Dynamics of Fishers' Responses to Social-Ecological Change in Coastal Mozambique: A Resilience Perspective

By

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B.Sc., Memorial University, 2004
M.A., York University, 2009

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Abstract

Change has become a ubiquitous force in a highly globalized and interconnected world. Coastal systems are being restructured by overfishing, globalization, climate change and other factors. Further, social and ecological changes in coastal systems interact across spatial and temporal scales creating challenges that are complex, nonlinear and often difficult to predict. These new challenges have the potential to push social-ecological systems past their experienced range of variability and thus have immense consequences for the both the health of marine ecosystems and the livelihoods of hundreds of millions of people who depend on marine resources for their survival. Addressing these challenges will require collaborative efforts informed by site-specific research on the dynamics of social-ecological systems.

Ultimately, this dissertation aims to contribute to efforts towards social-ecological system sustainability. Specifically, the purpose of the research is to improve our understanding of how small-scale fishers in Mozambique have adapted over time to cope with a particular set of challenges and how likely fishers are to cope effectively with future changes in their complex social-ecological systems. The dissertation is organized around four research chapters, each of which addresses a specific research objective.

Detailed knowledge of historical social-ecological conditions is a critical entry point for understanding small-scale fisheries systems. While fisheries landings data are often the primary source for historical reconstructions of fisheries, reliance on data of a single type and/or from a single-scale can lead to incomplete or misleading conclusions. Moreover, in the case of many small-scale fisheries landings statistics are often incomplete and/or inaccurate. Therefore, Chapter 2 combines data from multiple sources and scales to reconstruct historical social-ecological system dynamics along the Mozambican coast. At the national scale, my analysis points towards trends of fishing intensification and decline in targeted species, and highlights the significant impact of small-scale fisheries on marine stocks. At the local scale, fishers are experiencing changes in fish abundance and distribution, as well as in their physical, social and cultural environments and have responded by increasing their fishing effort.

In the context of multiple drivers of change, it has become increasingly important to identify how communities are responding to livelihood stressors. In Chapter 3, I examine how fishers are adapting to social-ecological change, and identify factors that facilitate adaptation and factors that inhibit adaptation. Primarily, fishers are adapting through intensifying their fishing efforts or by diversifying their livelihoods. Adaptation is facilitated by fishers' groups, occupational pride and family networks. It is inhibited by limited assets, adaptive actions with negative social and ecological impacts, competition over declining resources and pervasive poverty. My data suggest that it is not the poorest fishers who are least able to adapt to change, but fishers who are locked into a declining fishery. I argue that adaptations are spatially and social differentiated and place-specific. Therefore, future adaptation initiatives aimed at strengthening the capacity of threatened communities to respond to livelihood stressors need to explicitly consider this complexity.

Millions of people around the world depend on shrimp aquaculture for their income and livelihood. Yet, the phenomenal growth of shrimp aquaculture during the last two decades has given rise to considerable environmental damage and social disruption at the local level. In Chapter 4, I analyze the impacts of employment at an export-oriented shrimp farm in central Mozambique on livelihood vulnerability of farm and non-farm employees. My data indicate that shrimp farm employees are less vulnerable to chronic stressors, such a pervasive poverty, than

non-farm employees, but more vulnerable to acute shocks, such as the White Spot Syndrome Virus (WSSV), associated with shrimp production than non-farm employees. I argue that future vulnerability research will need to account for this duality as aquaculture development spreads along the Western Indian Ocean.

In response to the speed and magnitude of contemporary change, understanding how much disturbance communities will absorb, where social thresholds lie and what coastal community systems might look like after a threshold is crossed are critical research questions. Chapter 5 evaluates the resilience of two fishing communities in central Mozambique and forecasts the outcome of moving past socially defined thresholds. My results indicate that coastal communities are continuously absorbing multiple sources of disturbance without shifting into different states. However, a 90% decline in catch rates would represent a threshold for both communities. At Zalala Beach, fishers would respond by permanently moving to another location whereas in Inhangome, fishers would respond by changing their professions. These results contribute to our understanding of social resilience.

Deliberate progress towards the goal of long-term sustainability depends on understanding the dynamics of social-ecological systems. Therefore, this dissertation aims to contribute to a growing body of theory and empirical evidence on how fishers negotiate livelihoods under conditions of rapid change and increasing vulnerability. The dissertation concludes by summarizing seven key research findings and by discussion some of the theoretical, methodological and policy contributions of my research to the literature.

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Acronyms

CCP	C*onselho Comunitário de Pesca* (community fishing council)
FAO	Food and Agricultural Organization of the United Nations
FRELIMO	*Frente de Libertação de Moçambique* (Front for the Liberation of Mozambique)
IDPPE	*Instituto de Desenvolvimento de Pesca de Pequena Escala* (Institute for the Development of Small-Scale Fisheries, Government of Mozambique)
IIP	*Instituto de Investigação Pesqueira* (Institute for Fisheries Research, Government of Mozambique)
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
MZN	Mozambican metical (national currency)
NACA	Network of Aquaculture Centres in Asia-Pacific
PCR	*Poupança e Crédito Rotativo* (saving and lending groups)
PI	Principle Investigator
ProPESCA	Artisanal Fisheries Promotion Project funded by the International Fund for Agricultural Development
RENAMO	*Resistência Nacional Moçambicana* (Mozambique National Resistance)
UEM-ESCMC	*Universidade Edaurdo Mondlane – Escola Superior de Ciências Marinhas e Costeiras* (University of Eduardo Mondlane - School of Marine and Coastal Sciences)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WB	World Bank
WSSV	White Spot Syndrome Virus
WCED	World Commission on Environment and Development
WWF	World Wildlife Fund

Glossary

Canoa tipo moma	Wooden fishing vessel (9-10 meters in length)
Chuabo	Local language, commonly spoken in central Mozambique
Combinados pesqueiro	Fishing cooperative
Comprador	Fish trader or middlemen
Courandeiro	Traditional healer
Lancha	Wooden fishing vessel (9-10 meters in length)
Machamba	Subsistence garden
Régulo	Traditional leader
Secretaria do Bairro	Village head
Sena	Local language, commonly spoken in central Mozambique

1. Introduction

Figure 1.1 Small-scale fishers in Mozambique (Fischer 1990).

Research Context and Objectives

He was an old man who fished alone in a skiff … and he had gone eighty-four days now without taking a fish.

- Hemmingway (1952)

The importance of marine resources for global livelihoods cannot be overstated. Hundreds of millions of people worldwide are directly dependent upon fishing for their survival (Allison and Ellis 2001, Allison et al. 2009). This dependence on fisheries is particularly acute for poor and marginalized populations in developing countries (Béné et al. 2007). As Hemmingway alludes in the above quotation, fishers are accustomed to adapting to variability within an unpredictable resource base. Yet, Hemmingway wrote the story of Santiago, an aging Cuban fisher and his relationship with the sea, years before industrial fishing, globalization and climate change challenged the resilience of even the most robust fishers. Today, after more than six decades of systematic exploitation, global fisheries are in crisis (Pauly et al. 1998, 2002). The ocean's capacity to provide food, maintain water quality and recover from periods of stress is being eroded by overfishing (Worm et al. 2006). Multiple factors, including sand mining, tourism, oil and gas and the internationalization of the shrimp trade, are driving coastal habitat loss, making people more vulnerable to coastal disasters (Adger et al. 2005b, Primavera 2006). These new challenges have the potential to push social-ecological systems past their experienced range of variability and thus have immense consequences for the health of marine ecosystems and the well-being of people whose livelihoods depend on fisheries (Perry et al. 2010). Addressing these challenges will require collaborative efforts informed by site-specific research on the vulnerability of fishers and their ability to cope with and adapt to social-ecological change.

Ultimately, this dissertation aims to contribute to the efforts towards social-ecological system sustainability, that is, the use of natural resources to meet the need of the present without compromising the ability of future generations to meet their own. Specifically, the purpose of my research is to improve our understanding of how small-scale fishers have adapted over time to cope with a particular set of challenges and how likely they are to cope effectively with future changes in their complex social-ecological systems. I focus on resilience and livelihood

dynamics to investigate how and why some people, places or groups are adaptive while others shift into undesirable states.

Research Objectives

Deliberate progress towards the goal of long-term sustainability depends on understanding the dynamics of social-ecological systems (Cumming et al. 2005). Many fisheries studies have examined some aspect of human-environment interactions in coastal systems, however the complexity of coupled social-ecological systems over time has not been well understood (Mahon et al. 2008). The dissertation aims to contribute to a growing body of theory and empirical evidence on how fishers negotiate livelihoods under conditions of rapid change and increasing vulnerability. Specifically, this dissertation has four objectives:

1. To reconstruct historical social-ecological system dynamics by combining data from multiple sources and multiple scales.
2. To examine how fishers are adapting to social-ecological change, and to identify some of the key factors that facilitate adaptation and some key factors that inhibit it.
3. To analyze the impacts of employment at an export-oriented shrimp farm on livelihood vulnerability.
4. To assess the resilience of livelihood systems and forecast the outcome of moving past socially defined thresholds.

I argue that by learning as much as possible about the dynamics of fishers' responses to change, research can provide insights which have the potential to improve fisheries policy and governance and contribute towards social-ecological sustainability.

Analytical Framework

To address these research questions, I situate the experiences of small-scale fishers within the literature on resilience, adaptation, vulnerability and livelihoods. This section introduces the central theoretical approaches used throughout the dissertation. Further development of each concept is integrated throughout the remainder of the chapters. For example, in Chapter 3 I combine adaptation and livelihood literature to explore how adaptation is facilitated, inhibited and socially differentiated at the household and community scale. In Chapter 4, I probe the

boundaries of the vulnerability literature by proposing that a single factor, namely employment at a shrimp farm, can simultaneously increase and decrease social vulnerability. In Chapter 5, I explore system resilience and the utility of socially defined thresholds for sustainability analysis.

Resilience

The scale and complexity of contemporary social and ecological change, combined with the failure of our traditional governance approaches to successfully manage natural resources, motivated scholars from a range of academic disciplines to look for new ways to understand the relationships between social and natural systems. One of the ideas to emerge from these interdisciplinary efforts is the concept of resilience. In 1973, C.S. Holling published a seminal paper on resilience and stability in predator-prey systems. Counter to the dominant thinking at the time, which emphasized equilibrium or the balance of nature, Holling suggested that systems could persist in multiple stable states. He argued that "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist" (Holling 1973, p. 17 as cited in Folke 2006). The concept was quickly adopted by academics in anthropology, environmental psychology, human geography, common property research, economics and other disciplines (Folke 2006). Today, resilience is defined as the capacity of a social-ecological system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (Gunderson and Holling 2002, Walker et al. 2004). My research approaches small-scale fishers' responses to change through the lens of resilience theory.

Social-Ecological Systems

One of the central pillars of resilience thinking is that human and natural systems are not conceived as separate systems. Rather, resilience thinkers argue that these two components are indivisibly linked and that systems should be seen as *social-ecological systems* (Berkes and Folke 1998).[1] The term social-ecological system is used to emphasize that the two components are equally important, that they function as a coupled, interdependent and interactive system and

[1] Also called coupled human-environmental systems (Turner et al. 2003) and socio-ecological systems (Gallopin 2006).

to stress that the delineation between subsystems is artificial (Berkes et al. 2003). In social-ecological systems thinking, it is understood that a two-way feedback relationship exists between system subcomponents: human actions affect biophysical systems, biophysical factors affect human well-being and humans in turn respond to these factors (Ommer et al. 2011). Social-ecological systems thinkers also stress that knowing the history of social-ecological transformations over time is critical to understanding the contemporary context within which individuals and communities respond to change (Ommer 2007). The need to investigate the whole social-ecological system represents an important departure from traditional fisheries science research which largely treated the study of biophysical systems as separate from the study of human subsystems (Berkes 2011). The analysis of fisheries livelihoods in this dissertation is made in the context of social-ecological systems.

Historical Contexts

Fundamentally within resilience analyses, social-ecological systems are understood to be the product of centuries of interactive restructuring between people and natural environments (Ommer 2007). Studies of social-ecological systems must, then, begin with thorough analysis of the history of social-ecological interaction within the system of interest (Walker et al. 2002, Seixas and Berkes 2003). Yet, many social-ecological systems analyses tend to be static. As Scoones observes, many resilience studies have "tended to ignore questions of dynamics and variability across time and space, often excluding from the analysis the key themes of uncertainty, dynamics and history" (1999, p. 480 as cited in Ommer 2007). This dissertation responds to calls for more nuanced understandings of the complex historical interactions between fishers and marine ecosystems by beginning with a historical analysis of the coastal fishery in Mozambique (Murray et al. 2006, St. Martin et al. 2007). As Berkes et al. (2003, p. 8) outline, "it is difficult or impossible to understand a system without considering its history, as well as its social and political contexts".

Adaptation

Researchers have generally approached studies of *adaptation* from two distinct traditions: global environmental change and resilience (Nelson et al. 2007). The global environmental change tradition evolved from social science research in the 1970s concerning environmental hazards

(Blakie et al. 1994). This approach gained considerable momentum as adaptation became a central focus of the Intergovernmental Panel on Climate Change (Smit and Pilifosova 2001). The IPCC defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Parry et al. 2007, p. 6). Environmental change research on adaptation takes an actor-centered approach and focuses on how people respond to environmental stressors and what factors influence social actors' response to stressors (Adger et al. 2005b, Smit and Wandel 2006, Nelson et al. 2007). The resilience approach to adaptation, on the other hand, emphasizes functioning of a system as a whole. For example, a society may be able to adapt well to a stressor from a social perspective (e.g. improved irrigation), but the ecological consequences of adaptation must be considered as well (e.g. ecological impacts of ground water pumping) (Nelson et al. 2007). Resilience thinkers argue that change is a fundamental aspect of any system and that adaptive dynamics are an inherent property of social-ecological systems (Berkes et al. 2003). Adaptation is seen as a function of the available resources, including financial, human, natural, physical and social capital, and the capacity of the system to respond to disturbances (Tompkins and Adger 2004). My research employs an adaptation approach to investigate fishers' capacity to respond to change.

Vulnerability

Vulnerability is a related analytical approach for understanding the response of social-ecological systems to stress or perturbations (Miller et al. 2010). In contrast to resilience, which has its roots in ecology, vulnerability research has been influenced by theoretical traditions in hazards research, human ecology, political economy and political ecology (Eakin and Luers 2006). Vulnerability is most often defined as the degree to which a system is susceptible to and is unable to cope with stressors (Parry et al. 2007). Vulnerability researchers are concerned with how responses to system stressors are socially differentiated (Miller et al. 2010). It is a core concept in the study of livelihoods and poverty (Chambers and Conway 1992). Importantly, vulnerability is seen as being shaped by historical processes, differential entitlements and power relations, rather than as a direct outcome of perturbation or stress (Blakie et al. 1994, Eakin and Luers 2006). While there are differences in vulnerability research approaches, vulnerability is commonly characterized as being a function of exposure, sensitivity and adaptive capacity

(Adger 2006, Parry et al. 2007, Marshall et al. 2010). The central concern of both vulnerability and resilience analyses is how people develop the capacity to cope with and live with change.

Fishers' Knowledge

In resilience thinking, a focus on uncertainty in social-ecological system dynamics has led to questions about the limits of scientific knowledge (Holling 1993). Resilience thinkers emphasize the importance of recognizing unknowns within our systems of study. This openness to unknowability in resilience thinking has been crucial for creating legitimate space for the incorporation of other types of knowledge into scientific inquiry, such as fishers knowledge (Cote and Nightingale 2012). Fishers' knowledge forms the core of the data for my dissertation. Following the seminal works of Bob Johannes (1981) and Firket Berkes (2012), I see fishers' knowledge as critical for sustainable governance of fisheries. I use the term fishers' knowledge to refer to "a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2012, p. 7). Often, local resource users are aware of changes in the resource base long before they have been detected by western science. Thus, fisher knowledge can complement scientific knowledge, not only in terms of adding to the range of information available, but also in terms of scale (Haggan et al. 2007, Berkes 2011). In Mozambique, fishers' knowledge on historical changes in the coastal social-ecological system is particularly valuable since long-term data sets are unavailable (Johannes et al. 2000). Throughout the research, I compared fishers' accounts with other sources of data (e.g. reports of drought with national precipitation data) and consistently found that they were aligned, thus validating both sources of knowledge. I have attempted to take a conscientious approach to the research and remain cognizant of the complexities involved in working with fishers' knowledge (Silver and Campbell 2005, Shackeroff and Campbell 2007).

Livelihoods

Based on the literature on capabilities (Sen 1981), assets (Swift 1989) and sustainability (WCED 1987), Conway and Chambers (1992) proposed the sustainable livelihoods approach as a means for understanding the lives of poor people. According to Ellis (2000, p. 10), "a livelihood comprises the assets (natural, physical, human, financial and social), the activities, and the access

to these (mediated by instititions and social relations) that together determine the living gained by the individual or household". The sustainable livelihoods framework recognises that households may be vulnerable to trends, shocks, seasonality and other factors from multiple scales that affect livelihood sustainability (Scoones 1998). A livelihood is considered to be sustainable when it can cope with and recover from shocks and stresses, and maintain and enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Chambers and Conway 1992). Stresses are characterized as continuously or slowly increasing pressure (e.g. chronic poverty); whereas shocks are characterized as acute spikes in pressure beyond the normal range of variability, usually discrete in space and time (e.g. rapid outbreak of a disease) (Turner et al. 2003, Marschke and Berkes 2006). In the livelihoods literature, assets are divided into five categories: financial capital (savings, credit), human capital (education, health), natural capital (land, trees, fish stocks), physical capital (infrastructure, material possessions), and social capital (kinship networks, associations) (Allison and Ellis 2001). Of interest is how people draw on different patterns of assets and institutional structures to adapt to stresses or shocks (Chambers and Conway 1992). Understanding how livelihood adaptation is negotiated at the household level is critical for strengthening existing adaptive capacity in small-scale fishing communities, for improving fisheries management and for rebuilding threatened communities (Allison and Ellis 2001, Coulthard 2008, Khan and Neis 2010).

Resilience, adaptation, vulnerability, and livelihoods frameworks are therefore appealing, and complimentary, perspectives because they offer dynamic and forward looking approaches for studying social-ecological change (Cote and Nightingale 2012). Together, these perspective can provide insights into the conditions under which some people, places or groups may be harmed by a given stressor, while others emerge either unharmed or in an improved position to withstand future shocks and stressors.

Introducing the Case Study

Why Mozambique?

Mozambique provides a particularly fascinating case for studying fishers' responses to social-ecological change for a number of reasons. First, fishing has been critical to Mozambican

livelihoods for centuries. In the early 1500s, when Portuguese explorers first arrived in Mozambique an estimated 10,000 people were fishing along the central coast (Ehnmark and Wastberg 1963). Today, the fisheries sector constitutes 28% of national export earnings (Menezes et al. 2011). Moreover, in 2007 over 370,000 fishers and collectors were engaged in the small-scale fishery (IDPPE 2009).

Second, very little information exists on the small-scale fishery in Mozambique (Johnsen 1992). Limited government resources, civil conflict until 1992 and the use of Portuguese as the official language have discouraged scholarly research in the country (Pitcher 2002). As a result, landings data for the small-scale fishery are only available for the last ten years (FAO 2011). In addition, only a handful of social science studies have been conducted on the fishery since independence (Menezes et al. 2009, 2011). This data-poor environment is troubling when we consider that the small-scale fishery accounts for more than 80% of total national landings and forms the basis of livelihoods for hundreds of thousands of people along the coast (FAO 2011).

Third, overfishing threatens the sustainability of social-ecological coastal systems in Mozambique. In response to the lack of data on the small-scale fishery, Jacquet et al. (2010) reconstructed estimates of historical landings in Mozambique. Their study indicates that landings for both the industrial and small-scale fleets peaked in the mid-1980s and have subsequently declined. The severity of this decline is made more apparent considering that Mozambique is one of the poorest countries in the world. In 2009, over half of the population was living below the national poverty line of 18 meticais of US$0.50 a day (GoM 2011). Four years later, Mozambique was ranked 185 out of 187 on the UNDP's Human Development Index (UNDP 2013). Formal employment in the country is very limited. Consequently, the small-scale fishery provides one of very few reliable livelihoods options for millions of people along the coast.

Finally, Mozambique offers a compelling case because it is a country characterized by change. Over the last 50 years, the country has experienced four distinct periods of transition: colonialism, periods of war (independence war 1964-1975; civil war 1977-1992), socialism and free-market capitalism. These significant changes occurred over a relatively short period of

time, making Mozambique an informative case for studying how rural communities negotiate livelihood under conditions of constant change.

The Small-Scale Fishery in Mozambique

Small-scale fishing forms the basis of livelihoods for hundreds of thousands of people in coastal Mozambique. In this dissertation, I use the term small-scale to mean vessels less than 10 meters in length, which is consistent with the Government of Mozambique's definition of the small-scale fishery (Afonso 2006). The majority of vessels in Mozambique are non-motorized three to five meter dugout canoes or seven to nine meter flat bottom wooden boats called *lanchas* (Johnsen 1992). Fishing is usually conducted in small groups (< 20) using seine nets, gill nets and hand lines. The small-scale fishery is a multi-species fishery focused primarily on shallow-water shrimp (e.g. *Acetes erythraeus*) and small pelagics such as sardines and anchovies (IIP 2005). Generally, a small portion of the catch is sold fresh for local markets; the rest is salted, smoked or dried and consumed by fishers and their households (Johnsen 1992, IDPPE 2009). The coastal fishery is treated as common property. National regulations include a minimum two inch mesh size on beach seines, to reduce the catch of juveniles, and a closed period from December until March. Small-scale fishers' livelihoods are diverse and adaptive. Most households involved in small-scale fisheries also depend on other livelihood activities such as farming, firewood collection, trade and transport (Menezes et al. 2011).

Research Approach

Place-Based, Case Study Analysis

I address the dynamics of livelihoods and resilience through placed-based, case study research. Placed-based, case study research is defined as descriptive analysis of a spatially linked, distinctive combination of social and environmental conditions (Turner et al. 2003). The rational for analyzing local articulations of a larger phenomenon is that the case may be "unique but is not singular" (Castree 2005, p. 541). That is, case study research assumes that analysis of a case can generate data that are useful for the specificity of place and for building general theory (Turner et al. 2003). Further, Castree argues that case study research "shows the world to be persistently *diverse*. Yet it shows that this diversity arises out of multiscaled *relations* such that it does not emerge *sui generis*." (2005, p. 541). Similarly, resilience research emphasizes the

importance of investigating the influence of processes operating at scales above and below the system of interest for understanding system dynamics (Gunderson and Holling 2002). By addressing the particularities of specific social-ecological systems, and being cognizant of multiscalar interactions, place-based, case study research can contribute to our understanding of the dynamics of livelihoods and the resilience of social-ecological systems. Just as studies of social-ecological resilience have helped to illuminate particular aspects of Mozambique's experience, Mozambique offers a useful comparative case for the study of theoretical questions related to coastal communities' response to change.

Mixed Methods

A complex social-ecological system cannot be captured using a single perspective (Berkes 2011). Rather, it is best understood through the use of hybrid approaches, spanning qualitative and quantitative traditions and built on stakeholder engagement (Miller et al. 2010). As Berkes et al. (2003, p. 7) argue:

> Recognizing the importance of qualitative analysis is one consequences of the recognition of complex system phenomena for natural resource management. By qualitative analysis we mean the understanding of the system's behavior to help guide management directions. Qualitative analysis follows from the nature of nonlinearity. Because there are many possible mathematical solutions to a nonlinear model and no one 'correct' numerical answer, simple quantitative output solutions are not very helpful (Capra1996). This does not imply that quantitative analysis is not useful. Rather, it means that there is an appropriate role for both quantitative and qualitative analyses, which often complement each other.

By combining robust quantitative data with the rich narratives of qualitative assessments, mixed methods research more closely reflects the complexities and contradictions of real lives (Adger 2006). By employing a mixed-methods research approach, I aim to ask better questions, which target gaps in our understanding of social-ecological system dynamics.

Field Research

To evaluate small-scale fishers' response to change in the Western Indian Ocean, I spent nine months in Mozambique between 2009 and 2012 (Table 1.1). In 2009, I conducted an initial field trip which allowed me to discuss project ideas with local stakeholders including fishers, village

heads, professors and students from the University of Eduardo Mondlane's School of Marine and Coastal Sciences (UEM-ESCMC) and employees from the Ministry of Fisheries Institute for the Development of Small-Scale Fisheries (IDPPE). With the assistance of local partners, I selected three research communities: one coastal fishing community (Zalala Beach), one estuarine fishing community (Inhangome) and one community engaged in export-oriented shrimp farming (Inhanssunge). Communities were selected due to their similarity in size, close proximity to one another (~30 km separates the furthest two communities) and their dependence on three different marine-resource based livelihood strategies. During my first field trip, I received permission from the village head of each community to conduct my research. I conducted the majority of the data collection between September and December 2010. In 2012, I returned to Mozambique to collect some final data and verify initial results with the research communities.

Table 1.1 Timeline of fieldwork in Mozambique.

	J	F	M	A	M	J	J	A	S	O	N	D
2009 Initial field trip, site selection												
2010 Primary data collection												
2012 Data collection and verification												

I used a combination of qualitative and quantitative research methods. Qualitative methods included interviews, participant observation, focus groups and literature reviews. Interviews were conducted in Portuguese, Chuabo or Sena with translation assistance from a Masters student from UEM-ESCMC and an IDPPE extension agent. Interviews typically lasted over an hour. In total, I conducted 86 interviews with fishers, 5 with fish traders (called *compradores*), 2 with IDPPE extension agents and 2 with village heads. In 2012, I conducted 2 focus groups, one at Zalala Beach and one in Inhangome, focusing on livelihood resilience. Details of the interviews and focus groups are found in the respective dissertation chapters and in Appendices A and C-E. I reviewed the peer-reviewed and grey literature, such as dissertations, technical papers and project reports, which are an important source of information, particularly in Africa where peer-reviewed publications are often limited (Jiddawi and Öhman 2002). In addition, the time spent in Mozambique also allowed me to engage in many informal discussions with fishers, peers at UEM-ESCMC and the IDPPE, managers at the shrimp farm and friends which added

substantially to my understanding of the complexities of marine based livelihoods in central Mozambique.

Quantitative data included household surveys and fisheries statistics. I conducted 268 household surveys in three communities. Surveys were conducted in Portuguese, Chuabo or Sena with the assistance of students from UEM-ESCMC and typically lasted under 30 minutes. Specific details on the surveys are found in the respective dissertation chapters and in Appendix B. Landings data were retrieved from the FAO's FishStat Plus database (2011). Data on the number of small-scale fishers in Mozambique were retrieved from the Government of Mozambique's small-scale fishers' census (1998, 2004, 2009).

Data analysis was based on triangulation of data from field notes, interviews, surveys and external sources including the peer-reviewed and grey literature. Qualitative data were coded by hand or using qualitative software (NVivo 9). Descriptive statistics for quantitative data were calculated and graphed using Microsoft Excel 2010.

Structure of Dissertation

My dissertation is based on four manuscripts, each of which can stand on its own but contributes to a larger narrative that runs throughout. The order of the chapters is purposeful. Chapter 2 describes how the coastal fishery system changed in the past, Chapters 3 and 4 describe how fishers are currently responding to multiple sources of change and Chapter 5 decribes what the small-scale fishery system might look like in the future.

In Chapter 2, *Historical perspective and recent trends in the coastal Mozambican fishery*, I combine national landings statistics with career history interviews with fishers to generate a multi-scale historical reconstruction that describes social-ecological interactions over time. The chapter is based on the idea that the behaviour of a system depends not only on its current structure, but also on its past. At the national level, our analysis points towards trends of fishing intensification and decline in targeted stocks. At the local level, fishers describe a range of drivers of and responses to change. We argue that historical reconstructions based on data of

multiple types and scales will capture the complexities that characterize interactions between fish, fishers and their social-ecological context more effectively than any single data type.

In Chapter 3, *Strengthening threatened communities through adaptation: insights from coastal Mozambique,* I investigate how fishers from two coastal communities are currently adapting to livelihood stress, by assessing household assets, adaptive strategies and factors that facilitate or inhibit adaptation. I find that adaptations are spatially and social differentiated and place-specific. My data suggest that it is not the poorest fishers who are least able to adapt to change, but fishers who are locked into a declining fishery.

In Chapter 4, *Impacts of export-oriented shrimp aquaculture on livelihood vulnerability: a case from the Western Indian Ocean,* I analyze how employment at a shrimp farm influences household vulnerability. Through the Turner et al. (2003) vulnerability framework, I evaluate exposure, sensitivity and adaptive capacity of shrimp farm employees and non-farm employees from a rural community in central Mozambique. I find that employment at the shrimp farm reduces employees' vulnerability to chronic stressors, but increases vulnerability to acute shocks associated with shrimp production.

In Chapter 5, *Assessing fishing communities' sustainability: insights from resilience thinking*, I apply the Cumming et al. (2005) resilience framework to two fishing communities. By having fishers' describe how they would respond to hypothetical decreases in catch rates, I identify social thresholds. After a 90% decline in catch rates, both communities would shift into qualitatively different systems yet the states would be different. Fishers from Zalala Beach would permanently relocate to find higher catch rates, while fishers from Inhangome would change professions. I discuss the implications for social-ecological sustainability and resilience theory.

In Chapter 6, I conclude my dissertation by summarizing seven key research findings of my doctoral research. Finally, I discuss some of the theoretical, methodological and policy contributions of my research to the literature on resilience, livelihoods and small-scale fisheries.

2. Historical Perspectives and Recent Trends in the Coastal Mozambican Fishery

Blythe, J.L., G. Murray and M. Flaherty. 2013. Historical perspectives and recent trends in the coastal Mozambican fishery. *Ecology and Society* (in press).

Abstract

Historical data describing changing social-ecological interactions in marine systems can help guide small-scale fisheries management efforts. However, while fisheries landings data are often the primary source for historical reconstructions of fisheries, we argue that reliance on data of a single type and/or from a single-scale can lead to potentially misleading conclusions. For example, a narrow focus on aggregate landings statistics can mask processes and trends occurring at local scales, as well as the complex 'social' changes that result from and precipitate marine ecosystem change. Moreover, in the case of many small-scale fisheries, landings statistics are often incomplete and/or inaccurate. In this paper, we draw on case study research in Mozambique that combines national landings statistics with career history interviews with fish harvesters to generate a multi-scale historical reconstruction that describes social-ecological interactions within the coastal Mozambican fishery. At the national level, my analysis points towards trends of fishing intensification and decline in targeted species, and highlights the significant impact of small-scale fisheries on marine stocks. At the local level, fishers are experiencing changes in fish abundance and distribution, as well as in their physical, social and cultural environments and have responded by increasing their fishing effort. We conclude with a discussion of the governance implications of my methodological approach and findings.

Introduction

> Few people would claim to know as much about how to catch fish as a good full-time fisherman. When it comes to understanding fish behavior and the many environmental factors that help determine and predict it, marine biologists must often take a back seat. This is hardly surprising. There are hundreds of times as many fishermen today as there are marine biologists, and their forebears were plying their trade and passing on their accumulated knowledge tens of centuries before anyone heard of marine biology. What *is* surprising is how little effort has been made by scientists to search out and record this information.
>
> - Johannes (1981, p. vii)

Coastal ecosystems around the world are being restructured by overfishing and other factors (Jackson et al. 2001, Myers and Worm 2003). In response, fisheries managers and researchers are calling for more nuanced understandings of the complex historical interactions between fishers and marine systems (Johannes 1981, Murray et al. 2006; St. Martin et al. 2007). Developing effective fisheries governance and management responses requires an understanding of social–ecological transformations, including major trends and the suite of behaviors, rationales and motivations that drive the interactions between fishers and their environments at different scales (Ludwig 1993, Ommer 2007).

Landings data are often the primary source for historical reconstructions of fisheries (Pauly et al. 1998, Garcia and de Leiva Moreno 2003). When combined with macro-level historical information and analysis, they can be useful for interpreting macro-level social-ecological interactions. However, we argue that reliance on data of a single type and/or from a single-scale can lead to misleading conclusions. For example, a narrow focus on aggregate landings statistics can mask processes and trends occurring at local scales, as well as many of the complex social changes that both result from and create marine ecosystem change (Murray et al. 2007). Furthermore, in developing countries, landings data are often incomplete and underestimate total catch, particularly by the small-scale sector (Zeller et al. 2007, FAO 2011). The under-representation of small-scale fisheries in national landings is due to a variety of factors, including political marginalization linked to their relatively low contribution to gross domestic product and the cost associated with monitoring spatially diverse, and often physically remote, fisheries by resource-limited governments (Béné 2003, Zeller et al. 2006, Jacquet et al. 2010). In Mozambique, for example, national catch data for the small-scale sector have been calculated using a sample of provinces which excluded the province with the largest number of active boats

(Jacquet et al. 2010). In these cases, there is a need to supplement aggregate landings statistics, such as those supplied to the Food and Agricultural Organization (FAO), with other data in order to better understand the dynamics of intensification, expansion, and stock depletion in coastal small-scale fisheries (Pauly and Zeller 2003; Murray et al., 2006; Murray et al., 2008; Berkes, 2003).

Fishers often possess a profound understanding of complex marine systems based on long-term interactions with their environment (Neis et al. 1999, Berkes et al. 2000). This accumulated knowledge, passed down through generations, is an important source of information about historical changes in local marine resources as well as social changes in marine social-ecological conditions (Johannes et al. 2000). In addition, fishers can provide critical information – particularly in data poor situations – on changes in stock distribution and abundance as well as changes in fishing effort and fishing practices that are critical for interpreting catch-rate data (Haggan et al. 2007).

In this paper, we draw on case study research in coastal Mozambique that combines national landings with career-history interviews with fish harvesters to generate a multi-scale historical reconstruction that describes social-ecological interactions within the coastal fishery, and provides insights into the utility of combining these types of data. We begin by presenting our methodology. The results and discussion section is presented in two sections: macro-scale restructuring based on landings data (1950 – 2009) and micro-scale restructuring based on fishers' knowledge. We conclude with a discussion of the major trends and the implications of a multi-source data approach for fisheries governance.

Methods

Study Site

In 2009, with the assistance of local researchers from the University of Eduardo Mondlane's School of Coastal and Marine Science (UEM-ESCMC) and staff at the Institute for the Development of Small Scale Fisheries (IDPPE), we selected Zalala Beach as our study site, because of its location near the productive Sofala Bank and its long history of both small-scale and industrial fishing. Zalala is located thirty kilometers north of Quelimane, on Mozambique's

central coast (Figure 1). Zalala has a multi-species fishery focused primarily on shallow-water shrimp (e.g. *Acetes erythraeus*) and pelagics such as sardines and anchovies (IIP 2005). Fishers fish from dugout canoes or larger wooden '*lancha*' vessels that the government of Mozambique defines as small-scale (Afonso 2006). *Lanchas* can accommodate crews of twenty fishers and are typically rowed or sailed. In 2009, there were two vessels with motors at Zalala Beach (A. Camunada, IDPPE, pers. comm.). Fishers primarily use gill nets, seine nets and hand lines (IDPPE 2009). Catches landed at the beach are dried (24.6%), salted (22.3%), smoked (23.4%), frozen (14.2%), or sold fresh (15.5%) (IDPPE 2009). The majority of fishers at Zalala Beach speak Chuabo or Sena as their first language and Portuguese as their second. Access to central markets in Zalala is limited by poor roads and limited motorized vehicle transportation. The majority of fish are sold to markets in surrounding districts by middlemen (called '*compradores'*) or consumed by fishing households.

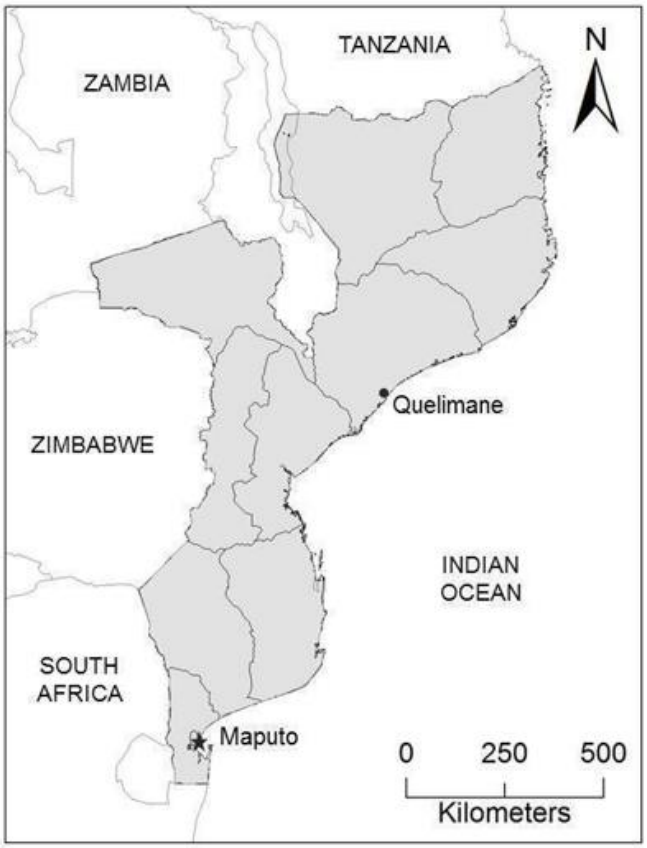

Figure 2.1 Map of Mozambique (grey). Zalala Beach, our study site, is located 30 kilometers north of Quelimane.

Macro-Scale Data

Landings data were retrieved from the FAO's FishStat Plus database (2011). They consist of total national marine capture production in Mozambique's exclusive economic zone between 1950 and 2009. Data include all quantities of fish, crustaceans and molluscs caught and landed, but exclude discards, harvest from aquaculture and marine mammals, inland capture, sponges and aquatic plants. Data on the number of small-scale fishers in Mozambique were retrieved from the IDPPE small-scale fishers' census (1998, 2004, 2009). Landings and fishers data were imported into, and graphed in, Microsoft Excel 2010. In order to describe socio-political, economic and governance trends at the macro level over the last five decades, we consulted the peer-reviewed literature on fisheries in Mozambique and publications from the Ministry of Fisheries. We also reviewed the grey literature, such as dissertations, technical papers and project reports, which are an important source of information, particularly in Africa where peer-reviewed publications are often limited (Jiddawi and Öhman 2002).

Interviews

In order to supplement landings and other macro-level data, we conducted semi-structured interviews, adapted for the study of fishing communities, with experienced fishers in Mozambique (McGoodwin 2001). Initial respondents were identified by the village head ('*Secretaria do Bairro*') based on two criteria: 1) that they derived their livelihood primarily from fishing and 2) that they had a minimum of ten years of fishing experience. Subsequent respondents were identified through snowball sampling by asking interviewees to suggest other experienced fishers at Zalala Beach (Davis and Wagner 2003). Interview questions were tested in a pilot study with students from UEM-ESCMC. We interviewed 15 fishers between September and December 2010 and 10 fishers between May and July 2012, which coincided deliberately with the high and low fishing seasons respectively. The majority of interviews were conducted mid-morning, on the beach, as fishers returned from fishing. Interviews were conducted in Portuguese, Chuabo or Sena with translation assistance from a Masters student from UEM-ESCMC and an IDPPE extension agent. Fishers were asked to describe changes in fish abundance and distribution, physical environment, social and cultural context, regulatory changes and fishing practices. Interviews typically lasted between 30 and 45 minutes. Throughout the interviews, we also emphasized the drivers of the observed changes, in an

attempt to understand fishers' perceptions of and responses to change. For example, when discussing changing boat type, we focused on when this change occurred, why it occurred and how it impacted their catch. Interviews were coded using qualitative software (NVivo 9). Descriptive statistics (mean age, years fishing and daily catch) were calculated using Microsoft Excel 2010.

Results and Discussion

Macro-Scale Restructuring in the Mozambican Fisheries: 1950-2009

The last fifty years of Mozambique's history can be divided into four fairly distinct socio-economic periods: colonialism, periods of war, socialism and free-market economy. Here we relate the available national landings data to these four periods (Figure 2.2).

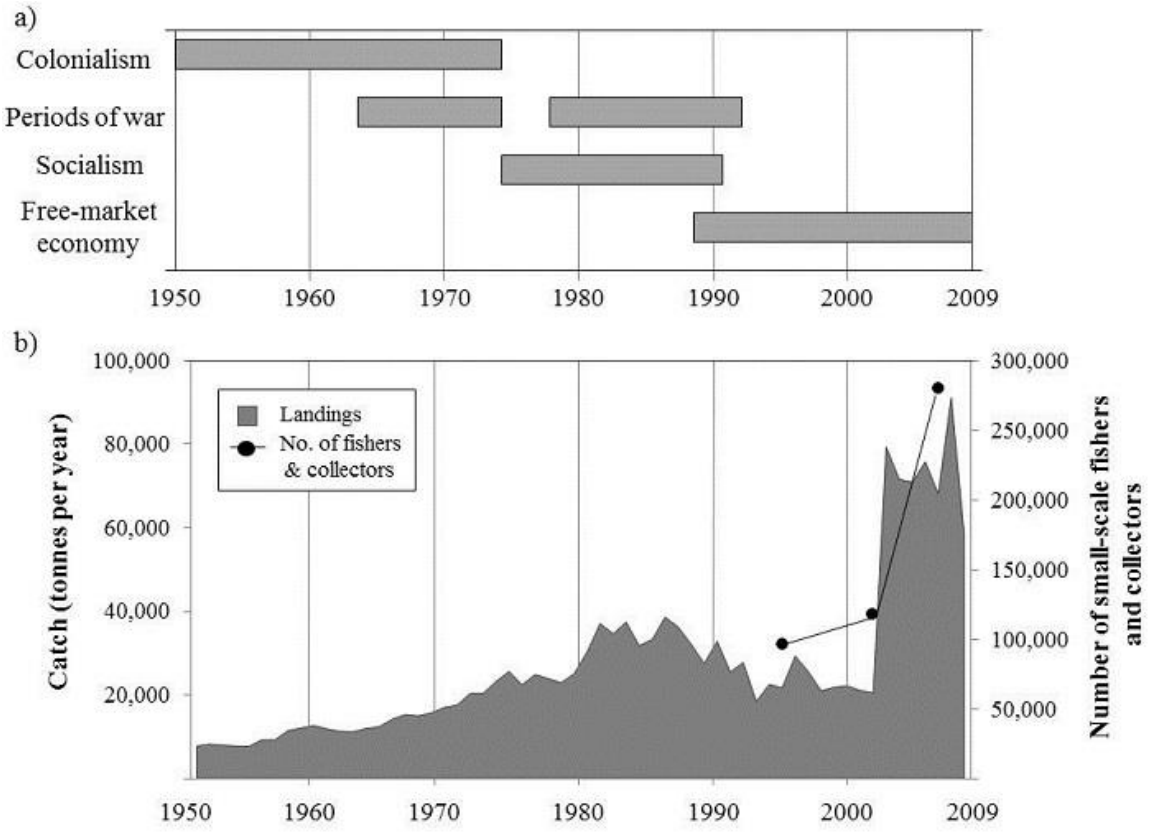

Figure 2.2 a) Periods of socio-economic change affecting coastal fisheries (adapted from Menezes et al. 2011), and b) total landings, 1950-2009 (FAO 2011) and total number of small-scale fishers (IDPPE 1998, 2003, 2009) in Mozambique.

In the 16th century, when the Portuguese arrived in Mozambique, an estimated 10,000 people were living along the Sofala bank and engaging in fishing (Ehnmark and Wastberg 1963). For the majority of the colonial period, fishing remained largely subsistence based, as trawling was prohibited by colonial fishery law (Lopes and Gervasio 2003). In the early 1960's, however, the Portuguese began to recognize the export earning potential of a shrimp fishery (Jacquet and Zeller 2007). They overturned the trawling ban, established a small industrial fleet that was owned and operated by crews from Portugal, and built large processing and freezer plants along the coast (Krantz et al. 1986, Menezes et al. 2011). During the colonial period, landings were not collected for the small-scale sector. However, it has been estimated that more than 16,000 rural fishers were active along the coast (Herrick et al. 1969). From the 1950s until the mid-1970s, national landings gradually rose (Figure 2.2).

Approximately 500 years of colonial rule came to a close when the Front for the Liberation of Mozambique (FRELIMO) initiated an armed campaign for independence in 1964. After a decade of conflict, which destroyed much of the country's infrastructure, FRELIMO established an independent socialist state. The new government nationalized and invested in the industrial fishery following the colonial war (Menezes et al. 2011). In 1976, Mozambique established a 200 mile exclusive economic zone. In need of foreign exchange, the government formed joint enterprises with private fishing interests in Japan, Spain and Norway, and traded fishing rights for aid from the Soviet Union (Jacquet and Zeller 2007). Although Mozambique's fishing grounds had not been fully surveyed, Norway suggested increasing the annual production of fish by 20,000 tonnes by 1985 through the adoption of bottom trawling (Avezedo 2002). By the early 1980s, shrimp made up over a quarter of total national landings and became Mozambique's second largest earner of foreign exchange, cashews being first (Jacquet and Zeller 2007, FAO 2011). Supported by these investments, industrial landings grew and peaked in the mid-1980s (Figure 2.2). The new socialist government also invested in the small-scale fishery. They introduced fishing cooperatives (called '*combinados pesqueiros*') in the early 1980s (Menezes 2009). The cooperatives focused on meeting state production targets and supported the small-scale fishers by providing fishing gear, building processing facilities and increasing access to central markets. This resulted in a new level of livelihood security in the small-scale sector (Menezes et al. 2011).

In 1977, a civil war erupted between the ruling socialist FRELIMO and the anti-communist Mozambique National Resistance (RENAMO), which led to mass migrations. Close to two million Mozambicans fled abroad, while approximately four million people were displaced internally (Azevedo 2002). The majority of internally-displaced people fled from fighting in the interior to coastal areas (Menezes 2009). Once along the coast, many refugees turned to fishing (Menezes 2008). Historical evidence suggests that the additional fishing pressure resulting from this migration led to declining landings during the civil war (Figure 2.2, Lopes and Gervasio 1999, Menezes 2011). During the civil war, little fisheries legislation was adopted and resource monitoring was limited (Afonso 2006). In 1992, both parties signed a cease fire agreement.

Towards the end of the civil war, the government began to transform the nation's centrally planned economy into a free-market system. In 1987, Mozambique adopted the International Monetary Fund's structural adjustment programs. In November 1990, the Constitution and first Fisheries Act were established (MoF 1995). These economic and political shifts created significant reforms in the government's relationship with small-scale fisheries. For example, fishing cooperatives were abolished (Menezes 2008), government service switched from direct intervention through the provision of services towards the creation of local governance institutions (Menezes 2009), and the government began promoting fisheries co-management (MoF 1995). In addition, free-market reforms led to hardship in many fishing communities; schools and health centers were closed and direct government assistance for small-scale fishers was reduced (Menezes 2009, Menezes et al. 2011). Landings fluctuated through the 1990s, but never returned to their 1980s levels (Figure 2.2). Yet, since the end of the civil war Mozambique has experienced steady economic growth. The government has begun to rebuild its resource-management capacity and allocated resources to improve monitoring of the small-scale fisheries sector (Afonso 2006).

Clearly something unusual happened in 2003 (Figure 2.2). In that year, the government began reporting small-scale catch data to the FAO for the first time and landings jumped from 20,515 tonnes in 2002 to 79,451 tonnes in 2003 (FAO 2011). These data indicate that small-scale fishers are catching more than 75 per cent of total national landings, which is very significant

considering that data for the sector is only available since 2003. Fortunately, by combining estimates of individual catch rates and total number of small-scale fishers Jacquet et al. (2010) reconstructed total marine catch for Mozambique between 1950 and 2005. While there is a level of uncertainty associated with their estimates, their reconstruction present two important points. First, small-scale landings reported since 2003 were based on a sample of fishing centers and provinces, which were not extrapolated countrywide. Therefore, Jacquet et al. (2010) estimate that Mozambique's annual catch rates were potentially between 47,000 and 177,000 tonnes higher than the reported data suggest. Second, reconstructed marine catch data indicate that small-scale landings peaked in the mid-1980s followed by a subsequent decline, which suggests overfishing of local resources (Jacquet et al. 2010). Thus, data provided to the FAO suggest that small-scale landings in Mozambique account for three-quarters of total marine catch and that they have been significantly under-reported. Reconstructed catch data suggest that national landings have declined since the 1980s, yet the explanatory power of the reconstruction data is limited by minimal input data and a high level of uncertainty associated with estimates. Alone, the existing data for the coastal Mozambican fishery cannot address the diversity of changes in fish abundance or distribution, location specific interactions of humans with physical environmental heterogeneity, social, cultural or regulatory changes or the impact of new technologies on marine landings. It is, therefore, critical to identify other sources of information that can complement the data provided to the FAO and contribute to our understanding of the interactions between small-scale fishers and coastal marine resources.

Micro-scale restructuring: fishers' knowledge

During the last few decades, fishers along Mozambique's coast have witnessed, participated in and responded to radical transformation within their social-ecological system. In this section, we present fishers' descriptions of change in the fishery along the Sofala Bank (Table 2.1).

Table 2.1 Common observations of change as described by fishers at Zalala Beach (n=25).

Themes	Common Observations
Changes in fish distribution and abundance	Declining stocks
	Reduced abundance of all species in inshore waters
Physical environmental changes	Unpredictable rains
	Increasing storm frequency and severity
Social and cultural changes	Increasing number of fishers
	Abandonment of traditional cultural practices
Regulatory changes	IDPPE extension
	Closed season, banning of mosquito nets
Changes in fishing techniques	Increasing boat length and power
	Increasing net size or changing net type
	Fishing in the open ocean
	Increasing fishing effort

Changes in Fish Abundance and Distribution

Fishers (n = 25; mean age = 42, stdv = 12.44; mean years fishing = 14, stdv = 7.41) have observed significant declines in marine stocks at Zalala Beach. They noted that both shallow-water prawns and small pelagics, the most important subsistence resources for the community, are less numerous then they were during the previous few decades. In the late 1990s, fishers reported catching an average of 2525 kilograms of fish per day per lancha boat between November and February, the high season on the Sofala Bank (Table 2.2). Today, fishers report that their daily catch, during the high season, has declined to an average of 1095 kilograms per day per lancha boat. This catch per unit effort (CPUE) data complements some of the qualitative data obtained during the interviews. For example, one fisher observed:

> *When I started fishing [16 years ago], there were many fish. With only one launch we would catch enough fish that we wouldn't have to continue fishing that day. Now, this is no longer the case. It takes many trips, and we catch only a little fish.*

In addition to declining catches, the spatial distribution and body size of their targeted species has changed. Fewer and smaller fish are caught in the inshore waters. One respondent noted:

> *I have to travel further to catch the fish I want to with my [seine] net. Here, along the edge of the beach you don't catch big fish anymore. To catch big fish you need to go to the open ocean with a gill net.*

Table 2.2 Average reported daily catch (kg) per lancha boat at Zalala Beach (n=10).

	High Season (November to February)	Low Season (June to August)
Current	1095.0 ± 309.5	136.0 ± 92.5
Historical (15 years ago)	2525.0 ± 1762.5	177.5 ± 132.6

Fishers identified changes in the physical environment along with socioeconomic and cultural changes as the primary drivers of the observed changes in fish abundance and distribution.

Physical Environmental Changes

Fishers perceived the nature and timing of seasonal rains to be different now than they had been in the past. Their perception is supported by data showing that the frequency of both droughts and flooding has increased in Mozambique during the last decade (Artur and Hilhorst 2011). One fisher explained, "[n]ow the weather is changing a lot. In October/November it no longer rains. Therefore, we're not catching as many fish". Seasonal precipitation is critical for marine productivity (Hoguane et al. 2012) and fishers at Zalala Beach clearly understand this relationship. One informant explained that "[w]hen rain doesn't fall, the fish disappear. When it rains, there are lots of fish and we catch lots of fish". Due to the correlation between rainfall and fish productivity, fishing communities are highly sensitive to changes in precipitation.

In addition to the unpredictable nature of rainfall, informants described increasing frequency and severity of coastal storms. For example, one informant stated "[t]he water is always agitated, there are stronger currents and storms never stop". Storms can have severe impacts on rural fishing communities. Small-scale, man-powered vessels are ill equipped for storms at sea. Storms damage homes that are typically made with mud walls and grass roofs, fishing gear and '*machambas*' (local term for subsistence gardens). In the most extreme cases, storms result in the loss of life. In 2010, several weeks before our interviews, a boat with 20 fishers was lost during a storm off Zalala Beach. The head of one of the fishers' associations explained that "[s]torms increase the number of deaths among fishers. This leaves a large number of orphaned children and widows behind".

Social and Cultural Changes

Fishers also described a range of social and cultural changes, including a rapid rate of in-migration and cultural shifts related to fishers' spiritual relationship with the sea. Informants consistently reported that the number of fishers at Zalala has been rising for years. Word has spread about good fishing conditions and an abundance of fish buyers at Zalala. With work becoming scarcer inland, and other fishing areas becoming increasingly overexploited, fishers from other districts and provinces have migrated to Zalala Beach. One fisher explained, "[t]he fishery was better before now. When immigrants came from Pebane, Moma and Angoche the amount of fish decreased." Often full crews of fishers arrive from other districts and do not permit local fishers to join them. In a few cases this has led to conflict between local and immigrant fishers. However, the most significant impact of the increasing number of fishers is the reduced total quantity of fish. In addition to migrants from other areas, local residents are also turning to fishing. One informant noted:

> *I've seen the number of fishermen increase and the number of fish decrease. Today people who have never dreamed of becoming a fisher are fishing and they all like to fish in the same area. So, how can there be many fish left in the sea?*

Older respondents described cultural changes occurring at Zalala Beach. They explained that some of the younger fishers have lost their fear of the ocean and respect for fishing traditions. When we asked what is driving the changes in the fishery, one respondent remarked:

> *The development of the world. A long time ago, no one slept in the open ocean, because there was a spirit there and people were afraid. But today, with development, no one is afraid, they go to the open ocean, cook there and sleep there, and the spirit has gone.*

Older fishers believe their ancestors control the marine resources and hold ceremonies at the beginning of each fishing season to ask them for good fishing conditions. They interpret the decline in fish stocks as a sign of ancestral anger, which the community has provoked because it has largely stopped holding these traditional ceremonies.

Regulatory Changes

Fishing regulations at Zalala Beach have gone through several transformations during the last two decades. Since the early 1990s, the IDPPE (Institute for the Development of Small Scale

Fisheries) has been sending extension agents to Zalala Beach. The agents work with fishers on methods for improving catch rates (by increasing access to gill nets and motors), catch preservation (through salting and drying) and safety (through the introduction of life jackets). By the early 2000s, extension programs also focused on establishing saving and lending groups (called '*poupança e crédito rotativo*' - *PCR*) and community fishing councils (called '*conselho comunitário de pesca'* - *CCP*) who enforce fishing regulations and facilitate PCRs. Some respondents indicated that these programs have helped them to increase their catch and improve their preservation techniques. Others believe that the assistance has led to more efficient fishing and thus a decline in the fishery. One respondent explained:

> *Now, there's lot of money in the district and we can get financing for buying fishing nets, therefore the number of fish is going down. We are many fishers and there's not enough fish for everyone.*

In 2000, Mozambique's government imposed an annual closed season for the small-scale fishery, from December to March. It also assisted in the development of fishers associations (CCP) who, among other things, help to enforce the closed season. Many fishers described how the closed season is a very difficult time for them, as they cannot generate daily income from the fishery and hunger becomes prevalent in much of the community. However, respondents also explained that over a longer period, the closed season is important for the health of the fishery. One fisher observed:

> *There didn't used to be a closed season. Now there is a closed season, during which there is only a little fishing. The closed season allows the fish to reproduce.*

In 2000, the government also banned fishing with mosquito nets due to their detrimental impact on larval fish populations. Before this regulation was introduced, the bags at the end of seine nets were commonly made of mosquito netting. Currently, the regulated mesh size is one inch, or as one fisher put it "two fingers width", although slightly smaller mesh is permitted in certain districts. For the most part, fishers at Zalala Beach agree with the mesh size regulation and comply with it (H. Manjor, IDPPE, pers. comm.).

Changes in Fishing Techniques

Fishers at Zalala Beach have had to adapt their practices in response to changes in fish distribution and abundance. Prior to the 2000s, the majority of them fished from traditional, rowed dugout canoes. Today, most of them use larger wooden lancha boats (Figure 2.3). Lancha boats are typically rowed or sailed, but increasingly fishers are acquiring motors to power these boats, the motors acquired through small loans. In addition to increasing vessel size, many fishers are changing from beach seine nets to gill nets, giving them access to previously inaccessible fishing grounds. One fisher explained:

> *Boats used to be of medium size (6m-7m). Now boats are 9m-10m and we fish with gillnets that can go deep in the open ocean. In the past we didn't have these things.*

Figure 2.3 A lancha boat (foreground) and its smaller predecessor, a traditional dugout canoe (background) at Zalala Beach (photo: J. Blythe).

Historically, fishers at Zalala Beach fished the inshore waters with beach seines. In response to decreasing inshore catch during the last decade, they have begun to travel further offshore in search of desirable catch. Fishers also described a decrease in their catch per unit effort. Respondents explained that they now make multiple and longer trips to catch the same quantity

of fish they used to catch in a single trip. One respondent observed that, "historically, fishers didn't sleep at sea, but now they sleep at sea to see if they can catch fish during the night". Another noted that*:*

> *When I first started fishing we used to catch a lot of fish, not like today when we only catch a little. After one trip you wouldn't have to fish any more. Today we need three or four trips to earn enough money.*

Respondents are well aware of the impacts of increasing their fishing intensity on marine resources. One fisher explained, "the lack of fish is due to us changing our type of boats, so now we can travel further into the open ocean and catch more fish".

Conclusion

Our macro and micro-level data provide clear evidence of the small-scale fishery's impact on marine resources in Mozambique. At the macro-level, our findings corroborate with other historical reconstructions, which suggest that the small-scale sector is responsible for up to three-quarters of national landings (Jacquet et al. 2010). National landings rose through the 1960s and 1970s as Portuguese colonials began to invest in an industrial shrimp industry. During the civil war, mass migrations to the coast placed additional pressure on the small-scale fishery. At the same time, the newly independent government formed joint enterprises with international partners, adding additional pressure to the fishery. In 2003, Mozambique began reporting small-scale landings to the FAO for the first time and landings jumped from 20,000 tonnes to almost 80,000 tonnes, demonstrating the huge impact of the small-scale sector on total national landings.

At the micro-level, fishers' indicate that the inshore, shallow waters are depleted and that fish length is decreasing, trends that have been documented elsewhere in Mozambique (de Boer et al. 2001) and in Africa (Atta-Mills et al. 2004). In addition, fishers at Zalala Beach report declining catch per unit effort. In southern Mozambique, de Boer et al. (2001) documented a similar decline. In contrast to claims that limited technology, poor infrastructure and weak capacity minimize the impact of small-scale fisheries (Menezes et al. 2011), we add our voice to the growing group of scholars who argue that small-scale fisheries can, under certain conditions,

lead to overexploitation of marine resources (see, Béné 2006, Alfaro-Shigueto et al. 2010, Jacquet et al. 2010).

By drawing on data from multiple sources and scales, we have been able to gain new insights into the drivers of social-ecological restructuring in coastal Mozambique. At the national scale, landings data point to peak catches in the mid-1980s, and a subsequent decline suggesting that national fisheries are overexploited. At the local scale, fishers' experiences substantiate macro-scale trends of overexploitation and highlight social, biophysical and cultural drivers of change. Fishers identify increasing fishing pressure as the primary cause of declining catches, and their observations are supported by government census data (IDPPE 1998, 2004, 2009). This trend is evident in other poor coastal countries, where the small-scale fishery offers a relatively accessible form of employment, and where fishery regulations are few and/or poorly enforced (Alfaro-Shinueto et al. 2010). Fishers explained that the lack of rain during the past few years has led to reduced marine productivity, a relationship that has also been identified by natural scientists in Mozambique (Hoguane et al. 2012). Fishers at Zalala also link declining marine productivity with the loss of traditional ceremonies to honor their ancestors, which have guided the rules of conduct at sea for generations. This loss of traditional culture has been documented in fishing communities in Kenya (McClanahan 1997), suggesting a wider spread trend of declining traditional management of natural resources along the east African coast. These nuanced descriptions of social-ecological drivers of change are not possible to identify through landings data alone. An important direction for future research will be to evaluate the relative importance of these multiple drivers of change in coastal systems.

Fisheries are dynamic social-ecological systems, characterized by change and variability. Fishers at Zalala Beach understand that multiple factors are driving changes in marine fish stocks, and they have responded by employing an equally varied set of adaptation strategies. Fishers' behaviors are motivated by multiple, interacting forces ranging from biophysical to cultural. It is critical that fisheries policies be sensitive to how fishers experience and respond to change and insufficient to try to discern these complexities from a single source of data. For example, over the last 15 years fishers at Zalala Beach have transitioned to bigger boats and bigger nets in response to increasing scarcity of inshore fish (ecological driver of change), but

also in response to increasing access to government loans (political/economic driver of change). Further, in response to declining catches fishers are making more trips per day and spending the night fishing at sea, which historically did not occur at Zalala. These modifications are logical responses to changes in marine stocks and fisheries regulations. Night trawls in Mozambique, for example, yield significantly larger catches than day trawls (de Boer et al. 2001). Fishers' responses are reflective of broader trends of intensification and spatial expansion in small-scale fisheries (McClanahan et al. 1997, Sabetian and Foale 2006). Their responses illustrate the iterative relationships between biophysical and social components of a social-ecological system.

Historical reconstructions of fisheries are essential for understanding and managing contemporary coastal systems (Bolster 2006, Ommer 2007, Murray et al. 2008). This is particularly true in Mozambique where landings data are recognized as incomplete (Jacquet et al. 2010) and "nothing is known about fishing pressure in the past" (p. 226 de Boer et al. 2001). We suggest that historical reconstructions based on data of multiple types and scales will capture the complexities that characterize interactions between fish, fishers and their social-ecological context more effectively than any single data type.

3. Strengthening Threatened Communities through Adaptation: Insights from Coastal Mozambique

Blythe, J.L., G. Murray and M. Flaherty. 2013. Strengthening threatened communities through adaptation: insights from coastal Mozambique. *Ecology and Society* (submitted).

Abstract

Change is a defining characteristic of coastal social-ecological systems, yet the magnitude and speed of contemporary changes is challenging the adaptive capacity of even the most robust fishing communities. In the context of multiple drivers of change, it has become increasingly important to identify how threatened communities adapt to livelihood stressors. This paper investigates how fishers from two coastal communities (Zalala Beach and Inhangome) adapt to livelihood stress, by assessing household assets, adaptive strategies and factors that facilitate or inhibit adaptation. Primarily, fishers are adapting through intensifying their fishing efforts or by diversifying their livelihoods. Adaptation is facilitated by fishers' groups, occupational pride and family networks. It is inhibited by limited assets, adaptive actions with negative social and ecological impacts, competition over declining resources and pervasive poverty. Our data suggest that it is not the poorest fishers who are least able to adapt to change, but fishers who are locked into a declining fishery. I argue that adaptations are spatially and social differentiated and place-specific. Therefore, future adaptation initiatives aimed at strengthening the capacity of threatened communities to respond to livelihood stressors need to explicitly consider this complexity.

Introduction

Coastal communities are facing increasing challenges to their daily livelihoods. While social-ecological systems evolve to accommodate variability, coastal systems are facing new sources of change linked, for example, to overfishing, climate change and global economic liberalization (O'Brien and Leichenko 2000, Lotze et al. 2006, Badjeck et al. 2010). These new challenges have the potential to push marine social-ecological systems past their experienced range of variability and thus have immense consequences for the well-being of hundreds of millions of people whose livelihoods depend on fisheries, particularly in the developing world (Perry et al. 2010). Further, social and ecological changes in coastal systems interact across spatial and temporal scales creating challenges that are complex, reoccurring, and often hard to detect (Khan and Neis 2010). Jentoft and Chuenpagdee (2009) have argued that these types of challenges should be characterized as wicked problems meaning they are difficult to define, vary depending on the perspective, and cannot be solved absolutely the way a math problem can be solved but rather tend to reappear. Given the vulnerability of small-scale fishing communities to these wicked problems, researchers have highlighted the importance of understanding how fishers are adapting to contemporary coastal change (MAE 2005, Daw et al. 2009). This paper builds on our understanding of how threatened coastal communities adapt to multiple drivers of change by analyzing how adaptation is negotiated in two small-scale fishing communities along Mozambique's central coast.

Adaptation refers to adjustments in social-ecological systems' behavior that are carried out in response to observed or anticipated changes in order to reduce damaging impacts or to take advantage of new opportunities (Smit and Wandel 2006, Parry et al. 2007). Adaptation is a continuous stream of activities, choices, and actions by various actors that occurs across multiple scales (Adger et al. 2005a, Osbahr et al. 2010). In much of the developing world, a large extent of adaptation will be enacted at the local level because national scale adaptation initiatives, such as National Adaptation Programmes of Action, are constrained by limited financial and human resources (Coulthard 2008, Blythe 2012). Accordingly, much research has focused on factors that influence adaptive capacity in resource-dependent communities at the local scale, but these factors remain better researched for agricultural systems than for fisheries (Daw et al. 2009). By

focusing on fishing livelihoods, this paper illustrates how patterns of asset holdings facilitate or inhibit adaptive strategies in rural fishing communities.

Fishing livelihoods provide a particularly useful platform for analyses of adaptation because they are known for being complex, dynamic and reactive to multiple sources of change (Allison and Ellis 2001). Based on the literature on capabilities (Sen 1981), assets (Swift 1989) and sustainability (WCED 1987), Conway and Chambers (1992) proposed the livelihoods approach as a means for understanding the lives of poor people. The livelihood approach seeks to unravel how patterns of asset-holding can create differential capacities for rural households in coping with periods of stress (Scoones 1998). As with adaptation, livelihoods can be understood as the choices and actions that people take to earn a living, meet their consumption needs, cope with uncertainty and respond to new opportunities (de Haan and Zoomers 2005). In the livelihoods literature, assets are divided into five categories: financial capital (savings, credit), human capital (education, health), natural capital (land, trees, fish stocks), physical capital (infrastructure, material possessions), and social capital (kinship networks, associations) (Allison and Ellis 2001). Of interest is how people draw on different patterns of assets and institutional structures to adapt to multiple drivers of change (Chambers and Conway 1992). Understanding how livelihood adaptation is negotiated at the household level is critical for strengthening existing adaptive capacity in small-scale fishing communities, for improving fisheries management and for rebuilding threatened communities (Allison and Ellis 2001, Coulthard 2008, Khan and Neis 2010).

During the last thirty years, coastal communities in Mozambique have adapted to declining fish stocks, periods of war and economic transition, and are now being confronted by the impacts of climate change. The extensive small-scale fishing sector in Mozambique thus provides a suitable case for examining how patterns of asset holdings affect households' capacity to respond to multiple drivers of change. Adaptive actions are influenced by antecedent social and cultural institutions and values, which are embedded in complex ecological and biophysical contexts making the social-ecological context a critical entry point for the analysis of adaptation (Adger 2003, Berkes et al. 2003, Ommer et al. 2011). In this article, I begin by presenting an overview of the social-ecological context in Mozambique, with a focus on drivers of change in the small-

scale fishery. I then describe my two study communities (Zalala Beach and Inhangome) and the study's methodology. Next, I explore fishers' assets and analyze adaptive strategies and factors that facilitate or inhibit adaptation along Mozambique's coast. Finally, I argue that poor households with diversified assets may be more adaptable than those highly invested in a declining fishery.

Drivers of Change in the Small-Scale Fishery

Mozambique is located on the southeast coast of Africa and is endowed with rich marine resources. Its coast, the third longest in Africa (2,700 km), is lined by sandy beaches, mangroves, sea grass beds and coral reefs in the north and south of the country (FAO 2007). Marine resources include crustaceans, demersal and pelagic finfish, and molloscs; tuna and prawn are the most valuable export species (FAO 2007). Mozambique has a tropical humid to sub-humid climate and receives the majority of its precipitation between December and March, the warmest months.

During the last few decades, climatic stressors have become more prevalent along the coast. While Madagascar protects Mozambique from the full intensity of the open ocean, the coast is still subjected to tropical cyclones. In recent years, both the frequency and severity of tropical storms have increased. For example, of the 15 cyclones that entered the Mozambique Channel and made landfall between 1980 and 2007, only four occurred between 1980 and 1993, whilst the other eleven occurred between 1994 and 2007 (van Logchem and Brito 2009). In 1998, an El Niño event led to mass coral bleaching in the northern part of the country (Muthiga et al. 2008). Mozambique is also vulnerable to droughts and inland flooding (Parry et al. 2007). In 2000, heavy rains burst the banks of the Zambezi river creating widespread flooding that left 800 people dead and displaced over half a million people (Christie and Hanlon 2001).

In addition to these climactic stressors, socio-economic changes are adding pressure to coastal social-ecological systems. In 1975, Mozambique became independent from Portugal and the new, leftist government established a one-party socialist state. For the small-scale fisheries sector, this meant that the state began to supply fishing materials and consumer goods to coastal communities, and to purchase, distribute and sell fish from small-scale fishers to national and

international markets through fishing cooperatives called *combanados pesqueiros* (Menezes et al. 2009). In 1977, civil war erupted between the ruling Mozambique Liberation Front (FRELIMO) and the anti-communist Mozambique Resistance Movement (RENAMO). Inland fighting drove up to four million people to the coast, adding pressure to the inshore fishery (Lopes and Gervasio 1999). Mozambique's economy, which was weakened during the independence war, continued to deteriorate during the civil war (1977-1992). In 1987, the nation began the transition from socialism to capitalism under the direction of the International Monetary Fund's structural adjustment policies. This period was characterized by the sale of state assets to private buyers and the removal of state-controlled markets (Pitcher 2002). Economic liberalization led to the abolition of the extensive fishing cooperatives along the coast and to the erosion of living conditions in many fishing communities (Menezes et al. 2009).

Living conditions in coastal communities have also been negatively affected by declining catch rates. Total marine national landings peaked around the mid 1980s and steadily declined until 2003 (FAO 2011). For the first time in 2003, the government began reporting small-scale data and landings jumped from 20,515 tonnes in 2002 to 79,457 tonnes (FAO 2011). While no data exist for the small-scale sector prior to 2003, catch reconstructions suggest that small-scale landings followed a similar trend as the industrial sector and peaked in the mid 1980s (Jacquet et al. 2010). These trends suggest that critical fisheries resources are overexploited. Today, Mozambique remains one of the poorest countries in the world. The United Nations Development Programme ranks it as 185th out of 187 countries on the human development index (UNDP 2013). In 2009, over half of the population was living below the national poverty line of 18 meticais or US$0.50 a day (GoM 2011). Formal employment is extremely limited. Consequently, the small-scale fishery provides one of the few reliable livelihood options for over 12 million coastal people in a country of 23 million (IDPPE 2009) – livelihood options that are currently in jeopardy.

Methods

Research Communities

A comparative case study approach is a useful way to illuminate the interactions between differential assets patterns and adaptive strategies. My two research communities, Zalala Beach

and Inhangome (Figure 3.1), were chosen because fishing is the primary occupation of men in both communities yet their assets, government support and fishing techniques differ.

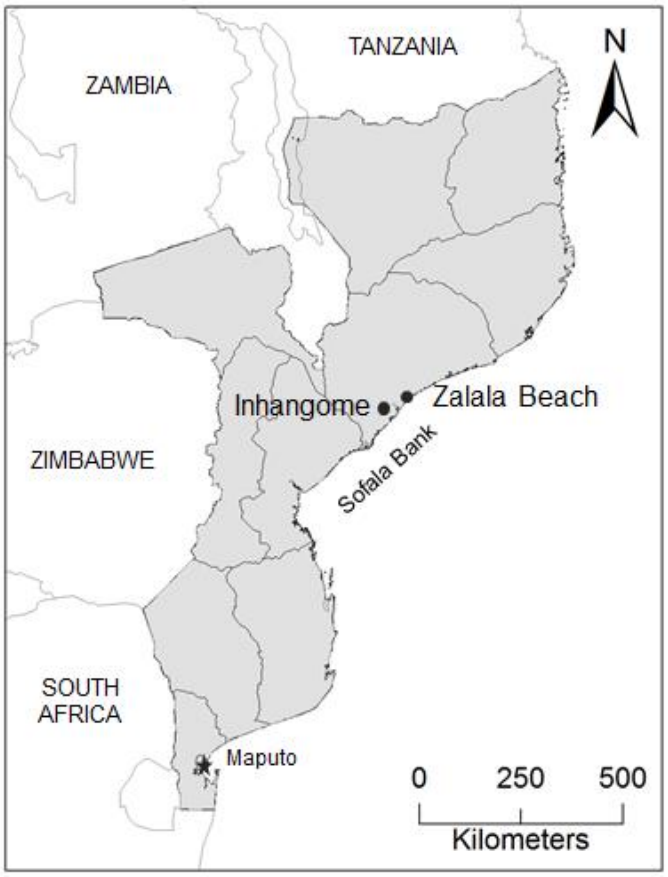

Figure 3.1 Location of the research communities, Inhangome and Zalala Beach, in Mozambique.

Inhangome (population 1,250) lies on the Rio dos Bons Sinais, twenty-five kilometers from the Indian Ocean. Fishers use dugout canoes (3-4 meters) in the estuary, fish with small nets or hand lines and target small shrimp, fish and crab. Poverty is pervasive and living conditions are very poor. Electricity is limited and the only community well contains brackish water. Inhangome is separated from the closest urban centre, Quelimane, by a 10 kilometer foot path and is inaccessible by motorized vehicles.

Zalala (population 2,690) is located along the productive Sofala Bank thirty kilometers north of Inhangome. Fishers use wooden vessels (called *lanchas* or *canoa typo moma*), which are typically 9-10 meters in length and accommodate crews of twenty fishers. Lanchas are primarily

rowed or sailed-- in 2009, two boats at Zalala Beach had motors (A. Camunada, IDPPE, personal communication). Fishers use seine nets along the beach and gill nets in the open ocean (IDPPE 2009). They focus primarily on shallow-water shrimp and pelagic fish such as sardines and anchovies (IIP 2005, Figure 3.2). Poverty is prevalent, but fishers at Zalala benefit from such government support as investment in infrastructure, including the construction of community wells and the maintenance of the road between Zalala and Quelimane, and fisheries extension training because it is being targeted by the government as an emerging small-scale fishing growth pole (H. Manjor, IDPPE, personal communication).

Figure 3.2 Characteristic multiple-species catch (composed primarily of shallow-water shrimp (e.g. *Acetes erythraeus*) and pelagics) by small-scale fishers in central Mozambique (photo: J. Blythe).

Data Collection

To assess local adaptation to livelihood stressors, I collected empirical data between 2009 and 2012. In order to develop research questions that were characteristic of local conditions, I conducted a literature review, consulted with Mozambican colleagues at the University of Eduardo Mondlane's School of Marine and Coastal Science and the Ministry of Fisheries'

Institute for the Development of Small-Scale Fisheries (IDPPE), and in 2009 discussed my proposed research with the village head (called *Secretaria do Bairro*), the chief and members of fishers' groups in each community.

The main unit of analysis was the household, which I defined as those living in the same compound (Osbahr et al. 2010). Household surveys (Zalala Beach n=93, Inhangome n=42) were conducted in September and October 2010. Surveys sought information on fishers' demographics (age, number of dependents), household assets and adaptive strategies. Survey categories were open-ended so that fishers could add assets or adaptive strategies that were not included in the initial list. I also designed qualitative, semi-structured interview questions to add individual experience data to the trends which emerged from the quantitative household surveys (McGoodwin 2001). Interview participants were identified by the village head and an Institute for the Development of the Small-Scale Fishery (IDPPE) extension agent, and then through snowball sampling. Utilizing translators, interviews (Inhangome n=12, Zalala Beach n=17) were conducted between October and December 2010. All survey and interview respondents were male. Typically in Mozambique, men fish and women are involved in non-fishing related activities including managing the *machamba* (local term for subsistence garden), household activities, children and finances. In 2011, interviews were coded for emergent themes. In May 2012, I returned to Mozambique and conducted a focus group with fishers in both communities. I presented a summary ofmy results from the 2010 fieldwork, and made adjustments and added clarifications as necessary. The time spent in the communities, the mixed methods (quantitative-qualitative) approach, plus repeat visits to communities over a three year period enabled validation of research findings.

Results and Analysis

Fishers' Assets

In this section, I describe and compare fishers' assets in Inhangome and Zalala Beach (Table 3.1).

Table 3.1 Summary of assets across the two study communities. Values indicate the percentage of total respondents (n) in each community who positively identified ownership of or access to each asset in household surveys.

	Respondents by area Percentage of n	
Asset	Zalala Beach (n=93)	Inhangome (n=42)
Financial		
Savings	54	70
Human		
Access to a doctor[†]	98	81
Access to a school for your children	66	90
Literacy	56	86
Primary education	70	74
Secondary education	12	17
Natural		
Access to fish	100	100
Livestock/poultry	49	52
Machamba	64	97
Physical		
Access to a well	86	36
Bicycle	28	36
Boat[‡]	62	69
Cell phone	30	21
House[§]	96	98
Net	56	86
Social		
Belong to a fishers' group	69	29
Family members in the community	77	98
Spouse	73	86

[†]In Inhangome, 38% of respondents use a hospital and 53% use a *courandeiro* (local term for traditional healer). At Zalala, 76% use a hospital and 12% use a *courandeiro*.
[‡]In Inhangome, all boats are dugout canoes. At Zalala Beach 6% of boats are dugout canoes and the remainder (94%) are larger *lancha* boats.
[§]In Inhangome, 74% of respondents' houses have grass roofs and 26% have metal roofs. At Zalala, 92% of respondents' houses have grass roofs and 8% metal roofs.

At first, Zalala Beach appears to be a relatively affluent fishing community. For example, fishers use large *lancha* boats vessels and seine nets that can measure more than 100 meters in length. The majority of fishers have access to clean drinking water and a formal hospital (Table 3.1). In addition, since the early 2000s, the IDPPE has assisted in the development of formal

fishers' groups (called *conselho comunitário de pesca – CCP*) and the majority of fishers at Zalala belong to a fishers' group (Table 3.1).

In contrast, Inhangome is a small estuarine fishing community. All respondents fish from small dugout canoes and, while more respondents from Inhangome own nets than at Zalala, their nets are smaller and less expensive. Very few fishers have access to clean drinking water and over half of fishers who report having access to a doctor use a traditional healer rather than a formal hospital (Table 3.1). The community is too small to receive government fishing extension support. Less than a third of fishers belong to a fishers' group (Table 3.1).

As I spent time in the two communities, however, it became clear that while expensive fishing gear and government support are lacking in Inhangome, fishers have other types of assets. In fact, assets are higher in 13 of the 18 asset categories in Inhangome (Table 3.1). For example, 70% of respondents have savings, as opposed to 54% at Zalala. They have higher school attendance, higher literacy rates and better access to school for their children (Table 3.1). In Inhangome, 26% of fishers' houses have roofs made of metal, as opposed to grass, which has been used as a proxy for wealth because metal is a more expensive material. By comparison, only 8% of respondents' roofs are metal at Zalala Beach. Fishers from Inhangome have more subsistence gardens (called *machambas*) and more extended family in the community.

That is, fishers at Zalala Beach can be characterized as highly invested in the coastal fishery: they fish with expensive sea worthy gear and receive government support, while their non-fishing-related assets are relatively low. In Inhangome, expensive fishing gear is limited, but other assets including natural, human and social capital are high. In the next section, I describe how differences in assets influence fishers' adaptation strategies and discuss factors that facilitate or inhibit adaptation in response to multiple drivers of change.

Adaptive Responses to Livelihood Stressors

Fishers' along the Mozambican coast have been resourceful in adapting to changing conditions and have developed a combination of fishing (intensification) and non-fishing (diversification) strategies in response to livelihood stressors (Table 3.2).

Table 3.2 Adaptive strategies in response to livelihood stress across the study areas. Values indicate the percentage of total survey respondents (n) in each community who identified using each adaptive strategy during the previous 12 months.

	Respondents by area Percentage of n	
Strategy[†]	Zalala Beach (n=93)	Inhangome (n=42)
Extra work (non-fishing)	33	67
Increase fishing effort	37	26
Loan from bank	5	2
Loan from family	50	70
Sale of fishing gear	12	10
Sale of livestock/poultry	30	50
Taking less food	74	71
Use of savings	56	32

[†]Fishers perform more than one type of adaptive strategy.

Adaptive Strategies: Intensify or Diversify

In interviews, fishers at Zalala indicated that their primary response to periods of stress is to intensify their fishing effort. They explained that in response to declining inshore catches they have shifted from fishing in the shallow waters along the beach with seine nets to fishing in the open ocean with gill nets. They have also increased the length of individual fishing trips, have begun fishing in the dark and started spending the night at sea. Beyond this, they have begun purchasing and selling blocks of frozen by-catch from industrial shrimp trawlers at sea to supplement their own lower catch rates. When asked what would improve their ability to adapt to future livelihood stressors, they identified improved fishing capacity including bigger nets, semi-industrial boats, motors for their boats, as well as better preservation methods (Coleman coolers, salting tanks and freezers). Their current adaptive strategies and ideas for improving those strategies in the future are based almost entirely on the fishery where, despite the challenges, all of those interviewed indicated that they desired to remain.

The primary adaptation strategy used by fishers in Inhangome to deal with difficult periods is to diversify their livelihoods. In response to livelihood stress, 67% of survey respondents participated in non-fishing related work (Table 3.2). Non-fishing work included collection and sale of wood from mangroves for fuel, sale of goats and chickens, work in the *machamba*,

production and sale of charcoal, work as a fish trader (called *compradores*), work as a bicycle mechanic, and casual labour in Quelimane. The choice to diversify may be related to the relatively broader nature of their asset base, compared to those at Zalala Beach. For example, 97% of Inhangome fishers have a *machamba*, compared with 64% at Zalala Beach, thus providing them with an alternative income source when fishing is low. Additionally, 86% of Inhangome fishers are literate, compared with just over half of fishers at Zalala, potentially giving Inhangome fishers access to employment in the city which would be inaccessible to non-literate fishers from Zalala Beach.

Factors that Facilitate Adaptation

Fishers' groups play an important role in enabling fishers to transcend the limitations of individual adaptive actions. At Zalala, 69% of survey respondents belong to fishers' groups (Table 3.1), which provide many important services to their members including representing fishers to government, NGOs and other institutions. The groups are also responsible for conflict resolution and enforcement of fishing regulations. Most importantly, by establishing saving and lending groups (called *poupança e crédito rotativo - PCR*) and helping fishers prepare financial loan documents, fishers' groups help fishers obtain credit for fishing gear and licences. A 44 year old fisher from Zalala explained, "It's very good to be part of a fishers' group. It helps a lot when it's time to pay for your fishing licence. When you have any problems they help right away. Full support." Lack of credit is an extremely limiting factor for fishers in both communities. Thus, by facilitating access to credit for fishing materials, fishers' groups increase fishers' ability to adapt to livelihood stressors.

Despite the fact that fishing is often characterized as a last resort livelihood option for the poorest of the poor, many fishers demonstrate a strong sense of occupational pride that motivates them to adapt in ways that will allow them to remain fishing (Pollonac et al. 2001, Béné 2003). This occupational pride is evident at Zalala Beach: for example, a 28 year old fisher explained that he chose to become a fisher, "because I observed other fishers who were living dignified lives." The prospect of living a dignified life, by participating in the prestigious coastal fishery, may be a motivating factor drawing fishers from other parts of the country to fish at Zalala Beach. A 38 year old fisher said that he became a fisher "because being a trader wasn't enough, so I sold my

motorbike and bought my first net [9 years ago]. After five years I bought my second net. Today I have five fishing nets." Fishers at Zalala participate in what has been a lucrative profession and they form the economic core of the community. There is a strong sense of attachment to occupation, which may contribute to fishers' decision to adapt through fishing-based strategies.

In Inhangome, family networks play an important role in facilitating adaptation during difficult times. The majority of fishers (71%) were born and raised in the community, have extended family in the community and are married (Table 3.1). In interviews, fishers said that their families provided many forms of support. Fishers identified loans from family as critically important during times of stress (Table 3.2) and household members helped fishers adapt by contributing multiple sources of income. Polygamy is common in rural Mozambique. A typical fishing household consists of a male fisher and several wives and children. In small-scale fishing communities the husband fishes and the wives engage in a range of livelihood activities, such as growing crops and collecting firewood, which helps to diversify household income. A 42 year old fisher explained, "When I'm fishing, my family is in the *machamba*. In the end, I put all the yields together and it helps us overcome our difficulties". Families also provide emotional support: a 23 year old fisher said that, "family accompany you to the hospital, they help you when you are sick by talking with you to distract you and telling you jokes." This strategy of investing in social capital, such as family networks, for support during periods of stress has also been shown to increase fishers' adaptive capacity elsewhere in West Africa (Perry et al. 2010).

Factors that Inhibit Adaptation

Our results suggest that limited assets, adaptive actions with negative social and ecological impacts, competition over declining resources and poverty inhibit successful adaptation among small-scale fishers. At Zalala Beach, human and social capitals are low: only half (56%) of fishers are literate, half have savings and less than three quarters are married (Table 3.1). These limitations may be reducing fishers' adaptive options, thereby forcing them to adapt through fishing-based strategies. Low literacy rates, for example, can limit access to wage work in urban areas. Significantly, during times of stress, only one in three fishers at Zalala took work outside of the fishery (Table 3.2). A 30 year old fisher described feeling locked in the fishery due to a

lack of alternative options by explaining (when asked if he wanted to continue fishing), “yes, because fishing is the only thing I know how to do”. These results are consistent with those found in a related study from Kenya, where fishers with fewer livelihood options were more likely to remain in a declining fishery (Cinner et al. 2009).

The difficulty of the dependency on fishing-based adaptations is more evident when one considers adaptive actions through a broader social-ecological lens. Increasing fishing effort may be beneficial for fishers in the short term, but sustained fishing pressure will undoubtedly create negative social and ecological impacts in the longer term. The majority of fishers (90%) at Zalala had moved semi-permanently or permanently from other areas to fish there. In interviews, some fishers reported that conflicts had occurred between local fishers and immigrant fishers over fishing territory and local women, showing that fishing-based adaptations that result in depleted stocks can lead to social conflict. Fishing-based adaptations also have the potential to amplify negative social and ecological feedbacks (such as social conflict and over-fishing) that may degrade the resilience of social-ecological systems by reducing social and natural capital, thereby reducing the capacity for future adaptive options.

In Inhangome, competition over declining resources has also led to conflict, most often as a result of the theft of fishing gear and housing material. Most fishers said they did not know why theft was occurring, but one 31 year old fisher remarked that ‘some fishers are too ambitious and they catch too many fish to the detriment of the other fishers’. During my 2010 research visit, I got to know one of the most successful fishers in Inhangome. He was locally famous for supporting 7 wives, 34 biological children and 7 adopted children. He owned 3 fishing nets, which he kept in a small hut near the river, making him one of the wealthiest fishers in the community. When I returned in May 2012, I found him in a state of despair. A few weeks before I arrived, the hut containing his nets had been burned down. They had cost him approximately 10,000 MZN each (equivalent to $334 US) and, at the age of 41, he explained, he would never during the remainder of his career be able to earn enough money to replace them. This type of conflict, which has also been documented in other rural fishing communities, erodes social capital and inhibits adaptive action (Marschke and Berkes 2006).

Poverty can lead fishers to remain in a declining fishery and adjust to diminishing returns. This situation, sadly, can contribute to a sense of hopelessness among fishers, sometimes referred to as a fatalistic life view (Murray et al. 1997). One 31 year old fisher from Inhangome hinted at this sense of hopelessness when he stated, "I don't want to make any changes for the future, I just want to think about today." A final, important point is that while fishers at Zalala Beach and Inhangome are practicing a range of adaptive strategies, both communities remain highly vulnerable to livelihood stressors due to pervasive poverty. Significantly, the most common adaptive strategy during times of difficulty in both communities is reducing food consumption (Table 3.2). All fishers interviewed mentioned that their households had experienced periods of food insecurity during the previous year. Sen (1999) warns that under persistent deprivation, marginalized people can learn to adapt their hopes and expectations to undesirable conditions. Reducing food consumption should never have to be thought of as a viable adaptive strategy in any community.

Conclusion

Change is a defining characteristic of coastal social-ecological systems, and human communities have developed strategies for dealing with variability within their system (Murray et al. 2006, Ommer 2007). Yet, the magnitude and speed of contemporary change is challenging even the most robust fishing communities to develop new adaptation strategies (McClanahan and Cinner 2012). Strengthening the capacity of threatened communities to adapt is essential not only for preserving the ecological resilience of marine ecosystems but also for the social services they can generate (Khan and Neis 2010). This paper provides an original contribution by documenting how fishers' are adapting to drivers of change in two communities in Mozambique, and by focusing on factors that facilitate or inhibit adaptive strategies in linked social-ecological systems. I found that fishers' are adapting through either intensifying their fishing efforts or diversifying their livelihoods and that their strategy is shaped by varying patterns of assets. Within the livelihood diversification literature, the decision to diversify is often divided into two categories: necessity, which refers to diversification as an involuntary and desperation action, and choice, which refers to diversification as a voluntary or proactive strategy (Ellis 2000). Based on the precept that the progression from a low to a high standard of living normally involves transition from diversification to specialization, diversification by necessity has

frequently been portrayed as a negative action (Ellis 2000). In India, for example, Coulthard (2008) found that specialized *Pattinaver* fishers saw diversification as a step backwards and chose to wait out lean years instead of diversifying. Similarly, fishers at Zalala Beach demonstrated a high sense of occupational pride and indicated their desire to remain in the fishery despite declining catch rates. In contrast, poorer fishers from Inhangome show remarkable diversification. Despite the fact that diversification is often the strategy of the poorest households, I argue that diversification increases adaptive options which places households in good stead during periods of livelihood stress. Further, by participating in a range of fishing and non-fishing related livelihood activities, fishers who diversify reduce fishing pressure which may contribute to long term sustainability of the social-ecological system.

Along the Mozambican coast overfishing is interacting with social, ecological and economic drivers of change and threatening the sustainability of coastal communities. In response to the diverse, dynamic and complex nature of these challenges, researchers have suggested that clumsy solutions will be required in order to strengthen threatened coastal communities (Khan and Neis 2010). Clumsy solutions draw on multiple perspectives, emphasize the importance of fishers' and harvesters' knowledge, and recognize that fisheries problems, and thus solutions, are not static. In Mozambique, where national scale fisheries programs are hindered by limited resources, understanding and supporting local adaptations will be critical for strengthening communities' capacity to respond to livelihood stressors. Many of the factors that inhibit adaptation in my two research communities, limited assets, actions with negative social and ecological impacts, competition over declining resources and pervasive poverty, are indications of problems that run deeper. Therefore, my results suggest that non-sectoral interventions that build human and social capital may be more effective in strengthening the livelihoods of coastal communities than those targeting fishing assets alone.

My data suggest that it is not always the poorest fishers who are least able to adapt to change, but fishers whose assets are invested in, and who are thus trapped in, a declining fishery. This research represents an important, but preliminary, step towards understanding how local communities are adapting to livelihood stressors along the Mozambican coast. A beneficial next step will be to explore the material outcomes of the adaptive strategies being employed. Can

adaptive actions foster both social well-being and ecological sustainability? As Khan and Neis (2010) identify, fisheries and coastal governance often involves difficult choices between equally desirable but contradictory goals.

4. Impacts of Export-Oriented Shrimp Aquaculture on Livelihood Vulnerability: a Case from the Western Indian Ocean

Abstract

Millions of people around the world depend on shrimp aquaculture for their income and livelihood. Yet, the phenomenal growth of shrimp aquaculture during the last two decades has given rise to considerable environmental damage and social disruption at the local level. While the majority of shrimp aquaculture currently occurs in Asia, investors are turning their attention to the high potential for shrimp production in the Western Indian Ocean. In this paper, I evaluate how employment at an export-oriented shrimp farm affects livelihood vulnerability of shrimp farm employees and non-employees in coastal Mozambique through household surveys and semi-structured interviews. I analyze vulnerability through the Tuner et al. (2003) vulnerability framework, which characterizes vulnerability as a function of exposure, sensitivity and adaptive capacity. I find that shrimp farm employees are less vulnerable to chronic stressors, such a pervasive poverty, than non-farm employees, but more vulnerable to acute shocks, such as the White Spot Syndrome Virus (WSSV), associated with shrimp production. I argue that future aquaculture research and programs will need to account for this duality as aquaculture development spreads along the Western Indian Ocean.

Introduction

Prawns for Mozambique are something like gold or diamonds.

- Tomé Capece, IDPPE, Ministry of Fisheries, 12th August 2009

Shrimp aquaculture has been promoted by national governments, private investors and international development agencies as a basis for raising rural incomes, improving food security and contributing to foreign exchange in tropical developing countries (Brummett et al. 2008). Millions of people now depend on shrimp aquaculture for their livelihood and that number is projected to grow (FAO 2012). Between 2001 and 2010, global shrimp aquaculture production tripled from 1.3 to 3.8 million tonnes (FAO 2010). In value terms, shrimp aquaculture production is currently worth more than $16.6 billion US per year (FAO 2010). Moreover, many economic forecasts predict an increase in the consumption of shrimp in the mid to long-term that can only be met by aquaculture (Bush et al. 2010). While Asia currently accounts for 89% of world aquaculture production in terms of quantity, investors are looking to replicate this growth in new areas such as sub-Saharan Africa where aquaculture is largely undeveloped (Brummett et al. 2008). The potential for aquaculture development in Mozambique, for example, is considered to be enormous. The tropical and sub-tropical climate is ideal, the coast is unpolluted, population pressure is low and there are three native species of Penaeid shrimp (FAO 2006). An estimated 33,000 hectares of land in Mozambique are considered suitable for aquaculture development (FAO 2006).

The phenomenal growth of shrimp aquaculture in recent years, however, has given rise to considerable environmental damage and social disruption at the local level (Béné 2005, Primavera 2006). Since the early 1990s, environmental and social scientists have criticised the often unplanned, unsustainable expansion of intensive shrimp farming (Flaherty et al. 2000, Alongi 2002). Conversion of sensitive wetland habitats, including mangroves, in coastal zones has led to severe criticism of the industry (Flaherty et al. 1999, Vandergeest et al. 1999, Lebel et al. 2002). From a social perspective, the development of intensive shrimp culture has often forced local stakeholders off their land and converted multiple-use coastlines into single-use monoculture resources, thus displacing traditional livelihoods and posing serious threat to the

well-being of coastal communities (Paul and Vogl 2013). The 'boom crop' nature of shrimp production has caused increasing levels of social and ecological vulnerability (Bush et al. 2010).

While the socio-economic and ecological impacts of export-oriented shrimp farming have been extensively studied in Asia (Flaherty et al. 1999, Béné 2005, Primavera 2006, Lebel et al. 2010), little research has focused on the social-ecological consequences of shrimp aquaculture in sub-Saharan Africa. Likewise, the impact of export-oriented shrimp culture on local livelihood vulnerability in sub-Saharan Africa has so far been under addressed. The purpose of this paper is to evaluate how employment at an export-oriented shrimp farm influences household vulnerability to multiple stressors in coastal Mozambique. Although definitions can vary, vulnerability is generally considered to be the degree to which a system is susceptible to, and unable to cope with, the adverse effects of a chronic or acute disturbance (Adger 2006). I utilize the Turner et al. (2003) framework for vulnerability analysis in sustainability science to investigate household vulnerability. In particular, I evaluate the exposure, sensitivity and adaptive capacity of shrimp farm employees and non-employees. I also draw on the sustainable livelihoods framework to understand how employment at a shrimp farm influences households' capacity to cope with acute shocks and chronic stressors (Chambers and Conway 1992). A focus on livelihoods provides one angle with which to examine differential household sensitivities and to investigate why some households are more vulnerable than others.

I begin the paper by introducing the research approach: I define vulnerability, introduce Turner et al.'s (2003) vulnerability framework and the sustainable livelihoods approach. Second, I present a brief history of aquaculture development in Mozambique. I then describe the study site, shrimp farm production system and research methods. Next, I present my results. A number of studies have shown that failure to consider local social-ecological conditions in shrimp aquaculture planning can lead to production systems that increase the vulnerability of coastal communities (Adger et al. 2005). Consequently, my discussion focuses on how vulnerability is experienced at the local level in order to contribute to improved shrimp aquaculture practices in sub-Saharan Africa. Finally, I argue that shrimp farm employees are less vulnerable to chronic stressors than non-farm employees, but more vulnerable to acute

shocks, such as the White Spot Syndrome Virus (WSSV), associated with shrimp production. Future vulnerability research and programs will need to account for this duality.

Vulnerability Framework

The academic use of term vulnerability has its roots in geography and natural hazards research (Adger 2006). Currently, vulnerability is a central concept in a variety of other disciplines including ecology, public health, poverty and development, livelihoods and famine, sustainability science and climate change and adaptation (Füssel 2007). The concept of vulnerability has become a powerful analytical tool for describing states of susceptibility to harm of both social and ecological systems, and for guiding analyses of actions designed to reduce risk to multiple stressors (Adger 2006). While vulnerability is conceptualized in very different ways by scholars from differing fields, and even with the same field, there are commonalities in the way vulnerability is understood and operationalized in research. Arguably, the most commonly cited definition comes from the Intergovernmental Panel on Climate Change (IPCC) who define vulnerability as the degree to which a system to susceptible to and is unable to cope with stressors (Parry et al. 2007).

While definitions and approaches vary, vulnerability is generally understood as being a function of exposure, sensitivity and adaptive capacity (Adger 2006, Parry et al. 2007, Marshall et al. 2010). *Exposure* is defined as the nature and degree to which a system experiences environmental or social disturbances (Adger 2006). Exposure is characterized by the magnitude, frequency, duration and spatial extent of the disturbance (Marshall et al. 2010). The vulnerability of social-ecological systems is understood to be a function of sources of disturbance operating at different spatiotemporal scales (Turner et al. 2003). Moreover, sources of disturbance are often subdivided into chronic stresses and acute shocks. Stresses and shocks are the result of interactions between external (e.g. national economic policies) and internal (e.g. changes in resource access) drivers of change (deHaan 2000, Armitage and Johnson 2006, Marschke and Berkes 2006). Stresses are characterized as continuously or slowly increasing pressure (e.g. chronic poverty); whereas shocks are characterized as acute spikes in pressure beyond the normal range of variability, usually discrete in space and time (e.g. rapid outbreak of a disease) (Turner et al. 2003, Marschke and Berkes 2006). *Sensitivity* is the degree to which a

system is affected by stressors or shocks (Adger 2006). The sensitivity of ecological components of a system could be related to physiological tolerances to change (Marshall et al. 2010). For example, certain corals are more sensitive to increases in sea temperatures than others (Johnson and Marshall 2007). Social sensitivity can be more difficult to characterize. Some have argued that the sensitivity of social components of a system depends on occupation (McClanahan et al. 2008, Cinner et al. 2012). *Adaptive capacity* describes the ability of a system to respond to stressors (Adger et al. 2004). In this study, I evaluate adaptive capacity by measuring household assets and adaptive strategies. In social systems, adaptive capacity can be built through institutions and networks that learn and store knowledge and experience, create flexibility in problem solving and share power among various actors within the system (Berkes et al. 2003). Characterizing vulnerability as a function of these three elements helps researchers analyze the vulnerability of a particular system.

Several research frameworks have been developed to measure the vulnerability of social and ecological systems (Adger and Vincent 2005, Luers 2005, Füssel 2007, Béné 2009). I draw on the Turner et al. (2003) framework for vulnerability analysis because it takes a systems-oriented approach to understanding vulnerability within linked social-ecological systems. Developed by the Research and Assessment Systems for Sustainability Program (http://sust.harvard.edu), the framework is informed by antecedent vulnerability research on entitlements (Sen 1981, Watts and Bohle 1993), hazards (Cutter et al. 2003) and pressure and release models (Blaikie et al. 1994). The framework emphasizes that: i) vulnerability results from exposure to multiple interacting stressors that occur across scales, ii) nonlinear changes will give rise to unexpected or surprise outcomes, and iii) subsystems and components, especially social units, will be differentially vulnerable (Turner et al. 2003).

Since vulnerability analyses that consider the totality of a complex social-ecological system are unrealistic, Turner et al. (2003) developed a simplified vulnerability heuristic to help guide empirical research (Figure 4.1). The diagram illustrates how elements of vulnerability of a bounded system at a particular scale (called ‘place’ in the heuristic) interact with human and environmental conditions within and across scales. The critical elements of the framework are: i) linkages between the vulnerability of place and the broader human and environmental

conditions, ii) stressors that emerge from these conditions, and iii) the coupled human-environment system in which vulnerability resides, including exposure, sensitivity and adaptive capacity (Turner et al. 2003). In this paper, I operationalize each of the three components of vulnerability for shrimp farm employees and non-farm employees in a rural community on the central Mozambican coast. The framework helps situate my analysis within the context of nested scales of social-ecological change, from transition in national political and economic policy to international spread of the White Spot Syndrome Virus (WSSV) (Figure 4.1).

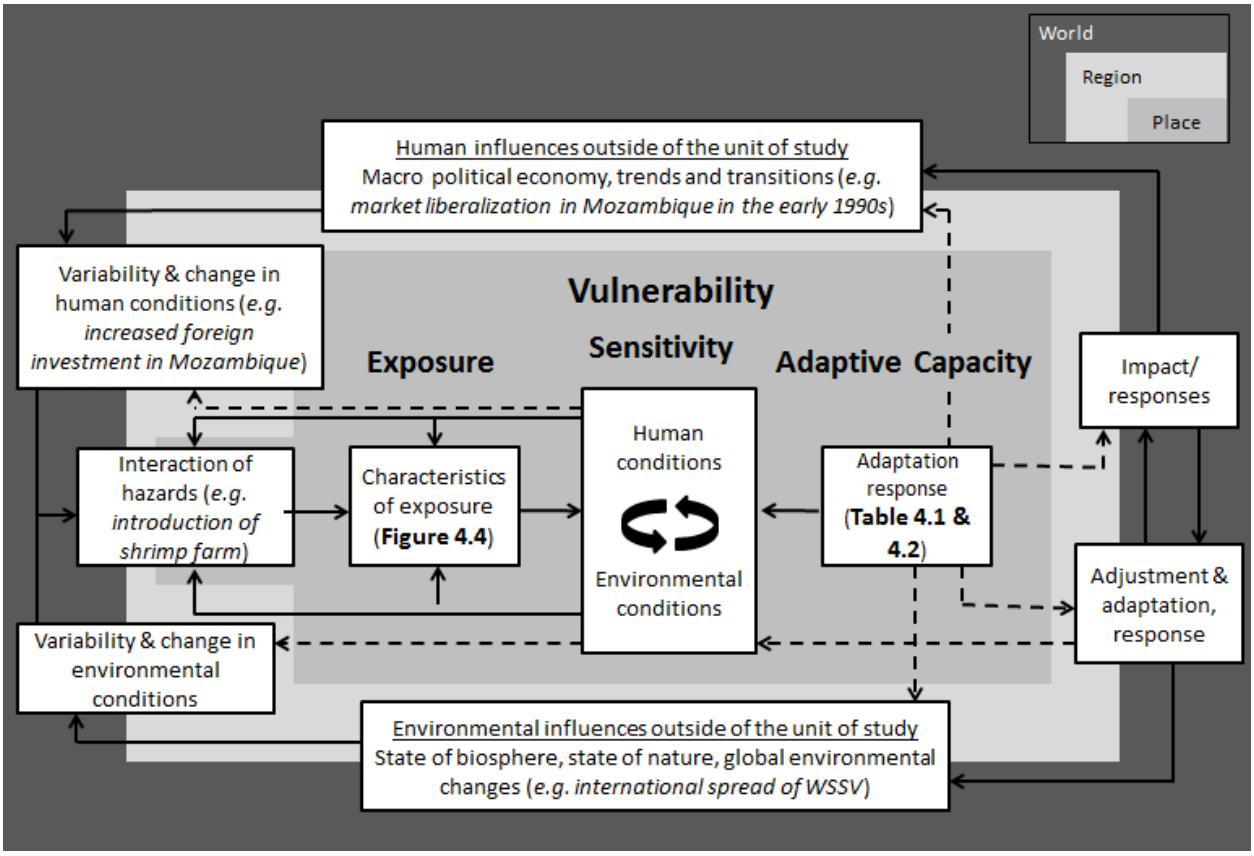

Figure 4.1 Vulnerability framework (adapted from Turner et al. 2003). The diagram represents the components of vulnerability (exposure, sensitivity and adaptive capacity) and their interactions within and across scales.

In addition to the Turner et al. (2003) vulnerability framework, I draw on the sustainable livelihoods approach to investigate how employment at an export-oriented shrimp farm affects household vulnerability. The term livelihood is used in many different ways. For the purposes of this paper, I use Ellis's (2000) definition, which refers to livelihoods as comprising the

capabilities, resources and activities required for a means of living. The sustainable livelihoods framework recognises that households may be vulnerable to trends, shocks, seasonality and other stressors from multiple scales (Scoones 1998). A livelihood is considered to be sustainable when it can cope with and recover from shocks and stresses, and maintain its capabilities and assets both now and in the future, without undermining the ecological components of the system (Chambers and Conway 1992). Assets are critical to how households maintain their livelihoods (Ellis and Allison 2004). In the livelihoods and vulnerability literature, assets are generally divided into five categories: financial capital (savings, credit), human capital (education, health), natural capital (land, trees, fish stocks), physical capital (infrastructure, material possessions), and social capital (kinship networks, associations) (Allison and Ellis 2001). In this paper, I explore assets as a component of household adaptive capacity and to help us understand how people make a living within evolving social and environmental contexts.

Brief History of Aquaculture in Mozambique

Prior to aquaculture, shrimp have been captured by local fishers along the Mozambican coast for centuries. Shrimp, however, did not capture colonial interest until the early 1960s when the Portuguese began to recognize the export earning potential of a shrimp fishery (Jacquet and Zeller 2007). They established a small industrial shrimp fleet and built large processing and freezer plants along the coast (Menezes et al. 2011). Following independence in 1975, the new Mozambican government formed joint enterprises with private fishing interests in Japan, Spain and Norway, and traded fishing rights for aid from the Soviet Union (Jacquet and Zeller 2007). By the early 1980s, shrimp made up over a quarter of total national landings and became Mozambique's second largest earner of foreign exchange following cashews (FAO 2011). Not unexpectedly, after two decades of sustained fishing pressure industrial shrimp landings peaked in the mid-1980s and have subsequently declined (Jacquet and Zeller 2007, FAO 2011).

The shrimp aquaculture industry in Mozambique is relatively young. Aquaculture was not traditionally practiced by Mozambicans. After independence, the development of commercial aquaculture was limited by the centralized economic system and a long, devastating civil war (Sadek et al. 2002, FAO 2006). In recent years, political stability and free-market economic policies have resulted in economic growth, which has generated momentum for commercial-

scale aquaculture. The Mozambican government first demonstrated their interest in developing commercial-scale shrimp aquaculture in the early 1980s. They evaluated three sites for shrimp aquaculture development – Maputo, Beira and Quelimane (Sadek et al. 2002). In 1988, the Government of Mozambique and the United Nations Development Programme established a 10 hectare pilot project for coastal shrimp aquaculture, which they ran with technical assistance from the FAO (Omar and Hecht 2011). During the project life, the farm produced 2.5 tonnes of *Penaeus indicus* per hectare per year (Omar and Hecht 2011). The main challenge confronting the pilot project was the lack of shrimp seed. There were no hatcheries in Mozambique at the time and the wild species in the area proved difficult to sort, had different growth characteristics and could not be cultured together (Sadek et al. 2002).

In the early 1990s, under the guidance of the World Bank and the International Monetary Fund, Mozambique shifted from a socialist to a free market economy and the commercial aquaculture sector began to gain momentum. The government's pilot farm was privatized and the first foreign investment in shrimp aquaculture occurred in the mid-1990s (Omar and Hecht 2011). In 2000, the Ministry of Fisheries split from the Ministry of Agriculture and took over responsibility for the aquaculture sector. Almost immediately, the Ministry of Fisheries began developing the country's first aquaculture policy (Sadek et al. 2002). For the first time, Mozambique's Action Plan for the Reduction of Absolute Poverty (2001-2005) highlighted the potential for aquaculture to contribute to increased foreign investments, export earnings and community level benefits, such as job creation, employment stability and improved infrastructure (Omar and Hecht 2011). In 2006, the government re-designed their aquaculture policies to promote development of the industry by including investment incentives such as reducing tax on fuel and removing import duties on feed (Macauhub 2006). Presently, the aquaculture industry operates within relatively strong environmental regulations. Any shrimp farm larger than 5 hectares must undergo an environmental impact assessment (Sadek et al. 2002). Commercial developments are not permitted to exploit wild stocks of *Panaeid* post-larvae or to capture spawners directly to supply hatchery operations (Sadek et al. 2002). Only extensive, as opposed to intensive, shrimp farming is permitted in Mozambique (Omar and Hecht 2011). Given that Mozambique is one of the poorest countries in the world, the government has done well in establishing a strong environmental regulatory framework for the aquaculture industry.

Mozambique's climate is ideal for aquaculture and 33,000 hectares of coastal land have been declared socially (meaning free of land use conflict) and ecologically suitable for aquaculture, yet the industry faces several difficulties (FAO 2006). Significant challenges include: lack of aquaculture tradition in the country, lack of knowledgeable staff and inadequate infrastructure to support the industry (Sadek et al. 2002). In addition, no feed is produced in Mozambique, so all shrimp feed must be imported. Consequently, only two commercial shrimp farms were in production in Mozambique in 2008 and a third laid dormant (Omar and Hecht 2011). Tellingly, while 600 tonnes of shrimp were produced at a value of $3 million US in 2006, only 157 tonnes were produced at a value of $1.6 million US the following year (FAO 2007). Employment in the aquaculture industry remains low. The industry employs an estimated to be between 500 and 600 people in a country of over 23 million people (FAO 2007).

Compounding the challenges already facing the commercial aquaculture industry in Mozambique, the White Spot Syndrome Virus (WSSV) appeared in 2011 for the first time in the country (FAO 2012). The global WSSV pandemic has been traced to the import of infected hatchery-produced *Paneaus japonicas* into Japan from Chinese hatcheries and has caused devastating multimillion dollar crop losses in shrimp farms across Asia (Momoyama et al. 1994). The outbreak of the virus in Mozambique, which poses no threat to humans, led to the mass death of all shrimp in one of the country's shrimp farms. Production was suspended indefinitely and the contracts of several hundred farm employees were terminated (Agencia de Informação de Moçambique 2011).

Methods

Study Site

Located on the southern coast of Zambezia, one of Mozambique's poorest provinces, the Inhanssunge district (population 91,989; area 745 km^2, Figure 4.2) is known for its mangrove lined estuaries, high temperatures and humidity. Wage work in Inhanssunge is very limited. Therefore, subsistence agriculture and fishing form the basis of livelihoods for 86% of the population (República de Moçambique 2005). Land holdings in the district are very small: 72% of land holders own less than a hectare of land and the district has approximately 22,000 farms with an average area of 0.5 hectares (República de Moçambique 2005). In spite of its poverty,

the district has relatively abundant natural resources including fertile soil, palm trees, estuaries for salt production and relatively good fishing resources. The district receives an annual average rain fall of 800mm, concentrated between November and March, and has an average temperature of 24°C to 26°C (República de Moçambique 2005). The largest urban centre in the Inhanssunge district is called Inhanssunge.

Figure 4.2 Location of the shrimp farm in Inhanssunge district, central Mozambique.

Shrimp Production System

The shrimp farm in Inhanssunge opened in 1994 (L. Galli, pers. comm.). Following a 6 year pilot project, production for sale began around 2000. The farm produces *Penaeus monodon* and

Penaeus indicus, which are produced in earthen ponds in an extensive environment. The farm is certified organic by the French government. In 2009, the farm consisted of 30-ten hectare ponds, five-five hectare ponds and 16-one hectare ponds (Figure 4.3). The farm employed approximately 300 people in 2009, the majority of whom live in the town of Inhanssunge. The company operates a hatchery in Nacala where larval shrimp are grown for 25 days prior to being transferred to the farm in Inhanssunge. Shrimp are fed pellets imported from Mauritius and harvested at approximately 125 days or 27 grams. The farm freezes and packages all shrimp on site. The majority of the farm's shrimp is exported to France.

Figure 4.3 Satellite image of the shrimp farm in Inhanssunge Mozambique (Google Earth 2013).

Surveys and Interviews

All data were collected between September and December 2010. I began my analysis by conducting surveys with shrimp farm employees (n=90, mean age=35, stdv=10.82) and non-farm employees (n=43, mean age=31, stdv=11.46), all of whom lived in Inhanssuge. Surveys focused on: i) stressors or challenges that people had experienced in the previous 12 months, ii)

household assets and iii) adaptive strategies. Survey categories were open ended so that respondents could add stressors, assets or adaptive strategies not included in the initial list. In order to complement the quantitative survey data, I conducted semi-structured interviews with shrimp farm employees (n=14) and non-farm employees (n=12). Non-farm employee interview respondents were selected with the assistance of the community chief, and subsequently via snowball sampling. Interview questions focused on the diversity of ways through which respondents adapted their livelihoods to cope with ongoing stressors.

Results

Exposure

I began my analysis by documenting the exposure of households in Inhanssuge to stressors and shocks (Figure 4.4). In the vulnerability framework (Figure 4.1), this data documents the characteristics of exposure.

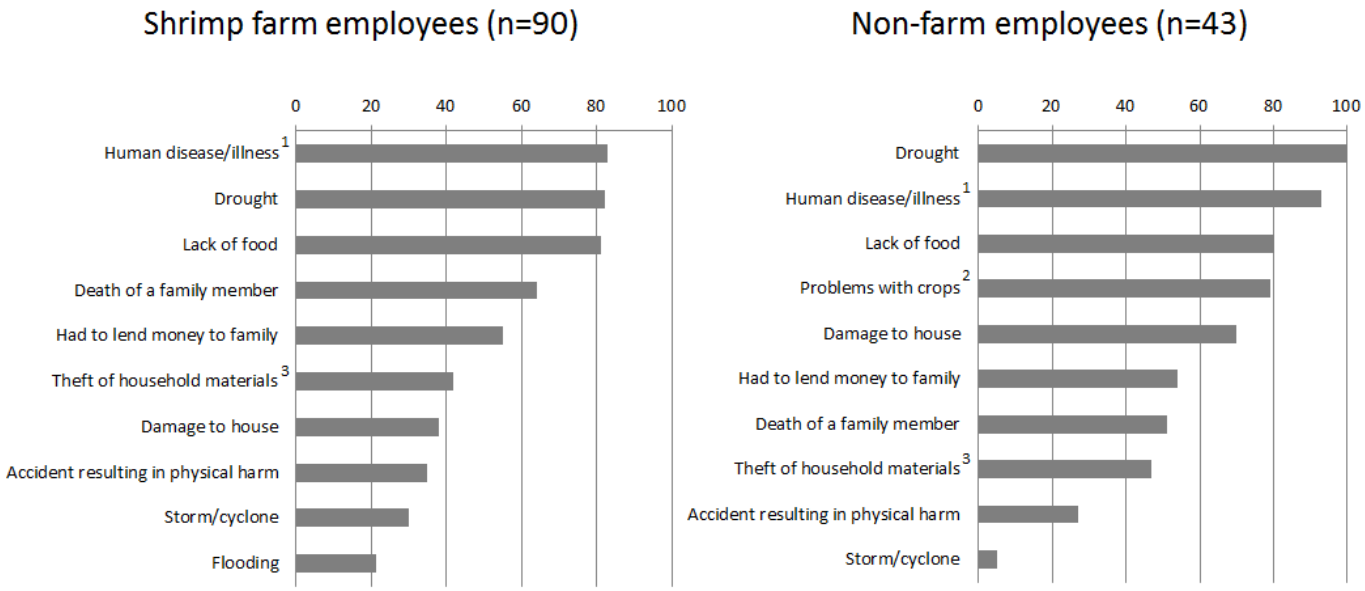

Figure 4.4 Summary of exposure to stressors and shocks in Inhanssunge, Mozambique. Bars indicate percentage of total survey respondents (n) that experienced each stressor or shock in previous 12 months.

[1]Illnesses included cholera, HIV/AIDS, malaria, tuberculosis and asthma.

[2]Problems with crops included reduced production, lack of rain and damage from pests.

[3]Stolen materials included rice, potatoes, chickens, bicycles, radios, clothing, fishing nets, and cell phones.

Three important points emerge from the exposure data. First, survey data demonstrate that livelihood stressors arise from multiple sources, including social, economic and environmental disturbances. Social stressors include disease of a household member, death of a family member and theft of household materials. Economic stressors include financial obligations to family. The most significant environmental stressors is drought, which impacted over 80% of households in both groups (Figure 4.4). In addition, 79% of non-farm respondents indicated that pests and lack of rain had reduced crop production in their subsistence gardens (called *machambas*). Interview respondents explained that the lethal yellowing disease, which kills palm trees, is a difficult environmental stressor. In interviews, respondents added that lack of jobs and limited infrastructure, including lack of roads, lack of drinking water and lack of electricity, create chronic stress for the community. Further, Inhanssunge residents explained that before the shrimp farm was established in the mid-1990s, the land was used by the community for making salt, for fishing and as a pasture for livestock. By physically blocking peoples' access to a common property coastal resource the farm has created an additional livelihood stressor for people in Inhanssunge.

Secondly, prior to the emergence of the White Spot Syndrome Virus (WSSV), households in Inhanssunge were facing nearly identical sources of stress irrespective of primary livelihood activity. Human disease, lack of food and drought affected over 80% of households of both shrimp farm employees and non-farm employees (Figure 4.4). More than half of all respondents had lost a family member in the previous year. Theft of food and household materials was a problem for survey respondents in both groups. The only point of variance in reported exposure was problems with crops. Zero farm employees listed problems with crops as a stressor, whereas 79% of non-farm employees identified problems with crops as a stressor (Figure 4.4). This difference is likely due to the fact that half of non-farm employees interviewed identified farming as their primary source of income. No respondents listed shrimp disease as a stressor because surveys were conducted in 2010, before the outbreak of the WSSV. I was unable to interview shrimp farm employees after the WSSV outbreak, but colleagues in Mozambique confirmed that the majority of employees at the shrimp farm were laid off. The outbreak undoubtedly exposed shrimp-farm workers to a new disturbance, which I discuss in the

sensitivity section. Nevertheless, exposure to chronic stressors was highly similar across the study groups regardless of primary livelihood activity.

Third, the exposure data demonstrate that sources of stress are not autonomous. Rather, disturbances within the coupled system interact within and across scales. Economic liberalization in the mid-1990s facilitated the establishment of the shrimp farm, which has blocked local access to previously communal land, demonstrating how changes at one scale can create stressors at other scales. Interview respondents explained that drought and the lethal yellowing palm disease have caused reduced agricultural production, which in turn led to food insecurity, demonstrating how change in biophysical components of a coupled system can create change in social components of the system. Further, respondents explained that lack of roads makes it more difficult to transport products to markets, lack of jobs leads to increased incidence of theft in the community and the lack of clean drinking water contributes to higher incidence of disease. Thus, changes in the natural environment interact with social vulnerability, and vice versa, within and across scales in coupled social-ecological systems.

Sensitivity

Following Allison et al. (2009), I analyze sensitivity by looking at primary occupation. My data indicate that while all households practice livelihood diversification, most households rely on a primary income generating activity. For shrimp farm employees, wages from the farm were the primary source of income. For non-farm employees, agricultural production was the primary source of income. Household sensitivity is directly related to primary livelihood activity. For example, shrimp farm employees are highly sensitive to disturbances that affect farm production. In this study, the WSSV suspended farm production for approximately one year (S. Chamo, pers. comm.). This is a shock to which shrimp farm employees are highly sensitive, yet has little impact on non-farm employees. Conversely, drought that reduces crop yield will have a major impact on household who depend on agriculture but relatively little impact on shrimp-farm employees. Therefore, livelihood sensitivity is dependent on primary occupation and the type of stressor or shock being experienced. Households in Inhanssunge are differentially sensitive depending on their exposure and occupation.

Adaptive Capacity

I evaluated adaptive capacity by measuring household assets (Table 4.1) and adaptive strategies (Table 4.2). In the vulnerability framework (Figure 4.1), this data represents adaptation response or adaptive capacity.

Table 4.1 Summary of assets in Inhanssunge, Mozambique. Values indicate the percentage of total respondents (n) in each group who positively identified ownership of or access to each asset in household surveys.

	Respondents by area Percentage of n	
Asset	Shrimp farm employees (n=90)	Non-farm employees (n=43)
Financial capital		
Savings	54	20
Human capital		
Access to a doctor	96	88
Access to a school for your children	91	91
Literacy	90	76
Secondary education	37	12
Natural capital		
Livestock/poultry	60	67
Machamba	97	95
Physical capital		
Access to a well	67	56
Bicycle	86	56
Cell phone	30	40
House	96	93
Metal roof	45	23
Grass roof	55	77
Social capital		
Family members in the community	93	91
Spouse	81	84

In general, assets of shrimp farm employees are higher than non-farm employees across the asset capitals categories. Here I discuss each of the five asset capitals in turn. I use household savings

as a proxy for *financial capital*. Shrimp farm employees have higher financial capital than non-farm employees (Table 1). At the farm, employees worked 6 days a week, 8 hours a day and earned an average of 2530 MZN per month (equivalent to $84 US), which is the minimum wage defined by the Government of Mozambique for the public sector (E. Jose, pers. comm.). I did not collect monthly income data from non-farm employees because subsistence farming livelihoods are largely derived from non-monetary sources, such as agricultural production for household consumption. However, it is safe to assume that the cash income of non-farm employees is lower than shrimp farm employees.

Shrimp farm employees have higher *human capital* than non-farm employees. Among respondents, 96% of farm employees had access to a doctor, whereas only 88% of non-farm employees reported having access to a doctor. In addition, 90% of shrimp farm employees were literate, as opposed to 76% literacy in non-farm employees. The administration director of the shrimp farm indicated that being literate could increase an individuals' chance being hired at the farm. Therefore, literacy is likely a precursor to employment at the shrimp farm as opposed to an outcome. However, in 2009 the farm was developing a literacy and math program for farm employees and working on a certificate for the on the job training that shrimp farm employees received (P. Massing,a pers. comm.). Consequently, employment at the shrimp farm has the potential to increase the human capital of farm employees.

Transportation, electricity, houses, cell phones, drinking water sources and health facilities are *physical capitals* that enable farmers to pursue their livelihood strategies. In Inhanssunge, the shrimp farm has improved a number of physical assets for all community members. In 2006, the shrimp farm installed electricity and the infrastructure developed to bring electricity to the farm was used to bring electricity to the Inhanssunge district as well (L. Galli, pers. comm.). Additionally, the shrimp farm allows their barge to be used by the community for bringing motorized vehicles across the river to the district and for emergency trips from the district to the hospital in Quelimane (L. Galli, pers. comm.). However, while some physical capital benefited the entire community, shrimp farm employees have higher access to drinking water, more bicycles and houses made of higher quality material than non-farm employees (Table 4.1). Therefore, the physical capital of shrimp farm employees is higher than non-farm employees.

Natural and *social capitals* were fairly similar between the two groups. Livestock ownership and subsistence gardens, which play a vital role in the livelihoods of rural communities in Mozambique, were comparable for farm employees and non-farm employees (Table 4.1). Likewise, the majority of respondents in both groups were married and had extended family in the community (Table 4.1).

A system's capacity to respond to stressors is an important determinant of vulnerability. Therefore, as the second component of my adaptive capacity analysis, I compared the adaptive strategies used by Inhanssunge residents in response to multiple stressors (Table 4.2).

Table 4.2 Adaptive strategies used in response to stressors in Inhanssunge, Mozambique. Values indicate the percentage of total respondents (n) in each group who identified using each adaptive strategy during the previous 12 months (n/a indicates the strategy was not available for that group).

Strategy[†]	Respondents by area Percentage of n	
	Shrimp farm employees (n=90)	Non-farm employees (n=43)
Changing crop type	0	48
Doing other work[1]	49	35
Extra work at The farm	52	n/a
Loan from The farm	34	n/a
Loan from bank	3	0
Loan from family	40	24
Sale of livestock/poultry	33	35
Taking less food	76	86
Use of savings	51	14

[†]Participants perform more than one type of adaptive strategy.

[1]Other work for shrimp farm employees included (from most to least common): working as a carpenter, tailor, fisher and bicycle taxi driver, working in the machamba, conducting small business and hiring out a wooden cart. Other work for non-farm employees included (from most to least common): working in the machamba, making bricks, selling chickens, and working as a security guard, telephone and radio technician and fisher.

Reducing food consumption is the most commonly used adaptive strategy in both groups and is indicative of the pervasive poverty in Inhanssunge. For farm employees, the next two most common strategies are taking extra work at the farm and the use of savings. In addition, over a

third of farm employees had taken a loan from the farm during the previous year. It is important to note that taking extra work at the farm and taking a loan from the farm are strategies that are not available to non-farm employees. Both groups took loans from family, although more farm employees made use of this strategy than non-farm employees. Furthermore, 49% of farm employees took other work during difficult periods while only 35% of non-farm employees took extra work in response to stress (Table 4.2). These data indicate that employment at the shrimp farm creates more adaptive strategies for farm employees in comparison to non-farm employees.

Interview data built on household survey results, which suggest that shrimp farm employees have more adaptive strategies available to them than non-farm employees. Three of the shrimp farm employees felt that their salary was fair. A 54 year-old farm employee noted that "before we would work and wouldn't have enough money to cover our basic expenses. Now, that's possible." However, the other eleven interview respondents felt that their salary was too low. They explained that they work hard, for long hours and their salaries do not cover their monthly household expenses. When asked what would improve their job, all respondents indicated an increase in salary. Yet, 11 of the 14 respondents stated that working for the farm has helped them cope with livelihood stressors. A 32 year-old respondent said that "a job helps in times of difficulty, like when there's disease in your house. When a farm employee is sick, they have direct access to a doctor." Respondents explained that working at the farm has helped them purchase food and school materials for their children. When they were lacking food, when a household member was sick and when their houses needed repair, farm employees took loans from the farm. When asked if there was anything else he would like to add at the end of an interview, a 21 year-old respondent said "they should open farms in other districts and provinces, so there would be paid jobs."

Synthesis

In this paper, I conceptualize vulnerability to be a function of exposure, sensitivity and adaptive capacity. In the following table (Table 4.3), I synthesize the components of my vulnerability analysis.

Table 4.3 Vulnerability analysis for shrimp farm employees and non-farm employees in Inhanssunge, Mozambique[†].

	Shrimp farm employees	Non-farm employees
Exposure		
Stressors (continuous)	+	+
Shocks (acute)[‡]	+	x
Sensitivity		
Occupation	Variable depending on the stressor (e.g. ↑ sensitivity to WSSV)	Variable depending on the stressor (e.g. ↓ sensitivity to WSSV)
Adaptive Capacity		
Assets		
Financial capital	↑	↓
Human capital	↑	↓
Physical capital	↑	↓
Natural capital	=	=
Social capital	=	=
Adaptive strategies		
Diversification	+	+
No. of adaptive strategies	↑	↓

[†]In this table, '+' indicates presence and 'x' indicates absence of a particular factor in the vulnerability analysis. '↑' indicates higher, '↓' indicates lower or reduced and '=' indicates equal value of a factor for one occupational group in relation to that factor for the other occupational group.

[‡]During my research, the only shock experienced by respondents was the outbreak of the WSSV. Therefore, shocks in this table refer to the WSSV.

Higher exposure to stressors and shocks will lead to higher vulnerability. In my research, both farm employees and non-farm employees are exposed to multiple chronic stressors (Table 4.3). However, only shrimp farm employees were exposed to the rapid outbreak of the WSSV (shock), making them more vulnerable to shrimp related shocks that non-farm employees. Higher sensitivity will also lead to higher vulnerability to stressors and shocks. The sensitivity of the two groups in my study is different because their primary livelihood strategies are different. Certain occupations will be more or less sensitive to a stressor or shock depending on the source of the disturbance. Shrimp farm employees are very sensitive to the outbreak of the WSSV, whereas non-farm employees, who are primarily farmers, are less sensitive to the WSSV. Finally, higher adaptive capacity will lead to lower vulnerability. Both groups engage in diversified livelihoods, yet shrimp farm employees' assets and adaptive strategies are higher than

non-farm employees thus reducing their vulnerability to multiple stressors. Therefore, my results indicate that shrimp farm employees are less vulnerable than non-farm employees to continuous stressors in Inhanssunge. However, shrimp farm employees are more vulnerable than non-farm employees to shocks that affect shrimp production. These results have significant implications for aquaculture development policy considering the high prevalence of shrimp disease in export-oriented aquaculture.

Discussion

Understanding how export-oriented shrimp aquaculture affects livelihood vulnerability is a critical task for governments, investors and civil society along the Western Indian Ocean as the industry begins to grow. Using the Turner et al. (2003) framework for vulnerability as comprised of exposure, sensitivity and adaptive capacity, I present a case study on the vulnerability of local livelihoods to the impact of one of east Africa's first large export-oriented shrimp farms. Here, I discuss the ways in which household vulnerability and livelihoods are connected.

In contrast to vulnerability analyses that focus on exposure to a single stressor (Cinner et al. 2012), vulnerability analyses within the sustainability sciences emphasize the importance of exploring exposure to multiple, interacting stressors and shocks (Turner et al. 2003). Exposure to multiple stressors was evident in Inhanssunge. Survey respondents from both groups, shrimp farm employees and non-farm employees, identified over ten stressors that they had experienced during the previous year (Figure 4.4). Building on the seminal work of O'Brien et al. (2000), which identified climate change and globalization as critical drivers of vulnerability in India, my results demonstrate that stressors can arise from social (e.g. human disease, food insecurity), economic (e.g. financial commitments to extended family) and environmental (e.g. drought) sources at multiple scales. My results support the argument that in rural communities, irrespective of livelihood, exposure to chronic, non-sectoral stressors such a poverty, food insecurity and disease contribute to household vulnerability (Mills et al. 2010). Moreover, my results add to a growing body of empirical evidence indicating that in linked social-ecological systems, changes in one component of a system (e.g. national economic liberalization) may drive

changes in another component (e.g. reduced access to commons) (Tuner et al. 2003, Walker and Meyers 2004).

Vulnerability analyses are considered most useful to decision makers when they are sensitive to the role of institutions and governance processes in increasing or decreasing exposure to stressors (Turner et al. 2003, Adger 2006). Unfortunately, during early aquaculture development in much Southeast Asia governments often failed to implement environmental regulation policies and thus permitted production with devastating environmental and social consequences (Primavera 2006). In Thailand, for example, even after appropriate environmental regulations were implemented, the government has been unable to effectively enforce regulations and damaging practices continued (Flaherty et al. 1999, Flaherty et al. 2000). By contrast, the government of Mozambique has been proactive in regulating the aquaculture industry before export-oriented shrimp production has spread throughout the country. Shrimp farms in Mozambique must undergo an environmental impacts assessment, practice only extensive farming and cannot use wild larvae for stocking (Sadek et al. 2002). The government, has therefore, reduced potential exposure to environmental stressors arising from unsuitable farm site selection, over stocking and biodiversity loss due to collection of wild larvae. In addition, the farm from my case study practices organic shrimp farming, further reducing exposure to potential environmental stressors associated with high chemical and antibiotic pond inputs (Paul and Vogl 2012). Clearly, however, despite proactive environmental regulations not all environmental stressors have been avoided. In 2011, the WSSV appeared in Mozambique and decimated national shrimp production.

Analyses of vulnerability should be cognizant that nonlinear drivers of change give rise to unexpected exposure and vulnerability in social-ecological systems (Turner et al. 2003). Drivers of change are often classified as either stresses, referring to continuously or slowly increasing pressure, or as shocks, referring to sudden or nonlinear spikes in pressure beyond the normal range of experience (Turner et al. 2003, Marschke and Berkes 2006). In my study, household disease and lack of food can be characterized chronic stressors to which households must continuously adjust. The sudden appearance of the WSSV, however, which led to the death of all shrimp on the farm and the termination of hundreds of farm employees, can be classified as a shock. The WSSV has decimated entire production systems of shrimp across southeastern Asia

and has been identified as one of the most significant sources of vulnerability for shrimp production systems (Hein 2002, Ahmed et al. 2008, Paul and Vogl 2013). If shrimp aquaculture is going to reach its production potential in Mozambique, further research on controls of shrimp disease will be required. It is important to note that some shocks and stressors may be common to an entire community, whereas others may be specific to some user groups (Marschke and Berkes 2006). Illness, for example, may be an on-going stress for some households with multiple members pursuing different livelihood activities, but may be a shock to another household which only has a few working members, especially if it affects the main income generator in a peak season. In Inhanssunge, the appearance of the WSSV was a shock for some households yet it did not affect others. The degree to which households were affected by the WSSV is explored below.

Household sensitivity, that is the degree to which a system is modified or affect by stressors, is related to livelihood. Households that are dependent on agriculture for their primary income are sensitive to drought and pests. Shrimp-farm employees, who are less sensitive to agricultural stressors, are highly sensitive to the outbreak of the WSSV. These results are broadly consistent with studies that have shown that different occupational groups have varied sensitivities to stressors. In Southwest Bangladesh, farmers, fishers and day labourers were differentially affected by the impacts of shrimp farming (Swapan and Gavin 2011). For example, saline water intrusion killed livestock, which negatively affected farmers but had no impact on fishers. In the Western Indian Ocean, Cinner et al. (2012) demonstrated that dependence on fishing and the use of particular types of gear increased people's sensitivity to coral bleaching resulting from climate change.

According to the UNEP (2008), shrimp farming can increase household income and reduce poverty. In my study, shrimp farm employees had more savings than non-farm employees. In addition, shrimp farm employees had the option of borrowing a portion of their salary from the farm to help them cope with periods of stress, a strategy that was unavailable to non-farm employees. I argue that these increased financial assets will reduce vulnerability amongst farm employees. In addition, shrimp farm employees in my study do not take on personal debt to finance aquaculture production the way small owner operated shrimp farmers do, which allows

them to avoid a driver of vulnerability experienced by many shrimp farmers (Ahmed et al. 2008). By comparison, the limited financial capital of non-farm employees may increase their vulnerability to multiple stressors. Despite the financial benefits associated with a regular paid salary, it is important to point out that there are well-documented cases of unfair employment practices in aquaculture. For example, some research findings indicate that aquaculture enterprises, especially large corporations, exploit local labour (FAO 2012). Shrimp farm employees in my study earn approximately $84 US a month working 6 days a week, 8 hours a day. While this salary in equal to the national minimum wage, many employees pointed out that they are often short on their monthly expenses. Almost all respondents indicated that they would like to see an increase in their salary.

The ability to learn from periods of change and crises is critical factors for building adaptive capacity (Berkes et al. 2003). I argue that shrimp farm employees' higher literacy rates and secondary education levels (Table 4.1) will translate into a higher ability to learn from periods of stress in comparison with non-farm employees. This will, in turn, increase shrimp farm employees adaptive capacity and reduce their vulnerability. I acknowledge that individuals with higher education levels were likely selected for employment before less educated community members but analysis of employment equity was beyond the scope of this study. Shrimp farm employees have access to a medical clinic at the farm, which can potentially improve their health and their human capital, leading to less vulnerable households.

In response to the damaging social and ecological consequences associated with intensive shrimp farming development through the late 1990s and into the 2000s, the Food and Agriculture Organization (FAO), Network of Aquaculture Centres in Asia-Pacific (NACA), United Nations Environment Programme (UNEP), World Bank (WB) and World Wildlife Fund (WWF) developed at set of international principles for responsible shrimp farming (FAO 2006). Their eighth principle states that aquaculture development should promote farms that operate in "a socially responsible manner that benefits the farm, the local communities and the country, and that contributes effectively to rural development, and particularly poverty alleviation in coastal areas, without compromising the environment" (FAO 2006, p. 11). In my case study, the shrimp farm brought electricity and access to the hospital during emergencies to the district, thus

contributing to community development and potentially reducing vulnerability of both groups to stressors. Elsewhere in Mozambique, cotton companies have developed infrastructure in their jurisdiction which benefited both the company and the local communities (Pitcher 2002).

Similarly, shrimp farmers in Bangladesh reported that physical capital, including better dwellings, latrines, electricity, access to government health complex, drinking water increased after the development of organic shrimp farming in their communities (Paul and Vogl 2013). When practiced in a socially responsible manner, shrimp farming can improve physical capital for the whole community thus reducing vulnerability. While both groups, shrimp farm employees and non-employees, benefit from electricity, it is important to note that physical assets are higher among shrimp farm employees and that blocked access to pasture and salt production land.

Turner et al. (2003) argue that analyzing a system's capacity to respond to stressors is critical for vulnerability analyses. I explored how households in Inhanssuge are responding to multiple stressors as part of my analysis and discuss those strategies here as the second component of adaptive capacity. Livelihood diversification is one of the most common ways that rural households use to cope with shocks and stressors (Scoones 1998, Ellis 2000, Marschke and Berkes 2006). Most often, studies have argued that diversified rural livelihoods are less vulnerable than undiversified livelihoods (Ellis 2000). In my research, this appears to be the case. Both groups practice highly diversified livelihoods. Both invest in livestock, subsistence gardens and take other types of work during stressful periods. Survey respondents identified nine adaptive strategies that they use in response to stressors (Table 4.2). Importantly, shrimp farmers have more adaptive strategies available to them than non-farm employees. For example, taking extra work at the farm and taking a loan from the farm were important adaptive strategies that are unavailable to non-farm employees. In this regard, shrimp farm employees are more diversified and less vulnerable than non-farm employees.

However, livelihood strategies are the product of the interaction between choices and constraints (Start and Johnson 2004). My research demonstrates that while the shrimp farm increases potential adaptive strategies for their employees, it also limits certain strategies for the

community. By blocking access to land traditionally used for making salt and grazing livestock, the shrimp farm is reducing diversification strategies for employees and non-employees alike. This case is not unique. Across Southeast and South Asia, residential, agricultural and forest lands are being converted into shrimp farms and blocking access to burial grounds, pastures, areas for drying nets and other common land (Primavera 2006). Blocking access to commons reduces livelihood diversification and adaptive capacity for both groups in my study. In addition, Cinner et al. (2012) warn that trade-offs can exists whereby diversification strategies that reduce sensitivity to the impacts of one stressors may increase sensitivity to another.

Arguably, the most useful vulnerability analyses demonstrate differential vulnerabilities, because sub-systems are rarely equally vulnerable (Turner et al. 2003). Livelihoods for farm employees in Inhanssuge have changed remarkably since the introduction of export-oriented shrimp aquaculture in the late 1990s. In particular, cash income for farm employees has increased. Many researchers argue that livelihood security of shrimp farmers should increase with increased income (Ahmed et al. 2008). My research demonstrates that the household assets of farm employees were significantly higher than non-farm employees. However, the shrimp farming system in Inhanssunge crashed after the outbreak of the WSSV, exposing the heightened vulnerability of shrimp farm employees to shrimp related shocks. Therefore, my research suggests that employment at an export-oriented shrimp farm can reduce vulnerability to chronic stressors but increase vulnerability to shocks associated with shrimp production. This trend has been documented in other systems. For example, cash incomes from small-scale fishing can be higher than earnings from agriculture or other casual labour options, but vulnerability and insecurity of fishing livelihoods is often higher (Béné et al. 2009). However, this duality is not commonly documented in the aquaculture or vulnerability literature.

Conclusion

This research explored the impact of employment at an export-oriented shrimp farm on household vulnerability in rural Mozambique. I found that household vulnerability is highly variable depending on a number of factors, including exposure to stressors and shocks, primary livelihood activity and household assets and adaptive capacity. Employment at the shrimp farm in my study reduced household vulnerability to chronic stressors, such a pervasive poverty, but

increased vulnerability to acute shocks related to shrimp production, such as the WSSV. I argue that reductionist representations of vulnerability, that attempt to draw linear connections between a single driver and the vulnerability of a particular social group, are not reflective of the complexities linking vulnerability and rural livelihoods. As shrimp aquaculture development continues along the Western Indian Ocean, governments, private investors and international development agencies will need to be cognizant to the varied impacts of export-oriented aquaculture on the livelihood vulnerability of local communities.

5. Assessing the Sustainability of Fishing Communities: Insights from Resilience Thinking

Abstract

Change has become a pervasive force in a highly globalized world with implications for the sustainability of ecological-social systems. Therefore, understanding how much disturbance communities will absorb, where social thresholds lie and what coastal community systems might look like if a threshold is crossed are critical research questions. The purpose of this paper is to evaluate the resilience of two fishing communities in central Mozambique in order to improve our ability to foster resilience in coastal communities. My results indicate that coastal communities are continuously absorbing multiple sources of disturbance without shifting into different states. However, a 90% decline in catch rates would represent a threshold for both communities. In response to the threshold the two research communities would respond differently. At Zalala Beach, fishers would respond by permanently moving to another location whereas in Inhangome, fishers would respond by changing their professions. These results contribute to our understanding of social resilience and thresholds and are, therefore, useful in policy terms since they contribute to the long-term goal of social and ecological sustainability.

Introduction

Change has become a pervasive force in a highly globalized and multi-level world with implications for the sustainability of ecological-social systems. In this context, researchers are increasingly interested in understanding how social-ecological systems will respond to rapid and often unpredictable change. The purpose of this paper is to evaluate the resilience of two fishing communities in central Mozambique. By resilience, I refer to the capacity of linked social-ecological systems to absorb disturbances and retain essential processes, structures and feedbacks (Walker et al. 2004, Folke 2006). Resilience research is concerned with the capacity of social-ecological systems to tolerate disturbance without collapsing into qualitatively different states (Gunderson and Holling 2002, Walker et al. 2004). Understanding and measuring the resilience of coastal communities is critical since effective fisheries management requires governance systems that can enhance the capacity to cope with uncertainty and surprise (Adger et al. 2005).

Global fisheries are in crisis (Jackson 2001, Pauly et al. 2002, Worm et al. 2006). The ocean's capacity to provide food, maintain water quality and recover from periods of stress is being eroded by overfishing (Worm et al. 2006). Internationalization of the shrimp trade is driving coastal habitat loss, making people more vulnerable to coastal disasters (Adger et al. 2005b, Primavera 2006). Furthermore, climate change is placing additional pressure on already threatened fisheries systems (Allison et al. 2009). The implications of these changes for human well-being are immense (Coulthard 2012). The fisheries sector provides livelihoods for an estimated 120 million people worldwide, 97% of whom live in developing countries (World Bank/FAO/WorldFish 2010). In this context, resilience thinkers have called for research that focuses on building resilience in fisheries systems (Allison et al. 2007, WorldFish 2010).

Building on the understanding of how small-scale fishers in Mozambique have adapted over time to cope with a particular set of challenges developed in Chapters 2 and 3, this paper adopts the Cumming et al. (2005) framework for the empirical measurement of resilience to explore how small-scale fishers will respond to future changes in their complex social-ecological systems. The paper begins with a theoretical overview of the concepts of resilience and the research

framework used throughout the paper. Next, it presents the research methods and study sites. This is followed by the results and analysis section. Finally, the paper concludes by reflecting on how the research contributes to our understanding of small-scale fishers' resilience and governance.

Resilience, Thresholds and Surrogates

The concept of resilience was built on observations that change and unpredictability are not exceptions in the behaviour of ecological systems, but rather are the underlying norm of ecological dynamics (Holling 1973, Folke 2006). Today, resilience is defined as the capacity of a social-ecological system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes (Gunderson and Holling 2002, Walker et al. 2004). A central concept in resilience thinking is that neither ecological nor social components of a system can be effectively understood without considering the linkages between the two and that the two function together as an integrated social-ecological system (Berkes et al. 1998, Folke 2006).

One of the central assumptions of resilience thinking is that social-ecological systems are seldom, if ever, stable. Rather, social-ecological systems are characterized by multiple stable states, which they can move between often without any signs of change or warning (Gunderson and Holling 2002). The concept of multiple stability domains is often described using a 'ball in a basin' heuristic (Figure 5.1). In the diagram, the ball represents the social-ecological system, the valleys represent stability domains, the arrows represent disturbance and the peak between stability domains represents a threshold. The bottom of each valley is mathematically defined as an attractor and social-ecological systems are drawn towards it (Walker et al. 2002). Resilience corresponds to the amount of disturbance a system can absorb before it is pushed over a threshold and into a new stability domain. Of interest, then, is locating thresholds for a particular social-ecological system.

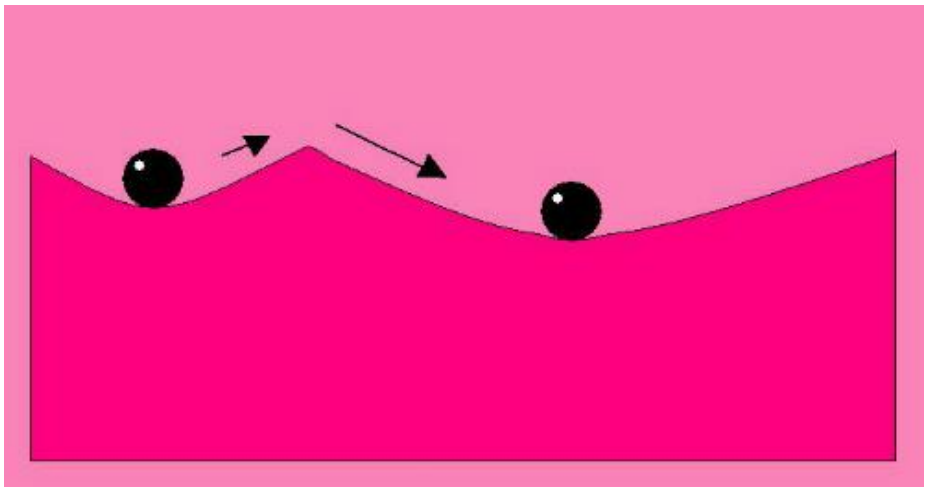

Figure 5.1 'Ball in a basin' heuristic depicting multiple stability domains for social-ecological systems. The *ball* represents the system, the *basins* represent stability domains, the *arrows* represent source of disturbance and the *peak* between stability domains represents a threshold. Adapted from Gunderson 2000.

Resilience thinking proposes that natural and social systems behave in nonlinear ways and exhibit thresholds (Folke 2006). Resilience researchers are interested in the ability of a system to absorb disturbance without crossing a threshold and shifting into a new state (Gunderson and Holling 2002, Berkes et al. 2003). Therefore, thresholds in social-ecological systems are important points of interest. Thresholds are defined as the point at which a system shifts from one state into a qualitatively different state (Cumming et al. 2005). Over time, social-ecological systems are continuously absorbing various sources of disturbance without exhibiting any evident effects. However, once disturbances pass a certain point or the cumulative influence of multiple disturbances push the system past a certain point, the system can experience a regime shift and move from one basin of attraction to another. Once a regime shift has occurred, a threshold has been crossed (Cumming et al. 2005). Measuring thresholds is difficult because the only sure way to identify a threshold is to cross it (Carpenter et al. 2005). Carpenter et al. (2005) point out that in the natural sciences, thresholds can be identified through manipulations of ecological systems, but in social or interdisciplinary science it may be impossible or unethical to induce a threshold event in a social-ecological system. It is, therefore, important to look for other ways of measuring resilience and thresholds in social-ecological systems, such as surrogates of resilience (Carpenter et al. 2005).

In response to the challenges associated with measuring resilience, Carpenter et al. (2005) called for the use of surrogates for resilience in empirical research in a special feature in the journal *Ecosystems*. By surrogates, they are referring to proxies for resilience that can be empirically measured. Surrogates are required because some aspects of resilience may not be directly observable so may need to be inferred. The most widely adopted framework to emerge from the *Ecosystems* special feature was introduced by Cumming et al. (2005). I chose to investigate resilience through the Cumming et al. (2005) framework because it provides the most comprehensive method for the empirical measurement of resilience without reducing the complexities of rural livelihoods to numerical factors. The authors proposed a three part framework for studying the resilience of social-ecological systems in the field. First, they propose that a system's identity is composed of four measurable variables: i) system components, ii) the relationships between the components, iii) sources of innovation and iv) sources of continuity. *Components* are the pieces of the system, the human and non-human actors, such a fish and fishers. *Relationships* are the ways the components interact, for example through fishing. *Innovation* refers to the elements of the system that generate change or novelty, such as the ability to target a diversity of marine species. *Continuity* describes the ability of the system to maintain itself as a cohesive entity and is facilitated by system memory, such as traditional fishing knowledge that is passed down through generations of fishers. Second, their framework calls for the selection of key system variables that are most likely to change, in other words, system thresholds. Third, the framework calls for the identification of possible future systems scenarios. In this paper, I build on the understanding of past and present dynamics of fishers' responses to change in central Mozambique developed in Chapters 2 and 3 and explore the resilience Zalala Beach and Inhangome using the Cumming et al. (2005) framework for the empirical measurement of resilience.

Cumming et al.'s (2005) framework acknowledges that, over time, some aspects of a system may change. However, if the system is to be considered resilient, the essential system components that characterize the system's identity must be maintained. For example, in a ranching system the system identity could be based on ranchers, livestock and a harvesting relationship between them. Replacing sheep with goats could be seen as change within the system, but not a loss of system identity. On the other hand, the loss of livestock or ranchers from the system or of the

harvesting relationship would represent a loss of identity. Since definitions of identity and the identification of critical variables will be based on human decisions and values, Cumming et al. (2005) argue that people who live in the social-ecological must be central to the research process. Therefore, I explore community resilience through interviews and focus groups with fishers in central Mozambique.

Methods

Data Collection

The analysis for this paper is guided by the Cumming et al. (2005) framework for the empirical measurement of resilience. The analysis begins by defining the scale of the research system of interest. I decided to focus on the community scale since my central research question seeks to understand how communities are resilient to change. I conceptualized community as the social and ecological variables spatially organized around the places called Zalala Beach and Inhangome. For the remainder of the paper, I refer to my study system as the Sofala Bank social-ecological system, which encompasses both study communities, since both communities are located along the highly productive Sofala Bank in central Mozambique. Once the scale of interest has been identified, the system identity (components, relationships, sources of innovation and continuity) should be determined by people who live in the study system (Cumming et al. 2005). I therefore began my analysis by conducting interviews with 13 fishers from Zalala Beach and 13 fishers from Inhangome between May and June 2012. Initial respondents were identified by the village head (called '*Secretaria do Bairro*') and then through snowball sampling by asking interviewees to suggest other experienced fishers. Interviews typically lasted between 45 and 60 minutes. Questions were grouped into four categories: i) system attributes, ii) system shocks and drivers, iii) thresholds and iv) future scenarios. The first category was designed to measure the first component of the resilience framework, that is understanding the composition of the system's identity. The second and third category was designed to address the second component of the resilience framework, that is the identification of key variables that are the most likely to push the system past a threshold. For the threshold section of the interviews, I asked how fishers would respond to sustained 30%, 50% and 90% declines in their normal days catch, based on a methodology developed by Cinner et al. 2011. The final portion of the interviews focused on the third component of the resilience framework: future scenarios. These

questions were centered primarily on whether fishers would encourage their children to enter the fishery or not and why. I used the likely of the next generating engaging in fishing to help forecast what each community might look like in the future. Interview questions were open-ended and fishers were asked to specify details such as how they might change their fishing effort for example.

I coded the responses as either continuing to fish or stopping fishing. It is important to note that in most rural fishing communities, livelihoods are diverse. Therefore, if fishers would decrease their fishing efforts and invest in other livelihood activities, I coded this as continuing to fish. It was not until a fisher indicated that he would completely change professions, leave the fishery and sell his gear, or permanently move to another location that I coded responses as stopping fishing. Stopping fishing is considered a threshold point in this analysis.

In order to strengthen resilience analyses, the Cumming et al. (2005) framework suggests the collection multiple sources of data. Following the interviews, I conducted a focus group in each research community in June 2012. Each focus group consisted of approximately twelve fishers (Figure 5.2). The discussions were guided by the principal investigator (PI) and a translator from the Universidade Edaurdo Mondlane – Escola Superior de Ciências Marinhas e Costeiras (UEM-ESCMC) who had been working with the PI in both communities since 2009. The goal of the focus groups was to clarify trends which emerged from the interviews and increase our understanding of drivers of change and which variables would be most likely to change in response to those drivers.

Figure 5.2 Focus group with small-scale fishers at Zalala Beach, June 2012 (photo: J. Blythe).

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Study Sites

Inhangome (population 1,250) lies on the Rio dos Bons Sinais, twenty-five kilometers from the Indian Ocean (Figure 5.3). Fishers use dugout canoes (3-4 meters) in the estuary, fish with small nets or hand lines and target small shrimp, fish and crab. Poverty is pervasive and living conditions are very poor. Electricity is limited and the only community well contains brackish water. Inhangome is separated from the closest urban centre, Quelimane, by a 10 kilometer foot path and is inaccessible by motorized vehicle.

Zalala (population 2,690) is located along the productive Sofala Bank thirty kilometers north of Inhangome (Figure 5.3). Fishers use wooden vessels (called *lanchas* or *canoa typo moma*) that are typically 9-10 meters in length and accommodate crews of twenty fishers. Lanchas are primarily rowed or sailed-- in 2009, two boats at Zalala Beach had motors (A. Camunada, IDPPE, personal communication). Fishers use seine nets along the beach and gill nets in the open ocean (IDPPE 2009). They focus primarily on shallow-water shrimp and pelagic fish such

as sardines and anchovies (IIP 2004). Poverty is prevalent, but fishers at Zalala benefit from such government support as investment in infrastructure, including the construction of community wells and the maintenance of the road between Zalala and Quelimane, and fisheries extension training because it is being targeted by the government as an emerging small-scale fishing growth pole (H. Manjor, IDPPE, personal communication).

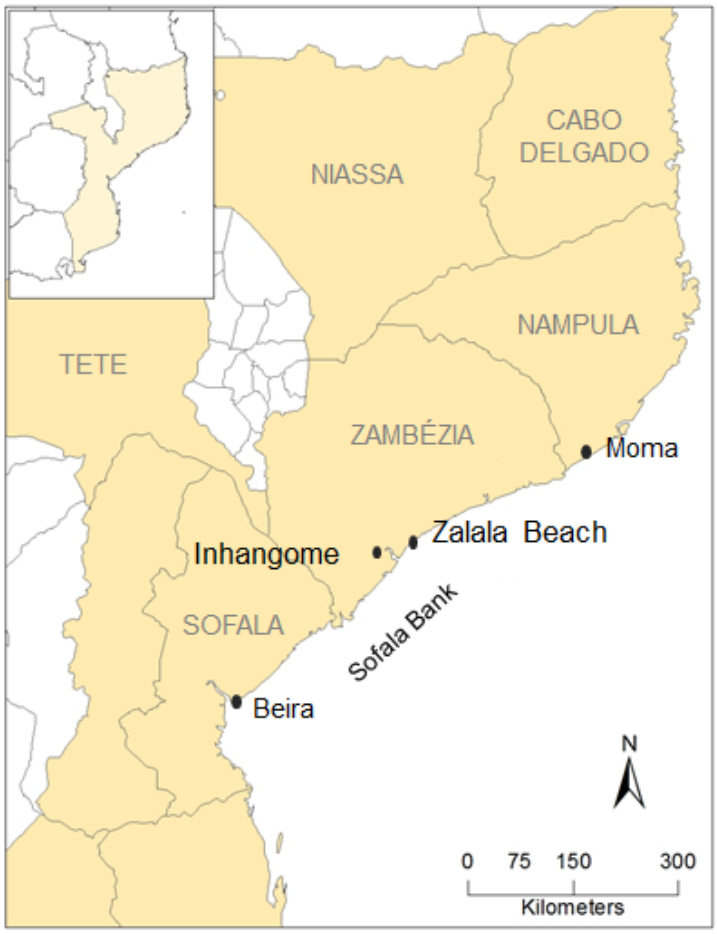

Figure 5.3 Location of the research communities, Inhangome and Zalala Beach, along the Sofala Bank, Mozambique.

Results and Analysis

Step One - System Identity

The first step in the resilience analysis of the Sofala Bank social-ecological system is to describe the system's identity through the four elements outlined in the Cumming et al. (2005)

framework: components, relationship, innovation and continuity. The analysis is based on examination of data produced in the two community focus groups and 26 fisher interviews.

In the two research communities, the presence of people and fish the *components* that are central to the system's identity. Fishing is the foundation for life in both research communities. For over half of respondents (n=26, mean age=32, stdv=9.34; mean years fishing=12, stdv=9.80), fishing is their only source of income. Of the remaining respondents, many supplement their fishing income with fishing related activities, including buying and selling fish, making ropes and mending nets. As well as being the primary income generating activity, fishing is also a critical source of food in both communities. Fish and fishers are not the only important components of the system. Rather they represent the elements that if completely removed from the system would result in a qualitatively different system. For example, the species of fish present in the system could change, but the system identity would remain relatively similar. Likewise, fishers could alter the type of gear they use, but as long as they are fishing they would still be a central component of a qualitatively similar system. Other important components of the system include households, fishing materials, machambas and compradores (Table 5.1).

Table 5.1 Elements of the Sofala Bank social-ecological system's identity, as identified in fishers' interviews, in central Mozambique (based on the Cumming et al. (2005) resilience framework).

Aspect of identity	Explanation
Components[†]	
Fish	Fish are the principal resource in both communities
Fishers	Fishers are the primary income earners for households
Households	The primary economic unit for both communities is the household
Fishing materials	Fishing materials (boats, nets, ropes) are central to the system because they allow fishers to catch fish
Machambas	Following fish, subsistence gardens (called *machambas*) are the most important livelihood resource for households in both communities. Agricultural products from the machambas are consumed within the household and sold for income
Compradores	Fish buyers, or middlemen, play an important role in purchasing fish and selling it in urban markets

Relationships[†]	
Social-ecological relationship	Social and ecological subsystems are intimately linked. For example, higher rainfall is associated with higher catch rates and higher income
Informal social relationships	Poor fishers, who do not own nets or boats, are often hired to fish for wealthier fishers at Zalala Beach. In addition, poor fishers sometimes take loans from their employers during difficult periods. Fishers in Inhangome borrow fishing materials from one another. These relationships are critical for fishing livelihoods
Formal social relationships	With the assistance of the IDPPE, savings and lending groups have been established and provide fishers with loans.
Innovation[†]	
Ability to target a diversity of species	Fishers in both communities use multiple gear (seine nets, gill nets, handlines) to target multiple species ranging from small pelagic fish to shrimp and mangrove crab
Livelihood diversification	Fishers demonstrate a remarkable ability to engage in multiple livelihood activities beyond fishing, including making and selling charcoal, working as a bicycle taxi drivers and in the machamba
Knowledge	Fishers are highly knowledgeable about their social-ecological system, which allows them to adapt their fishing practice and to engage in a range of livelihood activities in response to stressors
Continuity[†]	
Generations of fishers	Ten of the 26 respondents' fathers were fishers; seven had grandfathers who were fishers. Multiple generations of fishers build a vast wealth of information about the fishery which is passed onto new generations
Closed season	From December until March a closed season is in effect along the coast, however, the small-scale fishery is only expected to follow the closed season for one month and only seine nets are banned (H. Manjor, IDPPE, pers. comm). The closed seasons coincides with the larval stage of many marine species, allowing them to growth without risk of being caught
Régulo	Each community has a *régulo*, or traditional leader, who is consulted on all major decisions for the community. The *régulo* plays a pivotal role in maintaining the relationship between people and place

[†]*Components* are the objects, agents and entities that make up the system. *Relationships* are the processes or interactions that link system components. *Innovations* are variables that relate to the development of new responses to change or stressors. Sources of *continuity* are variables that maintain system identity through space and time.

The Sofala Bank social-ecological system identity is characterized by a range of ecological and social *relationships* (Table 5.1). For example, marine primary productivity (an ecological system component) is dependent on freshwater input (a biophysical system component) into coastal waters, either through river runoff or coastal rainfall drainage (Hoguane et al. 2012). Socially, the small-scale fishery system is composed of numerous interactions between individuals and groups. For example, the relationship between fishers and compardores is critical for the Sofala Bank system. When a fisher from Inhangome comes ashore he will often find half a dozen compradores waiting to bargain for his catch. The fisher collects money from each *comprador* until one had outbid the others. Once an agreement is reached, the successful compardor washes the catch, ties it to his bicycle and heads for Quelimane. From the time the catch is landed until it is heading to town for sale takes less than 30 minutes. More formal social relationships, such as savings and lending groups, are also important for the system. At Zalala Beach, fishers have organized small loans programs (called '*poupança e crédito rotativo'* - *PCR*) with the assistance of the IDPPE. The minimum contribution is 50 MZN (equivalent to approximately $1.70 US). Contributions are pooled and once you have contributed you may take a loan from the pool. Loans must be repaid within 30 days with 10% interest. At the end of the PCR period, which typically runs for 12 months, the pool and interest generated gets divided evenly amongst all contributing members. In the Sofala Bank system, social and ecological components also interact. For example, Hoguane et al. (2012) have demonstrated that small-scale fishery landings between 1998 and 2008 in Mozambique are positively correlated with rainfall with a two-year time lag. Thus, the livelihoods of fishers along the Sofala Bank are intimately connected to ecological components of the system and vice versa.

Fishers in Mozambique are familiar with fluctuations in marine resources and have been adapting accordingly for generations. Yet, the influx of new fishers, the steady decline in catch rates and the rising cost of fishing materials are challenging the traditional relationships of fishers in both communities. In response to these challenges, respondents are responding by improving their fishing practices. For example, when fishers cannot afford to purchase their own fishing materials, they borrow materials and take small loans from other fishers. A 28 year-old fisher from Zalala responded, "I am used to the challenges and I deal with them however I can. When I need some fishing materials, I ask my colleagues and friends to borrow so I can go

fishing". Fishers also explained that to cope with livelihood challenges, they fish harder. A 48 year-old fisher from Zalala noted that, "We thank God for what we have and just keep waiting for opportunities to come. Because of fishing I can live. Even if fishing is low, I just keep trying to fish". In addition to improving their fishing practices, respondents reported that they rely on agricultural production to supplement lean fishing. A 41 year-old fisher from Inhangome explained:

> *As my wives work in the machamba it helps to deal with these problems. It is difficult to deal with these challenges. When my wives see me falling down in my fishing, they go to work for other people in their machambas to get a little money to sustain the household.*

Innovation is a critical element of the small-scale fishery system's identity. Mozambique is endowed with fairly diverse marine fisheries resources, including crustaceans, pelagic fish and molluscs which creates potential for sustained biodiversity (FAO 2007). Small-scale fishers possess a profound understanding of the social-ecological coastal system and have been innovative in developing methods to catch a variety of species (Table 5.1). Currently, the small-scale sector accounts for close to 80% of total marine catch (FAO 2007). Small-scale fishers also exhibit innovative, diverse livelihood strategies. Traditional knowledge, passed down from one generation of fishers to the next represents an important source of *continuity* in the Sofala Bank social-ecological system (Table 5.1). In addition, in most rural communities in Mozambique, the *régulo* is an elder who presides over all important decisions made by the community and provides advice based on the communities' experiences. From an ecological perspective, the closed season represents an important source of continuity in the Sofala Bank social-ecological system's identity.

Step Two - Thresholds

Having defined the Sofala Bank system's identity, the next stage in the resilience analysis is to identify critical thresholds beyond which the system would lose its identity (Cumming et al. 2005). While many households in the Sofala Bank system rely on diversified livelihoods, fishing is the primary income source for all respondents.

The two most common livelihood stressors for fishers in central Mozambique are declining catch rates and lack of fishing materials. Fishers are reporting declines in their catch per unit effort in both Inhangome and at Zalala Beach. A 28 year-old fisher said, "It's been hard to earn a living because of the lack of fish and fish is how we survive in Inhangome". Fishers also explain that the price of ropes and nets has been increasing while their availability has been decreasing. A 33 year-old fisher from Zalala explained, "There are many difficulties for fishers. There is a lack of stores for buying fishing materials. We have to make long trips to Moma or Beira to obtain materials". In 2012, no retail outlets sold fishing materials Quelimane, which is the closest urban centre to both research communities. In addition, respondents identified lack of fishing boats at a challenge. Respondents explained that for many fishers boats are simply unaffordable. They also reported that the wood supply used for making fishing boats is declining. In Inhangome, fishers often borrow or rent dugout canoes. At Zalala Beach, fishers without boats are often hired by fishers who own boats to fish for them and in return receive a portion of the sales. Since declining catch rates was the most important stressor identified by the majority of interview respondents, I decided to explore fishers' responses to declining catch rates as the threshold for the Sofala Bank system. If fishing ceased to occur in the research communities, the system would have crossed a threshold into a qualitatively different system.

Several important points emerge from the threshold data. First, the proportion of fishers who would exit the fishery and adopt a new profession or permanently leave their community increased with the severity of the hypothetical decline in catch (Figure 5.4). Second, fishers from Zalala Beach were more likely to exit the fishery or leave the community in response to hypothetical catch decline than fishers from Inhangome. In Inhangome, all fishers would continue to fish in response to a 30% decline, 75% would continue to fish in response to a 50% decline and 54% would continue to fish in response to a 90% decline (Figure 5.4). At Zalala Beach, on the other hand, only 77% of fishers would continue to fish in response to a 30% decline, 67% would continue in response to a 50% and 34% would continue in response to a 90% decline in catch (Figure 5.4).

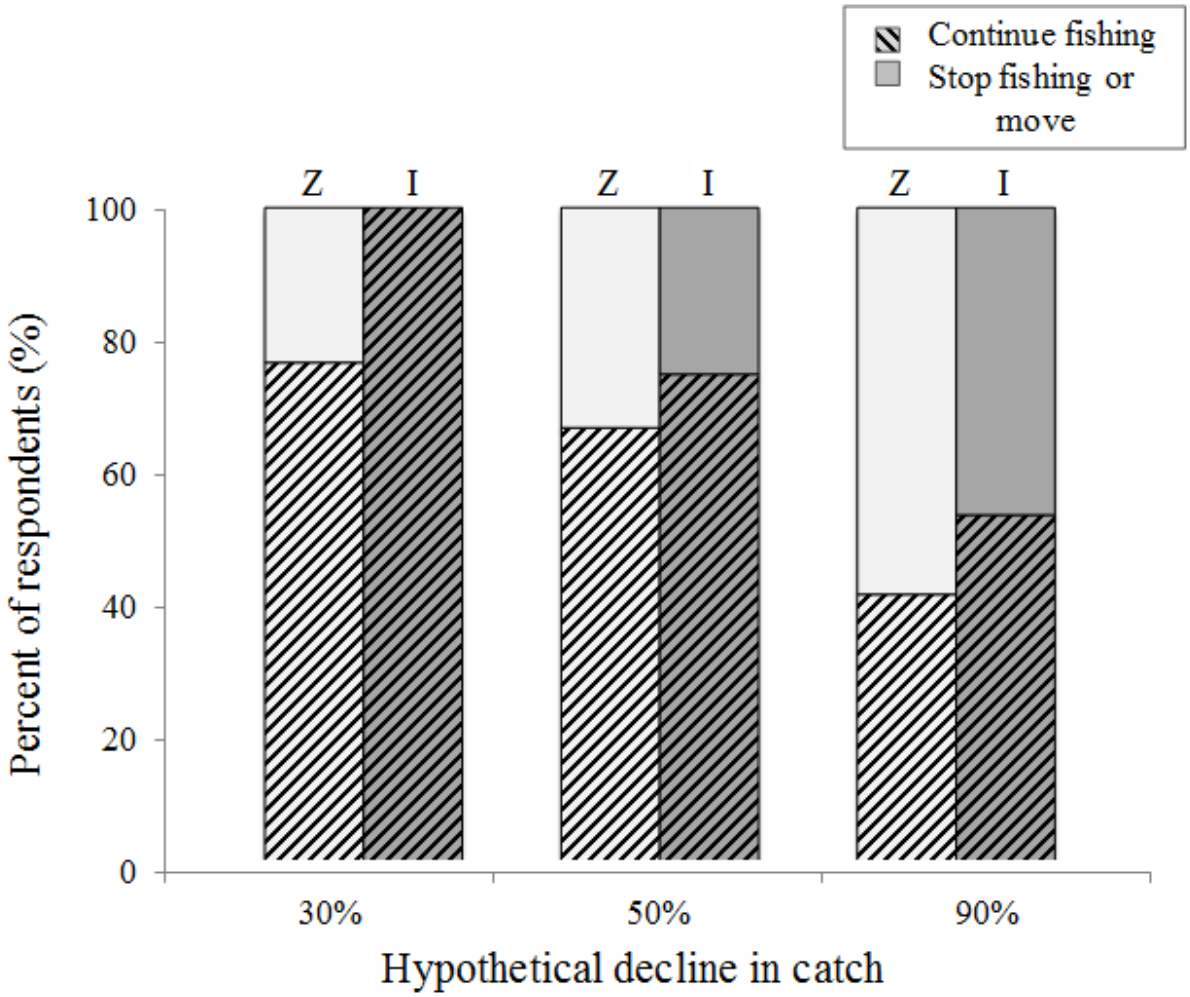

Figure 5.4 Fishers' responses to hypothetical declines in catch rates from two communities in central Mozambique. Fishers' responses include: i) continue to fish or ii) stop fishing or leave the community. Respondents from Zalala Beach (n=13) are depicted by a 'Z' above the columns. Respondents from Inhangome (n=13) are depicted by an 'I' above the columns.

Many of the respondents who indicated that they would continue to fish in response to declining catch rates explained that they would also engage in other livelihood activities or alter their fishing practice. To compensate for decreasing landings, fishers explained they would invest more time in their machambas and would look for other work, for example as bicycle taxi drivers. A 24 year-old fisher said, "I can't stop [fishing], I would stay and continue fishing here in Inhangome. I could not live in any other place. I would chop wood to make charcoal and work in the machamba". In response to declining catches, many fishers also explained that they would continue to fish, alter their gear, and where and when they fish. In addition, fishers

indicated that they are accustomed to adapting to variability in marine stocks. A 48 year-old fisher from Zalala Beach said, “I will not leave, but I will see how the fish will go. Because catch can fall and two years afterward rise again. I will continue living here and fishing. I can move for a time and the comeback”. Since livelihood diversification and modification of fishing techniques involve a continued relationship between people and fish, these adjustments to the system would not represent a threshold for the Sofala Bank system.

However, in cases where respondents indicated that they would either exiting the fishery or move permanently to another location, a threshold would be crossed and the system would become qualitatively different. At Zalala Beach, half of respondents who would not continue fishing would move permanently to another location. A 39 year-old fisher explained that in response to a 30% decline in catch, ‘I would change from fishing at Zalala Beach to fishing in Sophino or in Namacura because I left my home [and moved to Zalala] to look for better living conditions and to make a life as a fisher”. In contrast, the majority (89%) of fishers who would not continue fishing in Inhangome indicated that they would stay in Inhangome and adopt another profession. Only 11% of respondents who would not continue fishing would move permanently from Inhangome. Some fishers from Inhangome made reference to their family heritage and a sense of place that would motivate them to stay in their community. In response to a 90% decrease in catch an 18 year-old fisher from Inhangome said, “I never thought of leaving because my parents are from here. I can only change my profession”. Whether respondents would leave their community or change their profession, when fishing stops in these communities a threshold would be crossed and the system would move into a new state.

The concept of hysteresis (Walker et al. 2002) in resilience thinking means that the way a system has behaved in the past can provide insights into how it might behave in the future. At Zalala Beach, 11 of the 13 respondents had moved from another location to fish at Zalala Beach, thus fishers had a history of migration. In response to declines in catch rates, many fishers from Zalala would continue to migrate, just as predicted by the concept of hysteresis. In contrast, all interview respondents from Inhangome were born and raised in Inhangome. Fishers from Inhangome indicated that in response to declining catch rates, they would remain in their community, which is also in line with their history.

Step Three - Future Scenarios

Having defined the identity of the Sofala Bank social-ecological system and potential system thresholds, the final stage of the resilience analysis involves defining a small number of possible future scenarios for the system (Cumming et al. 2005). Future scenarios are defined based on the main drivers of change in the system and their impacts on system properties of interest. If the system is likely to shift into one of the alternate states, then the system is not considered resilient (Folke 2006). In my study system, the property of greatest interest is the ability of people to fish in their community. In this section, I describe three possible future scenarios for the Sofala Bank social-ecological system and discuss the likelihood of a shift into each scenario.

The first possible future scenario for the Sofala Bank social-ecological system is that fishers will adapt to challenges to their livelihoods but will continue to fish. Fishing livelihoods are notoriously dynamic, they are accustom to accommodating fluctuations in marine resources, climactic conditions and socioeconomic factors, such prices for fish or fishing materials (Coulthard 2008, Badjeck et al. 2010). In the first scenario, since fishing will continue in the community, the system would retain its identity. The second possible future scenario is that fishers will remain in their communities, but be driven into other professions in response to severely decreased landings. Since the relationship between people and fish would be broken, this scenario would mean a loss of system identity. The third possible future scenario is that fishers will continue to fish, but they will permanently leave their communities and relocate to locations where fishing is still possible. In this scenario, since the community would be dissolved as fishers and household relocate in different places, the system's identity would be lost.

Following the identification of the system's identity, thresholds and possible future scenarios, the final step in the resilience analysis is to consider the likelihood of the system shifting into one of the alternative scenarios. There are several indications that marine landings along the Sofala Bank will continue to decline. First, between 2002 and 2007 the number of small-scale fishers in Mozambique jumped from 118,247 to 280,040 (IDPPE 2004, 2009) and the number continues to rise (according to fishers in the two research communities). Second, while there are no landings

data for the small-scale sector before 2003, catch reconstruction estimates indicate that small-scale landings peaked in the mid-1980s and have since been in decline (Jacquet et al. 2010). Third, in 2011 the government of Mozambique approved a $43.5 million US project called ProPESCA designed to increase the capacity of the small-scale sectors. This project will motorize small vessels and add more, bigger nets to the small-scale sector. Therefore, fishers are likely to experience continued declining catch rates in along the Sofala Bank.

In response to hypothetical declines in catch rates of 30% and 50% most respondents indicated that they would continue to fish while investing in other livelihoods activities. It was not until a 90% decline in stocks that close to half of interview respondents indicated that they would leave the fishery or leave their community (Figure 5.4). Therefore, fishers' responses indicate that despite continuing declines in catch, the Sofala Bank social-ecological system in unlikely to experience a shift in states. Rather, fishers will diversify in order to continue fishing in their communities. What is interesting is that after a 90% decrease in catch, fishers from the two communities would respond differently. At Zalala Beach, the majority of fishers would leave the community and move to a place where fishing was still possible. In this sense, fishers expressed an attachment to occupation, which would discourage them from leaving the profession. A 33 year-old fisher said "I will encourage my sons to become fishers because this is where we come from. I inherited it from my father and they must know how to do it. It's an art we use to make money and to sustain ourselves and they will grow up knowing how the fisher's life looks." In Inhangome, on the other hand, fishers indicated that after a 90% decrease in catch, they would permanently exit the fishery, but they would stay in Inhangome. Many fishers from Inhangome expressed a strong attachment to place and a reluctance to leave their community and birthplace. Given this analysis, it seems unlikely that the Sofala Bank social-ecological system will shift into an alternate state in the near future. However, if catch rates continue to decline, separate communities within the Sofala Bank social-ecological system will shift into different state: some will migrate while others will look for alternative professions.

The goal of resilience management is to prevent social-ecological systems from moving into undesirable states (Walker et al. 2002), yet the task of identifying undesirable states is fraught with complications. The Cumming et al. (2005) framework emphasizes that a system's identity

must be described by the stakeholders who constitute the social in social-ecological systems, in other words the people who live within the system. Further, they explain that local stakeholders should select the properties of interest, the loss of which would indicate a loss of system resilience. However, the Cumming et al. (2005) framework fails to address how desirable and undesirable scenarios for the system should be described and by whom. In this regard, Lebel et al. (2006) pick up where the Cumming et al. (2005) framework leaves off. The authors propose we must also ask 'For whom is resilience to be managed, and for what purpose?' and 'What are the consequences of alternative courses of action for different stakeholder groups? (p. 19-20 Lebel et al. 2006). The characteristics of a desirable state are likely to differ depending on which individual or group is describing them. I found that fishers' have considerable heterogeneity in their response behaviour to system stressors. In response to declining catch rates fishers from Zalala would choose to move locations whereas fishers from Inhangome would choose to change professions. An important policy consideration is that some system regimes may be considered desirable by one segment of society and undesirable by another. Policy and actions should create forums where all opinions about future scenarios, solutions, the status of targeted species and social and ecological requirements are represented.

Conclusion

As rapid change increasingly impacts coastal communities, understanding how much disturbance communities will absorb, where thresholds lie and what coastal community systems might look like after thresholds are crossed are critical research questions. Resilience thinking offers a powerful theoretical lens through which to contextualize these questions and gradually resilience frameworks are being developed to measure resilience on the ground. This paper builds on the theoretical and methodological concepts of resilience by evaluating resilience in two coastal fishing communities in central Mozambique through the Cumming et al. (2005) framework for resilience analysis.

Our results indicate that coastal communities are continuously absorbing multiple sources of disturbance. I found that declining catch rates are critical drivers of change that may represent an important system threshold for communities in the Sofala Bank social-ecological system. In the case of a 30% or 50% decline in catch rates, both research communities would continue in

their present state. A 90% decline in catch rates would represent a threshold for both communities. Interestingly, in response to 90% declines in catch rates the two research communities would respond differently and their history may provide insights into how they will respond to threshold events. At Zalala Beach, which has a history of migration, fishers would respond to a 90% decline in catch by permanently moving to other locations where fishing would still be possible. In Inhangome, where fishers have lived in the community for generations, fishers would respond to a 90% decline in catch by changing to other professions and remaining in their community.

Resilience thinking is based on the understanding that change and unpredictability are central components of system dynamics. Yet, my research suggests that by analyzing the types of change systems have experienced in the past, by applying frameworks for the empirical measurement of resilience and by having people who are central to the system identify system thresholds, we will be able to increase our understanding of the complexities of coastal system resilience and will be better prepared to respond to future uncertainties. This type of knowledge about coastal systems is useful in policy terms since it contributes to the long-term goal of social and ecological sustainability.

6. Conclusion

Actions towards sustainability will require understanding of the dynamics of complex social-ecological systems (Folke et al. 2003). Thus, the focus of this dissertation is the study of social-ecological system dynamics over time. Specifically, the research focuses on how small-scale fishers along Mozambique's central coast have dealt with a specific set of challenges in the past and how they might cope with future changes in their social-ecological system. In particular, the dissertation addresses four research objectives: i) to reconstruct historical social-ecological system dynamics by combining data from multiple sources and scales; ii) to examine how fishers are currently adapting to social-ecological change; iii) to analyze how employment at a large scale shrimp farm affects livelihood vulnerability; and iv) to assess the resilience of small-scale fishing livelihood systems. This chapter reviews the major research findings of the four main dissertation chapters, discusses some of the limitations of the research and presents some theoretical, methodological and policy contributions of this research to the literature.

Principle Research Findings

Research finding 1: ***By combining fishers' knowledge with landings data, new insights can be generated into the drivers of and responses to social-ecological dynamics in small-scale fisheries over time.***

Landings data for the small-scale fishery in Mozambique are limited (data only exist from 2003 onwards) and underestimate catch for the small-scale sector (Jacquet et al. 2010). This lack of reliable data creates a significant barrier against successful understanding and management of the coastal Mozambican fishery considering small-scale landings account for more than 80% of total national landings (FAO 2011). In Chapter 2, in order to supplement landings data, I conducted career history interviews with fishers in central Mozambique designed to improve our understanding of social-ecological restructuring along the coast. Fishers' knowledge proved to be an invaluable source of information. Fishers provided detailed descriptions of: change in fish distribution and abundance; physical environmental changes; social and cultural changes; regulatory changes; and how they had modified their fishing practice in response to the experienced changes.

The research demonstrates that the coastal fishery cannot be adequately analyzed from data from a single source. Particularly in cases where data are incomplete and underestimate catch, there is a need to supplement aggregate landings statistics, such as those supplied to the Food and Agricultural Organization (FAO), with other data in order to better understand the dynamics of intensification, expansion, and stock depletion in coastal small-scale fisheries (Pauly and Zeller 2003; Murray et al., 2006; Murray et al., 2008; Berkes, 2003). I argue that fishers can provide critical information – particularly in data poor situations – on changes in stock distribution and abundance as well as changes in fishing effort and fishing practices that are critical for interpreting catch-rate data (Haggan et al. 2007). Furthermore, historical career interviews provide a powerful means to collect and preserve accumulated experience on which future change will be based. As Springer (2011, p. 307) argues:

> *The qualitative evidence of stakeholders – essential human dimensions in the social-ecological system of fisheries – is important data in any time period. When linked over the long term, such evidence can provide us with a vital chain of development in attitude, culture, economy, ecology and society, not only locally, but also nationally and globally.*

Historical reconstructions based on data of multiple types and scales will capture the complexities that characterize interactions between fish, fishers and their social-ecological context more effectively than any single data type.

Research finding 2: ***Small-scale landings are in decline along the Sofala Bank, Mozambique.***
Prior to this dissertation research, the only landings data which existed for the small-scale fishery in Mozambique prior to 2003, were reconstructed catch estimates calculated by the Fisheries Centre at the University of British Columbia (Jacquet et al. 2010). While there is a fairly high level of uncertainty associated with their estimates, their reconstruction suggests that small-scale landings peaked in the mid-1980s followed by a subsequent decline, which suggests overfishing of local resources (Jacquet et al. 2010). More data on the small-scale fishery is clearly needed. By interviewing older fishers in central Mozambique in Chapter 2, my dissertation research adds weight to the claim that landings in central Mozambique are in decline. Fishers from Zalala Beach indicate that the inshore, shallow waters are depleted and that fish length is decreasing. In data poor countries like Mozambique, additional data on the status of the fishery is critically important for fisheries governance.

Research finding 3: ***It is not the poorest fishers who are least able to adapt to change, but rather fishers who are highly invested in a declining fishery.***

Chapter 3 investigates how fishers' are adapting to drivers of change in two communities in Mozambique by focusing on livelihoods, assets and adaptive strategies. Primarily, fishers in central Mozambique are adapting through intensifying their fishing efforts or by diversifying their livelihoods. Intensification involves increasing the length of individual fishing trips, fishing in the open ocean as opposed to along the shore and fishing at night. Diversification involves taking extra non-fishing related such as the sale of wood from mangroves for fuel, sale of goats and chickens, work in the *machamba*, production and sale of charcoal, work as a fish trader (called *compradores*), work as a bicycle mechanic, and casual labour in Quelimane. Despite the literature that portrays diversification as the strategy of the poorest households, I argue that diversification increases adaptive options, which in turn increases their ability to adapt to periods of livelihood stress. Further, by participating in a range of fishing and non-fishing related livelihood activities, fishers who diversify reduce fishing pressure which may contribute to long term sustainability of the social-ecological system. Therefore, I argue that it is not the poorest fishers who are least able to adapt to change, but fishers who are highly invested in, and thus locked into, a declining fishery.

Research finding 4: ***Fishers' adaptations are facilitated by fishers' groups, occupational pride and family networks; adaptation is inhibited by limited assets, adaptive actions with negative social and ecological impacts, competition over declining resources and pervasive poverty.***

Small-scale fishers in Mozambique are very poor yet they demonstrate a remarkable range of adaptive actions. Not unexpectedly, fishers do not undertake adaptive actions autonomously: they are assisted by a number of factors. By facilitating dialogue between fishers and government employees and NGOs, assisting with conflict resolution and negotiating credit for fishers, fishers' groups play an important role in supporting fishers' adaptations. In addition, fishers demonstrated a strong sense of occupational pride, which motivated them to undertake adaptations within the fishery rather than turning to other professions. Finally, family networks play a critical role in facilitating adaptation by providing loans, additional sources of income and emotional support to fishers.

On the other hand, several factors inhibit fishers' ability to adapt to stressors. Limited assets, such as low literacy rates and lack of savings, reduce the number of adaptations available to fishers. When other alternatives are limited and fishers respond to declining catch by increasing their fishing efforts, a negative feedback cycle is created. Overfishing can lead to social conflict and ecological damage, which can in turn lead to further resource exploitation. This type of cycle inevitably inhibits constructive adaptive actions. Many of the factors that inhibit adaptation in my two research communities, limited assets, actions with negative social and ecological impacts, competition over declining resources and pervasive poverty, are indications of problems that run deeper. Therefore, my results suggest that non-sectoral interventions that build human and social capital may be more effective in strengthening the livelihoods of coastal communities than those targeting fishing assets alone.

Research finding 5: ***Shrimp farm employees' are less vulnerable to chronic stressors, such as poverty, than non-farm employees but more vulnerable to acute shocks, such as the White Spot Virus Syndrome, associated with shrimp production.***

Global demand for shrimp is projected to grow; therefore investors are looking for new areas for shrimp aquaculture production. The Western Indian Ocean has an ideal climate for shrimp production and is largely undeveloped. In order for shrimp aquaculture to be sustainably developed along the east coast of Africa, research is needed on the impacts of shrimp farming on local communities. By comparing the livelihood vulnerability of shrimp farm employees and non-farm employees I found that employment at an export-oriented shrimp farm in Mozambique reduced employees' vulnerability to chronic stressors in comparison with non-farm employees. Farm employees had higher financial, human and physical capital than non-farm employees making them stronger in the face of stressors. In addition, a number of adaptive strategies, including taking extra shifts or taking a loan from the company, were available to assist farm employees that were not available to non-farm employees. However, in 2011, the White Spot Virus appeared in Mozambique for the first time and all the shrimp farm employees were laid off for approximately one year. This event exposed a nuance of vulnerability not often discussed in the vulnerability literature. While working at the farm reduced employees' vulnerability to chronic stressors, the appearance of the WSSV demonstrated that they are very vulnerable to acute shocks that affect farm production. Non-farm employees were not vulnerable by the

outbreak of the WSSV. This duality is an important contribution to discussions of livelihood vulnerability.

Research finding 6: ***Using occupation as a proxy for sensitivity is a useful way to measure sensitivity in empirical analyses of vulnerability.***

In the literature, vulnerability is often characterized as a function of exposure, sensitivity and adaptive capacity. While the theoretical basis of this understanding is well developed, the methodology for measuring these characteristics lags behind. In particular, measuring the sensitivity of a system, meaning the degree to which a system is affected by a stressor or shock, is largely undefined. This dissertation research builds on the suggestion that sensitivity of social systems can be measured by using occupation as a proxy for sensitivity (Allison et al. 2009, Cinner et al. 2011). I propose that household sensitivity is directly related to primary livelihood activity. For example, shrimp farm employees are highly sensitive to stressors that affect the shrimp production systems, such as the WSSV. On the other hand, non-farm employees who rely on subsistence agriculture are highly sensitive to stressors that affect the agricultural production system, such as drought. Improving the methods for empirical analyses of vulnerability is an important step towards understanding the vulnerability of social-ecological systems to global change.

Research finding 7: ***Fishers can identify social thresholds and explain how they would respond, thus increasing our understanding of resilience in social-ecological systems.***

One of the goals of resilience research is contribute to governance systems that prevent social-ecological systems from moving into undesirable states. Effective governance depends on the system being able to cope with stressors and shocks in the face of unpredictable change. This requires understanding of how much disturbance a system can absorb, where thresholds lie and what social-ecological systems might look like a threshold is crossed. My dissertation research contributes to this goal by evaluating the resilience of two fishing communities in central Mozambique. In Chapter 5, I found that communities are constantly absorbing multiple sources of disturbances without losing their principal identity. I identified that declining catch rates are critical drivers of change that have the potential to push these systems into qualitatively different states. In response to 30% and 50% decline in catch, both communities would retain their

identity. After a 90% decline in catch a threshold would be crossed and both communities would shift into a qualitatively different state. The history of each system provides insights into how they will respond to threshold events, a concept referred to as hysteresis. At Zalala Beach, where the majority of fishers have migrated from other areas, fishers would respond to a 90% decline in catch by permanently moving to another location where fishing would still be possible. In Inhangome, where the majority of fishers have had family in the community for generations, fishers would respond to a 90% decline in catch by changing their primary occupation and remaining in their community. By having fishers, who are the central social component of fishing communities, define thresholds and explain how they would respond, this research contributes to a body of knowledge that can be used to guide coastal governance. An important area for future resilience research along the Mozambican coast will be to have central stakeholders describe desirable and undesirable system configurations and then identify ways to build resilience within coastal systems.

Limitations of the Research

Inevitably, each research approach will have both strengths and weaknesses. There are three areas where I see space for strengthening my dissertation research.

My field research approach, which was based three field seasons of several months each spread over a period of 3 years, had both merits and drawbacks. Since I did not remaining in my research communities for a year or more consecutively I lost depth in my research. My research would have benefited from longer immersion in my research communities. However, I argue that the depth lost was made up for by several factors. First, by returning to the communities over a number of years, I was able to develop strong relationships with community members. Second, the time I spent in Canada analyzing and reflecting on the research in between field seasons allowed me to improve my research questions, tools and find holes in my data which needed to be filed. Third, by working with my communities over a number of years, I was able to observe inter-annual trends, such as variability in catch rates and the outbreak of the White Spot Virus, which I would have missed if I had only remained in the field for one or two seasons.

In Chapter 3, I examined how fishers are adapting to multiple sources of change along the Mozambican coast. My data demonstrate that fishers are adapting through fishing intensification or livelihood diversification. However, my data cannot speak to the impacts of those actions on the social-ecological system. Therefore, while my research provides an important indication of how fishers are currently behaving, it has limited explanatory power because it cannot address how adaptive actions are impacting on the system. The research would be strengthened by exploring the material outcomes of the adaptive strategies being employed.

Finally, resilience thinkers propose that resilience is built through four factors: i) learning to live with change and uncertainty, ii) nurturing the diversity for reorganization and renewal, iii) combining different types of knowledge for learning and iv) creating opportunity for self-organization (Berkes et al. 2003). By documenting how coastal social-ecological systems have behaved in the past and identifying where potential thresholds may lie, my data improves our understanding of past crises and potential future disturbances, and addresses the first factor, learning to live with change and uncertainty. In addition, my research contributes to the potential for reorganization and renewal (second factor) by documenting fishers' historical experiences, and thus adding to social-ecological memory for the coastal Mozambican fishery. Furthermore, my research has benefited from combining fishers' knowledge, landings data, peer-reviewed literature, dissertations, technical papers and project reports, which is the third factor for building resilience. However, my research does not address the fourth factor for building resilience. More attention to multi-scale interactions would strengthen the research. Moreover, the research would benefit from a closer analysis of the capacity for self-organization.

Contributions to the Literature

Contributions to Theory

My dissertation aims to contribute to the efforts towards social-ecological system sustainability. Specifically, my research aims to contribute to our understanding of how small-scale fishers have adapted over time to cope with a set of challenges and how likely they are to cope effectively with future changes in their complex social-ecological systems, through the lens of resilience thinking. The research provides insights about the interactions between, and within, social and

ecological sub-systems over time. While my research does not propose a new theory, it makes important contributions that advance our thinking on existing theories in four areas.

First, one of the biggest critiques of resilience theory is that while it is a very effective way to describe the behaviour of complex systems theoretically, it is a difficult concept to operationalize. My research addresses this limitation by using socially defined thresholds of change to predict how two communities will respond to future events. By having the communities identify potential system thresholds and then having them explain how they would respond to those thresholds, I was able to quantify the resilience of fishing communities. This approach contributes towards making resilience theory more empirically useful.

Second, my research speaks to the importance of including historical analysis in resilience analyses, particularly since it may provide insight into how a system will respond to a threshold event in the future. Hysteresis, that is the notion that the past behaviour of a system can offer insights into its future behaviour, is a concept that is briefly mentioned in the resilience literature but it remains largely underdeveloped. In my resilience paper, the past behaviour of a community was a strong predictor of their future behaviour. This finding adds weight to the concept of hysteresis and suggests that future research will make important contributions to resilience theory.

Third, by demonstrating that a single factor may simultaneously increase and decrease vulnerability depending on the stressors, my research improves our theoretical understanding of vulnerability. This duality is largely absent from the literature thus far and represents an important contribution of the research.

Finally, in 2009 Ian Scoones published an important review paper on livelihoods research. In the paper, he identified several failings of the livelihoods approach. By combining resilience theory with the livelihoods approach, we can address these failings. His first critique is about the lack of engagement with processes of globalization in livelihoods research. In this regard, resilience's emphasis on the importance of scale addresses this concern. My research, for example, considered how changes ranging from the local to the global scale may affect small-

scale fishing livelihoods. Next, Scoones identifies the lack of engagement with global environmental change as a limitation within livelihoods research. To this point, resilience literature emphasizes the importance of considering social-ecological systems, thus advocates for research that explores how changes in the environment, including climate change, impact rural livelihoods. Finally, Scoones argues that livelihoods research often fails to grapple with long-term shifts in rural economy. Resilience theory emphasizes not only spatial scales, but also temporal scales. Based on the case studies I have presented in my dissertation, I argue that livelihoods research can be strengthened by combining it with a resilience research approach.

Contributions to Methods

My dissertation makes three contributions to methods for the empirical analyses of resilience. First, in Chapter 2, my research demonstrates that fishers' knowledge is a critical source of data for historical reconstructions of fisheries, particularly in data poor regions of the world. Fishers' knowledge adds depth and detail to historical reconstructions not attainable based on landings data alone. Further, fishers' catch estimates can provide baseline catch data when landings data are not available, as is the case in Mozambique. Understanding the historical of system dynamics is a critical step for any resilience analysis.

Second, by using occupation as a proxy for measuring sensitivity, my research improves our ability to study system vulnerability. Methodological details on how to measure sensitivity in vulnerability analyses, based on the exposure, sensitivity and adaptive capacity frameworks, have been surprisingly lacking. My research in Chapter 4 addresses this gap.

Third, my dissertation research adds to the Cumming et al. (2005) framework for the empirical analysis of resilience. Cumming et al. (2005) propose a research framework based on three steps: i) defining the systems' identity (which is made up of system components, system relationships, sources of innovation and sources of continuity), ii) identifying potential system thresholds and iii) defining a number of possible future scenarios. The first element of this framework, defining the systems' identity, is well explained in their original paper. However, details on how social thresholds should be defined are less clear. In my research, I adapted a methodology used by Cinner et al. (2011) to define social thresholds. Through fishers'

interviews, I identified that declining catch rates were the most challenging disturbance for the communities. Then, I had fishers explain how they would respond the hypothetical reductions in catch rates. In this way, without forcing the systems to pass a threshold, I were able to identify where thresholds would lie for each community. This is an important methodological contribution to resilience research since thresholds are often difficult to detect until they are crossed.

Contributions to Policy

I would like to begin this section by acknowledging that I have no formal training in policy development or implementation. Therefore, the aim of my dissertation research is to be policy relevant as opposed to policy prescriptive. In this context, my research makes two policy relevant contributions.

Three decades ago Ludwig et al. (1993) called for conservation action that superseded scientific consensus. They argued that action to curb resource exploitation was urgently needed based on the existing scientific data. Yet, their call has gone largely unheeded and marine resources continue to be exploited at an alarming rate. In Mozambique, official landings data are incomplete yet my data suggest that inshore marine stocks are heavily depleted. Mozambique's problems of overfishing and a growing number of small-scale fishers show no signs of waning. These results suggest that the long term sustainability of the Mozambican fishery will require policy directed towards reducing fishing efforts.

In order to strengthen the livelihoods of rural fishers, policies and international programmes in Mozambique are often focused on improving the fishing capacity of fishers. For example, in 2011 the government of Mozambique approved a $43.5 million US project, called ProPESCA, which will motorize small vessels and add more, bigger nets to the small-scale sector. However, my data suggests that policy aimed at broader sectoral interventions, that strengthen human and social capital, may be more effective at building adaptive capacity in rural fishing communities. In Chapter 3, I found that many of the factors that inhibit adaptation in my research communities, limited assets, actions with negative social and ecological impacts, competition over declining resources and pervasive poverty, are indications of broader community problems often

associated with poverty. Therefore, my results suggest that non-sectoral policy interventions that build human and social capital may be more effective for strengthening the livelihoods of coastal communities than those targeting fishing assets alone.

Ultimately, my research demonstrates that fishers are infinitely adaptable agents within social-ecological systems. They have a history of responding to multiple drivers of change and they employ a variety of adaptation strategies, which they constantly adjust.

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Appendix A

Historical Interview (2012)

Date: _____

Age: _____When did you start fishing?_____

General questions:
1. Where were you born?
2. In you were not born at Zalala Beach, when did you move here? Why did you move?
3. Why did you become a fisher?
4. Was your father a fisher? Your grandfather?

Boat
5. What type of boat do you fish from? Do you own the boat?
    1. If yes, did you previsouly work on an industrial ship? For how long?
    2. Or, were you previously a skipper? For how long?
    3. Or, were you previously a crew member? For how long? No
6. When you started fishing, what type of boat did you use?
    1. If the type of boat changed, when and why did you change the type of boat?

Gear
7. Currently, what type of net do you use? What material is the net made of? What size of mesh?
8. When you began fishing, what ype of net did you use?
    1. If the type of net has changed, when did you change and what was the motivation for changing net types?

Catch
9. During which months do you catch the most fish and shrimp?
10. During the high season, how much do you catch per day (Kg)?
11. When you started fishing, how many kilos would you catch during the high season (Kg/day)?
12. During which months do you catch the least fish and shrimp?
13. During the low season, how much do you catch per day (Kg)?
14. When you started fishing, how many kilos would you catch during the low season (Kg/day)?
15. How are you dealing with the declining catch (other work, make more trips, fish at night, change net type, use a better boat)?

Fishers

16. Why do you think people are coming here to fish? (problems inland, lack of jobs, profitability of fishing)?

Weather

17. Has the weather changed since you started fishing here?
    1. If yes, how does it impact on the amount you catch?
18. Is there anything else you would like to add about changes in the fishery at Zalala Beach?

Entrevista Histórica (2012)

Data: _____

Idade:_____ Quando você começou a pescar?_____

Perguntas genéricas:
1. Onde você nasceu?
2. Se você não é de Zalala quando que você se mudou para cá? Por que você se mudou?
3. Por que você se tornou um pescador?
4. Seu pai era um pescador? Seu avô?

Barcos
5. Como que tipo de barco você pesca? Você e o proprietario?
    1. Se sim, você trabalhou antes em um navio industrial? Por quanto tempo?
    2. Ou, você foi capitão? Por quanto tempo?
    3. Ou, você foi antes um tripulante? Por quanto tempo?
6. Quando você começou a pescar, qual o barco que você usou?
    1. Se o tipo de barco mudou, quando e por que você mudou de barco em que pesca?

Material
7. Agora, qual o tipo de rede que você usa para pescar? A rede é feita de qual material? Qual é o tamanho da malha?
8. Quando você começou a pescar, qual o tipo de rede que você usou?
    1. Se o tipo de rede mudou, quando voce alterar o tipo de rede e qual foi o motivo?

Pesca
9. Durante quais meses você pesca mais peixes e camarões?
10. Durante a alta temporada, quanto você pesca por dia (Kg)?
11. Quando você começou a pescar, quantos quilos você pescava por dia durante a alta temporada(Kg)?
12. Durante quais meses você pesca menos peixes e camarões?
13. Durante a baixa remporada, quanto você pesca por dia (Kg)?
14. Quando você começou a pescar, quantos quilos você pescava por dia durante a baixa temporada(Kg)?
15. Como você está lidando com o declinio da pesca? (tem outro trabalho, faz mais viagens, pesca de noite, muda o tipo de rede, usa um barco maior)

Pescadores

16. Por que você acha que as pessoas estão vindo pescar aqui? (problemas no interior, falta de empregos, a pesca dá lucro?)

Tempo

17. Será que o tempo mudou desde que comecou a pescar?
    1. Se sim, como isso afeta a quatidade de peixe que você pega?
18. Tem mais alguma coisa que você gostaria de adicionar sobre as mudanças na pesca na praia de Zalala?

Appendix B

Household Survey (2010)

Date: _____

Age: _____

Level of education: primary school ( )
secondary school ( )
none ( )

Can you read and write? Yes/No (please circle)

Are you the primary earner in your family? Yes/No (please circle)

How many people in your family/how many people do you support?_____

Which stressors have you experienced in the last 12 months?	**Yes**	**No**
flood		
drought		
severe storm		
catch less fish		
decreased price of fish		
increased cost of nets/equipment		
damage to fishing gear		
theft of fishing gear		
accident		
disease/illness		
death of a family member		
social conflict		
lack of food		
theft (if yes, what was stolen?)		
had to lend money to family		
house falling apart/damage		
others? (please list)		

How to you cope with those stressors?	Yes	No
taking less food		
extra work (if yes, what kind of work?)		
change net size/type (if yes, please explain)		
change of profession (if yes, change to what profession?)		
sale of fishing equipment		
sale of livestock/poultry		
loan from PCR/bank		
loan from a family member		
use of savings		
others? (please list)		

Do you own the following?	Yes	No
net (if yes, what type?)		
• seine net		
• gill net		
• fishing pole		
boat (if yes, what type?)		
• dugout canoe		
• lancha with sail		
• lancha you row		
• lancha with motor		
machamba		

house (if yes, what type?)		
• steel roof		
• grass roof		
livestock		
cell phone		
bicycle		
access to a well		
access to a school for your children		
access to a doctor (if yes, what type?)		
• courandeiro		
• hospital		
savings ($)		
are you married?		
extended family in the community		
belong to a fishers' group		
moved from another area to fish in the present location		
others? (please list)		

Pesquisa Doméstico (2010)

Data: _____

Idade: _____

Nível educação: nível priméria ( )
nível secundaria ( )
nenhum ( )

Você sabe ler e escrever? Sim/Não (por favor círculo)

Você é quem recebe o maior salário na sua família? Sim/Não (por favor círculo)

Quantas pessoas tem no sua família/ pessoas você suporta? _____

Que tipo de dificuldade você enfrentou nos últimos 12 meses?	**Sim**	**Não**
inudação		
seca		
tempestade		
captura de poucos peixes		
redução nos preços dos peixes		
aumento dos preços de redes		
danos nos equipamentos de pesca		
roubo de equipamento de pesca		
acidente		
doença		
morte de um membro da família		
conflito social		
falta de comida		
roubo (se sim, o que foi roubado?)		
emprestar dinheiro para sua família		
danos nos casa		
outros? (adicione)		

Como você resolveu esses dificuldades?	**Sim**	**Não**
poupou comida		
fez outros trabalhos (se sim, que tipo?)		
mudou o tamanho/tipo da rede (se sim, por favor explicar)		
mudou de profissão (se sim, que tipo?)		
vendeu o equipamento de pesca		
venda de gado / aves		
empréstimo no PCR/banco		
empréstimo de família		
uso da poupança		
outros? (adicione)		

Você tem?	**Sim**	**Não**
rede (se sim, que tipo?)		
• arrasto		
• emalhe		
• linha de mão		
barco de pesca (se sim, que tipo?)		
• tronco escarado		
• lancha vela		
• lancha remo		
• lancha motor		
machamba		

casa (se sim, que tipo?)		
• telhado de aço		
• telhado de grama		
criação de animal		
celular		
bicicleta		
acesso ao poço		
acesso a escola para seus filhos		
acesso ao medico (se sim, que tipo?)		
• courandeiro		
• hospital		
poupança ($)		
é casado?		
membros da família na comunidade		
pertence a um grupo de pescador		
você veio de um outro local para pescar?		
outros? (adicione)		

Appendix C

Fishers' Interview (2010)

Date: _____

Age: _____ Gender: _____

General

1. How long have you been a fisher?
2. Did you have a different profession before you were a fisher? What was it?
3. Why did you become a fisher?
4. Were your parents fishers?
5. Are you the primary earner for your family? If not, who is and what do they do?

Historical

6. How was the fishery before the 1990s? (before the IDPPE and fishers' organizations?)
7. Has the type of fishing gear used in Zalala[2] changed over time? Why?
8. Has the species of fish caught changed over time? Why?
9. Have fishing regulations changed over time? How?
10. What are the biggest changes in the fishery since you have been fishing?
11. What is causing these changes?

Ecological

12. What species do you fish? Why is this your target species?
13. Have you noticed a decline in the amount of catch?
14. If yes, what do you think is causing the change?
15. Are you changing your practices to compensate for this change? Do you use different gear or go further to fish? Explain.
16. Are you concerned about the decline in fish? Why?
17. How does the environment affect fishing?
18. Have you seen changes in the environment since you have been fishing here? Explain.
19. Describe the effect of storms on the community.

Technological

20. What type of boat do you fish from? Have you ever used a different type of boat? If so, when and why did you change?
21. Has the type of net you use changed? From what to what? Why?
22. How many days a week do you fish? How many hours a day?

[2] Fisher interviews were conducted with fishers at both Zalala Beach and Inhangome.

23. Has the amount of time you spend fishing changed? Why?
24. Where do you fish? Do you have to travel further to fish now? If yes, why?
25. What type of gear would improve your catch?

Economic

26. Do you sell you catch to compradores, the community or consume it?
27. How long have compradores been buying fish from Zalala?
28. Which type of species to the compradores want to buy?
29. How are you paid for your catch?
30. Do you agree with the prices paid by the compradores?
31. Do you have any savings?
32. Do you have any debt? If so, to who?

Regulation

33. What are the rules about fishing in Zalala?
34. Do you need a license to fish in Zalala? Do you have a licence?
35. Is there a closed season? If so, when is it?
36. Are there regulations about the mesh size in nets? Is this followed in Zalala
37. Who enforces the rules?
38. Have the rules changed since the 1990s?

Social

39. Are you part of a fishers group?
40. What is the role of fishers groups?
41. How does being part of a fishers group help you?
42. What role do women play in the fishery in Zalala?
43. Are there conflicts between local and immigrant fishers in Zalala? Explain.
44. Are there conflicts between artisanal fishers and commercial fishers? Explain.
45. Is this new, or have there always been conflicts?

The Future

46. Do you want to continue fishing? If not, what profession would you like to do?
47. What are the main challenges for fishers in Zalala?
48. If you could make changes, what would improve your ability to fish?
49. What changes would improve your life/wellbeing in Zalala?
50. Would you consider aquaculture? Why?

Entrevista Pescadores (2010)

Data: _____

Idade: _____ Sexo: _____

Geral

1. Há quanto tempo você é pescador?
2. Você teve alguma profissão diferente antes de ser pescador? Qual era?
3. Por que você se tornou um pescador?
4. Os seus pais eram pescadores?
5. Você é quem ganha a maior renda em sua família? Se não, quem é e o que faz?

História

6. Como era a pesca antes dos anos 90? (antes das organizações de Pescadores e do IDPPE?)
7. O tipo de equipamento de pescagem usado em Zalala mudou ao longo do tempo? Por que?
8. As espécies de pescados mudaram ao longo do tempo? Por que?
9. Os regulamentos da pesca mudaram ao longo do tempo? Como?
10. Que são as maiores mudanças na pesca desde que você começou a pescar?
11. O que está causando as mudanças?

Ecologia

12. Que espécie você pesca? Por que seu alvo é esta espécie?
13. Você observou um declínio na quantidade de pesca?
14. Si sim, o que você acha que está causando a mudança?
15. Você está mudando suas práticas para compensar esta mudança? Você usa algum equipamento diferente ou vai mais longe para pescar? Explique.
16. Você está preocupado com a redução dos peixes? Por que?
17. Como o meio ambiente afeta a pesca?
18. Você viu mudanças no meio ambiente desde que você tem pescado aqui? Explique.
19. Descreva o efeito das tempestades na comunidade

Tecnologia

20. Com qual tipo de barco você pesca? Você já usou algum tipo de barco diferente? Em caso afirmativo, quando e por que?
21. O tipo de rede que você usa mudou? De que para que? Por que?
22. Quantos dias na semana você pesca? Quantas horas por dia?
23. A quantidade de tempo que você gasta pescando mudou? Por que?
24. Onde você pesca? Você tem que ir mais longe para pescar agora? Se sim, por que?
25. Que tipo de equipamento melhoraria sua pesca?

Econômico

26. Você vende sua pesca aos compradores, a comunidade ou o consome?
27. Há quanto tempo os compradores têm comprado os peixes de Zalala?
28. Que tipo de espécie aos compradores querem comprar?
29. Como é você pago pela sua pesca?
30. Você concorda com os preços pagos pelos compradores?
31. Você tem alguma economia/poupança?
32. Você tem alguma dívida? Em caso afirmativo, a quem?

Regulamento

33. Que são as regras sobre a pesca em Zalala?
34. Você precisa de licença para pescar em Zalala? Você tem uma licença?
35. Existe um periodo fechado para pesca? Em caso afirmativo, quando é?
36. Existe regulamentos sobre o tamanho das telas nas redes? Isto é seguido em Zalala?
37. Quem aplica as regras?
38. As regras mudaram desde o dos anos 90? Explique.

Social

39. Você é parte de um grupo dos pescadores?
40. Qual é o papel dos grupos dos pescadores?
41. Como é que ser parte do grupo do grupo de pecadores te ajuda?
42. Qual papel que as mulheres desempenham na pesca em Zalala?
43. Existe conflitos entre pescadores locais e imigrantes em Zalala? Explique.
44. Há conflitos entre Pescadores artesanais e comerciais? Explique.
45. Isto é novo, ou sempre tem tido conflitos?

Futuro

46. Você quer continuar pescando? Se não, que profissão você gostaria de ter?
47. Quais são as principais dificuldades para os pescadores em Zalala?
48. Se você pudesse fazer alguma mudança, o que melhoraria sua habilidade em pescar?
49. Quais mudanças melhorariam sua vida/bem estar em Zalala?
50. Você consideraria a piscicultura/aquacultura? Por que?

Appendix D

Shrimp Farm Employee Interview (2010)

Date: _____

Age: _____ Gender: _____

1. Level of education: primary school ( )
   secondary school ( )
   none ( )

2. Can you read and write?
3. How long have you worked for the shrimp farm?
4. How did you find out about the job at the shrimp farm?
5. Were there any requirements to get the job? If yes, what were they?
6. Are you the primary income earner for your family? If not, who is and what do they do?
7. How many people in your family/how many people do you support?
8. Would other members of your family like to work at the shrimp farm? Why/why not?
9. How many days a week do you work?
10. How many hours/day?
11. What is your monthly salary?
12. Is your salary fair? Why?
13. Where did you work before the shrimp farm?
14. Has your life improved since working at the shrimp farm? If yes, how?
15. Does working at the shrimp farm help you manage your daily challenges (for example, drought, disease, lack of food, etc?) How? Can you give an example?
16. Have you taken a loan from the shrimp farm? If yes, why?
17. When you are sick, do you get time off work? Is it paid or unpaid?
18. Do you buy shrimp from the shrimp farm? Why/why not?
19. How was this land used before the shrimp farm was here?
20. Are there people in the community who are jealous of your job? Does this create conflict?
21. Does your extended family (i.e. brothers, aunts, nephews, etc.) ask for more help/money from you since you are working at the shrimp farm?
22. What could be done to improve your job at the shrimp farm?
23. Is there anything else you would like to add about working at the shrimp farm?

Inhanssunge (non-farm employee) Interview (2010)

Date: _____

Age: _____ Gender: _____

1. Level of education: primary school ( )
   secondary school ( )
   none ( )

2. Can you read and write?
3. What do you do to earn money (what is your profession)?
4. Are you the primary income earner for your family? If not, who is and what do they do?
5. How many people in your family/how many people do you support?
6. What do you grow in your machamba?
7. What are the biggest problems in Inhanssunge?
8. How do these problems affect the community?
9. Have you observed changes in the environment? (drought/flood etc.)
10. How do these changes affect the community?
11. Please describe the effect of storms on the community.
12. Please describe the effect of disease on the community.
13. Please describe the effect of theft on the community.
14. Do you have savings?
15. Do you have any debt? If so, to whom?
16. Would you consider participating in small scale aquaculture? Why?
17. Would you like to work at the shrimp farm? If yes, why?
18. What improvements would you like to see in Inhanssunge?
19. What changes would improve your standard of living/wellbeing?

Entrevista a Empregada Fazenda de Camarão (2010)

Data: _____

Idade: _____Homem/Mulher: _____

1. Nível educação: nível priméria ( )
nível secundaria ( )
nenhum ( )

2. Você sabe ler e escrever?
3. Quanto tempo você trabalhou para a fazenda de camarão?
4. Como e que você soube deste emprego na fazenda de camarão?
5. Havia alguns requisitos necessarios para este emprego na fazenda de camarão? Se sim, quais eram?
6. Você é quem recebe o maior salário na sua família? Se não, quem é e o que faz?
7. Quantas pessoas tem no sua família/ pessoas você suporta?
8. Outros membros de sua família querem trabalhar na fazenda de camarão? Por que/porque não?
9. Quantos dias de semana você trabalha?
10. Quantas horas num dia?
11. Que é o seu salário mensal?
12. Acha que este salário e justo? Por que?
13. Onde trabalhava antes de ser empregado na fazenda de camarão?
14. A sua vida melhorou desde que trabalha para fazenda de camarão? Como?
15. O seu emprego na fazenda de camarão lhe ajuda a lidar com os desafios do dia a dia (como a seca, a doença, a falta do alimento, etc.?) Como? Pode você dar um exemplo?
16. Você ja alguma vez pediu um empréstimo a fazenda de camarão? Porque?
17. Quando esta doente pode pedir despensa do trabalho? É pago ou não pago?
18. Você compra o camarão de fazenda de camarão? Por que/porque não?
19. Como esta terra foi usada antes da fazenda de camarão vir para aqui?
20. Há individuous na comunidade que estao ciumentos de seu trabalho? Isto cria algum conflito?
21. Sua família extensa (isto é irmãos, tias, sobrinho, etc.) pede mais ajuda/dinheiro de você desde que você está trabalhando em fazenda de camarão?
22. Que podia ser feito para melhorar seu trabalho na fazenda de camarão?
23. Há qualquer outra coisa que você gostaria de adicionar sobre o trabalho na fazenda de camarão?

Entrevista Inhanssunge (2010)

Data: _____

Idade: _____Homem/Mulher: _____

1. Nível educação: nível priméria ( )
   nível secundaria ( )
   nenhum ( )

2. Você sabe ler e escrever?
3. O que faz para ganhar dinheirão (qual e sua profissão)?
4. Você é quem recebe o maior salário na sua família? Se não, quem é e o que faz?
5. Quantas pessoas tem no sua família/ pessoas você suporta?
6. O que costumam cultivar nas suas machambas?
7. Quais são os maiores problemas em Inhanssunge?
8. Como estas problemas afetam os communidades?
9. Você observou alguma mudança no meio ambiente? (seca/ inundação etc.)
10. Como estas mudanças afetam os communidades?
11. Por favor, descreva o efeito das tempestades na comunidade
12. Por favor, descreva o efeito das doenca na comunidade
13. Por favor, descreva o efeito das roubo na comunidade
14. Você tem alguma economia/poupança?
15. Você tem alguma dívida? Em caso afirmativo, a quem?
16. Você consideraria a piscicultura/aquaculture pequena escala? Si sim, por que?
17. Você gosta de trabalhar na fazenda de camarão? Si sim, por que?
18. Que melhorias você gostaria de ver em Inhanssunge?
19. Quais mudanças melhorariam sua vida/bem estar?

Appendix E

Resilience Interview (2012)

Age: When did you start fishing?

System attributes

1. How long have people been fishing at Zalala[3] Beach?
2. Was your father a fisher? Was your grandfather a fisher?
3. Do you have any other sources of income? If yes, what are they?
4. Were you born in Zalala Beach? If not, why did you move here?

System drivers

5. What are the main challenges to earning your living as a fisher?
6. What is causing these changes?
7. How do you cope with these challenges?

Thresholds

8. If your catch decreased by 30%, how would you cope or adapt? Would you continue to fish at Zalala Beach or change your profession or the location where you fish? Please explain.
9. If your catch decreased by 50%, how would you cope or adapt? Would you continue to fish at Zalala Beach or change your profession or the location where you fish? Please explain.
10. If your catch decreased by 90%, how would you cope or adapt? Would you continue to fish at Zalala Beach or change your profession or the location where you fish? Please explain.
11. If fishing became prohibited at Zalala Beach, would you stay? What would you do for income or to sustain yourself?

Future Scenarios

12. If you have children, will you encourage them to become fishers? Why or why not?
13. Is there anything that could cause you to leave Zalala Beach? Please explain.
14. Is there anything you would like to add?

[3] Resilience interviews were conducted with fishers at both Zalala Beach and Inhangome.

Entrevista Resiliência (2012)

Idade: Quando você começou a pescar?

Os atributos do systema

1. Há quanto tempo as pessoas pescam na praia de Zalala?
2. Seu pai foi pescador? Seu avô foi pescador?
3. Você tem outra fonte de renda? Se sim, o qual são?
4. Você nasceu na praia de Zalala? Se não, por que você se mudou para cá?

Os drivers do systema

5. Quais sãos os principais desafios de se ganhar a vida como o pescador?
6. O que esta causando estes desafios?
7. Como voce lida com esses desafios?

Limiares

8. Se a sua pesca diminuisse 30%, como você lidaria-se ou adaptaria-se? Você continuaria a pescar na praia de Zalala ou trocaria de profissão ou local? Por favor, explicar.
9. Se a sua pesca diminuisse 50%, como você lidaria-se ou adaptaria-se? Você continuaria a pescar na praia de Zalala ou trocaria de profissão ou local? Por favor, explicar.
10. Se a sua pesca diminuisse 90%, como você lidaria-se ou adaptaria-se? Você continuaria a pescar na praia de Zalala ou trocaria de profissão ou local? Por favor, explicar.
11. Se a pesca fosse proibida na praia de Zalala, você ainda ficaria aqui? O que você faria para conseguir uma renda ou sustento?

Cenários futuros

12. Se você tem filhos, você os encorajaria / incentivaria a se tornarem pescadores? Por que? Por que não?
13. Existe alguma razão que faria com que você deixasse de viver na praia Zalala? Por favor, explicar.
14. Existe alguma coisa que voce gostaria de acrescentar?