptions (adapted from Dohmen et al., 2005)

“How do you see yourself? Are you generally a person who is fully prepared/willing to take risks or do you try to avoid taking risks? Please tick a box on the scale, where the value 0 means: “unwilling to take risks” and the value 10 means “fully prepared/willing to take risks”

• Occupational attachment (adapted from Marshall et al., 2012)

A. Working in the ocean (fishing/diving/collection) is what you love doing the most
B. Being a fisherman/diver/collector is a lifestyle- it is not just your job
C. You would **happily** consider another occupation other than fishing/diving/collectioning if the need arose
D. If needed, you are prepared to completely change the way you fish/extract to stay a fisherman/diver/collector

• Perceived opportunities (adapted from Marshall et al., 2012)

A. You have many options available to you other than being a fisherman/diver/collector
B. All changes bring opportunities, they only need to be recognized
C. If the quality and quantity of marine resources declines, there is little you can do to respond

• Quality of life (World Values Survey Association, 2005)

Ultimately, how satisfied with your present quality of life? From 1-10; 10 being very satisfied, 1 being very unsatisfied.

**B.2 Scale construction**

• Social relations scale

PCA was performed on the questions of social capital, trust, and the need to belong. A strong single factor was found with a Cronbach’s ($\alpha = .91$) on five items (minus trust variable ‘F’). This
was retained and responses were aggregated and averaged. The same procedure was followed with the following scales.

- **Foresight and flexibility**

  \((\alpha = .85)\)

<table>
<thead>
<tr>
<th>Foresight</th>
<th></th>
<th>Flexibility</th>
<th></th>
<th>Future of fishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td></td>
<td>H.</td>
<td></td>
<td>E.</td>
</tr>
<tr>
<td>If the abundance of marine resources declines, you just wait and hope things will change for the best</td>
<td></td>
<td>I often assess how things might be in the future and try to influence the future with my daily behaviour</td>
<td></td>
<td>You want your children and family to be involved in artisanal fishing and diving</td>
</tr>
</tbody>
</table>

- **Information sharing**

  All variables were retained for an \((\alpha = .90)\).

- **Locus of control**

  \((\alpha = .79)\).

<table>
<thead>
<tr>
<th>Locus of control</th>
<th></th>
<th>Locus of control</th>
<th></th>
<th>Locus of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.</td>
<td></td>
<td>F.</td>
<td></td>
<td>C.</td>
</tr>
<tr>
<td>To a great extent you feel that life is out of your control</td>
<td></td>
<td>You feel that what happens in your life is mostly determined by people in powerful positions</td>
<td></td>
<td>When you get what you want, it is usually because of luck</td>
</tr>
</tbody>
</table>