“Vulnerability of coastal fishing communities to climate variability and change: implications for fisheries livelihoods and management in Peru”

DISSERTATION

zur Erlangung des Grades eines

Doktors der Sozialwissenschaften

- Dr. rer. pol. -

Angefertig am

Zentrum für Marine Tropenökologie

dem Fachbereich Geographie

der Universität Bremen

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Bremen
Mai, 2008

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zmt
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Tag des öffentlichen Kolloquiums: Juli 2008

To my parents, Benjamin and Francine,
for their constant love and support
- you inspire me each and every day!

Acknowledgements

This PhD is the result of a three year research financed by the European Union-funded project CENSOR (Climate variability and El Niño Southern Oscillation: Impacts for natural resources and management, contract 511071). Many individuals have provided me with academic and emotional support, guiding me through this life learning experience. I am indebted to all of them and if not named they are certainly not forgotten.

I would like to thank Prof. Dr. Hellmuth Lange and Prof. Dr. Michael Flitner for supervising this thesis. I greatly appreciate the support and advice provided during these three years by Prof. Dr. Matthias Wolff within the CENSOR project.

In Peru, my supervisor Dr. Jaime Mendo from the Universidad Agraria La Molina (UNALM) in Lima provided invaluable assistance. Without his constant support this PhD would not have been possible, Gracias Profe! I was hosted for nearly two years by the Fisheries Faculty of the UNALM and I am grateful for the help and camaraderie provided by the staff and students.

My research in Peru was also made possible by a variety of organizations and individuals within these: Fundacion para el Desarollo Agrario, Universidad Nacional San Luis Gonzaga de Pisco, Universidad Nacional de Piura, the Vice-Ministry of Fisheries regional offices in Piura and Pisco, and the Instituto del Mar de Peru. Additional financial support for the organization of stakeholder meetings and the making of the 'CENSOR documentary' from the PASARELAS SSA EU-INCO DEV project is also acknowledged. Moreover participation in conferences and expert meetings throughout these three years, which provided an arena to receive helpful feedback, were made possible thanks to the following organizations: International Human Dimensions Programme on Global Environmental Change, Inter-American Institute for Global Change Research, Global change SysTem for Analysis, Research and Training, Food and Agriculture Organization of the United Nations, University of East Anglia and the WorldFish Center.

While many individuals provided support during the fieldwork in Peru I would like to acknowledge by name: Victor Ramos, Jose-Antonio Tapia Verme, Sandra Cordova, Fabian Machiavelo, Gina Manrique, Jorge, Oimer and Gerald: you made surveying under the burning sun an enjoyable experience! Ricardo Gordillo, Ricardo Bandin, Alex Acasiete, Diego de la Cadena Mory and Eduardo "Chiki" del Carpio Willstatter provided not only invaluable insight and contacts into the artisanal fishing industry but also friendship.

My deep appreciation goes to the Revoredo family in Lima, especially Diana Revoredo, and to Magaly Arrieta, Tania Mendo, Kelly Ortega and Cecilia Villacorta. My stay in Peru was not only an academic experience but the discovery of a country and a culture that I will forever cherish. The friendship you provided during these sometimes challenging moments will never be forgotten!

In Germany I would like to acknowledge the help and friendship from colleagues and fellow students at the Center for Tropical Marine Ecology and within the CENSOR project. In particular my warmest thanks go to: Gesche Krause, Petra Käpnick, Dr. Ursel Selent, Gabriele Boehme and Flora Vadas from the ISATEC master program for her help during the fieldwork. Fellow PhD students Marc Taylor, Jenny Leal-Flórez, Sonja Ruckert, Gertraud Schmidt and Connie Roder provided invaluable moral support (and sometimes a roof!). Muchissimas gracias to Alejandro Espinoza, Jorge Paramo and Friedemann Keyl for the many enjoyable coffee breaks and making me believe that I was indeed a ‘researcher’. Finally I would like to thank Ricardo Chero and Leyla Knittweis, who endured my constants doubts and made me smile.

My stay in Germany would have not been the same without the presence of my flat mates Ingo, Kelly and Tania, who provided coffee and laughter that kept me going.

I am also indebted to Nadi, Anna, Laurent, Christelle, An, Anne-Marie and Giulia who despite the distance encouraged me during all those years, listen to me in time of need, visited Germany and Peru, providing solace and laughter. Reynaldo, who has been by my side during this entire PhD, deserves a special mention for his constant friendship and support, for putting up with my long absences and cheering me up when all seemed unattainable.

My family has been my backbone during this research. I would like to say a heartfelt thank you to my brother and my mother and father for encouraging and believing in me every step of the way. Maman merci pour toujours être la quand j’ai besoin d’aide, que ferais-je sans toi…Papa, c’est un peu à cause de toi que je me suis lancée dans cette aventure qu’est le doctorat, merci d’être une source d’inspiration!

Social sciences are the study of human society and of individual relationships. This PhD is about individuals and their families in Sechura and Pisco who have opened their hearts and invited me into their daily lives. I am forever grateful to all of those who kindly embraced my presence and shared with me their knowledge. They are the soul of this thesis. A particular thought goes to the fishermen in Pisco and their families who have greatly suffered after the August 2007 earthquake.

Abstract

The warm phase of El Niño Southern Oscillation (ENSO) is characterized in Peru by positive sea surface temperatures and negative sea level pressure anomalies. Biotic responses to this event range from changes in species composition, abundance and biomass, changes in reproductive success, larval dispersal and recruitment, as well as changes in food availability, competition and predation. The thesis characterized fishermen livelihoods and how they responded to El Niño events in two sites in the North (Sechura) and South (Pisco) of Peru. Additionally, it explored how institutions enable or constrain fishermen livelihoods and responses to El Niño. While both sites have different histories of ENSO related impacts, they share the fact that the artisanal fishing sector plays an important role in the local economy. Livelihood assets exhibit mixed patterns with Pisco possessing a stronger livelihood platform in terms of assets but lower incomes than in Sechura. This finding highlights the fact that income is not an accurate measure of resilient livelihoods and needs to be contextualized. Seasonal migration is a livelihood option practiced by fishermen in both sites depending on seasonality, the *de facto* open access facilitating fishermen mobility. The thesis also identified that fishermen are largely dependent on marine resources for their livelihoods, occupational pluralism being low at both sites. Diversification being considered a risk-reduction mechanism and a building block towards resilient livelihoods, the findings suggest that fishermen are vulnerable to external shocks due to their high reliance on fishing activities. Moreover, disturbances do not only include climate variability, but also market changes to which fishermen must adapt.

El Niño events engender negative livelihood outcomes in the North, where floods have a significant impact on households and the collapse of the scallop fishery considerably decreases incomes. Conversely, in Pisco the increase in scallop landings provides an economic “bonanza” for fishermen. An array of coping strategies can be observed in both sites, mainly prey-switching and migration. However, in Sechura, exiting the fisheries sector is also a favored strategy. Additionally, the damages of the devastating floods in the North poses considerable strain on livelihoods and disaster risk reduction initiatives in these communities are needed.

Current institutional arrangements in the artisanal fishery, with the *de facto* open access, enable migration, an important livelihood option and coping strategy during El Niño in both communities. With the current chorus of dissatisfaction and trend towards regionalization of the fishery, changes in this property right regime should be carefully evaluated before being implemented. Finally, the thesis revealed that formal institutions negatively affect livelihood outcomes in both sites, the failure of decentralization, hence institutional interplay, hampering fisheries management. With El Niño being a recurrent phenomenon on the Peruvian shores, expected to increase in frequency due to global climate change, adaptive management strategies focusing on diversification of livelihoods, migration and property rights are imperative. The livelihood framework combined with institutional analysis and the resilience perspective provided a useful insight into the complex range of assets and activities affected by climatic events as well as the responses of fishermen. This work is, hitherto, one of the few empirical studies exploring fishermen livelihoods in Peru and further research is warranted as well as the incorporation of the findings into ecological and biological studies looking at the dynamics of the artisanal fisheries, especially in the context of El Niño.

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List of Abbreviations

CENSOR	Climate Variability and El Niño Southern Oscillation: implications for natural coastal resources and management
CEP	Centro de Entrenamiento de Paita
CERPER	Certificaciones Pesqueras
CLD	Causal Loop Diagram
DICAPI	Direccion General de Capitanías y Guardacostas del Perú
DIREPRO	Dirección Regional de Producción
EN	El Niño
ENSO	El Niño Southern Oscillation
EPSEP	Empresa Peruana de Servicios Pesqueros
EU	European Union
FAO	Food and Agriculture Organization
FIUPAP	Federación de Integración y Unificación de los Pescadores Artesanales del Perú
FONDEPES	Fondo Nacional de Desarrollo Pesquero
GDP	Gross Domestic Product
GECHS	Global Environmental Change and Human Security
GFL	General Fishing Law
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HCLME	Humboldt Current Large Marine Ecosystem
IHDP	International Human Dimension Programme on Global Change
IIAP	Instituto de Investigaciones de la Amazonía Peruana
IMARPE	Instituto del Mar del Perú
INRENA	Instituto Nacional de Recursos Naturales
ITP	Insituto Tecnológico Pesquero
ITQ	Individual Transferable Quotas
LN	La Niña
NIE	New Institutional Economics
OIE	Old Institutional Economics
PCA	Principal Component Analysis
PIP	Policies, Institutions or Processes
PROMPEX	Commission for Export Promotion
PROCLIM	Programa de Fortalecimiento de Capacidades Nacionales para Manejar el Impacto del Cambio Climático y la Contaminación del Aire
PRONAA	Programa Nacional de Asistencia Alimentaria
SES	Socio-Ecological System
SLA	Sustainable Livelihoods Approach
SLP	Sea Level Pressure
UNALM	Universidad Nacional Agraria La Molina
US	United States

CHAPTER 1

INTRODUCTION

1. Research rationale

1.1 Climate variability and artisanal fisheries

Fisherfolk depend for a major part of their livelihood on resources whose distribution and productivity are known to be influenced by climate dynamics (Allison et al. 2005). Since climatic factors affect the biotic and abiotic elements that influence the numbers and distribution of fish species, most research on climate variability and fisheries is targeted for a detailed understanding of the mechanisms causing fluctuation in fish stock size and distribution (see seminal work by Cushing 1982; Glantz 1992). Additionally, the body of research related to the impact of climate variability on fisheries has historically been focused on oceanic regime changes and the major pelagic fish stocks of upwelling zones that are the target of large scale industrial fisheries (Klyashtorin 2001; Yanez et al. 2001; Guti et al. 2007). Changes in artisanal fisheries due to climate dynamics and the human dimension of these changes have in the past received little attention by researchers and policy makers (Allison et al. 2005). While studies focusing on fluctuating stocks, livelihoods systems and fisheries management have been undertaken in Africa (Sarch and Allison 2000; Conway et al. 2005; Perry and Sumaila 2006; Allison et al. 2001), Asia (Craig et al. 2004) and higher latitude regions like Canada and Greenland (Hamilton et al. 2000; McGoodwin 2007), remarkably, research empirically examining the impacts of climate variability on small-scale fishermen is still sparse. Understanding the linkages between climate variability and resulting changes in artisanal fishermen livelihoods is essential for designing appropriate policies and management strategies in the fisheries sector. Additionally, climate change and projected increased climate variability are likely to place additional stress on fish production systems, many of which are already threatened by overexploitation and habitat degradation (FAO 2008; Nellemann et al. 2008). The impact of global warming on the fisheries sector in socio-economic terms is difficult to asses not only because of the great uncertainty regarding the extent and rate of climate change, but also due to the uncertainty surrounding the impacts on bio-physical processes. Studying the complex way in which fishermen were impacted, have coped or adapted to past climatic events can provide insights into what policies and strategies could be put into place to face the new challenges of global change. This research thus springs from a dual necessity: the lack of empirical studies related to climate variability impacts on small-scale fisherfolk, and the lack of knowledge of the implications of future climate change on artisanal fisheries. The El Niño Southern Oscillation (ENSO) is one of the most well-known inter-annual climate variability phenomena. ENSO is an irregular oscillation of 3-7 years involving a warm (El Niño - EN) and enhanced cold (La Niña - LN) phases that evolves under the influence of the dynamic interaction between the atmosphere and the ocean. During the warm phase of ENSO, the eastern tropical Pacific is characterized by equatorial positive sea surface temperatures (SSTs) and negative sea level pressure (SLP) anomalies, while the western tropical Pacific is marked by off-equatorial negative SSTs and positive SLP anomalies (Wang and Fiedler 2006). Although ENSO effects are felt globally, the major signal occurs in the equatorial Pacific, especially in the south-east Pacific Humboldt Current Large Marine Ecosystem (HCLME) located on the shores of Peru and Chile (Lehodey et al. 2006).

1.2 Peru and El Niño

The HCLME is the most productive large marine ecosystem in the world, providing about 15% of the world's fisheries catch (FAO 1998). The total harvest of the artisanal near shore fishery is relatively low compared to the pelagic harvest. However, the livelihoods of thousands of fishermen are dependant on this diverse fishery, where several species of fish and invertebrates are exploited (Wolff et al. 2003). From 1950 to 2003 there have been eight EN events of varying intensity affecting Peru with the 1982–83 and 1997–98 being the strongest ones. During the same period, there were eight cold phase events (La Niña), the latest one in 1999-2000 (Wang & Fiedler 2006). ENSO warm events dramatically reduced the abundance and/or shifted the distribution of certain species like the Peruvian anchoveta (*Engraulis ringens)*, the Peruvian hake (*Merluccius gayi peruanus*) and mussels (*Aulacomya ater)* (Arntz et al. 2006; Taylor et al. in press). On the contrary, an increase in the abundance and/or spatial distribution of jack mackerel (*Trachurus picturatus murphyi*), invertebrates like scallops (*Argopecten purpuratus*) and octopus (*Octopus sp.*), and warm water crustacean species like shrimp (*Penaeus sp.*) can be observed (Espino 1999; Ñiquen and Bouchon 2004). While the impacts of EN on aquatic organisms have been well researched in Peru (Arntz 1986; Wolff et al. 2007), few studies have been reported on the impact of these events on artisanal fishermen livelihoods (Meltzoff et al. 2005). The body of work relating to the socio-economic impacts of EN in Peru focuses mainly on the industrial fishing sector (CAF 2000; Broad et al. 2002) and on agricultural-based livelihoods (Reyes 2002; Valdivia et al. 2003). Hitherto, this general lack of knowledge of how changes in ecological systems affect the livelihoods of Peruvian artisanal fishermen, and how they respond to theses changes, hinders the design of adaptive management strategies for the artisanal fisheries sector and warrants studies that can inform policies.

1.2.1 Artisanal fisheries management and the role of social sciences

The challenge and necessity of investigating the human dimension of fisheries and explore the social dimension of ecosystem management has also been a major driver for the author to undertake this study. The importance of the social dimension in ecosystem management has been acknowledged in recent years (Townsley 1998; Glaser 2006; Pauly 2006), and in fisheries management numerous authors put forward the necessity to incorporate in the management process societal goals and "realities", as well as the impact of policies and regulations on fishing communities (Catanzano and Rey 1997; Caddy and Cochrane 2001; Kaplan and McCay 2004; Pollack et al. 2008). Recently in the development discourse, artisanal fisheries have been recognized as a contributor at the local scale to poverty alleviation, rural development and food security, and at the national scale to economic growth (see Béné et al. 2007). The development of "people-centered" approaches in natural resource management and the impetus to undertake participatory research have also allowed over the years to include users in fisheries research and management (Symes 2006). Despite these advances, currently anthropology and related social sciences play a negligible role in informing fisheries management compared to their colleagues in ecology, biology and economics (Pauly 2006). Research in Peru related to the artisanal fishing sector adheres to this state of affairs, with few published studies attempting to understand fishermen livelihoods in coastal communities (Wosnitza-Mendo et al. 1988). Peruvian artisanal fisheries management follows the trend of many Latin America countries, where fisheries research has mainly focused on biological-ecological aspects, with limited attention paid to socio-economic issues (Salas et al. 2007). Additionally, industrial fisheries in the region have been the subject of extensive research over the years, with small-scale fisheries often being marginalized (Charles et al. 2007).

Moreover, Peruvian artisanal fisheries currently operate in the context of human and biophysical processes such as EN, overexploitation, globalization and global warming that might jeopardize their long term sustainability. In recent years, diverse frameworks, concepts and methods have been made available to fisheries managers in an effort to explain interactions between aquatic ecosystems and resource users, and design appropriate management interventions. These include the ecosystem approach, concepts of resilience, institutions and the livelihoods analysis. Mainstreaming of these concepts into fisheries policy as well as the development of strong diagnosis methods that integrate them are still sparse, especially in Peru. This research will provide the opportunity to bring together existing theories and concepts as well as operationalizing them to study the impacts of climate variability on fisherfolk involved in small-scale fisheries. To conclude, the work presented here has been driven by the desire to shift the focus of fisheries management in Peru, especially in relation to climate variability, from purely ecological and biological approaches to a perspective that takes into account the human dimension. This was made possible by the author's participation in the European Union funded CENSOR project (Climate variability and El Niño Southern Oscillation: implications for natural coastal resources and management). CENSOR aims at enhancing the detection, compilation, and understanding of ENSO effects on the coastal zone and its resources, to mitigate damage, better use beneficial effects, and thus improve livelihoods. One of its objectives is to develop conceptual and quantitative ecosystem/resource-use and socio-economic models as tools for an adaptive management approach.

1.3 Thesis aims

This thesis is one of the first empirical studies in Peru examining coastal fishermen livelihoods, and the human dimension of the interaction between climate-driven resource fluctuations and livelihoods. The general objective can be summarized as:

> To understand how artisanal fishermen livelihoods in Peru are secured in the context of ENSO-driven climate variability and its implication for artisanal fisheries management in the context of future climate change

The specific research objectives are to:

1) Characterize fisherfolk livelihoods in two Peruvian costal communities to understand how livelihoods are constructed and maintained
2) Understand how livelihoods are impacted and maintained during El Niño events
3) Establish how institutions enable or constrain fisherfolk livelihoods and adaptation processes
4) Explore the implications of the results for relevant research and policy, especially in the context of future climate change

The development of the research objectives was an iterative process. Throughout the first year of the thesis, preliminary fieldwork and discussion with Peruvian stakeholders, ultimately the end-users of this work, shed light on the relevance of the research objectives and the feasibility of the research methods. This approach allowed for reflexive learning and puts this research at the crossroad of inductive and deductive approaches. An overview of how each chapter addresses these objectives is presented below and summarized in Figure 1 while general methods used are available in Chapter 3.

In Chapter 2, frameworks and concepts used to understand interactions between aquatic ecosystems and resource users are reviewed in order to suggest a framework to study the impacts of climate variability on fisherfolk involved in small-scale fisheries. The central task of this chapter is thus to connect existing concepts to gain a better understanding of how fisherfolk cope and adapt to changes in complex marine social-ecological systems. Afterwards, in Chapters 4 and 5, the thesis explores fishermen livelihoods in two coastal regions. Chapter 4 deals with the building blocks of livelihoods, while Chapter 5 explores livelihoods options, outcomes and constraints. The aim is to provide insight into ways fisherfolk make a living within their broader environmental and institutional context. In Chapter 6 the research investigates how fishermen livelihoods were impacted by EN, with a focus on their coping and adaptation strategies. The thesis then explores if institutions are inhibitors or promoters of fisherfolk resilience to climatic events in Chapter 7. By examining the scallop fishery, the thesis unveils how institutions responded to climate variability and how these responses affected fisheries management and livelihoods. Finally, in Chapter 8 management implications of response mechanisms, coping strategies and adaptation processes of fishermen and institutions are discussed. Additionally, possible implications of the results for relevant research and policy, especially in the context of future climate change, are presented.

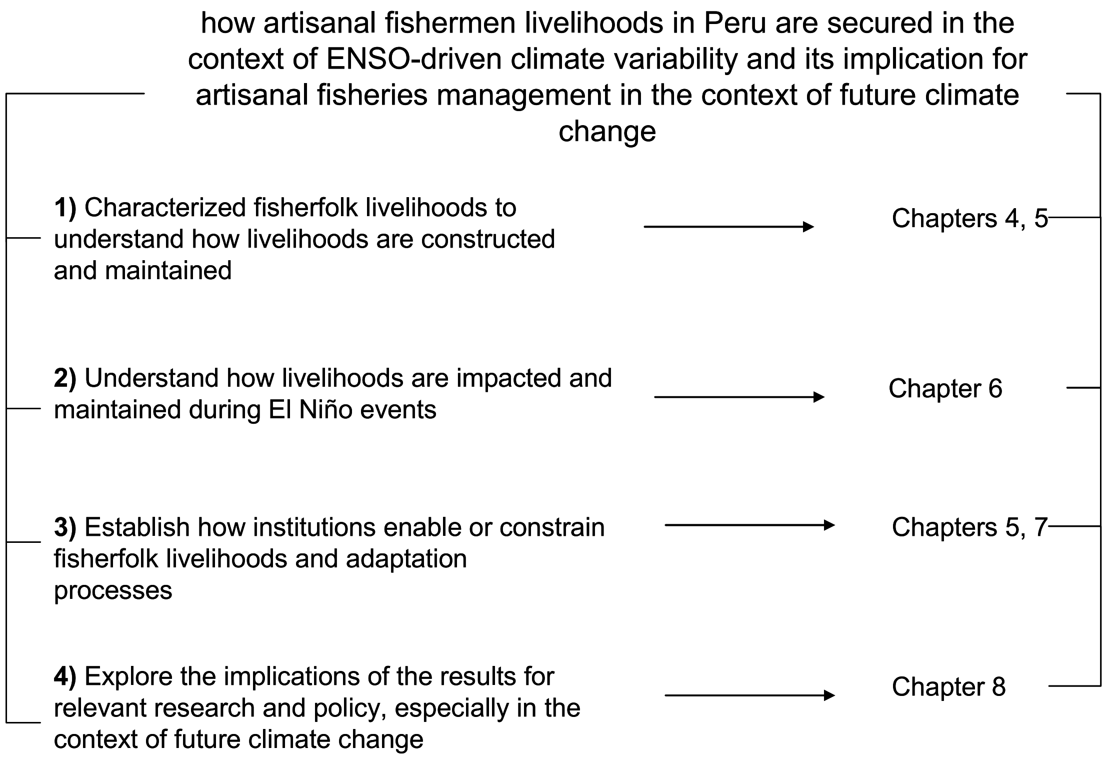

Figure 1Thesis structure in relation to research objectives

CHAPTER 2

FISHING FOR CHANGE: THE STUDY OF FISHERFOLK RESILIENCE TO CLIMATE VARIABILITY FROM A LIVELIHOODS AND INSTITUTIONAL PERSPECTIVE

"If you don't know what you're talking about, call it „system"; (...) if you don't know how it works, call it „process"." Zawodny(1966) cited in Schneider and Bauer(2007)

2.1 Introduction

Around 90% of the 38 million people recorded globally as fishers are classified as small-scale (Béné et al. 2007 p. 2). Small-scale fisheries (also referred to as artisanal) can be defined as relatively labor intensive and using small fishing vessels (if any) operating in near-shore waters for subsistence or commercial purposes (local consumption or export)[1] (FAO 2005). Many fisheries world wide have declined sharply or have already collapsed over the last decades due to overfishing (Pauly et al. 1998). Moreover, major fishing grounds are concentrated in only a few areas of the oceans and inland waters, in zones threaten by pollution, mismanagement of freshwater and coastal development (Nellemann et al. 2008). With strong evidence of accelerated global warming impacting marine life (Perry et al. 2005), climate change is likely to alter artisanal fisheries already under stress. A plethora of concepts can be used to understand how climate variability and change affect artisanal fisherfolk, and how these [will] respond to and mediate such changes. While conceptual frameworks can be as diverse as case studies, understanding the epistemological nature of the variety of knowledge used in research is not just a mundane academic exercise: it is about understanding how concepts are created, interpreted and how they could be linked to provide more powerful insights into the study of complex and coupled systems. Additionally, as Ostrom posits, while there are no single blue prints or 'panacea' for studying human-environment interactions, "without a common taxonomy of core variables, research conducted by scholars from multiple disciplines tends to focus on variables of major interest to their own disciplines […]" (Ostrom 2007 p. 15186). Therefore one might wonder: What research frameworks can help us

[1] This is a broad definition. One must recognize differences between small-scale fishermen in developed and developing countries, mainly based on financial capital and size of boats. See FAO (2005)

understand how fisherfolk livelihoods are maintained while socio-ecological systems undergo changes? What makes systems in which livelihoods unfold vulnerable, persist or transform?

The goals of this chapter are threefold. A first objective is to untangle the conceptual fuzziness surrounding resilience and vulnerability. In the last few years major reviews have explored the links between the concepts of resilience, vulnerability and adaptation in an attempt to develop a shared conceptual framework for the study of environmental changes and their impact on human communities (Adger 2000; Carpenter et al. 2001; Folke et al. 2003; Klein et al. 2003; Folke 2006; Gallopin 2006; Janssen and Ostrom 2006b; Janssen et al. 2006). These will be re-visited, underlying their contribution to the study of the interactions between marine ecosystems and fisherfolk. While resilience thinking is a powerful framework for integrating natural and social dynamics, it is difficult to operationalize in the field (Carpenter et al. 2001), and fails short to clearly address institutional dynamics and governance issues (Anderies et al. 2004). In this chapter it is argued that theories of institutions and the sustainable livelihood approach, both widely used not only in the fisheries literature (Noble 2000; Allison and Ellis 2001; Jentoft 2004; Imperial and Yandle 2005; Wilson et al. 2006) but also by practitioners in donor agencies (DFID 2001; Allison and Horemans 2006), should complement the resilience perspective to address its pitfalls. A second objective of this chapter is thus to situate research on resilience of marine socio-ecological systems within the framework of livelihood security and theories of institutions. The concept of livelihood security and how it applies to the study of fisherfolk resilience and climate variability is presented. Then an overview of theories of institutions, outlining major themes in the study of fisheries governance is put forward. A third objective is to provide a framework integrating the resilience perspective (which includes vulnerability), and the livelihoods and institutional approach in the study of complex interactions between the human dimension of fisheries and climate variability and change.

2.2 Resilience

2.2.1 Emergence of the resilience perspective

The concept of resilience is now used in a great variety of interdisciplinary work concerned with the interactions between people and nature (Carpenter et al. 2001; Folke 2006). The concept was originally used by ecologists in the 1970s in their analysis of population ecology. It was mainly interpreted as a concept for understanding ecological systems in order to be able to predict how they reacted to small disturbances (Grimm 1996). Ecologist C.S Holling first introduced it, stating that:

> "resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb change of state variable, driving variables, and parameters, and still persist" (Holling 1973 p. 17).

This is in contrast to stability, defined by Holling (1973) as the ability of a system to return to a state of equilibrium after a temporary disturbance. A very stable system would not fluctuate greatly but return to 'normal' quickly while a highly resilient system might be unstable under significant fluctuations (Handmer and Dovers 1996 cited in Klein et al, 2003). As described by Folke (2006), Holling's concept of resilience challenged the single equilibrium, global stability focus of ecological research, stating that ecosystems are inherently dynamics and equilibrium states are not something one should seek (Gunderson 2000; Klein et al. 2003). Stuart Pimm's 1984 article on the stability of ecosystems offers the only other moderately cited definition without strong affiliation to the work of Holling (Schoon 2005). According to Odenbaugh (2006), Pimm defines system resilience as the speed of return to a steady state following a disturbance, that is how fast the variables return to their equilibrium, the focus being on the efficiency function. Holling himself acknowledges this measure of stability as 'engineering resilience' and contrasts it with his preferred definition of 'ecological resilience': the magnitude of disturbance that can be absorbed before the system restructures while maintaining the existence function (Holling 1996).

In the field of fisheries science and marine ecology these developments led to new conceptual models that encompassed the role of history and non-equilibrium dynamics in the tempo and mode of ecosystem change (Hughes et al. 2005 p. 381). Less focus was placed on maximum sustainable yield and the design of 'optimal' harvesting of targeted stocks in systems that were assumed to be stable (Hughes et al. 2005 p. 380). In management terms, this is a profound shift from traditional perspectives, which attempt to control changes in systems that are assumed to be stable, towards an approach aiming at adapting to uncertainty and surprise (Adger et al. 2005b). Since ecological systems are dynamic, management strategies also must incorporate uncertainty, non-linearity, and policy experiments to learn about the ecosystem (Olsson et al. 2004). Resilience perspective thus became the theoretical foundation for work related to adaptive management (Folke 2006). Adaptive management deals with the unpredictable interactions between people and ecosystems, emphasizing the importance of feedback*s* from the environment in shaping policy (Berkes and Folke 1998a p. 10) and of the ability to learn and experiment (Armitage et al. In Press, Corrected Proof). Fisheries stock management under uncertainty and adaptive management have been extensively studied (see for instance Glantz and Thompson 1981; Clark et al. 1995; Cole 1996; Gordon and Munro 1996; Flaaten et al. 1998; Rothschild 2005). Rooted in Holling's work, adaptive management as a strategy for fishery management was further developed within the concepts of social-ecological systems and complex adaptive system.

2.2.2 Social-ecological systems and fisheries

Socio-ecological systems (SESs) refer to social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units at multiple temporal and spatial scales (Anderies et al. 2004; Janssen and Ostrom 2006a). The work by Berkes and colleagues (1998b; 2003b) has been central in the use of the concept of resilience when studying socio-ecological systems. They put forward that social and ecological systems are complex adaptive systems, having a number of attributes that are not observed in simple systems, such as nonlinearity, uncertainty, emergence, scale and self-organization (Berkes et al. 2003a). Box 1. describes those main attributes while it is acknowledged that complex systems have numerous other characteristics. Resilience in this context is defined by Berkes and colleagues (2003a p. 13) as: 1) the amount of change the system can undergo and still retain the same control on function and structure, or still be in the same state, within the same domain of attraction, 2) the degree to which a system is capable of self-organization, 3) and the ability to build and increase the capacity for learning and adaptation. Adaptive capacity is considered an aspect of resilience that can be defined as the ability of systems to change inherent properties to return to a reference or alternative state they belong to. The question of whether the new alternative state is a more 'desirable' one is particularly relevant, shedding light on the fact that adaptation does not always lead to desirable outcomes ('mal-adaptation'). Adaptive capacity thus translates into increasing the ability and speed to evolve and adapt to new situations as they arise and the flexibility to experiment and adopt novel solutions (Walker et al. 2002).

Nonlinearity and Uncertainty: Nonlinearity is related to inherent uncertainty. Complex systems organize around one or several possible equilibrium states or attractors. There is no simple equilibrium but several equilibriums (stability/attraction domains).

Scale: Many systems are hierarchical (sub-systems nested in large systems). Different processes occur at different scales. Behaviour of a sub-system at one scale is qualitatively different from that of a sub-system at another scale (e.g. household unit compared with a region). Processes at different scales do not function independently of one another.

Emergence: Occasionally the interaction of process and pattern at one scale produces emergent organization at a larger, slower scale (production of unexpected processes and structures). Thus change is not only non-linear, it can be structural (structural view of emergence). Resilience can be considered an emergent property of a system (one that cannot be predicted).

Self-organization: Open systems will re-organize at critical points of instability. For instance disturbances select for "fitness" of individuals, species adapt, and the system re-organises to accommodate the change. Self-organization produces macroscopic patterns that emerge through local, small-scale interactions. Of fundamental importance to self-organization is memory. Memory, accumulated history and experience, gives a system the ability to re-organize.

Sources: (Hartvigsen et al. 1998; Peterson 2000b; Berkes et al. 2003a)

Box 1 Attributes of complex adaptive systems

The resilience perspective aims at understanding how SESs evolve, transform or collapse overtime, identifying major drivers and variables behind these dynamic of changes. Berkes and colleagues (2003b) use Holling's adaptive renewal cycle to illustrate the dynamic cyclic change of socio-ecological systems. The adaptive cycle (Figure 2) involves the movement of a system through four phases: 1) a period of rapid growth and exploitation (r); 2) a phase of accumulation, monopolization, and conservation of structure, during which resilience tends to decline (K); 3) a very rapid breakdown or release phase (creative destruction (Ω); 4) and, finally, a relatively short phase of renewal and reorganization (α) (Walker et al. 2002). In this phase, the system can still retain previous components to remain within the same configuration as before or new components can enter (i.e. species, institutions, polices), a new emerging system appearing (Walker et al. 2002). This idea of renewal is relevant to natural resource management where crisis (deforestation, over fishing, natural disasters etc.) can trigger the opportunity of an adaptive renewal cycle in systems capable of adapting and learning (Berkes et al. 2003a).

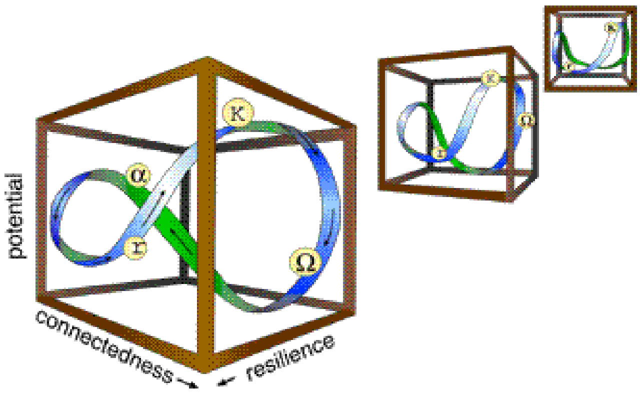

Figure 2 Resilience is another dimension of the adaptive cycle. Resilience shrinks as the cycle moves toward K, to expand as the cycle shifts rapidly into a "back loop" to reorganize accumulated resources for a new initiation of the cycle. Source of text and picture (Gunderson and Holling, 2001)

Resilience thinking has thus evolved from the narrow definition of “engineering resilience” with its focus on efficiency and recovery to socio-ecological resilience where transformability and adaptation are key aspects (Table 1). Complex system theory and the concept of resilience assert that management of socio-ecological systems can be improved “by making them more adaptable and flexible, able to deal with uncertainty and surprises, and by building capacity to adapt to change” (Berkes et al. 2003a p. 9).

Table 1 Resilience concepts, from the more narrow interpretation to the broader social–ecological context (Folke 2006)

Resilience concepts	Characteristics	Focus on	Content
Engineering resilience	Return time, efficiency	Recovery, constancy	Vicinity of a stable equilibrium
Ecological/ecosystem resilience and Social resilience	Buffer capacity, withstand shock, maintain function	Persistence, robustness	Multiple equilibria, stability landscapes
Social-ecological resilience	Interplay disturbance and re-organization, sustaining and developing	Adaptive capacity transformability, learning, innovation	Integrated system feedback, cross-scale dynamic interactions

This resilience perspective has been recently integrated into the epistemic community dealing with the human dimension of aquatic ecosystems. The papers by Mahon et al (In Press, Corrected Proof), Hughes et al (2005) and Olsson et al (2004) provide valuable uses of the concept of resilience in marine social-ecological systems research. They all approach fisheries management from the resilience perspective, highlighting the importance of embracing uncertainty as well as learning and adaptation. Wilson (2006) in his treatment of ocean fisheries as complex adaptive systems contends that there is a mismatch between ecological and management scales. To improve feedback, multi-scale governance must be in place, while the fine-scale (individual fisherman knowledge) should be integrated into science. Scale refers to the spatial, temporal, quantitative, or analytical dimensions used by scientists to study object and processes (Gibson et al. 2000; Cundill et al. 2005) and is central to the resilience perspective. For instance temporal scale can vary from days (fishing trips and daily water turbulences) to decades (political changes or inter-decadal oscillations), to centuries (climate change). The issue of scale in marine ecosystems and human interaction was reviewed by Perry and Ommer (2003). The authors posit that scale is central to SESs, as the choice of scale affects the identification of systems variables, patterns and dynamics (Figure 3). They argue that appropriate scales of natural science analysis must be used when building management policies, and that both social and natural science analyses need to be aware of the "shifting baseline" problem (Perry and Ommer 2003). The "shifting baseline syndrome" was introduced by Pauly (1995) and refers to the fact that the baseline can change significantly depending on the chosen time scale. Sáenz-Arroyo et al (2005), when investigating fishermen's perception of environmental change in Mexico's Gulf of California, reveal that despite times of plentiful large fish still being within living memory, few young fishers appreciated the abundance and productivity of fishing sites. They argue that such rapid shifts in perception of what is natural help explain why society is tolerant of biodiversity loss.

The burgeoning literature related to SESs and fisheries is a reflection of how resilience thinking is influencing fields outside of ecology, ranging from ecological economics to cultural theory (Folke 2006). On the whole the SESs and the resilience approach provide a bridge between natural and social science by using the same terminology when referring to social and ecological systems, thus providing a 'meta-language'. Abel and Stepp in their editorial of a special issue of Conservation Biology titled 'A New Ecosystems Ecology for Anthropology' stated that: "It would seem today that anthropology and the other social sciences have embraced ecology as never before." (Abel and Stepp 2003 p. 1). However, Adger (2000) warns that simply taking the concept of resilience from the ecological sciences and applying it to social systems assumes that there are no essential differences in behavior and structure between socialized institutions and ecological systems. Social sciences have a long standing tradition of research in this field that must be taken into account and brings a much needed dimension in the concept of resilience, especially in the interpretation of how and why systems persist in time. The adoption of the vulnerability concept by the epistemic community using the resilience perspective is one way to deal with the limitations of the latter.

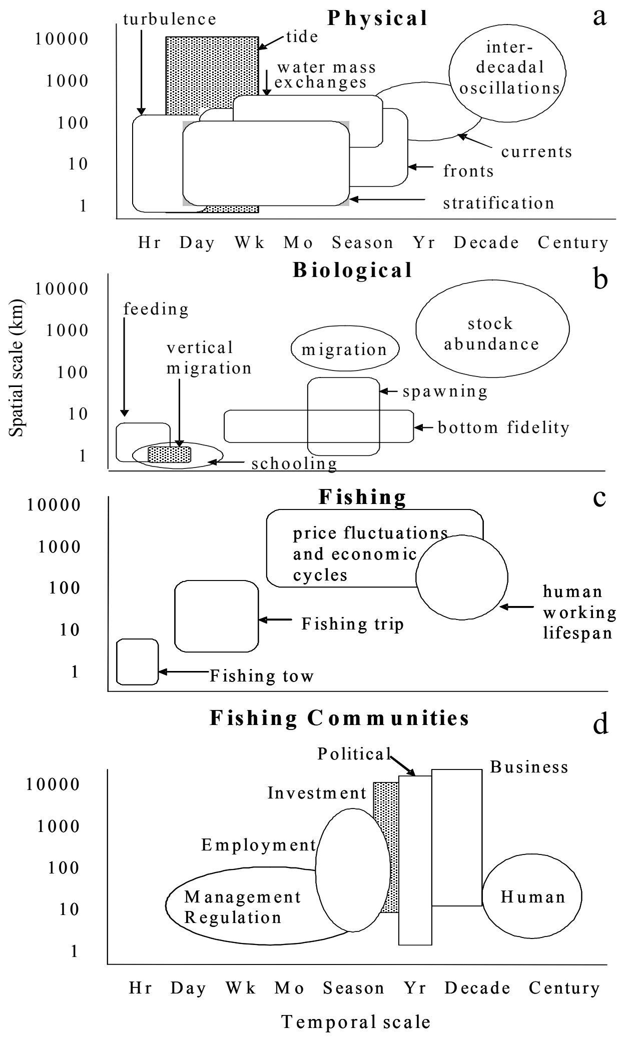

Figure 3 Space/time-scale diagram of characteristic processes from the natural sciences: (a) physical; (b) biological and from the social sciences; (c) fishing; (d) fishing communities. From Perry and Ommer (2003)

2.3 Vulnerability

The concept of vulnerability can be identified as stemming from five schools of thought: the social constructivist and political economy approaches, political ecology, and the natural-hazard and climate change literature.

2.3.1 Political economy, social constructivism and political ecology

Political economy analysis is concerned with the interaction of political and economic processes in a society: the distribution of power and wealth between different groups and individuals, and the processes that create, sustain and transform these relationships over time (Collinson 2003). Political economy conceptualizes vulnerability in terms of powerlessness: differential economic and political power play a role in determining differential vulnerability of individuals and groups (Greenberg and Park 1994). It was widely used in the fields of famine, hunger and entitlements (O'Brien 1985; Watts and Bohle 1993). In the realm of fisheries, Iberra et al (2000) identified how different economic policies in Peru, Chile and Mexico where used to deal with overcapitalisation and over-fishing, rendering the fisheries more vulnerable. They highlight the importance of the political and economic context in the development of Latin American fisheries (agrarian reform, military government and neo-liberal ones in the 1990s). In contrast to political economists who emphasize structural factors and power relations, constructivist theorists focus on the role of human agency and culture in explaining differential vulnerability. Themes such as culture, ethnicity, religion and gender become individual determinants of vulnerability that allow a better understanding of its underlying causes (Fordham 1998; Cannon 2002). However, as for political economy, this approach could be labeled as ‘reductionism’ and is effective in explaining the causes of vulnerability when combined with other approaches. For this reason the political ecology framework was developed, with its particular emphasis on environmental problems.

Political ecology is concerned with the relationship between nature and society, and embodies the assumption that environmental problems and solutions are highly politicized and unequally suffered or perceived (Blaikie and Brookfield 1987 p. 6 ; Bryant 1992; Blaikie 1995; Bryant et al. 1997). It allows to investigate whether environmental benefits and costs emanating from ecological changes are distributed unequally among actors, and whether such distribution reinforces existing social and economic inequalities and power relations, leading to conflict (Blaikie 1995). Bryant (1998) argues that at the heart of political ecology research is the notion that politics should be 'put first' in the attempt to understand how human-environment interaction may be linked to the spread of environmental degradation (Bryant 1998 p. 80). In this vision, political ecology gives a particular focus on the way meso and macro scale political and economic forces set the context for local environmental action and interaction (Robbins 2003). For instance Doods (1998) links the decrease in restaurant consumptions in the United States (U.S) with changes in lobster trade that directly affect the Miskito population in Honduras. If wages are too low in Honduras due to lower demand in the U.S, this can lead to a shift from fishing activity to lodging and agriculture which results in increased rates of deforestation (Dodds 1998p. 101). This case study highlights how local ecological change can be linked to macro-level economic changes.

The inability of economic theory to predict human behavior in novel, poorly understood situations suggests that it has severe shortcomings in explaining human behavior in many human–ecological interactions (Gale 1998; Peterson 2000a p. 325), warranting the use and incorporation of approaches like political ecology. However, it has been argued that political ecology tends to overlook ecological dynamics and focus upon the structure of human systems, representing nature as a passing object transformed by human actors (Peterson 2000a). While this type of research may yield important social science insights and findings, a political ecology that does not address the physical environment falls short of its trans-disciplinary objective (Little 1999).

2.3.2 Hazards approach and IPCC definition of vulnerability

The concept of vulnerability is often considered as having its roots in the study of natural hazards (Hewitt 1983). John Dewy and Harlan Barrows are cited among the founding fathers of ‘geography as human ecology’ on which the hazard research is based (Mileti 1999; Cutter et al. 2000). Dewey put forward that humanity lives in an hazardous world that results in human insecurity and environmental hazards which are not independent from society but are shaped and defined by human actions (Dewey 1929 cited in Mileti, 1999). Barrows, based on Dewy’s work, was one of the first scholars to extensively investigate how US society could adjust to floods. In the 1960s and 1970s, inspired by his predecessors, Gilbert White and colleagues focused on (1) the identification and distribution of hazards, (2) the range of adjustments that are available to society and individuals, and (3) how people perceive and make choices regarding hazard events (Cutter et al. 2000 p. 714-715). These earlier works, pinned down as the ‘hazard paradigm’, were criticized on the basis that they considered only hazards themselves and not enough the particular contexts in which they were embedded (Cutter 1996). The neglect of structural factors and the focus on biophysical factors were deemed insufficient in the study of the interdependence between hazards and society. As a result a new approach focusing on hazards *in context* (Mitchell 1989) recognized that hazards are a physical and social phenomena (Cutter et al. 2000). Disaster and hazard research thus evolved to incorporate the concept of vulnerability developed by political ecology. In this context vulnerability is defined as a risk of exposure and is seen as a pre-existing condition (potential exposure) (Cutter et al. 2000). Wisner and colleagues (2004) in their definition of vulnerability to hazards bridge the notion of social vulnerability in political economy and the biophysical risk/hazard perspective by stating:

> "By vulnerability we mean the characteristics of a person or group […] that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard […]. It involves a combination of factors that determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or series or 'cascade' of such events) in nature and in society." (Wisner et al. 2004 p. 11)

Bridging the gap between a focus on natural stimuli and exposure, and social determinants of vulnerability was driven by new research focusing on the vulnerability of people to impacts of climate change (Janssen et al. 2005). In global change and climate change research vulnerability is as an integrative measure of the threats to a system (Cutter, 1993; Boughton et al., 1999; McCarthy et al., 2001). When referring to the concept of vulnerability, the Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as:

> "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity." (McCarthy et al. 2001 p. 995)

Vulnerability is therefore made up of a number of components including exposure and sensitivity to hazard and the capacity to adapt:

$$\textbf{Vulnerability} = f\textbf{(exposure, sensitivity, adaptive capacity)}$$

In IPCC terminology, sensitivity is the degree to which a system will respond to a change in climatic conditions. This could be measured, for example, by a proportional change in ecosystem productivity as a result of perturbations in temperature or precipitation (i.e. change in catches). Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of variability with which it can cope. Vulnerability, according to the IPCC definition, thus presents an external dimension (exposure) and an internal dimension (sensitivity and adaptive capacity) (Füssel and Klein 2005).

From a fisheries perspective, few studies have looked at the vulnerability of the fishing sector to climatic stress. One of these is the vulnerability assessment of capture fisheries and aquaculture to climate change conducted by Allison et al (2005) and Handyside et al (2006). Figure 4 presents the conceptual model used in both studies where vulnerability is a function of the potential impacts (PI) of climate change, reduced or modified by peoples' or institutions' adaptive capacity (AC): V = *f*(PI, AC). The aim of both vulnerability assessments was to capture a snapshot of present-day vulnerability of fisheries production systems to future climate changes at the global scale. In the case of capture fisheries, Allison et al (2005) explored potential impacts of climate change and adaptive capacity with indices using: 1) the number of fishers and their economic and nutritional dependence on fish to assess sensitivity, 2) measures of overall health, education and governance, 3) and the size of the economy for the country being considered. They concluded that Asia, the Amazon and Western Sahara regions would be most at risk from increasing air temperature changes (projections to 2050 from the IPCC 2001 assessments). Most sensitive countries were China, Indonesia, India, Vietnam, Mauritania and Peru. While the analysis was a first attempt to identify vulnerable countries to climate change in terms of fisheries, data used for the exposure index (air temperature) is inappropriate to fully explain changes in aquatic systems. More refined studies at the large ecosystem level and case study level are needed to insure that vulnerability assessment of this type take into account ecological processes.

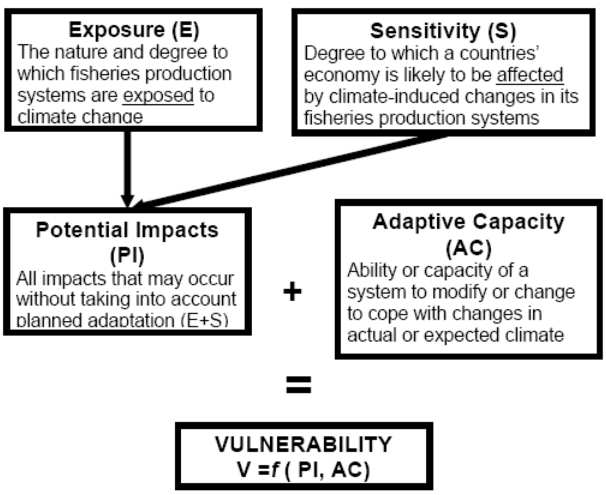

Figure 4 Conceptual model for vulnerability assessment at the global scale Allison et al (2005)

At finer scales, assessments of vulnerability of fisherfolk to environmental change are likewise limited. Nagy and colleagues (2006) provide one of the few studies investigating the impact of climate variability on fisheries in Argentina using a vulnerability approach based on the driver-pressure-state- impact-response framework. However, the analysis falls short of encompassing adaptive capacity beyond the individual level, that is what roles aspects like governance play in the vulnerability of fishermen. Both studies show the limitations of the vulnerability approach when it fails to integrate different scales (individual behavior, social processes at a lager scale) and ecological dynamics.

2.4 Fisherfolk resilience: towards a framework

The present review has shown that the concepts of resilience and vulnerability stem from two different knowledge base: the natural science one with its roots in ecology and the more social science one with emphasis on social construction, power, hazards and exposure. This distinction is not only attributable to their respective roots in different disciplines, but also to the fact that they were produced by particular people, at particular times and places, and in different institutional contexts. Janssen et al (2006) bibliometirc analysis of the knowledge domains of resilience and vulnerability offers an interesting perspective on the development of both concepts. One could argue that the two concepts are mutually inclusive: increased resilience leads to decreased vulnerability and vice-versa. Adger et al (2005c) when investigating the impact of Hurricane Katrina on New-Orleans stated that : "The *resilience (or conversely, the vulnerability)* of coastal societies is more tightly linked to larger-scale processes today than in the past." (Adger et al. 2005c own italics). O'Brien and Vogel (2004) similarly posit that "some would argue that resilience increases the capacity to cope with stress and hence serves as a loose antonym for vulnerability" (p.1).

Research on fisherfolk and climate variability and change provides the opportunity to explore the combined use of the concepts of resilience and vulnerability, and could contribute to a better understanding of the 'political', 'social' and 'ecological' interpretations of human-environment interactions. Based on this review vulnerability is defined as a function of exposure and resilience:

$$\mathbf{V}=\boldsymbol{f}\ \textbf{(exposure and resilience)}$$

Exposure refers to the kind and magnitude of disturbance (stressor) the system is exposed to. Taking the Peruvian Humboldt current system as an example, the stressors could be the intra-annual variability ENSO, global climate change or changes in international fisheries markets. At the national or regional scale it could refer to political and social changes (decentralization, neo-liberal fisheries policies). Resilience is defined as a function of changes in absorption, self organisation and adaptive capacity:

Resilience = *f* (changes in absorption+ self organisation + adaptive capacity)

Changes in absorption refer to the amount of change the system under study can undergo and still retain the same controls on function and structure, or buffering (absorptive) capacity. In the case of the Peruvian fisheries this would mean to what extent artisanal fishermen can carry out productive activities without any change. Self-organization refers to the ability of a system to return to a reference or desirable state without changing any of its inherent properties. This translates into enough redundancy to provide continuity of function and application of existing available responses to address the problem. The response of a system to change can arise organically, reflecting the self-organizing capacity of the system, or more mechanistically (Dalziell and McManus 2004). In this case, this would refer to fishermen response to changes using available coping strategies such as intensification of fishing effort or what Perry et al (In revision) called "ridding out the storm", that is waiting for the crises to pass. Coping does not emphasize the strategic nature of planned adaptation, putting more stress on reactive responses, self-organization that does not involve major changes in social-ecological systems. Adaptive capacity refers to the ability of a system to change inherent properties to return to a reference or alternative state. It translates into increasing the ability and speed of the system to evolve and adapt to new situations as they arise, the application of novel responses to address the problem. Adaptation strategies of fishermen can range from change in target species and migration. Table 2 presents the conceptual framework when applied to the study of fisherfolk resilience[2]. In terms of scale, the focus is on aquatic system (freshwater or marine, boundary defined by management unit or ecological criteria depending on the case study). Two sub-systems (levels) have been identified: the local scale and the regional, national scale or global scale (meso and macro levels depend on the case study).

[22] This framework elaborates on concepts developed by Berkes (2003), Anderies (2004), and more recently Ostrom (2007). The relation with Ostrom multitier framework will be discussed further in the chapter.

The temporal reference is the present (current resilience) while the variable of concern within the subsystems are the actors involved in the fishing sector.

Table 2 Studying resilience of fisherfolk: the example of climate variability

	System boundary	
	Sub- system 1 Harbours/villages/municipalities bays ecosystem	Sub - system 2 Region/Country/World
Variable of concern in the system	Actors in the fishing sector (users and governance system) Resource units	Actors in the fishing sector (users and governance system)
Exposure = Disturbance/stressor Shock versus gradual change	Social Economic and Political settings (Human drivers) Intra-annual variability, ENSO and climate change (ecosystem drivers)	Social Economic and Political settings (Human drivers) Intra-annual variability, ENSO and climate change (ecosystem drivers)
Resilience		
Change in absorption	To what extent can actors carry on productive activities (fishing) without changes and resource units remain within their domain of attraction	To what extent can users and governance system carry on activities ("business as usual") without any change
Self-organisation	Actors and resource units response	Actors response
Adaptive capacity	Actors change and learning?	Actors change and learning?

Now that the different components of vulnerability and resilience have been defined and the system bounded, how can this framework be transformed into an operational one? How can specific fisherfolk responses be clearly identified and measured? One of the difficulty encountered in resilience research is to define 'what to measure' and 'for what' (Carpenter et al. 2001). At the micro scale, the sustainable livelihoods approach (SLA) is a powerful tool for understanding people's lives in the context of a changing environment, exploring in details fishermen strategies and responses to change while broadening fishery discussions beyond fishing per se to emphasize the entirety of individual, household or community sources of livelihoods (Charles 2005). The concept of livelihood thus provides valuable insights and a way to render operational the resilience framework presented here.

2.5 Livelihoods security

2.5.1 The sustainable livelihoods approach and livelihood security

The sustainable livelihoods approach (SLA) developed in the 1980's is increasingly adopted to achieve a more accurate understanding of natural resource management systems (Carney

1998). A livelihood can be defined as the capabilities, assets and activities required for means of living (Chambers and Conway 1992). The concept of sustainable livelihood seeks to bring together the critical factors, assets and activities, that affect the vulnerability or strength of household strategies (Ellis 2000; Allison and Ellis 2001). People can access, build and draw upon five types of capital assets: human, natural, financial, social and physical (Box 2). The way in which people combine and transform those assets, and how through relationships with other actors, markets and society they expand their asset base is a characteristic of livelihood inquiry (Bebbington 1999). In Figure 5, markets and other institutions like law and social relations and organizations (NGOs, government agencies, private sector) and related policies are understood as policies, institutions or processes (PIPs). They differ from the vulnerability context by being endogenous to the norms and rule of the society under study (IDS Accessed 4/01/2008).

Natural capital – the natural resource stocks (soil, water, air, genetic resources etc.) and environmental services (hydrological cycle, pollution sinks etc) from which resource flows and services useful for livelihoods are derived.

Physical capital – physical assets comprise capital that is created by economic production processes. It refers to the basic infrastructure and producer goods needed to support livelihoods.

Economic or financial capital – the capital base (i.e. cash, credit/debt, savings, and other economic assets) which are essential for the pursuit of any livelihood strategy.

Human capital – the skills, knowledge, ability to labour and good health and physical capability important for the successful pursuit of different livelihood strategies.

Social capital – the social resources (networks, social claims, social relations, affiliations, associations) upon which people draw when pursuing different livelihood strategies requiring coordinated actions.

Source: (Badjeck 2004) adapted from (DFID 2001) and (Scoones 1998)

Box 2 Livelihoods capital assets

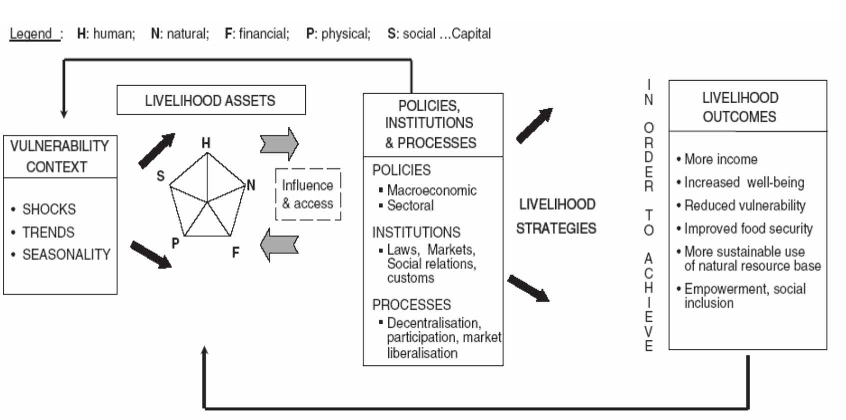

Figure 5 Rural livelihoods framework (Allison and Horemans 2006)

For instance climatic stress whether seasonal or on a decadal scale enters within the vulnerability context. Livelihoods are thus affected by a vulnerability context which is conceptually similar to the concept used in hazard and climate change research (Allison and Horemans 2006). PIPs can mediate access to assets while actors can change or transform the rules that govern access, distribution and transformation of assets (Bebbington 1999). Livelihood strategies are the range and combination of activities and choices that people make in order to achieve livelihoods outcomes. Livelihoods therefore are about how actors can mobilize capitals and capabilities to achieve well-being, building on the seminal work by Sen on entitlements, development, and capabilities (Sen 1981; Sen 1999). The sustainable livelihoods approach is well recognized as an integrated mechanism for poverty reduction and natural resources management that is cross-sectoral and one that encompasses all the assets (natural, human, physical, and social) of a community. Yet, the relevance of this approach in ensuring human security has not been sufficiently explored in the current discussion on human security and social development. This is an important drawback because the notion of security brings to the livelihood concept the notion of equity ("whose security?") and mainstreams livelihoods in the current environmental security debate.

2.5.1.1 Human security and livelihood security

From an historical perspective, security has emerged in the 17th century as a normative concept typically interpreted mainly in terms of what it means to the nation-state, and primarily in terms of military security (Goran 1997), later on to incorporate individual security with the development of 'social security' in what can be called the traditionalists perspective (Brauch 2005). A broader perspective seeks to extend the agenda to incorporate economic, societal and environmental sectors (Buzan et al. 1997). Nowadays security research embraces this wider perspective, with human security research focusing on the way diverse social and environmental processes combine to affect human well-being, including people's health, economic opportunities, and political freedoms. The United Nations identifies freedom from want (the development agenda) and freedom from fear (the security agenda), as the two concepts encompassing the idea of human security (Annan 2000). The Global Environmental Change and Human Security project, a core project of the International Human Dimensions Programme on Global Change, focuses especially on freedom to take action on one's own behalf in response to changing environmental conditions, in addition to freedom from want and freedom from fear (GECHS Accessed 01/03/2008). In this context individual should have the options to end, mitigate or adapt and the freedom to exercise these options. Ellis's definition of livelihoods is the starting point of this thesis's approach to livelihood security:

> "A livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by individuals or household." (Ellis 2000 p. 10).

Building on this definition the concept of livelihood security is defined as:

> "Livelihood security means the freedom to engage in activities that are necessary for the pursuit of *sustainable* livelihood options. It means creating socio-ecological systems which give people the access to assets necessary for this pursuit, which provide building blocks for the maintenance of livelihoods in the face of critical and pervasive threats and situations".

Emphasis is put on the word *sustainable*. Indeed while freedom to choose and freedom from want are emphasized, they are in the context of a limited natural resource base. Additionally, the problem remains that 'one person's security is often another's insecurity'. Security can refer to a subjective, psychological feeling of being secure and an objective situation of being legally secured (Brauch 2005). This dual aspect of objective and subjective feeling of security has been an area of inquiry for many scholars in the social sciences (Brauch 2005), and the emerging debate on the concept of security as it relate to environmental and human security is : (1) what security and (2) whose security (Goran 1997). This can be translated into "what resilience" and "whose resilience" need to be maintained in the face of socio-ecological changes. Thus the concept of livelihood security, going beyond the traditional SLA, encompasses the notion of equity and fairness.

2.5.2 Fisheries livelihoods and climatic stresses

Climate-induced changes to resource flows can fundamentally affect the viability of the livelihoods of the poor (SEI et al. 2003). In the climate change literature the concept of livelihoods is employed to understand the vulnerability context of communities (Adger 1999; Morris et al. 2002; Ziervogel and Calder 2003), with work on fisheries focusing on climate variability, fluctuating stocks and livelihoods systems (Sarch and Allison 2000; Allison et al. 2001). Different types of climate variability impacting on fisherfolk can be linked to the various elements of the livelihoods framework. Livelihood security can thus be undermined by changes in livelihoods capital assets, access to these assets and ability to exercise livelihood options. In Allison et al (2005), the author of this thesis undertook an extensive review of the possible impacts of climatic stress on the five livelihood assets, and the following sub-sections draw heavily on that work.

2.5.2.1 Changes in natural capital

Possible impacts of climate change and climate variability, and related natural hazards on fishermen are centered around changes in stock distribution and abundance (Roessig et al. 2004). In Taiwan the landing of mackerel purse-seine fishery experienced a dramatic decrease of 47,75% following the 1997/98 El Niño due to changes in SSTs in the area between Taiwan and Japan (Suna et al. 2005). Similarly in Chile the warmer SSTs lead to the collapse of the horse mackerel with catches during EN a third of what they were in the mid-1990's (Avaria et al. 2004). In Peru, the industrial sector relying on pelagic species like anchovies and sardines (for oil and fish meal), was the most affected during EN 1997-98. Total volumes of landings decreased by 55% compared to 1996 (CAF 2000). It is worth noting that while the fishery sector was adversely affected by the reduced stock of anchovies and sardines in the eastern pacific upwelling areas fishermen in Denmark received near record prices for Baltic sprat, a competing species for fishmeal production (MacKenzie and Visser 2001). Changes in migration routes and biogeography of fish stocks can also affect fishermen's fishing effort; for instance increased travel time can lead to increase fuel and ice costs (Mahon 2002). Dalton (2001) showed that fluctuations in SSTs, including El Niño events, have significant effects on fishing effort in the albacore tuna, Chinook salmon, sablefish and squid fisheries in Monterey Bay, California. Fishing effort is defined by Dalton as the number of vessels or boats landing an individual species. Under a scenario of SSTs corresponding to the ENSO events of 1983 (increase of 1.2º Celsius), this number decreases by 60% for sablefish fishery and 400% for squid fishery (Dalton 2001). This dramatic fall in the squid fishery is partly explained by the forward-looking behavior of fishermen: prices only decreased by 50% but squid harvesters expectations of increased costs due to increased SSTs decreased the number of boats (Dalton 2001). Changes in species abundance could also lead to changes in harvest and processing costs due to retooling (change of gear, boat) to harvest the new abundant specie (Knapp et al. 1998; Broad et al. 1999). The capacity to quickly adapt to new harvesting techniques and tools will determine the success of certain fisheries. In Peru, during EN 1997-98, boats equipped with gill nets and pure seine nets were adapted into trawl nets for the new shrimp resource that appeared in the northern part of the country (Carbajal and Alvitres 1998). Moreover climate change and increased climate variability could also result in the arrival of new tropical species or environmental conditions that favor the development of certain species against others. The Peruvian bay scallop (*Argopecten purpuratus*) is highly susceptible to the rise in SST triggered by ENSO events. During the EN period of 1983–1985, the scallop harvest in Independence Bay - Pisco in the South of Peru was the highest ever recorded, catches rising by 920% compared to 1980-82 (Palomino 1985). While some invertebrates like scallops and octopus experienced an increase other species suffered mass mortalities like crabs and sea urchins (Arntz 1986). Fishermen, following an opportunistic behavior, dramatically increased their profits with the “scallop boom” and the introduction of species such as mahi-mahi and shark was initially highly profitable for the artisanal fisheries sector (Broad et al. 1999; Broad et al. 2002). However, several factors undermined potential benefits to fishermen of additional species in 1997-98: the market price of mahi-mahi dropped to below US$1 due to over-supply, the ‘Asian crisis’ decreased export demand, and there was a lack of adequate gear (Broad et al. 1999). While EN negatively affects pelagic fisheries in the Humboldt current system (Peru-Chile), La Niña events (cooling of SST) lead to increased catches and revenues for the industrial sector dedicated to capture of anchovies for fishmeal production (Ordinola 2002).

2.5.2.2 Reduced financial capital, damage to physical capital and changes in livelihood outcomes

Changes in the availability of fish products (natural capital) can affect total revenues and harvesting costs (net revenues) of fishermen. Decreased revenues for fishermen due to the decline in total catch and stock abundance are commonly cited as a consequence of natural disasters and climate variability (Mahon and Joseph 1997; Callaway et al. 1998; Knapp et al. 1998; Lum Kong 2002; Mahon 2002). In Belize, Hurricane Mitch destroyed the main lobster and fin-fishing grounds of the northern part of the country in 1998. This translated into a loss in production of 65,000lbs that year (Gillet 2003). Based on comprehensive daily logbook records during 1982–1999 and a fishing cost survey it was estimated that the loss of the Taiwanese mackerel purse-seine fishery during the 1997/1998 EN to be US$6,22 million for 1998 (Suna et al. 2005). Climate variability and change through sea-level rise, storminess and floods can lead to decreased harvesting capacity. Loss of revenues can be the result of closures of fisheries activities during a weather anomaly (Siung-Chang and Lum Kong 2001; Lum Kong 2002) or the reduction of fishing days due to increased weather variability such as increased frequency of storms and changes in wind patterns (Broad et al. 1999; Mahon 2002; Nagy et al. 2006). In Newfoundland, warmer temperatures and low water levels between 1975 and 1999 led to an increase in closures of the recreational salmon fishery (Dempson et al. 2001). Storm and severe weather events can destroy or severely damage infrastructures and equipments such as ports, landing sites and boats (Jallow et al. 1999). For instance during hurricane Gilbert in 1998, Jamaican fishermen lost 90% of their traps resulting in a loss of revenue and high cost of repairs, as well as the inability to resume fishing activities promptly (Aiken et al. 1992). In Belize, losses in relation to the loss of fishing tackle and associated infrastructures as a consequence of Hurricane Mitch (1998) has been estimated at US$ 1,2 millions (Gillet 2003). More recently in the Florida Keys an estimated one-fourth to one-half of all commercial spiny lobster traps were tangled or destroyed by the passage of Hurricane Katrina in 2005 (Buck 2005). Climatic events outside the normal range (from El Niño to natural disasters) can also have an impact on transportation and marketing systems (Catto 2004). In Peru, during EN of 1997-98, rural fishing villages in the northern part of the country were damaged by heavy rains and were unable to get their products to markets due to washed out roads and bridges (Broad et al. 1999; CAF 2000). In Mississippi, about 95% of the 62 seafood dealers were destroyed or so severely damaged that commercial fishermen were unable to sell their catch or buy fuel or ice (Buck 2005). A reduction in financial capital through the lack of access to credit and loans can also be observed. In Peru, at the time of the 1997-98 EN, a percentage of catch value was put into a recently privatized social security and health organization for industrial fishermen (Broad et al. 1999). As a result of decreasing catches the agency’s coffer quickly ran dry (Broad et al. 1999, p.15). This left fishermen without a safety net and access to financial resources to cope with the difficult economic situation. The lack of financial assistance to fishermen during fisheries crisis is a pivotal problem in developing countries, while in countries like Canada and Norway social safety nets and public programs provide important support (Badjeck et al. in prep.)

2.5.2.3 Reduced human capital

The effects on human capital could be felt in terms of health and safety, and food security. Injury and death are the direct health impacts often associated with natural disasters linked to climatic stresses such as floods and hurricane, in the case of injury reducing the physical capabilities of fishermen to pursue their livelihoods. Studies have also shown that the EN cycle in certain areas is associated with changes in the risk of diseases transmitted by mosquitoes, such as malaria and dengue fever, and diseases caused by arbodviruses other than the dengue virus. The risk of malaria in South America, Central Asia, and Africa (areas where the majority of small scale fishermen are located) has been shown to be sensitive to variability in climate driven by EN (Patz and Kovats 2002). Small coastal rural communities often lack potable water, sewage and drainage; health sector problems are thus often enhanced by climatic events such as ENSO's. Additionally, marine phytoplankton blooms caused by increased SSTs can result in red tides that could cause diarrhoeal and paralytic diseases linked to shellfish poisoning (Hales et al. 1999; Patz 2000). Safety while pursuing fishing activities is a significant issue in fishing communities because of changes in weather and storm events or, in the case of artic communities, stability and safety of ice and snow. Indeed personal safety in artic communities practicing ice fishing can be jeopardized by unpredictable ice conditions in winter making travel dangerous (Berkes and Jolly 2001). Catto (2004), presenting the impacts of climate change for Atlantic Canadian fisheries communities, also puts forward that changes in seasonality and storminess may necessitate operational changes by fish harvesters, with implication for both health and safety search-and-rescue operations. Impacts to food security related to access and availability of important traditional food species could equally be significant in a scenario of decreased catches due to climate change events. The risk of malnutrition and undernutrition for communities highly dependent on fish as a source of protein (Ogutu-Ohwayo et al. 1997), combined with changes in diet (reduction of protein from fish source) are some of the possible effects. Decline in commercial fisheries, leading to decrease in income, can also reduce the ability to purchase store-bought food during periods of natural resource scarcity (Callaway et al. 1998). Finally, infrastructure damages due to extreme events or flooding can cut access to local markets, reducing the availability of food products as well as increasing their prices, resulting in higher incidence of malnutrition in communities (Niiya 1998) .

2.5.2.4 Impact on social capital

At the local scale it could be argued that changes in abundance patterns and displacement of stock could similarly lead to conflicts over property rights and resource access. For instance in Peru the "scallop boom" in the south (Pisco) triggers a flow of migrants from all over the country who are opportunistic fishermen wanting to share the bonanza of the EN event (Meltzoff et al. 2005). However, since the last EN artisanal fishermen in Pisco have been forming small associations to qualify for marine tenure to develop scallop aquaculture

(Meltzoff et al. 2005). With the open access of the scallop fishery removed and climate variability being a common feature of the Humboldt Current System, one can wonder how migrants fishermen will respond to this management scheme and social conflict can be foreseen. In Southern Africa, increasing frequencies of droughts are forecasted, leading to greater variability in lake levels and river flows, affecting lakeshore and river floodplain livelihoods that incorporate fishing (Conway et al. 2005). Under increasing uncertainty, migratory fishing becomes a more rational livelihood strategy than investing in a stable village-based existence. As in Peru, this opportunistic behavior of fishermen resulting in increased levels of displacement and migration can put a strain on communal-level management and resource access systems, while decreasing commitment to stable settlement affects investment in community level institutions and services. In the case of extreme events and natural disasters the destruction of one sector infrastructure (e.g. agriculture, tourism, and manufacturing) could lead to the displacement of the labor force into the fishing sector if the latter was not significantly affected, leading to conflicts over scarce labor opportunities. Mahon (2002) observed that in Antigua and Barbuda, during Hurricane Luis in 1995, the destruction and damage to tourist infrastructures resulted in the transfer of workers from this sector into fishing for short term employment, adding pressure to fishing stocks and labor supply. In the case of Africa, it is put forward that droughts affecting agriculture may also push people out of agriculture and into fishing (e.g. Senegal in the late 1990s) (Conway et al. 2005).

2.5.3 Integrating livelihood security in the study of resilience

As shown above the livelihood framework and its focus on assets can be used to clearly understand the pathways in which climatic stresses affect fisherfolk livelihood security. As mentioned before, one of the difficulty encountered in resilience research is to define what to measure and for what (Carpenter et al. 2001). The advantage of the livelihood framework is that for each of the capital assets, indicators can be derived and the concept has been vigorously debated in the literature (Campbell et al. 2001) and used by practitioners (DFID 2001; Allison and Horemans 2006). The aim of the indicators is to measure changes (qualitatively and quantitatively) in the distribution and access to assets. Table 3 provides an example of the type of indicators that can be used based on the review of the impact of climatic stresses on capital assets. Changes in capital assets can be used as surrogates to measure resilience, more specifically changes in absorption, self-organization and adaptive capacity. Indeed once the system has been bounded (scale and unit of analysis, see Table 2) and a reference state defined (for instance temporal scale before a climatic stress), levels of resilience can be evaluated according to shifts of indicators between the reference and the disturbed state. In evaluating the impact of past climatic stresses, it might be difficult to obtain a baseline of livelihood assets and strategies before the events. In this context secondary data to create the baseline as well as open-ended questions to explore changes overtime can be used.

Table 3 Capital assets change and climatic stress: possible indicators

Capital Assets	Criteria - Change (Δ) in Capital	Potential Indicator
Natural	Δ in Harvest	Catch
		Catch structure (size of fish, species composition and numbers)
		Landings by fishing zones
Physical	Δ in Equipment	Investment in fishing equipment due to loss, re-tooling (negative impact) or increased income (positive impact)
	Δ in Housing infrastructure	Changes in condition of house (flooded, partly destroyed, re-location etc.)
	Δ in Items owned of the household	Investment in household appliances (due to loss or increased income)
	Δ in Public infrastructures	State of landing sites
		Access to roads
Financial	Δ Income of fishermen	Profitability (Fishing effort, Landings, Prices, Fuel costs)
		Other activities (agriculture, services)
		Change in proportion of day spent at sea due to weather (Changing daily and seasonal calendar)
		Subsidies (access to credit, emergency aid)
Human	Δ Health of fishermen and household members	Impoverished/improved diet for family members
		Increased occupational health hazards
		Presence of diseases
	Δ Fishing skills	Increased "traditional skills" based on past experience and knowledge sharing
		Increased "modern skills" based on formal training
Social	Δ in social networks	Increased migration (increased number of fishermen or boats)
		Membership to a fishing association
	Δ in social mobilization	Increased number of groups to face negative effects of climatic stress
		Increased number of fishermen associations

Ashley et al developed a methodology to assess wildlife enterprises in terms of their economic and livelihood impacts (Ashley et al. 1999; Ashley and Hussein 2000), highlighting the advantages of the livelihoods framework and its pitfalls when using indicators (Table 4). The creation of indicators can be highly subjective and to avoid this, researchers should always follow the principles underlying each asset. Additionally, to circumvent the issue of bias, researcher have to co-produce them with the actors involved in fishing activities through experts' elicitation techniques, focus groups and interviews (Campbell et al. 2001).

Table 4 Livelihood approach and impact assessment through indicators: challenges and issues (Badjeck 2004)

Advantages	Problems
▪ Gets closer to the reality of how rural people live their lives and judge development impacts than narrow definitions of impact focusing only on economics, or only on social change. ▪ Recognises complexity while providing useful tools or structures for assessing it. ▪ Lays strong emphasis on assets and on issues of vulnerability/security, both of which are recognised to be key issues for poor people. Source: Ashley *et al*., 1999	▪ What to measure? What are the indicators of improved livelihoods? ▪ Many components of livelihoods cannot be quantified. ▪ Nor converted in one denominator for comparing or combining measures of livelihood change. ▪ How to define people sense of 'well-being'? ▪ Criteria for judging livelihood security vary from place to place, person to person. But making comparisons across areas/enterprise requires some common indicators. Many livelihood impacts occur over the long-term. These may be among the most important. Yet there is a risk of assessing wishes and fears, rather than actual impacts, if evaluation focuses too much on possible impacts

The capital assets being interconnected, indicators interact dynamically with each other as shown in Figure 6 with a causal loop diagram (CLD). CLDs are a powerful tool for understanding complexity of dynamics systems, thus resilience, by identifying underlying assumptions about the linkages and causality in the system. The use of CLD to conceptualize livelihood security appears suited for linking the asset approach with the resilience perspective, giving a more explicit systems perspective to the SLA (see Campbell et al. 2001; Habtemariam and Gibbon 2002). Knowing what are the mechanisms, pathways and causal relationships of resilience allows a better understanding of how livelihood security is maintained over time. Figure 6 illustrates the dynamic nature of capital assets using a CLD for a hypothetical fishery. Although not shown in the example in Figure 6, causal relationships can be qualified as positive or negative. This ability to qualitatively explore relationships can provide a surrogate measure for resilience. Some scholars have argued that the evaluation within a complex adaptive systems worldview should place a priority on responding (adapting) to feedback (Bennett et al. 2005; Plummer and Armitage 2007). Using CLDs allows for the identification of feedback loops. Feedback loops are a succession of cause-effect relations that start and end with the same variable and control the dynamic behavior of the system over time. The resilience perspective combined with the livelihood security approach becomes thus a powerful tool to understand how fisherfolk can cope and adapt to disturbances like climate variability and climate change, with a particular focus on feedbacks when using CLDs. While they are powerful frameworks for integrating natural and social dynamics at the micro-scale (actor level), socio-economic development and legislative and marine management regimes are largely defined at regional scales (Charles 2001). These are seldom fully integrated in research related to individual fishermen adaptation. The strength of the SLA is that it aims to reflect the complex range of assets and activities on which people depend on for their livelihoods. However, concerns have been expressed about the approach, mainly that it is stronger on the micro details than on how these may be linked to macro policy, and that it does not address issues of politics and of power (Norton and Foster 2001). Murray (2001), in his review of concepts and methods related to livelihood research, argues that one of the weaknesses of the SLA is that inequalities of power and conflicts of interest are not sufficiently acknowledged, "either within local 'communities' themselves or between 'communities' and, for example, regional elites and government agencies" (Murray 2001 p. 7). Similarly, Allison and Horemans (2006) posit that the analysis of PIPs is cursory, and the importance of markets and macro-economic linkages is diminished by the overemphasis on the 'asset pentagon'. Relating meso-scale to micro-scale processes is essential for exploring how fisherfolk maintain livelihood security. In this context the study of institutions and institutional change is crucial to understanding what makes individuals or social groups change their priorities and regularize new forms of behavior (relevant to understanding self-organization and adaptive capacity). In institutional analysis of SESs, Anderies et al (2004) argue that a major focus has been on either harvesting decisions of resources users (operational processes – actor level) or policy choices (collective choice processes – meso and macro level). Little work has been done to analyze together the operational and the collective choice level. To complete the proposed framework and go beyond a rapid appraisal of PIPs, it is necessary to fully understand the governance system using theories of institutions. The following section briefly describes theories of institutions and their use in fisheries management, and how they can be incorporated to form a hybrid-framework to explore livelihood security and resilience of fisherfolk.

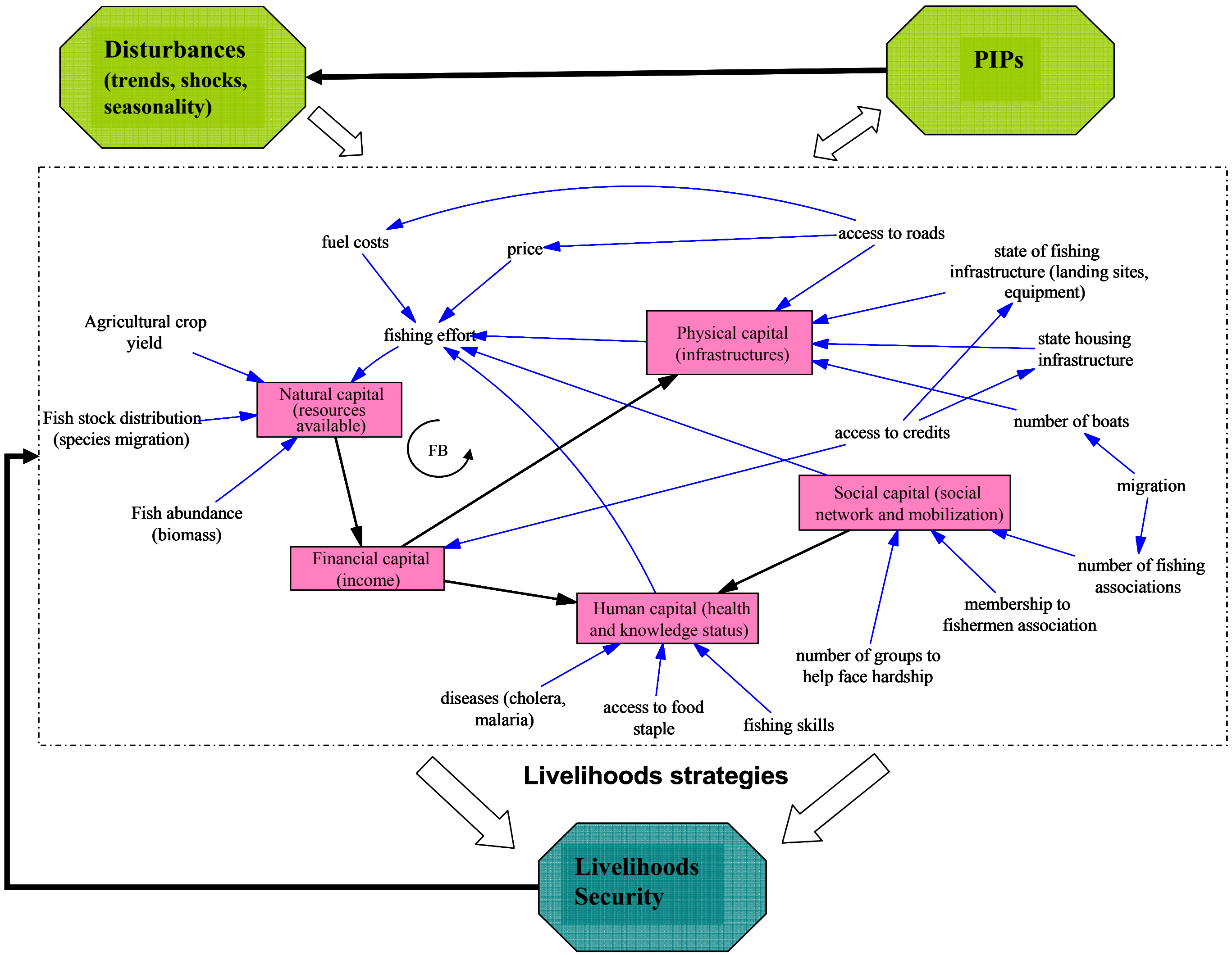

Figure 6 Identifying resilience of fisherfolk livelihood security with causal loop diagrams: a theoretical example. Dotted square refers to interactions within the assets pentagon (five assets in pink). The green hexagons refers to policies, institutions and processes (PIPs) and disturbances, the blue one to final outcome of livelihood security. FB is an example of a feedback loop.

2.6 An institutional approach to the study of resilience and vulnerability

A number of scholars have defined the concept of institutions and their work largely relate to the study of processes of institutional creation and change, which means analyzing economic, social and political factors that create and make institutions alter their structures and operational strategies. Leading contributors to institutional thought come from the fields of economics, political science and sociology. But what are institutions? What is their role in fisheries management? Albeit with brevity due to space constraints, an overview of the theory of institutions will be provided, with a focus on new institutional economics. Then its use in fisheries management research, especially in the context of resources fluctuations and climate variability will be introduced.

2.6.1 Theories of Institutions

2.6.1.1 "Old" Institutional Economics

Led by Gustav Schmoller (1838-1917), the German Historical School of institutional theory insisted that economic processes operated within a social framework, which was in turn shaped by a set of cultural and historical forces (Scott 2001 p. 2). Economic behavior was thus contingent upon its historical, social and institutional context[3]. These ideas were adopted by early American institutional economists such as Thorstein Veblen, John Commons, Westley Mitchell and Walton Hamilton. They criticized the classical abstract deductive reasoning of neo-classical economics, the hypothesis of the 'economic man', where people are highly rational and operate in a perfectly competitive economy in equilibrium, with perfect information flow and where analysis pay no attention to historical change (Peukert 2001; Scott 2001). As observed by Spiegel (1971 pp 631-632), Veblen rejected the orthodox "hedonistic conception of man as a lightning calculator of pleasures and pain". Old institutional economists (OIE) not only believed that institutions existing within a culture played a significant role in the economic dynamics of that society. Their concept of

[3] The German Historical School is thus characterized by a cross-disciplinary methodology: One must look at economic life with the eye of a historian and sociologist, as well as an economist. *Historicism*, was based on the idea of gathering facts and studying them in relation to their historical significance (inductive analysis).. Weber's explanation of the influence of Protestantism on capitalism, albeit coming from a sociologist, is a good example of this (see Peukert, 2001).

institutions rested on the idea that habits[4] were the basis of human action, with knowledge and learning central to an actor's behavior. Accordingly, an institution was defined as "a way of thought or action of some prevalence and permanence, which is embedded in the habits of a group or the customs of a people […] Institutions fix the confines of and impose form upon the activities of human beings." (Hamilton 1932 p. 84). OIE are a departure from orthodox economics with its attempt to understand how actors behave in a society not only in terms of rational maximizing agents, but also in terms of their environment (whether social, political, or cultural). This leap from the traditional approach can be considered an attempt to study the dynamics of a society in a multidisciplinary perspective.

2.6.1.2 "New" Institutional Economics

'New institutional economics (NIE) as old institutional economics believed that institutions mattered but contrary to OIE, it put forward that "the determinants of institutions are susceptible to analysis by the tools of economic theory" (Matthews 1986 p. 903), hence not shying away from neoclassical economics. NIE purpose is to explain the determinants of institutions, their evolution over time, and to evaluate their impact on economic performance, efficiency and distribution. Two approaches strongly rooted in neoclassical economics are present in NIE: transaction costs, and the theory of collective action (Nabli and Nugent 1989).

2.6.1.2.1 Transaction Costs Theory

Transaction cost theory was developed by Coase (1937) and puts forward that transaction costs are the costs of running the economic system, of "doing business", and can be considered *ex-ante* and *ex-post*. As an example, the costs of arranging a contract are *ex-ante* while monitoring and enforcing it are *ex-post*, as opposed to production costs, which are the costs of executing the contract (Matthews 1986 p. 906). Transaction costs can therefore include costs such as costs of discovering trading partners and monitoring performance (Parada 2002), and are to a large extent what Matthews called the "costs of relations between people and people" (Matthews 1986 p. 906). North, in seminal contributions (North 1989; North 1991), extensively discusses the role of institutions in minimizing enforcement costs, reducing risk in transactions, and hence on trade, making long term economic planning possible and profitable (Heiskala 2007 p. 256). North argues that in close knit communities,

[4] Hodgson (1998) defines a habit as a "form of self-sustaining, non-reflective behavior that arises in repetitive situations" (p.178). Hodgson GM (1998) The Approach of Institutional Economics. Journal of Economic Literature 36: 166-192.

transaction costs between villagers are low since people know each other and rely on social networks to provide constraints (North 1991). As trade expands, personal ties and practices such as ostracism that work in a small community are no longer effective, and the development of an institutional environment that provides incentives for contract fulfillment is necessary to make possible transacting and engaging in long-distance trade (North 1991 p. 100). Transaction costs are thus key to the performance of economies (North 1989), and institutions can be considered transaction cost-minimizing arrangements (Nabli and Nugent 1989 p. 1336). Expanding on this idea North defines institutions as:

> "(…) the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North 1991 p. 97).

The non-interactive divide between formal and informal institutions proposed by North has been criticized on the basis that this dichotomy fails to capture the empirical overlap and interrelationships (Mehta et al. 1999, p.16). Hodgson (2006) argues that "the dividing line between institutions that are entirely "formal" on one hand and entirely "informal" institutions on the other is false, because "formal" institutions always depend on non-legal rules and inexplicit norms in order to operate." (Hodgson 2006 p.11). He puts forward that one possibility is to make the formal/informal distinction one of explicit versus tacit rules. This is in concordance with Zenger et al (2002) approach that defines formal institutions as rules that are readily observable and explicit and informal institutions, in turn, as rules based on implicit understandings, being in most part socially derived and therefore not accessible through written documents or necessarily sanctioned through a formal position (Zenger et al. 2002 p.2).

Issues related to transaction costs are closely related to the theme of property rights (Demsetz 1988), Nabli and Nugent (1989 p. 1336) putting forward that "the existence of property rights might reduce conflicts and facilitate cooperation, in both cases resulting in a reduction in transaction costs". According to Coase (1960), externalities[5] can be internalized if property rights are well established. In Coase's view, if property rights are well defined and

[5] Some of the costs (negative externalities) or benefits (positive externalities) of activities/decisions "spill over" onto third parties. See the work by Pigou on where environmental problems are considered externalities. Pigou AC (1932) The Economics of Welfare

transactions costs are very low or inexistent, then it may be possible for the parties involved in an externality situation to reach an efficient solution by bargaining and negotiations. Nevertheless, Coase outlines that the decision on property rights will affect the distribution of income in the final outcome. This is the essence of what has been labeled the "Coase Theorem." North in his work extensively discusses the issue of property rights when he addresses the issue of economic developments stating that:

> "A capital market entails security of property rights over time and will simply not evolve where political rulers can arbitrarily seize assets or radically alter their value." (North 1991 p. 101).

Building on the property rights approach collective action theory addresses issues of social dilemmas related to public goods and the free-rider[6] problem. The extensive literature on collective action is too large to be addressed here; nevertheless a brief overview of the theory and how it relates to NIE is presented below.

2.6.1.2.2 Theory of collective action

The theory of collective action was developed by Olson to account for the ability of economic groups to provide collective goods for their members (Olson 1971). Oslon tried to understand under which conditions individuals can achieve cooperation, looking specifically at interests groups seeking to lobby governments, and how to address the free-rider problem in the case of public goods. As summarized in Paavola and Adger (2005) and Nabli and Nugent (1989), Olson argues that determinant of success in collective action are the nature of the group (size, age etc.), its homogeneity and purposes, and individuals still possessing the incentive to ride free due to the nonexclusive character of public goods. Elinor Ostrom's pioneering work moves the core of the analysis from the firm and interest groups to its use in common pool resources (CPRs), forming the basis of the rebuttal of the argument posited by Hardin on the "Tragedy of the Commons". Ostrom and colleagues define CPRs as:

> "natural and human constructed resources in which (i) exclusion of beneficiaries through physical and institutional means is especially costly, and (ii) exploitation by one user reduces resource availability for others" (Ostrom et al. 1999 p. 218).

[6] Individual who enjoys the groups benefits created by the contribution of others without paying the costs Henrich J (2006) Cooperation, Punishment, and the Evolution of Human Institutions. Science 312: 60 - 61

Hardin (1968) argued that these characteristics of common goods created a situation where if one user limits his use of the good and other users do not, and the resource still collapses, then the user faces a dilemma and will not have any incentives to restrain his use. However, Ostrom and colleagues (2002) put forward that the logic of the tragedy of the commons does not take into account human motivation, rules governing real commons do not always permit free access, and resource systems themselves have dynamics that influence their response to human use (Ostrom et al. 2002 p. 3). Common property and collective action approaches, grounded in new institutional economics, therefore suggest that individuals can act for the collective rather than their individual good if institutions mediating social relationships and making of cooperation a rational strategy exist (Ostrom 1990; Bromley 1991). Theories of institutions have thus been widely used to gain an understanding of their role in common-pool resource management (Noble 2000; Ostrom et al. 2002; Dietz et al. 2003), and explain why some institutions and institutional arrangements more than others successfully manage natural resources (Wade 1988; Ostrom 1990; Baland and Platteau 1996; Dolsak and Ostrom 2003). Agrawal (2001) in his synthesis of the empirical work on collective action and CPRs identified more than 30 variables critical to enable the sustainability of the commons. Key factors identified were (a) characteristics of resources, (b) nature of groups that depend on resources, (c) particulars of institutional regimes through which resources are managed, and (d) the nature of the relationship between a group, and external forces and authorities such as markets, states and technology (Allison and Badjeck 2004 p. 50). Ostrom outlines that while it is important to identify what structural variables lead to successful mode of collective action, their shear number impedes the development of one large causal theory (Ostrom 1998 p. 16). She points out that research should focus on developing coherent scenarios that start with relatively simple baseline models and then change one variable at a time; from such scenarios one can move to formal models (Ostrom 1998 p. 16). To conclude collective action theory and the transaction approach share the belief that an actor behavior is not driven by impersonal historical forces (Hotimsky et al. 2006 p. 2), but by self-interest and bounded rationality, using an utilitarian perspective assuming that actors make decisions by weighing costs and benefits. Indeed Ostrom posits that:

> "one of most powerful theories used in contemporary social sciences -rational choice theory- helps us understand humans as self-interested, short-term maximizers" (Ostrom 1998 p. 2).

However, Ostrom points out that a second-generation model of rationality is needed, where concepts of reputation, reciprocity, trust and various other norms of behavior are included (Ostrom 1998).

2.6.1.3 What about social capital?

Paavola and Adger (2005 p. 364), citing Ruttan (1999; 2001), argue that the concept of social capital is useful to institutional economics because it extends the analysis of NIE to the relationships between culture, beliefs and behavior on the one hand and the institutional, economic, and environmental outcomes on the other. This is what Ostrom seemed to advocate when talking about a second-generation model of rationality (Ostrom 1998). Social capital is a highly valued term in social science and has emerged as one of the dominant concepts for explaining various social and economic phenomena.

Bourdieu (1986) pioneering work expanded the notion of capital beyond its economic conception, introducing the concept of cultural capital. However, it is Coleman's work, and later Putnam's, that were essential in the creation of a broader, unifying concept of social capital. Coleman defines social capital as a variety of entities part of social structures that facilitates relations between actors of that structures (Coleman 1988). Putman builds on this definition to posit that social capital encompasses networks, norms and social trust that facilitate coordination and cooperation for mutual benefit (Putnam et al. 1993). When applied to natural resource management, Pretty and Ward (2001) define it as the relations of trust, reciprocity, common rules, norms and sanctions, and connectedness in institutions. These definitions are closely related to North's definitions of institutions and the concepts of informal institutions (especially when talking about networks and trust). In the sustainable livelihood approach (SLA), social capital means the social resources upon which people draw in pursuit of their livelihoods, and include networks and connectedness, membership of more formalised groups and relationships of trust, reciprocity and exchanges (DFID 2001).

Paavola and Adger (2005) put forward that there are two form of social capital: an asset which can be created and passed on by individuals and a public good bound up with institutions. In this thesis, it is put forward that in the SLA approach social capital is considered as a private good (individual micro level of analysis) that is available to individuals or households

(Allison and Badjeck 2004) and when applied to institutions it refers to its public dimension, the main difference being that:

> "public dimension of social capital reside in networks that enhance overall economic performance [from a transaction cost perspective] rather then that of specific agents [in the private dimensions]" (Paavola and Adger 2005 p. 363).

The study of social capital at the macro level is thus important to complement the institutional economics approach and the SLA framework.

NIE, from an economics perspective, oscillates between hyper-rational agents (game theory) and adaptive agents with low-rationality (evolutionary theory) (Young 1998). This is in contrast with the Veblenian emphasis (OIE) on habits of thoughts and on the fact that markets are not an eternal feature of human society (Parada 2002 p. 49). While it is too complex to develop here, it is worth nothing that the NIE approach to social dilemma has been contested in other areas of social sciences. For instance social constructionist views hold that one cannot have an over-reliance on a utilitarian perspective of human behavior: institutions are embedded in social, economic, cultural and power structures that shape individual action (Hotimsky et al. 2006). Critics of the rational theory approach in political sciences argue that the "idea that human action is to some degree price elastic" (Shapiro 2005 p. 52) does not yield valuable insight into why people engage in certain activities that do not benefit them. For instance ideals and values can lead people to cooperate (Green and Shapiro 1996). Additionally, from a structuration perspective developed by Giddens (1984), actors have the ability to construct new institutions. Thus institutions can shape the decision-making process of actors, being a primary mechanism to mould and facilitate particular outcomes; however individuals have the agency to change institutions to reach desired outcomes. This is similar to the capability theme addressed in the livelihoods framework. NIE, through institutional analysis, can thus be a powerful tool to analyze society-nature interactions with a focus on how social system respond to ecological changes and how these changes shape social systems. However when using institutional analysis, one must be aware of its limits in order to adequately explain social phenomena. In the next section a bird's eye view of how institutional analysis has approached fisheries management and climate variability is presented.

2.6.2 Institutions in fisheries

Since these developments, theories of institutions and institutional analysis have been widely used in natural resource management and more specifically in fisheries. Institutional analysis examines how institutional arrangements affect users' behaviour and incentives to coordinate, cooperate and contribute in the formulation, implementation and enforcement of management regimes (ICLARM 1996). The central role of institutions in determining environmental outcomes has been put forward by several scholars (Ostrom 1986; Ostrom 1988; Imperial 1999b). Some argue that the fisheries literature does not adequately address notions of institutional design and performance, and the institutional challenges facing ecosystem-based management (Imperial 1999a; Imperial and Yandle 2005). When analysing the variety of institutional arrangements in fisheries Imperial and Yandle (2005) showed that different institutional arrangement lead to different levels of performance. Similarly Rudd (2004) and Jentoft (2004) posit that an institutional approach to fisheries management facilitates critical examination of important cross-cutting issues, and that the efficacy of fisheries management is largely a question of institutional design and dynamics.

2.6.2.1 Institutional design

Dolsak and Ostrom (2003) provide a good overview of the challenges faced when managing natural resources. They argue that the characteristics of a particular common pool of resource as well as the characteristics of resource users have a strong effect on institutional design. Generally common-pool resources' characteristics that can lead to successful governance are:

> "(…) small size, stable and well-delineated resource boundaries, relatively small negative externalities from resource use, ability of resource users to monitor resource stocks and flows, (…) and well understand dynamics of the resource." (Dolsak and Ostrom 2003 p. 12)

In fisheries small-sized, well-delimited and stable resource boundaries are not always found. This is a particular challenge for migratory fish stocks such as tuna and halibut. Taking the example of shared stocks between Canada and the U.S in the Gulf of Maine, Herbert (1995) highlights how adequate management of transboundary fish resources is constrained by political and geographical delimitations. Indeed the fisheries agencies of Canada and the U.S. instead of focusing on conservation of shared resources competed on its extraction and policies were aimed at the control of violation of the boundaries between the two countries.

This is particularly relevant in the context of climate variability and change, with fish species possibly changing their stock distribution. Forecasted temperature changes in the Pacific Islands could lead to a spatial redistribution of tuna resources to higher latitudes within the Pacific Ocean (World Bank 2000). Consequently, distant water fishing fleets should be able to adapt to changes in tuna distribution compared to domestic fleets which are restricted to exclusive economic zone (World Bank 2000). This could lead to increased conflict between industrial foreign fleets and national ones over the stock of tuna and would warrant appropriate fisheries agreement. Similarly, Miller (2000) observed that changes in sea surface temperatures and circulation patterns experienced in the North Pacific has led to divergent trends in Northern and Southern salmon abundance. This directly affected the abundance-based management agreement between the US and Canada (Pacific Salmon Treaty) and led to conflicts in the management of the stock. Furthermore, climatic variations may destabilize efforts to cooperatively manage resources that are shared among multiple jurisdictions (Miller 2000; Miller and Downton 2003; Miller 2007). Munoz (1988), referring to EN impacts on pelagic fishery management in the Eastern Pacific also highlighted the importance of international cooperation. Hannesson (2005) argues that establishing property rights to fish is more complicated than establishing property rights to land for resources on and underneath land due to their migratory nature. Defining boundaries for fisheries resources is thus a particular issue of aquatic resources.

Property rights systems are often classified into four categories (Allison and Badjeck 2004 p.21):

- Open access (*Res nullius*) – where access is free and open to all (or there are no well defined use rights)
- State Property (*Res publica*) – where rights to a resource are held in trust by governments for the benefits of citizens and certain rights (use rights) may be granted to citizens through state licensing schemes
- Common Property (*Res communes*) – rights are held by an identifiable community of users with rights to exclude others
- Private Property (*Res privata*) where an individual or firm has the rights to exclude others from using the resource

Literature on how characteristics of property rights affect fisheries management is extensive (see for instance Gordon 1991; Toufique 1997; Crean 2000; Shotton 2000; Béné et al. 2003a;

Newkirk 2006). Few fisheries are truly defined as open-access with customary tenure system such as common property often found in developed countries, while private property is a more common feature of developed ones but exist in developing countries in the form of aquaculture enterprise or small ponds (Allison and Badjeck 2004). Individual transferable quotas (ITQ) are the most commonly used regulatory form of restricting access (private property scheme) but their success is still debated (Hannesson 2005). Changing property rights regimes can have a detrimental effect such as those portrayed by Marshall (2001). Marshall describes how the privatization of marine commons on the Canadian east coast for the development of aquaculture has undermined small fishing communities' ability to get access to wildlife resources. Scott (2000) provides an interesting overview of the evolution of property rights in fisheries (Table 5) highlighting how declining stocks are often an incentive to restrict access to a fishery. The creation of property rights can be a self-organization process, what Menger (1981) (cited in Hodgson 2006 p.13) called "organic" institutions, where as a consequence of changes users change the rules of access. It can also be a more top-down approach where rules are imposed to users, referred to by Menger as "pragmatic" institutions (designed).

Going back to Dolsak's and Ostrom's (2003) proposition that one of the factors that lead to successful governance is the ability to monitor and understand the dynamics of resources, the fisheries literature highlights the uncertainty surrounding the dynamics of fish stock (see for instance Gordon and Munro 1996; Flaaten et al. 1998), especially under disturbances such as climate variability (Glantz and Thompson 1981; Rothschild 2005; Allison et al. 2001). Uncertainty is inherent to fisheries management. Managers routinely face difficulties in designing effective policies to ensure the sustainability of stocks due to uncertain knowledge, as the collapse of the cod banks in Canadian waters highlighted (Mitchell 1997). Nevertheless, scientific uncertainty and lack of knowledge is not always the reason for bad governance as highlighted by the Peruvian case study. The 1973 EN provided to Peruvian institutions involved in fisheries management increased knowledge to deal with the impact of climatic events on the fisheries industry. After the 1973 collapse, the Ministry of Fishery was empowered to exercise tighter regulation and management of marine resources (Zapata and Broad [undated]). However, limited proactive measures aimed at minimizing the negative and enhancing the positive impacts on the fisheries sector during EN 1997-98 were implemented, which many attribute to the government's economic policy of minimal intervention in private sector activities (Broad et al. 1999). In this case forecasting did not prevent massive labour disruption, increase in illegal fishing and apparent biological and economic collapse of the fishery (at least short term) (Broad et al. 1999).

Table 5Historical evolution of property rights in fisheries (Scott 2000).

	1000 AD	**1215 Magna Carta**	**1600 Grotius**	**1750 Naval powers**	**1900 Exhaustibility**	**1960s**	**1990s**
Inland							
Pond	Stock right	Stock right					
River	Catch right	Catch right				Regulated	
Tidal							
River	Catch	Free		Free	Regulated	Regulated & licensed	
Inshore	Catch	Free		Free	Some regulated	Regulated & licensed	ITQ
Offshore	Catch	Free	“None”	Free	No regulation	Regulated & licensed	ITQ
National sovereignty		Declared	“None”	3-mile limit		12 to 50 non limit	200 (EEZ) non limit
				Treaty Waters		Fishery Treaties	Fishery treaties
				“Open seas”			Law of the Sea

This reveals that lack of information in decision-making regarding climate variability and fisheries management response is not always the only determinant; behavioral attitudes and estimation of risks are also key factors. Consequently a focus on cultural and normative factors affecting institutional performance is warranted (De la Torre-Castro 2006). Institutional design based on imperfect knowledge is a challenge facing fisheries around the world, especially in the context of climate variability and global changes. When assessing how fisherfolk are impacted by and respond to climatic stresses, understanding the role played by institutional design such as property right characteristics in shaping their behavior is essential. However institutions are not static, rather they are dynamic like the systems they belong to. It has been argued that in natural resource management the extent to which environmental or resource regimes yield outcomes that are sustainable is a function not only of the allocation of tasks between or among institutions operating at different levels but also of cross-scale interactions among distinct institutional arrangements (Young 2002b p. 266). In fisheries management, co-management and decentralization have been portrayed as one way to increase cross-scale interaction and lead to efficient institutional arrangements.

2.6.2.2 Institutional interplay: the example of co-management and decentralization

Institutions interact with one another both horizontally or a the same level of social organization (i.e. interaction between government agencies dealing with natural resources) and vertically or across levels of social organization (i.e. interaction between local level of land tenure and national regulations) (Berkes 2000; Young 2002b). This interaction among scale and across scales can be referred to as interplay[7]. Horizontal interaction has been a major focus of the fisheries literature through the advocacy of co-management arrangements as a mean to achieve good governance (ICLARM 1996; Lane and Stephenson 2000; Castilla and Defeo 2001). Co-management has been defined by many authors but the approach of Sen and Raakjær Nielsen (1996) is one of the most used scheme (see for instance Wilson et al. 2006) and will be explained after Allison and Badjeck (2004). Sen and Raakjær Nielsen (1996) classify co-management into five broad types: instructive, consultative, cooperative, advisory and informative, according to the balance between the roles that the two groups play (Figure 7). This classification is based on the relative power given to stakeholders. It has been argued that that excluding users from resource management results in negative management outcomes (see for instance Castilla and Defeo 2001). However, Berkes (Berkes 2000; Berkes 2004) puts forward that pure "informative" local-level management will not work by itself. Instead of focusing on redesigning institutions at one level attention should be directed towards the cross-scale linkages between the different levels. Similarly, in their review of co-management in Asian fisheries, Wilson and colleagues (2006) posited that cross-scale institutional linkages were essential for successful co-management, the state having an important role in using its authority to structure and balance interactions between various groups in order to allow them to be responsive to the changing demands of aquatic resource management. The enthusiasm for co-management was rapidly cooled down by some scholars (see seminal papers by Agrawal and Gibson 1999 who criticize the notion of '"perfect community" as a steward of resources and; Leach et al. 1999 who put forward that one should

[7] In this thesis interplay and cross-scale interaction are used as synonyms

look at the broader role of institutions not only communities). Likewise the initial fervor displayed by proponents of decentralization in natural resource management was countered by the realization that if decentralizing meant only the devolution of responsibilities without increasing capabilities (whether financial or normative) at the local level, management outcomes would be as detrimental as top-down approaches (Satria and Matsuda 2004; Ribot et al. 2006).

<table>
<tr><td colspan="3">Government Leads</td><td colspan="2"></td></tr>
<tr><td colspan="2"></td><td colspan="3">User Groups Lead</td></tr>
<tr><td>Instructive
Management centralized in government.</td><td>Consultative
Government consult users but solely responsible for decision-making; controls the process.</td><td>Cooperative
Government and users cooperate as equal partners in decision-making.</td><td>Advisory
Users make decisions, based on government advice where necessary; government has a role in endorsing user-group decisions.</td><td>Informative
User-group based management; government delegates authority for decision making to users who are only responsible for informing government on these decisions.</td></tr>
<tr><td></td><td colspan="3">CO-MANAGEMENT</td><td></td></tr>
</table>

Figure 7 Typology of co-management arrangements (Allison and Badjeck, 2004 adapted from ; Sen and Raakjaer Nielsen, 1996)

Decentralization refers to the systematic and rational dispersal of power, authority and responsibility from the central government to lower or local level institutions (Pomeroy and Berkes 1997 p.469) and often responsibility are the only things government are willing to devolve. The examples of decentralization and co-management highlight the fact that interaction between different scales is an essential aspect of good fisheries governance. However, the focus has so far been on the functional scale, which is the interaction between levels of social organization and political linkages (local versus regional and national institutions). Yet, spatial and temporal dimensions of scale and fit with ecosystems are key issues when addressing institutional change in the context of climate variability.

2.6.2.3 Fit and scale

The resilience perspective described in section 2.2 puts great emphasis on the issue of scale. In terms of spatial scale, managing an estuary, a bay or high see fisheries requires different kinds of management regimes. The problem of fit revolves around how institutional characteristics can "fit", be compatible with the characteristics of the biophysical systems with which they interact (Young 2002a). Cumming and colleagues (2006) argue that scale mismatches between social and ecological components are widespread in socio-ecological systems. Re-visiting the issue of transboundary migratory stocks, one can clearly see that an institution operating only at the national level would not be able to control the effect of fishing on stock outside of its jurisdiction, cooperation between countries thus being warranted (Miller 2007). Additionally, fisheries management must operate at various temporal scales (Figure 8) to deal with seasonal, intra-annual resource fluctuations as well as infrastructure and development planning (Garcia 2004).

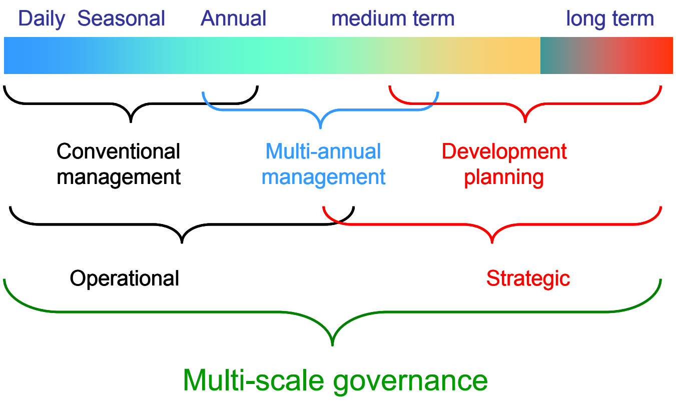

Figure 8 Temporal scale and fisheries management (Garcia 2004)

How can the "mismatch" problem be resolved? While multilevel-governance has been portrayed as the solution, Lebel et al (2006) add that the ability to detect thresholds in a timely manner, and the capacity to build knowledge about ecological processes into institutions should improve the fit between rules and ecosystems, and allow societies to take measures to prevent ecosystems from crossing thresholds. Allison et al (2005) argue that while models are being developed to be more accurate and better predict stock dynamics and climate anomalies, and accuracy allows the reduction in uncertainty, interpretation of information is still an issue and forecast providers should consider explicitly how the fisheries sector and all its stakeholders (i.e. government, large- and small- scales sector) would benefit from such information. Greater emphasis is also needed on downscaling the results of models to a management scale (e.g. from global model to regional and basin level). Knowledge building and institutional learning are thus essential for decreasing the mismatch between institutions and ecosystems and necessary for institutions to design adaptive management strategies. Additionally, institutions must not only design adaptive strategies, they must sometimes also undergo changes themselves.

The aim of this section was not to give an encompassing view of institutions in fisheries management, but rather to highlight some of the main features that need to be addressed when trying to understand how institutions respond and adapt to environmental change and how they inhibit or enable user's responses to these changes. The focus on interaction, scale and feedback between scales is reminiscent of the system perspective. As for livelihoods, causal loop diagrams can be used to conceptualize these interactions and feedbacks and provide a qualitative understanding of the behavior of institutions (Young et al. 2006). Institutions are thus treated as a system with its actors, boundaries and dynamic interactions. Institutions are relevant to the study of fisherfolk responses because they regulate human-environment interactions, co-evolve with environmental change, and mediate social responses (Bakker et al. 1999). Governance is derived from the Latin word “gubernare” which means to “steer”; by analyzing how institutions are or could be “steering” livelihood security in a desirable direction, one obtains a greater understanding of the role of institutions in maintaining livelihood security.

2.7 Hybrid conceptual framework to study resilience of fisherfolk:

The multitier framework for analyzing social-ecological system proposed by Ostrom (2007) is used as basis to integrate the resilience perspective (which includes vulnerability), and the livelihoods and institutional approach in the study of complex interactions between the human dimension of fisheries and climate variability and change. Ostrom (2007) posits that a plethora of variables can affect patterns of interactions and outcomes observed in empirical studies of SESs. In such a context, there is a need to organize attributes under a framework that addresses governance arrangements and specific problems related to SESs. As a result she presents a multitier framework for analyzing a SES and the main variables included in that framework. The framework further elaborates the Institutional Analysis and Development framework developed by scholars involved in the study of collective action at Indiana University and the framework developed by Anderies et al. (2004) for examining the robustness of SESs (Ostrom 2007). A multitier framework signifies that there is a number n- of tiers (layers, elements, variables) that can take different configuration. This refers to the fact that there are several levels of analysis for a SES, and at each level a certain number of variable and patterns can be identified, putting forward that SES are nested systems. Ostrom in her framework depicted in Figure 9 presents the highest tier variables (basic conceptual map) while in Figure 10 second-tier variables are introduced with more details.

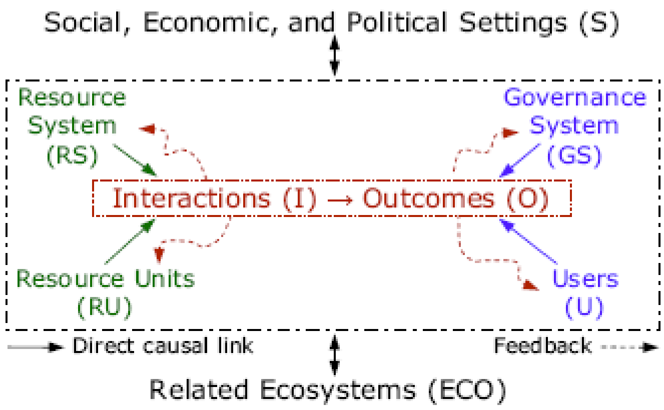

Figure 9 Multitier framework for analyzing SES (Ostrom, 2007)

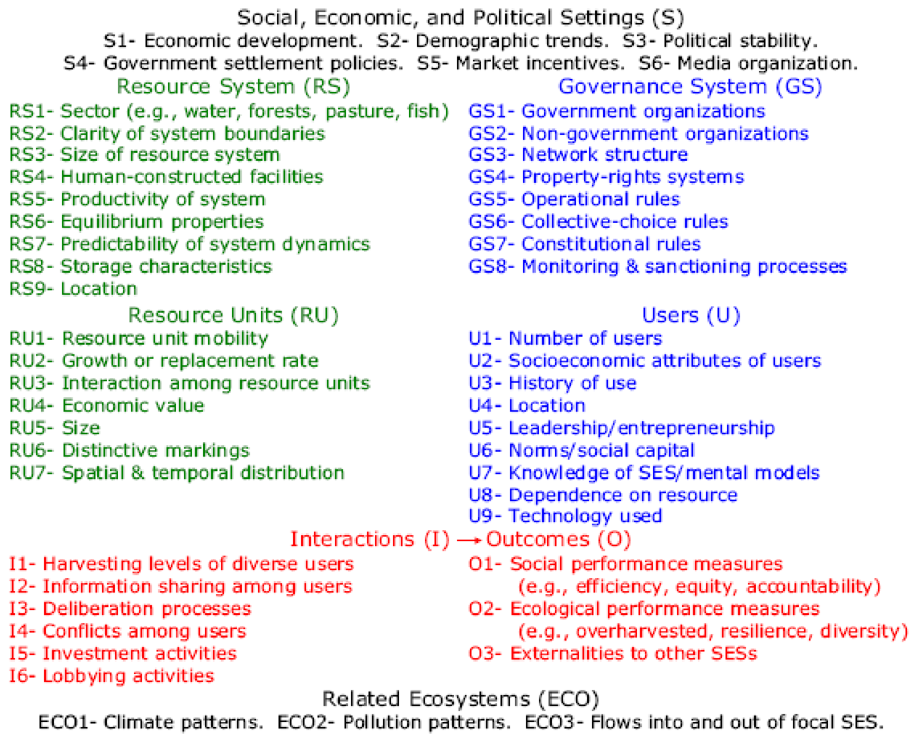

Figure 10 Second-tier variables in framework (Ostrom, 2007)

The framework proposed in Figure 11 is inspired by Ostrom's, but it tries to incorporate the livelihoods approach, the concept of sustainable livelihoods having become an important organizing framework for practitioners in multilateral donors, NGOs and government agencies. Allison and Horemans (2006) pointed out that some scholars objected to the use of the term livelihood strategies, arguing that strategies implies planning and choice which is not always the case for fisherfolk. Here Ostrom's term "interactions" referring to a bundle of actions that can or cannot be planned and are reactive is more suited. This hybrid framework is of interest to those not seeking to propose a "blue print" for the study of resilience of fisherfolk that must be followed; rather, it highlights the importance of a truly multidisciplinary endeavor in resilience research where strength from past approaches are incorporated into new empirical work. After the system boundaries are defined (as presented in section 2.4) the hybrid framework allows for the operationalization of the study of resilience by specifically looking at the impact of a disturbance on the asset pentagon and on the four attributes that characterize governance systems which are design, fit, scale and interplay.

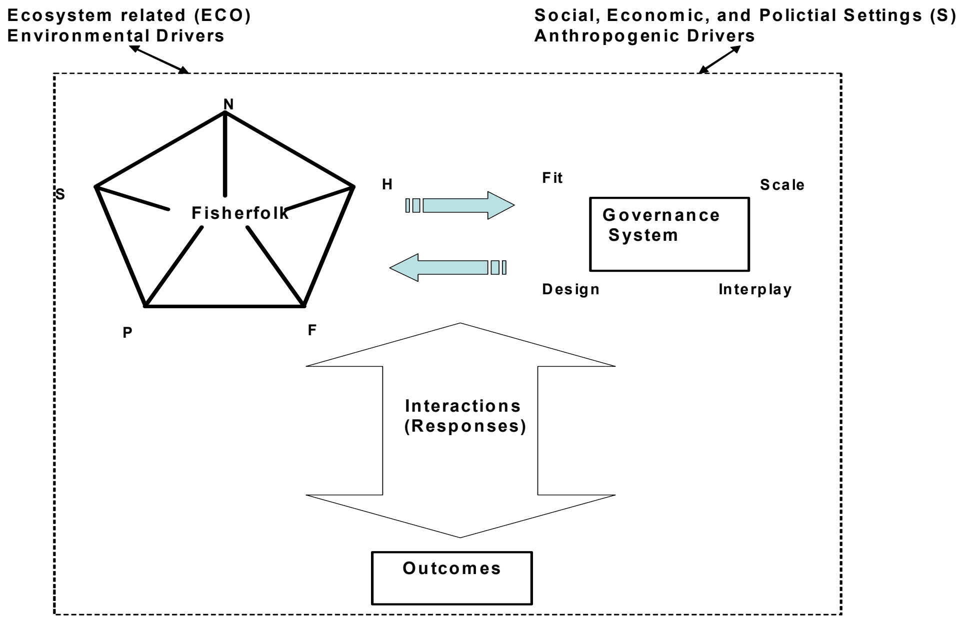

Figure 11 Hybrid framework for the study of fisherfolk resilience.

2.8 Conclusion

"When the only tool you have is a hammer, everything around you starts to look like a nail." (Shapiro 2000)

Digging through the shear amount of concepts and approaches used nowadays to appraise fisherfolk interactions with their resource base and the role played by the institutional context and climatic stress in maintaining or disrupting their livelihoods was a daunting task. The objective was not to provide a blue print or ready made tool; rather it was to highlight the fact that complex socio-ecological problems cannot be dealt with narrow approaches based on disciplinary lines or schools of thoughts. Research frameworks must seek to connect existing concepts in order to provide more powerful insights. While scientists have a tendency to “fish for change”, always looking for new ways and concepts to explore problems at hand, one should always take a reflective stance and explore what other existing approaches can be linked to enhance knowledge. This chapter, the conceptual foundation of the thesis, was an attempt to incorporate into fisheries research the resilience perspective without loosing the insights brought by institutional and livelihoods concepts developed in the last 20 years.

CHAPTER 3

STUDY SITES AND METHODS

"The dangers of theorizing while safely ensconced in the ivory tower are not exaggerated. Yet [...] throwing out the methods of modern science along with quantification and statistics [. . .] is putting the researcher in more danger – the danger of being wrong with no way to show it."(Gladwin et al. 2002; cited in McDougall and Braun 2003)

3.1 Introduction

This chapter presents an overview of Peruvian artisanal fisheries and a description of the two study sites. The institutional arrangements pertaining to the artisanal sector as well as the impact of EN are briefly reviewed. Specific emphasis is placed on aspects that are of particular relevance to the analysis in subsequent chapters. Additionally a summary of the methods used is presented, both for the data collection and the analysis.

3.2 Peruvian artisanal fishery

3.2.1 Characteristics: fleet, target species and socio-economic features

Peru has a coastline of more than 3 000km long and is dominated by the Humboldt-Peru eastern boundary current system, one of the most productive eastern boundary systems in the world (Levin et al. 2002). This system is characterized by coastal upwellings, wind–driven masses of cold nutrient rich waters replacing nutrient poor surface warm waters, resulting in a highly diverse and productive fishery (Wolff et al. 2003). Peru's fisheries sector is the second highest generator of foreign currency after mining, accounting for 1,124 million dollars in exports in 2001 (FAO 2003). More than 95% of fisheries catches belong to the industrial sector, with pelagic resources such as anchovy, jack mackerel and chub mackerel (Majluf et al. 2005). The artisanal fishery represents only 1,2 to 2,4% of the catches with an average of 100 to 200 thousands tons per years (Majluf et al. 2005). In spite of its low contribution to total catches, the sector plays an important socio-economic role in the country. More than 37 700 artisanal fishermen operate along the coast while around 10 000 artisanal boats have been reported (IMARPE 2008). Artisanal fishermen target more than 270 species. Some of the most common fish species caught include corvina (*Cilus gilberti*), choicyruff (*Seriolella sp.),* Peruvian seabass (*Paralabrax humeralis*), smoothhound (*Mustelus sp.)* as well as mullets (*Mugilidae*), silversides (*Odontesthes regia regia*), weakfish (*Cynoscion analis*) and dolphin fish (*Coriphanea sp.)* (Majluf et al. 2005). Fishing areas in Peru can be divided into three zones (adapted from Corporación Andina de Fomento 2000 p. 143):

- Northern zone: High variety of fishing resources due to large continental platform and the Cromwell current. Some of the most common invertebrate species are giant squid, scallops, octopus, and snails. Demersal species include weakfish, seabass, croacker, shrimps, smoothhound, ray and small pelagic like the anchovy can also be found
- Central zone: costal resources mainly in shallower waters with species like lorna, pejerrey, mullet and some invertebrates like scallops, snails and mussels. During the summer sardine are concentrated in Pisco and Pucusana, south of Lima, and in the spring in Callao (Lima). The jack mackarel dominates this zone in October (Huacho y Pucusana) and spring (Callao). The chub mackarel is frequently fished in October around Huacho. Anchovies are located offshore (up to 300 miles from the coast)
- Southern zone: Accidental coastline characterized by small continental platform. Species include anchovy, choicyruff, bonito, silverside and some invertebrates like scallops, snails and mussels

In the last ten years the artisanal fishing sector has undergone several changes. According to Estrella et al (2006), over the last decade the taxonomic composition of catches has changed from a dominance of fish species (anchovy and sardine) to a dominance of invertebrates (jumbo squids and scallops). Additionally, the number of fishermen has increased by 34% while the number of boats by 54%, increasing the fishing effort in the sector (IMARPE 2008). The highest number of fishermen is observed in the Piura region, in the North of the country, and has increased by 43% since 1995 (IMARPE 2008). Fishermen migration and adoption of fishing as a main economic activity have been attributed to two factors: the open access nature of the fishery and ease of entry into the sector. With positive demographic trends and poverty levels in Peru, fishing is seen as a "refuge" where employment can easily be found (IMARPE 2008). In addition, when local resources become overexploited fishermen have a tendency to migrate to more favorable fishing zones (Majluf et al. 2005).

Currently the Peruvian artisanal fleet is composed mainly of gill and drift nets (33,0%) and hooks and lines (28,4%) (IMARPE 2008). The gear description that follows is based on FAO's definition and classification of main types of gear (Nedelec and Prado 1990). Gill and entangling nets are strings of single, double or triple netting walls, vertical, near by the surface, in mid-water or on the bottom. Target species are pelagic, demersal and benthic ones. Driftnets, a special type of entangling net, are used to catch schooling pelagic species like herring, mackerel and sardines, but also tuna and pelagic squid. Trawlers are cone-shaped nets which are towed on the bottom or in mid-water. Target species are bottom, demersal and pelagic species. In Northern Peru trawlers are sometimes used by artisanal fishermen. Hook and lines are gear where the fish is attracted by a natural or artificial bait (lures) placed on a hook fixed to the end of a line or snood, on which they get caught. Target species are pelagic, demersal and benthic species. They can either be operated by hand in small fishing boats or by mechanic systems in larger ones. Purse seiners represent 12,3% of the fleet (IMARPE 2008). They are a type of surrounding nets which are large netting walls set for surrounding aggregated fish both from the sides and from underneath, thus preventing them from escaping by diving downwards. Target species are school of pelagic species. Beach fishermen, present in small numbers along the coast, are defined in this study as fishermen catching species without a boat, mainly through snorkeling from the shore. The diving fishery consists of a small motor boat and a compressor for diving. The crew usually comprises four or five persons, two of which are divers. Divers manually capture benthic invertebrates and sometimes fish with harpoons. It is worth noting that according to IMARPE data the diving fleet has seen in the last ten years a significant increase, from 5.1% in 1995 to representing 13,7% of the fleet in 2005 (IMARPE 2008). The high demand for bivalves such as scallops in the international market could explain this increase.

3.2.2 Political and administrative framework

Artisanal fisheries problems in Peru are, by and large, similar to those of other developing countries: adverse economic conditions, sparse technical assistance, inadequate basic services, short-term approach to use and management of aquatic resources, over-exploitation, production changes due to natural or anthropogenic phenomena, and deficient marketing system (Mendo et al. 2002 p. 25). Moreover the artisanal sector has not been considered in development planning in terms of poverty reduction and food security. The legal framework in Peru has observed various changes throughout the years. The General Fishing Law (GFL) of 1971[8] that regulated the sector in the 80's was characterized by state control. The government owned Pesca-Perú dedicated to fishmeal production, EPSEP (Empresa Peruana de Servicios Pesqueros) dedicated to the commercialization of direct human consumption fishery products and CERPER (Certificaciones Pesqueras) dedicated to fishery certification. Additionally, municipal councils and political authorities were obligated to control the price given to the consumer according to a system established by the Fisheries Ministry[9.] It is interesting to note that pre-hispanic fishermen in Peru had a common property regime (*Res communes*), where rights were held by an identifiable community of users with rights to exclude others. For instance, in the Andean world, beaches were the property of those who lived nearby and only certain zones where accessible for fishing (Rostworowski 2005). The Spanish rule introduced the concept of the "Mar Grau para todos los Peruanos[10]" which is still alive in the mind of most Peruvians. The GFL of 1992 currently forms the basis for the exploitation of fisheries resources in Peru. The GFL states that aquatic resources are state property (*Res publica*) and certain use rights may be granted to citizens through licensing schemes. Table 6 presents the main characteristics of the GFL. There is no territoriality related to the extraction of aquatic resources, the Peruvian fishery being considered a regulated open-access fishery (*de-facto* open access).

[8] General Fishing Law, Law Decree N° 18810 - 1971
[9]. Law Decree N° 18810 Art.20.
[10] Grau [a famous Peruvian General] sea for all the Peruvians

Table 6 General Fishing Law (1992) adapted from Mendo et al, 2002, p.37

Objective	Regulates fishing activities in order to promote its sustainable development as a source of food, employment and income. Ensure the responsible use of aquatic resources, optimizing economic benefits as well as biodiversity (Art.1)
Aquatic Resources	Aquatic resources found in waters under the jurisdiction of Peru, belong to the national patrimony (Art.1), for which the State regulates the integrated management and exploitation of these resources, taking into account that fisheries are of national interest (Art. 2)
Additional Tasks	Fisheries policy, zoning, research and capacity-building, extraction and classification of resources, processing, aquaculture, prohibitions and sanctions, intra-institutional coordination, general fishery registry
Fisheries	The ministry, based on scientific evidence and socio-economic factors determines the type of fisheries, management, quotas, moratoriums and fishing zones as well as regulating fishing efforts, minimum catch size (Art. 9)
Artisanal Fisheries	The states promotes its development as well as capacity-building and technological transfer to artisanal fishermen, providing incentives and benefits following the appropriate rules and norms

With the liberal approach of Fujimori's government in the 90's, the 1992 GFL aimed to attract private and foreign investments. This liberal approach and the promotion of exports were reinforced in 2001 when the Regulation of the GFL was implemented by the transitional government of Valentin Paniagua [11]. The objective of the latter change was to simplify norms and favour investment with fiscal initiatives such as the reduction of income taxes for aquaculture companies. The Aquaculture Law and its Regulation[12] was promulgated at the same time and establishes two modalities to undertake aquaculture activities: through concessions (sowing in the ground or suspended culture in nets) and authorizations (stocking and re-stocking purposes), as long as they do not interfere with other traditional activities[13]. In protected areas such as the Paracas National Reserve, special regulations[14] prevail: in "special concessions" only suspended culture is allowed and seed collection from natural banks is prohibited. Suspended culture

[11] Regulation of the General Fishing Law, Supreme Decree Nº 012-2001-PE - 2001

[12] Law for the Promotion and Development of Aquaculture, Law Decree N° 27460 - 2001 and Regulation of Law for the Promotion and Development of Aquaculture, Supreme Decree N° 030-2001-PE

[13] Art. 13.2 of LPDA (D.S N° 030-2001-PE) stipulates that the accreditation of areas occurs taking into account the fact that selected areas must not interfere with other traditional activities being undertaken in the zone

[14] Law of Natural Protected Areas and its Regulation, Law Decree Nº 26834 - 1997

requires significant capital investments that often fishermen association are not able to bear. All the modalities presented must follow rigorous standards to fulfil sanitary requirements of local and export markets. Table 7 provides a summary of the main institutional arrangements relative to property rights regime in the aquaculture sector, as well as highlighting some bottlenecks of the law. It is worth noting that aquaculture also refers to the culture in natural environments without the need to complete the full life cycle (from larvae development to harvesting)[15]. As a consequence sea-ranching of scallop resource and stock-enhancement activities are considered aquaculture activities despite the fact they do not involve a full life cycle. For bivalve aquaculture the general practice in Peru is thus to retrieve seeds from the natural environment and sow them in closed areas (delimited areas by nets in the water); once sowed they are fattened and then harvested, mainly aimed at the international market.

Table 7 Aquaculture property right regime

	Activities permitted	Limitations	Problems
Concessions	Private or public, legal or natural persons From 10 (subsistence aquaculture) to 30 years (large scale aquaculture) both renewable (Art. 40.1 LPDA)	Cannot interfere with other traditional activities	Conflicts with other users
Authorizations	Communities and fishermen social organizations as well as research entities. For stoking and re-stoking. 10 years renewable (Art. 14.1 LPDA)	Only as a complement of income generation (RM N°102-2006-PRODUCE/DNA)	Stoking and re-stoking currently the main economic activity
Special concessions	Development of aquaculture activities in natural protected areas for fishermen associations. Only suspended culture. 3 years renewable (Art. 27.2 LPDA)	Bottom culture and seed collection from natural banks prohibited	Fishermen collect seeds from natural banks and do not possess the financial capital for suspended culture

One of the corner stone of the Aquaculture Law and it accompanying Regulation is the notion of natural banks which are defined as the assemblage of benthic organism where a taxonomy predominates in a specific geographic area[16]. The notion of natural banks, due to their migratory nature, is a constant source of conflicts between users and the administration in the establishment of aquaculture areas. Currently there are no management plans for the scallop fishery, regulation of capture size being the only management measure (65 mm minimum size) and the elaboration

[15] Art.3, Law Decree N° 27460 - 2001
[16] Art. 82 LPDA, Supreme Decreee N° 030-2001-PE

of the norms and regulation in this sector is heavily influenced by social and economic interests, hindering management (Mendo et al. 2002). In addition to these legal provisions, the main commercial fisheries possess their on management regulations (Reglamentos de Ordenamiento Pesquero) (FAO 2003). Furthermore, the GFL defines artisanal fisheries[17] as a fishing activity practiced by individuals or companies with or without a boat and these must have a maximum capacity of 32,3m^3 and a maximum length of 15 meters, with a predominance of manual labour. Catches must be mainly for human consumption and only artisanal activities are permitted within the five nautical miles from the coastal zone [18].

The political structure of decision-making in the fisheries sector is divided into two levels: national and regional (Table 8 and 9). Since 2002 Peru is divided in 25 regions[19] with their respective elected regional government. Previously, under the highly centralized Fujimori's administration, Peru's 24 regions have been administered by devolved extensions of the central bureaucracy (Schneider and Zuniga-Hamlin 2005). The Production Ministry – Vice-Ministry of Fisheries is now the principal entity governing the national fishing sub-sector and the Peruvian Marine Institute (Instituto del Mar del Perú – IMARPE) provides scientific advice. The different departments that make up the Vice-Ministry of Fisheries (aquaculture, artisanal fisheries etc.) all have their respective competencies and branches in regional offices. Despite the presence of regional branches the management process remains heavily centralized (Mendo et al. 2002). Organization among Peruvian artisanal fishermen and lobbying power are low despite the presence of a national organization (Federación de Integración y Unificación de los Pescadores Artesanales del Perú – FIUPAP). At the local level the number of fishermen organizations has been growing due to the fact that only registered associations can access grounds for scallop aquaculture. Currently little cohesion exist among these different associations due to competition for aquaculture sites among themselves as well as with other artisanal fishermen who traditionally fish in the areas (Mendo et al. 2007).

[17] Art. 29, Regulation of the General Fishing Law, Supreme Decree N° 012-2001-PE - 2001
[18] Art. 63.1, Regulation of the General Fishing Law, Supreme Decree N° 012-2001-PE - 2001
[19] Organic Law of Regional Government, Law Decree N° 27867 - 2002

Table 8 National formal organizations involved in the fisheries sector

Actor	Major regulatory responsibilities
Production Ministry (PRODUCE)	Formulates, authorizes, supervises and executes national policies related to extractive, productive activities and the transformation industry and the industrial and fisheries sector
Vice Ministry of Fisheries	Formulates, executes and directs policies in the sub-sector fisheries which include marine and continental fisheries and the extraction, processing and aquaculture of aquatic resources
Departments within the Vice Ministry (Dept. of Aquaculture, Extraction and processing, Artisanal Fisheries, Environment and Control)	Technical bodies responsible for the development, implementation and supervision of policies related to their sub-sector. They are headed by a national director
National Commission for Aquaculture	Multi-stakeholder commission where the Secretariat is held by PRODUCE. Proposes activities (capacity building, technological transfer) and management plans
Instituto del Mar del Perú (IMARPE)	Scientific research on fisheries resources and their environment for the rational management and protection of these resources. Advisory body for the Vice-Ministry of Fisheries on a scientific and technical basis
Instituto Tecnológico Pesquero (ITP)	Promotes, executes and disseminates scientific programs that promote technological transfer for the adequate manipulation, conservation and processing as well as sanitary control of fisheries products
Fondo Nacional de Desarrollo Pesquero (FONDEPES)	Promotes, executes and provides technical and financial support for the development of the artisanal fisheries and aquaculture
Centro de Entrenamiento de Paita (CEP Paita)	Capacity building and educational activities for workers involved in the fisheries sector and aquaculture, especially the artisanal fishing sector
Instituto de Investigaciones de la Amazonía Peruana (IIAP).	Develop research in the Amazon region on natural resources
Ministry of Defence - Guard coasts (Direccion de Capitania)	The DICAPI is involved in the zoning of territorial water, the enforcement of these zoning rules and the control of sea transport activities
Ministry of Agriculture – National Institute of Natural Resources (Instituto Nacional de Recursos Naturales - INRENA)	INRENA is a decentralized organism of the ministry of agriculture who is the national authority on renewable natural resources and rural environment
Ministry of Mines and Energy	To certain extent involved in the control of contamination of aquatic resources
Commission for Export Promotion (PROMPEX)	Promotes fisheries sector products on the international market through cross-sectoral coordination

Table 9 Regional formal organizations involved in the management of fisheries resources in Sechura Bay's (Piura) and Paracas and Indenpendencia Bay (Ica)

Actor	Major regulatory responsibilities
Regional Government and its respective departments (Gerencia)	Formulates, authorizes, supervises and executes environmental policies and plan (zoning) in accordance to local regional plans
Regional Direction of Production (Direccion Regional de Production - DIREPRO)	Formulates, executes and directs policies in the sub-sector fisheries at the regional level. Can emit Directorial Resolutions (Resolution Directorial) on certain aspect of management such as zoning for aquaculture sites
Departments within the DIREPRO (Dept. of Aquaculture, Extraction and processing, Artisanal Fisheries, Environment and Control)	Technical bodies responsible for the development, implementation and supervision of policies related to their sub-sector at the regional level. They report to the regional director of DIREPRO and their respective central department. At the local level they are involved in primary data collection (i.e. landings) and control operations (inspectors)
Regional Offices IMARPE- Paita and IMARPE Pisco	Scientific research on regional fisheries resources and their environment for the rational management and protection of resources. They report to the head office in Lima: cannot authorize norms and regulations (all decisions in Lima)
Regional Office Instituto Tecnológico Pesquero (ITP)	Promotes, executes and disseminates scientific programs that promote technological transfer for the adequate manipulation, conservation and processing as well as sanitary control of fisheries product at the regional level, reports to central agency. Cannot authorize norms and regulations (all decision in Lima)
Fondo Nacional de Desarrollo Pesquero (FONDEPES)	Promotes, executes and provides technical and financial support for the development of the artisanal fisheries and aquaculture at the regional level. Cannot authorize norms and regulations (all decision in Lima)
Centro de Entrenamiento de Paita (CEP Paita)	Capacity building and educational activities for workers involved in the fisheries sector and aquaculture, especially the artisanal fishing sector. Mostly fishermen from the Northern part of Peru
Navy and coastguards (DICAPI Pisco and DICAPI Paita)	The DICAPI is involved in the zoning of territorial water, the enforcement of these zoning rules and the control of sea transport activities
INRENA Pisco (National Paracas Reserve)	Management of the reserve

3.3 El Niño and the fisheries sector

Abiotic changes due to EN in Peru include strong increases in temperature, less intense upwelling, changes in oxygen, salinity, freshwater and sediment input as well as increased sea level (Arntz et al. 2006 p. 246). Biotic responses resulting from these environmental changes include changes in species composition, abundance and biomass due to emigration, immigration, changes in reproductive success, larval dispersal and recruitment, as well as changes in food availability, competition and predation (Arntz et al. 2006 p. 246). Pelagic species are especially sensitive to EN events and the impact of these events on their population dynamics and the economic impact on the industrial sector have been extensively studied (Pontecorvo 2001; Broad et al. 2002; Chavez et al. 2003; Alheit and Niquen 2004; Bertrand et al. 2004; Ñiquen and Bouchon 2004). Niquen and Bouchon (2004) offer an interesting study of the effects of EN on small pelagic, which are summarized in Figure 12. While the prevalence of anchovy drastically decreases, other species like sardine and jack mackerel strive. This results in taxonomical catch changes, with an increased percentage of other pelagic resources and a reduced percentage of anchovy (Ñiquen and Bouchon 2004). Increased SSTs also bring a variety of (sub) tropical immigrants and expands the distribution zone of some species. For instance during EN 1982–1983 and 1997–1998 penaeid shrimps (*Xiphopenaeus kroyeri*), and rock lobsters (*Panulirus gracilis*) from the Panamic Province appeared in Peru (Arntz 1986; Arntz et al. 2006). These species, as well as dolphin fish, tuna and diamond shark became a new economic opportunity for the artisanal fishing sector (CAF 2000).

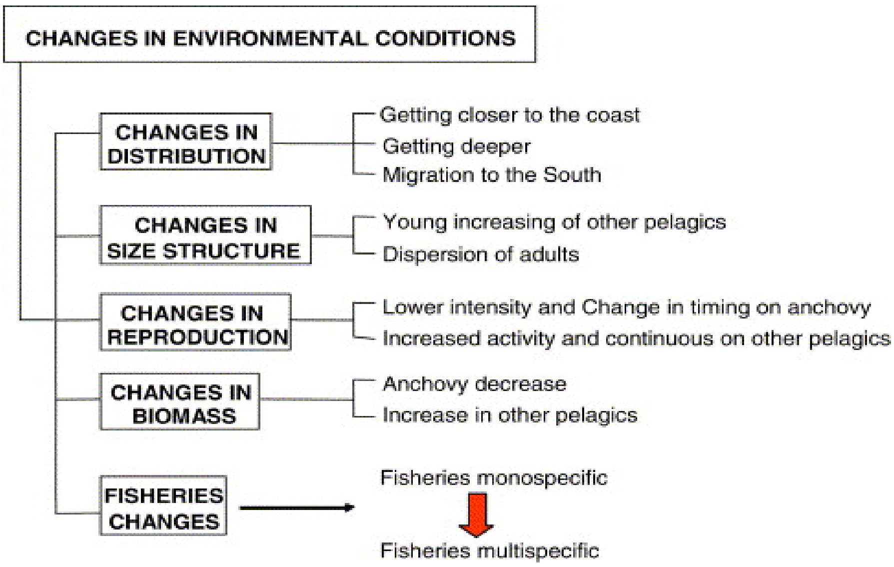

Figure 12 Effect of El Niño on pelagic species (Ñiquen and Bouchon 2004)

While demersal species such as hake, lorna extended their area southward, cold-adapted benthic upwelling species such as mussels, clams, snails and crabs were negatively affected by EN (Arntz et al. 2006). However, benthic invertebrates such as scallop (*Argopecten purpratus*), purple snail (*Thais chocolata*) and octopus (*Octopus mimus*) proliferated under warmer conditions (Arntz et al. 2006). The (normal) cold upwelling conditions (summer water temperature of about 16°C) were drastically altered in Central Peru (Pisco) to tropical warm water conditions (around 25°C), affecting scallop population dynamics by increasing growth rate and recruitment, as well as the bay's scallop carrying capacity (Wolff and Mendo 2000; Mendo and Wolff 2003). Conversely, in Northern Peru (Sechura Bay) increased rainfall and river runoff may negatively impact the benthic communities (Arntz et al. 2006). Vadas et al. (2008) developed a predictive model for the Sechura scallop harvest. This modified model demonstrates a significant negative correlation between scallop catches and river discharge. River discharge causes a significant increase in mortality probably via decreased salinity and/or increased sedimentation rates. Moreover, increased fluvial discharge in the North, resulting from higher precipitations between January and April 1998, negatively impacted the shrimp fishery, with the destruction of production infrastructures (hatcheries) (CAF 2000). The strong rainy season also caused damage on infrastructures such as landing sites, boats and transportation routes (CAF 2000). The latter particularly hindered the commercialization of fishery products. It has been estimated that the cost of EN on the fisheries sector in 1998 was 73, 7 millions of soles (26, 3 millions of dollars[20]) (Table 10). This had a negative effect on the country's balance of payment of around 8,4 millions soles (CAF 2000). The major losses were registered in the industrial fishing sector (processing and exportation). During EN 1997-98, the total volumes of landings decreased by 55% compared to 1996 (CAF 2000).

Table 10 Damages to the fishery sector in Peru during EN 1997-98 (1, 000 of Nuevo soles) (CAF, 2000)

Type of damage	Total damage	Indirect	Direct	Effect on the balance of payment
Infrastructures	41, 800	41, 800		8, 400
Reduction of catches	19, 260	-	19, 260	-
Shrimp industry	12, 610	-	12, 610	-
Total	**73, 670**	**41, 800**	**31, 870**	**8, 400**

20 Exchange rate of 1998

Artisanal fisheries were diversely affected depending on the migration and abundance of certain species but no published studies specifically examining the impact on the sector and on fishermen livelihoods were found.

3.4 Multiple-case studies approach

The research was carried in two study sites: Pisco, in South-Central Peru and Sechura, North of Peru (Figure 13). Similarities reside in the differential effect of EN, while differences in the presence in one site of a marine National Park and tourism among others. A multiple-case study approach was warranted to understand the differential impacts of climate variability in coastal Peru. Multiple-case studies designs based on the prediction of contrasting results but for predictable reasons allow for the development of a rich theoretical framework, and the evidence is more compelling for the generalization of findings (Yin 2003). The degrees of contrast and similarity among the sites will allow this empirical based work to be of relevance for other regions of Peru, as well as providing external validity to the findings.

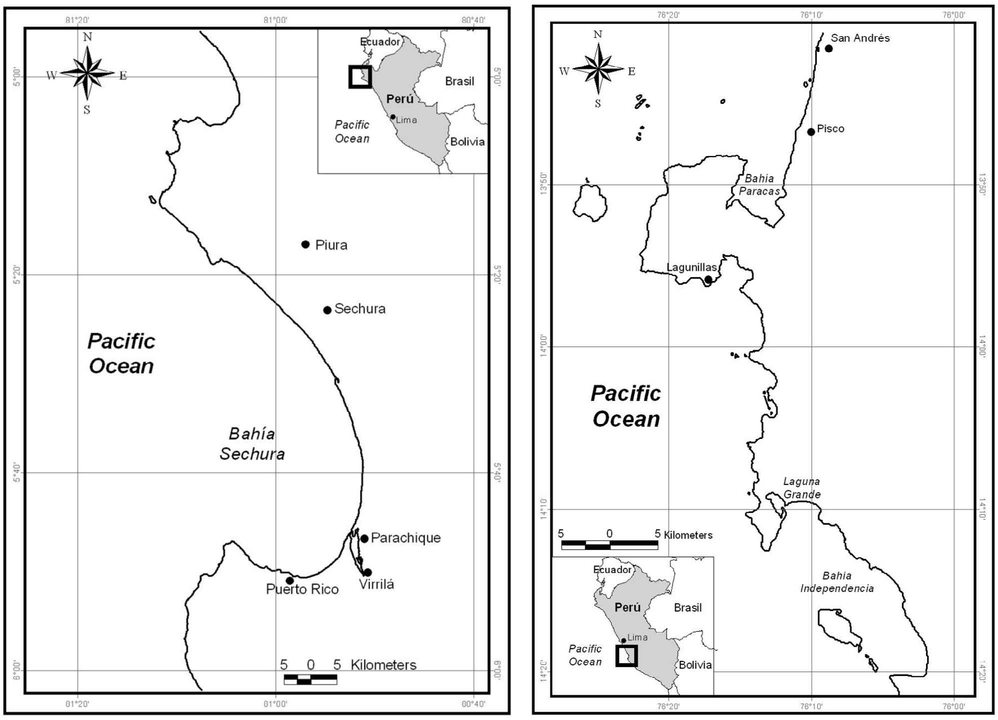

Figure 13 Map of Study sites

3.4.1 Region of Piura: Bahia de Sechura

Piura is an arid coastal region located in northern Peru, 1200km north of Lima. Piura is derived from the Quechua word “Pirhua”, which means granary or more broadly supply base (Alban Ramos 1985). Indeed the region in an important agricultural center in the country with rice, lemon and mango production for the local and international markets. Fisheries landings, while representing only 7,1% of the regional gross domestic product (GDP) in 2001, represented 28,6% of the national sectoral GDP (Tarazona, 2005). The region is divided into eight provinces, the province of Sechura being one of the most populated, with 17,7% of the total regional population (Chapa 2005). More than 40% of the population lives below the poverty line (i.e. with less than two dollars a day per capita), and 12,5% is trapped in extreme poverty, with less than one dollar a day (Flores Ysla et al., 2005). Fishing activities are an important source of revenue, providing work to more than 30% of the economically active population in 1993 (Chapa 2005). Sechura Bay (5,6° S, 80,9° W) is relatively shallow with depths of less than 30 meters and extends over 89 kilometres. It is situated within the zone of transition between cold water transported from the south by the Humboldt Current and warm water of the tropical equatorial region (Taylor et al. 2007). The Lobo de Tierra Island located at 15 hours by boat from the Bay is another important fishing area in the high seas where artisanal fishermen mainly extract invertebrates (scallop and squid). In the Bay, there are three main docks ("caletas") with associated settlements: Constante, Parachique – La Bocana and Puerto Rico. Diving is a recent activity brought by fishermen from the South in the late 80's and early 90's. Based on available data it is estimated that the diving fishery currently represents 25% of the fleet in 2005 compared to 19% in 1995 with more than 30% of the 6 000 artisanal fishermen are involved in the fishery (Pers. comm. Fiesta; DIREPE 1995; DIREPRO 2005b). Of the 155 species extracted in the bay, principal resources include (Gonzales and Yepez, 2007):

- anchovy *Engraulis ringens* – 92.9% of total landings mainly for the industrial sector
- giant squid *Dosidicus gigas* - 2.5 %
- scallop *Argopecten purpuratus* 1.1 %
- Patagonian squid *Loligo gahi* 0.8 %
- longnose anchovy *Anchoa nasus* 0.6 %,
- snake eel *Ophichthus remiger* 0.6 %,
- mullet *Mugil cephalus* 0.3 %

The El Niño phenomena results in catastrophic consequences in the region of Piura, having been referred to as the "*castigo de Piura*" ("Piura's curse") (Reves 1983). During the 1997–1998 El Niño the total accumulated rainfall in the city of Piura was 1802mm, thirty times its normal value (Takahashi 2004) which resulted in river discharge in the bay four times higher than normal. The floods caused negative impact on agriculture, with a third of the cotton and rice production being lost (Niiya 1998; Van der Veen 1998), food security becoming a severe problem in the area (Niiya 1998). The cost of staple foods such as rice and cooking oil was heightened by heavy damage to transport infrastructures. More than 10% of rural housing infrastructures were destroyed while 40% of transport route were damaged (CIPCA and COER 1998). Additionally, the usually dry watersheds became active and formed in Sechura a lagoon called “La Niña”. This lagoon is the result of effluents from the Piura River augmenting the water level of the Las Salinas Lagoons and transforming them into a lake were fishes such as mullets, species favouring brackish waters, became abundant (Goicochea 1998).

3.4.2 Region of Ica: Bahia Paracas and Independancia

The region of Ica is divided into five provinces. The province is located 250km South of Lima, and is characterized by the presence of the Paracas National Reserve, the only marine reserve in the country created in 1975. The reserve attracts a significant number of national and international tourists each year, with in 2001 nearly 99 000 people having visited the reserve (ERM 2002). It’s main agricultural productions are cotton and grapes (mainly for the manufacture of wine and the Pisco liquor) (ERM 2002), with agriculture representing 15% of the regional GDP (Gobierno Regional de Ica 2006). Fisheries, with 8% of the regional GDP (Gobierno Regional de Ica 2006), play an important economic role in coastal towns, especially the province of Pisco. The province is one of the main seafood provider of the large Lima urban market (ERM 2002). Official statistics characterizes 29,2% of the population as poor and 2,4% as extremely poor (INEI 2004). Additionally, Pisco is considered a province with negative migration balances (ERM 2002).

Independencia and Paracas Bay are located within the province (14°S-76°W) and are relatively shallow (5 to 25 meters). Independancia Bay is situated within the Paracas National Reserve, and has an area of 150km^2. Paracas Bay, adjacent to Independancia but located outside the reserve is a smaller bay. Both bays are heavily influenced by upwelling conditions. The main pelagic fish species extracted are anchovy, jack mackerel, sardines and chub mackerel (Mendo et al. 2005). Invertebrates with the high landing volumes are scallops, mussels, abalones, snails and clams (Mendo et al. 2005). The south of Peru saw the beginning of diving activities with the apparition in 1941 of the first diving equipment with compressor in Pucusana, near Pisco (Zavala Lopez No date). The Peruvian scallop fishery started in Pisco in the 1950’s while the first experiences with intensive culture were initiated in 1979

(Valdivia & Benites 1984, Valdivieso 1990). The province became the hub of the scallop diving fishery and until now the most skilled divers are considered to come from the area. It is estimated that 39% of the 3059 artisanal fishermen from the Pisco area are involved in the diving fishery, representing 46% of the fleet (Mendo et al. 2005). The Paracas National Reserve restricts the extraction of aquatic resources. Under special conditions only fishermen associations are allowed to culture scallops in the Reserve while in Paracas Bay, outside the reserve, companies own most of the aquaculture sites. In Independancia Bay main landing sites are Lagunilla, Laguna Grande-Muelle and Rancherio, the latter being a human settlement which in 1999 consisted of 102 "ranchos" (sheds) while Laguna Grande had 59 "ranchos". In Lagunilla there are no human settlements. In Paracas Bay the main landing site is El Chaco while near Pisco, San Andres is the commercial hub where products are sold to intermediaries from Lima. Sea temperatures during the year normally fluctuate between 12°C (bottom) y 16°C (surface) while during EN events temperature reach values above 20°C (Wolff and Mendo 2000).

3.5 Methods

Methodological pluralism is the favored method of inquiry used, with a combination of quantitative and qualitative methods rooted in the social sciences, breaking away from the traditional approach in Latin America to focus assessment of artisanal fisheries solely on ecological and biological aspects (changes in biomass, catches) to inform policy. Additionally, in the identification of processes in social settings the subjectivity of the researcher must be down-played by a co-definition of fundamental processes with actors in the system studied using participatory methods. The multi-method approach comprised archival research, participant observation, semi-structured and unstructured interviews, workshops and surveys. Research was carried out in two municipalities and one settlement around Sechura Bay: Sechura, Parachique and Puerto Rico. In Pisco, field work was conducted in two municipalities: Laguna Grande and San Andres. These locations are characterized by being the principal fishing docks in both study sites. Additionally, in Sechura, some field work was conducted in the Lobo de Tierra Island (temporary fishing settlement). A fundamental problem in research is defining what the unit of analysis is; that is individuals, groups or communities (Yin 2003). In this work the unit of analysis is related to the way the research questions were defined. These focused on fishermen livelihoods and responses to El Niño events thus information relevant to individual fishermen was collected (i.e. fishermen survey instead of household survey). However, it is acknowledged that households, groups, communities and supra-communities entities influence fishermen livelihoods and behavior so while the focus was individual the research strategy was designed to understand contextual variables that influence fishermen livelihoods. Local community in this study is defined principally in terms of place or location where a group of interacting people are tied together for instance by residence, not necessarily identity (Berkes et al. 2001).

To elicit how climate variability affects fishermen in depth unstructured and semi-structured interviews were conducted with selected informants. These concentrated on perceptions of how EN affected their fishing activities and their households, and more generally what factors inhibited rather than encouraged their activities. A fishermen survey complemented this information while providing socio-economic parameters to inform the livelihood analysis. Unstructured and semi-structured interviews to key informants were also used to determine the major constraints faced by the artisanal fisheries sector in terms of management. Interview topics included the articulation between national and regional authorities, the effectiveness of fisheries policies and the impact and management of EN events. Evidence of the findings for responses of institutions to climate variability is driven by secondary data, namely reports, policy statements, planning documents and archival research of fisheries legislations. Workshops and focus groups also provided the mean to understand stakeholders' perception of the impact of EN and the current fishery management regime. Finally, to understand how different driving forces affect institutions' responses, a conceptual model was developed using causal loop diagrams. Table 11 provides a summary of the methods used while the following sections explore them in more details.

Table 11 Summary of methods

Research Objectives	Methods
Characterize fisherfolk livelihoods to understand how livelihoods are constructed and maintained	Interviews, observation, surveys and workshop
Understand how livelihoods are impacted and maintained during El Niño events	Interviews, surveys, workshop and focus group
Establish how institutions enable or constrain fisherfolk adaptation processes	Archival research, interviews, workshops, focus groups and causal loop diagrams

3.5.1 Research Methods – Data collection

3.5.1.1 Archival research

Researchers should make a maximum use of historical and secondary data to supplement the primary data collected. Too often, these sources of data are rejected outright as being unreliable (Smith et al. 1983). The first phase of a research should thus focus on a comprehensive secondary data collection (Smith et al. 1983). Information pertaining to the artisanal fisheries sector in Peru and in the study sites was thus collected at the onset of this thesis. Published and unpublished studies, government reports, academic thesis, newspapers and library archives were revised. It is worth noting that little published information exist on the artisanal sector and on the specific impacts of EN.

3.5.1.2 Workshops and focus groups

A series of workshops were undertaken between March 2005 and 2007. All workshop results were compiled in reports made available in Spanish to participants (i.e. Mendo et al. 2006a; Mendo et al. 2006b).[21] The first two workshops were conducted at the onset of the thesis in Pisco and Sechura in 2005. Participants ranged from fishermen, government representatives and businessman (Annex 1). The objectives of the workshops were to:

- Establish a first contact with users of fisheries resources in the two bays
- Understand the asset base on which fishermen rely in the study sites
- Establish what constraints and problems each study site faced in terms of fisheries and coastal management.

Participants were divided into groups of 5 to 7 persons; groups were formed to ensure heterogeneity of actors (fishermen – aquaculture and non-aquaculture, government officials etc.). In each group a moderator was elected and CENSOR project members were instructed to remain passive observers, only intervening to respond to inquiries about the methodology and doubts, and taking notes. In the first activity each group identified assets available to fishermen using the livelihood framework. The second activity of the workshop was a participatory ranking exercise. Problem ranking is a way of quickly identifying main problems experienced by individuals or groups (Mikkelsen 1995). Divergent ranking can be compared and consensus reached through discussion (Mikkelsen 1995). In each group a brainstorming session was initiated on problems related to the use and management of

[21] Some are available on the project website www.censor.name

fisheries resources in the area. Each participant was asked to rank the problems from one to five (least to most important problem). The total sum of each vote was used to establish a ranking of problems in each group. Then, for the five most important problems, the causes, consequences and possible solutions were identified. Finally, based on each group works, a consolidate table was create relating the five most important problem in each site based on the value of votes assigned to them.

After these first two workshops, five others were undertaken between 2006 and 2007. Central components of these events were group discussions and experts input. The objectives of these workshops were to:

- Assess local perception of scallop fishery management issues and the impact of climate variability on scallop resources
- Present preliminary results to obtain feedback, ensuring triangulation of the research results

The meetings provided a learning platform for the researcher, allowed institutions, communities and fishermen to get acquainted with the research and comment on preliminary results, as well as permitting the exchange of ideas between users and authorities who seldom meet in such venues. These workshops were instigated by the CENSOR project to address the particular issue of the scallop fishery which is an important resource for artisanal fisheries in both bays and is subject to drastic changes during El Niño events. The formats of the workshops were: expert presentations followed by discussion with participants and a plenary were main results of the discussions were presented. Experts were not only "academics" but representatives from government as well as presidents of fishermen organizations and representatives from companies. Three of the five of the workshops were open to the general public. Fishermen, by being presenters, were given the opportunity to share their knowledge, reversing the power relation and moving the research from simply extracting to empowering fishermen (Chambers 1997 p. 154). The feedback from users and local experts allowed the author to contextualize the findings, avoid bias and mis-interpretation, and basically ensure triangulation of the data. Triangulation is a method to overcome the problems that stem from relying on a single method, single data set or single investigator (Mikkelsen 1995 p. 81).

Additionally to the workshops three focus groups with fishermen, one in Sechura and two in Pisco, were undertaken in December 2006 and January 2007. Focus groups are somewhere between " a meeting and a conversation" (Agar and MacDonald 1995; cited in Kidd and Parshall 2000), where participants relate their experiences and reactions among presumed peers. Homogenous focus groups are an optimal way to obtain in-depth information about certain activities (Mikkelsen 1995). The focus group in Sechura was composed of migrant fishermen involved in scallop extraction. The objective was to understand migration patterns of fishermen and responses to EN events. In Pisco individuals involved in scallop extraction were asked to share their experiences within the activity, highlighting trends, constraints and responses to EN.

3.5.1.3 Observations and interviews

Observation is widely used in classical anthropology and is an indirect method of data collection that stresses the importance on dialogue rather than extractive techniques (Mikkelsen 1995). Participant and non-participant observation was undertaken throughout the field work. Participant observation included activities such as snorkelling with divers, taking part in communal kitchen meal preparation and community group meetings. Participant observation implies getting to know people, establishing a rapport and a relationship of mutual trust (True 1989). Non-participant included walks in communities and observing unloading of catches at the main fishing docks as well as fish market activities. Key informants semi-structured interviews were also undertaken to obtain specific knowledge on the study sites and the fisheries. Key informants are individuals anticipated to have a particular insight or opinions abut the topic under study (Mikkelsen 1995 p. 75). They ranged from fishermen (presidents of association), individuals in the private sector (aquaculture and fishing companies), NGOs and international donor agency workers, academic experts, individuals in government agencies and leaders of community groups (i.e. communal kitchen). Semi-structured interviews are appropriate when one has specific objectives but still wants to leave room for exploration during the interview (True 1989). Probes were used to steer the conversation towards specific topics (Annex 2). Manual recording was the favoured method for recording data during the interview, combined with post-interview write up. In addition informal and open-ended interviews were conducted, with no premeditation of questions. The characteristic of this approach is that information is collected from different people on different topics (Mikkelsen 1995). This less systematic approach offers to the researcher the possibility to deal with delicate questions that cannot be spelled out right (True 1989), such as those related to corruption.

3.5.1.4 Audiovisual interviews

As part of the project CENSOR a 25 minutes documentary on climate variability and the scallop fishery was co-produced by the author (Annex 3). Key informants were involved in the development of the script. The video was filmed during June and July 2007 and a first screening occurred in March 2008. The interviews and focus groups in the video provided an invaluable opportunity to capture stakeholder perception of the impact of EN on their livelihoods and triangulate information collected during previous field work.

3.5.1.5 Quantitative approach: fishermen survey

In order to collect data to support the livelihood analysis, a fishermen survey was designed and conducted (Annex 4). The survey had two main components:

1. basic data on socio-economic profile of respondents and details on fishing activity
2. questions specifically pertaining to climate variability and El Niño

The first part of the questionnaire consists of close ended questions aimed at collecting socio-economic information such as age, birth place, educational level, income, housing characteristics, type of fishing activity and membership to an association. This section of the survey was designed based on a survey conducted by the Universidad Agraria La Molina (UNALM) in Pisco in the fall of 2005 where more than 1 500 fishermen were surveyed. The objective was to allow researchers in the University to compare the results of this thesis with their work. Often surveys are conducted in a vacuum and it was felt important to build on the work already undertaken. The second part of the questionnaire consisted mostly of open ended questions to explore how El Niño affects livelihoods. First fishermen were asked which other income generating activities they participated in and if women in their household also engaged in such activities. Then fishermen were asked what were their target species (up to five) in non- EN years and during EN. A series of open ended questions regarding EN and their fishing activity followed, investigating whether respondents changed income generating activities during EN (which ones?), how EN affected their economic activities (i.e. operational costs, income) and if they had to change fishing zones (which ones?). Respondents were then asked how El Niño affected their households and if they required and received help during such events (what? from whom?). To explore the different dimensions of social capital a specific section of the survey addressed issues such as if the respondent or a member of his household are part of a community group, how their engagement helps their household and if the group provided assistance during EN. Finally it is worth noting that in the second phase of the survey data collection a specific section on migration was added, as interviews and workshops data revealed it to be an important aspect of livelihoods.

A pre-test of the survey occurred in January 2006 in Pisco to evaluate its effectiveness. The survey was then conducted in February and March 2006 in Pisco, and June 2006 in Sechura. A second phase occurred in December 2006 (Sechura) and Jaunary 2007 (Pisco). Surveys were administrated with the help from students from local universities (Universidad Nacional de Piura and Universidad San Luis Gonzaga, Pisco) and the author was involved in all the survey campaigns. Students were trained and conducted pre-tests of the questionnaire in order to ensure their understanding of the questions and their ability not to guide or cloud responses from fishermen. At the time of the survey design, statistics provided by DIREPRO were used in Sechura to estimate the fishermen population and gear composition. Data regarding artisanal fishermen ranged from 4 500 to 6 000 (DIREPE 1995; DIREPRO 2005b) while national statistics only reported 3 320 (PRODUCE 2004). Diving boat with compressors represented nearly 40% of the fleet (DIREPRO 2005b). The difficulty to obtain reliable statistics is an issue that plagues many developing countries and the lack of reliability of the data was highlighted by key informants. It was thus decided to use lower-end estimate and assume a population ranging between 3 500 and 4 000. Sample size, based on the approach by Bunce et al (2000) was thus set at 350 fishermen. In Pisco, the recent study by the UNALM provided valuable grounds to design the sampling strategy. Around 3 000 artisanal fishermen were estimated to operate in the area, with nearly 40% involved in the diving fishery (Mendo et al. 2005). In actuality, while a total of 650 surveys were conducted only 572 were selected for this study (rejection of survey was for instance based on too many missing questions and pre-test surveys being excluded). In Sechura 333 fishermen were surveyed while in Pisco 239. These sample sizes, despite falling short of the target in Pisco, still represent good estimates.

The sampling design was initially based on a stratified random design. Nevertheless, in the field, surveying depended on fishermen willingness to take part in the study and the design can thus be re-qualified as convenience sampling rather than random. Finally, it is worth noting that in the sampled population the high count of divers is not only due to the real importance of this fishery in each study sites but also to sampling bias. Divers come more frequently to the docks to unload their product while fishermen using nets and line often stay on boats. While the research team tried to correct this issue by going at sea to survey fishermen on boats, the proportion of divers was still higher than expected (50% in this study compared to estimates of 40%). Therefore, albeit the relatively big size of the sampled population gives allowance for inference about the larger population of fishermen in both sites, these caveats warrant the use of non-parametric statistical analysis and careful extrapolation of the results from the surveyed sample to the larger population with the use of triangulation.

3.5.1.6 Fieldwork limitations and ethical considerations

Doing fieldwork and research in environmental and development studies raises important ethical concerns. Ethical guidelines such as informed consent and confidentiality, the latter when requested, were followed throughout the fieldwork. The issue of power differential between the researcher and the researched and how this affects research outcomes from a scientific point of view was also taken into account (Chambers 1997). Being a foreigner, an educated individual at the post-graduate level and a woman can all pose challenges during fieldwork, especially in a male dominated sector. Informants might mislead the researcher by providing deceitful information that serves their own interests, involvement in certain activities might be limited and lack of trust due to the status of ‘outsider’ hinders the exchange of information. These challenges were mainly addressed with one strategy: building trust with *time*. Indeed research was conducted over nearly two years in Peru and great care was given in building relationships of trust and ‘learning to learn’ from fishermen. Additionally, language barrier was not an issue and the use of interpreters not warranted, peeling away another layer of ‘remoteness’ between the researcher and actors in the fisheries sector.

3.5.2 Research Methods - Data analysis

3.5.2.1 Data processing and initial stages of analysis

Survey data was assembled into an Access database as well ws Excel spreadsheets. Attention was given to missing data, naming of variables and coding for open-ended questions. A codebook was created involving components such as the code, brief description, type of data (categorical, continuous etc) and in certain cases guidelines for when to use the code to ensure they were exclusive codes, avoiding overlapping of ‘meaning’. For multiple responses (target species, type of impact) responses were coded then a presence (1) and absence (0) matrix was created. Once initial data scrutiny and coding were completed, statistical analysis was undertaken. Interviews, workshop data and focus groups were conducted in Spanish. Notes were manually recorded and then used to write English summaries of each respondent answers in the case of interviews, and reports in the case of workshops and focus groups. Recording using devices only occurred during the taping of the CENSOR documentary. Sity-five nterviews were organized into separate files and entered into the Atlas.ti software (Scientific Software Development, Berlin, www.atlasti.de) for coding.

3.5.2.2 Analysing qualitative data

With the Atlas ti. software open and axial coding was used to analyze interview data. Open coding involved creating inductively codes with a line-by-line revision of the summaries in order to categorize the data (Strauss 1990). Axial coding is the next stage after open coding where categories are linked together in order to identify causal relationships. Whereas open coding fractures the data into categories, axial coding puts the data back together by making connections between the categories and subcategories (Kendall 1999 p. 747). The objective is to establish specific connections between categories and sub-categories (Figure 14). Quotations within the thesis are used to illustrate the categories and provide support to the interpretations of interviews.

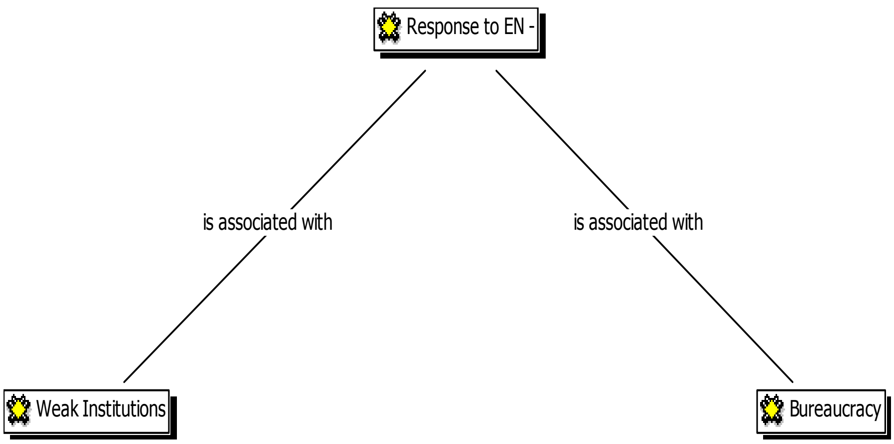

Figure 14 Atlas Network View of code "Negative institutional response to El Niño"

3.5.2.3 Quantitative analysis

3.5.2.3.1 Univariate analysis

Exploratory data analysis included summary statistics (quantitative variables) and frequency tables (qualitative ones). Due to the biased identified in section 3.5.1.5 in the sampling and the data following a highly non-normal distribution, non-parametric methods were used. All the analyses were performed using SPSS software version 15.0 and the statistical significance level was set at 5%. The Mann-Withney *U* test was used to identify differences among sites for numerically codified variables (i.e. presence absence of target species). The Pearson Chi-square test was used to establish the relationship between two categorical variables (i.e. gear type and educational level). To analyze how a categorical variable differed from its hypothesized proportions within one population a Chi-square goodness of fit test was used (i.e. distribution of type of gears). Finally, Spearman correlation was used to measure the association between variables (ordinal or continuous) such as codified type of gear (1 to 9) and income.

3.5.2.3.2 Multivariate analysis

Classification tree analysis comprises a set of model-free methods for analyzing multivariate data (Biggs et al. 1991). The classification tree procedure in SPSS creates a tree-based classification model. Classification trees explain variation of a single response variable by one or more explanatory variables. The response variable is categorical and the explanatory variables can be categorical and/or numeric (De'ath and Fabricius 2000). The tree is constructed by repeatedly splitting the data, defined by a simple rule based on a single explanatory variable. The tree stops growing when no additional questions will improve the ability to predict the value of the dependent variable, as measured by the selected criterion. For instance the classification tree is used to determine if site and gear type are predictors of formal rule compliance (holding licenses and fishing cards). Classification trees used in this thesis were created with algorithms based on statistical significance (chi-square statistics) (Biggs et al. 1991).

Factor analysis is a form of exploratory multivariate analysis that is used to either reduce the number of variables in a model or to detect relationships among variables. Principal component analysis (PCA) is designed to reduce the number of variables that need to be considered to a small number of indices (called principal components) (Manly 2004). The objective is to obtain two or three principal components that provide a good summary of all the original data (Manly 2004). PCA in this work is used for instance to identify how target species and type of fishing activity explain the total variance in one site. Cluster analysis is another factor analysis method concerned with the identification of groups of similar objects (Manly 2004). Hierarchical techniques such as dendogram using percent disagreement and Ward's method of linkage are particularly useful if the data for the dimensions included in the analysis are categorical in nature. Cluster analysis is used to identify the distance (level of dissimilarity) between gear groups based on target species (presence/absence data). The objective is to assess whether the type of fishing activity is closely associated with the type of target species. PCA and cluster analysis together provide a mean to identify patterns and structure in the data.

3.5.2.4 Causal loop diagrams

System dynamics, firstly proposed by Forrester (1961), applies the engineering principles of feedback and control to social systems in order to understand their behaviour over time. The purpose of a system dynamics study is to understand the causes of a dynamic problem, and search for policies that alleviate or eliminate them (Barlas 2002). Causal loop diagrams articulate our understanding of the dynamic of a system (Figure 15). A causal relation between variable (A) and (B) is represented by an arrow and means that the input variable (A) has some causal influence on the output variable (B). A positive (+) influence means that a change in (A), *ceteris paribus*, causes (B) to change in the same direction and a negative (-) influence, *ceteris paribus*, means a change in an opposite direction, such as an increase in (B) causes a decrease in (D). A feedback loop is a close circle of variables and their interdependencies and is either positive (reinforcing) or negative (balancing). A short line indicates that there is a delay between a change in (A) and the corresponding change in (B). Causal loop diagrams are used to analyse the scallop fishery dynamics in Pisco and Sechura in order to provide a conceptual model of formal institutional behaviour under ENSO conditions in Chapter 7. The causal loop diagrams are constructed based on interviews and workshop data.

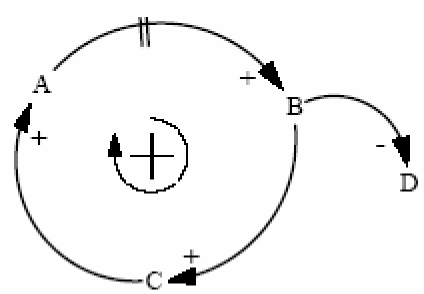

Figure 15 Causal loop diagram

CHAPTER 4

LIVELIHOOD ASSETS: WHAT ARE THE BUIDLING BLOCKS OF LIVELIHOOD SECURITY?

4.1 Introduction

Livelihood analysis provides a useful framework to move beyond the image of rural people livelihoods solely dependent on natural resources but rather on a range of assets that enables them to achieve livelihood security. The concept of livelihoods thus seeks to gain an understanding of people's strengths (assets or capital endowments) and how they endeavor to convert these into positive livelihood outcomes (DFID 2001). Livelihood security has been defined in Chapter 2 as:

> "The freedom to engage in activities that are necessary for the pursuit of sustainable livelihood outcomes. It means creating socio-ecological systems which give people the access to assets necessary for this pursuit, which provide building blocks for the maintenance of livelihoods in the face of critical and pervasive threats and situations."

The capital assets that can be accessed by fishermen are grouped into five categories, and can be described as the "livelihood platform" (Bond et al. 2007). These comprise human, financial, physical, social and natural capitals (see Chapter 2). Although the term 'capital' is used, not all the assets are capital stocks in the strict economic sense of the term in which capital is the product of investment which yields a flow of benefits over time (DFID 2001). Capital assets are the basic building blocks upon which individuals are able to undertake production, engage in labour markets, participate in reciprocal exchanges with other individuals or households (Ellis 2000, p31). Knowledge of fishermen livelihood platforms will provide a better understanding of how fishermen livelihoods respond to climate variability (Chapter 6) as it has been argued that the stronger and more varied the asset base is, the greater is people's adaptive capacity and the level of security of their future livelihoods (Cooper et al. 2008). Moreover assets should not be seen through an instrumentalist lens as only a way to maintain livelihoods. As posited by Bebbington (1999), capital assets "are not simply *resources* that people use in building livelihoods: there are assets that give them the *capability* to be and to act" (p. 2022). Therefore they not only provide a mean to achieve livelihood security, they also give a meaning to these livelihoods (Bebbington 1999).

4.2 Objective and methods

The objective of this chapter is to map out the different assets fishermen draw upon in building their livelihoods in Sechura and Pisco. In conducting the analysis within this chapter, the focus is on the characterization and identification of differences between study sites in terms of "livelihood platforms''. The detailed description of the methods as well as the descriptive and multivariate statistical analysis used in this chapter can be found in Chapter 3. The sub-sections below purport to recall the specific set of empirical data used for this chapter.

4.2.1 Workshops and interviews

In order to better understand livelihood realties of fishermen and ground the thesis on peoples' self-understandings of what are the assets on which they can draw to achieve desired livelihood outcomes, workshops were undertaken in each study site at the onset of this research. Stakeholder workshops were conducted in May 2005 in Pisco and Sechura, and overall 50 participants attended these events. Stakeholders ranged from government officials, representatives from IMARPE and fishermen organizations as well as experts from local Universities. Participants were divided into groups and asked to identify the assets on which fishermen depend for their livelihoods. The workshop data was supplemented by interviews and participatory observations undertaken throughout the field work.

4.2.2 Fishermen surveys

In order to collect data to support the livelihood analysis, a fishermen survey was designed and conducted. A total of 572 fishermen were surveyed, the content of the survey paying particular attention to the socio-economic characteristics of each respondent. The choice to administer open-ended question in some cases was to avoid researcher bias, and thus get a better understand of the range of factors that shaped each asset.

4.3 Understanding the asset base in Sechura and Pisco: learning from resource users

The workshops were seen as a mean to generate a common understanding of livelihoods realities that would enrich the analysis of survey data. Tables 12 and 13 present a summary of the group exercises involving the identification of the major assets in each site.

4.3.1 Human capital

Human capital represents the skills, knowledge, ability to labor and good health that together enable people to pursue different livelihood options. Participants in both study sites noted that formal education was insufficient. While they agreed that primary education was attained by most fishermen in their communities, they felt that secondary education was still not accessible. Participants also pointed out that traditional knowledge, described as fishermen experience and "know-how", was undervalued by authorities and should be integrated into management plans. The incidence of decompression illness for diving fishermen was highlighted as particular health-related problem, especially in Sechura where no decompression chamber is available in the Isla Lobo de Tierra located at a 15-hour boat distance from the mainland. In Pisco this problem increased during periods of high abundance of bivalve resources. Additionally, few divers are licensed, implying that they did not undertake a dive course explaining the safety measures regarding their activity. In discussions participants highlighted the poor service provision heightened by the lack of health insurance available to fishermen. Finally in Sechura it was noted that during EN events the incidence of gastric diseases increased. This will be further discussed in Chapter 6.

Table 12 General characteristics of the asset base in Sechura based on stakeholder workshop (n=35)

Capital Assets	Main Characteristics
Human	• Formal education low, fishermen traditional knowledge considered important • No health or life insurance. Lack of health professionals. Health problems: decompression illness and injuries with fishing equipment. Gastric problems during EN events.
Social	• Many formal fishermen groups (associations, guild, and trade unions) but not well organized. Presence of NGO • Women more involved in the productive process with development of scallop aquaculture (post-harvest) • Conflicts with fishing rights in Isla Lobo de Tierra and with temporary migrants
Physical	• Private infrastructures: no housing programs. No drainpipe and sewage infrastructures. Limited water supply. Houses are subject to flooding during EN • Fishing infrastructures: docks are in fragile state, jetties collapsing and sanded-in; vulnerable to EN. No decompression chamber. No freezing and cold storage plant • Roads: main road to Piura in good state but access to some docks difficult. During EN 83 difficult commercialization, in 98 more prevention work so less effect
Natural	• Fish resources in decline (anchovy, chub mackerel, jack mackerel, sardine). Shellfish resources (scallops, surf clam, snail etc) abundant but on a seasonal basis • Aquaculture activities • Predominance of small farmstead but no land title
Financial	• Private loans mostly for stock enhancement activities, fishing activities without government subsidies • High interest rates from private institutions (>25%). Cannot fulfill the prerequisite for collateral (house title, possession of own boat etc.) Informal lenders, as much as 75% interest rate • Few fishermen save and invest. Most have agreements with buyers and owners of boats

Table 13 General characteristics of the asset base in Pisco based on stakeholder workshop (n=25)

Capital Assets	Main Characteristics
Human	• Most fishermen have primary education but little secondary education • Low number of licensed divers • No health or life insurance. Decompression illness is a problem for divers, especially in times of resource abundance
Social	• Many formal fishermen groups (associations, guilds and trade unions) but few are active and organized. Number of groups multiply during EN • Poor product commercialization and marketing => controlled by intermediaries • Desire to create a regional fishermen association to represent their interests • Women participation in the activity is low except for algae collection and in San Andres where they sell catches of their husbands • There are no NGO promoting artisanal fisheries
Physical	• Freezing and cold storage plant and one decompression chamber • New post-harvest processing plants • Fishing infrastructures: ±600 boats registered but diving and drag net fleet "boliche" highly mobile
Natural	• High biodiversity, Paracas National Reserve • Fish fluctuate more than shellfish resources (i.e. Silverside species) and increased fishing effort • New and potential resources to develop: sea cucumber, algae, seahorse • Pollution a threat to resources. Households in-equitable access to potable water
Financial	• Access to credit limited, only government institutions • Need for private investment (aquaculture, marketing of products) • No safety nets from the government when losses occur

4.3.2 Social capital

Social capital was described to participants as social networks, presence of formal organizations and mechanisms in place to participate in the decision-making process. In both sites participants felt that while fishermen groups were present, they lacked organization and did not voice their concerns. In Pisco they repeatedly expressed that intermediaries in the fisheries sector and the disorganization of fishermen was an impediment to obtaining good prices for their products. The development of new activities in both sites provided the impulse to increase the level of organization as well as the involvement of women. In Sechura the development of aquaculture activities resulted in the burgeoning of fishermen groups, albeit in a hap-hazard manner, and an increase in the engagement of women in the post-harvesting sector. In Pisco women involvement in the commercialization of fishing products and the extraction of algae were also portrayed as increasing trends. Women in both sites were deemed generally well organized through women clubs and communal kitchens. The influx of migrants and conflicts over access to resources were also highlighted as problems eroding the cohesion of fishermen. In Pisco the desire to form a regional organization to defend the interest of local fishermen and their access rights was expressed. Finally, outside intervention through NGOs and the private sector were perceived as an essential building block to reinforce social capital. In Pisco the installation of the gas pipeline increased the funding for community projects through the company PlusPetrol but participants felt that an NGO specifically promoting the fishery sector and protecting fishermen rights was needed. In Sechura the presence of an NGO is currently playing an important role in the socio-economic development of the bay. This highlights the positive role extra-community organizations can play in building social capital in both study sites.

4.3.3 Financial capital

Financial capital was put forward as the ability to save and access credits and loans. Participants in both sites felt that banking institutions and other formal lending bodies were not responsive to their needs and the provision of comprehensive financial services was incomplete. Most fishermen do not have a house or land title, nor possess a boat that would allow them to fulfil the collateral requests made by formal institutions, which combined with high interests rates result in barriers to access micro-finance products. It was highlighted that micro-finance products in the private sector were mostly geared towards aquaculture activities, ignoring the diversity of fishing activities and subsequent needs of fishermen. Finally, it was observed that fishermen themselves lacked saving habits which decreased their ability to invest further in productive activities inside or/and outside the fishing sector. A high reliance on the informal sector as well as on boats owners, intermediaries and processing plans in terms of safety nets and providers of loans was put forward by participants.

4.3.4 Physical capital

Physical capital was described to participants as the basic infrastructures and producer goods needed to support livelihoods. The most striking difference between sites were the complaints expressed by participants in Sechura in terms of inadequate housing conditions, the absence of government housing programs and water and sanitation infrastructures. Additionally, dwellings were deemed extremely vulnerable to EN events. In both sites the lack of adequate potable water supply was perceived as a problem. In terms of fishing infrastructures Sechura appeared to be less well endowed than Pisco. It was mentioned that the dire state of fishing docks were a risk during flooding events and the lack of a decompression chamber posed a great occupational health risk. The absence of freezing and cold storage plants accessible to artisanal fishermen was also mentioned in Sechura.

4.3.5 Natural capital

Natural capital was put forward to participants as the wide range of natural resources on which fishermen can draw to sustain their livelihoods. Small scale and subsistence agriculture were identified as an important natural capital in Sechura. In Pisco participants were proud to have the Paracas National Reserve in their region and acknowledged the high biodiversity of the area. However they mentioned that fishing effort increased in the last few years, mainly due to increase in fleet size and capacity. A similar assessment was put forward in Sechura, especially for small pelagic species. In both workshops while the high diversity of resources was pinpointed, their fluctuating nature was presented as a key characteristic. Finally new target species in Pisco and the development of aquaculture in Sechura was seen as a reflection of the high potential of the zones in terms of aquatic resources.

4.4 Fishermen capital assets

The findings of the previous section were instrumental in obtaining an insight about the asset base on which fishermen in Sechura and Pisco rely to achieve livelihood outcomes. However, they did not generate detailed information on these assets. Drawing extensively from survey data, the following sections decipher the five capitals assets of the livelihood platform.But, before describing each capital individually, general characteristics of the sampled population in terms of fishing gear and some demographic traits are presented.

4.4.1 Typology of fishermen and demographic characteristics

Fishermen were categorized into groups with reference to the gear they used. In the sampled populations, as shown in Table 14, divers and purse-seiners are the most important groups (respectively 55,9% and 16,0 %), followed by gill and drift net users (13,5%) and hook and lines users (5,1%). The distribution of the type of gear differs across the two study sites (X^2 =15,91 d.f.=8,00, p<0,05). Pisco has no trawlers and a lower proportion of purse seiners (13,9% compared to 17,5%) as well as a lower proportion of hook and line gear (2,9% compared to 6,6%). Difference in type of gear is dependent on the type of resources in the study area and will be further explored in the section on natural capital asset. The survey data also revealed that few fishermen reported using different types of gear: in Sechura 6,9% of fishermen reported to use more than one fishing gear while this proportion is 7,6% in Pisco.

Basic demographic characteristics of the sampled populations are presented in Table 14.
Migration status can be defined in a variety of ways. In this case migrants are fishermen born outside the province of the study area (province of Pisco and province of Sechura). Additionally a differentiation is made between migrants from the regions of Ica and Piura, where the study sites are located, and other regions of Peru (Table 14).

Table 14 Fishing gear and demographic characteristics across survey sites of sampled population (N=572). Percentage and mean of valid answers.

	Sechura (n=333)	Pisco (n=239)	All Sites (N=572)
Fishing Gear[a]			
Beach Fishermen	0,6	3,4	1,8
Diver	55,9	55,9	55,9
Gill and Drift net	11,5	16,4	13,5
Hook and Lines	6,6	2,9	5,1
Purse Seine	17,5	13,9	16,0
Trawling	0,9	0,0	0,5
Diver and other	3,6	4,6	4,0
Gill and Drift net and other	1,5	1,3	1,4
Purse Seine and other	1,8	1,7	1,8
Multi Gear[b]	6,9	7,6	7,2
Civil Status[a]			
Divorced	0,6	0,8	0,7
Live in Partner	31,5	33,1	32,2
Married	36,3	46,4	40,6
Sinlge	28,5	18,0	24,1
Widowed	3,0	1,7	2,4
Age[c]	34,3 (± 12,3)	41,9 (± 13,1)	37,5 (± 13,2)
Number of Children[c]	2,4 (± 2,4)	3,0 (± 2,9)	2,7 (± 2,6)
Migration			
Birth Place[a]			
Inside Province of Sechura	58,0	0,0	33,9
Inside Region of Piura	16,9	0,0	9,9
Inside Region of Ica	2,1	5,5	3,5
Inside Province of Pisco	1,8	83,0	35,5
Others	21,1	11,5	17,1
Residency Time[c]	14,7 (±12,7)	16,9 (±13,8)	15,6 (±13,2)

a. Percentage of valid answers

b. Multi Gear: total of variables Diver and other Gill, Drift net and other , Purse Seine and other

c. Mean

In Pisco fishermen are primarily born in the study area (83%) whereas in Sechura only 58% are born within the Province, the total number of immigrants representing 42% of the surveyed population (Figure 16). Immigrants in Sechura come primarily from within the Piura region, from cities located in the hinterland where agriculture is the main occupation, and from other regions of Peru, mainly the center and south of the country (Chiclayo, Lambayeque, Lima and Pisco). In

Pisco immigrants come primarily from outside the region of Ica, mainly from the center of the country (Callao, Chimbote, Lima) and the Andes (Puno).

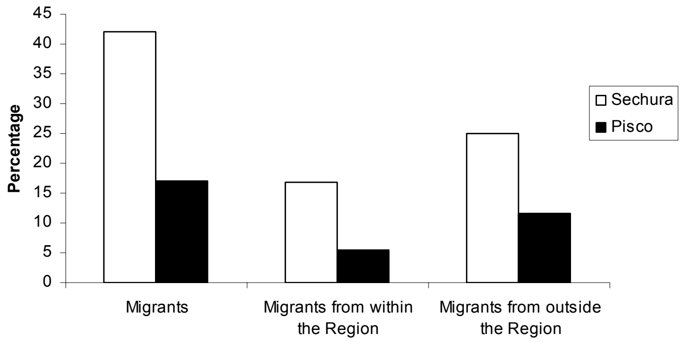

Figure 16 Migrants distribution across survey sites. Percentages

While Sechura has more immigrants, no significant differences where observed in terms of years of residency between sites (Z=-0,963, p>0,05). When performing a Pearson chi-square test to assess the independence of the variables site and civil status, a significant statistical difference is observed (X^2=11,12 d.f.=4,00 p<0,05). Survey data show data a higher proportion of fishermen surveyed are married or living with a partner in Pisco than in Sechura (79,5% compared to 67,9%), which is expected since younger adults would have a higher probability to be single.

4.4.2 Human capital

Fishermen educational level and whether they have received capacity building courses related to their activity is used as a proxy to assess formal knowledge. Four different education categories are used to define educational level: 1) primary school, 2) secondary school, 3) technical and 4) university level. To assess more informal type of knowledge based on experience at sea, age and years fishing are used as a proxy. Finally, the propensity to incur injuries is used as proxy of occupational risk to illustrate the health dimension of human capital. In both sites, as shown in Tables 15, the majority of respondents possess a formal education until the secondary level while the overall completion rate is 58,7%. A difference is observed between sites in terms of level of studies achieved (X^2 =27,50 d.f.48,00, p<0,05) and if respondents received any capacity building course (X^2 =6,63 d.f.=1,00, p<0,05). Secondary level education is more widespread in Pisco than in Sechura, and has a higher completion rate in the former (Table 16). Similarly, post-secondary education is more prevalent in Pisco. When desegregating survey results by type of fishing activity, in Sechura a significant difference between gear category in terms of the level of study is observed (X^2 74,27= d.f.=32,00, p<0,05) while in Pisco no significant difference is observed (p>0,05).

Table 15 Formal knowledge across sites. Percentages of valid answers.

	Sechura (N=333)	Pisco (N=239)	All Sites (N=572)
Level of Education			
Primary School	50,5	29,1	41,6
Secondary School	43,2	61,5	50,8
Technical	4,3	5,1	4,6
University	1,2	3,4	2,1
None	0,9	0,9	0,9
Completed Studies	59,8	57,0	58,7
Capacity Building	50,6	39,5	46,1

Table 16 Completion of studies by educational level across sites. Percentage of valid answers.

	Sechura (n=325)	Pisco (n=229)	Total (n=554)
Primary School	56,9	25,4	44,3
Secondary School	40	65,4	50,2
Technical	2,6	6,9	4,3
University	0,5	2,3	1,2

Using the classification tree method, with level of study as dependant variable and type of gear as an independent one, two gear groups are identified in Sechura: divers and other types of gear. The diver group is a significant predictor of secondary level education while the other types of gear are a significant predictor of primary education. This means that divers possess a higher propensity to have secondary education than other groups in Sechura. In terms of capacity building survey data from Pisco reveal that fishermen received less capacity building than in Sechura (Table 4.4). When desegregating survey results by type of fishing activity, in Sechura a significant difference between gear category in terms of capacity building is observed (X^2 21,00= d.f.=8,00, p<0,05). As for level of education, no significant difference is observed (p>0,05) in Pisco. The classification tree method, using capacity building as the dependent variable, revealed two groups in Sechura: divers, trawlers and multi-gear purse-seiners also using other gears, and in a second group the rest of the gear categories. The first group is a significant predictor of having received capacity building. In a close ended question fishermen were asked what kind of capacity building they received. Responses included fishing (i.e. diving, safety at sea) with 46,2%, aquaculture with 22,2% and environmental awareness with 16,2%. Figure 17 presents the break down of type of capacity building received by sites. It is worth noting that capacity building in aquaculture and fishing are more mentioned in Sechura while environmental education and leadership courses (management, organizational) had higher incidences in responses in Pisco. Informal fishermen knowledge was significantly different between sites ($p<0,05$), with Sechura being characterized by a younger population with less experience at sea (Table 17). When asked if they incurred injuries during their fishing activities, 18,5% responded yes with no major difference between sites.

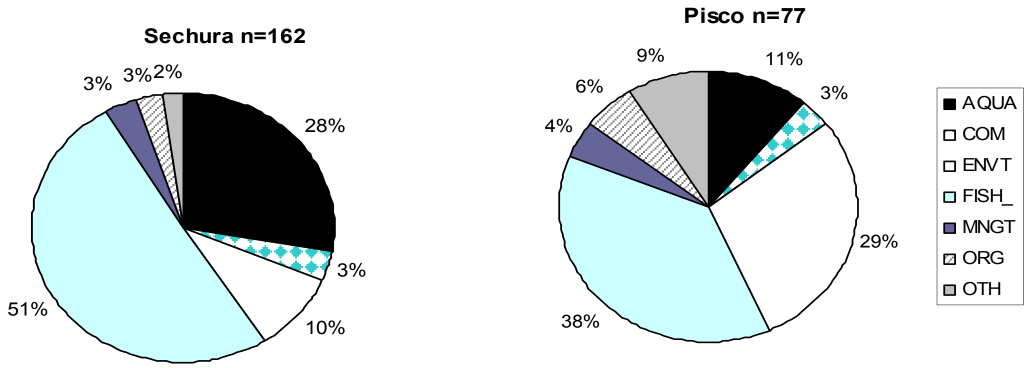

Figure 17 Type of capacity building received. Percentage of valid answers.

Table 17 Age and years of fishing and incidence of injuries across sites. Mean and percentage of valid answers.

	Sechura N=333	**Pisco** N=239	**All Sites** N=572	**Z score**	**P**
Informal Knowledge[a]					
Age	34,3 (± 12,3)	41,9 (± 13,1)	37,5 (± 13,2)	-7,026	0,000
Years Fishing	16,7 (± 13,1)	23,8 (± 13,2)	19,6 (± 13,6)	-6,838	0,000
Health Risk[b]					
Injuries	19,3	17,2	18,5		0,584

a. Mean. Mann Withney Test (2-tailed)
b. Percentage. Pearson Chi-square

4.4.3 Financial capital

Whether fishermen have obtained a credit and have a life or social insurance is used as proxy to understand the dimension of financial capital. Only 15% of fishermen responded they had received a credit while 8,9% and 6,9% possessed social insurance and life insurance respectively (Figure 18). Tests of statistical significance revealed a difference between sites in terms life insurance (X^2 =13,16 d.f.1,00, p<0,05) while no difference where observed for the other two variables (p>0,05). Additionally, distribution of variables by type of gear revealed no differences in both sites. It is worth noting that these variables reflect formal safety nets and forms of borrowing. There is much informal borrowing and forms of saving for difficult times in rural communities, for instance through neighborhood credit groups ("junta vecinal") or fishermen association providing assistance in case of death or diseases.

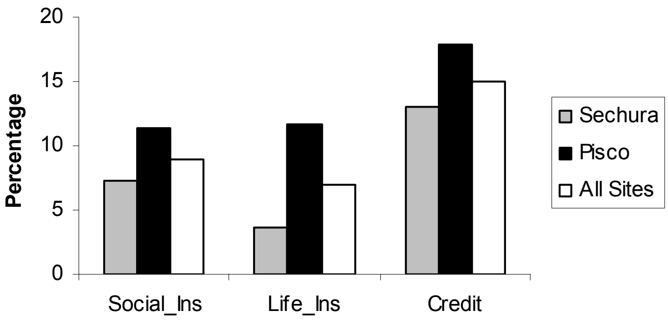

Figure 18 Distribution across site of possession of social and health insurance and credit. Percentage of valid answers.

4.4.4 Social capital

Formal rule compliance (adherence to the law) is measured with the question "What type of document do you hold ?". In Peru fishermen by law have to be registered with the navy, and possess an identification document, whether a fishing or diving license, crew identification card or armador license. Membership to formal fishermen organizations is used as a measure of fishermen ability to create networks and trust each other. Membership to community groups, ranging from religious to credit groups, is used as a measure of network and reciprocity at the community level which may provide the basis for informal safety nets among fishermen households.

Overall 77,6% of fishermen hold an identification document (Table 18) with a higher propensity in Pisco (89,3% compared to 68,3%). A significant difference was observed between sites in terms of the type of document respondents held (X^2 =96,72 d.f.8,00, p<0,05). Based on the classification tree method, with type of document as a dependent variable and type of gear as dependent one, this difference can be attributed to the high number of fishermen not holding any identification in Sechura (31,7%) and possessing a fishing card in Pisco (57,1%). When desegregating the results by gear type a significant difference is observed in Sechura (X^2 85,19= d.f.=56,00, p<0,05) and Pisco (X^2 102,43= d.f.=48,00, p<0,05) with two groups being identified: divers and other types of gear. In Pisco, the diver group is a significant predictor of what type of document a fisherman holds with only 33,4% of divers possessing a fishing license while 80,4% of fishermen in other groups possessed one. It is worth noting that 33,9% of divers possess a diving license which implies that overall 67,3% have an identification document, a value still lower than for other gear groups. In Sechura, the diver group is also a significant predictor of what type of document a fisherman holds with 36,2% of divers not holding any type of documents. Additionally, more fishermen in other gear groups hold a fishing license (31,1% compared to 18,1% for divers). As in Sechura, divers also posses diving licenses but with a lower propensity than in Pisco (22,1%). These results reveal that informality is greater in Sechura than in Pisco, with the diving group being the most informal one in both sites.

Overall 52,6% of fishermen are member of a fishing organization and membership to is unequally distributed across sites with 41,7% in Sechura and 52,6% in Pisco (X^2=9,70 d.f.=1,00, p<0,05). When desegregating these results by gear type with the classification tree method no significant differences were found in both sites (p>0,05). The results show that while fishermen are more formally organized in Pisco than in Sechura, the type of fishing activity in both sites is not a good predictor for membership to associations. Fishermen were then asked through an open ended question if they or a family member belonged to a community group in order to broaden the notion of social capital beyond formal fishing groups. Overall 60,9% of respondents mentioned that at least one member of their household belong to a community group with no significant difference across sites (p>0,05). When asked what type of group they belonged to in an open ended question, respondents reiterated adherence to fishing groups (44,5%) and mentioned religious groups (43,2%), mainly evangelic. In Sechura households are more involved in religious groups than in Pisco (Figure 19). Other difference among sites are expressed with a higher involvement in Pisco in credit groups, political groups and football teams, while women involvement in the group "vaso de leche", a government led organization dealing with food security, was only mentioned in Sechura.

Table 18 Measure of social capital across sites. Percentage of valid answers.

	Sechura N=323	Pisco N=234	All Sites N=557	P Value[a]
Type of document				0,000
Fishing card	24,2	57,1	38,8	
Armador card	1,1	0,4	0,8	
Fishing and crew card	13,5	8,0	11,1	
Fishing, crew and diving card	0,0	0,9	0,4	
Fishing and diving card	2,5	0,9	1,8	
Crew card	14,6	1,8	8,9	
None	31,7	10,7	22,4	
Diving card	12,5	19,2	15,4	
Diving and crew	0,0	0,9	0,4	
Fishermen Organization				0,002
Yes	47,1	60,6	52,6	
Group Membership				0,548
Yes	61,9	59,4	60,9	

a. Pearson Chi-square

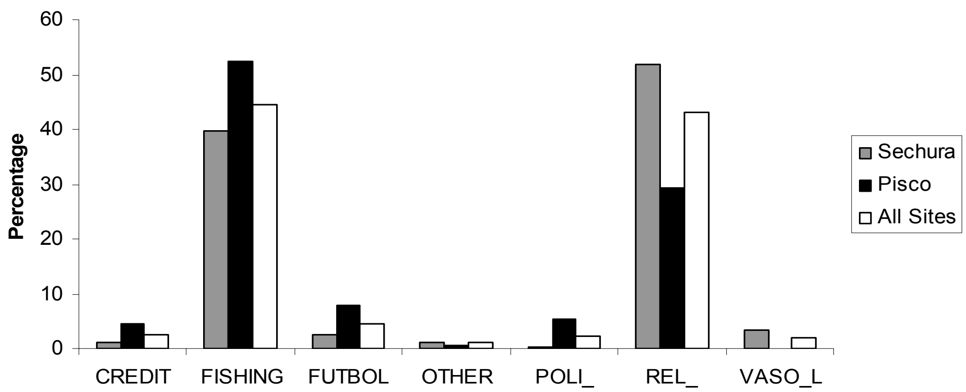

Figure 19 Distribution of type of groups across sites. Percentage of valid multiple responses (n=339).

In another open ended question fishermen were asked how the involvement of household members in these groups helped their families (Figure 20). Some respondents expressed that their membership did not provide any help (24%), with a high level of dissatisfaction in Pisco (39,3%). In Sechura and Pisco respectively spiritual help involving greater family and community cohesion (48,9% and 14,9%), provision of food (6,3% and 17%), economic assistance (5,8% and 7,4%) and credits (2,6% and 5,2%) were the most mentioned categories.

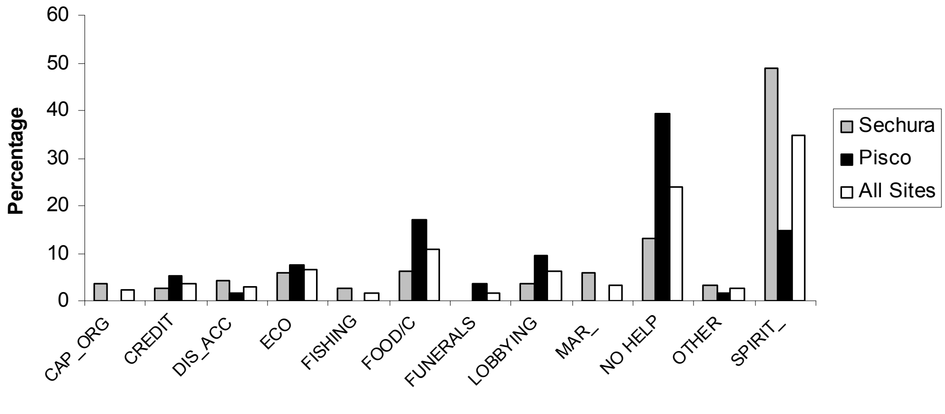

Figure 20 Distribution of type of help received across sites. Percentage of valid multiple responses (n=299)

4.4.5 Physical capital

Fishermen physical capital includes their productive assets such as boats and other form of property (land, rented house etc.) and household assets. Household assets include liquid assets (cellular, refrigerator, car etc.) and housing characteristics (for instance type of household material). Additionally physical capital includes access to utilities and service infrastructures such as electricity and water. First difference between sites will be identified in this section, followed by an exploration of the variance within the data taking into account the type of fishing activity (gear). All the components of physical capital are presented in Table 19 with their respective mean and standard deviation. Differences among sites were tested with the Mann-Whitney test U (2-tailed), Z and P value being also available in Table 19.

Table 19 Physical capital variables across sites. Shaded areas with P values<0,05

	Sechura		Pisco		All Sites		Z score [c]	P Values
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation		
Productive Assets [a]								
OWN_VES	0,06	0,23	0,05	0,22	0,06	0,23	-0,297	0,767
OTHER_IM_C	0,15	0,36	0,14	0,34	0,14	0,35	-0,514	0,607
Service Infrastructure [a]								
WATER_SU	0,88	0,33	0,97	0,16	0,92	0,27	-4,206	0,000
SEWAG_FA	0,33	0,47	0,90	0,31	0,56	0,50	-13,503	0,000
ELEC	0,78	0,41	0,94	0,24	0,85	0,36	-5,198	0,000
House ownership [b]	1,14	0,35	1,19	0,39	1,16	0,37	-1,516	0,129
Housing Characteristics [a]								
NBR_ROOM	2,36	1,10	3,00	1,43	2,62	1,29	-5,588	0,000
ADOBE	0,00	0,00	0,16	0,36	0,06	0,24	-7,330	0,000
BRICK	0,80	0,40	0,84	0,37	0,81	0,39	-1,294	0,196
QUIN	0,07	0,25	0,00	0,00	0,04	0,20	-3,986	0,000
RUSH_M	0,14	0,34	0,00	0,07	0,08	0,27	-5,513	0,000
Liquid Assets [a]								
TEL	0,14	0,35	0,20	0,40	0,17	0,37	-1,663	0,096
CABLE	0,21	0,41	0,05	0,22	0,14	0,35	-5,381	0,000
CEL	0,59	0,49	0,13	0,34	0,40	0,49	-11,118	0,000
INTER	0,01	0,08	0,01	0,09	0,01	0,08	-0,334	0,738
WASH_M	0,07	0,25	0,06	0,24	0,06	0,25	-0,168	0,867
COMP	0,02	0,15	0,03	0,16	0,02	0,15	-0,077	0,939
REFRI	0,25	0,43	0,46	0,50	0,34	0,47	-5,317	0,000
CAR	0,02	0,12	0,03	0,16	0,02	0,14	-0,861	0,389

a. Binary variables (1=presence; 0=absence), mean can be read as percentages
b. Binary variable (1=owner; 2=renting); mean not read as percentage
c. Computed using Mann Whitney U test 2-tailed

In terms of productive assets a majority of fishermen surveyed in both sites do not own their boats (94%). Some respondents (14%) hold other types of property (14%), from interview data these ranging from small land holdings to other small dwellings. The distribution of liquid assets cable, cellular and refrigerator differ significantly across sites ($p<0.01$). In Sechura 21% and 59% of fishermen possessed a cellular and access to cable while in Pisco this proportion was only 5% and 13%. However, 46% of respondents in Pisco had a refrigerator comparatively to only 25% in Sechura. Another significant difference ($p<0.01$) was observed in term of household characteristics. Fishermen in Sechura reported that their houses were made of quincha (7%) and rush-mat (14%) while in Pisco such material was not present. Quincha is a traditional construction system that uses mainly wood and cane or giant reed, forming a framework covered in mud and plaster. Both quincha and rush-mat are inexpensive construction characteristics of low income dwellings. Additionally the mean number of rooms per dwelling was lower in Sechura (2,36, ±1,10) than in Pisco (3,00, ±1,43). Access to service infrastructure also shows a significant difference among sites ($p<0.01$) whith Pisco having overall greater access to facilities such as electricity, water and sewage. The proportion of the latter was highly different between Sechura (33%) and Pisco (90%).

To explore the variance within the data taking into account the type of fishing activity (gear) in each site principal component analysis is used. In Sechura three components were extracted, accounting for 49,98%, 19,07% and 5,50%, respectively, of the total variance, and between them account for 74,55% of the variance. Based on factor scores (Table 20), the first component consisted mainly of variables related to service provision and liquid assets (highest loadings) while in the second component the variable with the highest loading was the type of fishing activity (Figure 21A). The third component consisted of the size of the houses (number of rooms) and was not graphically represented since it explained only 5,50% of the variance.

Table 20 Physical capital and type of fishing activity: Component loadings

Component (% of variance)	Sechura			Pisco	
	C1 (49,98)	**C2 (19,07)**	**C3 (5,50)**	**C1 (45,20)**	**C2 (32,46)**
Fishing Gear	**0,482**	**-0,800**	**0,357**	-0,085	**0,996**
Productive Assets					
OWN_VES	0,159	0,196	-0,142	0,008	0,054
OTHER_IM_C	0,176	0,020	0,114	0,155	-0,045
Service Infrastructure					
WATER_SU	**0,310**	0,129	0,077	0,145	0,080
SEWAG_FA	**0,585**	0,277	-0,050	0,196	0,125
ELEC	**0,544**	0,250	-0,057	0,134	0,119
House Ownership	0,081	0,097	**-0,358**	-0,204	-0,112
Housing characteristics					
NBR_ROOM	0,241	**0,491**	**0,836**	**0,973**	0,225
ADOBE	-	-	-	-0,109	0,031
BRICK	**0,357**	-0,085	0,026	0,105	-0,020
QUIN	-0,188	0,150	-0,012		
RUSH_M	-0,272	-0,014	-0,021	0,007	-0,047
Liquid Assets					
TEL	**0,346**	0,317	-0,037	0,063	0,203
CABLE	**0,477**	**0,358**	-0,113	**0,222**	0,149
CEL	**0,435**	**0,305**	-0,121	0,175	0,063
INTER	0,229	0,064	-0,037	0,107	0,085
WASH_M	0,077	0,212	0,012	0,137	0,010
COMP	0,036	0,098	0,013	0,115	-0,003
REFRI	**0,542**	0,211	-0,025	**0,228**	0,067
CAR	0,030	0,146	0,015	**0,204**	0,046

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Empty cells: variable had zero variance

In Pisco two components were extracted, accounting for 45,20% and 32,46%, respectively, of the total variance, and between them account for 77,66% of the variance. Based on factor scores (Table 20), the first component mainly consisted of the variable number of rooms and house ownership while the second component was related to the type of fishing activity (Figure 21B). If focusing initially on the first components, these results can be interpreted in the following manner: service provision and house size in Sechura explain the variance in the data set while in Pisco house ownership and dwelling size explains the variance. When looking at the second components, the type of fishing activity explains the variance in the data set in both sites.

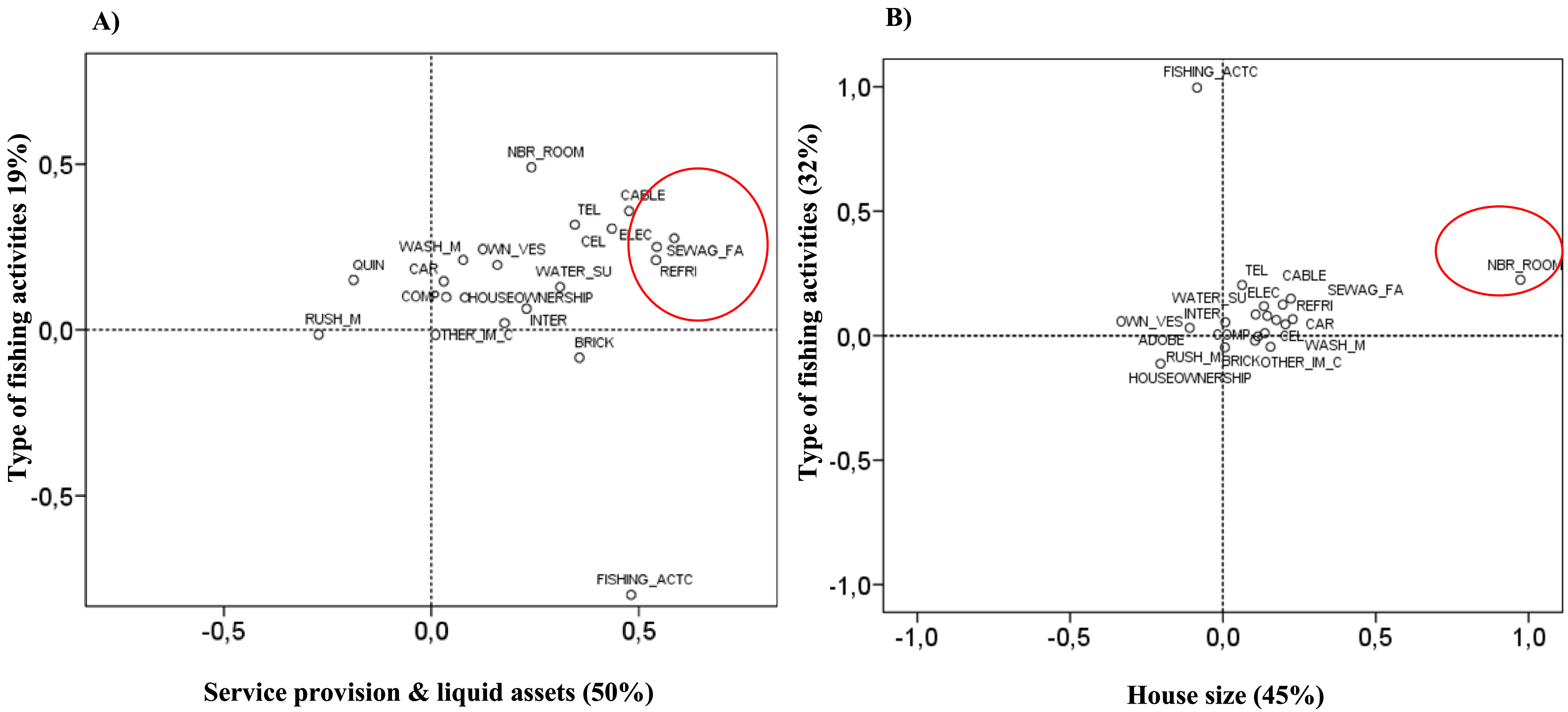

Figure 21 Component plot of fishing activity and physical capital variables for Sechura (A) and Pisco (B)

4.4.6 Natural Capital

Natural capital is the term used for the natural resource stocks from which resource flows and services useful for livelihoods are derived. Here the focus is on aquatic resources fishermen rely on for their livelihoods. In an open ended question fishermen were asked what their main target species were. A total of 44 species were reported by fishermen and answers, after presence-absence codification, were divided into fish and invertebrate species and descriptive statistics are presented in Tables 21 and 22. The most mentioned littoral fish species were seabass (17%), blenny fish (6%) and cabinza grunt (4%). For pelagic fish species, anchovy (7%), chub mackerel (7%), mullet (6%), smoothhound (4%), jack mackerel (3%) and bonito (3%) were the most important target species. In terms of invertebrates captured by diving scallop (39%), octopus (25%) and snails (23%) were mentioned as target species. In Sechura, squid (11%), giant squid (7%) and shrimp (6%) were also mentioned as important target species while in Pisco they were not reported. This is consistent with the northern geographical distribution of these warm water species. Significant differences ($p<0,05$) across sites are only observed for invertebrates species associated with the diving fishery (Table 22). Clam, octopus, scallop and surf clam species are consistently more reported in Sechura than in Pisco, with scallops presenting the highest difference (46% versus 19%), highlighting the importance of these species for the diving fishery in Sechura (Figure 22).

Figure 22 Scallop divers in Sechura Bay. Photo M-C Badjeck

Table 21 Target species across sites, means of valid multiple responses. Shaded areas with P values<0,05 (Table continues next page).

	Species[a]	Sechura (n= 248) Mean	Std. Deviation	Pisco (n=94) Mean	Std. Deviation	Total (n=342) Mean	Std. Deviation	Z score[b]	P value
Scientific Name	**Littoral Fish**								
Labrisomus sp.	Blenny fish	0,03	0,18	0,12	0,32	0,06	0,23	-0,832	0,406
Acanthistius pictus	Brick seabass	0,02	0,13	0,00	0,00	0,01	0,11	-1,243	0,214
Isacia conceptionis	Cabinza grunt	0,02	0,15	0,07	0,26	0,04	0,19	-1,381	0,167
Seriolella sp.	Choicy ruff	0,00	0,06	0,01	0,10	0,01	0,08	-0,789	0,430
Anisotremus scapularis	Grunt- Peruvian	0,02	0,13	0,01	0,10	0,01	0,12	-1,253	0,210
Rhinobatos planiceps	Guitarfish-Pacific	0,01	0,11	0,03	0,18	0,02	0,13	-0,407	0,684
Menticirrhus sp.	Kingcroaker	0,00	0,00	0,04	0,20	0,01	0,11	-0,062	0,950
Sciaena deliciosa	Lorna drum	0,00	0,00	0,04	0,20	0,01	0,11	-0,062	0,950
Stellifer minor	Minor Stardrum	0,00	0,06	0,02	0,15	0,01	0,09	-0,394	0,693
Citharichthys sp.	Pacific sanddab	0,02	0,14	0,05	0,23	0,03	0,17	-0,278	0,781
Paralonchurus peruanus	Peruvian banded croaker	0,08	0,27	0,00	0,00	0,06	0,23	-0,832	0,406
Trachinotus paitensis	Pompano	0,02	0,15	0,00	0,00	0,02	0,13	-0,560	0,575
Myliobatis sp.	Ray	0,02	0,13	0,03	0,18	0,02	0,14	-0,307	0,759
Paralabrax sp.	Seabass-Peruvian	0,19	0,39	0,12	0,32	0,17	0,38	-0,926	0,354
Epinephelus sp.	Snowy grouper	0,03	0,17	0,00	0,00	0,02	0,14	-0,307	0,759
Prionotus sp.	Volador	0,00	0,00	0,02	0,15	0,01	0,08	-0,789	0,430
Engraulis ringens	Anchovy	0,06	0,24	0,09	0,28	0,07	0,25	*-1,748*	0,080
Sarda chiliensis chiliensis	Bonito-Eastern Pacific	0,01	0,09	0,07	0,26	0,03	0,16	-1,691	0,091
Cynoscion analis	Weakfish-Peruvian	0,08	0,28	0,00	0,00	0,06	0,24	-0,543	0,587

a. Binary variables (1=presence; 0=absence), mean can be read as percentages b. Computed using Mann Whitney U test 2-tailed

Table 22 Target species across sites, means of valid responses, Shaded areas with P values<0,05 continued from Table 21.

Scientific Name	Species[a]	Sechura (n= 248) Mean	Std. Deviation	Pisco (n=94) Mean	Std. Deviation	Total (n=342) Mean	Std. Deviation	Z score[b]	P value
	Pelagic Fish								
Coryphaena hippurus	Perico, dolphinfish	0,00	0,06	0,03	0,18	0,01	0,11	-1,119	0,263
Scomber japonicus	Chub mackerel	0,08	0,28	0,04	0,20	0,07	0,26	-1,425	0,154
Cilus Gilberti	Corvina	0,00	0,00	0,01	0,10	0,00	0,05	-0,557	0,577
Not Specified	Fish	0,02	0,14	0,02	0,15	0,02	0,14	-1,487	0,137
Trachurus picturatus murphyi	Jack mackarel	0,02	0,14	0,06	0,25	0,03	0,18	-1,156	0,248
Mugil cephalus	Mullet	0,05	0,22	0,07	0,26	0,06	0,23	-0,277	0,782
Sardinops sagax sagax	Sardine	0,00	0,06	0,00	0,00	0,00	0,05	-0,616	0,538
Scomberomorus sierra	Sierra	0,00	0,06	0,00	0,00	0,00	0,05	-0,616	0,538
Odontesthes regia regia	Silverside	0,00	0,06	0,04	0,20	0,01	0,12	-1,253	0,210
Mustelus sp.,Triakis sp.	Smoothhound	0,05	0,22	0,01	0,10	0,04	0,19	-0,612	0,541
	Invertebrates Diving Fishery								
Concholepas concholepas)	Abalone	0,00	0,00	0,07	0,26	0,02	0,14	-1,487	0,137
Gari solida	Clam	0,09	0,28	0,03	0,18	0,07	0,26	-3,942	0,000
Cancer sp.	Crab	0,00	0,00	0,19	0,40	0,05	0,22	-1,856	0,063
Aulacomya ater	Mussel	0,00	0,00	0,18	0,39	0,05	0,22	-1,768	0,077
Octopus mimus	Octopus	0,29	0,45	0,16	0,37	0,25	0,44	-4,198	0,000
Tagelus dombeii	Razor clams	0,00	0,00	0,05	0,23	0,01	0,12	-1,253	0,210
Argopecten purpuratus	Scallop	0,46	0,50	0,19	0,40	0,39	0,49	-5,932	0,000
Not specified	Shellfish	0,00	0,00	0,01	0,10	0,00	0,05	-0,557	0,577
Stramonita sp.	Snails	0,21	0,40	0,30	0,46	0,23	0,42	-0,690	0,490
Mesodesma donacium	Surf clam	0,10	0,31	0,00	0,00	0,08	0,27	-2,320	0,020
	Invertebrates Nets and Lines								
Dosidicus gigas	Giant squid	0,06	0,24	0,00	0,00	0,04	0,21	-0,963	0,336
Panulirus gracilis	Lobster	0,00	0,06	0,00	0,00	0,00	0,05	-0,616	0,538
Xiphopenaeus sp.	Prawn	0,01	0,09	0,00	0,00	0,01	0,08	-0,789	0,430
Not speficified	Shrimp	0,07	0,25	0,00	0,00	0,05	0,22	-1,768	0,077
Loligo gahi	Squid	0,11	0,31	0,00	0,00	0,08	0,27	-1,128	0,259

To explore the variance within the data taking into account the type of fishing activity (gear) in each site a principal component analysis was undertaken. In Sechura three components were extracted, accounting for 66,03%, 6,60% and 3,61%, respectively, of the total variance, and between them account for 76,24% of the variance. Based on factor scores (Tables 4.12 and 4.13), the first component consisted of items related to fishing activity, followed by seabass and invertebrates species scallop, octopus, snails and squid. Of particular note, the fishing activity variable correlated relatively strongly with the first component (-0,661). This implies that type of gear is one of the most important variables explaining the variance in the data. The second component was related to diving fishery invertebrates and littoral fishes, with invertebrates having the highest loadings. Components one and two are graphically represented in Figure 23A. The third component is not graphically represented (explaining only 3,6% the variance) and the items with highest loadings were type of fishing activity and the specie Peruvian seabass.

In Pisco three components were extracted, accounting for 67,38%, 4,9% and 3,77% respectively, of the total variance, and between them account for 76,05% of the variance. Based on factor scores (Tables 23 and 24), the first component mainly consisted of invertebrate species related to the diving fishery, with the highest loading being snails, octopus, crabs and scallops. The second component again included invertebrate species related to the diving fishery as well as Peruvian seabass. Components one and two are graphically represented in Figure 23B. The third component is not graphically represented (explaining only 3,77% the variance) and the items with highest loadings were type of fishing activity and pelagic species (anchovy and dolphinfish). One of the main outputs of these results is that in Pisco fishing activity does not explain the variability within the data and while invertebrate species explain part of the variance, in Sechura littoral species play particular role.

Table 23 Target species and type of fishing activity: Component loadings

		Sechura			Pisco		
	Component (% of variance)	**C1 (66,03)**	**C2 (6,60)**	**C3 (3,61)**	**C1 (67,38)**	**C2 (4,9)**	**C3 (3,77)**
	Fishing Activity	**-0,661**	-0,113	**0,742**	0,252	0,196	**0,947**
Scientific Name	**Littoral Fish**						
Labrisomus sp.	Blenny fish	0,242	-0,088	0,040	0,024	**0,457**	**-0,369**
Acanthistius pictus	Brick seabass	0,186	-0,075	0,052			
Isacia conceptionis	Cabinza grunt	0,109	0,121	0,239	0,259	0,151	-0,001
Seriolella sp.	Choicy ruff				0,052	0,100	0,094
Anisotremus scapularis	Grunt- Peruvian	0,009	0,156	0,001	0,154	0,059	-0,222
Rhinobatos planiceps	Guitarfish-Pacific	-0,115	0,035	-0,011	0,202	-0,010	-0,035
Menticirrhus sp.	Kingcroaker	-	-	-	0,210	0,044	0,016
Sciaena deliciosa	Lorna drum	-	-	-	0,056	0,166	0,121
Stellifer minor	Minor Stardrum	-	-	-	0,175	0,024	-0,036
Citharichthys sp.	Pacific sanddab	-0,016	0,024	-0,080	0,144	-0,031	-0,145
Paralonchurus peruanus	Peruvian banded croaker	-0,118	**0,415**	0,006	-	-	-
Trachinotus paitensis	Pompano	-0,001	0,275	0,012	-	-	-
Myliobatis sp.	Ray	-0,077	0,122	-0,078	0,202	-0,010	-0,035
Paralabrax sp.	Seabass-Peruvian	**0,569**	**0,328**	**0,703**	0,039	**0,534**	0,160
Epinephelus sp.	Snowy grouper	0,297	0,067	0,196			
Prionotus sp.	Volador	-	-	-	0,131	0,030	0,098
Cynoscion analis	Weakfish-Peruvian	-0,119	**0,417**	0,061	-	-	-
	Pelagic Fish						
Engraulis ringens	Anchovy	-0,292	-0,027	0,044	0,095	0,030	**0,436**
Sarda chiliensis chiliensis	Bonito-Eastern Pacific	0,133	0,116	0,135	0,234	0,053	0,117
Coryphaena hippurus	Perico, Dolphinfish	-	-	-	0,030	0,034	**0,344**
Scomber japonicus	Chub mackerel	-0,030	0,262	**0,389**	0,171	0,146	-0,024
Cilus Gilberti	Corvina				0,154	0,059	-0,222
Not Specified	Fish	0,001	-0,118	-0,043	-0,073	-0,022	-0,167
Trachurus picturatus murphyi	Jack mackarel	-0,090	0,066	0,154	0,156	0,171	0,072
Mugil cephalus	Mullet	-0,069	**0,347**	-0,020	0,273	0,101	0,071
Sardinops sagax sagax	Sardine	-0,028	0,061	-0,064	-	-	-

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Empty cells: variable had zero variance

Table 24 Target species and type of fishing activity: Component loadings

	Component (% of variance)	Sechura C1 (66,03)	C2 (6,60)	C3 (3,61)	Pisco C1 (67,38)	C2 (4,9)	C3 (3,77)
Scientific Name	**Pelagic Fish**						
Odontesthes regia regia	Silverside	-	-	-	0,166	0,149	0,006
Mustelus sp.,Triakis sp.	Smoothhound	-0,097	0,223	-0,029	0,021	0,017	0,177
	Invertebrates Diving Fishery						
Concholepas concholepas)	Abalone	-	-	-	**-0,354**	**0,348**	-0,153
Gari solida	Clam	0,068	-0,252	-0,204	-0,004	-0,282	-0,026
Cancer sp.	Crab	-	-	-	**-0,554**	**-0,338**	-0,146
Aulacomya ater	Mussel	-	-	-	-0,137	-0,706	-0,035
Octopus mimus	Octopus	**0,530**	**-0,564**	-0,123	**-0,621**	**0,537**	-0,229
Tagelus dombeii	Razor clams	-	-	-	0,097	-0,043	-0,181
Argopecten purpuratus	Scallop	**0,579**	**-0,571**	**-0,322**	**-0,373**	**-0,480**	-0,089
Not specified	Shellfish				0,091	-0,004	-0,070
Stramonita sp.	Snails	**0,404**	**-0,557**	-0,151	**-0,832**	-0,173	-0,201
Mesodesma donacium	Surf clam	-0,033	0,016	**-0,330**	-	-	-
	Invertebrates Nets and Lines						
Dosidicus gigas	Giant squid	-0,220	0,100	-0,048	-	-	-
Xiphopenaeus sp.	Prawn	-0,051	-0,009	0,129	-	-	-
Not speficified	Shrimp	-0,229	0,080	0,047	-	-	-
Loligo gahi	Squid	**-0,368**	0,152	0,116	-	-	-

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Empty cells: variable had zero variance

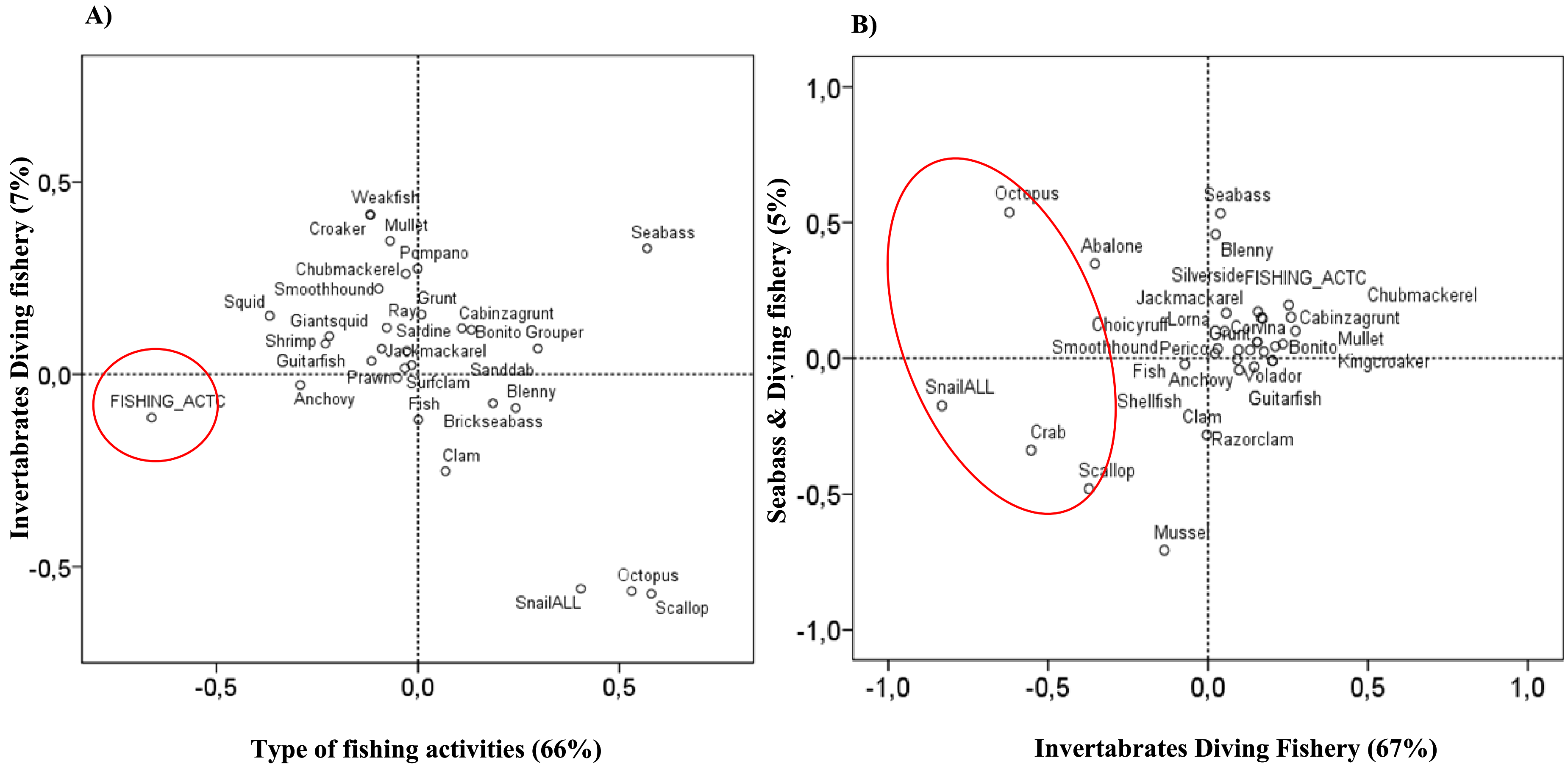

Figure 23 Component plot of fishing activity and target species for Sechura (A) and Pisco (B)

To investigate in more detail the dissimilarities in terms of gear and type of species in each site, a cluster analysis was used to find the true groups of fishermen that are assumed to exist based on target species. The results of the cluster analysis for Sechura and Pisco are presented in Figure 24A and 24B respectively. In Sechura clustering of the presence/absence species data first identified two groups: divers and purse seiners and other gears, separated by a disagreement level of about 95%. In Pisco clustering first identified two groups: gill and drift nets and divers, separated by a disagreement level of about 54%. Divers in Sechura are thus well separated in terms of target species compared to Pisco. Overall the disagreement level between groups is higher in Sechura than in Pisco, suggesting that gear groups share more target species in Pisco than Sechura. Of particular note is in Pisco the well separated group formed by divers and beach fishermen where as in Sechura divers and beach fishermen are the most separated groups.

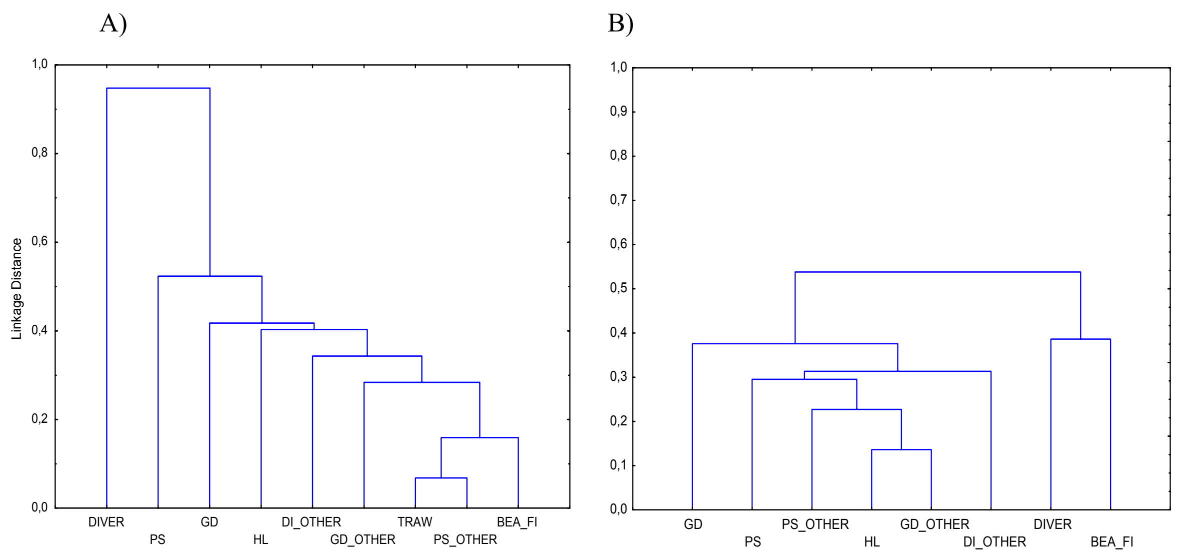

Figure 24 Dendogram from hierachical cluster analysis (Ward's method and percent disagreement), using species presence absence data and types of gear for Sechura (A) and Pisco (B)

4.5 Discussion

4.5.1 Human capital

Human capital is not only the result of formal education, but includes practical learning that takes place on the job, as well as non formal education, such as specific training courses that are not a part of traditional formal educational structures (Davidsson and Honig 2003). Overall the survey showed in both sites that 50,8% of fishermen attended secondary school with a competition rates of 50,2%. These low percentages are consistent with low values of completion of secondary education (30,7%) in Peruvian rural zones (INEI 2007). The lack of perceived relevance of formal education provision to fishing communities, coupled with the need to earn income from a young age could be factors to that explain low completions rates (Petersen 2007). In interviews fishermen often mentioned the inability to secure enrolment fees and the need to earn extra-income for the family as a reason to drop out of school. In Chapter 5 the motivation behind respondents' adoption of fishing as an occupation will be further explored. These low percentages of attendance and completion of secondary level studies (and to some extent primary level ones) are another barrier faced by fishermen in terms of developing their capabilities and entrepeurnarial skills. Literacy and numeracy skills are important factors in the livelihoods of fishing communities with fishing activities often requiring practices of record keeping, communication, management of business activities and marketing (FAO 2006). Additionally, possessing skills only specific to the fishing profession can make movement out of fishing difficult when occupational diversity is sought (Townsley 1998). Our data revealed that secondary education is more widespread in Pisco than in Sechura with higher completion rates in Pisco. This regional disparity is also observed by national statistics, with completion rates in Piura of 37,6% compared to 46,3% in Pisco (INEI 2007). Difference can be attributed to geographical and inequalities in educational access. However, it is worth noting that the migratory nature of fishermen might make them more inclined to not complete their education (Petersen 2007). When desegregating results by gear types, divers have a higher propensity to achieve secondary education than other groups in Sechura while in Pisco no gear differences were observed. Diving is an activity that involves learning new techniques that are not traditionally embedded in Sechura, an area traditionally geared towards line and net fishing. Perhaps, as put forward by Davidsson and Honig (2003), individuals with higher amounts of human capital, whether formal or informal, have greater self-confidence, enabling them to make a choice toward independent entrepreneurship (Davidsson and Honig 2003).

In terms of capacity building, less then half of the fishermen surveyed acknowledged having received training, with fishermen in Pisco reporting less training than in Sechura. It is worth noting that an NGO has been actively present for the last two years in Sechura while in Pisco capacity building activities have significantly decreased since another NGO pulled out due to lack of financing. Additionally, Sechura is located at a two-hour drive from the Centro de

Entrenamiento Pesquero (CEP) run by IMARPE in Paita. The CEP is a major sector specific training center in the Northern part of Peru and to a certain extent could explain higher capacity building reporting in the area. When desgragating the survey results by gear type a significant difference is observed in Sechura while none in Pisco, with more divers reporting to have received training. Again, this may be attributed in the active role played by the local NGO in terms of capacity building related to scallop aquaculture. Type of training received confirmed this, with a higher proportion of surveyed fishermen in Sechura having received training related to aquaculture compared to Pisco. However, Pisco experiences a higher percentage of fishermen with training related to managerial skills (10%) and environmental education (29%) compared to Sechura (6% and 10% respectively). Workshop and interview data in Pisco reveal that the presence of the company PlusPetrol and the constant challenges faced in terms of pollution are the main drivers behind these types of training. The lack of managerial skills in Sechura, combined with lower level of education could be an impediment to develop new businesses and move from fishermen to entrepreneurs. It has been argued that some research tends to support the existence of a positive relationship between human capital and entrepreneurial activity (Davidsson and Honig 2003). In this context, it has been posited that government polices should focus not only on agricultural rural development, but also on endowing poor rural people with the skills permitting them to “escape” rural poverty (Rigg 2006). Informal type of learning based on experience at sea appears to be more prevalent in Pisco than in Sechura. However, these results should be interpreted with caution as they are based variables which do not encompass all the dimension of fishermen knowledge. Workshop participants felt fishermen knowledge was little if not acknowledged by decision makers and more attention should be paid on fishermen ability to share their experiences of the environment surrounding them with decision makers and scientists. Participants also highlight the problem of fishing-related injuries and illnesses, especially in the case of diving. While a relative low number of fishermen reported occupational injuries (18,5%) it is important that authorities include in sectoral policies provisions for occupational safety, health, and accident prevention.

4.5.2 Social capital

Of all the different capital assets, social capital is probably the least tangible and so the one that is least understood (Bebbington 1999). This chapter has focused on fishermen individual social capital based on Airriess et al. (in press) argument that social capital is not “a thing possessed by a community because a community is an outcome of social relationships; only individuals or institutions are able to possess social capital". Although there are many different definitions of social capital the one put forward by Pretty and Ward (2001) is used, with its four central aspects: relations of trust; reciprocity and exchanges; common rules, norms and sanctions; connectedness, networks and groups. Social capital is thus the idea that social bonds and social norms are an important part of the basis for sustainable livelihoods (Pretty and Ward 2001). When evaluating rule and norm compliance by fishermen a significant difference was observed between sites and gear groups, with Sechura having a higher rate of informality than Pisco, the diver group being the most informal one in both sites. Uncovering the reasons behind these differences is not simple, but a first approach involves linking the higher rates of immigration and the development of the recent development of the diving activity in Sechura in the last ten years as possible explanation of greater informality. Additionally, interviews revealed that the administrative process behind the obtainment of licences and fishing or diving cards is plagued by red-tape and costs (money and time) that fishermen are often not willing to bear. Informality and non-compliance to rule has been shown to interfere with management goals and efficiency (Bodiguel 2002). Currently in Sechura, the regional Fisheries Office and the Municipal Fisheries Office have great difficulty in managing the artisanal sector due in part to the lack of information regarding the number of users.

Social bonds and networks can be divided into three categories: bonding, bridging and linking social capital. *Bonding* social capital involves linkages or 'strong ties' within groups and is viewed in an horizontal form, referring to the strong social bonds and effective organisations within a homogeneous group (Narayan 1999; Grafton 2005; DaCosta and Turner 2007). Over all only half of the fishermen surveyed belong to a fishermen organization, a type of bonding capital. Membership differs across sites, with Pisco having a higher percentage of fishermen engaged in fishing groups than Sechura. No gear differences were observed in terms of membership. Pisco over the year has undergone substantial changes with the creation of the Paracas National Marine Reserve in the 1970s, conflicts with the fishmeal industry in the 1990's and 2000's PlusPetrol Camisea gas pipeline near the reserve. These developments have encouraged fishermen to create ties in order to defend their interests. Sechura is a less closed-knit community with a constant influx of migrants and a rift existing between traditional fishermen using lines and nets and divers involved in the new aquaculture industry.

Disputes mainly involve claims of increase drug abuse and unrest in communities due to migrants and conflicts, sometimes violent, between divers involved in aquaculture and fishermen using nets over access rights. However, an increasing trend has been observed in Sechura as a consequence of the development of the aquaculture industry. Nevertheless higher level of membership in Pisco does not indicate whether these groups function or not. The workshop and interview data point out that fishermen groups lack organization, and the level of trust within the groups is low. Elite capture, where leaders of association put forward their own interest, was highlighted as a specific problem. The issue of rent-seeking elites in rural areas is often mentioned as a factor undermining the success of co-management of natural resources (Beck and Nesmith 2001; Allison and Badjeck 2004) and has been observed in both study sites. Additionally, group formation and continuity over time, according to interviews, is highly influenced by external factors such as market changes and environmental ones. In this context while community groups are often portrayed as stewards of natural resources, the uncertainty surrounding their effectiveness and longevity will be an impediment to the promotion of resilience (Pretty and Ward 2001).

Bridging social capital is concerned with linkages across similar, but different, groups or social networks (Grafton 2005) highlighting the heterogeneous form of social networks (DaCosta and Turner 2007). Bridging social capital may also play a crucial role in generating regional co-operation across fishing communities and in conflict resolution across competing fishing gears and interests (Grafton 2005). The survey revealed that a majority of fishermen (or a member of their household) are members of a community group in both sites (60,9%). Religious groups, mainly evangelic ones, are particularly prevalent in Sechura and one of the major benefits of being part of community groups was mentioned to be a “spiritual” one, with greater family and community cohesion, often the women in the household being actively engaged in such organizations. Informal social networks formed by religious affiliation might encourage contributions to the public good either directly through their activities or indirectly through a sense of connectedness created by these memberships (Owen and Videras 2007).. Interview and workshop data revealed that women are women play a particular role in Sechura with their strong involvement in women clubs and communal kitchen as well as church groups, while in Pisco their involvement seemed to be greater in the commercialization of fisheries products, especially in San Andres. In Pisco, sport activities, through football teams, provide a platform for networking among fishermen and a higher engagement in credit and political groups is observed. The latter can be explained by the nature of municipal politics in the Province of Pisco and Region of Ica: being near the capital Lima fishermen in the area are heavily solicited by political parties during elections as observed during field work in 2006.

Whether as members of a fishing organization or a community group, a quarter of respondents in Sechura and nearly 40% in Pisco felt their membership to the groups did not provide them any benefits. As highlighted earlier, the functioning of organizations, involvement of users and the benefits they receive from them is as important, when exploring social capital, as the actual membership to particular organizations. Overall, does who felt satisfied with their involvement in fishing or community groups, expressed that these were able to assist them when facing household shocks such as diseases, burials and food insecurity while nearly 10% mentioned economic assistance or loans. Lobbying was also put forward as a benefit from being part of a group, were respondents felt their interest were put forward to local authorities, groups and social networks thus acting as *linking* capital.

4.5.3 Financial capital

Overall financial capital was similar across sites with the exception of access to life insurance, with fishermen Pisco having a greater access to this service. For all variables no differences in terms of type of gear were observed, highlight access to financial capital, or lack of thereof, is systemic within the surveyed sites. Access to formal sources of credit was weak in Sechura and Pisco. The formal financial system in Peru provides very limited rural and agricultural finance services and most financial institutions focus uniquely on serving urban clients (Campion 2007). Workshop data revealed that the lack of rural and sectoral service provision combined with a lack of fishermen saving and investment skills as well as the presence of prohibitive interest rates, represented barriers to access. If institutions lend at all, it is primarily to the aquaculture sector and larger business. Results of the exploration of social capital in both study sites also revealed that community groups were sometimes used for economic assistance and loans (around 10% overall) and in times of distress. The lack of access to formal financial service is the main driver behind these initiatives, albeit these remain insufficient to meet the needs of fishermen and their households. Fishermen to be able to fulfill the high initial capital requirements often rely on private enterprises, traders or money lenders. As observed in other fishing communities, informal sources of credit are disadvantageous for fishermen and result in high interest rates, and credit is frequently linked to unfavourable terms of trade and the establishment of exploitive relationships (Tietze and Villareal 2003). To avoid the creation of dependency and client-patron relationship fishermen should be encouraged to draw formal agreements with these businesses, and sectoral policies should favor public private partnerships. Additionally, they should reduce the perception of high credit risk that often service providers experience in Peru (Wenner et al. 2007). Currently, formal specialized micro-finance rural institutions exist in Peru (Campion 2007) along with government-led programs loan programs in the fishery sector. These formal micro-finance institutions should pay particular attention to elite-capture in communities as mentioned in the previous section. As Amin (2003) put forward: “subsidized credit has a disappointing history of being politically manipulated and diverted from its intended beneficiaries, the poor” (p.59). With this caveats, while polices at the macro level should be put into place, fishermen should also increase their associative capabilities. Indeed, groups are often used as financial intermediaries or guarantors of loans, replacing the traditional collateral requirements (Tietze and Villareal 2003). Acclaimed models such as the Grameen Bank (Amin et al. 2003) were no collateral are required as group members mutually guarantee each other’s loans requires social capital in its structural (type of organization) and cognitive (trust) forms that are currently sparse in both study sites.

4.5.4 Physical capital

Physical capital encompasses productive assets such as boats; land and other dwellings that directly contribute to the generation of income. The results show that in both study sites the majority of fishermen do not own their own vessel nor possess other properties, limiting their ability to generate income other than with fishing as an occupation. Liquid assets are consumable goods easily accessible, which can be exchange for cash, sometimes being considered as financial capital for this latter reason. Of interest is the fact that liquid assets are overall more reported in Sechura than Pisco. They are also more readily available to the individual fishermen than adequate housing characteristics and service infrastructure. Another dimension of physical capital is public infrastructure and service provision. The results clearly show a disparity between sites, especially in terms of electricity and sewage and sanitation facilities provision. In terms of electricity provision 78% of respondent in Sechura reported having access while this figure was 945 in Pisco. Among Latin American countries, the urban-rural disparity is most extreme in Peru for electricity provision (Fay and Morrison

2007). While access to electricity in the data is above regional averages for Ica and Piura, respectively 83,55 and 56,2% (INEI 2007), the results reflect the regional disparities observed in the country. Sewage and sanitation infrastructure exhibits an even greater disparity with only 33% of the respondents having access to these facilities in Sechura compared to 90% in Pisco. Again these figure are in line with regional statistics, with 31% of the population in Piura living in dwellings without proper toilet facilities compared to 14,2% in Ica. Difference in service provision have been attributed to a deficient decentralization policy and a focus on urban areas (Escobal 2001). Additionally, it is worth noting that Pisco is characterized by the presence of the Paracas National Reserve which makes it a hub for tourism and holiday-related activities, an impetus for better service provision and infrastructure development.

If looking at each sites independently, the type of fishing activity explained some of the variance within the data set more in Pisco than Sechura , respectively 32% and 19%. The results show that the type of fishing activity seems to have little effect in the distribution of assets in Sechura, meaning that lack of access to service infrastructure is a systemic problem not confine to particular gear groups. Sechura is characterized by high immigration rates which imply that informal settlements are expanding at a rapid rate, without significant improvement in service provision. The province of Sechura thus bears the brunt of inadequate rural development policies with under-development and absence of roads and infrastructures. Housing characteristics also greatly differed between sites, with Sechura presenting a higher proportion of rush mat and quincha materials, which are low cost materials, and smaller dwellings (less number of rooms). Qualitative information revealed that dwellings are extremely vulnerable to flooding and no government housing program is in place for the new migrants. Additionally interviews, workshop data and participant observation show that fishing infrastructure (docks, cold storage and decompression chambers) are in a dire state in Sechura, especially in the Puerto Rico docks. It has been argued that inadequate infrastructure undermines growth and competitiveness and hampers the fight against poverty, exclusion, and inequality (Fay and Morrison 2007).

4.5.5 Natural capital

This section aims at describing fishing strategies based on target species in order to identify the level of heterogeneity of the fishery in both study sites. Salas and Gartner (2004) posit that while one cannot make rigid differentiation between fishermen, these are not an homogenous group (Table 25). Specialists concentrate in one area and one species or fishing method while generalists fishermen can more easily switch activities or gear and can change more easily target species (Salas and Gaertner 2004). Most small scale fishermen are considered generalists, even when traces of specialization are observed (Salas and Gaertner 2004). Target species can be defined by multiple factors such as the commercial value and the availability in easily accessible ecosystems and not only its abundance (Tzanatos et al. 2005).

Littoral and pelagic fishes presented no statistical differences among sites. Target species that differentiated both sites were invertebrates ones, namely clam, octopus, scallop and surf clam. Scallop and octopus were more reported in Sechura while in Pisco the snail, crab and mussel fishery were more prevalent in answers. Other site differentiation resided in the absence of a giant squid, shrimp and squid fishery in Pisco, which is consistent with the geographical distribution of these species.

Table 25 Diferences between generalists and specialist fishermen (Smith and McKelvey 1986 adapted from ; Salas and Gaertner 2004)

Characteristics	Generalist	Specialist
Time frame	Short	Long
Flexibility	High	Low
Technology	Not specialized	More specialized
Activities	Wide range	Limited
Fix costs	Low	High
Operation costs	Variable	Variable
Opportunity costs (due to change of activity)	Low	High

When exploring the variance within the data taking into account the type of fishing activity in each site several conclusions can be drawn. In Sechura, the type of gear used, littoral fish species like seabass and weakfish, snail, octopus and scallop and the squid fishery explained most of the variance in the data set, with fishing activity, scallop and seabass loading heavily on the first factor of the principal component analysis. In Pisco, the most important variables explaining the variance within the data sets were target species of the diving fishery (snail, octops, mussel, scallop) and littoral fish species seabass and blenny fish. The structure of the artisanal fleet in Sechura consisted of two marked groups corresponding to divers and non-divers. And in Pisco of divers and beach fishermen and the rest of the gear groups, with the difference between groups were smaller. Fishermen in Pisco are thus more generalists and have a higher level of heterogeneity than in Sechura in terms of target species, as observed in other small scale fisheries (Tzanatos et al. 2005). In Sechura the diving group appeared to be highly specialized. This high specialization can be explained by market forces: since 2000 the bay has obtain sanitary certificate to export to the European Union and the demand by traders and intermediary for the scallop species has been in a constant increase in the last few years. While the survey data showed that divers were highly specialized, it is worth noting that in interviews line and net fishermen reported that diving boats also used nets underwater, depleting the seabass species. Thus while specialization is higher based on species preferences, fishermen remain opportunistic in terms of fishing strategy. These results highlight the fact that, as in other small-scale fishery, the heterogeneity of the small scale fishery makes single species management approach meaningless (Tzanatos et al. 2005 p.156). The management goals of the multi-species management and the ecosystem approach is to set harvest levels of target species while maintaining the sustainability of other species in the ecosystem, which are connected with the target species through prey–predator relationships or other biological and environmental factors (Morishita 2008 p.23). In the last years ecosystem models have been designed in Peru (see for instance ECOPATH model of Sechura Bay by Taylor et al. 2007). However these models so far have not translated into management policies. For instance in Sechura Bay the regional government, in synch with national polices, is heavily promoting the development of the scallop aquaculture. By regarding divers has a homogenous group only relying on scallops and promoting mono-species aquaculture, it down plays the importance of resources like octopus and snails.

4.6 Conclusion

The study discerned major axes of differentiation between the livelihood platform of Pisco and Sechura. Human capital and physical capital were higher in the Pisco, lower educational levels and public infrastructure and service provision mainly explaining the differences. In terms of social capital, differences start to blur. While informality is higher in Sechura, both sites exhibit a highly informal diving group. This warrants policies at the regional level promoting the adoption of fishing and diving cards at low costs. While membership to fishermen organizations was higher in Pisco, dissatisfaction also followed the same trend. Likewise, issues of lack of trust and elite capture were common to both sites but migration trends posed specific challenges to Sechura. In terms of natural capital Sechura presented a high variety of species but a more specialized diving fishermen group than in Pisco, as a result of the promotion of scallop extraction and aquaculture.

Finally, similarities among sites include a lack of access to financial capital, which was highlighted as a major constraint to the development of income generating activities. These results underscore the fact that to build and secure the assets in both study sites broad general policies at the national level will not be able to tackle the specific problems faced by these communities. Their differences in asset endowment can be traced to a variety of historical, social and political factors. As other studies in rural areas of Peru have shown (Kristjanson et al. 2007), while national policies are important, policies need to be region-specific and may even have to be community specific. Interventions at different scales is needed with a sectoral approach for promoting access to financial services, a regional approach for investing in public service infrastructure and education in the North, and an ecosystem-based approach that takes into account the level of heterogeneity of the artisanal fishery in both sites and the impact of migration, as well as local level capacity building to upgrade human and social capital.

CHAPTER 5

LIVELIHOODS OPTIONS, OUTCOMES AND CONSTRAINTS

5.1 Introduction

Livelihood options are the range and combination of activities and choices that people make in order to achieve their livelihood goals. It is now well recognized that rural income portfolios and activities are diverse (Carney 1998; Ellis 2000; Smith et al. 2001) and that the pursuit of alternative sources of livelihood are a necessity as much as a choice (Ellis and Allison 2004). Diversification is defined as the process by which households construct increasingly diverse livelihood portfolios, making use of increasingly diverse combinations of resources and assets (Niehof 2004 p. 321). It has been argued that diversification and building a portfolio of livelihood options is a primary means by which many individuals reduce risk and cope with uncertainty (Ellis 2000; Barrett et al. 2001; Eakin 2005). Only recently income characteristics and occupational diversity has been a focus of research related to artisanal fisheries (Allison and Ellis 2001; van Oostenbrugge et al. 2004). A growing body of literature is also arguing that migration is an important facet of livelihoods dynamics in fishing communities (Kramer et al. 2002; Marquette et al. 2002; Ellis and Allison 2004). Migration itself represents a diversification strategy which in certain cases can enable households to overcome credit and risk constraints and facilitate investments in relatively high return activities (Wouterse and Taylor 2008). Diversification and migration are thus critical research issues in the analysis of livelihoods. Moreover, as shown in Chapter 2, livelihoods unfold at the micro level but are shaped by meso and macro level policies. The micro-macro links are important to decipher the constraints imposed on livelihood options and outcomes. For instance, the identification of how institutions hamper or improve people's ability to construct and secure livelihoods is essential to connect the institutional context with individuals or household strategies (Ellis et al. 2003). A specific arena of inquiry is the devolution of power to local communities through co-management and decentralization initiatives. Decentralization has been portrayed as a mean to improve cross-scale linkages (Adger et al. 2005a) resulting in "good governance" of natural resources (Batterbury and Fernando 2006). However, while local government and decentralization strategies provide building blocks for improved livelihoods, the potential failures of governance also reside in such initiatives being ill-conceived and wrongfully implemented (Batterbury and Fernando 2006).

5.2 Objectives and methods

The objectives of this chapter are to understand the livelihood options exercised by fishermen and livelihood outcomes. It seeks to answer the following questions: what activities do fishermen pursue? What outcomes do they achieve? Another objective is to explore how institutions enable or constraint livelihoods. Chapter 3 offers details on methods used for analysis, the section below only highlighting the type of data used within this Chapter.

5.2.1 Workshops and interviews

The workshops conducted in 2005, where a participatory ranking exercise was undertaken, provide the data necessary for analyzing how the institutional environment affects fishermen livelihoods. Subsequent workshops conducted between 2006 and 2007 offered the opportunity to refine the initial analysis and triangulate preliminary results. The interviews with users, government authorities and NGO workers also allowed the triangulation of the ranking exercise results collected at the inception of the study. Particular attention during interviews (semi-structured) was placed on the understanding of the interaction between government agencies and users and the identification of bottle necks in current fisheries management.

5.2.2 Fishermen survey

Information was gathered on the portfolios of occupations to assess the importance of, and dependence on, fishing activities. In order to take into account women's activities as contributors to household income ('family income'), fishermen were also asked if women living in their household engaged in an activity. Activity was defined as any occupation that is generating revenues or goods to the family and direct dependents. Income was divided into monthly fishing and family income. Respondents often felt more at ease expressing their income by week or days. In these instances the values were multiplied by the number of average working days (three weeks a month). The migration section of the survey was added in the second phase of fieldwork with the objective of understanding the importance of seasonal migration as a livelihood strategy. Seasonal migration referred to changes in fishing grounds, areas outside the bays understudy.

5.3 Occupation and livelihood diversification

Fishermen were asked in an open-ended question what kind of activities they engaged in to sustain their household. While respondents mainly rely on fishing as a primary activity (100% in Sechura and 99,8% in Pisco), they also mentioned agriculture, taxi driving and owning a small business as alternative occupations (Figure 25). A difference was observed between sites regarding the type of activities they were involved in (X^2= 39,65 d.f.=11,00, p<0,05). Agriculture is an alternative source of income in both sites, with a greater percentage of fishermen involved in farm activities in Sechura (8,7% Sechura and 5,6% in Pisco). In Pisco a greater number of fishermen mentioned working in processing plants (2,6% versus 1,2%) and miscellaneous activities (6,1% versus 4,2%). This category ("OTHER") includes such diverse activities as lender, and football player. The mean number of occupations per fishermen (1,34 ± 0,62) did not vary among sites (*Z*=-0,502, p>0,05) nor was it correlated with the type of fishing activity (rs=0,501 p>0,05).

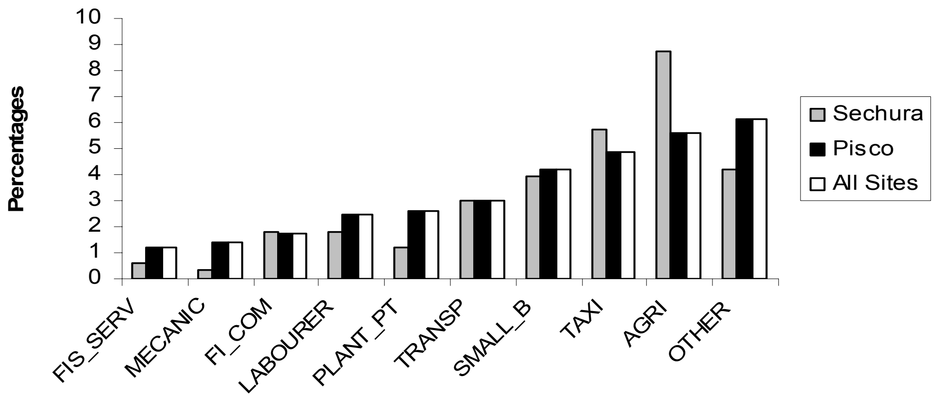

Figure 25 Distribution of type of occupations across sites (excluding fishing). Percentage of valid answers (n=437 open ended question).

To explore the motivation behind the engagement of respondents in fishing activities, a sub-sample of fishermen (N=344) were asked the open-ended question. "Why did you start fishing?". Economic hardship, ranging from the necessity at a young age to sustain the family income to no other occupational opportunity being available, was the most prevalent type of answer with 41,3% of respondents mentioning it. This was followed by fishing being considered a family tradition, providing more money and being a more enjoyable activity, especially compared to farm work (Figure 26). Indeed respondents highlighted that 'life at sea' and the freedom they enjoyed could not be provided by other type of occupations. While a significant differences between sites was observed for the reason "economic hardship" (X^2= 16,66 d.f.=5,00, p<0,05), for the other variables no significant differences were encountered (p>0,05). In Pisco, a greater number of fishermen expressed that the lack of economic opportunity and poverty were the main reason for entering the sector (59,1% versus 36,8% in Sechura) Using the classification tree method, with reason to enter fishing as the dependant variable and type of gear as the independent one, no gear group were identified as a significant predictor of motivation to enter the fishery sector.

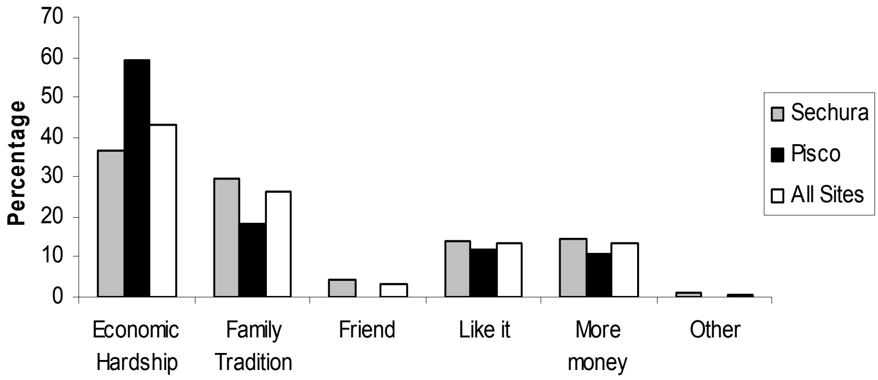

Figure 26 Reasons for choosing fishing as an activity. Percentage of valid answers (n=332 open-ended question)

Respondents were then asked if women in their household were engaged in income generating activities and what these were (open-ended question). A difference was detected in the engagement in activities (X^2= 12,03 d.f.=1,00, p<0,05) and the type of activities (X^2= 21,83 d.f.=10,00, p<0,05) among sites. More women in Pisco than in Sechura possess an income generating activity (38,4% versus 24,3%). Overall women's involvement are mainly in small business (36,1%), which includes for instance restaurants or small informal stores, and post-harvesting activities in the fisheries sector (33,5%), such as processing or commercialization. In Sechura they are more involved in small businesses (44,9% versus 29,2%) and in agriculture (2,9% versus 1,1%). However, in Pisco formal employment is more important with occupations such as professor or nurse (Figure 27). The mean number of occupations per women (1,07 ± 0,26) did not vary among sites (Z=-1,133, p>0,05).

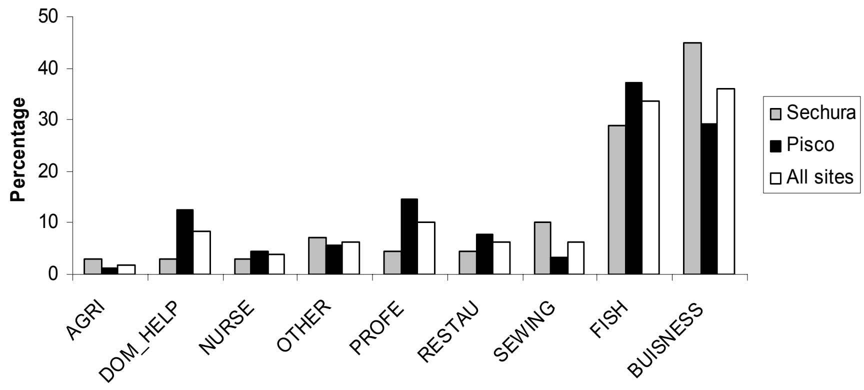

Figure 27 Distribution of type of women occupations across sites. Percentage of respondents (N=572) (Number of answers n=333).

5.4 Migration as a livelihood strategy

Migration status is here presented as temporary/seasonal migration. Fishermen were asked if they ever migrated in order to find better fishing grounds. A majority of fishermen responded they had moved to other fishing grounds, and overall seasonal migration mostly occurred in the summer (Table 26). Using the classification tree method with "Have you migrated" as a dependent variables and type of gear as an independent one no predictors could be observed. However, tests of statistical significance revealed a difference between sites, with fishermen in Pisco changing fishing zones in greater proportions, especially in the summer (83,75), while in Sechura migration occurred mostly during the winter (50%).

The decision to migrate was made by fishermen themselves, only 19% reporting that they followed the decision of the owner. While no significant difference was found between sites and types of gear, a classification tree revealed that the position on board of a boat (crew, diver, owner etc.) was a good predictor of who took the decision to migrate (Figure 28). Fishermen who are crew have less of a tendency to decide on their own whether they migrate or not. For those who did not migrate, the major reasons invoked for not doing so included family ties, habit (including good knowledge of their traditional fishing grounds) and the perception that species abundance in their current area was satisfactory.

Table 26 Migration as a livelihood strategy. Percentage of valid answers

		Sechura n=249	Pisco n=95	Total n=344	P values[a]
Have you migrated?					0,009
	Yes	63,1	78,3	67,4	
Seasons					0,000
	Both	4,5	0	1,4	
	Winter	50	20,4	29,6	
	Often	13,6	8,2	9,9	
	Summer	36,4	83,7	69	
Decision					0,464
	Own	78,9	73,1	77	
	Owner	18,3	20,9	19,1	
	Both	2,8	6	3,8	
If not why?					0,63
	Access Conflicts	1,4	0	1,1	
	Costs	4,3	0	3,3	
	Family	27,1	30	27,8	
	Habit	24,3	20	23,3	
	No Opportunity	14,3	10	13,3	
	Did not want	4,3	0	3,3	
	Species good here	20	25	21,1	
	Other	4,3	15	6,7	

a. Pearson Chi-square

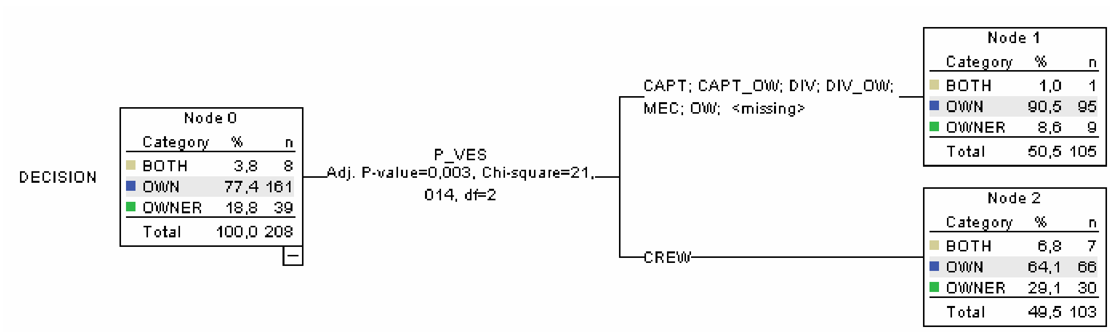

Figure 28 Classification tree (CHAID growing method) with dependent variable 'decision' to and independent variables: Site, Fishing activity and position on board

5.5 Livelihood outcomes

Livelihood outcomes are the achievements or outputs of livelihood strategies. While one should not assume that people are entirely dedicated to maximizing their income, it is nonetheless a useful measure of successful livelihood outcome, albeit it needs to be contextualized. Additionally to income, fishermen were asked to estimate their monthly expenditure in order to identify if they could rely on a safety net or disposable income for investment in productive activities. Mean monthly income from fishing activity is soles 728,7 ± 760,5 (1 soles:0,36 USD). Total family income is soles 804,4 ± 885,3 and total expenditure 523,9 ± 406,5. These figures highlight that overall fishing is a primary source of income and that disposable income is available to households (34,9% of income available for savings and investments). However these values differed greatly among sites ($p<0,05$) with Sechura having greater mean fishing income and family income, and lower family expenditure (Table 27). The disposable income available in Sechura represents 46,1% of total family income compared to only 14,4% in Pisco.

Table 27 Fishing and total family income and expenditure across sites in soles (1 soles:0,36 USD)

	Sechura n= 333		**Pisco n=239**		**All sites n=572**		**Z [a]**	**P Value**
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation		
Fishing Income	831,0	935,3	588,8	375,2	728,7	760,5	-3,116	0,002
Family Income	934,2	1073,9	642,7	528,5	804,4	885,3	-3,547	0,000
Family Expenditure	503,6	424,6	550,3	380,9	523,9	406,5	-3,721	0,000

a. Computed using Mann Whitney U test 2-tailed

Similarly a significant difference was observed in the distribution of income quartiles across sites (X^2= 22,93 d.f.=3,00, $p<0.01$) with Sechura demonstrating a higher percentage of respondents in the top quartile, while fishermen in Pisco were mainly concentrated in the middle quartiles (Table 28).

Table 28 Family income quartiles across sites. Percentages

	Sechura n=333	Pisco n=239	Total n=572
Income quartiles			
I	23,0	25,9	24,3
II	17,1	32,4	23,9
III	29,4	25,5	27,6
IV	30,5	16,2	24,1

These findings are further explored by examining correlations between the type of fishing activity, boat ownership, number of activities in which women and fishermen engage in, possession of other properties (land etc.) and family income (Table 29). A significant positive correlation is found between family income and ownership of other properties. In Sechura, the type of fishing activity is negatively correlated to income levels. Contrary to what could be expected the level of occupational diversity (number of activities) does not seem to be associated with income levels. Additionally, when performing a Pearson Chi-square test of statistical significance, income portfolios (type of activities) across quartile did not vary in each sites (p>0,05).

Table 29 Correlation between family income and fishing activity, ownership of productive assets and occupational diversity[a]

	Sechura (n=333)	Pisco (n=239)	All Sites (n=572)
Fishing Activity	0,034*	0,132	0,032*
Vessel Owner	0,739	0,269	0,586
Possesses other properties	0,002**	0,001**	0,000**
Nbr. Eco. Activities Women	0,671	0,292	0,322
Nbr. Eco. Activities Fishermen	0,071	0,634	0,220

a. Spearmans rank correlation coefficients.*p<0,05, **p<0,01

Using the classification tree method, with family income quartile as dependant variable and type of gear and site as independent ones, two gear groups are identified in Pisco: divers, beach fishermen and purse-seiners using various gears and the reminder of gear types (Figure 29). The group comprising divers is a significant predictor of being part of the third quartile while those using other gears are significant predictors for the first quartile. This means that divers, beach fishermen and purse-seiners using various gears have a higher propensity to belong to the wealthier groups. In Sechura no gear types are identified as significant predictor.

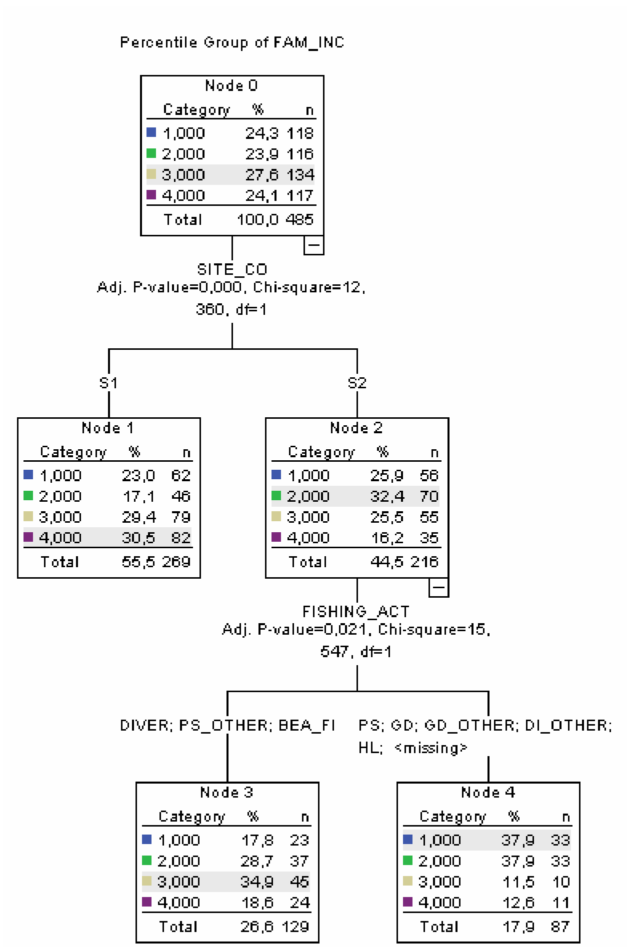

Figure 29 Classification tree (CHAID growing method) with dependent variable family income quartile and independent variables site and fishing activity.

5.6 'Narratives from below': Users' perception of fisheries management and its impact on livelihoods

The workshops conducted in 2005 were a unique opportunity to understand the challenges resources users faced in Sechura and Pisco through a ranking exercise. On both sites marine pollution was highlighted as the main threat due to lack of adequate infrastructure and to non-compliance to environmental norms. In Pisco (Table 30) participants identified a weak institutional environment and organizational deficiencies (these mostly related to fishermen organizations) as a cluster of problems hampering fisheries management. The low social capital at the micro level was associated with a lack of leadership and skills in fishermen organizations that posed serious constraints to users' ability to manage their own resources and market their products. Pisco's participants were particularly adamant that this low social capital posed enormous challenges for the adequate commercialization of their catches. Indeed commercialization in fishing docks around Peru is controlled by intermediaries who either sell the products to processing plants or wholesalers in Lima's main seafood markets.

At the macro level the weak institutional environment in the form of insufficient enforcement of the legal framework (i.e. moratoriums), the 'absence' of the state and inadequate policies was pinpointed as a cause of overexploitation. It is worth noting that while participants in the workshops blamed authorities for their inability to control and enforce the legal framework, they acknowledged that fishermen themselves played an important role in resource degradation, departing from the theoretical paradigm that communities are the best custodians of resources. In Sechura (Table 31) participants associated overexploitation not only to fishermen behavior and the absence of state control and enforcement, but also to the nature of property rights. Indeed open access was deemed to be a cause of resource degradation and the need for restricting access through the regionalization of the fishery was put forward. Interviews with fishermen and government representatives revealed the same tendencies:

"*The Achilles' heel [of the fishery] is the fact that there is not limit of access to (…) resources*"

P28: UI-5-BB-Piura.rtf - 28:5 (11:11)

"*Right now in the sector there is a regionalization movement to fight off immigration. In Parachique people do not want people from Pisco. [But] There is a lack of information regarding the migration of the fleet (…)*"

P40: UI-7-BA-Lima.rtf - 40:4. (27:27)

Corruption, informality (non rule compliance) and deficient policies was another cluster of problems attributed to fisheries management in Sechura. These issues are intimately interconnected; indeed one could argue that informality is an offspring of bureaucracy which leads to corruption. The fact that participants separated the two issues highlights their fundamental preoccupation as users: the inability to be formal and exercise their rights while respecting the legal norms, and the corruption and bureaucracy within the state apparatus. On both study sites participants advocated a reform of the state, whether through administrative decentralization, simplification of procedures and a stronger presence of authorities at the local level to ensure rule compliance by users.

Table 30 Identifying and ranking problems in Pisco. Workshop in Pisco in 2005

Total Points	Problem	Causes	Consequences	Solutions
11	**1) Marine Pollution**	Fishmeal industry	Loss of biomass and biodiversity	Adapt/improve the norms. Better technology. Ensure compliance with the law
		Waste water from urban areas	Deteriorating water quality.	Treatment of residual waters.
6	**2) Lack of capacity building**	Lack of interest (users). Lack of time and money	Low technical knowledge. Overexploitation	Motivation. Financing to capacitated
5	**3) Commercialization**	Perishable product. Lack of organization. Lack of infrastructure. Seasonality of resources	No equitable distribution of income to fishermen.	Implementation of refrigeration equipment. Processing plant for added value products
		Centralization. Lack of help for lack of trust	Deterioration of fishing fleet	Agreement with the state to establish commercialization point Promotion o fish and seafood consumption
4	**4) Organization/ Weak institutions**	Political interference within the organizations. Lack of leadership	Poor protection of resources Insufficient management	Capacity building of new leaders. Participation of , and assessment by the university
4	**5) Overexploitation**	Lack of consciousness from fishermen	Scarce fishing resources Ecological consequences	Management plans (authorities)
		Lack of control illegal fishing	Affects the fisherman economy	Efficient control from the Navy and Ministry of Fisheries. Sanctions

Table 31 Identifying and ranking problems in Sechura. Workshop in Sechura in 2005

Total Points	Problem	Causes	Consequences	Solutions
23	**1) Pollution**	Fishmeal industry and industrial boats. Non-compliance of environmental norms No contamination limits Lack of control Effluent from the river Piura	Disappearance of species Environmental risk which would limit possibility of export	Drastic control and sanctions. Relocation of fishmeal plants. Elaboration of contamination limits Environmental education Waste water treatment Fund with boat owners and exporters to ensure sanitary accreditation
14	**2) Overexploitation, high fishing effort**	Open access. Oversized fleet. Transport of seeds and fishing of juveniles Lack of capacity building and compliance to norms. No environmental conscience	Scarce resources Poor success for scallop culture Scarcity of seeds in the Bahia. Low prices	Fleet regionalization. Promotion of aquaculture. Limit access to artisanal fisheries and capture quotas Protected area. Zoning moratorium Strengthening and control of authorities. Capacity building for fishermen - reactivation of a fishermen school
7	**3) Corruption, deficiencies of policies and control**	Bureaucracy. Lack of clear rules Lack logistical means Influence of the industrial sector	Discouragement, informality Disorder in the fishing activity Administrative procedures difficult Concessions only for industrial	Reform and modernize the state system Stronger presence of authorities Administrative decentralization Bay patrimony for artisanal fishing
7	**4) Informality**	Inequity in the compliance of norms. Excesses of the bureaucracy No knowledge of administrative process	Corruption No incentive to be formal No access to credit Illegal fishing	Formalization of activities Simplify administrative procedures for better control and formalization
5	**5) Lack of Infrastructures**	Wrong state policy. No attention from the state Lack of budget and internal conflict in docks	No value of the production Pollution and sanitary problems	More investment from the state, NGO, private sector etc. More active participation from the population

Analysis of the interviews triangulated the workshop data, with interviewees identifying informality, lack of trust and overall weak institutional environment as the major causes of the absence of adequate resource management. The Atlas.ti network view (Figure 30) shows that the codes 'Lack of trust', 'informality' and 'weak institutions' are causal factors that lead 'No management', code which refers to the absence or/and inadequate management of resources (i.e. absence of management plan). The code bureaucracy was also indirectly associated to inadequate management through corruption, lack of trust and informality.

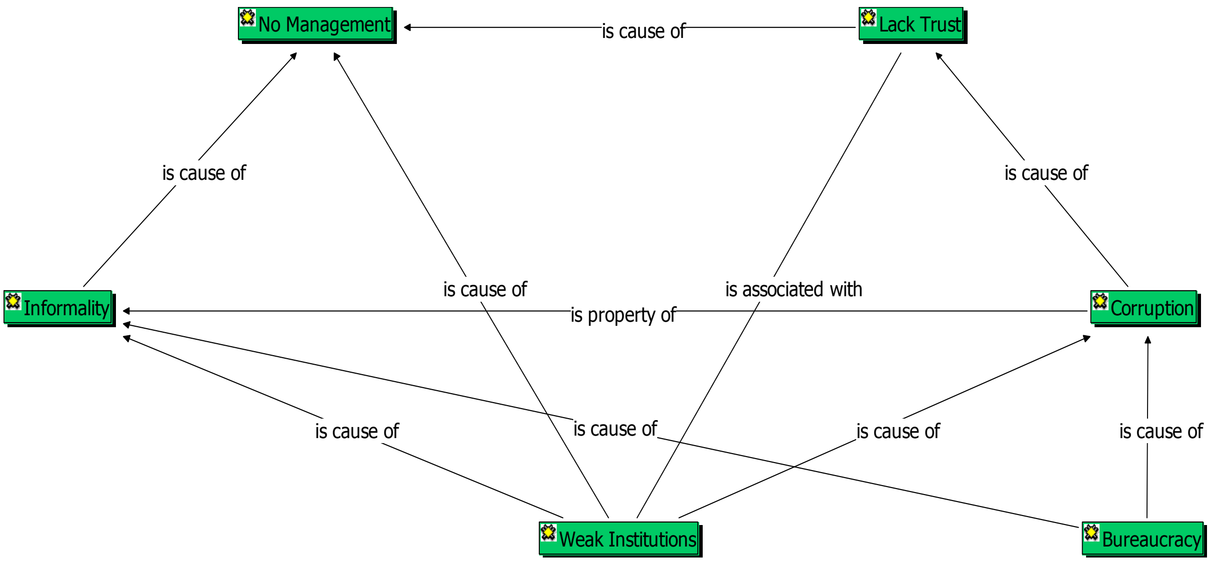

Figure 30 Network view of code "No management"

The slow administrative process and heavy bureaucracy is exemplified by the case of the special concessions in Pisco. Special concessions for scallop aquaculture are renewable every three years in the Paracas reserve but since 2001 fishermen associations were awaiting for the approval of new concession licenses. The process to obtain a license is tedious (Figure 31) and involves several organizations at the regional and national levels. From 2001 to 2006 the process stalled due to the inability of fishermen to fulfill the different perquisites (e.g. presentation and approval of a management plan), INRENA and PRODUCE lack of communication as well as INRENA delay in approving the licenses in order for PRODUCE to issue them. In February 2006 a fishermen association was fined for undertaking aquaculture activities in an area since 2004[22]. However fishermen complained that they had indeed started the process to obtain a license in 2004 but the process plagued by bureaucracy constrained them to operate illegally. This Kafkaesque situation illustrates how the institutional context can hinder the achievement of livelihood outcomes.

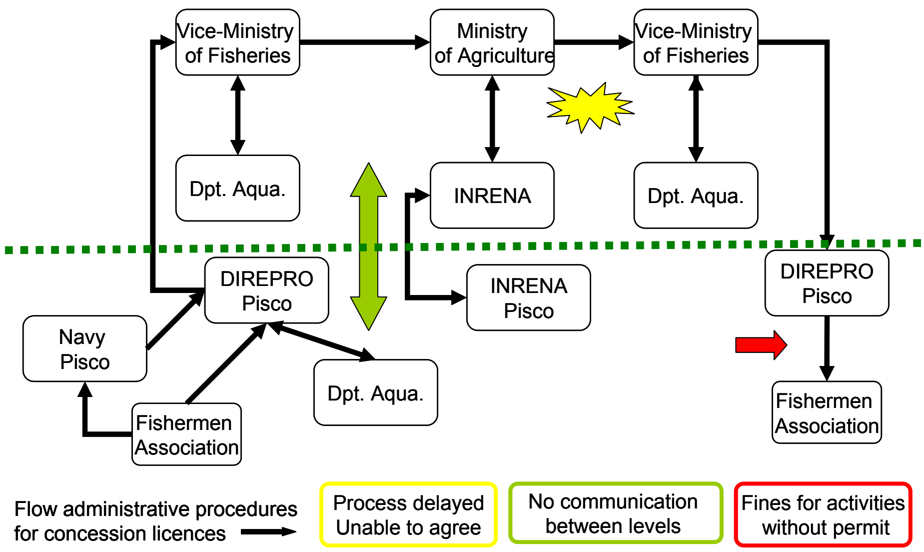

Figure 31 Steps to obtain a special concessions in Pisco (below the green line) and Lima (above the green line)

The stronghold Lima, the capital, has on the decision making process despite the regionalization effort is deeply felt not only by fishermen but also local authorities in Pisco. However users recognize that devolution of power to local institutions with low financial and technical capabilities will not lead to adequate management either:

"There is no development with centralism. The central government does not want to give power to the regional government (...) But these people are not prepared to assume responsibilities: 'worst the cure than the disease'. Institutions here are not prepared."

P50: UI-21-BB-Pisco.rtf - 50:2 & 50:3

[22] R.D Nª 273-2006-PRODUCE/DINSECOVI published 24/04/2006

In Sechura, the regional office of the Vice-Ministry of Fisheries is actively involved in zoning efforts regarding authorizations and concessions for scallop stock enhancement and culture. While regional decrees are being promulgated at the regional level[23], workshop discussions highlighted that they could never be implemented without the tacit accord from Lima: the ability to design management plans that respond to local needs, crises and conflicts with users is hampered by this lack of autonomy.

5.7 Discussion

5.7.1 Occupational diversity or dependence on marine resources?

Most analyses on income diversification in rural Peru are a by-product of the literature on rural poverty and agriculture-based livelihoods (Escobal 2001), with no published work on occupational diversity in coastal fishing communities. Half of agricultural households' net income in Peru is derived from non-farm activities, suggesting that diversification could indeed exist in agrarian economies (Escobal 2001). The results presented here are at variance with these findings and the general adage that livelihood occupational multiplicity is becoming more common and more pronounced in rural areas (Rigg 2006) and that coastal communities do not depend solely on fishing (van Oostenbrugge et al. 2004). Dependence on fishing was extremely high on both sites with few respondents engaged in any other activity. The average number of activities (1,34) in which respondents were engaged was not associated with the type of gear, emphasizing that low occupational pluralism is systemic. When engaged in other activities, agriculture and moto taxis are the main source of alternative income on both sites, with agriculture being more important in Sechura. Fishermen initially engaged in fishing activities mainly because of poverty and lack of alternative opportunities ('economic hardship'). In this context in Pisco, fishing appears to be the occupation of 'last resort', a safety valve for the rural poor (Béné 2003) made possible by the open access nature of aquatic resources in Peru. However, in Sechura the data provide some caveats to this 'old paradigm' of fishing as a last resort. Indeed family tradition also played an important role in the decision to engage in the activity. It suggests that fishing

[23] i.e. RD Nº 007-2005-GRP-420020-100 for zoning of authorization areas

remains in certain circumstances a traditional occupation, entry being modulated by kinship connections to the activity. Additionally on both sites, maybe surprisingly, fishermen also stated that they entered fishing not because they were poor but because they could generate more income and enjoyed their activity. This corroborates recent literature suggesting that fishermen are not the 'poorest of the poor' (Allison and Ellis 2001; Béné 2003; Béné et al. 2003b). It also places emphasis on the occupational culture and identity of fishing (Davis 1986) to which respondent adhered: the notion (true or false) to be freer and more independent than in land locked activities.

The role of women in livelihood generation was also explored. Overall less than half of the respondents reported that women in their household engaged in income generating activities, the main ones being small businesses and pots-harvest activities in the fisheries sector. More women in Pisco are engaged in an occupation, mainly in commercialization of fisheries products. Interviews revealed that women from San Andres are the ones leading the sales of their husbands' catches, controlling the money flows, practices which have been observed in other small-scale fisheries (Bennett 2005). The focus on gender exploring occupational pluralism thus reveals that women are still a 'human capital' untapped in these communities, as few are involved in income generating activities. Policies should aim at promoting not only women involved in fisheries, but also those engaged in other income generating activities such as small businesses and agriculture. On the whole the findings highlight the complexity behind the dynamics of livelihood options on both sites. Diversification is not as prevalent as the literature would suggest, with a high dependence on marine resources. Additionally engagement into fishing activities is based on contextual socioeconomic variables, and is as much a choice as a strategy motivated by necessity.

5.7.2 Seasonal migration as a livelihood strategy

Migration has been identified has an important livelihood strategy on both study sites for all types of gear, yet patterns and motivations behind migration processes are currently poorly understood and researched in artisanal fishing communities in Peru. In other small-scale fisheries, it has been shown that seasonal availability of fisheries resources play an important role in shaping migration patterns (Marquette et al. 2002). Study findings reveal strong seasonal patterns reflecting the distributional range of target species on both sites. This seasonal mobility is made possible by the *defacto* open access nature of the fisheries, open access being portrayed in the literature as facilitating fishermen mobility (Curran 2002; Curran and Agardy 2002; Marquette et al. 2002). However, the workshops and interviews revealed that a chorus of dissent is growing among fishermen on both study sites, especially in regards to the exploitation of scallop resources, a sedentary resource. Smith et al (2005) identified different types of livelihood strategies in their study of inland fisheries in developing countries based on the level of diversification. They argued that highly specialist full time fishermen needed restricted access and effective management measures to sustain their incomes. Conversely fishermen for which fishing was a subsistence activity of 'last resort' thrived in fisheries characterized by open-access and overexploitation would often ensue. A successful, self-regulated open access regime will not be ill-fated if fishermen were highly diversifying and relying on other resources. It is argued here that in light of the findings artisanal fisheries on both sites are experiencing an important shift since the development of the scallop, and more broadly bivalve aquaculture, and the specialization and territoriality of the diving fishery might in the long term hamper migration patterns.

5.7.3 Livelihood outcomes: what can income tell us?

High poverty and social inequality remain striking features of the Peruvian society even after recent periods of economic expansion (Valdivia 2004). In the year 2000, more than half of the Peruvian population remained under the poverty line, with the rate increasing two-thirds in rural areas (Valdivia 2004). In 2004 the poverty line was established by the government at 113 soles per month (INEI 2004), which is less than forty dollars a month. On both sites fishing income is greatly above the poverty line (on average between 642 and 934 soles), highlighting the fact that fishermen are not 'the poorest of the poor' as argued before. If one focuses solely on economic outcomes, Sechura overall achieves better livelihood outcomes than Pisco with higher incomes and lower family expenditures. Moreover, distribution of income across quartiles is more heterogeneous and skewed towards the top quartile in Sechura, implying that more fishermen are economically well off than in Pisco. In the latter, income differences by type of fishing activity was observed, with divers, beach fishermen and purse seiners using multiple gears having a stronger tendency to be in the third quartile compared to other groups. In Sechura no gear types are identified as significant predictor of income quartile, from which one can speculate that income levels are not determined by the type of fishing activity. Considering the high diversity and abundance of fisheries resources in the area this is not surprising. While studies of rural livelihoods emphasize the importance of income composition (Ellis et al. 2003), in this study occupational diversity (number of activity) and income portfolio (type of activity) is not associated with income levels in both sites. With these findings emphasis is placed again on the fact that fishing income is playing a critical role in overall household income in both communities.

Finally the ownership of productive assets (possession of other properties such as land) was found to be significantly correlated to household income on both sites, highlighting the fact that diversification is not only engaging in different activities, it is also possessing an array of assets. Here it is worth recalling the findings of Chapter 4 where overall physical and human capitals in Pisco were higher than in Sechura. In the past, distinct poverty profiles in Peru have been explained by the distinct regional allocation of human, physical, financial and organizational assets as well as the endowment of public goods (Escobal 2001) rather than solely individual income. Additionally, it has been argued by several scholars that asset based measures are a more accurate measure of socio-economic status than income (Filmer and Pritchett 2001; Vyas and Kumaranayake 2006). If only looking through the lens of income Sechura appears to achieve better livelihoods outcomes, but in light of the findings in Chapter 4, the high level of income and low level of human and physical capital rather highlight the failure to transform household income into durable assets that would help build more resilience livelihoods. Thus it is not all about maximizing income, but about reducing vulnerability through the building of a resilient livelihood platform.

5.7.4 Institutional design and cross-scale interaction

In Peru decentralization is a live policy issue (Muñoz et al. 2007) and it has been argued that the power relationships between national, regional and local levels are characterized by a fragile institutional system and self-seeking political system (Muñoz et al. 2007). Hitherto, the institutional arrangements in the artisanal fisheries sector have not been the subject of academic endeavors and government reform, the focus being on industrial fisheries (see for instance Ibarra et al. 2000). The present analysis has shown that the micro-macro interactions were inefficient, if existent. Efforts to decentralize political powers and responsibilities in terms of fisheries management have clearly failed in Sechura while in Pisco the interactions between users and the state are hampered by bureaucracy and corruption, all of these affecting negatively fishermen livelihoods. From a methodological perspective, this underlines the importance of not only conducting studies at the micro levels in order to avoid "forging generally narrow and often static interpretations of village conditions." (Rigg 2006 p. 196). Within the debate about 'rescale governance' (Batterbury and Fernando 2006), it has been argued that the ability to engage effectively at multiple scales is crucial for regional systems (Young 2002b) and contributes to the resilience of social-ecological systems (SES) (Adger et al. 2005a). The current latent centralism in the artisanal fisheries sector is thus a constraint to building resilient SES, however it was acknowledged that decentralization in the context of local institutions with low financial and technical capabilities will not lead to increased resilience. The Peruvian state is thus left with a dual task: upgrade the capabilities at the local level to manage the fisheries while ensuring that the devolution of not only responsibilities but also power takes place. Initiatives such as those undertaken in November 2006 by the government to allow regional offices to collect revenues from fines in order to finance enforcement activity (PRODUCE 2006) are a first step in this direction. Finally the findings challenge the current institutional design of *de facto* open access. The government, with the promotion of aquaculture activities, hence private property regimes, needs to evaluate the "spatial dimension of management". Open access is a central component of livelihood dynamics and while aquaculture offers economic opportunities to fishermen, the lack of consideration in policies of migration patterns and property rights that is currently observed will lead to un-sustainable outcomes.

5.8 Conclusion

The level of dependence on marine resources has proved to be important in determining the capacity to adapt to change (Turner et al. 2007) and diversification a form of self-insurance (Barrett et al. 2001) and a building block of resilient livelihoods (Marschke and Berkes 2006). The findings can thus suggest that fishermen on both sites are vulnerable to external shocks due to their high reliance on fishing activities. Additionally, results revealed that income measures are not an adequate tool for evaluating livelihoods outcomes in the context of our case studies since it is the combination of public and private assets that enhance the livelihood platform. The research also highlights the importance of seasonal migration and how the *de facto* open access regime enables fishermen to pursue this livelihood option. Finally, the findings contribute the ongoing debate on decentralization in natural resource management and the need to not only improve cross-scale interaction but also to upgrade the technical and financial capabilities of regional institutions.

CHAPTER 6

IMPACTED, COPING OR ADAPTING? FISHERMEN LIVELIHOOD SECURITY IN THE CONTEXT OF EL NINO

6.1 Introduction

Important climatic drivers in fish production systems include: water temperature, precipitation oceanographic variables such as wind velocity and wave action. Changes to these drivers can bring about significant changes to ecosystems and their resident fish populations. Changes to aquatic ecosystems can disrupt ecosystem functioning, bring about changes to the population dynamics of fish stocks and thereby impact on fish production. These changes can significantly affect fishermen dependent on fluctuating resources for their livelihoods and can be coupled with floods, drought and other type of extreme events that can engender negative livelihood outcomes. The impacts of climatic stress can be linked to the various elements of the livelihood framework (Balgis et al. 2005; Elasha et al. 2005). In this context, changes in assets reflect not only the degree of impact, but also the coping and adaptive capacity of fishermen. Coping strategies are short-term and immediate responses to disturbances (Vasquez-Leon et al. 2003). Coping does not emphasise the strategic nature of planned adaptation, putting more stress on reactive responses, self-organisation that does not involve major changes in social-ecological systems. Adaptive strategies are more permanent changes that people make in their livelihoods (Vasquez-Leon et al. 2003) and can either be a process, action or outcome in a system in order to better adjust, cope and manage changing conditions (Smit and Wandel 2006) and ultimately enhance resilience. Responses mechanisms such as adaptation and coping practices can be differentiated along several dimensions: by spatial scale (local, regional, national), by sector of activity or by actors (individuals, communities, governments) (Adger et al. 2007).

6.2 Objectives and methods

This chapter explores how fishermen livelihoods security is maintained during EN. It seeks to assess how assets change and how fishermen respond to these changes in their livelihood platform. The objective is to understand what coping and adaptation strategies fishermen adopt in Pisco and Sechura. While the Chapter focuses on individual adaptation, it is also complemented by a succinct analysis of government responses in the region of Piura.

6.2.1 Workshop and interviews

The interviews and workshops conducted between March 2005 and March 2007 in both sites provide evidence for the types of impact and response fishermen and institutions undertook. Interviews to fishermen and women aimed to elucidate the type of impact and the different strategies adopted by individual and households to cope with changes. Interviews to local authorities and aid organizations in Piura had for objective a better understanding of government's responses to disruption in fishing communities. Finally the workshops provided the opportunity to explore if the current changes in the scallop fishery, especially in Sechura, are part of an adaptation process.

6.2.2 Fishermen survey

The notion of the five capitals (natural, physical, human, social and financial) is used, albeit loosely, to capture and analyze fishermen perceptions of impacts of EN and coping and adaptation strategies. A section of the questionnaire focused on the impact on fishing activity, asking respondents to specify what were their target species and if they changed fishing zones during EN. An open-ended question elucidated how their fishing activity was impacted by the event and what coping strategies they adopted (if they changed activity, which one). A second section of the questionnaire focused on impacts on households and if they could cope on their own ("did you need help during EN?"). Households were loosely defined as people living in the same dwelling. Finally, a series of question elucidated if formal social networks and organization played a role in the coping strategies ("did you received help?"; "from whom?").

6.3 Impact of EN on Natural capital

In an open ended question fishermen were asked what their main target species were during EN. A total of 49 species were reported by fishermen and answers, after presence-absence codification, were divided into fish and invertebrate species and descriptive statistics are presented in Tables 32 and 33. The most mentioned littoral fish species were seabass (6%), weakfish (6%) and pompano (4%). For pelagic fish species, mullet (15%), bonito (6%), perico (6%) and chub mackerel (4%) were the most important target species. In terms of invertebrates, scallop (37%) and octopus (17%) were the most mentioned ones. Shrimp (10%) and prawn (5%) were also mentioned as important invertebrate species but mostly in the North. Significant differences ($p<0,05$) across sites are observed for a variety of species (Table 32). Most significant differences ($p<0,01$) for littoral fishes are for fish only reported in Sechura: the banded croaker (5%) and weakfish (13%), to the exception of seabass (11% versus 2% in Pisco). For pelagic species mullet and sierra experienced the greatest differences among sites, with mullet being an important target species in Sechura (23% versus 8% in Pisco) while sierra was not mentioned (5% in Pisco). Scallop, an invertebrate which is traditionally the target species of the diving fishery, also experiences a striking difference among sites, being consistently more reported in Pisco than Sechura (65% versus 8%), which is consistent with sharp decreases in abundances in the North. It is also worth noting that it is by far the most mentioned target specie in Pisco, highlighting its importance for the artisanal sector during EN in that area. Conversely, octopus is more reported in the North (25% versus 10%) and with mullet is the most important target specie in Sechura. Finally, invertebrate species that are not the target of the diving fisheries (i.e. shrimp and giant squid) were either not reported or represented only 1% (shrimp and lobster) of the answers in Pisco.

Table 32 Target species across sites, means of valid multiple responses. Shaded areas with P values<0,05 and * P values<0,01 (Table continues next page).

	Species[a]	**Sechura (n=208)** Mean	Std. Deviation	**Pisco (n=220)** Mean	Std. Deviation	**All Sites (n=428)** Mean	Std. Deviation	**Z score**[b]	**P Value**
Scientific Name	**Littoral fish**								
Labrisomus sp.	Blenny fish	0,01	0,10	0,01	0,10	0,01	0,10	-0,056	0,955
Acanthistius pictus	Brick seabass	0,00	0,07	0,00	0,00	0,00	0,05	-1,028	0,304
Isacia conceptionis	Cabinza grunt	0,00	0,07	0,02	0,15	0,01	0,12	-1,574	0,115
Arius sp.	Catfish	0,00	0,07	0,00	0,00	0,00	0,05	-1,028	0,304
Seriolella sp.	Choicy ruff	0,00	0,00	0,00	0,07	0,00	0,05	-0,972	0,331
Anisotremus scapularis	Grunt- Peruvian	0,01	0,10	0,01	0,12	0,01	0,11	-0,386	0,699
Rhinobatos planiceps	Guitarfish-Pacific	0,02	0,14	0,01	0,10	0,01	0,12	-0,891	0,373
Menticirrhus sp.	Kingcroaker	0,00	0,00	0,02	0,15	0,01	0,11	-2,184	0,029
Sciaena deliciosa	Lorna drum	0,00	0,07	0,01	0,10	0,01	0,08	-0,530	0,596
Stellifer minor	Minor Stardrum	0,00	0,07	0,01	0,12	0,01	0,10	-0,948	0,343
Citharichthys sp.	Pacific sanddab	0,01	0,12	0,01	0,12	0,01	0,12	-0,069	0,945
Paralonchurus peruanus	Peruvian banded croaker	0,05	0,22	0,00	0,00	0,03	0,16	-3,452	0,001*
Trachinotus paitensis	Pompano	0,02	0,14	0,06	0,24	0,04	0,20	-2,285	0,022
Myliobatis sp.	Ray	0,01	0,10	0,02	0,15	0,02	0,13	-1,068	0,286
Paralabrax sp.	Seabass-Peruvian	0,11	0,31	0,02	0,13	0,06	0,24	-3,925	0,000*
Epinephelus sp.	Snowy grouper	0,02	0,14	0,00	0,00	0,01	0,10	-2,064	0,039
Prionotus sp.	Volador	0,00	0,00	0,01	0,10	0,00	0,07	-1,377	0,169
Cynoscion analis	Weakfish-Peruvian	0,13	0,34	0,00	0,00	0,06	0,24	-5,514	0,000*
	Pelagic Fish								
Engraulis ringens	Anchovy	0,02	0,14	0,04	0,19	0,03	0,17	-1,072	0,284
Sarda chiliensis chiliensis	Bonito-Eastern Pacific	0,03	0,17	0,08	0,27	0,06	0,23	-2,378	0,017
Scomber japonicus	Chub mackerel	0,05	0,22	0,03	0,16	0,04	0,20	-1,354	0,176
Cilus Gilberti	Corvina	0,01	0,10	0,00	0,07	0,01	0,08	-0,628	0,530
Not Specified	Fish	0,01	0,12	0,00	0,07	0,01	0,10	-1,060	0,289
Trachurus picturatus murphyi	Jack mackarel	0,02	0,15	0,03	0,18	0,03	0,17	-0,487	0,626

a. Binary variables (1=presence; 0=absence), mean can be read as percentages b. Computed using Mann Whitney U test 2-tailed

Table 32 Target species across sites, means of valid responses, Shaded areas with P values<0,05 and * P values<0,01 (continued from previous page)

	Species[a]	Sechura (n=208) Mean	Sechura Std. Deviation	Pisco (n=220) Mean	Pisco Std. Deviation	All Sites (n=428) Mean	All Sites Std. Deviation	Z score[b]	P Value
Scientific Name	**Pelagic Fish**								
Coryphaena hippurus	Perico, dolphinfish	0,04	0,19	0,08	0,27	0,06	0,23	-1,709	0,087
Sardinops sagax sagax	Sardine	0,03	0,17	0,01	0,10	0,02	0,14	-1,507	0,132
Not Specified	Shark	0,00	0,00	0,01	0,10	0,00	0,07	-1,377	0,169
Scomberomorus sierra	Sierra	0,00	0,00	0,05	0,21	0,02	0,15	-3,108	0,002*
Odontesthes regia regia	Silverside	0,00	0,07	0,02	0,13	0,01	0,11	-1,285	0,199
Mustelus sp.,Triakis sp.	Smoothhound	0,04	0,19	0,02	0,13	0,03	0,17	-1,269	0,205
Thunnus sp.	Tuna	0,01	0,10	0,00	0,00	0,00	0,07	-1,456	0,145
Anchoa nasus	White anchovy	0,00	0,00	0,01	0,10	0,00	0,07	-1,377	0,169
	Invertebrates Diving fishery								
Concholepas concholepas)	Abalone	0,00	0,00	0,00	0,07	0,00	0,05	-0,972	0,331
Gari solida	Clam	0,00	0,07	0,00	0,07	0,00	0,07	-0,040	0,968
Cancer sp.	Crab	0,00	0,00	0,01	0,10	0,00	0,07	-1,377	0,169
Aulacomya ater	Mussel	0,00	0,07	0,03	0,16	0,02	0,13	-1,829	0,067
Octopus mimus	Octopus	0,25	0,43	0,10	0,29	0,17	0,37	-4,134	0,000*
Atrina maura	Penshell	0,01	0,10	0,00	0,00	0,00	0,07	-1,456	0,145
Tagelus dombeii	Razor clams	0,00	0,00	0,01	0,12	0,01	0,08	-1,688	0,091
Argopecten purpuratus	Scallop	0,08	0,27	0,65	0,48	0,37	0,48	-12,249	0,000*
Not specified	Shellfish	0,01	0,10	0,00	0,07	0,01	0,08	-0,628	0,530
Stramonita sp.	Snails	0,09	0,28	0,05	0,22	0,07	0,25	-1,501	0,133
Mesodesma donacium	Surf clam	0,01	0,12	0,00	0,00	0,01	0,08	-1,785	0,074
	Invertebrates Nets and Lines								
Dosidicus gigas	Giant squid	0,03	0,18	0,00	0,00	0,02	0,13	-2,740	0,006*
Panulirus gracilis	Lobster	0,05	0,21	0,01	0,10	0,03	0,17	-2,439	0,015
Xiphopenaeus sp.	Prawn	0,09	0,29	0,00	0,07	0,05	0,21	-4,248	0,000*
Not speficified	Shrimp	0,19	0,40	0,01	0,12	0,10	0,30	-6,138	0,000*
Loligo gahi	Squid	0,05	0,21	0,00	0,00	0,02	0,15	-3,287	0,001*

a. Binary variables (1=presence; 0=absence), mean can be read as percentages b. Computed using Mann Whitney U test 2-tailed

To explore the variance within the data taking into account the type of fishing activity (gear) in each site a principal component analysis was undertaken. In Sechura two components were extracted, accounting for 69,41%, and 4,88% respectively of the total variance, and between them account for 74,29% of the variance. Based on factor scores (Table 34), the first component consisted of items related to octopus, snails and mullet species, with octopus heavily loading on the factor. In the second component, highest loadings were for littoral species weakfish, seabass and banded croaker. Components one and two are graphically represented in Figure 32.A. Similarly in Pisco two components were extracted, accounting for 73,23% and 5,04% respectively of the total variance, and between them account for 78,27% of the variance. Based on factor scores (Table 34), the first component mainly consisted of species scallop, mullet and pompano, with scallop having the highest loading. The second component included octopus and bonito, with octopus having the highest loadings. Components one and two are graphically represented in Figure 32.B. The results show that in Sechura octopus explains the main variance within the data set while in Pisco the variance is explained by scallop and mullet. In none of the sites the type of gear plays role in explaining the variance.

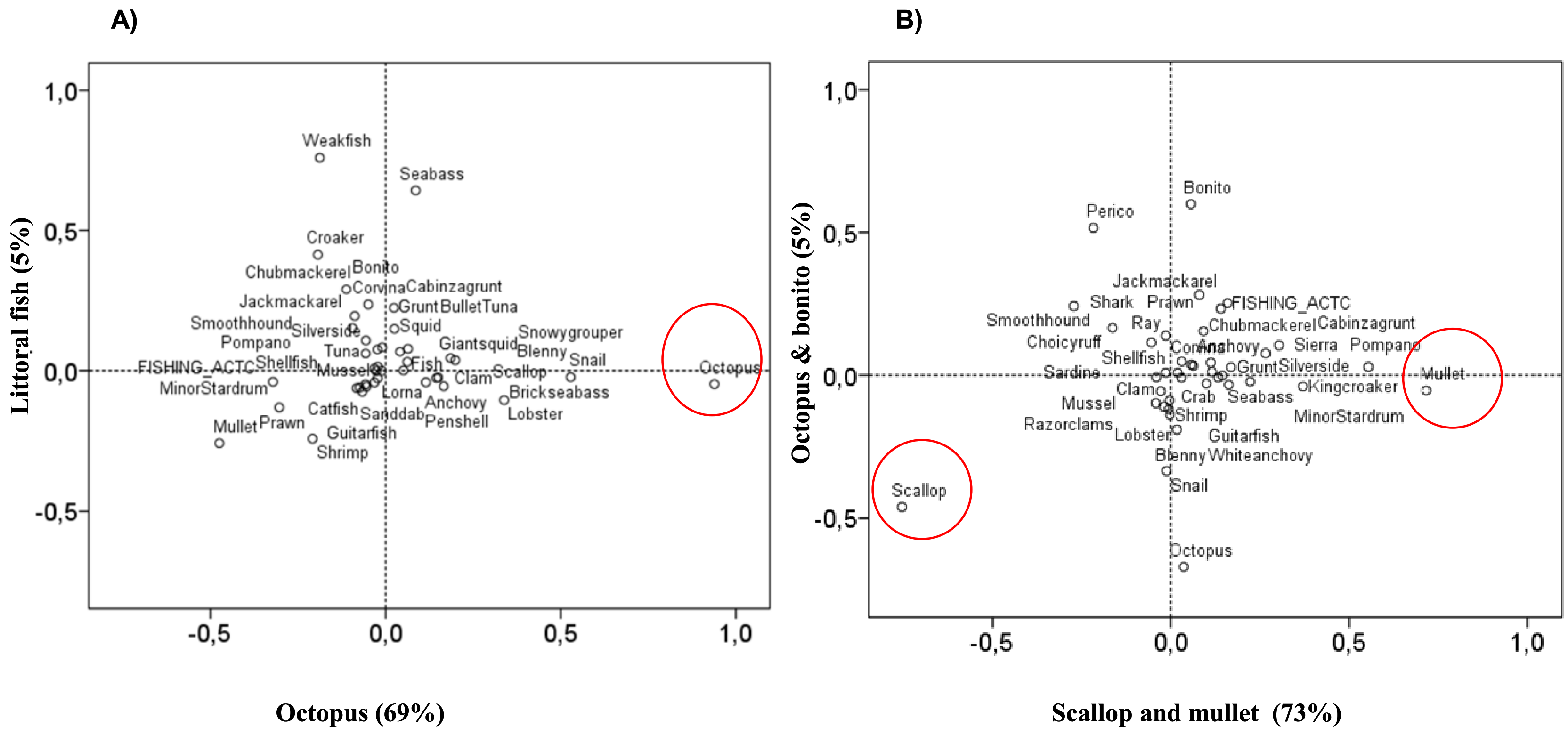

Figure 32 Component plot of fishing activity and target species for Sechura (A) and Pisco (B)

Table 33 Target species and type of fishing activity: Component loadings (Table continues next page)

	Component (% of variance)	Sechura C1 (69,41)	Sechura C2 (4,88)	Pisco C1 (73,23)	Pisco C2 (5,04)
	Fishing activity	-0,322	-0,040	0,159	0,252
Scientific Name	**Littoral fish**				
Labrisomus sp.	Blenny fish	0,185	0,044	0,017	-0,190
Acanthistius pictus	Brick seabass	0,150	-0,024	-	-
Isacia conceptionis	Cabinza grunt	0,024	0,224	0,140	0,233
Arius sp.	Catfish	-0,055	-0,057		
Seriolella sp.	Choicy ruff			-0,055	0,113
Dosidicus gigas	Grunt- Peruvian	0,025	0,150	0,169	0,028
Rhinobatos planiceps	Guitarfish-Pacific	-0,067	-0,074	0,132	-0,008
Menticirrhus sp.	Kingcroaker			0,371	-0,039
Sciaena deliciosa	Lorna drum	-0,022	0,014	0,144	-0,001
Stellifer minor	Minor Stardrum	-0,074	-0,060	0,223	-0,023
Citharichthys sp.	Pacific sanddab	-0,058	-0,048	0,162	-0,033
Paralonchurus peruanus	Peruvian banded croaker	-0,194	**0,413**	-	-
Trachinotus paitensis	Pompano	-0,057	0,108	**0,554**	0,029
Myliobatis sp.	Ray	-0,023	-0,027	-0,014	0,137
Paralabrax sp.	Seabass-Peruvian	0,086	**0,643**	0,115	0,012
Epinephelus sp.	Snowy grouper	0,062	0,031	-	-
Prionotus sp.	Volador			0,031	0,048
Cynoscion analis	Weakfish-Peruvian	-0,188	**0,760**	-	-
	Pelagic Fish				
Engraulis ringens	Anchovy	-0,032	-0,042	0,112	0,044
Sarda chiliensis chiliensis	Bonito-Eastern Pacific	-0,050	0,236	0,057	**0,599**
Scomber japonicus	Chub mackerel	-0,112	0,291	0,092	0,154
Cilus Gilberti	Corvina	-0,024	0,076	0,058	0,037
Not Specified	Fish	0,115	-0,041	-0,041	-0,007
Trachurus picturatus murphyi	Jack mackarel	-0,088	0,195	0,080	0,281
Mugil cephalus	Mullet	**-0,475**	-0,258	**0,716**	-0,054
Coryphaena hippurus	Perico, dolphinfish	-0,032	0,007	-0,217	0,516
Sardinops sagax sagax	Sardine	-0,083	-0,062	-0,015	0,009
Not Specified	Shark			-0,163	0,165
Scomberomorus sierra	Sierra			0,303	0,104
Odontesthes regia regia	Silverside	-0,010	0,084	0,266	0,076
Mustelus sp.,Triakis sp.	Smoothhound	-0,095	0,152	-0,272	0,242
Thunnus sp.	Tuna	0,064	0,078	-	-
Anchoa nasus	White anchovy			0,099	-0,029

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
Empty cells: variable had zero variance

Table 34 Target species and type of fishing activity: Component loadings continued from Table 6.X

	Component (% of variance)	Sechura C1 (69,41)	Sechura C2 (4,88)	Pisco C1 (73,23)	Pisco C2 (5,04)
Scientific Name	**Invertebrates Diving fishery**				
Concholepas concholepas)	Abalone			-0,003	-0,138
Gari solida	Clam	0,145	-0,026	-0,028	-0,057
Cancer sp.	Crab			0,030	-0,009
Aulacomya ater	Mussel	-0,011	-0,001	-0,042	-0,098
Octopus mimus	Octopus	**0,939**	-0,048	0,036	**-0,670**
Atrina maura	Penshell	0,166	-0,055		
Tagelus dombeii	Razor clams			-0,006	-0,119
Argopecten purpuratus	Scallop	0,199	0,037	**-0,754**	**-0,461**
Not specified	Shellfish	-0,026	-0,002	0,019	0,009
Stramonita sp.	Snails	**0,528**	-0,023	-0,012	-0,335
Mesodesma donacium	Surf clam	-0,057	0,061		
	Invertebrates Nets and Lines				
Anisotremus scapularis	Giant squid	0,051	0,001		
Panulirus gracilis	Lobster	0,338	-0,104	-0,019	-0,111
Xiphopenaeus sp.	Prawn	-0,304	-0,130	0,063	0,033
Not speficified	Shrimp	-0,209	-0,242	-0,004	-0,089
Loligo gahi	Squid	0,041	0,068		

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Empty cells: variable had zero variance

6.4 Impact of EN on fishing activities and fishermen responses

6.4.1 Impact on fishing activities

Fishermen were asked in an open ended question how EN affected their fishing activities. Four main components were extracted from the numerous codes the answer generated: impacts on fishing incomes, on the environment, commercialization and operational costs, and for each component significant differences were observed between sites (Table 35). Impact of EN on income followed opposite trends in Sechura and in Pisco, with a 68% decrease and 72% increase in income respectively. Difficult commercialization of products, code which encompasses damages to infrastructures such as roads and docks and decrease in price of certain species due to high abundance, was a particular concern in Sechura (10%):

"There was enough squid, and mullet because of the freshwater but we could not bring them to the markets because of the broken roads; prices were low because nobody could buy due to the low economy; the bridge fell, we had to move with chalanas [small boats]"

Survey ID 293 Purse seiner Sechura

In Pisco and Sechura an increase in operational costs was also one of the main impacts fishermen identified (25% and 22%). In both sites the re-tooling costs (nets, compressor etc.) provided some strain to income. Additionally, in Pisco fishermen had to sometimes go further than their traditional fishing grounds and inflation was permeating with prices of petrol and food rising due to the high demand:

"(…) Operational costs increased by 100%, the petrol to go and find fishing zones where the commercial sizes [of scallop] is bigger. The trip to go to the work zone increased and the food."

Survey ID 78 Diver_other Pisco

In Sechura fishermen especially complained about the rising prices of food which made trips at sea more expensive (and as such considered a separate category in the coding) and the costs of adapting to new species such as the mullet. Additionally, fishing activities were hampered by adverse weather conditions ('mar movida', 'the moving sea' and the constant rains):

"I went for the mullet in the lagoon (…), there was enough but the price was low and the rain would not let us work; there was not enough income from fishing, we were in debts (…)"

Survey ID 295 Gill and drift nets Sechura

"The scallop disappear; I had to buy new equipment; the rains was paralyzing us, we did not go out [at sea], we waited for it to pass; there was product, but going bad because the buyers were in Chiclayo and they could not use the highway"

Survey ID 256 Diver Sechura

Significant differences between sites were observed in terms of the abundance of resources, with more fishermen in Sechura mentioning they saw a decrease in species available to them (6% versus 2%). In Pisco more fishermen mentioned that their operational costs remained constant (5% versus 1%).

Table 35 Impact of EN on economic activity[a] across sites. Shaded areas with P values <0,05

	Sechura n=266		**Pisco n=221**		**All Sites n=487**		**Z scores**	**P value**
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation		
Fishing Income								
Increase	0,14	0,35	0,72	0,45	0,40	0,49	-12,894	0,000
Decrease	0,68	0,47	0,10	0,29	0,41	0,49	-12,938	0,000
Constant	0,15	0,36	0,18	0,38	0,16	0,37	-0,759	0,448
Environment								
Increased Fish.Res.	0,08	0,27	0,08	0,27	0,08	0,27	-0,101	0,919
Decreased Fish.Res.	0,06	0,25	0,02	0,13	0,04	0,20	-2,475	0,013
Negative Env.Factors	0,07	0,26	0,01	0,12	0,05	0,21	-3,057	0,002
Commercialization								
Difficult	0,10	0,30	0,01	0,09	0,06	0,23	-4,182	0,000
Good	0,01	0,09	0,01	0,09	0,01	0,09	-0,186	0,852
Operational costs								
Increased	0,22	0,42	0,25	0,43	0,23	0,42	-0,702	0,483
Decreased	0,00	0,00	0,01	0,12	0,01	0,08	-1,904	0,057
Increase in Food $	0,10	0,30	0,01	0,12	0,06	0,24	-3,904	0,000
Constant	0,01	0,09	0,05	0,23	0,03	0,17	-3,073	0,002

a.Binary variables (1=presence; 0=absence), mean can be read as percentages of valid answers to open-ended question
b. Computed using Mann Whitney U test 2-tailed

6.4.2 Responses to changes in natural capital

Fishermen were asked if during EN they performed any changes in their activities. Overall respondents mentioned undertaking changes (64,8%) and a significant difference among site was observed (X^2 6,463= d.f.=1,00, p<0,05) with fishermen in Sechura performing changes in a higher proportion (Table 36). Based on the classification tree method, with change of activity as a dependent variable and type of gear as dependent one, no groups were identified in both sites. Fishermen were then asked in an open ended question what type of change they undertook (Table 36). In Pisco changes were mainly made in the fishing activity, with changes in target species and gear, a high number of fishermen especially mentioning a switch to scallop or/and diving (44,4%). In Sechura responses included changes in target species and gear as well as working in processing plants. A significant number of respondents (44,9%) exited the fisheries sector to undertake agriculture activities or pursue activities such as carpenter (‘worker’ code) and moto-taxi driver. Additionally 5,1% of respondents in Sechura mentioned they were unable to pursue any income generating activities.

Table 36 Strategies to cope with changes in natural capital. Percentage of valid answers.

		Sechura n=249	Pisco n=95	All Sites n=344
Change				
	Yes	70,2	50,9	64,8
Type of Change				
Within the fishery sector		*49,9*	*77,7*	*56*
	Species	20,4	18,5	20
	Gear	18,3	11,1	16,8
	Diving (scallop)	2	44,4	11,2
	Worker fishing indus.	9,2	3,7	8
Outside the fisheries sector		*44,9*	*22,2*	*40*
	Agriculture	16,3	7,4	14,4
	Worker	11,3	14,8	12
	Moto taxi	11,2	0	8,8
	Other	6,1	0	4,8
No work		5,1	0	4

When desegregating these results by gear type with the classification tree method a difference could be observed, albeit not between sites (Figure 33). The diver, diver and other, and trawler groups are significant predictor of change in target species while the others gears are a significant predictor of changing activity specifically to diving.

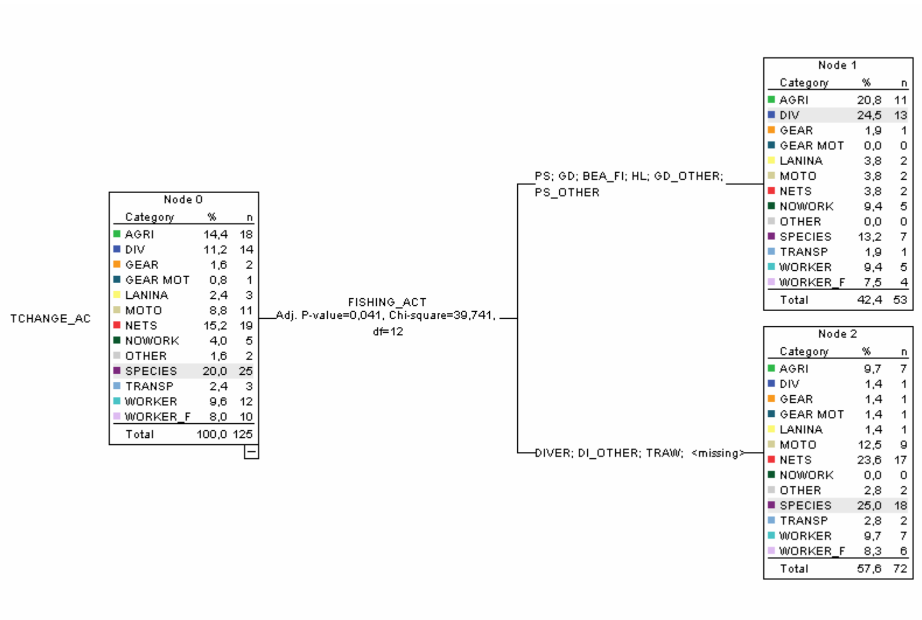

Figure 33 Classification tree (CHAID growing method) with dependent variable Type of change and independent variables: Site and Fishing activity.

In a separate question fishermen were asked if they changed fishing zones during EN. The majority of fishermen responded by the affirmative (59,2%) with no differences between sites and gear groups identified (p>0,05). In Pisco the majority of the migratory movement took place within the province, mainly to Bahia de Independancia (63,2%), where several scallop banks are located. Additionally a smaller percentage mentioned having to go more offshore than usual (Figure 34). In Sechura migration patterns are more diversified. Fishermen either migrated towards the North (30,2%), in ports like Paita and Talara or went to the Isla Lobos de Tierra (17,5%). In these areas shrimp and squid fisheries operated. Migration within the bay also occurred (23%), and a number of respondents specifically mentioned fishing in the Laguna La Niña, the lagoon created due to the increased water flow into the Bocana de Virrila estuary. Additionally, fishermen also migrated to the centre and south of the country (16,7%).

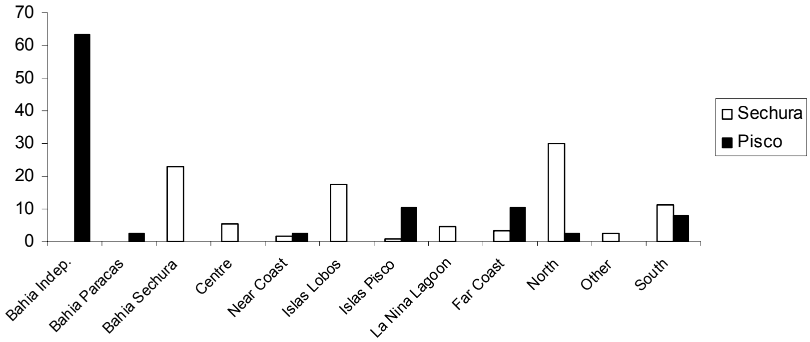

Figure 34 Changes in fishing zones during EN. Percentage of valid answers.

6.4.3 Integrated view of impacts and response strategies

In order to obtain a better understanding of what key variables explain the variance within the data a principal component analysis (PCA) was performed for each sites. In Sechura a first attempt was made to perform a PCA taking into account fishing activity as one of the variable but only one component could be extracted. Indeed fishing activity was the key variable explaining the variance within the data (factor loading 1,845). For Pisco two components were extracted accounting for 65,96% and 9,05% respectively of the total variance, and between them account for 75,01% of the variance. Based on factor scores (Table 37), the first component consisted of changes in the activity and fishing income and the second one on fishing activity. In stark contrast to Sechura, fishing activity in Pisco thus accounts for very little of the variance in the data, changes in the activity (fishermen response) being a more important factor.

Table 37 Impacts of EN on fishing activity: Component loadings

	Sechura	Pisco	
Component (% of variance)	**C1**	**C1 (65,96)**	**C2 (9,05)**
Fishing Activity	**1,845**	0,060	**0,997**
Fishing Income			
Increase	0,019	**-0,630**	0,042
Decrease	0,033	**0,652**	-0,127
Constant	-0,032	0,074	-0,035
Changes in Activity			
Changes in Activity	-0,040	**0,792**	0,078
Changes in fishing grounds	-0,006	0,386	0,241
Environment			
Increased Fish.Res.	0,015	-0,019	-0,178
Decreased Fish.Res.	-0,013		
Negative Env.Factors	-0,026	0,309	-0,147
Commercialization			
Difficult	-0,010	-0,013	-0,236
Good	0,022	0,036	-0,237
Operational costs			
Increased	-0,028	-0,288	**0,407**
Decreased		-0,099	0,298
Constant	-0,005	-0,167	-0,011
Increase in Food $	0,029	-	-

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
Empty cells: variable had zero variance

6.5 Impact on households

Overall 58,1% of respondents felt that EN had a negative effect on their households. Significant differences are observed between sites (X^2=196,250 d.f.=3,00, p<0,05), with negative effects being strongly felt in Sechura compared to Pisco (86,6% compared to 20,6%). When desegregating these results by gear type no significant differences were found in Sechura (p>0,05). Conversely in Pisco the divers, beach fishermen and purse-seiners using several gears group was identified as a good predictor of positive impact on households compared to other gear groups (Figure 35). This reveals that in Sechura whether fishermen are impacted by EN at the household level is not necessarily dependent on their type of activity while in Pisco being a diver, beach fishermen and purse seiners is a good predictor of perceiving positive impacts.

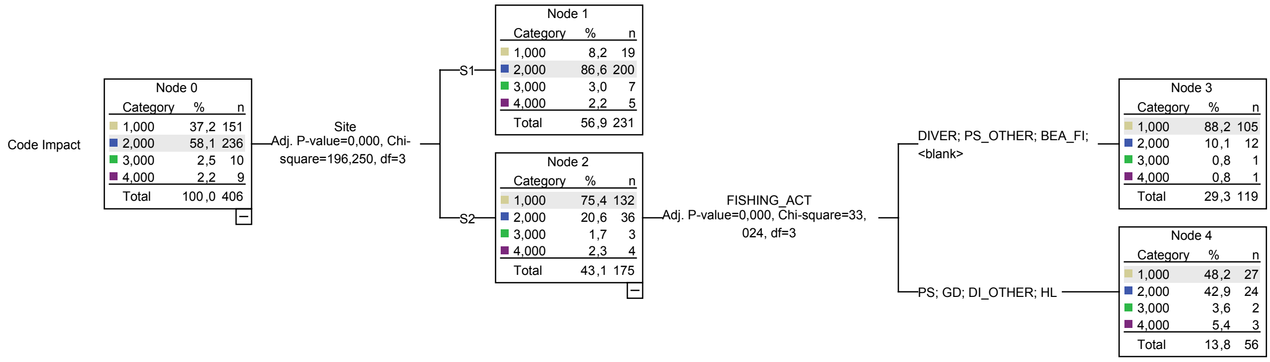

Figure 35 Classification tree (CHAID growing method) with dependent variable Type of impact (1.Positive, 2. Negative, 3.More or less, 4.No effect) and independent variables: Site and Fishing activity.

Fishermen were then asked in an open ended question to specify what kind of impacts their household experienced (Table 38). As expected striking differences were observed between sites (p<0,01). In Sechura most respondents reported damages to dwellings, partial or total (57%). During the workshop conducted in 2005 (Chapter 4) participants stressed the fact that most dwellings around Sechura bay were located in low-lying areas subject to floods. In Parachique, after the last EN a coastal defense was built to protect the settlement as observed during village walks. Interviews revealed that fishermen are aware that this protection might no be sufficient and re-location to more sheltered areas necessary. Nevertheless, they appear to have a selective acceptance of risk when it comes to housing. Inhabitants consider moving an expensive solution, especially since most of them do not have a land title, being unable to sell and re-invest the money in a new parcel.

Table 38 Type of impact on households of EN across sites. * P values<0,01

	Sechura (n=270)		**Pisco (n=202)**		**All sites (n=472)**		**Z**	**P value**
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation		
Household Revenues								
Increased	0,03	0,17	0,58	0,50	0,26	0,44	-13,330	0,000*
Decreased	0,19	0,39	0,14	0,35	0,17	0,38	-1,274	0,203
Constant	0,03	0,17	0,09	0,29	0,06	0,23	-2,814	0,005*
Physical and Productive Assets								
Loss of house	0,57	0,50	0,01	0,07	0,33	0,47	-12,781	0,000*
Loss of house equip.	0,03	0,17	0,00	0,00	0,02	0,13	-2,451	0,014
Purchase of Fishing equip.	0,01	0,09	0,15	0,36	0,07	0,26	-6,168	0,000*
Purchase of House	0,01	0,09	0,19	0,39	0,09	0,28	-7,007	0,000*
Purchase of House equip.	0,01	0,12	0,19	0,39	0,09	0,29	-6,562	0,000*
Purchase of Land	0,00	0,06	0,09	0,28	0,04	0,19	-4,527	0,000*
Assets did not increase despite gain	0,01	0,09	0,06	0,24	0,03	0,17	-3,305	0,001*
Commercialization routes and Basic Household Products								
Difficult	0,12	0,32	0,04	0,18	0,08	0,27	-3,146	0,002*
Good	0,00	0,06	0,01	0,10	0,01	0,08	-0,843	0,399
Lack of basic household products	0,19	0,39	0,04	0,20	0,12	0,33	-4,741	0,000*
More basic household products	0,00	0,06	0,09	0,29	0,04	0,20	-4,682	0,000*
Human Capital								
Diseases	0,05	0,21	0,01	0,10	0,03	0,18	-2,341	0,019
Ability for More education	0,00	0,06	0,06	0,24	0,03	0,16	-3,679	0,000*
New skills	0,01	0,11	0,04	0,18	0,02	0,14	-1,766	0,077
Not affected	0,14	0,35	0,04	0,18	0,09	0,29	-3,763	0,000*

a. Binary variables (1=presence; 0=absence), mean can be read as percentages.b. Computed using Mann Whitney U test 2-tailed

Fishermen also mentioned a decrease in household revenues (19%) and the lack of basic household products such as staple foods like rice, cooking oil and sugar (19%). Other challenges faced by households are the damage of access roads and public infrastructures which hinders the commercialization of staple foods and business activities, limiting fishermen options to diversify:

"*The flood did not affect the house where I live because I live in the higher 'part' but it affected me economically, there is no more work and you cannot diversify because there is nothing.*"

Survey ID 146 Diver Sechura

"The movement of food and petrol was impossible due to the bad state of the highway; you could not sell nor buy anything; there was no food."

Survey ID 233 Diver Sechura

Furthermore fishermen mentioned an increase in diseases (5%), ranging from gastric diseases to malaria:

"Water came into the house because of the rains (...) there were mosquitoes that caused diseases."

Survey ID 285 PurseSeiner_Other Puerto

In Pisco EN overall had a positive impact on household revenues, with 58% of respondents mentioning an increase. Additionally, respondents mentioned they were able to build or purchase a house and buy household equipment such as televisions (19%), as well as buying land and providing better food for their families (9%). In terms of human capital increased revenues were invested in education of the respondents or dependants (6%) and EN gave them the opportunity to learn new skills, diving (4%). Fishermen also reported that the increase in revenues allowed them to acquire new fishing equipment (nets, boats, diving suit etc.):

"Really good fishing seasons, there was work for everybody. I did not know how to dive but necessity made me learn. I bought a house and two boat s(...)."

Survey ID 17 Diver San Andres

Nevertheless, some respondents also mentioned that despite an increase in their revenues they did not increase their asset base by making investments (6%).

6.6 Social capital: did fishermen and their household cope

Fishermen were asked if they required assistance during EN. Not surprisingly site differences were observed (X^2=54,965 d.f.=1,00, p<0,05), with 56,4% of fishermen needing help in Sechura compared to only 23,77% in Pisco. When desegregating these results by gear types no significant differences were found in Sechura (p>0,05) (Figure 36). The results show that the type of fishing activity is not a good predictor for whether fishermen required help. Conversely in Pisco the divers, beach fishermen and fishermen using gill and drift and other gears nets group was identified as a good predictor of requiring no assistance compared to other gear groups.

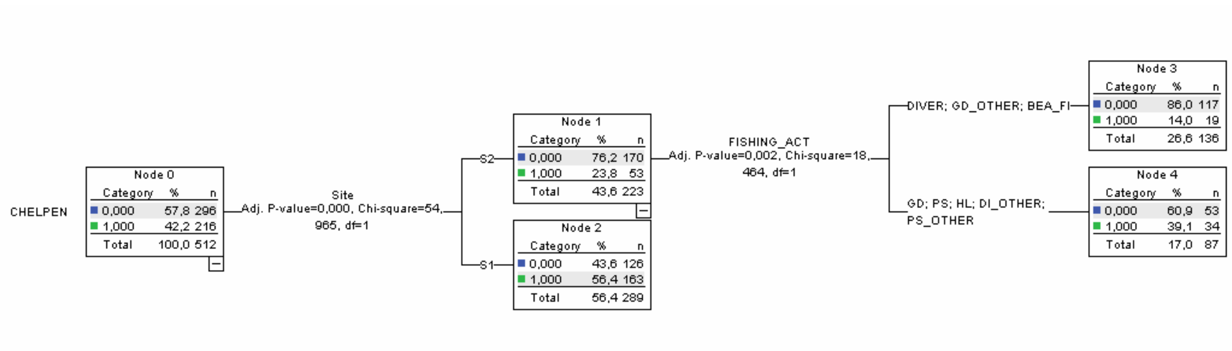

Figure 36 Classification tree (CHAID growing method) with dependent variable "Needed help?" (0.No 1.Yes) and independent variables: Site and Fishing activity.

In Sechura and Pisco only a small number of respondents mentioned having received assistance (16,08% and 8,74%). In Sechura emergency aid to households came primarily from the government (54,08%) through regional and national programs such as Civil Defense and the National Program for Food Assistance (Programa Nacional de Asistencia Alimentaria – PRONAA). Respondents specifically singled out assistance from municipalities (22,45%) who are an essential nexus for delivering aid coming from outside the province. Finally, fishermen mentioned receiving assistance from financial institutions such as banks and cooperatives (11,22%). Family and friends, as well as civil society (NGOs and religious groups) also played an important role in providing assistance (Figure 37). It is worth noting that fishermen associations are not part of fishermen coping strategies, providing only 1,02% of the aid received. Responses in Pisco differ, with family and fishermen associations having a greater role in providing assistance with 26% and 12% respectively compared to 14% for government. In terms of aid, households in Sechura mainly received food and construction material to rebuild houses. In Pisco assistance mainly consisted of economic aid.

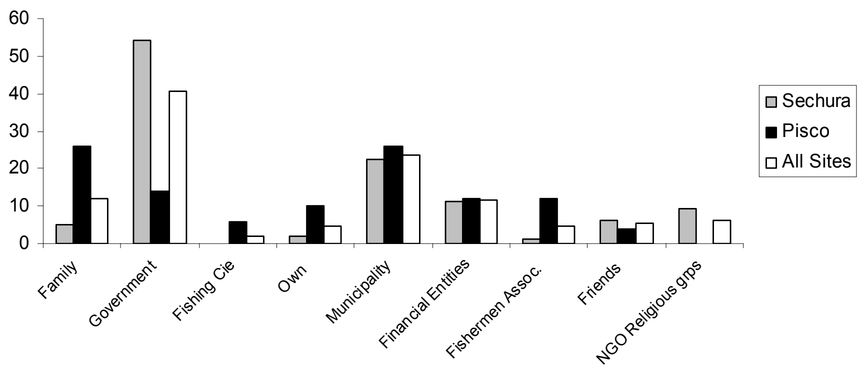

Figure 37 Who provided assistance during EN? Percentage of valid answers.

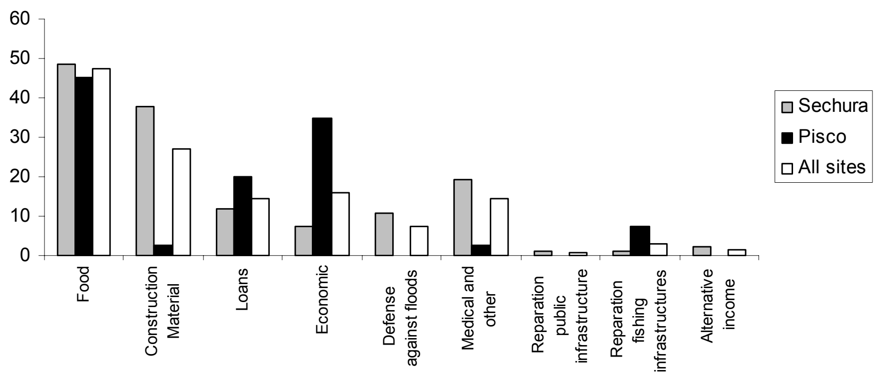

Figure 38 What kind of help did you received? Percentage of valid answers.

6.7 'Narratives from above': institutional response in Sechura and market changes

Disaster management plans at the national level were written for the first time by the Fishery Ministry during El Niño event of 1998 (CAF 2000). There is no evidence of climate variability being mainstreamed into artisanal fisheries management, short-term responses after events rather than long-term management policies being elaborated. During workshops, participants put forward that currently climate variability was not integrated into planning and management. As one Peruvian participant noted in the CENSOR workshop conducted in September 2006 in Chile: "*the current legislation can be a problem for adaptive management: the law does not take into account eventualities* [uncertainties]". Interviews revealed that EN events in Piura offered a window of opportunity to facilitate adaptation processes in the region. Indeed the EN events of 1982-83 and 1997-98 and their ensuing high physical damage provided the stimulus to design and implement programs aiming at integrating climate variability into regional development planning and develop cross-sector interaction on this issue:

"1998 post El Niño started the beginning of a network of relations: we need to get together to face Niño (...) In the last two and a half years in Piura the topic of climate change has been on the agenda."

P32: UI-10-BB-Piura- GTZ technical advisor

At the national level, the Peruvian government initiated the PROCLIM program, Programa de Fortalecimiento de Capacidades Nacionales para Manejar el Impacto del Cambio Climático y la Contaminación del Aire (National Capacities Strengthening Program to Manage Climate Change Impact and Air Pollution). The regional government with the aid of several international agencies initiated a series of studies on the impacts of EN and possible adaptation and mitigation measures. The Autoridad Autónoma de Cuenca Hidrográfica Chira Piura (Autonomous Authority of the Chira Piura Drainage Basin) is the leading government agency in this endeavour and has been promoting the integration of climate variability into the planning process with the help of the German cooperation (GTZ)

"*Since last January the PDRS [GTZ] is assessing the Autoridad Autonoma to help mainstream, position the study [on climate change] in regional institutions [in order] to define strategies. The objective is to insert the results of the project into the planning processes so that they transform themselves into working documents. They are trying to design a regional by-law on climate change strategies and sustainable development for the Piura region.*"

P32: UI-10-BB-Piura- GTZ technical advisor

While a multi-sectoral program, the focus of PROCLIM is mainly on the agricultural sector in the region of Piura. Interviews in regional and municipal entities involved in the fisheries sector revealed that users and fisheries managers were unaware of the program outputs. Review of project documents (see for instance Tarazona 2005) also showed an emphasis on the ecological and biological impacts of EN in the region, with little information on the impacts on livelihoods and no documented typology of coping mechanisms.

The after-math of the EN 1997-98 also corresponded with the development of scallop aquaculture. Since 1999-2000 Sechura is experiencing a scallop boom due to optimal growth conditions for scallops, and the subsequent increase in fishing effort and migration. Favourable international and national markets, the issuance of the sanitary certificate for export to the European Union, and lower landings in the south of the country favoured this expansion of the fishery (Flores Ysla et al. 2005). The development of aquaculture due to this favourable international market led to increased migration fluxes with settlements along the bay growing in a hap-hazard way in flood-prone areas. While this activity offers economic opportunities to fishermen, it is particularly sensitive to changes in river discharge and can thus be considered highly vulnerable to EN events. In 2006, amid fears of a strong EN event, fishermen involved in aquaculture expressed fears of loosing their investments, as well as their inability to maintain their household due to lack of savings. The same year, in May, a red tide event resulted in the mortality of 70,5% of scallop stocks in stock-enhancement areas (DePeru.Info 2007). In response the government granted a credit consisting of scallop seeds for re-sowing with a two-year period of grace for repayment. If aquaculture activities continue to increase in the bay the question remains on whether the government will be able to provide to operators during

EN events emergency aid that covers losses. Thus while the EN event of 2006 was mild, the red tide revealed the vulnerability of these operators.

6.8 Discussion

6.8.1 Impact on natural capital

Target species during EN events showed marked changes compared to normal years. In Sechura, more fishermen mentioned targeting mullet and shrimps than during normal years, with octopus also playing an important role in the fishery. The main mentioned target species that observed a sharp decrease during EN are scallop (-38%) and snail (-12%). In Pisco, scallops observe the only sharp increase as a target species (+46%) while snail (-25%) and crab (-18%) observed the sharpest decrease. Conversely to normal years the type of gear did not explain the variance in the choice of target species in both sites, indicating that fishing strategies during EN are not based on gear but on the availability of species. In normal years, fishermen surveyed in Sechura are highly specialized, focusing on the scallop fishery, while during EN they become generalists. In Pisco the reverse is observed: during normal years fishermen in Pisco are more generalists than in Sechura but with EN the scallop becomes the main target species. These findings illustrate the flexibility of fishermen, who exhibit an opportunistic behaviour with changes of abundances.

6.8.2 Impact on physical capital

The survey results show that in Sechura the floods impact on public infrastructure such as roads were perceived as an important limitation to the marketing of fishery products as well as the purchase of goods such as food items for households. However, it is the impact on dwellings that was perceived as the most important impact in Sechura, with more than half of the respondents reporting damage or loss of houses. It was estimated that in the last EN in Peru 100,000 homes were either damaged or destroyed by floods and landslides, affecting around half a million people, three-quarters of those in rural areas (Reyes 2002). The data presented here is consistent with findings of other studies conducted in coastal areas hit by extreme events (see for instance Birkmann and

Fernando 2008). What is striking is the fact that re-location did not occur despite the intensity of the event. There is a vast literature on flood prone areas and risk aversion of house owners in terms of relocation (Tobin and Montz 1988) and risk perception (Etkin 1999; Miceli et al. 2008). Behavioural experiences play an important role in the perception of risk, Halpern-Felsher et al (2001) showing that personal experience with natural hazards can decrease the perception that the chance of experiencing negative outcomes from another event are high. This ‘survival syndrome’ applies to Sechura, where fishermen are aware that another flooding event will destroy their dwellings but consider the probabilities negligible in the short term. Risk management partly involves preparing for the future because one thinks it is more costly to have a ‘wait and see’ attitude, which is not the case in Sechura. Wood posits that a characteristic of poverty is uncertainty and short-term behaviour, securing livelihoods and “the preparation for the future [are] continuously post-poned for survival in the present- the Faustian bargain.” (Wood 2003 p. 468). While re-location of dwellings is warranted in Sechura, it is clear that without financial incentives these will not take place. Additionally, it has be argued that disaster preparedness was positively associated with risk perception (Miceli et al. 2008), which could explain the low level of risk reduction strategies observed in settlements along Sechura Bay. In Pisco the impact on physical infrastructure was positive, with respondents being able to purchase new productive physical capital as well as assets for their households.

6.8.3 Responses to changes

6.8.3.1 Short term adaptation strategies

Fishermen responded to changes in natural capital in several ways. One coping strategy was to change fishing zones: in Pisco fishermen concentrated their activity in Bahia Independancia, more specifically in Laguna Grande were scallop extraction was striving. In Sechura migration was mainly directed outside of the bay, towards northern ports or the centre and south of the country. It has been argued that migration increases the flexibility of fishermen and while presenting difficulties for fishery management agencies, it should be taken into account in fisheries policies (Johnson and Orbach 1990). In Pisco, changes in target species and gear in order to take part in the scallop fishery were the main strategies adopted by the majority of fishermen surveyed. In Sechura two responses strategies were identified: staying with the fishery sector but changing target species or gear, and exiting the artisanal fishery. Diversification into other sectors relied mainly on agriculture, low lying areas in the Piura region being less affected by floods than the 'alto Piura', the Andean part of the region (Reyes 2002). Mullet and shrimps offered new opportunities to fishermen with the fisheries sector, allowing them to cope with the loss of more traditional target species.

6.8.3.2 Long term adaptation strategies

In Sechura adaptation to EN was not observed, especially in term of housing, as mentioned above. However, major changes in they bay occurred in the last 10 years with the development of the scallop fishery and aquaculture. Aquaculture requires high levels of capitalization and intensive levels of management, these risks compounded by a high risk of disease outbreak (DaCosta and Turner 2007). This new livelihood option is extremely vulnerable to changes in environmental factors. One avenue to explore in terms of policies is risk-transfer mechanisms and microfinance tools to help small operators build up financial resilience to climate variability. In the agricultural sector in Peru small microfinance activities have grown over the years in rural areas. Currently in this sector weather insurance products (index-based risk transfer products) are being developed to help small farm holders face climate-related risk (Skees et al. 2007). In the fisheries sector there is a need to increase access to financial services and explore the feasibility of weather insurance products. As Linnerooth-Bayer in her analysis of risk-transfer instruments put forward:

> *"The purpose of refocusing disaster aid is not to replace it with unaffordable private insurance but rather to complement post-disaster humanitarian aid with pre-disaster support of risk management programs that combine prevention and risk transfer"*
>
> (Linnerooth-Bayer 2005 p. 1046)

In this context the development of financial instruments to reduce risks in this activity needs to be investigated. FAO has already undertaken several studies on risk management in aquaculture (Secretan et al., 2007; Van Anrooy et al., 2006) and a study at a local level based on this information and the experience gained in the agricultural sector should be undertaken. But for these type of initiatives to be successful formal institutions in the Region of Piura need to acknowledge the necessities of fishing communities when facing EN, and reduce the knowledge gap that exist between agriculture and fisheries in terms of coping and adaptation mechanisms to climatic stresses. In Pisco fishermen adapted to EN since 1982 by developing aquaculture in the bays following “boom years”. This will be dealt in more details in Chapter 7.

6.8.4 Can household cope on their own?

It has been argued that household behaviour for coping that involves risk-sharing is a common way of dealing with crises and that kinship plays an important role in recovering from a shock (Dekker 2004). Findings from Sechura reveal that fishermen and their households heavily rely on government aid to cope with livelihood changes, local networks and family and friend providing little help. This might be due to the systemic nature of EN impacts, where all households are impacted indiscriminately, leaving none to help the other. The government still has a role to play and should intervene, especially in promoting adaptation processes such as relocation. However, while government should steer the adaptation process there is a need to develop community-driven emergency response strategies in order to reduce reliance on the state. For instance, fishermen associations could play a greater role in disaster preparedness and response.

6.9 Conclusion

The level of flexibility and autonomous response of the artisanal fishery to changes in natural capital during EN is an important feature of fishermen livelihoods in times of climatic stresses. Fishermen adopted mainly three coping mechanisms: prey switching, migration or exiting the fisheries sector. The findings highlight the differential impacts of EN on both study sites. Additionally, while apparently remote and unconnected physically, the dynamics between Sechura and Pisco through migration play an important role in the development of the fishery and this will be explored in the next Chapter.

CHAPTER 7

CLIMATE VARIABILTY AND THE PERUVIAN SCALLOP FISHERY: THE ROLE OF FORMAL INSTITUTIONS IN RESILIENCE BUILIDNG

7.1 Introduction

Resilience in social-ecological systems can be defined as the ability to absorb disturbance, the degree to which a system is capable of self-organization, and the capacity to learn and adapt (Resiliance Alliance; Berkes et al. 2003b). Theories of institutions have been widely used to gain an understanding of their role in environmental change (O'Riordan and Jordan 1999; Young 2002a; Young et al. 2006) and institutions within social-ecological systems have been considered as vehicles through which resilience can be enhanced or compromised (Bingeman et al. 2004). Adaptive capacity can be defined as the ability of institutions to change inherent properties to return to a reference or alternative state of the system they belong to. The question of whether the new alternative state is a more 'desirable' one is particularly relevant, shedding light on the fact that adaptation does not always lead to desirable outcomes ('mal-adaptation'). Adaptive capacity thus translates into increasing the ability and speed to evolve and adapt to new situations as they arise, and the flexibility to experiment and adopt novel responses to address the problem (Walker et al. 2002). In this context, response is defined as any action taken to manage environmental change, in anticipation of that change or after change has occurred (Thompson and Adger 2005). The analysis of institutional responses to climatic events allows us to gauge what role they play in the maintenance of the adaptive capacity of the system under study. In this chapter the formal institutional responses to climate variability focus on the explicit aspects of rules, norms and knowledge relevant to the management of the scallop fisheries in Peru. During ENSO events the Peruvian bay scallop (*Argopecten purpuratus*) undergoes substantial changes in its stock size. In the North of the country strong warm ENSO events are synonymous with floods and river discharges that negatively affect scallop biomass, while in the South increased sea surface temperatures lead to an increase in stock size.

7.2 Objectives and methods

This chapter explores how formal institutions respond to climate variability and resource fluctuations in the scallop fishery, and what role they play in the maintenance or erosion of resilience. More specifically its objectives are threefold: 1) to understand how formal institutions in the scallop fishery respond to climate variability in Peru with a focus on the El Niño phenomena, 2) to identify what role they play in the maintenance of system resilience and 3) to develop a conceptual model of the scallop fishery to inform future interventions and policies. In the following sub-section the methodology used is described but for further details the reader is referred to Chapter 3.

7.1.1 Interviews and secondary data

Evidence of the findings for response of institutions to climate variability is driven by secondary data analysis, interviews and stakeholder meetings. Secondary data analysis consisted of the content analysis of reports, policy statements, planning documents and archival research of fisheries legislations. Interviews were conducted between March 2005 and June 2006 with key informants from government agencies, fishermen associations, and non-governmental organizations to capture their perception of how ENSO affected the scallop fishery. Topics included the articulation between national and regional authorities, the effectiveness of fisheries policies and the impact and management of ENSO events.

7.1.2 Stakeholder meetings and causal loop analysis

Seven stakeholder meetings were held between 2005 and 2007. Central components of these events were group discussions and experts input. The meetings provided a learning platform for the author on local perception of management issues and the impact of climate variability on scallop resources. Finally, to understand how different driving forces affect institutions' responses, a conceptual model of formal institutional behaviour under ENSO conditions was developed using system dynamic concepts and causal loop diagrams.

7.3 Impact of ENSO

The Peruvian bay scallop is highly susceptible to changes in SST triggered by ENSO events. During the El Niño period of 1983–1985, the scallop harvest in Independence Bay - Pisco was the highest ever recorded, yielding around 40 000 tons as opposed to about 1000 tons in previous normal years (Figure 39). The (normal) cold upwelling conditions (summer water temperature of about 16°C) were drastically altered to tropical warm water conditions (around 25°C), affecting population dynamics by increasing growth rate and recruitment, as well as the bay's scallop carrying capacity (Wolff and Mendo 2000). Scallops can reach a commercial size (65 mm) in one or one-and-a-half years in normal years and six to twelve months during El Niño events. Cold events have been shown to have negative impacts on scallops populations: at low temperatures spawning and recruitment decrease (Wolff et al. 2007) leading to a decrease in landings. During the El Niño 1982-83 a time lag was observed between temperature peaks and increases in landings (Figure 39). This could be explaining by the fact that fishing effort reached its peak in 1984-85 once the population cohort of 1982-83 reached its marketable size and entry into the fishery by migrants was at its highest during this period. In 1997–98, the scallop stock increased but instead of waiting for the cohort biomass to build up, small juvenile scallops of low market value were extracted leading to lower landings.

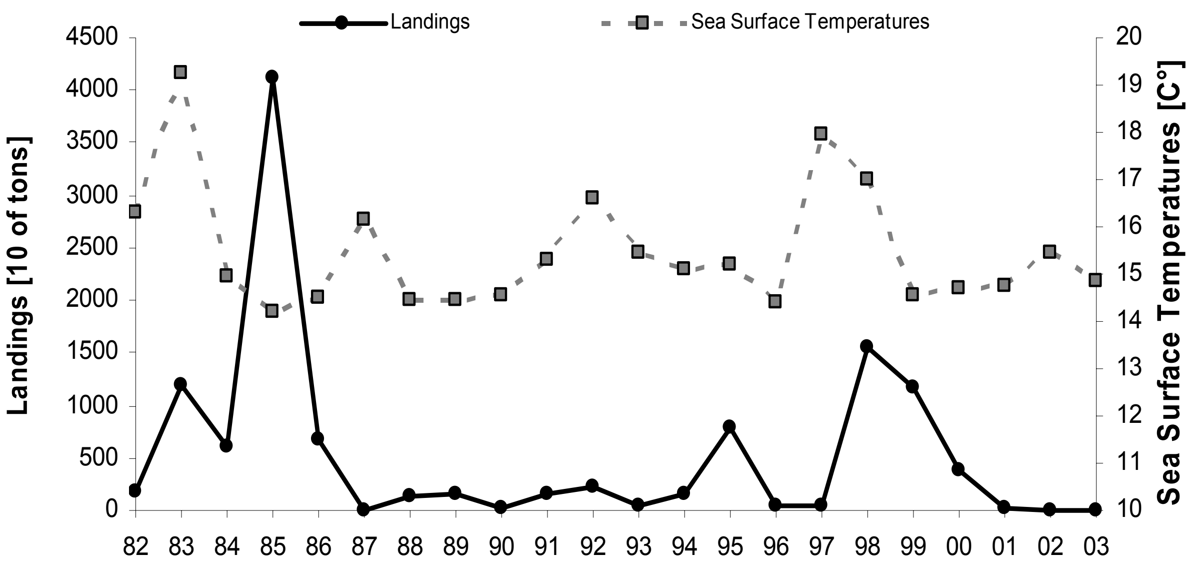

Figure 39 Annual catch and sea surface temperature changes in Pisco 1982- 2003 (Flores et al. 1994; Mendo and Wolff 2003; Guevara and Estrella unpublished).

In Sechura during El Niño events an inverse relationship exists between scallop landings and increased SST and river discharge in the bay (Figure 40). During the 1997–98 El Niño the total accumulated rainfall in the city of Piura was 1802mm, thirty times its normal value (Takahashi 2004) which resulted in river discharge in the bay four times higher than normal. The low scallop catches in 1997-98 in Sechura have been suggested by fishermen to be the result of river discharge: freshwater input into the bay could be decreasing salinity beyond the scallops' tolerance limit or/and increasing mortality with higher sedimentation rates. Taylor et al (2007) developed a model which demonstrates a significant correlation between both spawning stock size and river discharge- mediated mortality on catch levels, substantiating observational data. Few studies have directly looked at the cold phase ENSO events (La Niña) impact on the scallop fishery in Sechura but recent modeling efforts (Vadas 2007) argue that the variation in scallop stocks is not dependent on temperature but river discharge, lower temperature having little influence on population dynamics, the bay being located in a transition zone near warm tropical waters.

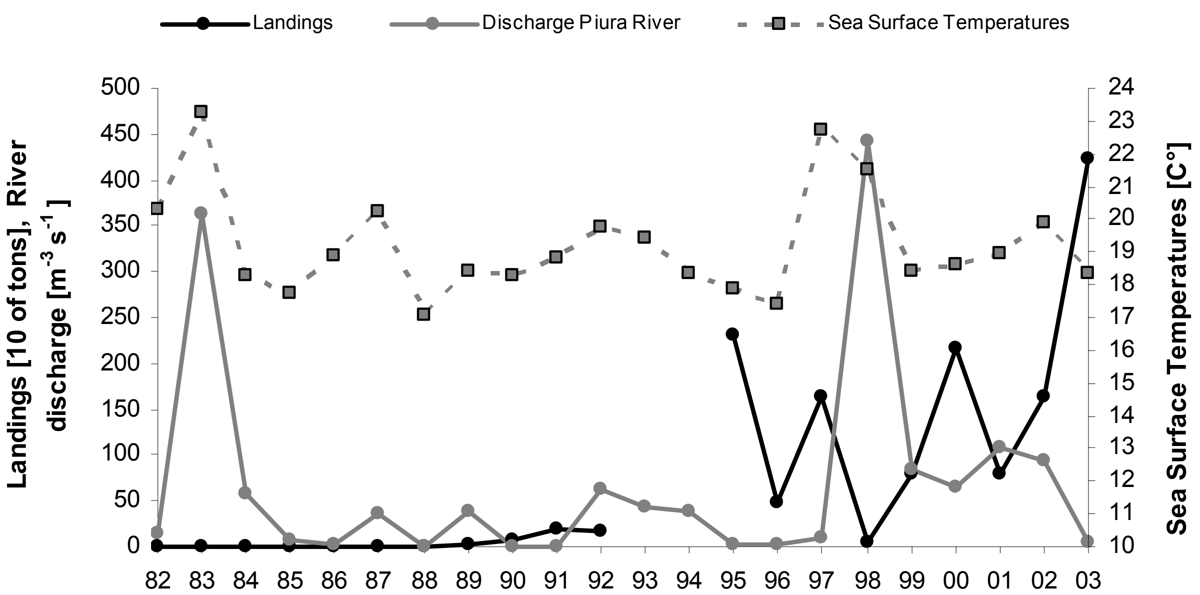

Figure 40 Annual catch, sea surface temperature (SST) and river discharge changes in Sechura 1982-2003. Landing data was derived from IMARPE catch statistics (Flores et al. 1994) and reports (Tafur et al. 2000; Flores Ysla et al. 2005; Guevara and Estrella unpublished). Data was unavailable for the 1992-94 periods. SST in Paita (a research station near Sechura used as a proxy) was provided by IMARPE-Paita coastal laboratory. River discharge data was granted by the *GeoforschungsZentrum (GFZ) Postam* and recorded by the Sistema de Alerta Temprana – Piura (SIAT), at the Sanchez Cerro Bridge, Piura River.

7.4 Formal institutional response to climate variability

7.4.1 El Niño of 1982-83: The surprise

Before the 1980s the international market for scallop was limited but in July 1983 Canada entered a scallop moratorium which resulted in a high demand for the Peruvian scallop in the North American markets (Echevarria Espezua 1985). The combination of a dramatic increase of scallop population due to warm SSTs and a growing international demand resulted in the first “scallop boom”. While during the first phase of El Niño commercially exploited shallow water bivalves and crabs disappeared (Arntz 1986), later on the increase in scallop populations led fishermen to rapidly focus on this specie. In 1982 scallops represented 8% of the total seafood catch and the following year 88.9% (Morales 1993). The response was not only local, fishermen from all over Peru entering the fishery due to its open-access nature. In the Paracas Reserve the population went from 250 families and 80 boats to 4 500 crew, 3 000 divers and 1 500 boats (Morales 1993). Apart from the minimum size limit (65 mm) there were no measures such as effort controls and harvest levels available to the authorities to control the extraction. The government, under pressure from fishermen’s associations and the advice of IMARPE, responded with fishing moratoriums, but these were not enforced nor respected (Table 39, B). From the interviews the absence of enforcement and control were partly attributed to the limited capacity the recently established regional office possessed and the lack of preparedness of authorities. According to the accounts of staff working in 1983, the Fisheries Regional Direction was not well managed and the workers were characterized by a lack of training and little experience (Table 39, A).

During 1983-84 private companies promoted the establishment of scallop sea farms in Independence and Paracas Bay. However, these sea farms being located on traditional fishing grounds were not successful due to the lack of adequate techniques and conflicts with artisanal fishermen (Garcia Carhuayo 1998). The state intervened in 1983 with a first of a series of new legislation for the zoning and development of the activity[24]. Subsequent to El Niño the activity decreased, migrants leaving and some fishermen from Pisco migrating to

[24] Supreme Decree N° 021-82-PE: authorization for the installation of culture sites or “criaderos” in the Paracas National Reserve. Ministerial Resolution Nº 260-83-PE: complementary norms for aquaculture of molluscs approved. Ministerial Resolution Nº N° 357-84-PE: temporary norms and regulations for the recollection of scallop seeds. Supreme Decree N° 016-84-PE: regulation for aquaculture of molluscs approved

other favourable zones like Sechura. Fishermen that persisted with aquaculture activities in Pisco had to organize themselves to obtain special concessions since by law only registered groups could have access to culture grounds. At the national level, the Ministry of Economy and finance declared in April 1989 that the development of aquaculture was a priority for the country[25]. In 1994 the government (Ministry of Agriculture - INRENA) elaborated the second management plan for the Paracas Reserve[26] based around tourism and aquaculture activities, which was not the case of the first one in 1979 (Garcia Carhuayo 1998).

7.4.2 El Niño 1997-98: Missed opportunity

The 1982–83 El Niño, which influenced climate around the globe, catalyzed government and scientific interest in developing forecasting capabilities (Broad et al. 1999). As a result by July 1997 the 1997-98 event was prognosticated and government measures took place shortly afterwards in September with the creation of a multi-sectoral task force on ENSO [27]. Special concessions in the Paracas Reserve were created in September 1997 for re-stocking purposes[28] in order to control the activity and limit access. However, so many fishermen wanted to enter the fishery that the Ministry had to suspend the reception of solicitudes and all procedures were halted[29], national level institutions responding rapidly to the "gold rush" triggered by forecasted information on the climatic event. However, regional offices were not given human (i.e. inspectors) and financial resources to ensure monitoring and enforcement. As a result between 1998 and 2000 in Independancia bay 14 organizations were formal (550 fishermen with 144 boats) while 36 were informal (1631 fishermen and 414 boats) (Proleon and Mendo 2002). Additionally, mortality of scallops due to high-density sowing occurred (Proleon and Mendo 2002), reflecting an inadequate adoption of knowledge, and over exploitation of the resource took place with the extraction of scallops below the minimum size (Mendo and Wolff 2002).

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[25] Supreme Decree N° 073-89-EF Declares that the development of aquaculture is of national utility and social interest for the country - 1989

[26][26] Management plan for the Paracas Nacional Reserve (1994) and the accompanying bianual operacional plan, R.J. No 055/93/INRENA - 1993

[27] Supreme Resolution N° 053-97-PE – 1997

[28] Ministerial Resolution Nº 406-97-PE Creation of special concessions for collection of larvae and re-stocking for social purposes - 1997

[29] Ministerial Resolution Nº 418-98-PE Suspension of all application procedures for concession and the attribution of concessions in the Province of Pisco – 1998

Table 39 Interview excerpts from Atlas.ti.5.0. Reference column reads: ID (for reference in text), Atlas.ti file number, unstructured or semi-structured interview (UI-SSI), code for Word file, site and interviewee.

ID	Codes	Quote	Reference
A	Response to El Niño and Decentralization	"[In 1982] Direccion Regional de Pesqueria moves from Pisco to Ica (30 persons) (DIREPES). Then it moves to La Puntilla [near Pisco]. They came with their lack of training, a lot of people, little experience and it was not well managed"	P51: UI-22-BB-Pisco Ex-regional fisheries office worker
B	Response to El Niño	[El Niño 82-83] "It was a total disaster, nothing was uniform [we exceeded] the limits of extraction. The state started to regulate but the contraband was born (scallop came out of gasoline drums) [...]"	P51: UI-22-BB-Pisco Ex-regional fisheries office worker
C	Migration	"I came here 15 years ago but in 1998 I went to Pisco during the boom and then I came back here after the boom."	P14: SSI-3-BB-Parachique (Sechura) - Fishermen
D		"I have been in Puerto Rico five years and I come from Pisco because here the product is better, a great variety"	P36: UI-13-BB-Puerto Rico (Sechura) - Fishermen
E	Migration and Conflict	"Problem during El Niño is that people from outside are coming. It is a social problem and now the associations are fighting because they are expecting another El Niño."	P60: UI-31-BB-San Andres (Pisco) – NGO worker
F		"Right now in the sector there is a regionalization movement to fight off immigration. In Parachique people do not want people from Pisco."	P40: UI-7-BA-Lima IMARPE staff
G	Centralization	"Lima has a plan, a directive to respond to ENSO, not the DIREPRO in Pisco. We have a normative dependency with Lima. If there was the decentralization, a mini-ministry that would give a better response to Niño. Also there is no budget, we depend on the region"	P31: UI-10-BA-Pisco Regional fisheries office worker
H	Bureaucracy	For a concession they need a resolution from INRENA and the Navy and then Produce.	P60: UI-31-BB-San Andres. (Pisco) – NGO worker
I	No Interaction (between actors)	[Regarding special concessions] "They [the fishermen] get together and go and see the congress but people do not receive them, there are failures and triumphs…"	P17: SSI-6-BB-San Andres Pisco - Fishermen

In Sechura in the early 1990s the scallop fishery developed due to the settlement of divers from the South. Between 1994 and 1997 the fishery experienced a “boom” which resulted in an increase of the fishing effort with nearly 500 boats involved (Tafur et al. 2000). However, this boom was cut short by the 98 El Niño, interviews revealing that divers either switched prey (for instance to warm water species like shrimps) or migrated South (Table 39, C). This migration flux increased the pressure on scallop resources in Pisco and workshop results highlight the fact that controlling access into the fishery was a major concern (Mendo et al. 2006a; Mendo et al. 2006b). Disaster management plans at the national level were written for the first time by the Fishery Ministry during this El Niño event (CAF 2000). Document analysis reveals that the major focus of the plan for the fisheries sector was anchovy (pelagic species mainly exploited by industrial fishermen and negatively affected by El Niño) and infrastructure damages, while there was no specific mention of resource management plans and regulations for coastal benthic resources such as scallops. The regional fisheries office in Pisco did not receive any specific instructions to deal with a new scallop boom (Table 39, G). Broad et al (1999) in a study on the impact of El Niño on Peruvian industrial fishery observed a similar behaviour in terms of institutional response: there were limited proactive measures taken in the fishery sector to minimize negative effects or enhance positive ones. This was a missed opportunity to learn from past events and mainstream climate variability into fisheries management, switching from short-term responses to long term management policies.

7.4.3 The 2000-06 period: Steps toward adaptation?

After the 1998 El Niño fishermen in Pisco formed associations in order to qualify for special concessions in the Reserve. Special concessions are renewable every three years but between 2001 and 2006 no concession renewals were approved. Among the factors that slowed the process of renewal is the discord between the Ministry of Fisheries and the Ministry of Agriculture (MINAG) branch that manages the Paracas Reserve over the management plans proposed by associations. Interviews with fishermen associations’ presidents and government officials revealed conservation objectives versus exploitation of the resource were at the center of the debate between the two agencies and that the bureaucratic red tape, no communication between the different agencies from the local to the national level as well as the absence of political will to reach an agreement impeded the renewal process (Table 39, H-I). Additionally, in 2000 the Peruvian government suspended the export of bivalve molluscs as a response to the discovery of the presence of Hepatitis A virus in a shipment from Peru in Spain[30]. Many organizations who at first were interested in acquiring a special concession gave up, seeing no short term benefits. Only a few organizations remained in the "stock enhancement" adventure, surviving by supplying the national market (Mendo et al. 2006a). The bivalve moratorium coincided with a cold ENSO event which resulted in low catches in the Paracas and Independancia bays.

In mid-2006 when positive SST anomalies appeared in the equatorial Pacific, workshop data (Mendo et al. 2006b) and interviews (Table 39 E-F) revealed that fishermen while hopeful of a new boom were fearful of the migration and chaos that would ensue. With a possible El Niño in sight and pressure from associations, the newly elected government urged the MINAG and the Navy to authorize aquaculture activities in the Reserve so that the Fisheries Ministry could issue a Ministerial Resolution granting special concessions (24 Horas Libres 2006). As a result in April 2007, after five years of stalemate, special concessions were granted[31]. The 2006-07 diving season in the end did not result in the expected scallop bonanza, SSTs only being slightly above normal temperatures, but the combination of a new political environment (presidential elections in 2006), the forecast of El Niño (albeit incorrect) and pressure from associations were drivers for institutions to enforce their policies. Nevertheless a preventive stand is still not taken by institutions: no scallop management plan that includes climate variability currently exists.

In Sechura the period of 2000-06 is characterized by an increased activity of the scallop fishery despite a trough in landings in 2001, attributed on the export moratorium (Figure 4). In 2002 warmer temperature could have favoured recruitment of scallops, landings going from 1 587 tons that year to 6 105 tons in 2004 (Gonzales and Yepez 2007) but more probably the increase in landing is due to and increase in fishing effort. Indeed interviews revealed that migration from the center and the south of the country (Pisco) increased during those years, causing conflict between the new migrants and local fishermen not involved in the diving fishery (39, D-F). In 2003-2004, the regional government granted 12 authorizations to

[30] Directorial Resolution Nº 0327/2000/DIGESA/SA - 2000
[31] For instance Directorial Resolution N° 027-2007-PRODUCE/DGA granting a special concessions to the fishermen association 'Asociacion Comunidad Artesanal de Extractores y Maricultores'

fishermen associations to conduct aquaculture activities in the bay. [32] Since then the number of associations undertaking sea-ranching activities without authorizations dramatically increased (DIREPRO 2005a). While the migration of fishermen during normal and cold years from the south and center of Peru to Sechura has over the years resulted in the development of the diving industry in the region, institutions have been unable to manage this booming fishery (Mendo et al. 2007).

7.5 Responding to disturbance: a synthesis

Disturbances can be defined as changes, surprises and crisis. Surprises are a qualitative disagreement between ecosystem behaviour and *a priori* expectations and become a crisis when they reveal an unambiguous failure of management actions and policy (Gunderson 2003). From a management perspective Folke and colleagues (2003) identify three generic responses when a crisis occur in socio-ecological systems: 1) no effective response, 2) response without experience and 3) response with experience. Figure 40 summarizes institutional responses to disturbances in Pisco and Sechura in the last 25 years.

No effective response refers to institutions that try to preserve the *status quo*, weakening the resilience of ecosystems. We observe that in Pisco formal institutions did not preserve the *status quo*, mainly due to pressure from fishermen adaptive capacity, individual fishermen being not only able to self-organize to fluctuating resources through the application of existing available responses (migration, prey switching) but also to adopt new techniques such a scallop culture. Prior to the 1990s, institutions in Sechura had no scallop fishery to manage but increased migration of scallop divers from the south after El Niño 1998 started to convert a developing fishery into a mature one. The absence of a regulatory framework and the failure of government agencies to make timely adaptive changes over the years could lead to a depletion of the stock. This inertia and the inability of national and regional governments for concentrated action culminated into a crisis in 2006 regarding marine tenure rights (Mendo et al. 2007).

[32] For instance Directorial Resolution N° 103-2003 GOB.REG-PIURA-DIREPE-DR granting authorizations to two associations in Sechura

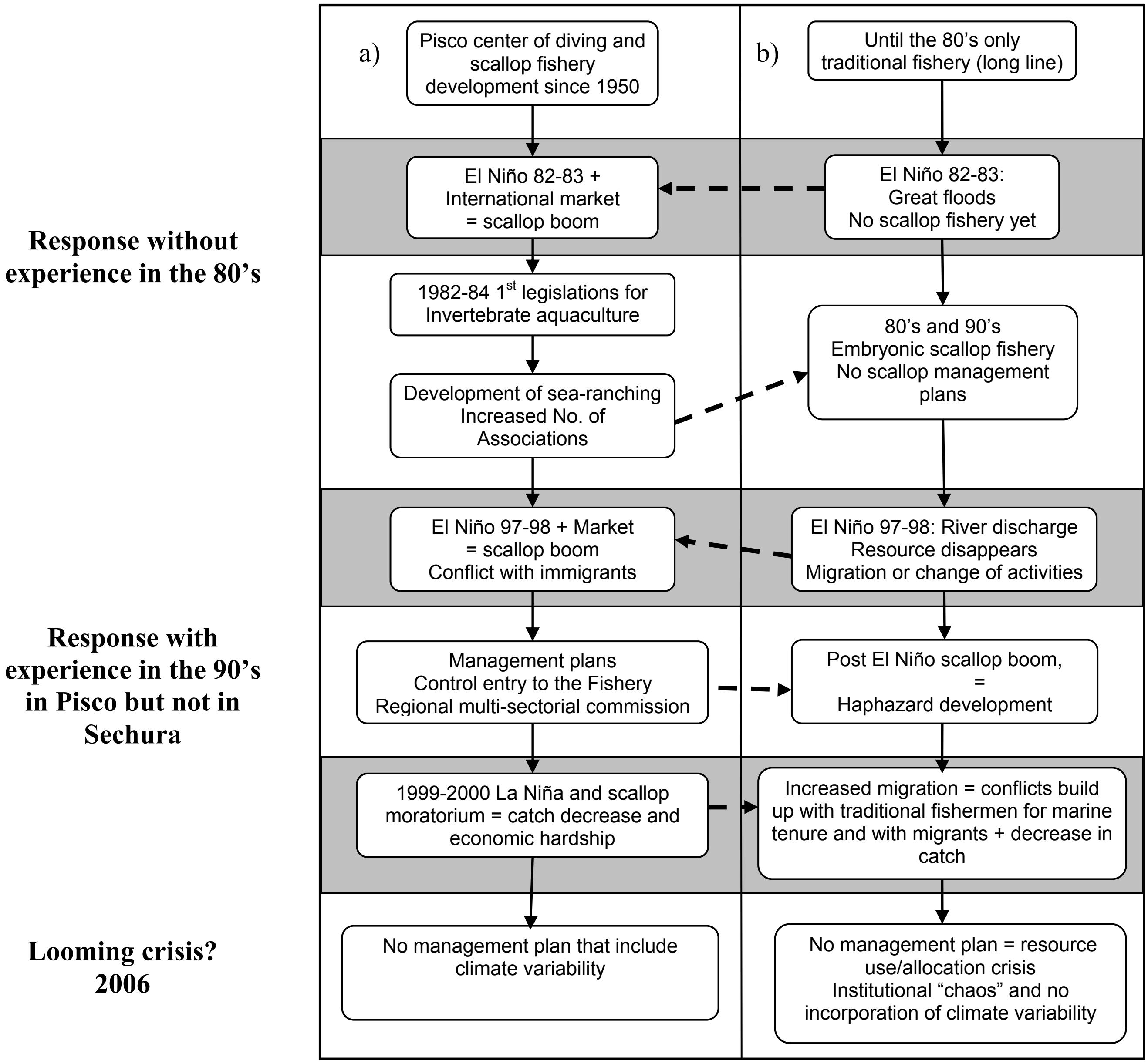

Figure 41 Institutional responses to disturbance over time in Pisco (a) and Sechura (b). Shaded areas are disturbances (environmental, socio – economic etc.) while non-shaded areas are responses. Dashed lines represent migration fluxes of fishermen.

The second type of response is when an institution or local resource-user responds to a crisis without previously tested policies at his disposal (Folke et al. 2003, p.360). This was observed during the 1982-83 El Niño where one of the strongest El Niño of the century took by surprise institutions and led to spontaneous adaptation by fishermen (migration, adoption of new technology). Formal institutions had no existing responses available apart from moratoriums and minimum size, and local authorities' capabilities were limited in terms of manpower and knowledge. Nevertheless, the disturbance was an opportunity to re-organize the fishery with the development of aquaculture legislations. In figure 6 we refer to this period "learning by doing" where institutions tried to formulate a new regulatory framework for scallop extraction (Figure 42, phase A). Additionally, the scallop boom created a platform for collective action with the increased number of fishermen associations since these were necessary to obtain concessions, as well as increasing scientific knowledge and technological change (development of sea ranching) which migrants would bring back to their regions. Following El Niño and driven by increased exports and neo-liberal policies, the policy landscape continued to flourish (Figure 42, phase B).

The third type of response is when institutional learning occurs based on previous crises and socio-ecological memory (Folke et al. 2003, p.360). Albeit some institutional learning occurred in Pisco in 1998 with measures to stop entry to the fishery promulgated, re-organization was not sufficient, instruments and allocation of resources to enforce management intervention were inexistent, and coordination and collaboration with local actors limited, leading to an enforcement crisis. The 1997-98 "boom" in Pisco and "bust" in Sechura only revealed the weakness of institutions to control access to the fishery and extraction of the resources (Figure 42 – phase C).

Since 2001 policies related to scallop extraction and aquaculture have overall remained unchanged, poorly implemented and enforced (Figure 42 – phase D). Government agencies and users need to reflect on the future direction of fisheries policies (extraction versus aquaculture) and how ENSO might impact them. The organizational failure to learn from past events and integrate them into on-going management and policy interventions highlights a lack of long term planning and mainstreaming of climate variability into fisheries management, despite the recurrent nature of ENSO events on the Peruvian shores.

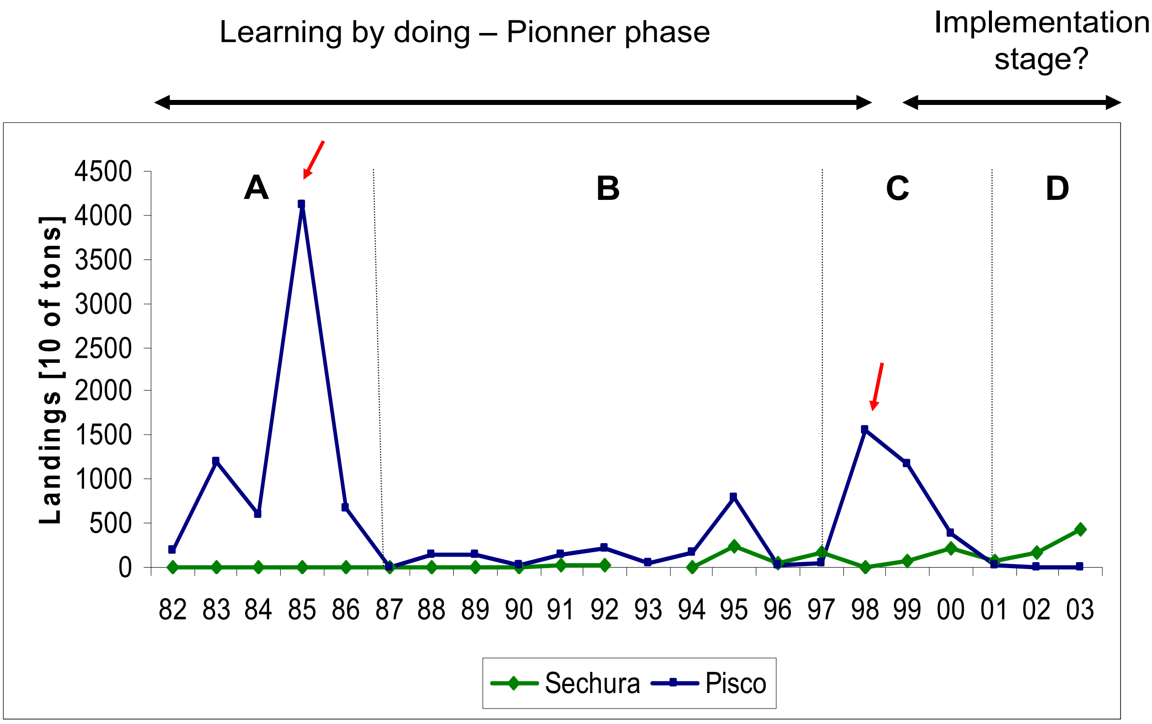

Figure 42 Phases of policy development for the scallop fishery for the period 1982 - 2003 related to landings in Sechura and Pisco. Identified are: a) from underdeveloped fishery to new regulations, b) exporting and regulating, c) "boom" and "bust" d) fast north, slow south.

7.6 Exploring the role of formal institutions in resilience building with causal loop diagrams

When assessing the resilience of social-ecological systems (SESs), one should identify key variables and fundamental processes to understand how their changes affect the system under study, in this case the scallop fishery. The purpose of this section is to identify processes that maintain the system or offer potential for other alternative state under ENSO conditions and what role formal institutions play in these processes based on the information compiled in the previous sections. To do so system dynamics concepts and causal loop diagrams are used to build a conceptual model of the fishery. One of the principles of the system perspective is that external forces do not explain everything: the causes of dynamic problems lye in a system structure that cannot cope with unfavourable external conditions (Barlas 2002). The system approach reminds us that a key factor for response [to change] is the presence of effective and tight feedback mechanisms or coupling of stimulus and response in space and time (Berkes et al. 2003b, p. 269). The conceptual system models have already been put forward as a framework for identifying resilience surrogate (Bennett et al. 2005) and in this section we posit that this method can be used in fisheries management.

7.6.1 Conceptual model description

The causal loop diagram in Figure 44 and 45 represents the scallop fishery in Pisco and Sechura under an ENSO scenario, taking into account current management practices and policies and was constructed based on the analysis presented above. In our effort to identify the underlying mechanisms that shape resilience and what role formal institutions play we made the following assumptions to simplify system representation:

- Environmental external drivers only include SST and river discharge despite the fact that factors such as pollution and algae blooms significantly affect scallop biomass.
- Fishermen are separated only into two groups: scallop divers and other fishermen. The scallop fishery is an open system and prey- switching is an adaptation strategy of other fishermen (gill nets, long line etc.) which has an impact on levels of effort and design of management interventions. The conceptual model however does not take into account the heterogeneity of the other fishermen.
- Similarly biomass changes in other species (predators, competitors and other commercial species) and impact of ENSO in other sectors (agriculture) can have impacts on the scallop fishery (prey switching and entry in the fishery sector, reduced biomass) but system boundaries had to be defined for the purpose of this study and these factors were excluded for the time being.

The conceptual model presented is divided into three components which reflect analytical and geographical scales: sub-system in Pisco and Sechura and formal institutions (market and government). Figure 7.6 presents the systems without the intervention of market or government institutions.

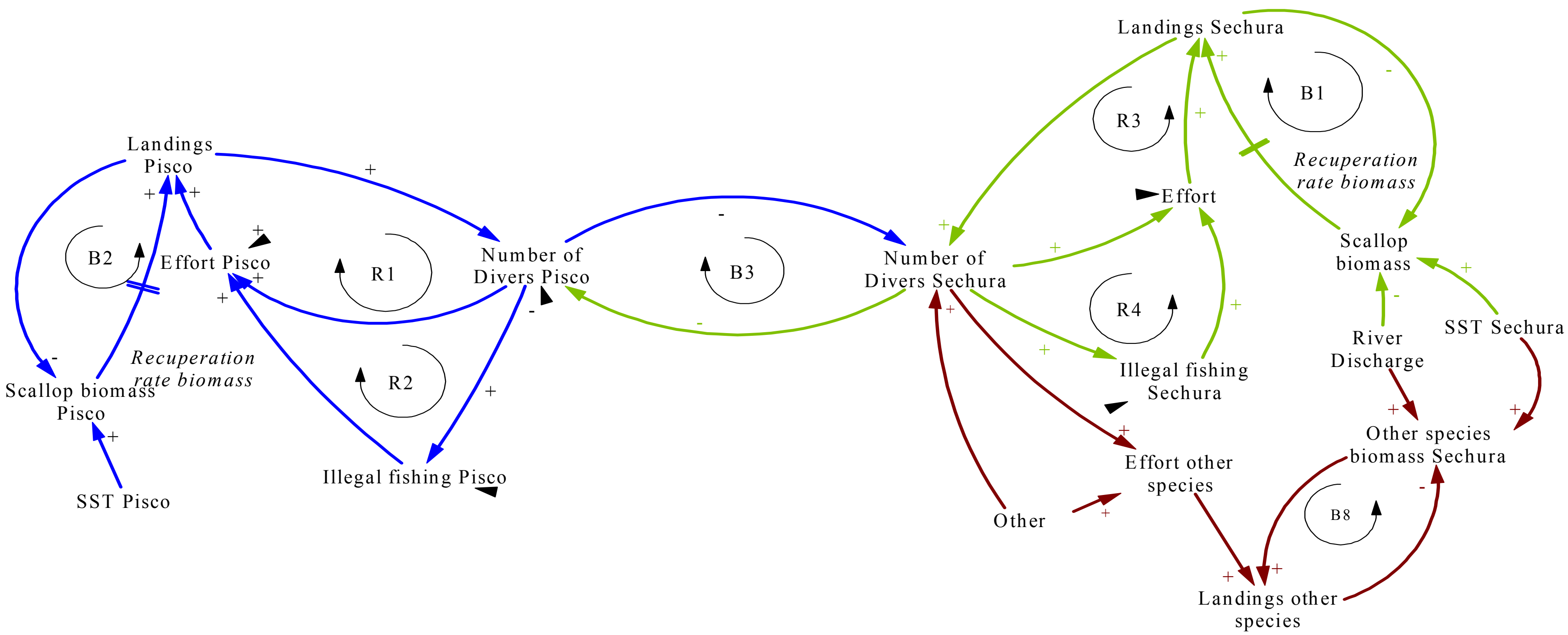

Figure 43 Conceptual model of scallop's fishery response to ENSO events using causal loop diagrams. Blue arrows represent Pisco, green arrows Sechura, and red ones the non diving fleet

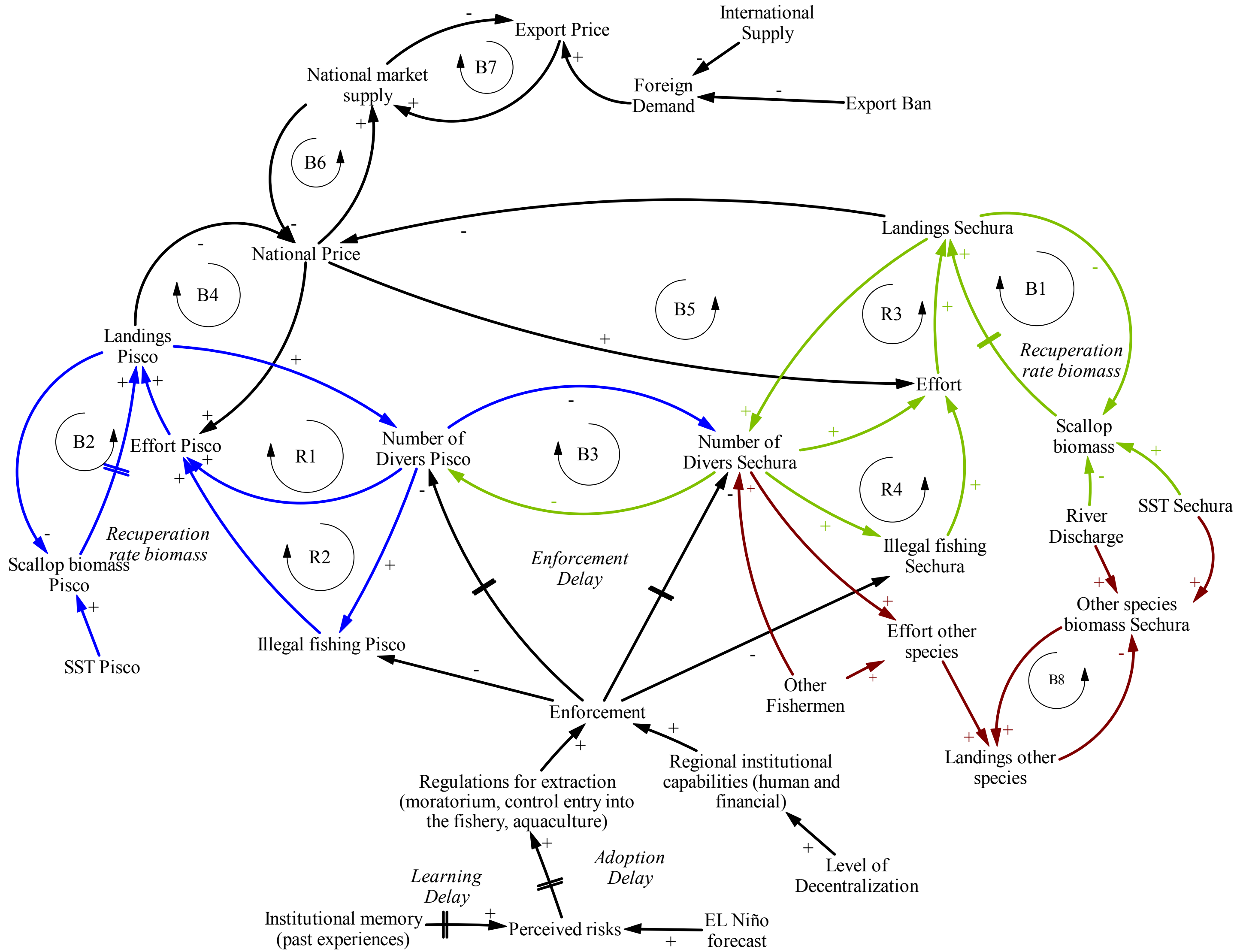

Figure 44 Conceptual model of the scallop fishery and institutional response to ENSO event. Black arrows represent institutional responses

7.6.2 Identifying causality and feedback loops

In the scallop fishery conceptual model we have identified eight balancing feedback loops and four reinforcing ones. Feedback loops are a succession of cause-effect relations that start and end with the same variable, the circular causality implying dynamism over time (Barlas 2002 p. 1147). Reinforcing (positive) feedback loops create growth or crash and tends to be destabilizing while balancing (negative) feedback loops tend to have a stabilizing effect on the system. The eight balancing loops in the model can be described as follow:

- B1: Scallop biomass mediates amount of catches that can be achieved overtime in Sechura
- B2: refers to same pattern as B1 but in Pisco
- B3: The number of fishermen in Pisco (fleet size) is related to the number of fishermen in Sechura (fleet size). Indeed the previous sections showed that strong migration patterns exist between these two locations based on boom and bust periods of the scallop fishery.
- B4 and B5: The amount of landings is linked to market prices in Pisco and Sechura, abundance and price following the economic law of supply and demand. This reflects government neo-liberal policies and free market economy described in other sections.
- B6 and B7: similarly at the national and international level, prices and amounts supplied are locked in the economic law of supply and demand with no government control possible.
- B8: for other species experiencing positive impacts of EN, biomass mediates the amount of catches that can be obtained over time. These species include shrimp and octopus favoured by warmer temperature and less affected by river discharge, and mullet favoured by brackish water.

The eight feedback loops highlight the fact that one way to stabilize the system and maintain its resilience is to maintain biomass and keep to a certain extent the open access nature of the fishery that permits migrations, allowing one bay ecosystem to recover while the other experiences a boom. The causal loop diagram places emphasis on the central role played by market forces and how inappropriate macro-economic policies could destabilize the system. But what process pushes away the system from an ‘equilibrium’, eroding its resilience? The four reinforcing feedback loops in the conceptual model presents the following characteristics:

- R1: An increased number of fishermen in Pisco leads to an increase in effort, resulting in increased landings. Based on the data presented above we know that an increase in landings in the area leads to an increase in the total number of fishermen due to migration.
- R2: As presented in other sections a larger number of fishermen increases illegal practices. By illegal practices we refer not only to the non-compliance with, for instance, the moratoriums set by state agencies but also non-compliance with local rules (fishing zones, daily limits). Illegal practices lead to increased effort and landings in Pisco.
- R3: refers to the same patterns as R1 but in Sechura.
- R4. refers to the same patterns as R2 but in Sechura

These reinforcing loops can spiral the system into decline and reduce resilience, driving the scallop stock to collapse. All the reinforcing feedback loops include the number of fishermen. This highlights the importance of regulation of fishermen migration and access to the fishery, which are endogenous and thus controllable variables, as opposed to exogenous variables such as SST, river discharge and international markets that play an important role, but are beyond the jurisdiction of (Peruvian) institutions. This underlines the fact that for the system to persist or shift to another state, formal institutions are key determinants. Additionally, the causal loop diagram illustrates the role knowledge (ENSO forecast, institutional memory) plays in changing the fishermen variable through regulations. The conceptual model also reveals the central role played by market forces, also highlighting that a better control of landings could ensure better prices for fishermen.

Another key feature of the model is the presence of delays intervening between causes and their effects. Delays are divided into two types: delays resulting from the time involved in processing physical material (material delays) and delays resulting from the time involved in perceiving and acting upon information (information delays) (Roberts et al. 1983). Four types of delays were identified: recovery rate of scallop biomass, rate of learning from past experiences ("social memory"), rate of adoption of new regulations and enforcement effectiveness, the last three one being considered information delays. In terms of information delays often individuals and organizations make decisions based on averaged or imperfect information (Roberts et al. 1983). For instance a small increase in scallop landings will not lead to migration but an above-average increase will cause fishermen to change fishing zones while institutions will only respond to significant changes in landings, resulting from higher number of fishermen. Our research shows that formal institutions do not respond instantaneously to changes while individuals respond immediately to information and small variations (hence the lack of delay in loops involving fishermen).

The causal loop diagram presented is a first attempt to build a system dynamic model in the study areas integrating ecological and social dimensions. Based on the data from interviews, workshops and archival research a representation of the fishery system could be undertaken. This type of approach offers the possibility to explore possible scenarios to solve complex management problems and can be used as a basis for formal quantitative models.

7.7 Discussion and conclusion: Pathways to resilience?

The Peruvian scallop fishery operates in a highly fluctuating environment where climate inter-annual variability is a key driver of changes. Formal institutions responses to climate variability varied according to the level of maturity (rate of exploitation) of the fishery. In Pisco where the fishery dates back to the early 1950s, formal institutions were mainly reactive to El Niño events and while past experiences had been integrated in the last strong event of 98 into the response mechanism, institutional and organisational adoption of past and new knowledge is still incomplete to maintain resilience. In Sechura, no response by formal institutions was identified, putting the fishery at risk (overexploitation and inability to adapt to flood events). The study also shows that while individual responses are spontaneous, ensuring a rapid process of adaptation, they do not always positively contribute to the sustainability of the resource and formal institutions are necessary to control fishing effort and access to the fishery through management interventions.

System analysis concepts and causal loop diagrams allowed us to conceptualize this system behaviour and identify processes that maintain or erode resilience. The conceptual model shows that formal institutions play a critical role in building resilience of the system through the creation and implementation of normative frameworks that maintain scallop biomass and control fleet capacity and behaviour by limiting the number of fishermen. The implementation at the regional level is jeopardized by low human and financial capabilities, and must be addressed to ensure the resilience of the system. Additionally, while controlling the level of fishing effort and entry into the fishery is crucial to maintain the resilience of the system, the role of formal institutions in fisheries management goes beyond this traditional function. The conceptual model shows that formal institutions through 'institutional memory' need to contribute to knowledge building regarding ENSO impacts and interventions, to reflect on past interventions and to adopt new approaches, all of which is not present in the current management framework. The resilience of the system thus depends on the ability of formal institutions to shape fishermen decision making by creating and enforcing a regulatory framework as well as the ability to build and adopt knowledge in order to self-organize and transform. Conceptual model are useful tools in that direction, allowing the exploration of various past, current and future scenarios to inform policy making.

The research shows that formal institutions are slow to learn, self-reorganize and respond to climate variability while fishermen responses are spontaneous, ensuring a rapid process of adaptation. Institutional responses are mostly ex-post, not strongly shaped by past experience, thus eroding the resilience of the system. However, fishermen responses sometimes lead to negative outcomes such as local stock overexploitation or 'invasion' of natural scallop habitats for scallop grow-out, and formal institutions play an important role in resilience building through the control of effort and entry in the fishery. In this chapter system dynamic concepts and causal loop diagrams have been used to conceptualize the fishery system to highlight key variables and processes. The study thus provides the opportunity to explore the usefulness of causal loop diagrams and conceptual models combined with participatory approaches in the exploration of the resilience of a system. The case study also illustrates that while individual adaptation, a feature of resilience, is occurring and will occur spontaneously, its effectiveness is strongly influenced by the ways in which formal institutions shape fishermen decision-making to engender positive management outcomes.

CHAPTER 8

CONCLUSIONS

8.1 Livelihood security and institutions: building blocks for resilient social ecological systems?

This thesis set out to explore the livelihoods of two coastal communities in Peru, and it did this bearing in mind the need to relate meso-scale and micro-scale processes to explore how fishermen maintain their livelihoods. In terms of livelihood assets, the study discerned major axes of differentiation between Pisco and Sechura. Human capital and physical capital were higher in Pisco, lower educational levels, and lack of public infrastructures and service provision in Sechura mainly explaining the differences. Differences in service provision in Peru have been attributed to a deficient decentralization policy, with a focus on urban areas and where settlements near the capital Lima are better endowed (Escobal 2001). Moreover, it is worth noting that Pisco is characterized by the presence of the Paracas National Reserve which makes it a hub for tourism and holiday-related activities, an impetus for better service provision and infrastructure development. Thus government macro policies and the economic environment are contextual variables that shed light on the difference between sites.

In terms of social capital, differences start to blur. While informality is higher in Sechura, both sites exhibit a highly informal diving fishery. This warrants policies at the regional level promoting the adoption of fishing and diving cards at low costs for this fishery. Membership to fishermen organizations was higher in Pisco but dissatisfaction also followed the same trend. This highlights the fact that measures of social capital based solely on membership or number of organizations are not sufficient to establish whether social capital is thriving or not in one area. Lack of access to financial capital was also highlighted as a major constraint to the development of income generating activities.

Natural resources are fundamental assets for fishermen's livelihoods. Fishermen in both sites while targeting various species usually do not possess more than one type of gear. In terms of natural capital Sechura presented a high variety of target species but a more specialized diving fishermen group than in Pisco, as a result of the promotion of scallop extraction and aquaculture. Indeed since 1999-2000 Sechura has been experiencing a scallop boom due to optimal growth conditions for the scallop, and the subsequent increase in fishing effort and migration. The latter is a specific characteristic of Sechura which has a significantly higher number of migrants than Pisco. The lack of management plans and regulations limiting access to the fishery, and the lack of enforcement of moratoriums is causing conflicts between the new immigrants, local divers and other artisanal fishermen. This development of the scallop fishery in the North, and more broadly bivalve aquaculture, and the specialization and territoriality of the diving fishery might in the long term hamper seasonal and permanent migration patterns.

Indeed seasonal migration has been identified has an important livelihood option enabled by the *de facto* open access regime. Further examining livelihood options, it was observed that diversification is not as prevalent as contemporary research in fishing communities and more broadly in the common property resources literature would suggest, with a high dependence on marine resources. Additionally, while engagement into fishing activities is often motivated by poverty and the lack of alternative opportunities, the prospect of improving livelihood outcomes, tradition, kinship and the "identity of fishing", where fishermen express a certain job satisfaction of being at sea, are also strong motivators. Fishing is thus as much a choice as a strategy motivated by necessity, putting a caveat on the idea that fishing is an activity of 'last resort' (Béné 2003). From a gender perspective, women are still an untapped human capital in both study sites, with Sechura exhibiting the lowest proportion of women engaged in income generating activities. Additionally, a high proportion of women are engaged in post-harvesting activities, accentuating household dependency on marine resources.

In terms of livelihood outcomes Sechura overall achieves better economic outcomes than Pisco with higher incomes and lower family expenditures. The high level of income and low levels of human and physical capitals in Sechura highlight the failure to transform household income into durable assets that would help build more resilience livelihoods. The results revealed that income measures are not an adequate tool for evaluating livelihoods outcomes in the context of our case studies since it is the combination of public and private assets that enhance the livelihood platform. It was also shown that the micro-macro interactions were inefficient on both sites, if existent. Efforts to decentralize political powers and responsibilities in terms of fisheries management have clearly failed in Sechura while in Pisco the interactions between users and the state are hampered by bureaucracy and corruption, all of these affecting negatively fishermen livelihoods outcomes.

On the whole, and in concordance with the adage that diversification is a risk-reduction mechanism and increases the resilience of livelihoods, the findings suggest that fishermen on both sites are vulnerable to external shocks due to their high reliance on fishing activities. Additionally, the lack of cross-scale interaction and ill-implemented decentralization policies put a strain on livelihood outcomes. Finally, the current institutional arrangement of *defacto* open access enables migration, an important livelihood option in both communities.

8.2 El Niño and livelihoods

Target species during EN events showed marked changes compared to normal years. Conversely to normal years the type of gear did not explain the variance in the choice of target species on both sites, indicating that fishing strategies during EN are not based on gear but the availability of species. In normal years fishermen survey in Sechura are highly specialized, focusing on the scallop fishery, while during EN they become generalists. In Pisco the reverse is observed: during normal years fishermen in Pisco are more generalist than in Sechura but with EN the scallop becomes the main target species.

In addition to prey switching, migration was another coping mechanisms adopted by fishermen. In Sechura two responses strategies were identified: staying within the fishery sector but changing target species or gear, and exiting the artisanal fishery. Diversification into other sectors relied mainly on agriculture, low lying areas in the Piura region being less affected by floods than its Andean part. Fishermen are thus highly flexible and respond quickly to changes. Increased operational costs were an issue on both sites with re-tooling costs providing some strain on income. EN also resulted in difficult commercialization of catches. Of particular concern for Sechura were damages to infrastructures such as roads and docks and decrease in the price of certain species due to oversupply.

The differential impacts on the livelihood platform and outcomes in Pisco and Sechura are mainly driven by differential environmental drivers (i.e. flooding). No clear adaptation process to climate variability in Sechura could be observed, rather responses to changes in the market environment. In Pisco it is the combination of market changes and adaptation practices that lead to the development of the scallop aquaculture. It remains unclear, based on the low level of diversification, how livelihoods could be secure in the face of changes in the marine environment due to climate change.

8.3 Formal institutions and El Niño: what role in resilience building?

Using as a case study the Peruvian bay scallop (*Argopecten purpuratus*) fishery, it is shown that formal institutions are slow to learn, self-reorganize and respond to climate variability while fishermen responses are spontaneous, ensuring a rapid process of adaptation. The conceptual model shows that formal institutions play a critical role in building resilience of the system through the creation and implementation of normative frameworks that maintain scallop biomass and control fleet capacity and behaviour by limiting the number of fishermen. However, the implementation at the regional level is jeopardized by low human and financial capabilities, and must be addressed to ensure the resilience of the system. Institutional responses are mostly ex-post, not strongly shaped by past experience, thus eroding the resilience of the system. The case study illustrates that while individual adaptation is occurring and will occur spontaneously, its effectiveness is strongly influenced by the ways in which formal institutions shape fishermen decision-making to engender positive management outcomes. Additionally, the importance of regulation of fishermen migration and access to the fishery, which are endogenous and thus controllable variables, as opposed to exogenous variables such as SST, river discharge and international markets that play an important role, but are beyond the jurisdiction of (Peruvian) institutions are highlighted. In summary, climate variability plays an important but not exclusive role in the dynamics of the scallop fishery in Peru. Other exogenous factors such as international market forces, and endogenous factors such the open access nature of the fishery at the national level, are key drivers of the system. With El Niño being a recurrent phenomenon on the Peruvian shores and expected to increase in frequency due to global climate change, adaptive management strategies focusing on migration, property rights and limiting extraction are imperative.

8.4 Fisheries management in the context of climate variability and change

It is now widely accepted that at least part of the earth's 0.6ºC warming during the 20th century is due to emissions of greenhouse gases caused by human activities. Over this period global average sea level has risen. Tide gauge data show that global average sea level rose between 0.1 and 0.2 metres (Houghton et al. 2001). Warm episodes of the El Niño-Southern Oscillation (ENSO) have been more frequent, persistent and intense since the mid-1970s, compared with the previous 100 years (Houghton et al. 2001). A future climate change is thus a reality for Peruvian fisheries, albeit it is not yet possible to gauge the magnitude and type of change. Reducing vulnerability to El Niño and helping building resilient livelihoods is how Peruvian institutions can steer changes towards desirable outcomes: socio-ecological systems which give people access to the necessary assets for the pursuit of their livelihoods, and which provide building blocks for the maintenance of livelihoods in the face of critical and pervasive threats and situations. The following policy recommendations are entry points towards creating resilient livelihoods:

1. Increase diversification through a gender approach

- Policies should aim at promoting not only women involved in fisheries, but also those engaged in other income generating activities such as small businesses and agriculture

2. Increase "self-protection"

- Promote and enable access to financial services for fishermen not only for investment in productive activities but also for the development of safety nets. In this context, risk transfer mechanisms should be explored in the case of Sechura.
- Upgrade social capital on both study sites through capacity building. For Sechura develop community disaster response programs embedded in existing institutions.

3. Address the issue of scale

- Currently migration patterns are not clearly integrated in fisheries policies and little information exist on fleet and crew movements. Because seasonal migration is an important livelihood option and a coping mechanism during EN, more knowledge should be built on this issue, and renegotiating the *de facto* open access regime should be made with care in the context of aquaculture development

- The lack of cross-scale interaction and hyper centralism in fisheries management is a clear constraint to livelihood outcomes and in the context of climate change might hinder adaptation processes. Thus the central government should not only delegate duties to regional authorities, it should also grant decision-making power and human and financial capital, as well as technical capabilities
- Interventions at different scales need a sectoral approach for promoting access to financial services, a regional approach for investing in public service infrastructure and education in the North, and an ecosystem-based approach that takes into account the level of heterogeneity of the artisanal fishery on both sites and the importance of migration, as well as local level capacity building to upgrade human and social capital
- The dynamics of the two systems under study are interconnected. Research and fisheries management plans should also seek to better understand and incorporate migration patterns

8.5 Outlook

The work presented here is one of the first studies on fishermen livelihoods in coastal areas in Peru. From a methodological perspective, it underlined the importance of conducting studies at the micro level in order to understand processes of change, as well as the need to integrate different approaches such as the resilience perspective and livelihoods and institutional analysis. Only part of the questionnaire and database created by the author through the CENSOR project has been used for this work. It is hoped that this data will be shared with actors involved in the political and scientific arena in Peru, especially those dealing with the ecological and biological dynamics of the HCLME, in order for them to better understand the human dimension of environmental change and the social dynamics at play to design management plans that are attuned to social realities.

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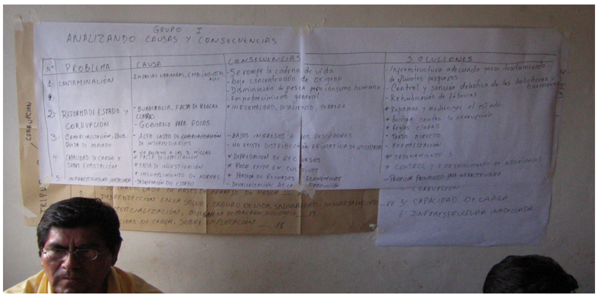
ANNEX 1

Workshops Pisco and Sechura



ANNEX 2

Example of interview guide

Interview guide for key informant (NGO workers, government officials, academics etc.): topic fisheries management

- How do national and regional levels of government interact, and which are their respective competencies?
- Describe the distribution of power between the national and regional level. At what stage of the policy process do they actively participate? (Policy formulation; implementation through laws, local laws, strategies, programs, or others; policy evaluation).
- For fisheries policies is the articulation between national and regional levels of government effective or poor? If it is poor, explain why. Do local communities participate? If yes, how? (what is their role)
- Legal issues: are there conflicting or overlapping jurisdictions; lack of regulation on zoning etc.
- Is there a problem with enforcement? If so what? What can be done?

Interview guide for key informant fishermen association: topic ENSO

Presentation of the CENSOR project and the thesis

How many active members does your association have? When was it created? What are it's main goals/objectives/projects

Local perception of vulnerability

- What are the main shocks and trends experienced by you and/or your members in the last 20 years (here aiming for a list of events)
- Which groups or households types are the most vulnerable to these shocks and trends?
- Why (explain criteria)
- Local perception of vulnerability (ENSO focused)
- What were the effects of the El Niño of 1998 for the members of your association?
- And in 1983? Can you compare both events' impact on you and/or your member's activities
- Who in the community (i.e. which user group) responded the best to the El Niño event in 1983?And in 1998?
- Who lost the most during the El Niño 1983? And in 1998?

Strategies for poverty reduction

- In terms of income what is the trend (increasing or decreasing) in the past 20 years?
- Which factors explain this trend/ these changes?

- Is fishing still a profitable activity?
- How do you and/or your members' access to additional income?
- What agency outside the community has helped you and/or your members in the last 10 years (government, projects, NGOs??) and how?
- Are they still active? If no longer helping then why not? (Try to probe for different views and expectations of government and non-government agencies

ANNEX 4

Survey
(Translated from Spanish, not all questions presented)

Place: Date:

Interviewer: Code:

INFORMATION - ARTISANAL FISHERMEN SURVEY – (FDA UNALM)

I. PERSONAL DATA AND FAMILY

1. **Fathers surname**...**2**. **Mothers surname**...
3. **Name** .... **4. Age** .... **5. Birth Place** ....

6. If the person is not from Pisco, in what year did he arrived? .... **7. Years fishing** ....….

8. Why did you start fishing?

9. Address..

avenue./street number. place

10. Sex │M│F │ **10. Marital status** │S│Live with partner │M│W│D│ **11. Number of children** ....

12. Studies │None │Primary │Secondary│Technical│Univ.│ **12.1. Studies status**│Finished│Not finished │

II. ACTIVITY DATA

Case: With boat activity:

1. **Gear type**
2. │Crew member│Diver│Cpt│Armador│**If the fisherman is a diver 2.1 how many times have you decompressed?**.............

2.2 Have you suffered injuries? │Y│N│

3. **N° hours/days dedicated to the activity**................ **4. N° days per week …………………..**

5. Beach fishermen │

6. N° hours/days dedicated to the activity................**7. Landing Points**

9. What document do you have as a fisherman? │fishermen card│diving card│without boat fishermen│

│armador card│crew card│none│ **10. Do you belong to a fishermen organization?**│Y│N│

11. Organization type.│guild│Asoc│syndicate│ **11.1 Name of the organization to which you belong**..

12. Three most important fisheries zones 1..

2………………………………………………3…………………………………………………………

13. Duration of the last fishing trip│ 1 day│2 to 3 days│more than 3 days│

13.a. If the trip lastes more than 1 day, what was the reason?
…………………………………………………………………….

14. Have you received capacity building courses in the last two years? │Y│N│ *If the answer is yes, indicate what type*:

14.1 │environmental│aquaculture│bussiness management│organization│merchandizing│fisheries│ others...

III. SOCIO ECONOMIC INFORMATION

1. Life insurance│Y│N│ **2. Social Insurance**│Y│N│ 3**. Nro. dependents** .... **4. Num. children in schooling age** ....

5. Monthly family income S/............ **6. Monthly family expenses** S/ ....

7. Monthly income from fishing activity S/............................... **8. House ownership** │own│ rented│

9. Number of rooms (*without consider: living room, dining room, kitchen, bathroom*). ....

10. Service infrastructure │W│S│E│T│Cable│Cel │Internet│**11. Housing characteristics**│B│A│Q│RM│

12. Did you received credit for the house?.│Y│N│ **13. Do you have others assets?** │Y│N│

13. Liquid Assets │washing machine│computer│refri│car│tv

Form E – Fishermen (FDA-UNALM Complement)

Date		Place	
Interviewer		FDA Code	
Surname		Mothers surname	
Name		Years fishing	

Economic Activity

E1. What are the main economic activities that sustain your family? Name them by order of importance
E2. Do the women in your house occupy any specific economic activity? Which ones?
E3. What species are present now in your catches?

Resource	Quantity	Measurement unit	Price / Measurement unit

E4. What species do you catch during El Niño?

Resource	Quantity	Measurement unit	Price / Measurement unit

E4b. Not working during El Niño?
E4c.Change of activity (to what?)
E5. How does your economic activity change during el Niño? Describe (For example operative costs; equipments; less incomes)
E5a. Change of fishing zones: Yes/No Where?.................................

Participation in collective activities (social capital)

E6. Do any of your family members participate in a social organization? (For example APA, religious/ charismatic group, credit), which ones?
E7. If yes ¿in what ways this participation helps your household?
E8. Did your participation in a group help you to face El Niño events?

Yes	
No	
Does not Know	

E9. If yes ¿how?
E10. ¿Are there any groups formed as response to El Niño?

Yes	
No	
Does not Know	

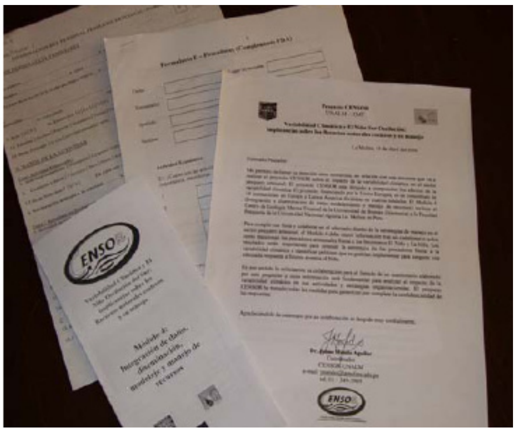
E11. If yes, which ones?

Change of fishing zone (city, region) for fishing activity - Migration

E12. ¿Have you moved since the beginning of your fishing career? **Yes / No** If yes, go to E14
E13. ¿Why you don't change your fishing zone if other fishermen do it?
E14. ¿What zones have you visited for short term stays? (seasonal)
E15. ¿To which cities have you moved (larger periods than a season or one time event) since you started fishing?
E16. Did you move base on your own decision, the captain or the armador one?
E17. How did you find where to migrate?

Climate variability impact on your family and household

E18. ¿Were you/your family affected positive or negatively by El Niño? **Yes/ No**
E19. Explain ¿how were you affected?
E22. Have you needed external help to support your home during El Niño events? **Yes/No**
E23. If yes ¿what type of help did you receive and who gave you that help?
E24. If not from who and what kind of help would you liked to receive?
E25. How do you find out if there is going to be El Niño?



ANNEX 5

Disclaimer

Gemäß §2 der Promotionsordnung der Universität Bremen, Fachbereich für Sozialwissenschaften versichere ich, dass:

1. die Arbeit ohne unerlaubte fremde Hilfe angefertigt wurde

2. keine anderen als die angegebenen Quellen und Hilfsmittel benutzt wurden

3. die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht wurden

Bremen, 27. Mai 2008

(M-C Badjeck)