THE ROLE OF SOCIOECONOMIC FACTORS IN CUSTOMARY CORAL REEF MANAGEMENT IN PAPUA NEW GUINEA

Thesis submitted by

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In March 2005

For the degree of Doctor of Philosophy
In the School of Tropical Environment Studies and Geography
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I declare that this thesis is my own work and has not been submitted in any form for another degree or diploma at any university or other institution of higher education. Information derived from the published or unpublished work of others has been acknowledged in the text and a list of references is given.

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CONTRIBUTIONS OF OTHERS

This work would not have been possible without the valuable contributions of a great many people. Funding for this project was provided by the David and Lucile Packard Foundation through a US$500,000 grant to the Wildlife Conservation Society. I collected these data as part of a Wildlife Conservation Society project, led by Dr. Tim McClanahan, that examined the effectiveness of coral reef management in the Indo-Pacific. My university fees and stipend support were provided by the James Cook University International Postgraduate Research Scholarship and a scholarship from the school of Tropical Environment Studies and Geography.

This thesis was supervised by Dr. David King, Dr. Alison Cottrell, and Dr. Stephen Sutton. I also collaborated with a number of other scientists on this project. Dr. Trevor Bond provided crucial guidance, technical support, and editorial feedback on applying the Rasch model to my study. Conversations with Dr. Rohan Arthur helped to spawn ideas and new ways of looking at the issues central to my thesis. Dr. Tim McClanahan, Dr. Michael Marnane, Dr. Glenn Almany, Dr. Tracy Clark are co-authors on several interdisciplinary publications that have resulted from or been inspired by the research conducted in this thesis. Their contribution was largely limited to the ecological aspects of these papers (which are not presented in this thesis). These co-authors did not contribute to the collection, design, or analysis of the socioeconomic data which forms the backbone of this thesis and had minimal contributions to the interpretation of the data presented in this thesis. Editorial support was given by Mrs. Dee Cinner.

Data were collected with the assistance of Mr. John Ben from the University of Papua New Guinea. His assistance was crucial in obtaining and interpreting these data. Mr. Ben also collected data for two sites, Madina and Fissoa after I left Papua New Guinea. Mr Paul Led also assisted with translation for research conducted in the Madang province.

ACKNOWLEDGEMENTS

I thank the people and leaders of all 15 communities for allowing me and John to work in their communities and accepting me into their lives and homes with open arms. *Yu pela orait streit.* Thanks to the PNG National Research Council, PNG Department of Environment and Conservation, and the PNG National Fisheries Authority. The David and Lucille Packard Foundation supported this research through the Wildlife Conservation Society. Thanks to all those who contributed to this work in supervising, editing, funding, generating ideas, and data collection. Thanks to all my family and friends for their moral support.

ABSTRACT

For generations, communities in the Pacific islands have employed a range of resource management techniques (including reef closures, gear restrictions, limiting entry, and the protection of spawning aggregations) to limit marine resource use. Because of their perceived potential to meet both conservation and community goals, these traditional resource management techniques are being revitalized by communities, governments, and conservation groups as an integral part of national and regional marine conservation plans in the Pacific. However, it is uncertain whether traditional management can provide a solid foundation for the development of these conservation strategies. Little is known about the social, economic, and cultural processes that enable communities to employ traditional management and it remains unclear if the traditional management systems will be resilient to the profound socioeconomic changes sweeping the Pacific region. Indiscriminate application of "traditional" solutions to present day problems in Pacific communities without understanding the socioeconomic context in which these systems can operate effectively may lead to disappointment with results and disenchantment with the conservation process if results do not meet expectations.

Theoretical and empirical studies have identified a number of specific socioeconomic factors that may influence the ability of a community to implement or maintain traditional management, but specific relationships between socioeconomic conditions and the use of traditional management practices are still not well understood. This thesis aims to examine the socioeconomic context within which select traditional management systems operate in Papua New Guinea and further debate on how these systems may be applicable in the modern conservation context by exploring the following research questions: Do communities with traditional reef closures have different socioeconomic characteristics than communities that do not? How do traditional closure systems reflect the socioeconomic conditions of the communities that implement them?

This thesis identified socioeconomic factors that may influence whether a community employs or maintains traditional management and prioritised 11 that could be collected within the research timeframe. These factors were population, size of the resource, distance to market, conflicts, settlement pattern, dependence on marine resources, modernisation, perceptions about the complexity of human-environment interactions, perceptions about the condition of the marine environment, social capital and occupational mobility. These socioeconomic factors were examined in 14 coastal communities in Papua New Guinea, five of which had traditional closures and nine of which did not. Data were collected using a combination of quantitative and qualitative techniques, including household surveys, key informant interviews, participant observation, and oral histories. A technique called Rasch modelling, commonly used in psychology and education, was employed to aggregate household-level socioeconomic indicators into thematic interval-level variables. Then the socioeconomic factors in the five communities that employ traditional closures of coral reefs were quantitatively compared with the nine communities that do not. Results showed that the constructs used to measure modernisation, social capital and occupational mobility had a slight but significant relationship to the presence of traditional closures, and the construct of dependence on marine resources was strongly related to the presence of traditional closures.

Two case studies were used to provide a more detailed examination of how dependence on marine resources influences whether and how communities can employ a traditional closure. One case study is from Ahus Island, Manus province where dependence on marine resources is extremely high. The other is from Muluk village on Karkar Island, where dependence on marine resources is low. These contrasting case studies help to provide more detail into the socioeconomic context within which these traditional practices operate and how a community's dependence on marine resources may determine whether and how traditional closures may meet their goals. The thesis concludes by exploring how traditional closures in Papua New Guinea focus on providing the communities with benefits rather than biodiversity conservation and examining how this leads to a fundamentally different resource governance model than we see in western

fisheries management and resource conservation. This utilitarian model of conservation may have a place in the modern conservation context of many developing countries where the social and economic burdens of Western conservation models are unrealistic.

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PROLOGUE

The purpose of this prologue is to provide some context into the industry relationship that enabled this research to occur. Although common in fields such as medical or pharmaceutical research, industry sponsors or partnerships are somewhat atypical for a human geography thesis. Thus, it is important for the reader to understand the context within which this research occurred and briefly review some of the benefits and limitations to this approach.

Research for this thesis was collected as part of a Wildlife Conservation Society (WCS) project that examined the effectiveness of different coral reef conservation strategies in Papua New Guinea and Indonesia. The research question that this project set out to answer: "what strategies are working in coral reef conservation?" is a question spawned by the woeful success rate of coral reef conservation initiatives worldwide (Burke, 2001; Burke & Maidens, 2004; Burke et al., 2002). Answering this question required an interdisciplinary approach that examined socioeconomic as well as ecological aspects of resource use and governance. Research for this project involved a total of 13 scientists in data collection and analysis. We examined reef governance institutions, socioeconomic conditions, and the ecological status of coral reefs in 29 coastal communities throughout Papua New Guinea and Indonesia.

As the lead social scientist for the project, I was in charge of defining, planning, conducting, and analysing all social science research for the project. The PNG component involved two social scientists (myself and a Papua New Guinean research assistant), while the Indonesian component involved five (myself and four Indonesian research assistants). My research focused on defining the formal and *de facto* reef governance institutions, examining relevant social and economic processes, and quantifying resource use patterns. The abundance and calibre of data we expected to generate from the project suggested that it might be appropriate for the scope of a PhD. James Cook University agreed and awarded me the highly competitive International Postgraduate Research

Scholarship to incorporate these data into a PhD. In consultation with my supervisors, it was decided that the scope of the PhD should be limited to socioeconomic processes influencing resource management in one country because national-level differences in socioeconomic factors may override the village-level patterns I was examining. One of the more interesting findings of the WCS study was that traditional reef conservation efforts appeared to be better at protecting coral reef resources than conventional marine reserves (McClanahan et al., in review). Thus, to figure out the social underpinnings of these traditional systems, I decided to focus the PhD thesis on Papua New Guinea, where there was a higher incidence of traditional conservation in the management sites.

The benefits of incorporating research from this project into a PhD were that WCS provided research funding that allowed for what has typically been a prohibitively expensive comparative study and that detailed interdisciplinary work was conducted which provided insights into the ecological questions about traditional management raised in Chapter II. The ecological data are presented in papers and are not included in this thesis (e.g., Cinner et al., in press; Cinner et al., in review-a; Cinner et al., in review-b; McClanahan et al., in review). The compromises were that data had to be collected in a way that would allow them to be easily integrated with the ecological data and that research was also conducted on WCS research priorities that were not covered in the scope of this thesis. For example, significant research was conducted on the composition of fish catch to examine how fishing pressure in six regions influence the size and trophic level of fish being captured (Cinner & McClanahan, in review).

CHAPTER I. INTRODUCTION

Background

Social, economic, and cultural factors play a large role in determining how individuals and communities utilise natural resources. These factors can influence whether something is perceived as a resource and put to extractive use, whether it remains unutilised, or whether it is actively exterminated (Nazarea et al., 1998). Likewise, the ways in which societies are organized to extract resources determines whether incentives are created to overexploit or sustainably use resources. For example, open-access regimes can create rational incentives for individuals to overexploit natural resources even though it is not in their long-term interest (Hardin, 1968). Conversely, some user-organized common property systems have successfully overcome the problems associated with open-access systems to sustainably use natural resources (Dietz et al., 2003a; Ostrom, 1990).

Contrary to Western society's propensity to manage marine resources as open-access situations, another paradigm of common ocean governance is prevalent in parts the Pacific islands, called customary marine tenure (Hviding, 1983; Johannes, 1978; Neitschmann, 1985; Ruddle & Akimichi, 1984; Ruddle et al., 1992), in which the access to inshore marine resources are generally controlled by social units including individuals, families, clans or other kinship-based institutions, and villages (Carrier, 1987; Ward, 1997). Access to spatially and environmentally defined areas, species, and/or harvesting technology can be regulated by marine tenure institutions (Hyndman, 1993). These marine tenure institutions can range from relatively simple communally owned marine areas from which outsiders are excluded to complex and overlapping systems of individual and family rights (Carrier, 1987).

Marine tenure regimes are particularly important because the ability to exclude outsiders from accessing marine resources forms the basis for other user-defined restrictions on resource use commonly referred to as traditional management. Many coastal

communities in the Pacific have traditionally employed resource management techniques similar to those used by modern fisheries managers, including restrictions on gear, season, reef areas, species, size and ownership of marine resources (Johannes, 1978; Ruddle, 1988; Zann, 1985). These forms of management are often embedded in ceremonies, religion, dietary restrictions, and other traditions rather than explicitly practised for conservation (Bulmer, 1982; Colding & Folke, 2001; Polunin, 1984). For example, in the New Ireland province of Papua New Guinea (PNG), many communities prohibit fishing or gleaning within a specific marine area following the death of a community leader, landowner, or other person of significance (Wright 1985). After some time, which can last up to several years, the restricted area is harvested and the fish are used for a feast that marks the end of the mourning period. These systems may have the potential to conserve marine resources (Hoffmann, 2002b; Johannes, 1978, 2002d; McClanahan et al., 1997; Ruttan, 1998).

In response to the degradation of coral reefs and inshore fishery resources in many Pacific countries, governments and conservation groups are examining whether and how traditional management regimes can be integrated into the modern conservation context (Hoffmann, 2002b; Johannes, 2002d). Basing resource conservation initiatives around traditional management and marine tenure regimes is particularly attractive to governments, non-governmental conservation organisations, and aid donors because enforcement of specific fishing regulations within a tenure is generally the responsibility of the resource owner (Asafu-Adjaye, 2000). As a result, marine tenure and traditional management may reduce the need for under-funded Pacific governments to regulate and enforce fisheries regulations (e.g., Hviding, 1996; Johannes, 1981).

Yet serious gaps remain in our understanding of whether and how traditional management systems can be applied to the modern conservation context. In particular, debates are inconclusive regarding whether these systems can conserve resources, how they differ in practice and intention from modern resource management strategies, and how they are affected by socioeconomic forces. Although socioeconomic factors can influence how individuals and communities are able to collectively organize themselves

to manage resources (Ostrom, 1990), very little is known about the social and economic frameworks that allow communities to employ or maintain traditional management regimes. Particularly, little is known about why some communities can maintain traditional management regimes while other communities cannot.

A framework for analysing and comparing common property regimes based on social, economic, and cultural factors was developed in Ostrom's pivotal work *Governing the Commons* (1990). Ostrom suggested that decisions to support or not support common property institutions depend on the internal norms of the users, the transaction costs of making collective decisions, and the expected benefits from cooperation. Ostrom postulated that these factors are determined largely by 'situational variables' rather than the individual rational calculators proposed by Hardin (1968), Oslen (1965), and the prisoners dilemma (see Ostrom, 1990). Prior to this, Hardin's (1968) widely accepted theory of a *Tragedy of the Commons* provided resource managers with three models of resource governance: 1) open-access, 2) state control, and 3) privatisation. Ostrom highlighted the viability of user-defined systems in collectively managing resources and provided a theoretical framework for analysing and comparing these regimes based on an array of situational variables that contribute to the internal norms and discount rates, expected benefits, and transaction costs.

To date, much of the research exploring the linkages between socioeconomic factors and traditional management regimes has been conducted as case studies or small comparative studies (Aswani, 2002; Baines, 1989; Cooke et al., 2000; Foale & Macintyre, 2000; Hviding, 1996; Watson, 1989). Despite the important contributions of these studies to understanding how socioeconomic factors influence traditional management regimes, a fundamental weakness of these approaches is that they have lacked the broader comparative component which allows us to discern larger patterns in how resource governance may respond to social and economic factors. As such, it has been difficult to draw conclusions that are farther reaching than an individual study site. To better understand how traditional management regimes are affected by social and economic

factors in a wider geographical context, larger comparative analyses are also required to complement the more detailed case studies (Pollnac & Johnson, in press).

The need for a broader understanding of these relationships is particularly timely because the Pacific is a region of profound social, economic, and demographic change (UNEP, 2002) and national and regional reef conservation strategies are being developed upon a foundation of traditional management which the resilience to these factors is not well understood. Indiscriminate application of "traditional" solutions to present day problems in Pacific communities without understanding the socioeconomic context in which these systems can operate effectively may lead to disappointment with results and disenchantment with the conservation process if results do not meet expectations. In terms of a regional conservation strategy, this could do more to undermine than promote regional reef conservation in the long term.

Aims and Objectives

This thesis aims to examine the socioeconomic context within which traditional management systems operate in PNG, and by doing so, further debates on whether or how traditional management may be applicable in the modern conservation context.

To achieve these aims, the following objectives are accomplished:

1) review current theory and empirical research to identify socioeconomic factors that may influence traditional management
2) describe socioeconomic conditions and governance regimes in 14 coastal communities in PNG
3) determine whether communities that do practice traditional management have different socioeconomic characteristics than communities that do not
4) describe how traditional management systems appear to operate in ways that compliment the local socioeconomic conditions

5) discuss how traditional management may provide lessons for modern conservation theory and practice

Operations to Determine Socioeconomic Factors Influencing Traditional Management in Papua New Guinea

This thesis used both case studies and comparative analyses to explore the socioeconomic context within which traditional management systems operate. Research for this thesis in was conducted in 14 coastal communities in PNG. A formal household survey was used to elicit data about resource use, perceptions about resources, and household socioeconomic characteristics from the heads of households. Techniques such as interviews with key informants and participant observation were also used to gather data on resource governance regimes and verify responses from the formal survey. These data were used to compare the socioeconomic characteristics of communities that employ traditional conservation techniques to communities that do not to determine whether there are broad patterns in how socioeconomic factors influence the presence of traditional management. Then, two case studies were used to provide in-depth detail on the most significant findings in the comparative analysis.

Thesis Structure

This thesis is divided into seven chapters: 1) introduction (this chapter); 2) literature review; 3) data collection methods; 4) site descriptions; 5) a comparative analysis of how socioeconomic factors are related to traditional management; 6) case studies of how traditional management reflects the local socioeconomic conditions, and 7) discussion and conclusions.

Chapter two contains a critical review of the relevant literature. The first section of chapter two focuses on describing the varying methods and techniques of governing

marine resources prevalent in the Pacific, with particular attention focused on the traditional systems. In particular, the role of traditional management systems is examined in light of the modern conservation context. Then, the academic context of debates about resource governance models is reviewed to provide a theoretical framework for exploring traditional management systems. A detailed review is presented of Ostrom's (1990) supposition as to how situational factors influence why some communities can effectively govern common resources and others cannot and supporting research for this view is presented from fields as diverse as economics and human ecology.

Chapter three contains details about the methods used to collect the data. The first section describes the quantitative and qualitative techniques used to gather information and details how communities and respondents were selected. Then there is a detailed discussion of the specific indicators that were collected and examined.

Chapter four presents qualitative site descriptions. The site descriptions provide maps of the study sites and a qualitative sense of population, infrastructure, settlement pattern, land tenure and distribution, and coastal resource governance regimes. A supplemental comparison of these and other socioeconomic indicators across the 14 study sites is presented in Appendix II.

Chapter five contains the analysis of how socioeconomic factors vary in communities with and without traditional management. To determine specific relationships between socioeconomic factors and traditional management strategies, socioeconomic conditions in communities with traditional reef closures are compared to communities without traditional closures. This chapter concludes that one construct developed in the analysis, dependence on marine resources, is the socioeconomic factor that appears to have the best relationship with the presence of traditional closures. These findings indicate that communities with traditional closures have lower dependence on marine resources than communities without traditional closures. However, an anomaly exists in that one of the communities with a traditional closure has extremely high dependence on marine resources.

Chapter six examines how traditional closures reflect the socioeconomic conditions of the communities that implement them. Two case studies are used to explore the anomaly described above. One case study examines how reef closures in a community with low dependence on marine resources fit into the social and economic framework of that community. The other case study examines how the community with high dependence on marine resources employs a different type of reef closure than the other communities- one that is better adapted to high dependence on marine resources.

Chapter seven provides a summary of the major research findings and a discussion of how these findings may help to understand the role of traditional management in the modern conservation context. Finally, some methodological issues and directions for future research are addressed.

CHAPTER II. LITERATURE REVIEW

Millions of people around the world depend on the beauty and bounty of coral reefs for income and subsistence livelihoods (Wilkinson, 2004). Coral reefs are fished, mined for construction materials and lime, attract millions of SCUBA divers, provide shoreline protection, and their impressive biodiversity has vast potential to be utilised in the pharmaceutical industry (Cesar et al., 2003). These goods and services provide $US30 billion in annual net benefits to World economies (Cesar et al., 2003).

Although coral reefs are among the most diverse and depended upon ecosystems on earth, they are also among the most fragile. Throughout much of the world, they are experiencing anthropogenic and natural disturbances that may eventually lead to the loss of the reef diversity and functions (Hughes et al., 2003; McClanahan, 2002). Almost 75% of coral reefs are located in developing countries (Wilkinson, 2004), so widespread coral reef degradation threatens the livelihoods of the millions who could least afford it (Cesar et al., 2003).

There are movements worldwide to manage and protect coral reefs and their fisheries (Wilkinson, 2004). Economists, conservationists, governments, and scientists note that reasons for protecting coral reefs can include: protecting livelihoods, protecting economic interests (e.g., fishing and collecting marine products for the aquarium trade), preserving reef functions (e.g., shoreline protection), and intrinsic value of nature as rationale for conservation strategies (Cesar et al., 2003; Cesar et al., 1997; Russ et al., 2004; Wilkinson, 2004 citing the action statement from the 2nd International Tropical Marine Ecosystem Management Symposium). A number of strategies have been attempted to manage and preserve coral reefs and their fisheries, including gear restrictions, minimum size limits, seasonal closures during breeding or other vulnerable stages, and effort reduction (limiting use through permits, alternative income projects, etc.). Many of these management techniques have roots in the single species management of considerably less complicated temperate ecosystems (Foale & Manele, 2004). However, management of

coral reef fisheries is particularly complicated because 1) catches are multi-species which can make single-species management methods such as monitoring effort, growth, and mortality expensive (McClanahan & Mangi 2004); 2) fishers in developing countries are considered the poorest segment of society, although often inaccurately (Pollnac et al., 2001b), making enforcement of regulations that might negatively influence their livelihood politically unfavorable (McClanahan & Mangi, 2004); and 3) national or local governments, particularly in developing countries, often lack adequate funding to monitor catch or enforce regulations (McClanahan & Mangi, 2004). Thus, fisheries management techniques designed for developed countries in temperate ecosystems are often too complex and costly to implement for coral reef fisheries in developing countries (Russ, 2002).

One of the most widely employed reef and fisheries conservation strategies is the marine protected area (MPA). MPAs restrict or prohibit extractive activities from a delineated area (Agardy, 1997; Pearce, 2002). This strategy seeks to provide opportunities for reproduction, spawning, and recruitment of marine species and prevent damage to habitat (Pearce, 2002). Robust stocks of fish and other living resources can then develop within the MPA and then may disseminate into adjacent areas (Pearce, 2002; Russ et al., 2004). MPAs are thought to be a better solution to multi-species fisheries associated with coral reefs because they attempt to protect the entire complex ecosystem rather than a single target species. Foale and Manele (2004 citing Willis et al. 2003) note that there are many more publications expounding the theoretical virtues of MPAs than empirical studies demonstrating their effectiveness, but that support for their efficacy is almost universal.

Unfortunately, fully-closed areas as a reef conservation strategy in developing countries have achieved limited success (e.g., McClanahan, 1999a; Pollnac et al., 2001a). The overwhelming majority of the designated MPAs associated with coral reefs are ineffective. For example, based on criteria such as the number of park staff, management facilities, community outreach programs, and the existence of a management plan, only 9% of 192 MPAs in the Caribbean are effectively managed (Burke & Maidens, 2004) and only 14% of the 332 MPAs in Southeast Asia whose management effectiveness can be

determined are effectively managed (Burke et al., 2002). The record of low success rates in MPAs has been caused by a mixture of poor funding and enforcement, poorly formulated management goals, lack of information on the ecological and social consequences of different management decisions, lost viability of traditional systems of management or poor acceptance of non-traditional management systems, and failure of management to reflect or adapt to changes in the economic, cultural or political environment (Bryant et al., 1998; Christie, 2004; Christie et al., 2003; McClanahan, 1999b; Pollnac et al., 2001a).

Despite the limited success of contemporary coral reef management strategies to date, there is evidence that certain social and cultural institutions, such as small-scale fisheries organisations, civilian groups and/or cultural practices have the potential for achieving, and have achieved, conservation (Becker & Ostrom, 1995; Colding & Folke, 2001; Dietz et al., 2003b; Johannes, 1981). These institutions can provide a sound foundation for the management of some natural resources (Ostrom, 1990; Ostrom et al., 1999). In parts of the Pacific, reef conservation strategies are being built upon traditional institutions that have the perceived ability to protect marine resources (Johannes, 2002d), but relative to our understanding of ecological aspects of conservation, little is known about how, when, and why these institutions operate effectively. Conserving biological diversity and ecological processes without understanding and addressing the social, economic and cultural factors that sustain this conservation may have little long-term utility (Christie, 2004; Christie et al., 2003). In the Pacific, complex sociocultural institutions dominate peoples' relationship with the sea (Hviding, 1996) and understanding these systems should be an integral part of any conservation effort in the region.

Governance of Marine Resources in the Pacific

In contrast to the open-access system by which marine resources are governed in most Western societies, in many parts of the Pacific islands, access to inshore marine resources is generally controlled by social units including individuals, families, clans or other kinship-based institutions, and communities (Carrier, 1987; Carrier & Carrier, 1989a;

Ward, 1997) in a system referred to as customary marine tenure. In a thorough review of customary marine tenure in PNG, Hyndman (1993) describes how access to spatially and environmentally defined areas, species, and/or harvesting technology can be regulated by marine tenure institutions. The excludability and complexity of marine tenure institutions ranges from relatively simple communally owned areas from which outsiders are excluded to the extremely complex system of individual and family rights to space, species, gear, and even specific techniques of using gear described by Carrier (1987), Carrier and Carrier (1989a) and Cinner et al. (in press) in the Manus province of PNG. Hunt (1997) states "Traditionally, there was no 'ownership' by one group of all rights, but rather a system of allocation of access and use rights." Although generally all core members have some exploitation rights, it is uncommon for these rights to be equal (Ward, 1997). It is also common for residents who are not core members to have limited, conditional rights which fall far short of equality of access (Ward, 1997).

Although customary marine tenure has been documented throughout the World (see Hviding, 1996 p. 18), it has reached the highest level of development in the Pacific (Ruddle & Akimichi, 1984), including Japan (Kalland, 1984; Ruddle, 1985), Melanesia (Aswani, 1999, 2002; Carrier, 1987; Cooke et al., 2000; Hviding, 1983, 1996; Johannes, 2002c; Malinowski, 1922, 1935; Polunin, 1984; Wright, 1985), Polynesia (Hoffmann, 2002a, 2002b), Micronesia (Johannes, 1978, 1981; Zann, 1985), Indonesia (Mantjoro, 1996; Ruttan, 1998), and Australia (Johannes & MacFarlane, 1984; Neitschmann, 1985). The legal standing of customary marine tenure, as recognized by individual states, varies substantially throughout the Pacific. In some states, colonial governments weakened or abolished existing customary marine tenure institutions (Johannes, 1981). Alternatively, in PNG, German and British colonial administrations recognized traditional fishing rights and tenure (Hyndman, 1993). Legal recognition of customary land or marine tenure is particularly important in the Melanesian context because land or water rights are the foundation of social, cultural, and legal identity in the region (Ballard, 1997; Hviding, 1996). Ballard (1997) claims "'Land'-as a shorthand for ties to locality, whether terrestrial or marine is the basis for membership and nationality for most Melanesians. A

claim to land, rather than some abstract notion of citizenship, is how the majority of Melanesians secure a foothold on the political stage and gain the attention of the state."

"Traditional Management" of Marine Resources

Some communities in the Pacific Basin not only utilise customary marine tenure to exclude others from exploiting resources, but also have certain practices, beliefs and/or dietary restrictions, which limit their own resource use. These practices have been called "traditional management," "taboos", "folk management," and "local management" (Dyer & McGoodwin, 1994; Pollnac & Johnson, in press). Pollnac and Johnson (in press) highlight some semantic problems associated with the term traditional, because the actual origins of certain practices are difficult to trace. However, for the purpose of this thesis, the term traditional management will be used.

Traditional management was brought to the attention of many resource managers, fisheries scientists, and marine biologists in the late 1970s by the works of Robert Johannes (Johannes, 1977, 1978, 1981). Johannes (1978) described how a vast network of traditional conservation practices existed throughout the Pacific that had potential to conserve marine resources, but noted that these systems were dying out in response to Westernisation. Since then, considerable research has attempted to describe these traditional systems and examine whether and how they can conserve resources.

Colding and Folke (1997; 2000; 2001) provide the most comprehensive reviews to date of the role and scope of traditional management on nature conservation for both terrestrial and marine environments. They suggest that unwritten social rules (taboos) may regulate human behaviour in ways that may play a major role in the conservation of natural resources. Taboos of natural resources can take many forms, including restrictions on where people can harvest resources, which resources can be harvested, and initiation requirements before people are allowed to access resources.

Descriptions of traditional marine conservation practices are widespread throughout resource management literature (i.e., Hunt, 1997; Johannes, 1981; Johannes, 2002a;

McCay & Acheson, 1987; Polunin, 1984; Ruddle et al., 1992; Ruddle & Johannes, 1985a, 1985b; Wright, 1985; Zann, 1985) and anthropological literature (Anderson, 1994; Carrier, 1987; Hooper, 1985; Hviding, 1983, 1996; Neitschmann, 1985; Zann, 1985). These descriptions generally suggest that traditional management practices employed similar techniques to those of modern fisheries managers (Berkes et al., 2000; Johannes, 1981, 2002a), which include limiting at least one of the following six factors: 1) spatial areas; 2) gear or harvesting technology; 3) time; 4) effort (through the number of participants); 5) types of species that can be harvested; and 6) number of fishes harvested (quotas). In many instances a particular strategy will limit more than one factor. While size restrictions play an important role in Western fisheries management, it is not a widespread strategy in the Pacific Basin (pers.com, R. Johannes, 2002) and is not a widely documented taboo throughout the world (Colding & Folke, 2001).

Spatial Restrictions

There are numerous documentations of reef closures throughout Melanesia, although they are almost all temporary. Hviding (1983) documents periodic closures (several weeks long) to allow fish aggregation in preparation for a large fish drive in the Marovo Lagoon, Solomon Islands. In the New Ireland province of PNG, there are also examples of reef closures before religious ceremonies (Polunin, 1984) and following the death of a landowner or village chief (Wright, 1985). In these instances, a concentrated effort of a family, clan, or the wider community may be applied to harvest the closed area for the feast (Cinner et al., in review-b; Wright, 1985). Spatiotemporal restrictions also include "fallow" rotation of fishing areas (Colding & Folke, 2001; Neitschmann, 1985). It should be noted that quite often the explicit purpose of spatial restrictions in traditional management is to "tame" the fish, making them easier to capture (Hviding, 1996; Johannes, 2002b),

Gear Restrictions

This form of taboo occurs when social groups ban specific harvesting technology or techniques (Colding & Folke, 2001). Gear restrictions, particularly on gill nets, spear

guns, and night diving are also frequently documented, but may only exclude non-owners from using the restricted technologies. Johannes (1981) also documents restrictions on the techniques used to poison reef fish with derris root. Communities generally ban a particular gear because it is perceived to be too effective (Hviding, 1996; Johannes, 2002d; Zann, 1985), destructive to the coral habitat, or because it results in extensive juvenile fish mortality (Johannes, 1981). Restricting harvesting technology to inefficient gear may also serve the dual purposes of providing access equity to resources and maintaining employment (Colding & Folke, 2001).

Temporal restrictions

Temporal restrictions occur when social groups ban access to resources during certain time periods which can be sporadic, daily, weekly, or seasonal (Colding & Folke, 2001). Temporal restrictions on marine resources seem to have three general purposes: reducing harvesting pressure, protecting spawning aggregations (Johannes, 1978), and preventing the disturbance of more highly favoured fish species (Hviding, 1996; Zann, 1985).

Effort restrictions

There are two types of effort restrictions discussed in the literature: limitations of who can utilise certain species and who can use certain gear. In PNG, individuals may not be allowed to participate in a particular fishery until they have undergone an initiation ceremony (Cinner et al., in review-a). The ownership of rights to specific harvest techniques as described by Carrier (1987) and Johannes (1981) serves to limit the participation in the fishery much as modern licensing does.

Species Restrictions

Taboos that limit the utilisation of a particular species for individual or groups of a certain age, gender, or social class are commonly called segment taboos or specific food taboos (Colding & Folke, 2001). A wide range of age, sex, totem, and community-wide practices limit or prohibit consumption of certain marine species (Colding & Folke, 1997,

2001; Hviding, 1996; Zann, 1985). There are generally four types of species restrictions discussed in the literature: dietary restrictions in the form of taboos on the consumption of certain species (Carrier, 1987; Zann, 1985), sacred species which have restrictions or bans on their harvests (Hviding, 1996; Zann, 1985), restrictions during particularly sensitive life stages of target species (Colding & Folke, 2001), and restrictions of certain types of species except for times of bad weather (Johannes, 1981).

Dietary restrictions can be somewhat limited in scope in that a particular species may only be restricted to women (particularly when menstruating), certain age groups, one particular family or clan, or during a particular time period such as during warfare (Colding & Folke, 1997; Johannes, 1981; Zann, 1985). Reasons for species specific taboos can include perceptions that the species is toxic, the species is viewed as a religious or totemic symbol, belief that the species is a reincarnated human, and avoidance due to appearance or behaviour (Colding & Folke, 2000, 2001). Species taboos can be inherited from patrilineal or matrilineal descent. In some instances the introduction of Western religions such as the Seventh Day Adventist Church (in which members do not eat shell fish or fish without scales) have also played a large role in limiting the consumption of certain marine species in some communities.

The consumption of sacred species may be limited to a particular class of people, thus limiting its total harvest (Zann, 1985). Some communities also limit the harvest of particular species (including giant clams, sea cucumbers, and other vulnerable inshore invertebrates) during times of good weather so that there would be easily accessible food during inclement weather (Johannes, 1981; Zann, 1985).

Number of fish harvested

Colding and Folke (2001) did not find any social taboos regulating how much of a resource could be withdrawn, and suggested that quota and stock yield management is absent in traditional management (citing Schlager, 1994, Wilson et al., 1994). However, Neitschmann (1985) reports that in the Torres Strait Islands, “taking more than enough to

share with kin networks is considered greedy and unsatisfactory behaviour and is not socially condoned." Avoidance of waste was also noted by Johannes (1981).

Enforcement and Compliance

Sanctions for violations of taboos can include payment of cash, compensation in the form of livestock, social alienation or exclusion, and gossiping or other forms of social pressure (Colding & Folke, 2001). Enforcement of specific taboos within a tenure is generally the responsibility of the landowner (Asafu-Adjaye, 2000). Some traditional fishing regulations are spiritual in nature and as such are self-enforcing (Colding & Folke, 2001).

Colding and Folke (2001) review a number of studies that suggest despite not being enforced by governments, compliance with taboos are high because of factors such as close kinship bonds in traditional societies, beliefs in supernatural enforcement of sanctions, and religious reasons. Berkes et al. (2000) also suggest that compliance may also be promoted by regularly reminders of the taboos during rituals, ceremonies, and other traditions.

"Traditional Management" in the Modern Conservation Context

By empowering community or self-enforcement of fisheries regulations, traditional management appears to provide a cost-effective means to reduce the burden on government intervention, regulation and enforcement (Hviding, 1996; Johannes, 1981). This is particularly important in the economic context of the Pacific where fisheries departments are typically under staffed and under funded (Johannes, 1981). As a result of the perceived ability to conserve resources and reduce government burdens, traditional management is making a resurgence and is forming the basis for modern fisheries management and conservation strategies (Hunt, 1997; Hviding, 1996; Johannes, 2002d). Countries such as Vanuatu and Samoa are basing national reef conservation strategies on foundations of traditional management (Johannes, 2002c, 2002d).

The merits of this "renaissance" of traditional practices as a basis for modern conservation strategy are somewhat unclear because the literature concerning the ability of traditional concepts and practices to meet modern conservation goals appears to be somewhat contradictory. Debates about whether or how traditional conservation should be integrated into the modern conservation context exist in fields as diverse as those in ecology (Hoffmann, 2002a, 2002b; Johannes, 2002a; McClanahan et al., 1997), anthropology, (Aswani, 1999, 2002; Hunt, 1997; Hviding, 1996; Hyndman, 1993; Ruddle, 1998; Ruddle & Akimichi, 1984; Ruddle et al., 1992; Ruddle & Johannes, 1985b), and economics (Chand & Duncan, 1997). These debates focus primarily on three main questions: 1) Can traditional management regimes meet conservation goals? 2) How are traditional concepts and practices different from those of modern conservation? and 3) How are traditional conservation practices related to socioeconomic processes? This section will review the literature on each of these questions to explore gaps in existing knowledge and define research priorities.

1) Can traditional management meet conservation goals?

A plethora of authors have used data from a wide range of disciplines to address whether traditional management regimes conserve resources. Compilations of resource management, common property, and economic perspectives as to the effectiveness of traditional management can be found in McCay and Acheson (1987), Ruddle and Akimichi (1984), Morauta et al. (1982), and Larmour (1997b). The vast majority of the literature is optimistic about the ability of traditional management practices to conserve resources. Of notable exception are the works of Polunin (1984) and Carrier (1987). Polunin (1984) claims that periodic closures for feasts are too short to have any real conservation value. This point was recently reiterated in Foale and Manele (2004). From several years of ethnographic work on Ponham Island in the Manus Province of PNG, Carrier (1987) also speculates that traditional practices do not effectively conserve resources. Understanding whether traditional management can conserve resources requires examining whether incentives are created to conserve resources and whether these practices can influence ecological systems.

The majority of the literature supports the notion that traditional reef management practices provide effective incentives for resource conservation. The bases for these arguments are two fold: 1) landowners must bear the entire cost of overexploitation and thus conservation is in their self interest; 2) that the complexities that arise from customary marine tenure arrangements can hinder development (and subsequent exploitation) of coastal resources.

An array of authors suggest that under customary marine tenure regimes where fishers are able to exclude others, the fishers have a vested interest in not over fishing (Hunt, 1997; Hviding, 1983, 1996; Johannes, 1981; McCay & Acheson, 1987; Ruddle & Akimichi, 1984). In such a situation, the cost of over fishing (i.e., reduced future harvests) accrues directly and entirely to the fisher owners (Johannes, 1981). McCay and Acheson (1987 p.11) simply state "if we can keep others out, it makes sense for us to do something about our own behaviour". Despite the popularity of this argument, its merits are somewhat overstated as it is well established that private property does not necessarily guarantee resource conservation (McGoodwin, 1990; Ostrom, 1990).

In the context of Melanesia, even though ownership rights provide the ability to exclude outsiders from accessing resources, the need to build repute among community members may provide incentives for overexploitation of marine resources. Carrier (1987) argues that the highly privatized customary marine tenure regime on Ponham Island does not encourage incentives for long-term accumulation of resources because the high social value associated with granting others the privilege to harvest marine resources constrains resource owners from exercising discretion. Carrier (1987 p. 162) states "Decisions that might have alleviated pressure on marine resources by limiting access to water, species, or techniques of capture would have been nonsensical within the social context of Ponham since they would have meant the loss of repute and social credit and the alienation of fellow Ponhams."

Customary resource rights in the Pacific are perceived by economists as inefficient and a prohibiting factor to economic development (Chand & Duncan, 1997). In particular,

complicated land ownership arrangements create a lack of security to land for investors, which can result in "under-utilisation" of resources (Chand & Duncan, 1997). Compensation to traditional land or water rights owners can add to the costs of a development project (Wright, 1985). In small-scale fisheries, local fishers may be reluctant to purchase necessary gear to pursue migratory species such as mackerel because tenure arrangements significantly restrict their fishing range and make the fishery unviable (Johannes, 1981). Although the disincentives to development provided by customary marine tenure may lead to *de facto* conservation, it should be noted that when resource extraction projects proceed in circumstances of insecure ownership agreements, environmental consequences may be more severe. Fear of additional compensation claims or contract re-negotiation encourages investors to get in and get out quickly, resulting in the best resources being taken first and minimal attention paid to environmental impacts (Duncan & Duncan, 1997).

Unfortunately, many of the conclusions to date both for and against the efficacy of traditional conservation have been largely anecdotal and lack convincing evidence. For example, historical evidence such as high pre-European contact population densities on infertile coral islands or species decline following the breakdown of traditional management practices has been used to suggest the efficacy of traditional conservation (Neitschmann, 1985; Zann, 1985). However, Pollnac and Johnson (in press) suggest that sustained harvesting may actually be a result of poor distribution channels and low demand rather than actual conservation practices. Furthermore, the majority of the literature regarding the effectiveness of traditional fisheries management regimes lacks integration with the biological sciences. As such, the reported conservation benefits (or lack thereof) associated with traditional management discussed so far have largely been anecdotal or theoretical speculation. To thoroughly examine whether traditional management can meet conservation goals, we must turn, at least in part, to the biological sciences to ascertain whether these practices have tangible effects on factors such as species diversity, species abundance, coral cover, fish size, and fish biomass. Among the biological research to date, conclusions as to the effectiveness of traditional fisheries management systems in meeting conservation goals are quite varied. Although there is

increasing interest in exploring the biological aspects of traditional reef management, the body of research conducted to date is quite limited. Many of the studies are highly contradictory and as a result, the body of work is seemingly inconclusive.

A number of the biological studies have been poorly designed, so their results are effectively inconclusive and their contribution to the debate should be viewed with scepticism. For example, Hoffmann (2002b) claimed that traditional reef closures in the Cook Islands were effective in improving fish abundance and benthic diversity. However, Hoffmann's study was marred by improper replication which may have artificially inflated her sample size (Underwood, 1997).

Few studies have utilised rigorous science to examine whether traditional practices conserve resource. Ruttan (1998) and Evans et al. (1997) found that traditional management of trochus shells (*Trochus niloticus*) in Eastern Indonesia was successful at regulating harvests to sustainable levels. Alternatively, in a study of the trochus fishery in the Solomon Islands, Foale and Day (1997) found that abundance of trochus in many sites under traditional management was low relative to other areas of the Pacific. McClanahan et al. (1997) found that sacred sites in Kenya, although able to increase fish catch in adjacent landing areas, were ineffective at protecting species diversity or ecological functions. Cinner et al. (in review-a) found that traditional periodic closures were effective at conserving both long and short-lived fish species. Perhaps the most insightful study on the subject is McClanahan et al. (in review), where traditional management, Marine Protected Areas (MPAs) co-managed by communities and Non Government Organisations (NGOs), and national marine parks in PNG and Indonesia were compared using standard indicators and methodologies. McClanahan et al. (in review) concluded that all three sites practicing traditional reef closures had higher fish biomass inside the reserve compared to outside, whereas only one out of four co-managed sites and none of the four national parks showed a difference on biomass inside versus outside. This suggests that traditional management can conserve resources at least as well as conventional conservation techniques.

Thus, to date, the debate concerning whether traditional management techniques can conserve resources has been a highly speculative affair largely dominated by case studies and anecdotal evidence. There is no clear answer regarding whether traditional management regimes provide incentives for the long-term conservation of resources. This seems to depend largely on local social, economic and cultural factors. The few well designed and properly replicated studies examining the ecological effects of traditional closures suggest that traditional conservation techniques can, in fact, conserve select marine resources. However, these are isolated cases and the science from these select cases is not extensive or conclusive enough to suggest that traditional conservation would provide a solid foundation for reef conservation throughout the Pacific.

2) How are traditional concepts and practices different from modern conservation?

Traditional conservation mechanisms can produce outcomes that are analogous to those desired by Western conservationists and some authors have drawn parallels between traditional management and Western fisheries management (Berkes et al., 2000; Johannes, 1981, 2002a), however, there appear to be profound differences in the application, intent, and conceptual underpinnings of these practices (Berkes et al., 1998, quoting Dwyer, 1994). Understanding how traditional systems differ from Western conservation is important because incongruence between communities' and outsiders' views about the roles and expectations of marine conservation could produce misunderstandings that lead to disenchantment with the conservation process (Cox & Elmqvist, 1997).

Although parallel in some respects, traditional and Western conservation are often practised differently. For example, traditional reef closures are generally temporary as opposed to permanently closed marine reserves advocated by Western conservation. Likewise, a species taboo may prohibit an individual from eating a particular species, but may not prevent that individual from capturing or killing the species. Practical differences such as these can have implications for how these systems affect the ecosystem, but perhaps more importantly, differences between Western and traditional

conservation are deeply rooted in cultural concepts and norms, including the very concept of conservation.

Resource economists and evolutionary ecologists suggest conservation is the sacrifice of short-term costs for long-term benefits (Ruttan & Borgerhoff Mulder, 1999 summarizing Clark 1973, Hames 1987, 1991, Rogers 1991; Smith & Wishnie, 2000). Ruttan and Borgerhoff Mulder (1999) suggest four principal conditions necessary for conservation: 1) the ability to exclude outsiders; 2) a mechanism within the group to exercise restraint (including sanctions for cheaters); 3) a mechanism by which offspring can inherit resources and benefit from conservation; and 4) no alternative forms of investment leading to higher rates of return than the conserved resource. In the context of Melanesia, customary marine tenure and traditional reef management practices can address the first three of Ruttan and Borgerhoff Mulder's principal conditions. However, the fourth condition will clearly vary from site to site depending on local socioeconomic circumstances. Thus, the conditions necessary for conservation are clearly present in Melanesia, but are these systems meant to conserve?

Debates about whether traditional management regimes are meant to conserve remain contradictory and inconclusive. Considerable evidence suggests that pre-colonial Pacific Islanders significantly depleted both terrestrial and marine resources (Diamond, 1991; Jackson et al., 2001), which has been used to suggest a conservation ethic did not exist among these communities (Diamond, 1986). Alternate hypotheses speculate that through such resource shortages, island communities became acutely aware of their ability to deplete the environment and developed conservation practices that regulated resource use (Johannes, 1981, 2002a; Ruddle & Johannes, 1985a). Johannes (2002a) states:

> For islanders to have devised conservation measures, they first had to learn that their natural resources were limited. They could only have done so by depleting them…If a culture never exceeded the sustainable limits of its natural resources then we should not expect it to have developed a conservation ethic. Moreover, those cultures that did possess such an ethic must have over harvested their natural resources earlier in their history. How else could they have learned that their natural resources had limits? This is not knowledge our species is born with.

In the Pacific, traditional forms of resource management are not always consciously practised as a conservation technique (Berkes et al., 2000; Hooper, 1985; Polunin, 1984; Ruttan, 1998; Wright, 1985). Often they are embedded in ceremonies, religion, dietary restrictions, and other traditions. For example, within the New Ireland province of PNG, prohibitions on fishing or gleaning within a specific reef area are practised following the death of a community leader, landowner, or other person of significance (Wright, 1985). After sufficient time (which can last anywhere from several months to 6 years), the taboo is lifted and the area is harvested for a feast which marks the end of the mourning period. Thus, the explicit intent of the taboo is to provide fish for a ceremony, but rebuilding fish stocks within the closure is clearly an implicit goal.

Other examples exist of limited access to spiritual places (McClanahan et al., 1997; Wright, 1985) and closures that facilitate ceremonial exchanges (Cinner et al., in review-b). In such scenarios, access to resources are limited for the economic, social, and physical well-being of coastal residents, rather than preservation of resources (Wright, 1985). Thus, although resources are consciously improved by these practices, conservation in the Western sense is but a by-product of other economic, spiritual, or social needs (Ruttan, 1998).

Differences also exist between the conceptually linear nature of western thought (and conservation) and the cyclical nature of Melanesian systems. Needs and relationships in Melanesia are often cyclical (Foale & Manele, 2004). For example, cultural obligations such as bride price ceremonies and feasts require the periodic accumulation of relatively large sums of resources to be redistributed. Traditional reef closures are sometimes implemented for periods of several months to years to build up a stockpile of resources for occasions such as feasts (Foale & Manele, 2004; Wright, 1985). Resources within the closure are then collectively harvested and afterward the area is open to harvesting.

This approach contrasts strongly with Western ideas of sustainable management that attempt to achieve a steady flow of benefits. For example, marine reserves seek to provide benefits to extractive users by maintaining resources inside the reserve and

increasing fishing yield outside the core through a spill over of fish to adjacent areas (Russ et al., 2004). This steady flow of benefits fits the economic and cultural needs of Westerners. For example, a Western fisher may have the need for a steady stream of income to repay monthly boat loans. Foale and Manele (2004) note that the traditional model is akin to saving money then spending it all and the western model is akin to keeping money in the bank and living off the interest.

This concept of Melanesians not maintaining capital is further compounded by cultural wealth distribution mechanisms (Foale & Manele, 2004). In Melanesia it is difficult for individuals to stockpile wealth because of cultural norms that require individuals to gain repute through perceived generosity (Carrier, 1987; Foale & Manele, 2004). Attempts at accumulating or maintaining personal wealth are often perceived as greedy by kin and community members and are met with social stigma. Therefore, the accumulation of wealth to meet obligations such as bride price requires periodic cooperation between loosely connected social units (Foale & Manele, 2004 citing Brooks, 1996). Carrier and Carrier (1989b) note that cooperation has to be induced rather than commanded. Thus, securing adequate resources for cyclical obligations involves the accumulation and expenditure of social as well as natural capital.

Thus, traditional management practices can conserve resources and the conditions necessary for conservation are present in Melanesia, but traditional conservation practices and engagement in cooperative behaviour is often to meet the cyclical needs of communities. This results in both practices and expectations that contrast strongly to linear systems of Western conservation. Western conservationists working in Pacific communities may need to either design strategies to reflect local values and practices or somehow change these values.

3) How are traditional management practices related to social and economic factors?

The ability of traditional management to fulfil conservation objectives is just a part of the larger debate as to what type of role traditional management can play in the modern

conservation context. If these systems are to provide a foundation for national and regional reef conservation in the Pacific (Hoffmann, 2002b; Johannes, 2002d), it is also important to understand whether these systems will be resilient to the intense demographic, social, and economic changes forecasted for the region (UNEP, 2002). Anecdotal evidence suggests that traditional management systems may die out in response to factors such as increased commercialisation of resources and the breakdown of traditional authority (Hoffmann, 2002b; Johannes, 1978; Thomas, 2001). Traditional management systems may be effective common-pool resource management institutions in situations of relatively low population density and subsistence economies, but may be rendered ineffective when these conditions change (Pollnac & Johnson, in press; Watson, 1989). For example, in a study of how resource management systems have evolved to reflect specific socioeconomic circumstances, Watson (1989) notes that there may be social, economic, and environmental consequences for societies that continue to rely on traditional systems of resource management when undergoing socioeconomic transformations. Watson (1989) found that severe social and environmental problems arose in Sarawak, Malaysia when traditional shifting cultivation management techniques broke down under market and population demands. The first step in understanding whether traditional management systems will be able to withstand or adapt to forecasted socioeconomic changes (e.g., UNEP, 2002) is determining how these and other common property regimes are related to socioeconomic factors.

Extensive theoretical and empirical research has shown that resource management institutions can be influenced by social and economic conditions (Henrich et al., 2001; Ostrom, 1990; Ostrom et al., 1999; Pollnac et al., 2001a; Pretty, 2003; Zanetell & Knuth, 2004). For example, in a study of the socioeconomic factors leading to successful community-based management of coral reefs in the Philippines, Pollnac et al. (2001a) found that factors such as small populations, a perceived crisis in the fishery, the presence of alternative income projects, and a high level of community participation in decision-making were related to the success of reef governance institutions. Research also indicates that socioeconomic factors influence traditional management (Aswani, 1999, 2002; Baines, 1989; Cox & Elmqvist, 1997; Harkes & Novaczek, 2002; Hviding, 1996,

1998; Pollnac & Johnson, in press; Watson, 1989). For example, Harkes and Novaczek (2002) also found that small populations were related to the presence of traditional reef management institutions in Eastern Indonesia.

Conclusions as to the importance of specific factors and how traditional management systems respond to them are not united, particularly for traditional management systems. For example, Watson (1989) and Evans et al. (1997) discuss how changing socioeconomic conditions, such as a drop in market price for cash crops, can render resource management strategies ineffective and inappropriate. Alternatively, Hviding (1996) documents how marine tenure rules became more exclusive for both commercial and subsistence activities in the Morovo Lagoon in response to increased prices of particular shells. Thus, while numerous studies have suggested that socioeconomic factors may be related to a community's ability to employ or maintain traditional management regimes, conclusions regarding specific relationships between socioeconomic conditions and traditional management practices remain unclear. A thorough review of the socioeconomic factors thought to be related to the management of common-pool resources will be presented later in this chapter.

Furthermore, much of the empirical research that has been conducted to date on how socioeconomic factors influence traditional management systems has utilised a case study approach, which does not allow the examination of the broader trends and system dynamics that are necessary to incorporate these systems into national and regional resource management planning. The few comparative studies that have addressed factors influencing common property institutions are marred by insufficient replication. For example, Aswani's comparison of marine tenure in the Roviana and Vonavona lagoons in the Solomon Islands provide a model for how socioeconomic and historical factors can result in three marine tenure patterns (Aswani, 1999, 2002). Aswani's speculation of how historical processes, socioeconomic factors, and demographic changes affect marine tenure in two coastal communities in the Solomon Islands suggest that market forces and other exogenous pressures will not necessarily transform customary marine tenure institutions into open-access regimes (Aswani, 1999, 2002). While insightful and well

presented, these studies were not sufficiently replicated to warrant applicability of the author's conclusions or models of marine tenure beyond the specific lagoons he studied. Thus, there is a clear need to move beyond the case study approach and examine whether socioeconomic factors influence traditional management over a broader geographical scale.

There is a lack of clarity on which factors are related to the implementation of traditional management and whether these factors operate over a broad spatial scale. This research gap suggests the need for an exploratory study that examines how traditional management is related to socioeconomic conditions over a broader spatial scale. This need is articulated by Pollnac and Johnson (in press), who develop theoretical and methodological priorities for research into traditional management. They conclude that there is a need for an exploratory approach that identifies the factors underlying traditional management. Likewise, in developing a theoretical and methodological framework for commons research, Agrawal (2001) claims that there is a need for theoretically-driven case studies to narrow the range of potential variables that scholars examine but also a "need to conduct large-N studies to identify the strength of causal relationships. Only then will it be possible to advance our understanding of how institutional sustainability can be achieved in the commons." This thesis will use both a comparative approach to examine whether and how the implementation of traditional management is related to certain socioeconomic characteristics and follow up with a case study approach to explore these differences in more detail.

A Theoretical Framework for Exploring the Role of Socioeconomic Factors in the Implementation of Traditional Management

Models of resource governance

For centuries, the dominant ocean governance paradigm in Western society embraced the notion that the marine environment was open to anyone wishing to exploit it. In 1609,

Hugo Grotius provided the intellectual foundation for the notion of the sea as an open-access resource with his thesis *Mare Liberum* (The Freedom of the Seas) (Grotius, 1609). His basic premise was that the sea could not be owned because occupation was the basis for property and the sea was not amenable to occupation. Although there were philosophical opponents to Grotius' notion, such as Selden (1652), his theory became widely adopted because open-access of marine space and resources provided a foundation for colonial trade, an expanding European fishing industry, and naval strategy (Ruddle & Akimichi, 1984). Grotius' doctrine remains deeply imbedded in the social and legal fabric of Western society.

However, by the 1830s, over-exploitation of open-access resources and the associated economic and environmental problems started to become apparent (McCay & Jentoft, 1998 citing Lloyd, 1977). In 1968, Hardin's definitive article on common property "*The Tragedy of the Commons*" (Hardin, 1968) demonstrated that from an economic point of view, it was in the interest of the individual to over-utilise resources under a common property system, as the benefits of such action rest almost entirely with the individual, while the burden is shared with the entire group of users. These characteristics have the potential to create incentives for individualistic behaviour that results in resource degradation. Hardin's theory suggests that the physical and legal accessibility of a common property system provides few incentives for users to limit their extractive effort, as this will only enable others to take more (Bee, 1990; Hviding, 1996).

Other models, such as Olsen's "Logic of Collective Action" (Olson, 1965) and the prisoner's dilemma (see Ostrom, 1990), have also been used to illustrate the collective action phenomenon that actions pursued in the best interest of the individual may run contrary to the interests of the larger society (Ostrom, 1990; Ruttan, 1998). The "Logic of Collective Action" suggests that unless individual's actions are noticeable or a coercive mechanism guides people toward pursuing common interest, then potential increased benefits of collective action are not enough and individuals will tend to act in self, rather than group interest (Olson, 1965; Ostrom, 1990). The prisoner's dilemma is an experimental game devised to examine cooperative behaviour in which individuals that

cannot communicate must decide to cooperate with each other or cheat. The payoff structure is lowest for mutual non-cooperation, medium for joint cooperation, and highest for one person who does not cooperate while others cooperate (Dietz et al., 2002; Ostrom, 1990; Ruttan, 1998). This game theory suggests that in an open-access situation there are incentives for individuals to not cooperate (i.e., cheat) while others cooperate.

The "Tragedy of the Common's," the "Logic of Collective Action," and the prisoner's dilemma all illustrate the problem at the heart of most common property debates: free riding. Free riding is when an individual obtains the benefits of collective action without contributing to the costs (hence free riding on the efforts of others). The problem of free riding occurs when people that do not contribute to the costs of collective action cannot be excluded from obtaining the benefits of collective action, and are thus motivated to free ride on the efforts of others (Ostrom, 1990). The importance of these models in the development of common property theory is that they demonstrate how individuals pursuing perfectly rational decisions can produce irrational outcomes such as degradation of the resource base upon which one is dependent (Ostrom, 1990).

Interpretations in fisheries management and ocean governance

In the fishery sector, rational decisions based on these models are said to drive intense competition among fishers, over-capitalisation, and over-exploitation of fish stocks (Hviding, 1996). Hardin later proposed that the two solutions to common property management regimes were either privatisation or socialism (Hardin, 1978). Both the problems and solutions proposed by Hardin became widely accepted and have had profound influences on natural resource management (Ostrom, 1990), particularly fisheries policy (McGoodwin, 1990) and ocean governance.

By the 1980's, Hardin's theory provided the rationale for an international movement to reduce the oceanic commons, and partially replace them with extended offshore jurisdictional zones controlled by states. In 1982, the United Nations Convention on the Law of the Sea (UNCLOS) began dismantling Grotius' doctrine of a free sea by

delegating stewardship of areas that were previously commons to states (Ruddle & Akimichi, 1984). Articles 55, 56, and 57 of UNCLOS established the Exclusive Economic Zone (EEZ) which extended coastal state jurisdiction from three nautical miles up to 200 nautical miles. Within the EEZ the coastal state has sovereign rights for the purpose of conserving and managing living resources and protecting the environment (United Nations Convention on the Law of the Sea, 1982, articles 55, 56, 57).

Hardin's theory also formed the conceptual basis for other fisheries policy interventions such as Individually Transferable Quotas (ITQs) which essentially privatize shares of marine resources. The ITQ system assigns fishers a fixed share of the annual quota to sell, use, or not use at their discretion. In some fisheries such as the United States north Pacific halibut fishery, the ITQ system has reduced intense competition and economic waste by abolishing the need for a derby-like open season (Ostrom et al., 1999). This has resulted in improved fisher safety and a better product for consumers because the fish can now be harvested year-round and sold fresh, rather than harvested in a single day and sold frozen (Ostrom et al., 1999).

Critique of "The Tragedy"

Despite the widespread acceptance of "The Tragedy of the Commons" and the prisoner's dilemma as a foundation for fisheries policy, there is a wide body of literature that argues against the universal validity of these model in common property systems, particularly in the fisheries. The arguments generally revolve around three main points: 1) these models contain unrealistic assumptions (Ostrom, 1990); 2) some common property regimes have rules restricting the use of the commons which do not allow individuals to become entrapped in the "Tragedy" (Hviding, 1996; McGoodwin, 1990; Ostrom, 1990; Rose, 1997); and 3) cultural traits and psychocultural adaptations of fishers and fishing communities often violate the behavioural assumptions in Hardin's model (Carrier, 1987; Poggie, 1978). In a critical review of applicability of "The Tragedy of the Commons" to fisheries, McGoodwin (1990 p.93) states "the commons, it turns out, does not mean the

same thing in all fisheries, and the behaviour of fishers everywhere does not conform with what [Hardin's] model predicts."

Both Hardin's "Tragedy of the Commons" and the prisoners dilemma contain several extreme assumptions that make their applicability somewhat unrealistic in many situations. These models assume that participants will not communicate with each other, other participants will not notice over-use and impose economic or social sanctions against offenders, and most importantly that participants are unable to change the rules of the situation (Ostrom, 1990; Ruttan, 1998). In reality, participants can communicate with each other (particularly in smaller communities), other participants may notice over use and socially alienate offenders, and in many situations, users are able to change the situation by adopting rules limiting access to resources. Therefore, interpretation of these models must be done with the understanding that they represent what may happen in a specialized set of circumstances which rarely reflects reality.

The most obvious argument against Hardin's model is that although collectively owned, some common property systems limit entry (Carrier, 1987), have rules that govern the use of the commons (Hviding, 1996; McGoodwin, 1990; Ruddle & Akimichi, 1984), and even provide incentives for reserved use of common resources (Ostrom, 1990; Rose, 1997). In these situations, Hardin's model is clearly not applicable. Thus, debates sparked by Hardin's thesis have led to a clear distinction between systems of management and systems of ownership (Rose, 1997). Hardin himself later regretted not distinguishing between managed and unmanaged commons in his original article (Hardin, 1998). It is now widely understood that while ownership of a resource may be common, access to the resource may not be open (Larmour, 1997a). The distinction between open-access and common property is critical because these two systems require profoundly different policies to effectively promote sustainable resource use. For example, Hardin's theory suggests that privatisation of resources is required to prevent overexploitation in a common property regime, however privatisation can actually undermine existing management regimes and exacerbate or create tragedies of the commons on customary land (McCay & Acheson, 1987).

These debates have also led to a distinction between concepts related to resources and concepts of property rights (Ostrom et al., 1999). Ostrom et al. (1999) and Berkes (1989b) note that common property is a system in which resource rights are held by a group of users while common-pool resources are natural or human resources which have the following defining characteristics: 1) they are difficult to exclude others from accessing and 2) exploitation by one user reduces the availability to others. It is these defining characteristics of common-pool resources, rather than the type of property rights, that make individuals following their short-term interests likely to produce outcomes unfavourable to anyone's long-term interest (Ostrom et al., 1999). Ostrom et al. (1999) suggest the term common-pool resource is used to refer to the resource system, regardless of the property rights involved.

A compelling case against the universal validity of "The Tragedy of the Commons" to fisheries is also brought forth by maritime anthropologists such as Carrier (1987), Poggie (1978) and Pollnac (1989) who find that some of the behavioural assumptions in Hardin's model may not be applicable to fishers or fishing communities. Carrier (1987 citing Gregory, 1982) notes how contrary to a Western materialist economy where individuals aim to accumulate wealth, Melanesian societies are frequently driven by a gift economy. In Melanesia, cultural ceremonies and gift exchanges act as wealth distribution mechanisms which can make the individual accumulation of wealth difficult. Instead, individuals aim to accumulate social capital by maximizing perceived generosity. Gift transactions, which can include providing access to marine resources, allow individuals to establish or maintain repute which is required for tasks ranging from buying commodities to gaining cooperation in building canoes or houses. Thus, decisions to exploit or not exploit marine resources may be driven by the desire to gain social standing, pay back a favour, create obligation, or exert the discretionary prerogative not to cooperate rather than economic gain. Poggie (1978) finds that fishers in a small-scale fishing village in Puerto Rico are more likely to defer gratification than non-fishers. Pollnac (1989) concludes that among fishers deferred gratification varies with income. McGoodwin (1990 p. 92-6) provides a thorough review of other ethnographic case studies that refute Hardin's behavioural assumptions. These studies suggest that due to

cultural traits and psychocultural adaptations, fishers will not necessarily try to maximize their individual short-term benefits as Hardin's model assumes. Thus, the behavioural assumptions used in Hardin's model are the extreme, rather than the norm.

Recent literature also suggests the importance of resource users' perceptions in defining common property problems. In a critical review of the universal validity of rational choice logic that forms the basis for Hardin's model, Burke (2001) concludes that commons dilemmas are limited to scenarios where there is an understanding that anthropogenic activities can degrade natural resources. Without this often overlooked basic understanding, there is no rational choice between individual benefits and collective ruin, thus no commons dilemma. Burke does not suggest that common-pool resources do not become degraded under these circumstances, but rather that this degradation results from perceptions, not the commons, and policy prescriptions for commons may be ineffective. McGoodwin also suggests that factors such as transitions to colonial and global production modes are more likely to cause a tragedy of the commons in a fishery than the fisheries being open-access (McGoodwin, 1990 p. 94).

Thus, the contextual factors of a particular fishery, which can include the presence of common property management regimes, cultural norms governing individual behaviour, psychocultural adaptations, market integration, perceptions of coastal resources, and colonial legacy can have profound influences on both how individuals are able to organize themselves and how common-pool resources are utilised. This suggests that models attempting to explain the collective action of resource users should examine the situational context of the common-pool resource rather than just the internal decision-making of individual users based on rational choice theory. Thus, this thesis will examine the situational context of communities to explain how and why certain communities in Papua New Guinea cooperate to collectively manage coastal resources.

An alternative model: Theoretical frameworks to explore user-organized common property management regimes

Although Hardin's model was flawed in definitions and utilised extreme assumptions which make its applicability limited, it raised the issue that remains at the heart of almost every common property debate: what is in the best interest of the individual may not be in the best interest of the larger society. Hardin suggested that private or state interests were necessary for effective management of common property. However, common property theorists suggests that users themselves can effectively organize the use of common-pool resources (McCay & Acheson, 1987; Ostrom, 1990). A plethora of case studies from around the world illustrating how users can organize themselves to effectively manage common-pool resources can be found in Larmour (1997b), Ostrom (1990), Dyer and McGoodwin (1994), and Berkes (1989b). In the context of PNG, where marine tenure has been the dominant marine resource management paradigm for untold generations, private and state organisation of marine common-pool resources has played a negligible role. Thus, this thesis will focus entirely on how communities organize the use of near shore common-pool resources.

Common property theory suggests that the crux of the common property problem is organizing users so that "they adopt coordinated strategies to obtain higher joint benefits or reduce their joint harm" rather than acting independently (Ostrom, 1990 p. 39). This organisation requires the development of rules limiting access to resources that provide incentives (usually by assigning individual rights to, or shares of, the resource) for users to invest in the resource instead of overexploiting it (Ostrom et al., 1999). To ensure cooperation and avoid free riding, this organisation also requires mechanisms to ensure a credible commitment that resource users will follow the rules and effective monitoring of these commitments so that resource users are assured that others are also sacrificing potential gains from breaking the rules (Ostrom, 1990). Credible commitments and effective monitoring are particularly important because the costs of being involved in this organisation can be quite high and the benefits are shared by all, regardless of whether they share the costs (Ostrom, 1990).

There are many instances of successful user organisation of resources, and many more of unsuccessful organisation. The question of relevance to resource managers is "what enables some communities to effectively organize while others cannot?" In her pivotal book on governing common-pool resources, Ostrom (1990) uses a number of empirical case studies from around the world to compare long-enduring regimes with unsuccessful ones. From this comparison, Ostrom (1990) and Becker and Ostrom (1995) develop a set of common characteristics shared by long-enduring small-scale common property regimes; 1) clearly defined geographic boundaries and membership rights; 2) congruence between rules and local conditions; 3) individuals affected by the rules can participate in changing the rules; 4) monitoring of the resources; 5) sanctions that increase with repeat offences or severity of offences (graduated sanctions); 6) the presence of conflict resolution mechanisms; and 7) resource users have rights to make, enforce, and change the rules. Ostrom (1990) and Becker and Ostrom (1995) suggest that these characteristics will contribute to the success of common-pool resource management institutions.

Several researchers have developed conceptual frameworks for analysing common property regimes (Agrawal, 2001, 2002; Ostrom, 1990; Wade, 1994). For example, Ostrom (1990) suggests three driving factors in the decision to adopt, modify, or maintain common property rules: 1) potential benefits of the rules; 2) the costs of monitoring and enforcing the rules; and 3) the shared norms of the users. Each of these factors is comprised of a number of situational variables. For example, potential benefits of engaging in the cooperative management of common-pool resources can be influenced by the number of resource users, the size of the resource, and the presence of conflict (Ostrom 1990). It is by examining these situational variables that common property regimes can be analysed and compared.

The conceptual models of collective action developed by Ostrom (1990), Wade (1994) and Agrawal (2002) differ significantly from those posed by Hardin, Olsen, and the prisoner's dilemma because they "place emphasis on situational factors rather than assumptions made about the internal calculation process" (Ostrom, 1990 p. 193). The

emphasis on how situational factors, rather than internal decision-making, affect the management and use of common-pool resources is supported by theoretical developments in the aspects of economics (Rudd et al., 2003) and human ecology (Berkes, 1989a) that deal with common property. For example, rather than focusing on the traditional economic foundation of rational choice and its associated (and often unrealistic) assumptions about perfect information and the ability to use the information in production/consumption decisions, Rudd et al (2003) examine how the emerging field of 'transaction cost economics' can been used to directly examine how situational factors affect the efficiency of different governance regimes in managing coral reefs. Likewise, in a comparative study across 15 communities throughout the world, Henrich et al. (2001) found that socioeconomic factors such as market integration and pre-developed cooperative strategies were more important determinants in economic decision-making than rational choice. Henrich et al. (2001) found that the higher the degree of market integration and the higher the payoffs for cooperation, the more likely people were to engage in cooperative behaviour.

The emphasis that common property researchers such as Ostrom (1990) placed on situational factors is also supported by the broader theory in human ecology used to explain cultural differences in humans which postulates "cultures and practices may represent alternate stable systemic adaptations" (Berkes, 1989a p. 75). In the context of common-pool resource governance, this theory suggests that specific institutions have evolved to best solve the common-pool resource dilemmas based on prevailing local factors. The independent evolution of common property regimes throughout the world suggests that under certain circumstances, collective action is the optimal response to resource depletion (Berkes, 1989a). Furthermore, the diversity of these regimes throughout the world suggests that these solutions must be fine tuned to the local situational factors. The importance of examining situational factors becomes apparent when we return to the prisoner's dilemma. By changing the context of the dilemma so that players have a high probability of meeting each other again, a cooperative strategy based on reciprocity, rather than independent action can prevail (Berkes, 1989a citing Axelrod, 1984; Ruttan, 1998).

The conceptual models developed by Ostrom (1990) and others (i.e., Agrawal, 2001; Agrawal, 2002; Wade, 1994) were incredibly important as a theoretical framework that shifted common property focus from internal decision-making to situational factors. However, they provided only a general framework with which to begin researching how social and economic factors influence how common-pool resources can be managed. Ostrom (1990) states "What is needed is further theoretical developments that can identify variables that must be included in any effort to explain or predict when appropriators using small-scale [common-pool resources] are more likely to self-organize and when they are more likely to fail. Such theoretical development not only should provide more useful models but also, and more important, should give us a general framework that can help direct analysts' attention to important variables to be taken into account in empirical and theoretical work." This thesis will seek to build on theoretical and empirical developments on which socioeconomic variables influence how common-pool resources are managed in PNG.

Socioeconomic factors that may influence how common-pool resources are managed

A number of theoretical, case studies, and a few comparative works have further expanded our understanding of the factors influencing common property institutions (e.g., Agrawal, 2001; Aswani, 2002; Berkes et al., 2000; Dietz et al., 2003a; Pollnac et al., 2001a). Rather than challenging Ostrom's framework, these developments complement her work by expanding upon the depth and breadth of the situational variables. In particular, recent research highlights the importance of social capital (Pretty, 2003; Uphoff & Wijayaratna, 2000), demographic factors (Harkes & Novaczek, 2002; Pollnac et al., 2001a), conflicts (Adams et al., 2003), dependence on natural resources (Zanetell & Knuth, 2004), perceptions of the environment (Nazarea et al., 1998), and modernisation (including quality of life and commercialisation of resources) (Cinner & Pollnac, 2004; Stonich, 1992) in the governance of common-pool resources. This section

will examine how these socioeconomic factors are thought to influence the management of common pool resources.

Social capital

Social capital refers to the bonds and norms in a society, and includes factors such as relationships of trust, reciprocity and exchange, and cohesiveness of groups (Pretty & Smith, 2004). When social capital is high, people will be more likely to engage in cooperative behaviour because they have the confidence that others will also do so (Pretty, 2003; Uphoff & Wijayaratna, 2000). The social bonds and trust associated with social capital are thought to facilitate cooperation by reducing the transaction costs of working together (Pretty, 2003). Social capital may be increased by investments in social relationships, such as providing free support, information, or labour (Scheffer et al., 2002) and when resource users are involved in many situations together (Ostrom 1990). The strength of these social bonds may also be influenced by factors such as cultural/religious homogeneity (Aswani & Hamilton, 2004; Scheffer et al., 2002). Curran and Agardy (2002) suggest that migration may hamper collective action by disrupting the reciprocity and trust required to develop social bonds. Likewise, immigrants may not perceive the locally-developed rules, processes, and authorities governing common property to be legitimate, and thus may not comply with established rules (Sutinen & Kuperan, 1999). As the number of potential decision-makers increases, the costs of engaging in cooperative behaviour may also increase (Ostrom 1990). Thus, migration, participation in community organisations, and participation in decision-making may be indicators of social capital.

Population

Demographic factors, such as the number of resource users can influence the pressure on the resource (Pollnac et al., 2001a; Pollnac et al., 2000), potentially making resources more difficult to collectively manage (Harkes & Novaczek, 2002). For example, Pollnac et al (2001) found that increased population density negatively influenced reef health in the Philippines. The number of resource users can also influence the difficulty in

organizing, monitoring, and enforcing common property systems (Ostrom, 1990). For example, in an exploratory study of common property management in Eastern Indonesia, Harkes and Novaczek (2002) noted an absence of common property systems in communities with populations above 3000. As the number of resource users increases, the costs of activities such as monitoring may increase and the benefits of collective action may decrease.

Settlement Patterns

Settlement patterns of particular communities appear to have influences on their access to specific resources and social and political organisation, ultimately influencing whether and how they manage a common-pool resource (Aswani, 1999; Aswani & Hamilton, 2004). For example, Aswani (1999) and Aswani and Hamilton (2004) suggest that different settlement patterns resulted in different social organisation structures and different access to marine resources in the Solomon Islands, influencing whether and how certain communities could develop and maintain marine tenure regimes. Aswani and Hamilton (2004) state "contemporary differences in management strategies are, in essence, the result of people's historical and spatial patterns of settlement across the landscape and adjoining seascapes, and the attendant impacts of these patterns on property relations."

Dependence on resource

Recent research has also indicated that dependence on resources may be an important factor in peoples' willingness to engage in cooperative behaviour (Ostrom, 2000). Lise (2000) and Zanetell and Knuth (2004) found that participation in common property management systems was positively related to dependence on resources. These empirical studies and the theoretical work of Agrawal (2001) suggest that high dependence on resources will likely be related to successful commons institutions. Reliance on resources for food and/or income, ownership of harvesting equipment, and effort allocated to resource extraction may be indicators of dependence on resources (Bunce et al., 2000; Zanetell & Knuth, 2004).

Markets

Markets can have profound influences on how common-pool resources are used and managed. A wide range of literature highlights the varying roles of markets in the overexploitation or management of resources and the potential range of scales at which these influences can occur (King, 1997; Kremen et al., 2000; Marquette et al., 2002; Siar, 2003; Wickramasinghe, 1997). For example, Johannes (1978) documents how the introduction of money economies led to weakening of traditional common property management in the Pacific. Likewise, Carrier and Carrier (1989b) document how an increase in trochus prices led to the decentralisation of harvesting rights on Ponham Island in PNG. Alternatively, other researchers have found that commercialisation of resources can create incentives for excluding others from accessing resources (Hviding, 1996; Ruttan, 1998). Bunce et al. (2000) suggest that the distance to markets can be an effective indicator of the extent that resource users' are linked to markets.

Occupational mobility

Pollnac (1998) suggests that occupational mobility, which is the ease of movement between different occupations, may also be important in governing common-pool resources. If a specific management strategy required limiting production of the resource for a period of time (for example, a fallow period), peoples' involvement in this strategy would partially depend on their ability to engage in alternate occupations. Pollnac (1998) suggests that the availability of alternate occupations could be used as an indicator of occupational mobility. Thus, indicators of occupational mobility might include a high number of occupations that a household is engaged in and involvement in economic activities that can be easily adopted or discarded as the situation requires, such as informal activities (e.g., casual labour).

Size of resource

The size of the resource being managed may influence the difficulty in devising collective governance regimes to manage it (Agrawal, 2001 citing Wade, 1988; Ostrom,

1990; Ostrom et al., 1999). Ostrom et al. (1999) and Ostrom (1990) suggest that the larger the resource system, the more difficult it may be to collectively manage the resource, particularly situations such as the marine environment where high resource mobility (for example, the migratory nature of some fish) make it difficult to measure the amount of resources available for allocation.

Conflicts

Conflicts over resources may also be a factor in whether and how people can effectively engage in cooperative behaviour (Adams et al., 2003; Carrier & Carrier, 1991; Dietz et al., 2003a) and can negatively affect the success of common-pool resource management (Christie et al., 2003). Ostrom (1990) suggests that the amount and type of conflicts can reduce the potential benefits of engaging in cooperative behaviour. McClanahan et al. (1997) noted that excessive conflicts among stakeholders in Kenya made cooperative involvement in resources between fishing communities and the Kenya Wildlife Service impossible. In a study of conflict resolution mechanisms in customary marine tenure systems in the Solomon Islands, Foale and Macintire (2000) found that areas were particularly susceptible to poaching when conflicts arose over ownership because no-one could claim rights of exclusion until the dispute was resolved. Conflicts can arise among stakeholder groups (for example, fishers that use different gear types), between different types of stakeholders (for example, tourism operators and fishers), and between varying levels of local, regional, or national agencies attempting to manage common-pool resources (Christie, 2004; Christie et al., 2003; McClanahan et al., 1997).

Modernisation

The degree to which people adhere to traditional lifestyles and practices may influence their involvement in traditionally-based management of common-pool resources. Factors such as lifestyle and access to markets can influence how individuals and communities use natural resources, and thus their willingness and ability to engage in collective behaviour. For example, Evans et al. (1997) note how the replacement of subsistence economies (in which resources were shared) with cash-based economies, urbanisation,

and the breakdown of traditional authority may have led to the collapse of traditional common-pool resource management systems in the Pacific. Alternatively, in an ethnographic account of marine resource governance in the Solomon Islands, Hviding (1996) documents how by placing a monetary value on specific shells, market forces strengthened community claims to common property. Thus, indicators of a modernized lifestyle and proximity to markets may be useful in determining whether and how modernisation influences common-pool resource management.

Perceptions of the environment

Local perceptions of the natural environment can have profound implications on how common pool resources are used and managed. For example, in a study on perceptions of natural resources in the Philippines, Nazarea et al. (1998) note how perceptions of natural resources can determine whether a resource is used, dismissed, or actively exterminated. Likewise, in a similar study in Indonesia, Pollnac (2000) discusses how community perceptions of natural resources can have significant implications on how those resources are managed. Common understandings of resource dynamics (e.g., what can affect and/or improve the conditions of resources) can make collective management of common-pool resources easier (Ostrom, 2000; Ostrom et al., 1999). It might also be expected that engaging in cooperative behaviour to restrict use of a common pool resource may be unlikely in situations where prevailing perceptions are such that people do not believe their actions can influence the environment. Involvement in cooperative behaviour or decisions to limit resource use may also be influenced by expectations of future benefits or returns (Ostrom 1990). These actions may be influenced by peoples' expectations of the condition of the resource and their past observations of resource conditions. For example, communities that observed past declines in their resources or expect future deterioration may be inclined to implement or support traditional management or other common property arrangements (Johannes, 2002d). On the other hand, communities that are engaged in common pool management may believe that the closure is sufficient to sustain the condition of resources, and may not perceive or expect a decline in resource conditions. Thus, perceptions of human-environment interactions and expected condition

of the environment may be useful indicators in examining how perceptions of resources may influence involvement in common pool resource management.

Leadership

The skills and assets of leaders can also clearly impact whether or how a common-pool resource is managed (Ostrom, 1990, 2000). A number of researchers note the importance of local leaders in the development and maintenance of common-pool resource governance (Harkes & Novaczek, 2002; Hviding, 1983; McClanahan et al., 1997; Pollnac et al., 2001a). For example, Harkes and Novaczek (2002) found that legitimate and strong leadership can influence whether communities in the Eastern Indonesian province of Muluku implement traditional common-pool resource management. Likewise, Pollnac et al. (2001a) note how supportive local leadership can influence the success of community-based resource management initiatives.

Other factors

There are a number of other factors that may influence how common-pool resources are governed, For example, Ostrom (1990) suggests that the temporal and spatial variability of a resource may influence how it is governed. Cultural factors such as social structure of a community and social factors such as reciprocity and trust have also been identified as important factors in whether and how people manage common-pool resources (Carrier & Carrier, 1989b; Ostrom, 1990). For example, Carrier and Carrier (1989b) describe how social structure on Ponham Island influences rights to access specific fishery resources.

Summary of socioeconomic factors influencing common-pool resource management

A number of situational factors were identified as having the potential to influence common property management, including: social capital, dependence on resources, modernisation, perceptions of the environment, conflict, population, settlement patterns, the size of the resource, occupational mobility, leadership, variability of the resource, social structure, and other factors. In some instances, the directionality of influence these

factors have on common property regimes is clear. For example, the likelihood of successfully managing a common-pool resource would be expected to increase with higher social capital. Alternatively, as the size of the resource and the population of resource users increases, one would expect the successful management of a common-pool resource to become more difficult. Other factors, such as perceptions of resources could have varying influences depending on the type of common-pool resource and the specific aspect of perceptions being measured. Figure 1 illustrates the situational factors thought to influence common-pool resource management and highlights the expected directionality. An expected positive influence is indicated by "+", an expected negative influence is indicated by "-", and an unknown influence is indicated by "?". Although this is by no means an exhaustive list of every potential factor that may influence how common-pool resources are used and managed, by building on the conceptual frameworks of Ostrom (1990) and others (Agrawal, 2001, 2002; Wade, 1994), it provides a theoretical and empirical foundation for an exploration of the factors related to common-pool governance. This thesis will use this framework as a guide in selection of indicators thought most likely to influence governance of common-pool resources in PNG. It should be noted that, depending on the specific research context, certain factors may be relevant to every study. Chapter III will discuss why some these factors (e.g., resource variability and leadership) were not incorporated in this specific study.

Figure 1. Conceptual diagram of situational factors influencing the management of common-pool resources.

Summary

In parts of Melanesia and the wider Pacific, user-defined common property institutions, called traditional management, are being promoted by governments and NGOs (Johannes, 2002c, 2002d). Conclusions of empirical studies suggest that although traditional management systems may not be intended for conservation, they can conserve some aspects of fishery resources. As a result, traditional management is making a resurgence and is forming the basis for modern fisheries management and conservation strategies (Hunt, 1997; Hviding, 1996; Johannes, 2002c, 2002d; King & Faasili, 1999). However, the resurgence of traditional management in the region is not supported by a solid theoretical understanding of the social, economic, and cultural mechanisms that allow these systems to operate. Theoretical and empirical studies have found that socioeconomic factors appear to influence the ability of communities to employ or maintain common-pool resource management regimes (Henrich et al., 2001; Ostrom,

1990; Ostrom et al., 1999). Understanding the relationship between traditional management and local socioeconomic conditions is a crucial first step in determining the applicability of these systems in the conservation context.

What is needed is a comparative study that explores the socioeconomic factors underlying involvement in traditional management (Pollnac & Johnson, in press). Despite an unclear understanding of which and how socioeconomic factors influence how individuals and communities cooperate to sustain common property regimes, this chapter identified several socioeconomic factors that are either reoccurring or well documented in the literature. These factors include: social capital (Pretty, 2003; Pretty & Smith, 2004; Pretty & Ward, 2001; Uphoff & Wijayaratna, 2000), modernisation and market conditions (Harkes & Novaczek, 2002; Henrich et al., 2001; Hviding, 1983, 1996), population and settlement patterns (Aswani, 1999, 2002; Ostrom, 1990), perceptions of the resource (Burke, 2001; Ostrom, 1990), conflict (Adams et al., 2003; Dietz et al., 2003a) and dependence on marine resources (Ostrom, 1990; Zanetell & Knuth, 2004). Although specific relationships of how these socioeconomic factors are related to traditional management systems are not well understood, particularly over a broad spatial scale, these factors provide a good starting point for exploratory studies into the socioeconomic factors influencing traditional management. It is hoped that by studying how these long-enduring traditional management systems may be adapted to prevailing socioeconomic, insights may also be gained in how modern conservation strategies could achieve better success by better reflecting socioeconomic conditions.

CHAPTER III. RESEARCH METHODS

This study examines how the presence of traditional reef management is related to socioeconomic factors. The previous chapter provided both a theoretical and applied rationale for an exploratory investigation over a broader spatial scale and identified specific socioeconomic factors likely to influence the implementation of traditional management. This chapter begins with a detailed description of the operations used to gather information about socioeconomic conditions and resource governance regimes in 14 coastal communities in Papua New Guinea (PNG). This chapter includes the general methods used to select both the communities and people surveyed followed by a description of the how each specific indicator used in the study was collected. A description of the methods used to analyse these indicators is presented separately in Chapter V.

Data Collection Techniques

To determine the local social, economic, and cultural factors influencing coastal resource use and governance, research was conducted into the socioeconomic and resource governance conditions in 15 communities throughout PNG (14 study sites and a pilot site). It should be noted that Tubusereia (in the Central province) was the first community studied and it was treated as a pilot site. The use of a pilot study provided an important opportunity to gather emically derived information (Poggie, 1978), such as what material possessions would make an effective modernisation scale based on material style of life, to test and refine questions in both Pidgin and English, and to gain a basic knowledge of the issues affecting marine resources in PNG. Although Tubusereia is a large village and not necessarily representative of other sites, it was an appropriate pilot site because of the complexity of the issues there and the proximity to Port Moresby (which provided opportunities to discuss the issues with experts at the University of Papua New Guinea, the National Fisheries Authority, and the dive tourism industry). The pilot study was an important part of assessing the issues affecting coastal resource use and management in

PNG and as a result, several questions were refined to be more effective and a few questions were added to address issues that came up during the pilot study. The pilot site was not included in the final analyses because the modified and additional questions made many of the pilot surveys not directly comparable to the revised surveys. Thus, only 14 communities are included in the analysis.

Field research for the pilot study and 12 of the sites occurred between October 2001 and June 2002. Research took place over one to three weeks per community using one to two trained local assistants to aid in data collection. Data at the two remaining sites (Madina and Fissoa) were collected by a trained research assistant between December 2002 and January 2003.

Study sites were purposively selected to encompass a wide range of social, economic, demographic, and resource management conditions (Agrawal, 2001). Random selection of coastal communities was not appropriate because the exploratory nature of the research required the incorporation of a wide range of socioeconomic conditions and traditional management regimes; the full spectrum of which may not have been available with a random sample of 14 communities. Agrawal (2001) notes that random selection of cases is often unrealistic in commons research and that intentional selection that ensures variation in independent variables will allow for causal inferences with relatively low levels of bias. Based on the fact that the communities were purposively instead of randomly selected, these communities are not considered a representative sample of coastal communities in PNG. Therefore, the conclusions drawn from this study are not necessarily applicable outside of the study sites.

Data collection consisted of a variety of quantitative techniques (e.g., systematic household surveys) and qualitative techniques (e.g., semi-structured interviews with key informants and recording of oral histories) to gather information and triangulate results. Household surveys were used to gather 16 of the 21 indicators examined at each site, while a combination of techniques were used to collect the remaining indicators (discussed below). Between 13 and 51 household surveys were conducted in each

community for a combined total of 506 surveys throughout the study (Table 1). Household sampling was based on a systematic sample design, where a sampling fraction of every i^{th} household (e.g., 2^{nd}, 3^{rd}, 4^{th}) was determined by dividing the total number of households in the community by the target sample size (de Vaus, 1991; Henry, 1990). The target sample size (i.e., number of households surveyed) in each community was determined by the time and resources available (e.g., number of assistants and number of days available to conduct the surveys).

Table 1. Number of Household Surveys per Community

Community	# of surveys	Community	# of surveys
Ahus	51	Madina	32
Andra	44	Mongol	28
Enuk	33	Muluk	41
Fissoa	30	Nusa Lik	13
Gabagaba	38	Patanga	41
Kilu	40	Riwo	37
Kranket	37	Wadau	41

Key informants were asked how one could define a household and several agreed that a single economic unit would share meals (i.e., have dinner together), which was adopted as the definition was used to delineate households. Therefore, for the purposes of this study, a household was defined as a relatively independent economic unit that may span multiple physical structures. For example, in some communities, a husband would live in one house with the sons and the wife would live in another house with the daughters. Although these were structurally separate, they were a single economic and decision-making unit and were considered one household.

In each household, the head of the household was interviewed. This could either be a male or female. In circumstances where the head of the household was not available, another adult from the household was interviewed. Interviews generally took between 25 and 40 minutes per household. Since household heads in many of the areas of PNG

studied were typically male, this resulted in 67% the respondents being male. Although this potentially introduced gender bias to the sampling, the needs and concerns specific to women were highlighted through female focus groups. A female Papua New Guinean facilitated open discussions loosely based on a set of questions (see "women's focus group" discussion guidelines in Appendix I).

Detailed descriptive assessments, adapted from the Rapid Rural Appraisal (RRA) framework (Chambers, 1983, 1994a) were used to verify the accuracy of the information gained from household surveys and to provide insights into the social, economic, and cultural context of resource use (Bunce et al., 2000). These assessments included semi-structured interviews with community leaders and resource users, recording of oral histories, transect walks (walking through the village with a community member to identify and verify issues), participant observations, daily and seasonal time-use analyses, women's focus groups, and analyses of secondary sources such as population censuses and fisheries records. Bunce et al. (2000) provide perhaps the most detailed and user-friendly description of these techniques and their application to coastal resource management.

Structured interviews of "key informants," such as community leaders, resource users, government officials and NGO employees were used to provide a more detailed examination of select issues, particularly resource use, governance, and compliance. Non-probability sampling techniques, including convenience sampling (for example, a respondent may be approached during resource use activities) or snowball sampling (where community members will suggest appropriate respondents) (Henry, 1990) were used to select key informants. Between 3 and 15 key informant interviews were conducted in each community. Several of the questions pertaining to perceptions and uses of coastal resources were identical to those posed in the household surveys, but these were generally followed up by more detailed questions. All survey forms (household, key informant, community leader, and women's focus groups) are presented in Appendix I.

Coastal Resource Governance Regimes

Resource user and community leader key informants were asked about the presence of traditional reef management and customary marine tenure. In particular, restrictions on where, when, or how people were allowed to harvest marine resources, whether certain species were *tambu* (not able to be consumed or sometimes touched by certain clans or lineages), and whether or not anyone was excluded from harvesting marine resources from the community's tenure were examined. Concordance between several respondents was required for the regime to be considered active.

Spatial restrictions included no-fishing areas and gear restrictions within a delineated area. These included gear restricted areas (where the use of specific gear were limited within a delineated area) and periodic closures (temporary closures that were periodically instated). Separate from the gear restricted areas were gear restrictions that limited who could use certain gear. Although not well enforced, the use of poison and explosives for fishing is illegal under national legislation, so additional local restrictions on these fishing techniques were not considered a management regime.

Three classifications of marine tenure were developed: strong, moderate, and weak. Weak tenure regimes included sites where anyone was permitted to fish on community reefs. These were typically areas where the community had migrated during colonial times and did not have traditional rights to marine resources or where the community had acquiesced from excluding people from harvesting resources from their customary areas. It should be noted that weak tenure does not equate to an open access system. For example, although anyone was allowed to fish in these areas, dive operators paid traditional owners in Kranket and Mongol to access dive sites located within their tenure. Moderate tenure regimes included sites where neighboring communities could fish on community reefs, but "outsiders" (i.e. people from farther away) had to seek permission (which they were not necessarily granted) to harvest fishery resources. For example, the community leader from Kilu claimed "People from Patanga (the neighboring community) can come here can come without restriction. People from town can troll outside [the reef], but if they come inside [the reef] people here will be cross." Strong tenure regimes

included sites where all non-owners were excluded. Non-owners could include both neighboring communities and sometimes community members who did not have rights to the specific resource. In areas with strong marine tenure regimes, marine resource could be owned in common by the community, by specific clans, or by individual families. Although important, the detailed genealogy that frequently is often presented with anthropological studies of marine tenure (e.g., Foale & Macintyre, 2000) simply could not be gathered in the timeframe of the research and was not included.

Socioeconomic Factors

This thesis is exploratory in nature, so data were collected on a range of factors that were believed to be related to traditional and common property management in PNG. A number of these factors were identified in Chapter II. These were: social capital, dependence on resources, modernisation, perceptions of the environment, conflict, population, settlement patterns, the size of the resource, occupational mobility, leadership, variability of the resource, social structure, and other factors.

The comparative nature of this study meant that there was a very limited amount of time spent in each community, so not every factor could be examined in the scope of this study. Some of the factors identified in Chapter II were not particularly relevant to this study. For example, resource variability may be an important factor to examine in situations where different resource conditions are being compared or where similar resources are compared in very different locations. However, this study sought to examine a single resource (coral reef fisheries) within a single country. The degree of variability in resource availability between sites was considered relatively low. Comparative studies of ecological conditions at the study sites found that the presence or absence of management had a larger influence on these resource conditions than habitat variations (McClanahan et al, in review). Furthermore, some social and cultural factors may also be difficult to collect information on under the research methodology used in this study. Uncovering and understanding potentially important social and cultural dynamics like lineage rights or whether there is ample trust in a community are complex

cultural processes that can take ethnographers years to unravel and may be better suited to longer-term ethnographic type research than to "snapshot" approaches such as this where researchers are in a community for a limited time. Likewise, not understanding sensitive social dynamics can make the collection of other indicators difficult. For example, examining the quality and calibre of leadership in a community can be awkward and potentially misleading in smaller communities if a researcher is unaware of personal histories and/or lineages.

Therefore, an extensive review of literature (see Chapter II), discussions with key informants in the pilot site, and discussions with experts about the difficulty of collecting certain indicators (pers. com. R. Pollnac and B. Crawford, 2001) were used to prioritise factors that would cover the main theoretical issues and could be addressed given the available methodology and relatively short research time per site. These factors are social capital, occupational mobility, dependence on marine resources, perceived condition of the environment, perceptions about the human-environment interaction, modernisation, market integration, settlement patterns, population, size of the resource, and conflict. Once these factors were identified, means of measuring and quantifying each factor were developed. The implications of not collecting certain indicators will be discussed in Chapter VII.

Some of these factors are straightforward and relatively easy to measure (e.g. the population of a community), while others are conceptual ideas that require several indicators to construct (e.g. a variable that measures how modernized a respondent's lifestyle is could be constructed by examining indicators such as the type of material a respondent's house is built of and the types of material possessions they own). More will be discussed on the theoretical and methodological issues associated with constructing variables from indicators in Chapter V. Standardized indicators for conducting socioeconomic assessments of communities dependent upon coral reefs have recently been developed (Bunce et al., 2000; Pollnac, 1998; Pollnac & Crawford, 2000) and were used wherever possible and appropriate. However, occasionally standardized indicators were not culturally appropriate and the development of locally specific indicators was

necessary (Nazarea et al., 1998; Poggie, 1978). The remainder of this chapter explains which indicators were collected and how indicators were grouped together to measure certain factors.

Household level factors

Dependence on marine resources

The number and types of occupations in which households participated were examined by asking respondents to describe the work they do that can bring food or money into their house. These occupations are grouped into the following categories: fishing, agriculture, forestry[1], tourism, formal (salaried) employment, and informal economic activities (e.g., selling or bartering at the local market). Respondents then ranked the occupations in order of importance (Pollnac & Crawford, 2000). Responses ranged from 0 (= no involvement) to 5 (= most important occupation for the household). The relative importance of fishing and agriculture was included in the measure of dependence on marine resources, the relative importance of salaried employment was included on the measure of modernisation, and the relative importance of informal economic activities was included on the measure of occupational mobility.

Fishing effort was determined by asking people the average number of fishing trips per week every member of the household was engaged in. If respondents reported seasonal differences in fishing effort, responses were averaged proportional to the length of each season. For example, if a respondent reported that only one member of the household fished 4 trips per week, except during the 3 month monsoon when he did not fish, an average of 3 trips per week was recorded for the household.

[1] There was very little involvement in either the forestry or tourism sectors, so these indicators were dropped from the final analysis.

Respondents were asked the percentage of fish catch that was either bartered or sold in the market. Respondents were also asked whether they had a boat and a motor. Table 2 shows the indicators of dependence on marine resources. Chapter V reduces these indicators into a single measure of dependence on marine resources.

Table 2. Indicators of Dependence on Marine Resources

Indicator	Measure
Rank of fishing	Six ordinal categories (0= no involvement in sector, 1= involvement is relatively unimportant, 5= involvement is most important occupation)
Rank of agriculture	Six ordinal categories (0= no involvement in sector, 1= involvement is relatively unimportant, 5= involvement is most important occupation)
Number of fishing trips per week	Recorded the average number of trips per week
Percentage of fish bartered or sold	Percentage of total catch that was bartered or sold
Possession of a boat	Presence/absence
Possession of a motor	Presence/absence

Modernisation

Material style of life is a method of measuring lifestyle based on the presence or absence of household possessions (Cinner & Pollnac, 2004; Pollnac & Crawford, 2000). To determine culturally appropriate indicators of a modernized lifestyle, key informants in the pilot study sites described items in the house of a modernized person and the house of an unmodernized person. Then the presence/absence or type of 7 of these items, such as a television, wood stove, electricity generator, and the type of walls, roof, and floor for each household was recorded.

The key informants in the pilot site also identified education and salaried employment as components of a modernized lifestyle. Respondents were also asked about their number of years of formal education. The years of formal education were then collapsed into ten ordinal categories (starting from 0 as the lowest score and ranging to 9 as the highest score) using the "categorize variables" function in SPSS statistical package. The importance of salaried employment was also considered part of a modernized lifestyle. Respondents whose households were engaged in salaried employment were asked to rank

the importance of this occupation relative to other occupations. This rank was included as part of the measure of modernisation.

Table 3 shows the 10 modernisation indicators and the methods used to operationalize them. In Chapter V, these indicators are combined into a relative measure of modernisation by using Rasch analysis (Bond & Fox, 2001).

Table 3. Indicators of Modernisation

Indicator	Measure
Vehicle	Presence/absence
Type of stove	1 if wood stove, 2 if modern stove (gas or electric)
TV	Presence/absence
Radio	Presence/absence
Type of roof	1 if thatch, 2 if metal, 3 if insulated
Type of floor	1 if sand or bamboo/buai, 2 if plank wood, 3 if cement
Type of walls	1 if bamboo/buai, 2 if plank wood, 3 if cement or fibro
Years of formal education	Ten ordinal categories (0=lowest, 9=highest)
Rank of salaried employment	Six ordinal categories (0= no involvement in sector, 1= involvement is relatively unimportant, 5= involvement is most important occupation)
Fortnightly expenditures	Cash expenditures over the past two weeks (recorded in PNG Kina)

Social capital

Social capital refers to the bonds and norms in a society, which may be influenced by factors such as group heterogeneity and engagement in common activities (Ostrom, 1990; Pretty & Smith, 2004). Respondents were asked whether and how they were involved in community or clan decision-making. Key informant interviews revealed that most decision-making happened at family or clan meetings. Thus, respondents were considered passive in decision-making if they attended the meetings but did not actively voice their opinion. Respondents were considered active in decision-making if they voiced their opinion at clan or community meetings.

Respondents were also asked about the number and types of community organisations they participated in. Depending on the needs of the particular study, migration status can

be defined in a variety of ways, including whether a person was born in another village, another language groups, another province, etc. Since use rights to marine resources in PNG are often delineated primarily at the village scale, in this study, migration was defined as being born in another village. Table 4 presents the indicators of social capital and how they were operationalized. Chapter V examines how these indicators fit together to make a scale of social capital.

Table 4. Indicators of Social Capital

Indicator	Measure
Involvement in decision-making	0 if not involved, 2 if passively involved, 3 if actively involved.
Involvement in community organisations	Number of community organisations the household was involved with
Emigration	0 if born in village, 1 if born in another village

Occupational mobility

Two indicators were used in examining occupational mobility: number of occupations and involvement in informal economic activities (e.g., owning a small trade store, driving a taxi, selling at the local market, etc.). The number of occupations each household was involved in was recorded by asking respondents to list all the jobs that members of the household did to bring food or money into the house. As previously discussed, the occupations were grouped into relevant categories such as fishing, agriculture, and informal economic activities. Respondents were asked to rank these occupations in order of importance. The relative rank of informal economic activities was included as a measure of occupational mobility. Table 5 shows the indicators that will be developed into a measure of occupational mobility in Chapter V.

Table 5. Indicators of Occupational Mobility

Indicator	Measure
Number of occupations the household is involved in	Recorded the total number of occupations the household was engaged in
Rank of informal economic activities	Six ordinal categories (0= no involvement in sector, 1= involvement is relatively unimportant, 5= involvement is most important occupation)

Perceived Condition of Coastal Resources

This study sought to identify perceptions of the past, present, and future conditions of fishery resources and understand predominant ideas of what can affect and improve these resources. Perceptions of household survey respondents regarding the condition of the fishery and condition of the reef were assessed on a ten point Likert scale (Likert, 1932) (with one being lowest and ten being highest) for three temporal periods: current (within the past 12 months), five years in the past, and five years in the future. This proved to be somewhat problematic and the response rate for this question was relatively low. Some respondents simply did not understand the abstract nature of the scale. Responses were verified with a previous question on the survey that asked respondents to describe the condition of the fishery. If responses for the two questions were not reasonably similar, the Likert scale responses were discarded. For example, one respondent described the condition of the fishery as excellent but only awarded it three out of ten on the Likert scale (ten being highest). A total of 85 respondents either did not answer or did not appear to understand the 10 point Likert scale. To discern whether respondents perceived a relative increase or decrease in resource abundance, two trend scores were developed for each resource (i.e., two for fisheries and two for coral reefs, totalling four trend scores).

The trend score for the future was calculated as follows:

$$T_f = L_1 - L_2$$

Where T_f is the trend score; L_1 is the Likert scale response for five years in the future; and L_2 is the Likert scale response for the present. This resulted in a positive trend score if respondents felt the resources were improving (i.e., if the future score was higher than the present score) and a negative trend score if the respondent indicated the resources were declining.

The trend score for the past as follows:

$$T_p = L_2 - L_3$$

Where T_p is the trend score; L_3 is the Likert scale response for the present; and L_2 is the Likert scale response for five years in the past.

These trend scores were then collapsed into ten ordinal categories (starting from 0 as the lowest score and ranging to 9 as the highest score) using the "categorize variables" function in SPSS statistical package. These four trend scores were then used to develop a measure of perceived condition of the environment (Table 6). Chapter V examines how these indicators are combined to make a scale by which peoples' perceived condition of the environment could be examined and compared.

Table 6. Indicators of Perceived Condition of the Environment

Indicator	Measure
Past trend of fish	Ten ordinal categories
Future trend of fish	Ten ordinal categories
Past trend of reef	Ten ordinal categories
Future trend of reef	Ten ordinal categories

Perceptions about the human-environment interaction

Respondents were also asked separate open-ended questions about what can affect and what can improve the condition of reef fisheries. Specifically respondents were asked: What can affect the number of fish in the sea? What could be done around (name of community) so that there would be more fish in the sea? What can affect the coral reef? What could be done around (name of community) to improve the coral reef?

Respondents were free to provide multiple responses to the question and list a number of factors that they felt could improve or affect the resource. When a respondent was finished listing the factors he or she felt could affect or improve the resource in question, a summary of their responses was provided and they were asked if there was anything else they would like to add. Responses were grouped into relevant categories. This process is called content organisation and can be used to analyse open-ended survey questions (Cinner & Pollnac, 2004; Nazarea et al., 1998; Pollnac, 2000; Pollnac &

Crawford, 2000). From initial surveys in the pilot study, 18 major response themes were identified for each question which then formed answer categories for following surveys. Therefore, responses to the open-ended questions were grouped into 18 major categories (see the "household survey" in Appendix I for the categories). Respondents were marked as either having mentioned a specific category or not mentioning the category. For example, a respondent either mentioned that using dynamite could affect the condition of the fishery or they did not mention that category. During the analysis, the categories were collapsed into eight categories of what could affect the fishery and nine categories of what could improve the fishery (Table 7).

Table 7. Indicators of Perceived Human-Environment Interaction

Indicator	Measure
Fish affected by fishing pressure	Presence/absence
Fish affected by destructive fishing techniques	Presence/absence
Fish affected by nets	Presence/absence
Fish affected by other gear	Presence/absence
Fish moved away	Presence/absence
Fish affected by land-based issues	Presence/absence
Fish affected by social or political issues	Presence/absence
Fish affected by other issues	Presence/absence
Fishery could be improved by reducing destructive fishing methods	Presence/absence
Fishery could be improved by reducing net use	Presence/absence
Fishery could be improved by social or political factors	Presence/absence
Fishery could be improved with reef closures	Presence/absence
Fish affected by fishing pressure	Presence/absence
Fish affected by destructive fishing techniques	Presence/absence
Fish affected by nets	Presence/absence
Fish affected by other gear	Presence/absence
Fish moved away	Presence/absence

Village Level Variables

Size of resource (fishing area)

Key informants were asked to show the boundaries of their village's marine tenure. Obvious terrestrial and marine landmarks (such as a point or edge of a lagoon) were used

to delineate a village's tenure area. The area of shallow water fishing grounds (encompassing sand, seagrass, and reef) was calculated (in km^2) by analysing 1:100,000 aerial photographs with the UTHSCSA Image Tool 2.0 for Windows program. Fixed geodetic points were not available on the photograph, so spatial calibration was achieved by measuring the distance between two easily discernable points near the centre of the actual photograph. Distortion in the edges of the photograph was not corrected for. Estimates of area include all shallow habitats above approximately 12 metres deep. Aerial photographs were not available for two of the sites, Madina and Fissoa, thus fishing area estimates were not available for these locations. Fishing effort per hectare of fishing ground was estimated by dividing the fishing pressure (described above) by the estimate of fishing ground size.

Population

Community populations were estimated by walking through the community and physically counting the households. Data from the household surveys about the average number of occupants per house were used to extrapolate the total population for the community (i.e., population = the mean number of occupations per house * total number of houses in the community) Official census and voting figures reported up to double the actual number of houses in a community and were thus deemed unreliable. It should be noted that only members of the household that were presently living in the house were counted. For example, household members that lived, worked, or went to school away from home were not counted. Although these members may contribute to or expend household income (which may be considered important in some demographic or economic studies), the focus of this research was primarily on resource use and governance. Non-resident household members were deemed to have marginal, if any, direct impact on local resources. Remittances, which could potentially reduce direct resource use, were considered as part of the informal economic sector and included in the occupational mobility variable. Relative fishing effort was calculated by dividing the number of households dependent on fishing by the fishing area.

Settlement pattern

Aswani (1999) detailed two types of settlement patterns in the Roviana and Vonavona lagoons that he found influential on common property regimes. This methodology was not adopted because it required a more detailed ethnographic analysis of intermarriage relationships and lineage analyses of chiefs than was available given the available research time at individual sites. Instead, a more simplistic version of grouping the communities into dichotomous measures of whether there were nucleated coastal settlements or dispersed coastal/inland settlements was adopted from Pollnac (1998). The nucleated coastal settlements include all small island settlements (e.g., Enuk, Kranket, Ahus, Andra, and Riwo) and larger island settlements where the majority of coastal residents had a view of the sea (e.g., Mongol and Muluk). The dispersed coastal-inland settlements included inland communities (in this study, inland is defined as being more than 750m from the sea) and villages which had a substantial proportion of the community living inland.

Distance to market

Key informants were questioned about where trade goods were bought and sold. The distance to markets was determined by measuring the distance (in kilometres) from the village to the nearest sizable market on a nautical chart. In all cases, this turned out to be the provincial capitol except in Gagagaba, where the distance was measured to the national capitol.

Conflicts

The presence of conflicts was determined by questioning key informants about whether any legal, violent, or highly confrontational conflicts over marine resources had arisen over the past 12 months. Conflicts could be within the community, with other villages, or with different stakeholders (e.g., dive operators or hoteliers). A dichotomous measure of the presence or absence of conflicts over the last 12 months was then developed.

Summary

Qualitative and quantitative techniques were employed to collect social, economic, and resource governance data from 14 coastal communities in PNG. Indicators were collected to reflect current theory and empirical research into the factors that may influence traditional management in Melanesia. This chapter presented the data collection techniques used to select communities and respondents, described the indicators used in the study, and operationalised the ways in which these indicators were developed and collected. Chapter V explores the validity of these indicators in measuring the desired characteristics. The following chapter familiarizes the reader with the study sites by presenting brief site descriptions.

CHAPTER IV. STUDY SITES

The previous chapter described the methodologies used to collect data and highlighted the variables that were measured. This chapter will provide a brief description of the 14 study sites, including details about population, village location, availability of markets, availability of farming land, infrastructure, marine tenure and other marine resource management strategies, and maps of village locations. The descriptions of the study sites are important to give the reader a qualitative sense of what the population, infrastructure, settlement pattern, land tenure and distribution, coastal resource governance regimes, and other aspects of life was like in each village. This study was comparative in nature, so site descriptions are relatively brief and do not entail the level of detail associated with ethnographic studies. Quantitative examinations and comparisons of the socioeconomic characteristics of each village are presented indicator by indicator in Appendix II.

The 14 sites were spread out over six regions: Central Coast (Central Province), Madang Lagoon (Madang Province), Karkar Island (Madang Province), Kimbe Bay (West New Britain Province), Kavieng (New Ireland Province), and Manus Islands (Manus Province) (Figure 2). For ease and efficiency of both mapping and presentation, the presentation of study sites are organised into these regional categories.

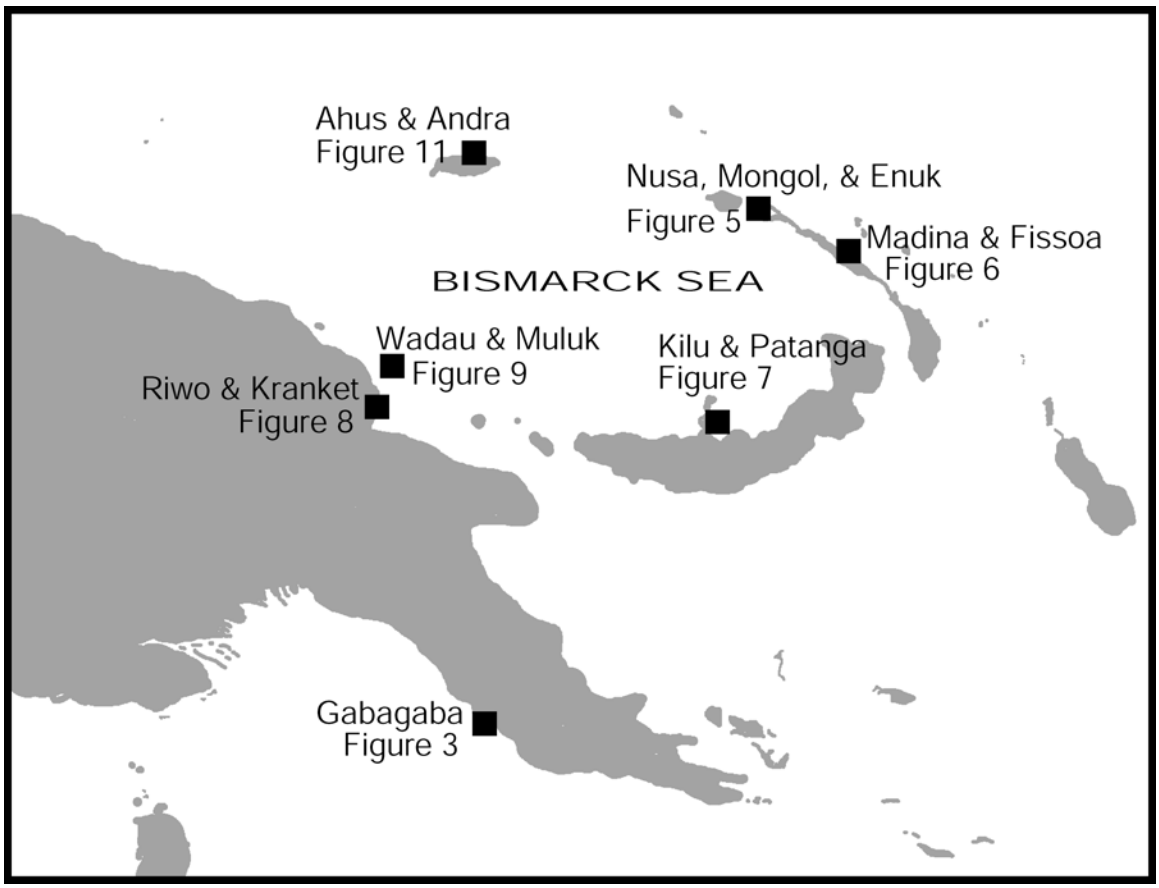

Figure 2. Map of Study Sites in PNG, including village names and figures associated with each inset. Note: not to scale.

Central Coast (Gabagaba Village)

The community of Gabagaba and the pilot site (Tubusereia) were studied in the Central Province (Figure 3). Populations in these communities were relatively high and the proximity to the national capital (Port Moresby) resulted in increased access to salaried jobs, education, and western goods compared to other sites. Although a substantial portion of both villages now live on land, Central Coast villages were historically built over the sea and a significant portion of the villages were over the sea (Figure 4).

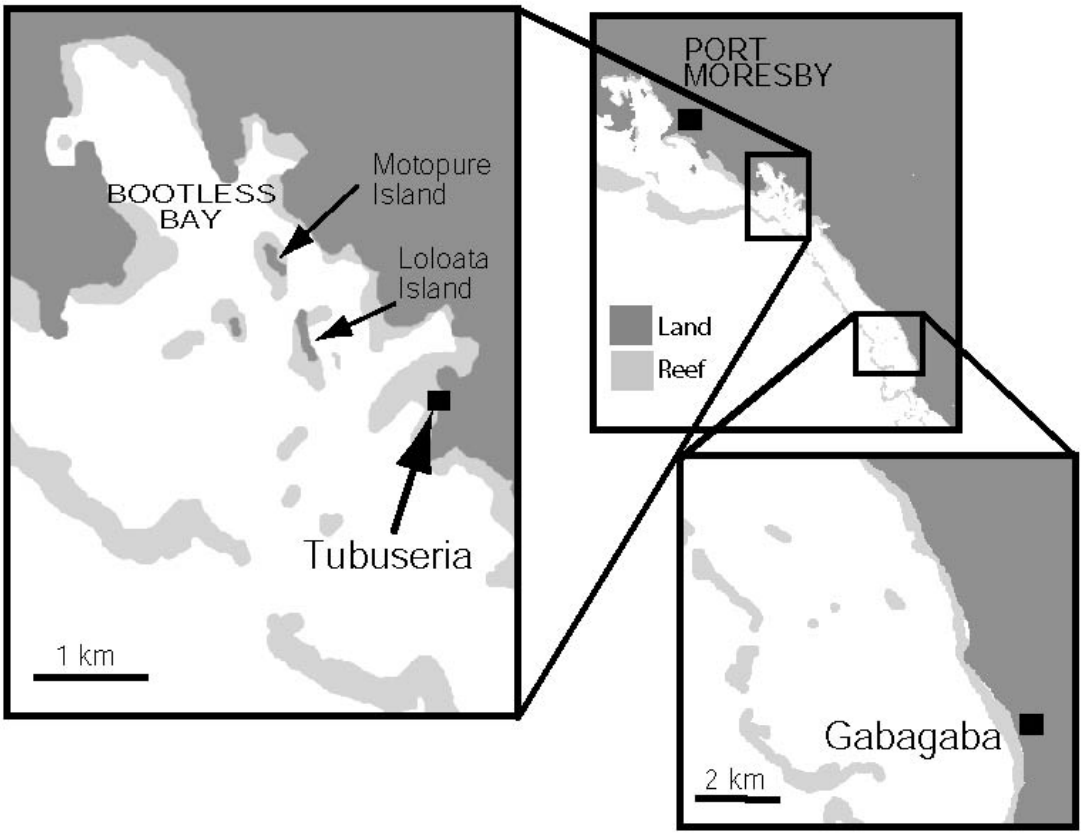

Figure 3. Map of Gabagaba and the Pilot Site (Tubusereia) in Central Province

Figure 4. Houses Over the Water in Tubusereia

Gabagaba is located approximately 58 km southeast of Port Moresby and is relatively large compared to the other communities examined in PNG; containing approximately 1,708 people in 206 households. The road to Gabagaba from the main highway was not paved. Public transportation between Gabagaba and Port Moresby was only 3 times per day and was relatively expensive. There was a primary and secondary school, consistent electricity, but no telephone service. There were several community water pipes running throughout Gabagaba, but they were only turned on once or twice per week.

Land in Gabagaba was divided into clan blocks, but registered blocks of land were common as well. Clan land was patrimonial property but there were instances where women were owners. For example, a female was entitled to inherit land if she had no male siblings. Community leaders in both communities suggested that land conflicts were a major issue, particularly regarding garden boundaries. The traditional land of Gabagaba extended 32 km along the coastline.

Relative to other communities examined in PNG, Gabagaba had marine tenure over an extremely large area. Other villages were actively excluded from fishing in the waters traditionally controlled by the Gabagaba villagers. Community leaders claimed that, if caught, violators could face either court or severe beatings. However, enforcement of traditional tenure has become difficult because of confusion relating to rights involved with intermarriages with other villages and increasing traffic, as the ocean is a major route to other villages along the coast. Fishing by other villagers has been the source of conflict on several occasions.

Kavieng and Tigak Islands (Enuk, Mongol, and Nusa Lik Villages)

Three communities were studied in the Kavieng and Tigak Islands area of the New Ireland province: Enuk Island, Mongol, and Nusa Lik Island (Figure 5). Kavieng is located on the northwestern part of the New Ireland main island. As the provincial capital, Kavieng had services such as an airport, grocery stores, banking facilities, several hotels and resorts, two dive operators, a fish processing facility, and banking services.

This part of the main island and the surrounding islands (also known as the Tigak Islands) were low lying.

Three communities were initially studied in the immediate vicinity of the Kavieng Township: Nusa Lik Island, Mongol, and Sivusat. However, only seven surveys were obtained from Sivusat, so they were omitted from the analysis. Mongol is situated next to Kavieng town and Nusa Lik is on an island 1 km offshore. Nusa Lik had 273 people in 25 houses on the approximately 0.24 km^2 island. Several residents were provided with electricity from a tourist resort on Nusa Lik. The Mongol area had 493 people in 92 houses along a narrow strip of beach. A few residents in Mongol had electricity and access to a municipal water supply.

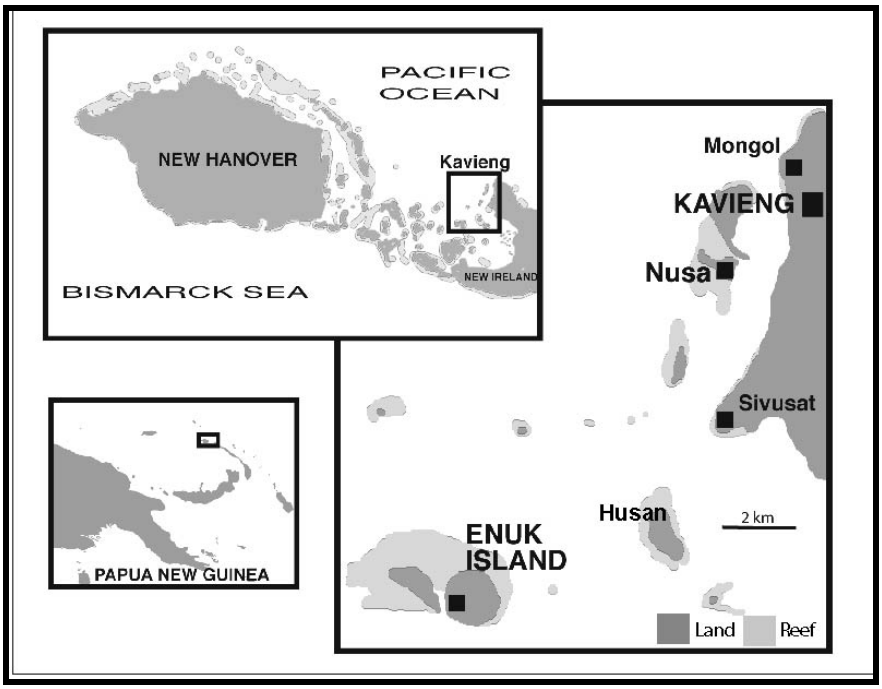

Figure 5. Map of Kavieng Area Sites (New Ireland Province)

Enuk is situated approximately 14 km. west of Kavieng. The community is spread over two islands separated by a narrow channel. The Eastern Island is approximately 0.78 km^2, while the Western Island is approximately 0.34 km^2. There were approximately 270 people on Enuk Island, in 66 houses. The majority of the population lived adjacent to the channel separating the two islands. Additionally, there was a dispersed population living

along the island's shore, but few people living in the interior of the island. Enuk Island was small and had very little infrastructure. There were no roads or vehicles. The island was not linked to the mainland by a public water taxi system, although the community collectively owned one boat that was occasionally used for public transport. There were no trade stores, there was a community school catering for students up to grade 6 (approximately 12 years old).

Access to adequate farming land for the three communities was quite limited. Although Enuk islanders had traditional rights to use some larger uninhabited islands for farming, they complained that wild pigs destroyed their gardens and it wasn't worth farming there. Land on Enuk was divided into matrilineal clan blocks. The land tenure situation in Mongol and Nusa Lik was complicated due to the high number of immigrants, who do not have customary land in the area. However, some immigrants were able to buy land from the traditional landowners or develop land use understandings.

Enuk islanders traditionally had tenure of the sea around the island. Key informants stated that fishers from Kavieng town must ask permission and/or go with a member of the Enuk community if they wish to fish on Enuk's reefs, but people from neighbouring villages could generally fish there. Key informants from Nusa community mentioned similar rights on their reefs, but also mentioned that many people from other parts of town fished there at night because the tenure was not enforced. Mongol residents generally had no tenure over the reefs adjacent to the community. A key informant from Mongol suggested that there is a spiritual (*Masali*) area in the sea where fishing is not allowed, but it was not corroborated by other informants, so it was not considered in subsequent analyses.

East Coast New Ireland (Madina and Fissoa Villages)

Two communities were studied in the East Coast of the New Ireland province: Madina and Fissoa. There were approximately 564 people in 92 houses in Madina and 277 people in 47 houses in Fissoa. The main road is relatively close to the coast and essentially

divides both communities into coastal and inland section. The houses in Madina and Fissoa on the coastal side of the road are clustered, but are dispersed on the inland side of the road. Relative to other sites, access to farming land in these two communities was ample, especially compared to the other sites in the New Ireland province. Although owned and inherited by women, land and marine resources are controlled by a traditional leader, called a *Maimai*. Traditionally, the *Maimai* was supposed to be the only person allowed to speak for the community. This has led to conflicts between traditionalists supporting the *Maimai*'s authority and the elected local level government officials.

Fishers from neighbouring villages were able to fish in Fissoa's fishing grounds, but not in Madina's. Madina has two types of traditional closures: a rainmaking site and a site for burial rites and fish aggregation. The rainmaking site (which was approximately 800m by 50m) was permanently closed to all the community. An exception to this was in conjunction to feasting that has some significance to the *Maimai*. The site designated for burial and fish aggregating purpose is normally closed for three to six months in a year. Both types of closures have sticks erected along the boundary to indicate that the area is off limits. Due to the perceived abundance of trochus shells and holothurians, people have poached the area, but allegedly only during rainy nights (when they won't be seen or heard). Poachers are dealt with according to the local level government courts and normally charged with traditional shell money and pigs for violating the area.

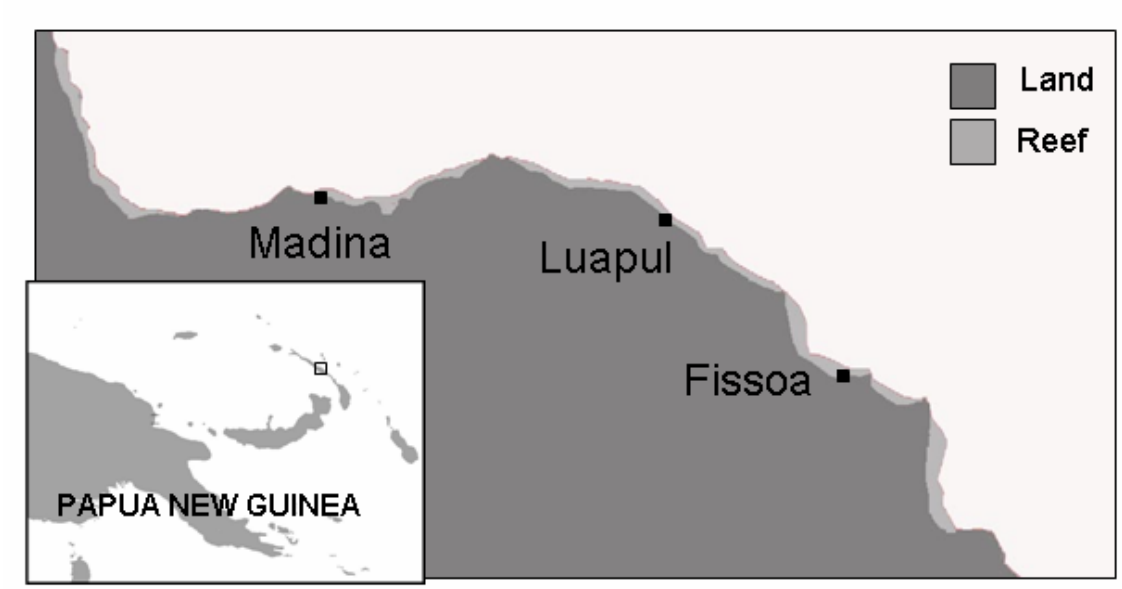

Figure 6. East Coast New Ireland Sites (Fissoa and Madina). Note: not to scale.

Kimbe Bay (Kilu and Patanga Villages)

Two communities were examined near the Walindi Plantation Resort and the Mahonia Na Dari research station in the West New Britain Province: Kilu and Patanga (Figure 7). Kilu village was approximately 16.5 km northwest of Kimbe town, the capital of the West New Britain Province. The community of Patanga was approximately 20.4 km northwest of Kimbe town and was comprised of three small village clusters (hamlets) that were approximately 250m apart. Kilu had 584 people in 93 households, while Patanga had 421 people in 90 households. Both villages were small and had very little infrastructure. The main road through the village was sealed and had frequent public transportation to Kimbe town. Patanga had a community school catering for grades 1 to 8 and Kilu had an elementary school that caters for grades 1 to 3. There were several trade stores in each village that sold staple items such as drinks, rice, tinned fish and cigarettes.

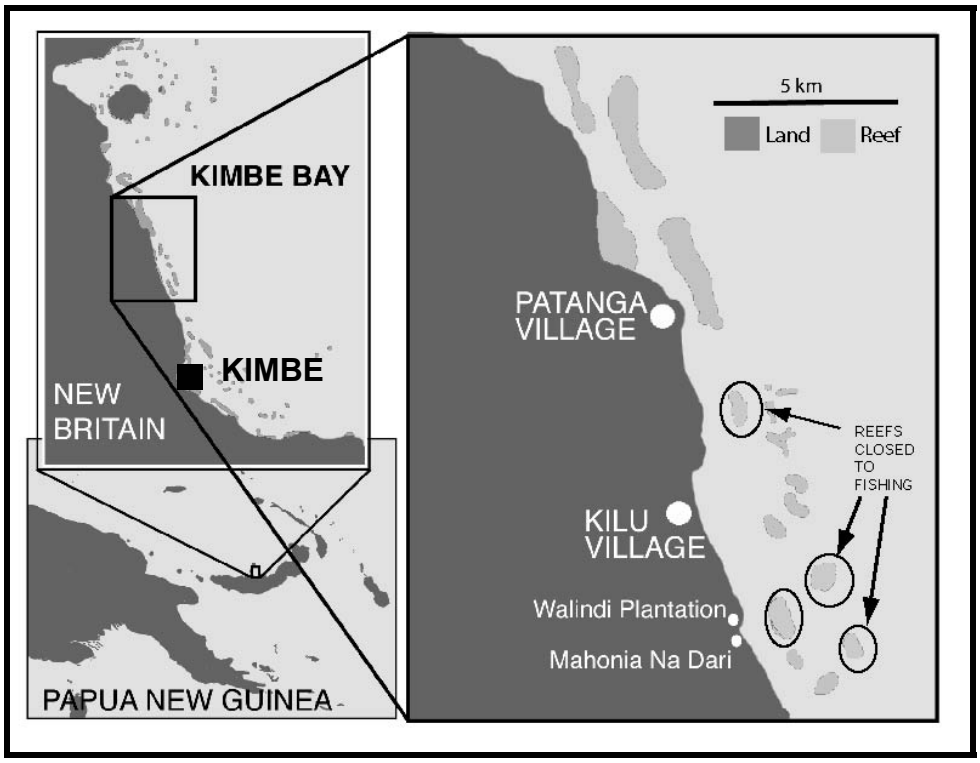

Figure 7. Map of Kimbe Bay Sites (West New Britain Province)

Residents in both areas had ample access to farming land. Access to land seemed to be well distributed through the traditional clan structure. Each clan had a specific block of land, which was then divided among families. A community leader in Patanga described the land distribution as follows:

> The community is composed of clans, which have established the land boundaries upon their initial settlement. Any clan member has the right to move to any of their clan land and settle upon the clan leader approval. This is okay for the sons of any male villager. However, this is not the case for any females, as they will have to do a customary ceremony prior to settling their sons anywhere on the clan land. The community land is divided into seven areas according to the seven forefathers of the village who came from Kupugara (the origin of this village).

The land tenure situation was very similar in Kilu.

Despite the fact that a Kilu community leader suggested that the community did not have control over the adjacent ocean, consultation with a number of key informants suggested that both Kilu and Patanga have traditional tenure of the ocean adjacent to their villages.

All key informants agreed that fishers from neighbouring villages were free to fish on each others reefs, however, people from villages further away or from Kimbe town were not allowed to fish within Kilu and Patanga's tenures.

A "no-take" protected area was established in 1997 on 4 reefs adjacent to the Kilu community. To date, this project has been largely driven by external stakeholders, such as Mahonia Na Dari, Walindi Resort, the Nature Conservancy, and James Cook University. The community claimed to be excluded from virtually all involvement in management. As a result, there was a lack of understanding of the rationale for the project and compliance with reserve rules was negligible (Cinner et al., 2003; Cinner et al., 2002).

Madang Lagoon (Riwo and Kranket Villages)

Two communities were studied in the Madang Lagoon (Madang province): Kranket and Riwo (Figure 8). Madang Lagoon is comprised of low lying islands adjacent to a relatively flat portion of the New Guinea mainland. Kranket Island was approximately 1.25 km from the Madang town peninsula. There were 2,127 people in 309 households on Kranket Island. The island was approximately 3 km long (east-west) and 1 km across at its widest point (north-south). There was an enclosed lagoon in the interior of Kranket Island, which almost closes off in the western section, but gives way to an open lagoon that provides sea access. Kranket Island was small and had very little infrastructure. There were no roads or motor vehicles. The island was linked to the mainland by a public water taxi system, which operated continuously from dawn until dusk. There were approximately five small trade stores that sold staple items and a community school catering for up to grade 6 students. A generator operated from around 6 p.m. until 10 p.m. There were also two small lodges that catered to backpackers.

Riwo Village was located adjacent to Jais Aben Resort, about 7 km by sea and 20 km by road from Madang town. There were 1,136 people in 124 houses in Riwo. The coastline was characterized by a number of small islands and inlets. The village itself was spread out between two main islands, one of which was connected to the mainland by a short

bridge. The other island had no direct links to the mainland, but there was frequent canoe and boat traffic between the island and the mainland.

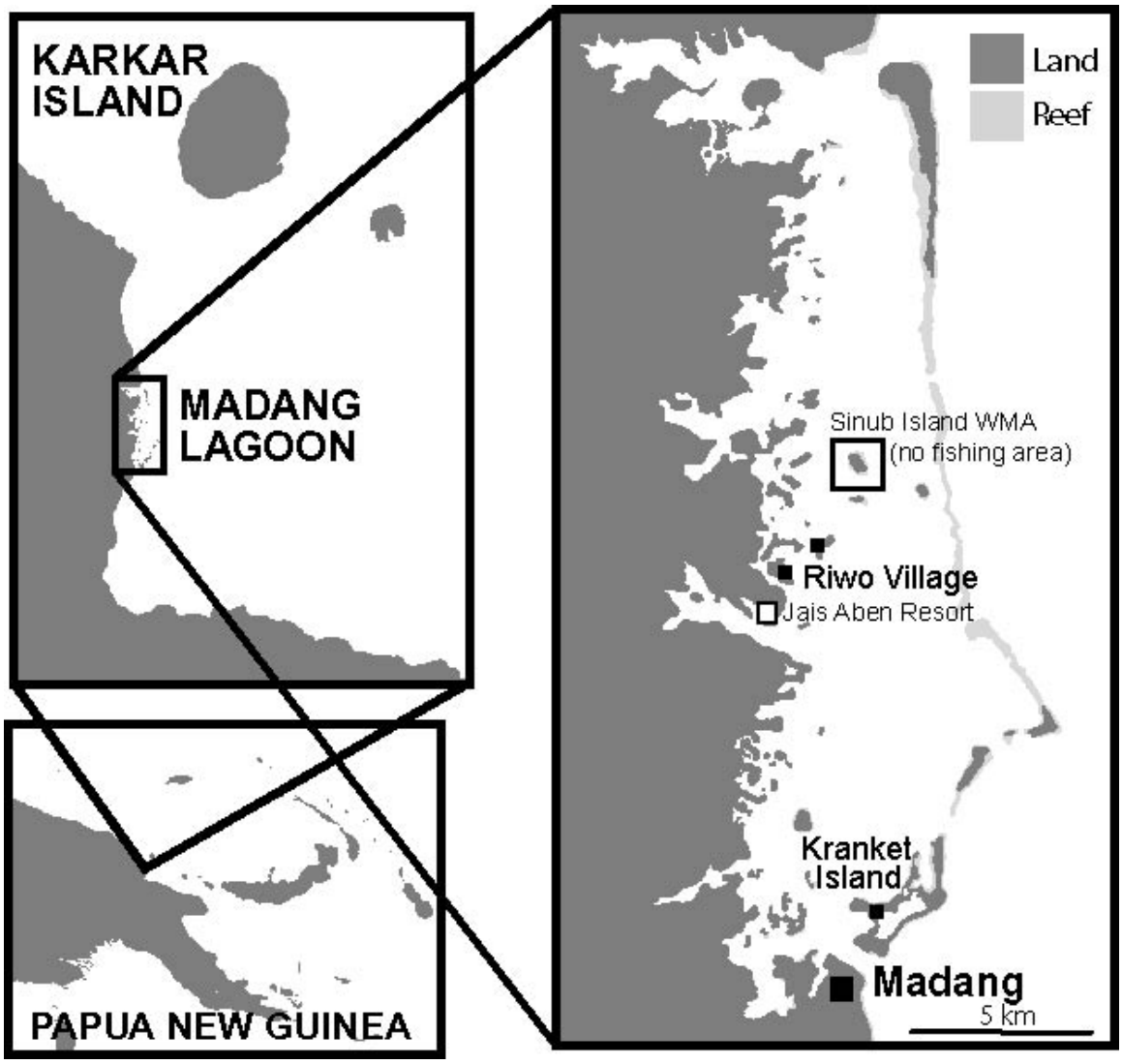

Figure 8. Map of Madang Area Sites (Madang Province)

Although both Riwo and Kranket islanders lived on small islands, both communities had access to farming land on the mainland. Clan chiefs on Kranket Island mentioned that only the eastern half of the island had traditional access to farming land on the mainland. However, most villagers had access to farming land on the mainland due to inter-marriages between clans from different areas. Kranket islanders pointed out that much of the land they traditionally used for farming has now been developed into businesses or

resorts in Madang town. In Riwo, clan leaders distributed mainland farming land amongst their members. However, land was not often distributed evenly. Based upon the origins of their grandparents, the land was partitioned according to who settled there first. Community leaders reported that some conflicts arose about land issues, but were generally resolved through land mediation.

Although Kranket islanders traditionally had tenure over the sea surrounding their island, they usually did not exclude other villagers from fishing. One respondent noted, "This is not like other areas, anyone can come here and fish." However, another respondent mentioned that he has traditional rights to a particular patch of reef on the northern side of the island (Kranket wall). He claimed to get money from dive operators when they take divers there and that nobody is allowed to fish there. Other community members did not corroborate these claims.

Villagers in Riwo exerted more control of their traditional sea tenure. Traditional landowners regularly collected user fees from divers and other tourists. Key informants reported inconsistent stories as to whether other fishers were excluded from their traditional sea tenure. Community leaders suggested that the reef was open to fishers from anywhere. However, some key informants reported that other villagers were not allowed to fish in Riwo's territory. In the past, each clan owned a particular area of reef, where fishing by other clans was excluded. However, key informants mentioned a breakdown of this system, so that any villager could fish throughout the Riwo territory. In practice, Riwo villagers fished throughout the lagoon, and it appeared as though villagers from surrounding communities fished in Riwo's tenure.

In addition to moderate marine tenure, the Riwo community in conjunction with the NGO Wetlands International, established the Sinub Island Wildlife Management Area in 1997. All fishing activity is prohibited on the reefs surrounding Sinub Island. A popularly elected committee from Riwo Village manages the marine reserve.

Karkar Island (Wadau and Muluk Villages)

The communities of Muluk and Wadau were studied, which are located on the eastern side of Karkar Island (Madang province) (Figure 10). Karkar is a high, fertile, volcanic island approximately 20 km from the mainland of PNG and approximately 60 km from Madang town. Karkar Island has very little infrastructure (Figure 10). The island was linked to the mainland by a public water taxi system, but the taxis only arrived and departed from one point on the island, which did not have public transportation linking it to other parts of the island.

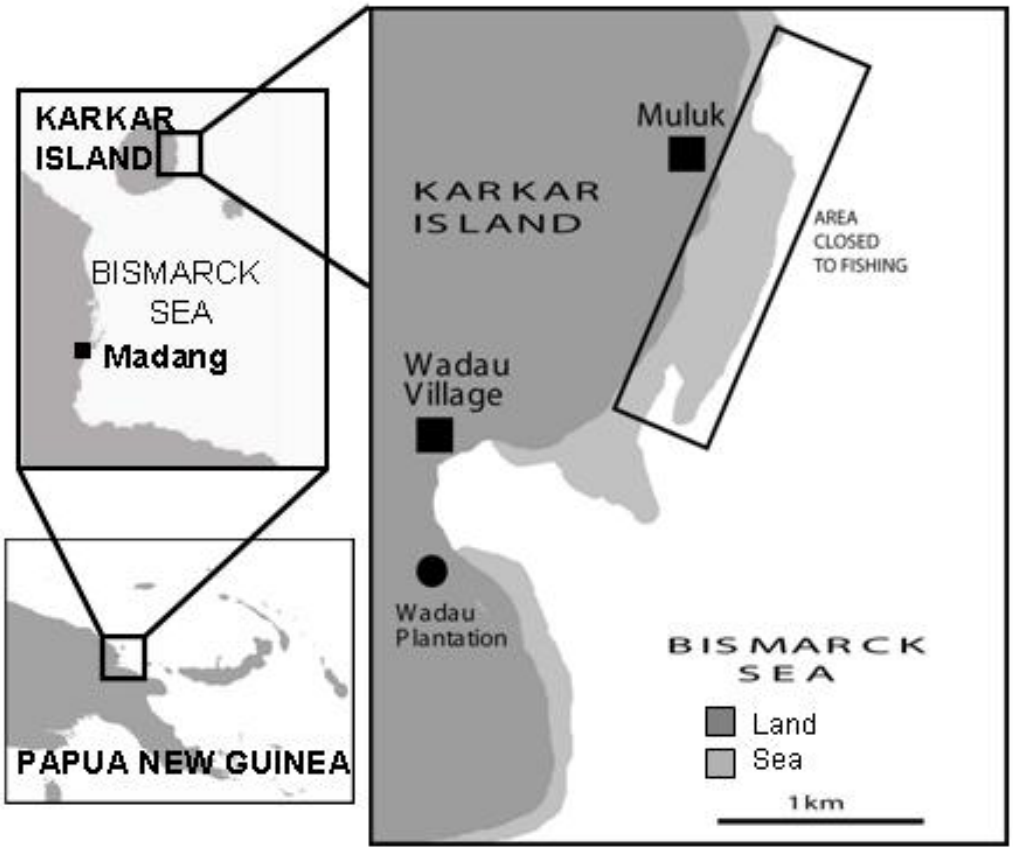

Figure 9. Map of Karkar Island Sites (Madang Province)

Figure 10. Wadau Village

Muluk had 333 people in 50 households and Wadau had 324 people in 50 households. The infrastructure of Muluk and Wadau were very similar. In both Muluk and Wadau, there were trade stores that sold staple items. A school was located several kilometres north of Muluk in the Ngor community. There was no tourist accommodation anywhere on the island, although the Wadau Plantation occasionally housed guests.

Access to land in both Muluk and Wadau was based on clan affiliation, which provided everyone with enough land for copra production and subsistence gardens. The villagers of Wadau were originally from the upland areas of Karkar, but were forced to settle along the coast during colonial times. Community leaders mentioned that the missionaries were responsible for the move to the coast. The village of Wadau was located on land traditionally owned by Muluk. Both communities recognize that the land tenure is officially owned by Muluk, but that Wadau villagers are allowed use of the area.

The village of Muluk had traditional tenure over the entire coastline adjacent to both Muluk and Wadau. Since residents of Wadau migrated to the area from the uplands of Karkar, they do not have traditional rights to the area. Muluk allowed Wadau residents to use the sea, but they do not have unrestricted rights to marine resources. A respondent from Muluk mentioned, "the sea around Wadau belongs to us. If we decide it is taboo, they must respect it."

Wadau had no system of reef closures. However, Muluk has practised a system of closing almost its entire reef area for 1-2 years when the fish catch rates are noticed to decline. The decision to close the reefs is reached through a consensus between the three clan-chiefs. Reef closure in Muluk generally occurs 2-3 times within a 10-year span. At the time of this research, their reef had been closed for approximately 6 months. Key informants were unclear as to when this periodic closure system began, but could confirm its presence for at least 60 years. After discussions with several key informants, it became apparent that the reasons for closing the areas so the fish would become tame and easier to catch, particularly while spear fishing.

There were also several initiation rights associated with a particular fishery, called a *bom bom*, where flying fish are speared with hand spears from a canoe at night. To participate in *bom bom* fishing, each man must first undergo an initiation ceremony. The man undergoing initiation will fish with an initiated fisherman for three nights straight. On the fourth day, he must go into the forest to find a bitter root (called *gorgor*) and wrap it in a leaf together with the hearts and liver of the fish he caught. Later in the evening the entire village gathers and the man has to crawl through the legs of the village chiefs. When he gets to the last chief, he must eat the leaf filled with bitter roots and fish hearts and have a burning stick of bamboo broken over his back.

Manus (Ahus and Andra Villages)

Ahus and Andra are small islands off the north coast of Manus Island (Figure 11). There were approximately 544 residents in 105 houses on Ahus Island. Ahus Island lies approximately 20.5 km to the northwest of Lorengau, the provincial capital. Andra Island had 479 people in 92 households and lies approximately 31 km to the northwest of Lorengau. There was very little infrastructure on either island. Ahus had a medical clinic, primary and secondary schools, several small trade stores, a petrol outlet, and a guesthouse. Water taxis frequently travelled between Ahus and Lorengau. Andra also had a medical clinic, primary school, trade stores, and petrol outlets.

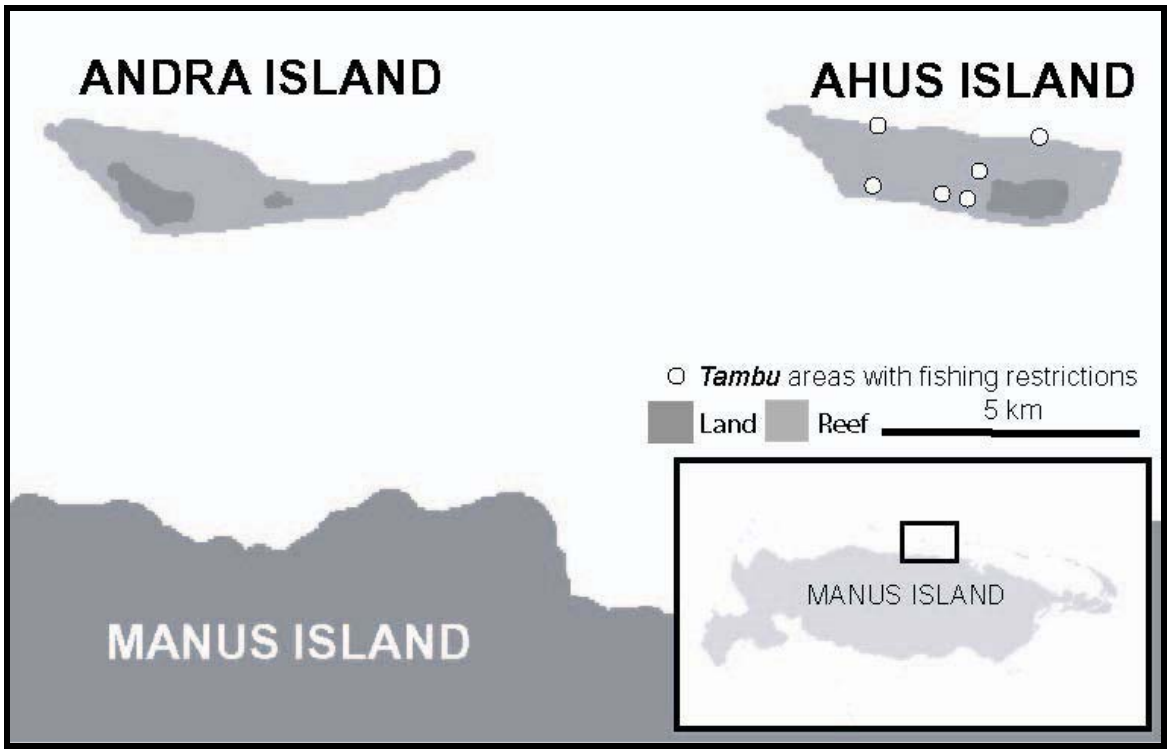

Figure 11. Map of Manus Sites (Manus Province)

Land in both Ahus and Andra was divided into clan blocks, however, individual families could own land if their forefathers originally cultivated the area. Clan land was handed down in a patrilineal system. Conflicts involving land were said to be a major issue in both communities. Land conflicts were normally resolved locally, however mediations

were held when matters became complex and further court hearing was normally called upon.

Sea tenure in both Ahus and Andra communities was extremely complicated and requires a more detailed explanation than other areas. In the Manus Province, small island communities historically supplied marine resources and specialized goods such as pottery and shell beads as part of a complicated network of trade (Carrier & Carrier, 1991; McEldowney, 1993). Marine tenure in these two communities is similar to what Carrier (1987) and Carrier and Carrier (1991) described in detail on neighbouring Ponham Island. Both communities claimed to have exclusive rights to fish the reef surrounding their islands and the water between the islands and mainland Manus. To ensure that island communities had desirable goods to trade, inland communities were largely excluded from accessing marine resources (Carrier & Carrier, 1991). These trade relationships may have helped form the basis for the complex marine tenure institutions that continue to regulate control over and access to marine resources along the north coast of Manus (Carrier, 1987; Carrier & Carrier, 1991; Hyndman, 1993).

The reef surrounding both communities is divided up into clan areas. However, clans, families, and individuals had differing rights to specific reef areas, species, gear, and methods of using gear. Villagers from any clan were allowed to line fish anywhere. Net usage was highly regulated, with some families having exclusive rights to certain types of nets and specific methods of net usage. Resources, such as sea cucumbers, trochus, coral (for lime production), dugongs and turtles, were owned by clans or individual families. Ahus has six reef areas that are restricted to fishing activities (Figure 11). Throughout most of the year, spear and net fishing within the restricted (tambu) areas are prohibited and harvesting of invertebrates is severely limited. Line fishing is, however, unregulated within the tambu area. Up to three times per year, each of the tambu areas may be harvested with spears and nets for a brief period of time (2 to 3 hours) to provide fish for ceremonial occasions that mark significant events in the village such as the opening of a community building or the conclusion of a mourning period (Figures 12 a and b).

Figures 12a and b. (a) Periodic Harvest of Ahus Reef Closure and (b) Ceremonial Feast to Mark the Opening of a Community Building (*haus boi*).

Summary of Coastal Resource Governance at the Study Sites

Four main types of traditional fisheries management were prevalent in the study sites: excluding other communities or non-users from accessing marine resources, spatial restrictions, gear restrictions, and species restrictions. Table 8 summarizes the tenure strength, closed areas, gear restrictions and species restrictions. As discussed in Chapter II, the ability to control or own marine resources (which includes excluding non-users from fishing grounds) in the Pacific is referred to as customary marine tenure. Customary marine tenure regimes varied from relatively open-access where outsiders were permitted to fish on community owned fishing grounds to complex marine tenure regimes where rights to specific reef areas, marine species, and gear types. As previously described in the methods section, reef tenure regimes were classified into three categories: weak, moderate, and strong.

Table 8. Distribution of Marine Tenure and Traditional Management Regimes

Village	Closed areas	Tenure Classification	Gear restrictions	Species restrictions
Ahus	Yes [1]	Strong	Yes [5]	Yes [7,8]
Andra	No	Strong	Yes [5]	Yes [7,8]
Enuk	No	Moderate	No	No
Fissoa	No	Weak	No	No
Gabagaba	No	Strong	No	No
Kilu	Yes [2]	Moderate	No	Yes [7]
Kranket	No	Weak	No	No
Madina	Yes [2,3,4]	Strong	No	no
Mongol	No	Weak	No	Yes [7]
Muluk	Yes [4]	Strong	Yes [6]	No
Nusa Lik	No	Moderate	No	Yes [7]
Patanga	Yes [2]	Moderate	No	Yes [7]
Riwo	No	Moderate	No	Yes [7]
Wadau	No	Weak	Yes [6]	No

[1]Spearfishing and net use prohibited in delineated area
[2]Reef area closed after person of significance in community dies
[3]Area closed for rainmaking
[4]Area periodically closed to promote fish aggregation or make fish "tame"
[5]Gear use restricted by ownership of certain gear and techniques
[6]Initiations are required before specific gear are used (hand spears to capture flying fish)
[7]Dietary restrictions on certain species
[8]Ownership of marine resources may restrict or regulate who can harvest specific species

Five of the 14 communities examined (36%) traditionally closed their reefs to fishing activity: Ahus, Muluk, Patanga, Madina, and Kilu. It should be noted that at Ahus, the restrictions extended only to spear guns and net fishing. Line fishing was allowed in the restricted area. The other sites temporarily prohibited all fishing activities. Details of the specifics of each closure were provided site by site in the previous section. Four of the communities, Andra, Ahus, Muluk, and Wadau had gear restrictions that limited the gear that certain people were allowed to use. In Ahus and Andra, restrictions on gear use were a result of traditional ownership rights that extended to gear types (such as net) and even techniques as to how nets were used. In Muluk and Wadau, initiation ceremonies were required before residents could participate in spearing flying fish at night (called *bom bom*). Restrictions on the types of species that people could eat, popularly known to anthropologists as "food avoidances", were the most prevalent type of traditional management encountered at the study sites. Seven of the fourteen sites had restrictions on the types of species that people were allowed to eat. It should be noted that a restriction on a particular species did not necessarily prevent the harvest or sale of that species, but only its consumption.

Summary

This chapter presented site descriptions of the 14 study sites. Qualitative and quantitative descriptors were used to examine population, village location, availability of markets, availability of farming land, infrastructure, marine tenure and other marine resource management strategies. This chapter showed that the study sites consist of communities that are diverse in many aspects- population size, access to marine and terrestrial resources, location, and distance to markets. The following chapter quantitatively examines and compares the social characteristics of communities with and without traditional management.

CHAPTER V. ANALYSIS OF WHETHER COMMUNITIES WITH TRADITIONAL CLOSURES HAVE DIFFERENT SOCIOECONOMIC CHARACTERISTICS THAN COMMUNITIES WITHOUT

This chapter explores how coastal resource governance regimes in Papua New Guinea (PNG) are related to socioeconomic factors and will answer the following research question: Do communities with traditional management have different socioeconomic characteristics to those communities that do not? The hypothesis is that the implementation of traditional management systems in PNG is related to social, economic, and cultural factors. There are five main sections in this chapter: 1) a brief review of the background of the research question; 2) a description of the data analyses used to explore how traditional closures are related to socioeconomic factors; 3) an analysis of socioeconomic factors influencing traditional management; 4) a summary of the findings, and 5) a discussion of the results in the context of other empirical and theoretical studies.

This chapter begins by reviewing the background of the research question and highlights the case for using a comparative approach to examine how socioeconomic factors are related to traditional management regimes. Since one of the data analysis techniques used in this chapter (Rasch analysis) has not yet been applied to the fields of common property or natural resource management, a portion of this chapter is dedicated to providing background information on why and how we measure social characteristics in the social sciences and explaining how to interpret the Rasch analysis. Then, the specific steps taken to compare social characteristics in the communities are detailed. After the results of the analysis are presented, the findings are summarised and discussed in the context of existing literature. The following chapter will use two case studies to build upon the results in this chapter.

Background

In many parts of the Pacific, marine resources are governed using customary marine tenure and traditional management (Colding & Folke, 2001; Johannes, 2002d). Because of their perceived potential to meet both conservation and community goals, these traditional resource management techniques are being revitalized by communities, governments, and NGOs as an integral part of national and regional marine conservation plans in the Pacific. However, it is uncertain whether these conservation strategies are being built on a solid foundation, as the resilience of traditional management systems in the face of the profound social and economic changes sweeping the Pacific region remains unclear. Numerous studies have suggested that changes in traditional management are attributed to social and economic factors (Aswani, 2002; Baines, 1989; Cooke et al., 2000; Foale & Macintyre, 2000; Hviding, 1996; Watson, 1989), however, specific relationships between socioeconomic conditions and traditional management are inconsistent in the literature and are still not well understood. The lack of clear understanding about how socioeconomic conditions influence traditional management regimes led to the development of the following research question:

Do communities with traditional management have different socioeconomic characteristics to those communities that do not?

Chapter II presented a conceptual framework for comparing the socioeconomic characteristics of communities with common property regimes developed in Ostrom's pivotal work *Governing the Commons* (1990). Ostrom (1990) emphasized the role of socioeconomic factors (which Ostrom called situational factors) rather than the internal rational calculators proposed by Hardin (1968) and Oslen (1965) in determining whether and how people could manage common property resources. Ostrom (1990) proposed that common property institutions could be analysed and compared by examining key socioeconomic factors. Chapter II summarised a number of empirical and theoretical studies to show that a range of socioeconomic factors could be important in influencing how individuals and communities cooperate to sustain common property regimes. These included: social capital (Pretty, 2003; Pretty & Smith, 2004; Uphoff & Wijayaratna,

2000), modernisation and market conditions (Henrich et al., 2001; Hviding, 1983, 1996), population and settlement patterns (Aswani, 1999, 2002; Ostrom, 1990), perceptions of the resource (Burke, 2001; Ostrom, 1990), conflict (Adams et al., 2003; Dietz et al., 2003a) size of the resource (Ostrom 1990) and dependence on resources (Lise, 2000; Zanetell & Knuth, 2004). These empirical and theoretical developments guided the selection of socioeconomic factors believed to be most likely to influence common property management.

To date, most research that has examined the social, economic, and cultural factors influencing traditional management regimes has used a case study approach (e.g., Hviding, 1996) or comparative approach with a very small number of replicates (e.g., Aswani, 2002). Despite the contributions of these studies to understanding traditional management regimes, a fundamental limitation of this approach is that they do not allow us to discern larger patterns in how traditional common property regimes may respond to social and economic factors. What is needed to complement the more detailed case studies and better understand how traditional management regimes are related to social and economic factors in a wider geographical context is a large-scale comparative assessment using standard indicators (Pollnac & Johnson, in press).

In this chapter, a comparative approach is used to explore how socioeconomic factors are related to presence of traditional reef closures in 14 coastal communities in PNG. To determine specific relationships between socioeconomic factors and traditional management strategies, this chapter will compare socioeconomic conditions in communities with traditional closures to those without traditional closures. Traditional closures, as opposed to other traditional management practices (e.g., species taboos), were examined because they appear to have the greatest potential conservation values and most closely approximate the most widely used coral reef fisheries conservation tool: the marine reserve. It was hoped that by exploring the socioeconomic processes that allow communities to employ traditional reef closures, some insight could be gained into the social principles that should be considered in planning and implementing modern marine reserves.

Introduction: Measuring Social Characteristics

Social scientists often seek to study, measure, and quantitatively compare underlying conceptual constructs in the human condition (called latent traits). Latent traits can include concepts as diverse as attitudes, beliefs, intelligence, quality of life, skills, abilities, wealth, and social status. Indeed, many of the themes that have been shown to influence how common-pool resources are managed (i.e., dependence on marine resources, modernisation, perceptions of the environment, and social capital) are latent traits. The difficulty for social scientists arises because these latent traits are not directly measurable.

However, there are aspects in the ways in which people live, believe, or behave that are indicators of the latent traits they possess. Since latent traits are not directly measurable, indicators are often used as proxy measures to create a conceptual "ruler" of the desired trait (Cinner & Pollnac, 2004; Poggie, 1978; Pollnac, 1989; Scones, 1995). For example, Cinner and Pollnac (2004) construct a scale of wealth based on the presence or absence of household possessions. Likewise, Chapter III discussed how in this thesis, key informants in PNG suggested that the presence or absence of a TV, a concrete home, and a costly metal roof might indicate a highly modernized lifestyle, whereas a bamboo floor and a thatch roof might indicate a less modernized lifestyle. Although each indicator may provide some information about the type of lifestyle someone leads, using a single indicator as the sole measure of how modernized someone's lifestyle is can be misleading. For example, someone may not like television and decide not to own one. If that was our only indicator by which we judged whether someone lived a modernized lifestyle or not, we may incorrectly classify the aforementioned person that doesn't like TV as someone that does not live a modernized lifestyle when that may well not be the case. So to improve the accuracy of our measure of latent traits, social scientists frequently construct variables that are the accretion of several indicators. The aim of these variables is to serve as rulers or scales by which people can be measured and compared on a continuum of a desired trait or characteristic. Fundamental to the practice of aggregating indicators is the notion that, when properly measured and constructed, variables represent more than a random group of indicators- they measure a latent trait.

Social scientists have devised a number of methods to construct variables[2] that measure latent traits. Analytical techniques that exist to construct variables from indicators include summation, factor analysis (Pollnac & Crawford, 2000), latent structure analysis (Lazarsfeld, 1959), log linear models, and item response theory (Bond & Fox, 2001). For example, in Cinner and Pollnac (2004) a factor analysis was used to construct a scale of material style of life based on the interrelationships between indicators of wealth. The relative wealth of groups of respondents was compared by examining differences in mean factor scores. However, Vaske et al. (2002) note how communicating the practical significance[3] of results from computed variables (such as the material style of life scales in Cinner and Pollnac, 2004) can be confusing because the scales are often measured in conceptually abstract units that lack intuitive appeal.

The partial credit Rasch analysis used in this research is part of the broad family of measurement techniques called item response theory. Rasch analysis is a technique used mainly in the fields of psychology and education that can provide an intuitive measure (and comparison) of latent social and psychological traits. Rasch analysis allows for the accretion of indicators that will produce the best approximation to an interval-level scale of the desired trait (Bond & Fox, 2001). Quality control of indicators, in the form of fit statistics, allows users of the Rasch model to only utilise indicators that contribute to the latent trait being measured (Bond & Fox, 2001). Appendix III discusses some mechanics of the Rasch analysis.

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[2] In the context of this thesis, there is a need to separate the terms variable and indicator. Indicator refers to a specific parameter that has been measured (for example, whether the household has a TV). The term variable refers to an aggregation of indicators used to measure a latent trait (for example, whether a respondent has a TV, radio, and other material possessions will be used to construct a variable that measures how modernized respondents' lifestyle are).

[3] Vaske et al. (2002) note that practical significance determines whether a relationship is meaningful involves a value judgment by the researcher and consumer of the research as to the implications of the findings.

Rasch analysis is conceptually similar (although analytically different) from applications of factor analysis in the social sciences (e.g., Cinner & Pollnac, 2004; Pollnac & Crawford, 2000). As with these applications of factor analysis, Rasch analysis also allows for the development of a scale based on indicators, but provides more information about the scale which consequently allows for more informed and more intuitive interpretations of the results. In particular, Rasch analysis allows one to view each indicator's position on the resulting measurement scale (Bond & Fox, 2001). This feature, in conjunction with fit statistics, helps to determine whether the accretion of indicators reflects the underlying conceptual construct being measured (a concept known as validity) and whether the indicators have produced a repeatable measure of the latent trait (a concept known as reliability) (Bond & Fox, 2001). One can also view the position of each respondent or even groups of respondents on the same scale. Therefore, Rasch analysis allows one to not only examine whether two groups of people have significantly different scores on a latent trait, but also examine the specific aspects of the trait that separate the two groups. This feature allows us to move beyond simply understanding THAT two groups have different amounts of a latent trait based on information such as abstract notions of significantly different factor scores (e.g., Cinner & Pollnac, 2004), to understanding HOW two groups are different based on an intuitive understanding of the aspects of the trait that separate them.

Although the Rasch model has yet to be used in common property or resource management studies, it was an attractive option for this thesis instead of the factor analysis or other alternatives because it can also: 1) handle missing values without discarding or deleting the case; 2) accept non-parametric data (i.e., non-normal, polytomous or dichotomous data); and 3) handle the combination of data types that were collected (i.e., polytomous, and dichotomous). These features were particularly important for this thesis because some respondents had missing values for specific indicators (in particular, the low response rate for the Likert scale responses perceived condition of resources discussed in Chapter III would have led to a high proportion of the cases being discarded if a technique that could not handle missing values was employed) and the

specific indicators were comprised of a range of data types. Other advantages of the Rasch model compared to alternative techniques are discussed in Bond and Fox (2001).

Methods

Research design

Not all socioeconomic variables could be analysed in the same way. Some of these factors were collected on a village scale (e.g., distance to market and population), while others were collected at the household scale (e.g., dependence on marine resources and modernisation). At the village scale, the sample size was too small (n=14 communities) to reliably combine village-level indicators into latent trait measures (Wright & Tennant, 1996 suggest a sample size of at least 30). Therefore, each village-level indicator was analysed separately. Alternatively, at the household-level, the sample size was adequate (n=506 household surveys) for the development of latent trait measures using Rasch analysis. Therefore, Rasch analysis was used to aggregate household-level indicators into measures of latent traits.

Figure 13 illustrates a conceptual model of the research design for how this thesis investigates the factors related to traditional closures. Each of the factors identified as potentially influencing traditional closures have arrows connecting them to the centre circle titled "presence of traditional closures." The factors on the left hand side of the circle are the village-level indicators. On the right hand side of the circle are the household-level variables. Arrows from the far right boxes indicate how Rasch analysis was used to aggregate specific household-level indicators into the household-level variables. The far right boxes reference Table 9, which highlights the specific indicators used to create each household-level variable.

Figure 13. Conceptual Model of Research Design

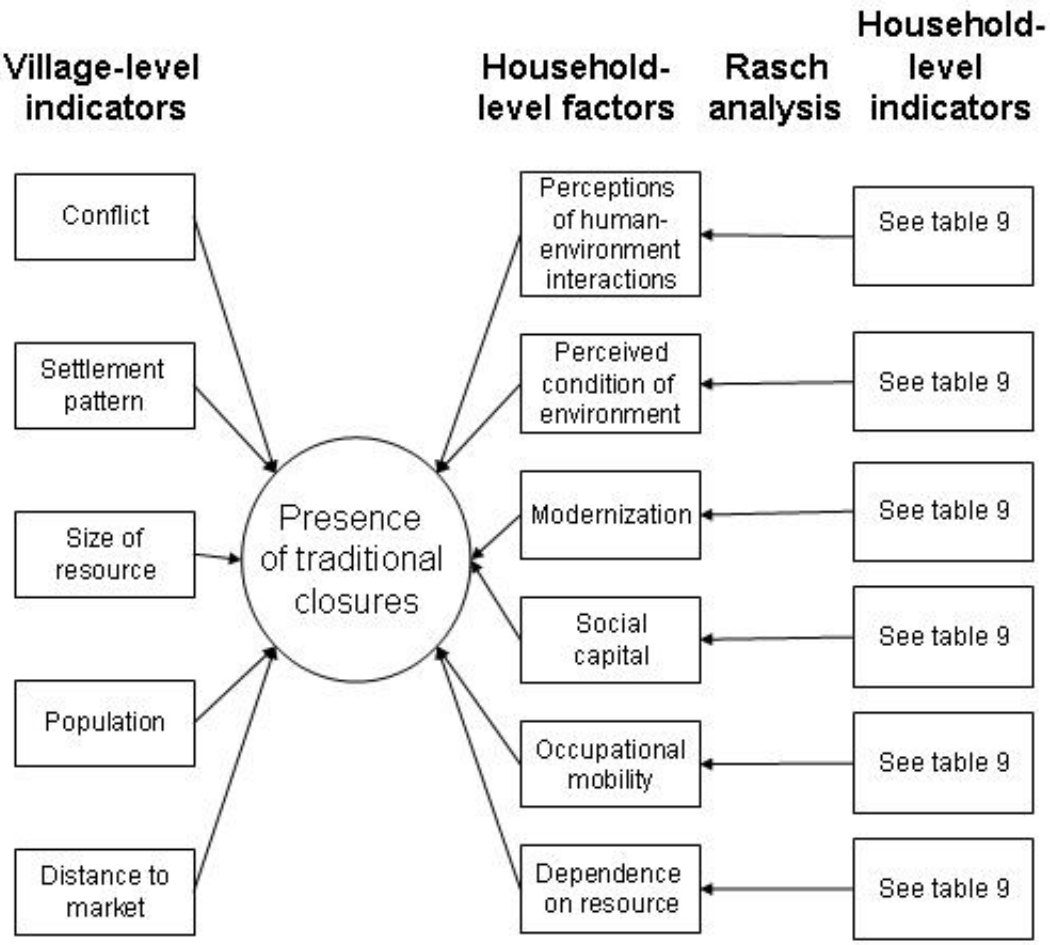

Table 9. Summary of Socioeconomic Factors and the Indicators Used to Measure Them

Factor	Description	Type of data	Collection method
Social capital			
Community participation	Number of community organizations household is involved in	Ratio	HHS
Participation in decision-making	Degree of involvement in decision-making (not involved, passively involved, or actively involved)	Ordinal	HHS
Migration	Whether respondent emigrated	P/A	HHS
Occupational mobility			
Occupational multiplicity	Number of occupations household is engaged in	Ratio	HHS
Involvement on informal economy	Rank relative to other occupations the household is engaged in	Ordinal	HHS
Dependence on marine resources			
Fishing pressure	Number of fishing trips per household	Interval	HHS
Involvement in fishing	Rank relative to other occupations the household is engaged in	Ordinal	HHS
Involvement in agriculture	Same as above	Ordinal	HHS
Level of subsistence	Percent of fish catch that is sold at the market	Percent	HHS
Ownership of gear	Whether household owns a boat and/or motor	P/A	HHS
Modernisation			
Education	Number of years of formal education	Ratio	HHS
Expenditures	Recent fortnightly expenditures	Ratio	HHS
Material style of life	a) Presence or absence of TV, radio, and vehicle	a) P/A	HHS
	b) Type of wall, floor, ceiling, and stove	b) Ordinal	
Involvement in formal economy	Rank relative to other occupations the household is engaged in	Ordinal	HHS
Perceived condition of resource			
Perceived trend in resource conditions	Perceived condition of fishery and coral reef a) five years ago minus current condition and b) current condition minus forecasted condition in 5 years (based on two Likert scale scores)	20 point scale	HHS
Perceptions of the human-environment interaction			
	Responses to open-ended questions regarding what can affect and improve the condition of the fishery	P/A of response category	HHS
Village-Level Indicators			
Size of resource	Area of reef, sand, and seagrass resources available to community	Ratio	Aerial photo; KII
Population	Village population	Ratio	HHS;
Settlement pattern	1 = nucleated coastal; 2 = dispersed coastal/inland;	Nominal	Obs.
Distance to market	Kilometres to the provincial capital	Ratio	Map
Conflicts	Presence of conflicts over marine resources	P/A.	KII

HHS= Household surveys; KII= Key informant interview; Obs. = Observation; P/A= present/absent

Operations to develop socioeconomic variables

The Rasch model operates using dichotomous or polytomous data, therefore the first step in developing a Rasch model for the household-level indicators was to transform the continuous indicators (years of formal education, fortnightly expenditures, fishing trips per week, number of occupations per household, and the number of community organisations the household belongs to) into ordinal indicators. This was done using the "categorize variables" function in SPSS statistical package. Ten ordinal categories were created, starting from 0 and ranging to 9. Variables that were originally ordinal or dichotomous were not transformed (with two exceptions discussed below).

The Rasch model requires that all of the variables in a model positively contribute to the desired latent trait. To meet this requirement, two of the variables had to be polarized: migration and rank of agriculture. Therefore, for the migration variable, migrants were given a "0" and locals were given a "1" and the indicator was renamed "local." This was done because migration was conceptually included on the social capital variable as a factor that could decrease social capital (Curran & Agardy, 2002). Therefore, to make it positively contribute to the attribute it had to be polarized. Likewise, the rank of agriculture, which originally had six ordinal categories (zero being no participation and 5 being the most important occupation in the household), was reversed (i.e., the lowest ordinal measure meant it was the most important occupation in the household). The relative importance of agriculture was conceptually part of a dependence on marine resource variable.

Then, Rasch analysis was used to aggregate the household-level indicators into five theory-driven variables. To develop a more viable scale, two of the variables (social capital and occupational mobility) were combined into a single variable primarily because there were not enough indicators to produce a reliable scale for either individual variable. It was expected that both of these variables would have the same directionality (i.e., occupational mobility and social capital would be higher in communities with

traditional management- see Chapter II), so grouping these variables together, although not ideal, was reasonable.

Analysing differences

Household-level variables

Rasch analysis was used to aggregate the specified indicators together and provide each respondent with a reliable interval-level score for each of the five household-level socioeconomic variables (dependence on marine resources, social capital and occupational mobility, modernisation, perceived condition of the environment, and perceptions of the human-environment interaction). Two types of analyses were then used to compare these mean socioeconomic variable scores in communities with traditional reef closures to the mean scores of communities without traditional closures; 1) differences in mean scores for each of the five household-level socioeconomic variables were compared graphically on an associated figure, and 2) when it looked as though a relationship might exist, a nested ANOVA was used to test for statistical significance using the SPSS 11.0 statistical software. The ANOVA is an analysis of variance technique used to determine whether two groups are significantly different based on the variance surrounding mean values. The nested variation of the ANOVA is used to ensure proper replication when data are collected using a hierarchical design such as this study (i.e., respondents were nested within communities and communities either had traditional management or did not) (Underwood, 1997). Therefore, the socioeconomic variables were the dependent variables, and the fixed factors were communities nested within traditional management. Q-Q plots and the Shapiro-Wilk and Kolmorogov-Smirnov tests were used to assess normality of the residuals. The ANOVA also requires the assumption of homogeneity of variance, which was determined using the Levene's test. When variables did not meet assumptions of homogeneity of variance, the variance of the groups was examined to determine how unequal variances might affect the results.

Village-level indicators

Two types of non-parametric analyses were performed to discern whether the presence of traditional management was also related to village-level factors: the Mann Whitney U test and Fisher's Exact test. Ordinal or interval village-level socioeconomic characteristics of communities with traditional management were compared to those of communities without traditional management using the Mann-Whitney U test. The Mann-Whitney U test is a non-parametric alternative to the T-test which is used to test whether two samples are independent. The Mann Whitney U test was used to examine whether mean village-level characteristics were significantly different for communities with traditional management compared with communities without traditional management. The frequency of dichotomous indicators, (i.e., settlement patterns and the presence of conflicts) in communities with traditional management was compared to communities without traditional management using a Fisher's Exact test. The Fisher's Exact test is a non-parametric analysis used to discern whether two samples are independent based on the frequency of observed responses in a 2x2 contingency table. A Fisher's Exact test is used when the two independent samples are small (Siegel & Castellan, 1988). Liberal p values were accepted for determining statistical significance ($p<0.1$), because this is an exploratory analysis and based on the moderate sample size of 14 communities, it was important not to exclude any variables that might be important (i.e., the consequences of committing a type I error were thought to be more grave than a type II error).

Results

Reliability and validity

There are two concepts crucial to determining whether an aggregation of indicators should be used as a measure of a latent trait: validity and reliability. Validity addresses the question of whether these indicators actually measure the latent trait that is being investigated, while reliability addresses how consistently this could be measured.

Validity of latent traits in Rasch analysis goes hand in hand with the concept of unidimensionality- that only one attribute, dimension, or latent trait at a time should be measured (Bond & Fox, 2001). Validity in Rasch analysis is determined in part by fit statistics, which are used as quality control measures to ensure that all indicators used are contributing to a single latent trait. Infit and outfit statistics examine different aspects of how well the data fit the expectations or requirements of the model (see Bond & Fox, 2001 for a discussion of model expectations and requirements). Both outfit and infit statistics can be measured as mean squares or as *t* distributions (Bond and Fox, 2001 note that the mean square statistics can be converted into normalized *t* distribution using Wilson-Hilferty transformation). Since the two measures are often used interchangeably, this thesis will only present mean square statistics, which have an expected value of 1.

Reliability is used to indicate the reproducibility of the measure (Linacre, 1997). Rasch analysis uses a reliability index that estimates the applicability of this measure to other respondents or indicator datasets. The reliability estimates range from 0 (not applicable) to 1 (perfectly applicable).

Rasch analysis allows for reliability and validity to be assessed separately for both respondents and indicators. This feature allows for judgements about the sample of respondents and the quality of indicators chosen. For example, respondent reliability provides information about how the same group of people would provide similar responses to a comparable questionnaire, whereas indicator reliability provides information about whether the ordering of indicators in the scale would likely be consistent if the same questionnaire was administered to another group of respondents. Thus, validity and reliability statistics are presented separately for indicators and respondents (Table 10).

The fit (validity) of the indicator measuring fortnightly expenditures was low. This suggested that the indicator was not contributing to the measurement of the modernisation scale. The indicator was removed from the analysis and the model was

reiterated. All fit indicators were then considered adequate, with most infit and outfit means very close to the expected value of 1 (Table 10).

Table 10. Fit Statistics for Variables. Estimates for indicators and respondents are presented separately.

Model statistics	Social capital and mobility	Perceptions of human-environment interaction	Modernisation	Dependence on marine resources	Perceived condition of the environment
Indicator estimates					
Mean[a]	-0.01	0.0	0.0	0.01	0.0
SD	0.91	1.05	0.88	0.81	0.6
Reliability index[b]	0.91	.99	.96	0.94	0.0
Infit mean square[c]	0.99	1.0	1.00	0.91	1.00
SD	0.16	0.09	0.14	0.36	0.11
Outfit mean square[c]	0.97	0.92	0.93	0.92	0.94
SD	0.20	0.20	0.23	0.38	0.09
Respondent estimates					
Mean[a]	0.09	-1.3	-.96	-0.70	-0.03
SD	0.67	0.87	.66	0.98	0.49
Reliability index[b]	0.47	0.14	0.73	.75	0.69
Infit mean square[c]	0.88	0.99	1.10	0.73	0.94
SD	0.75	0.37	0.94	0.72	0.85
Outfit mean square[c]	0.97	0.92	0.93	0.95	0.94
SD	0.78	0.53	0.93	1.36	0.86

[a]The mean statistic estimates the average respondent ability or indicator difficulty, using an origin scale (i.e., baseline) of zero logits.
[b]The reliability index estimates the applicability of this model to other respondents and indicators. The reliability estimates range from 0 (not applicable) to 1 (perfectly applicable).
[c]The mean squares infit and outfit statistics are reported as chi-square statistics divided by their degrees of freedom and have an expected value of 1. Variation between observed data and what the model expects is the difference between one and the mean squares statistic. For example, the dependence on marine resources infit mean squares is 0.73; therefore, there is 27% less variation in the observed data than the expected data. Likewise the modernisation infit mean squares is 1.10, therefore, there is 10% more variation in the observed versus expected data.

The reliability estimates for most variables were high, with the exceptions of the indicator estimate for the perceived condition of the environment, and the respondent estimates for perceptions of the human-environment interaction. The low reliability for the indicators in the perceived condition of the environment variable is likely a reflection of the relatively low response rate (recall from the methods section that some respondents had difficulty with the Likert scale). The low respondent reliability score for the perceived condition of the environment simply means that if the same group of people were given a similar set of questions also designed to measure perceived condition of the environment, they are likely to score differently on the new questions. Given the non-representative sampling design through which communities (and ultimately respondents) were selected, the model is not necessarily applicable to other communities (as discussed in the methods section), so the low respondent reliability does not impede the use or interpretation of this model. For more detailed information regarding interpreting fit statistics, the reader is referred to Bond and Fox (2001). The reliability and fit statistics for the social capital and occupational mobility indicators, suggest that grouping these concepts into a single measure was acceptable.

Socioeconomic differences between communities with and without traditional management

An example of how to interpret Rasch analysis

This is the first known application of Rasch analysis to this type of social science research. As a result, most readers will be unfamiliar with the analysis and how to interpret the results. An example of how Rasch analysis is analysed and interpreted is presented in this section. This example will use the results of the modernisation measure and go through step-by-step how to understand and interpret the figures.

Ten indicators were used to construct a measure of modernisation (Table 9), recall that due to poor validity, the fortnightly expenditures indicator was discarded from the final analysis. Figure 14 shows how Rasch analysis combined these indicators to form a measure of modernisation. Indicators on the top of the scale are associated with a highly

modernized lifestyle whereas indicators on the bottom of the scale are associated with an unmodernized lifestyle. Some of these indicators were recorded as present/absent, while others had ordinal categories. Rasch analysis displays these indicators differently. The present/absent indicators are only presented once, whereas each ordinal category is presented for an ordinal indicator. For example, Figure 14 shows how the ordinal categories of education are displayed separately on the scale in a hierarchical manner (i.e. $\geq$ 12 years of education is higher on the modernisation scale than 0-3 years of education). It should be noted that Rasch analysis might estimate more than one ordinal category on the same level (indicating that there were no real differences between the categories). Therefore, these ordinal categories were combined, so the number of ordinal categories displayed on the Rasch output may not always match the number of ordinal categories used in the raw data. For example, originally there were ten ordinal categories for eduction, but several of the categories occurred together (e.g., 0-1 years and 2-3 years), so these were combined (e.g., 0-3 years) to produce a total of six distinct ordinal categories (Figure 14).

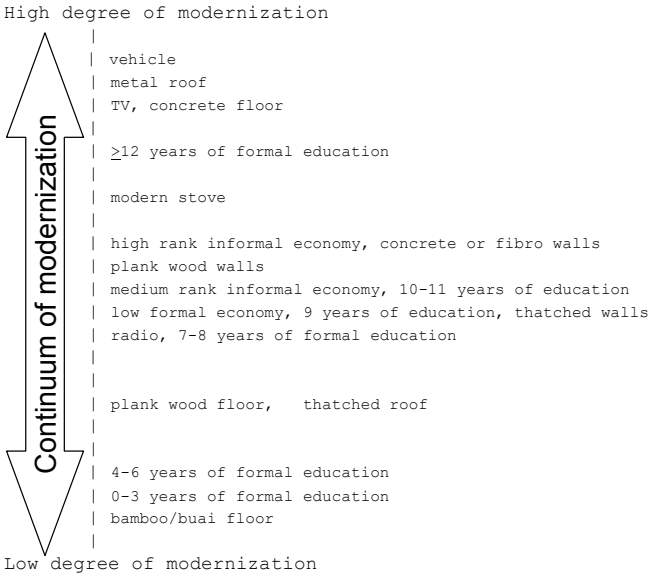

Figure 14. Modernisation Scale

By examining the distribution of indicators on Figure 14, it is clear that this measure of modernisation makes conceptual sense. A highly modernized lifestyle is associated with a vehicle, a metal roof, a TV, a concrete floor, and more than 12 years of education.

Alternatively, an unmodernized lifestyle is associated with low education and plank wood or bamboo/buai floors (buai is a type of palm), and a thatched roof. The fit statistics in Table 10 help to confirm that this measure is both valid and reliable.

On the same scale, individual respondents (and/or groups of respondents) can also be plotted. Figure 15 shows three sample respondents on the modernisation scale previously illustrated in Figure 14. A standard unit of measurement (a logit or log odds unit-see below for description of logits) is used to measure the modernisation levels of both respondents and indicators. Thus, we can judge the level of modernisation of both an indicator and a respondent by their relative positions on the scale. Respondents are likely to have indicators that occur on their measurement level. Thus, respondent a, who is high on the scale, is likely to have a vehicle, metal roof, TV, and a concrete floor (indicators of a highly modernized lifestyle). Alternatively, respondent c, who is low on the scale, is likely to have less than 3 years of education and bamboo/buai floors (indicators of an unmodernized lifestyle). The indicators that lie in between respondent a and respondent c are what likely separates these two individuals in terms of how modernized their lifestyle is. By examining the indicators that characterise and separate two respondents, an intuitive feel can be gained for whether differences in these scores are meaningful.

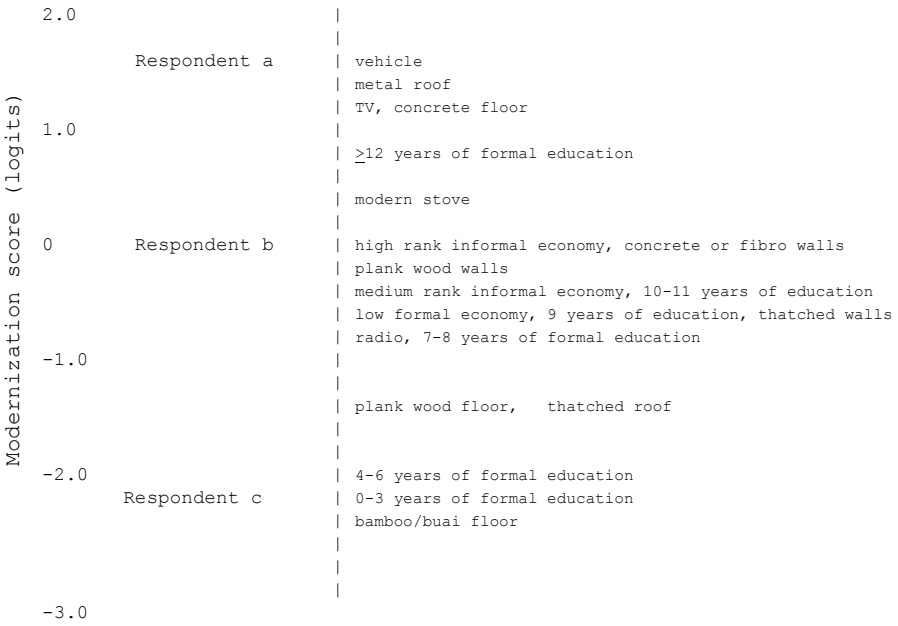

Figure 15. Modernisation Levels of Three Sample Respondents

There are two basic aspects one must understand and consider when interpreting both respondents and indicators on a single Rasch scale: 1) the position of both respondents and indicators on the scale are expressed in log odds units; and 2) probabilities are set at 0.5.

1) Log odds units. Interpreting the Rasch analysis is relatively easy because the position of each indicator and each respondent are based on a single hierarchical scale of log odds units. A log odds unit (logit) is the natural log of an odds ratio[4]. Therefore, one logit is the distance along the specified variable continuum that increases the odds of a respondent having a certain indicator by a factor of 2.718 (i.e., the value of the natural log) (Bond & Fox, 2001).
2) Probabilities. The probability that a respondent will correctly answer or possess a specific indicator is set at 0.5 (Bond & Fox, 2001). Therefore, a respondent has a 50/50 chance of possessing an indicator when the respondent's score and the indicator's score are equal. For example, respondent a on Figure 15 has a 50/50 chance of having a vehicle. When a respondent's score is higher than an indicator's score, that person has a better than 50% probability of having that indicator (the probability of having it depends on how many logits higher the respondent's score is than the indicator's score), and vice-versa (Bond & Fox, 2001). For example, in Figure 15, a radio is exactly 1 logit lower than respondent b. Therefore, the probability of respondent b having a radio is 75%. Alternatively, a TV is exactly 1 logit higher than respondent b, so the likelihood of respondent b having a TV is 25%. Qualitative judgments can be made about the practical significance of differences by simply examining the distance between two scores. Applications in education research have shown that any difference less than 0.5 logits is usually considered to have little substantive meaning (pers. com. T. Bond, 2005)

[4] The odds ratio is a method of comparing whether the probability of a certain event (in this case, whether a certain indicator is possessed) is the same for two groups

Thus, there are two aspects to consider in interpreting whether differences are meaningful: the distance between two scores (considering standard error) and the actual indicators that characterise and separate the scores. When examining differences in groups (as is done in this thesis), the mean scores can be examined quantitatively through statistics that compare whether means are significantly different (e.g., Mann-Whitney test, T-Test, analyses of variance).

This thesis presents a separate figure for each of the five variables developed with Rasch Analysis (modernisation, dependence on marine resources, social capital and occupational mobility, perceptions of the human-environment interaction, and perceived condition of the environment). As in Figure 15, each of these figures will display the variable construct (i.e., the specific indicators that comprise the variable) on the right hand side and respondents on the left hand side. However, rather than display individual respondents, the following figures will display an error bar chart of each community's score for that variable and 95% confidence interval.

To compare mean values between communities with and without traditional closures, the error bar chart will also indicate the mean score for communities with traditional closures and the mean score for communities without traditional closures. The indicators that lie in between the two means are what likely separate the two groups. As previously discussed, the distance between the groups is measured in logits, so the probability that one community will have a specific socioeconomic indicator while the other will not can be determined by the distance between the community groupings. Since this technique allows one to determine how the groups are different (in terms of the probability that each group will possess specific indicators), this provides more information than only testing for statistical significance. Results of the ANOVA will also be presented.

Modernisation

The modernisation variable was developed by aggregating material style of life indicators, such as the type of household possessions and household construction material

(see Table 9). Respondents with low modernisation scores were likely to have bamboo/buai floors and 0-3 years of formal education (Figure 16, right hand side). Respondents with high modernisations scores were more likely to have a vehicle, TV, metal roofs, and more than 12 years of formal education.

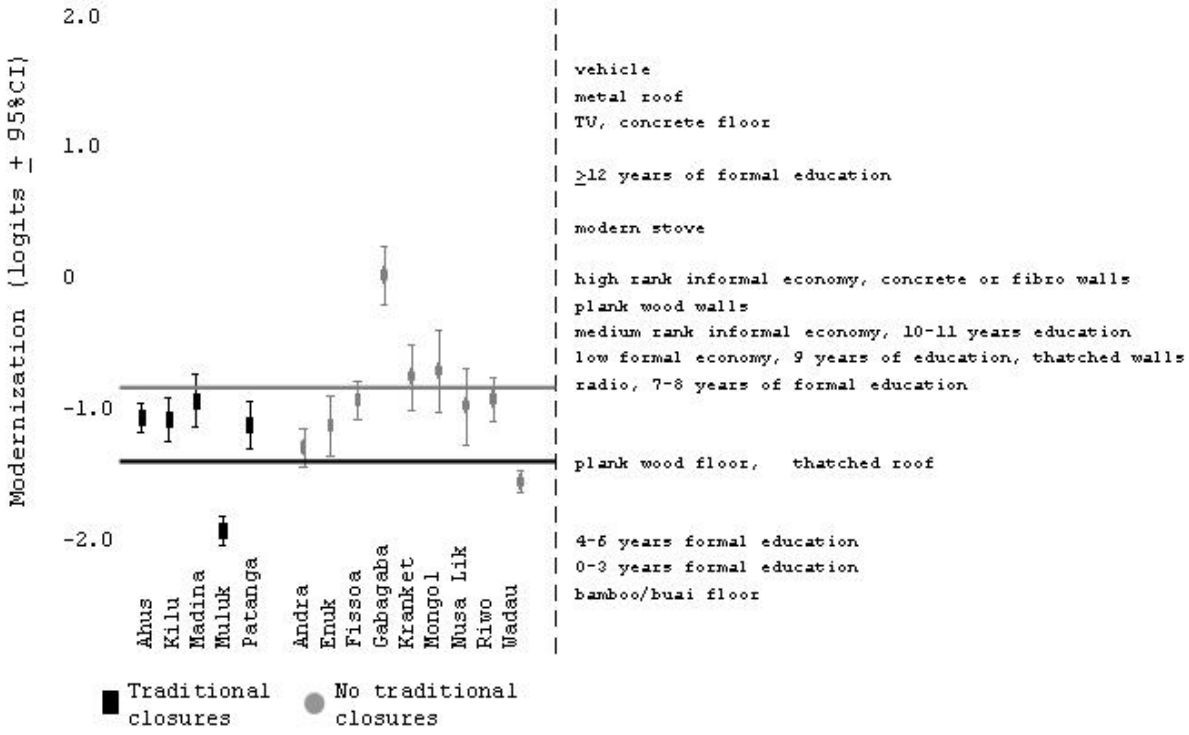

Figure 16. Comparison of Modernisation in Communities with and without Traditional Closures. Modernisation is measured along the y axis in logits. Indicators on the right hand side were used to construct the modernisation variable. Error bar charts on the left-hand side of the figure represent each community's score on the variable + 95% confidence interval. The mean modernisation score for all communities with traditional closures is indicated by the black horizontal line and the mean score for all communities without traditional closures is indicated by the grey line. The indicators on the right-hand side of the graph adjacent to the black and grey lines are what likely separates the two groups of communities in terms of their degree of modernisation.

Communities with traditional reef closures had a lower mean modernisation score (-1.25 $\pm$ 0.12[5]) than communities without (-0.95 $\pm$ 0.1) (Figure 16). The nested ANOVA was used to determine whether this difference was statistically significant. A nested ANOVA was run and the residuals of variables were then tested for normality. Q-Q plots showed

[5] All errors are 95% confidence intervals

that the residuals were close to the expected values, but results for both the Shapiro-Wilk and Kolmorogov-Smirnov tests indicated that there were departures from normality. Analyses of variance are robust to non-normality (Underwood, 1997). Underwood (1997) states that outcomes and interpretations of analyses of variance "are not affected by the data being non-normal." Of potentially more concern was the heterogeneity of variance in the sample. Results from the Levene's Test for homogeneity of variance test showed that the data met the assumption of homogeneity of variance. The variance of both groups was examined and the larger group had slightly larger variance (1.02 compared to 0.91). The implications of this type of violation of the assumption of homogeneity meant that the ANOVA would be more conservative (i.e. there was a risk of calling an effect not significant when it was significant). This risk was viewed as acceptable and the analysis was conducted. The ANOVA results showed these differences were statistically significant ($F = 13.6$, df = 13, $p > 0.001$, see Table 11).

Table 11. Results of Nested ANOVA Test for Whether Communities with Traditional Closures have Different Mean Modernisation Scores than Communities without

Source	Type III Sum of Squares	*df*	Mean Square	F	P
Corrected model	90.7 [a]	13	7.0	13.6	0.001
Intercept	528.8	1	528.8	1033.4	0.001
Traditional closure	10.1	1	10.1	19.7	0.001
Village nested in traditional closure	79.8	12	6.6	13.0	0.001
Error	248.7	486	0.5		
Total	908.8	500			
Corrected total	339.4	499			

[a] R Squared = .267 (Adjusted R Squared = .248)

Although the difference in the mean score is statistically significant, Rasch analysis allows us to examine the actual indicators that lie between the two mean values to determine whether there is practical significance between the two values (i.e., the black and grey horizontal lines in Figure 16). The indicators more likely to be associated with the communities without traditional closures (grey horizontal line Figure 16) include a radio and a 7-8 years of formal education, while the indicators associated with the communities with traditional closures include a plank wood floor and a thatched roof

(black horizontal line in Figure 16). The probability that communities with traditional management will have the indicators associated with communities without traditional management is 7% lower. Figure 16 shows that these differences are accentuated largely by the exceptionally low score of Muluk (with a traditional closure) and the exceptionally high score of Gabagaba (without a traditional closure). Communities with traditional closures appear to have very little variation within the communities compared to communities without traditional closures. Although the error bars are 95% confidence intervals, which can be influenced by both sample size and the total size of the community sampled, the standard deviations were examined and were lower in the communities with traditional closures (64.6) than in communities without (70.2). This suggests that variability in modernisation within a community may also be related to the presence of traditional closures.

Dependence on marine resources

The dependence on marine resources variable was constructed by aggregating the following indicators: participation in fishing, participation in agriculture, fishing effort, possession of boats and motors, and the proportion of fish bartered or sold (see Table 9). Respondents with high dependence on marine resources scores were likely to possess a boat and motor, were minimally involved in agriculture, ranked fishing as the top occupation, engaged in more than 10.5 fishing trips per week, and sold or bartered more than 80% of their catch (Figure 17- right hand side). Respondents with low dependence on marine resources scores ranked agriculture as an important occupation, but not fishing, and made an average of 1 or fewer fishing trips per week.

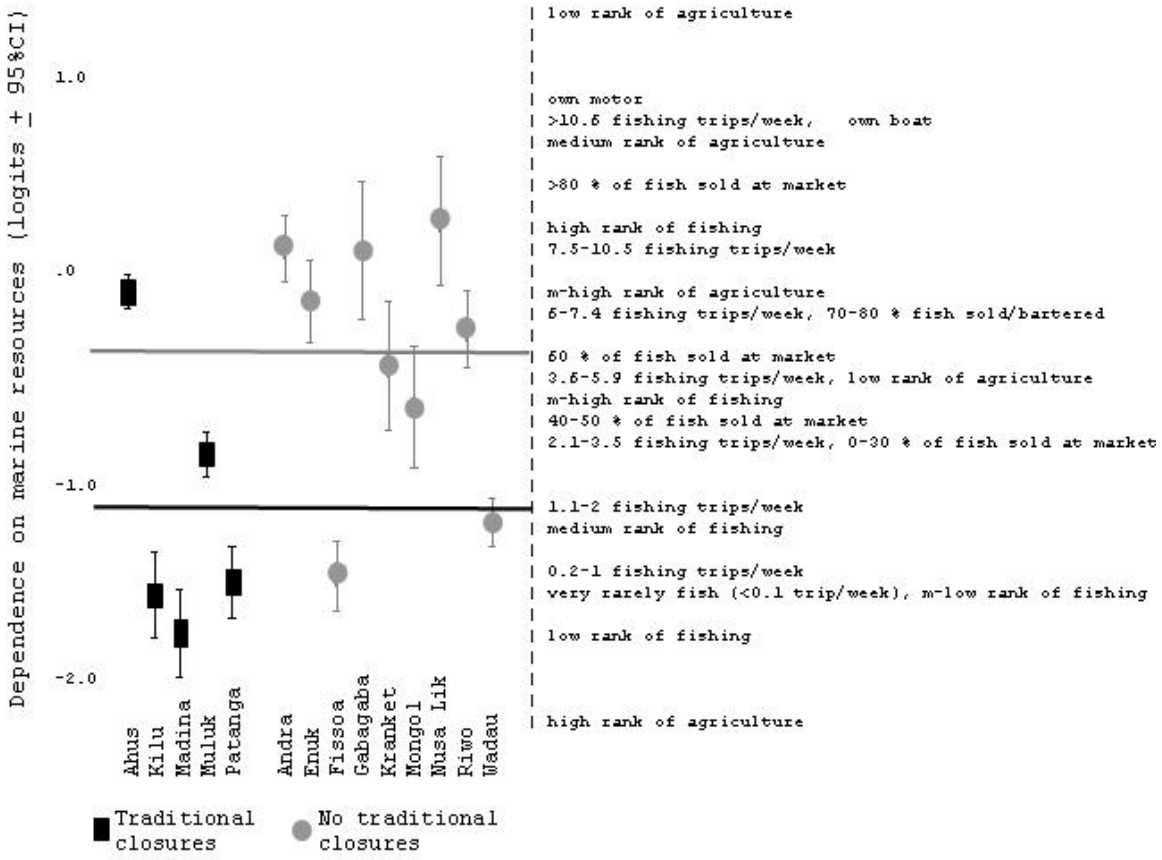

Figure 17. Comparison of Dependence on Marine Resources in Communities with and without Traditional Closures. Dependence on marine resources is measured along the y axis in logits. Indicators on the right hand side were used to construct the dependence on marine resources variable. Error bar charts on the left-hand side of the figure represent each community's score on the variable + 95% confidence interval. The mean dependence on marine resources score for all communities with traditional closures is indicated by the black horizontal line and the mean score for all communities without traditional closures is indicated by the grey line. The indicators on the right-hand side of the graph that lie in between the black and grey line are what likely separates the two groups of communities in terms of their dependence on marine resources.

Communities with traditional closures had lower dependence on marine resources than communities without (Figure 17). Communities with traditional closures had a mean dependence score of -1.1 ($\pm$ 0.14) compared to -0.46 ($\pm$ 0.12) in communities without traditional closures, a significant difference of 0.6 logits. As with the previous variable, the assumption of normality was not met based on the Kolmorogov-Smirnov tests, but Q-Q plots indicated that these variations were likely slight. Analyses of variance are robust to departures of normality (Underwood, 1997), so the violation of this assumption was viewed as acceptable. Results from the Levene's Test for homogeneity of variance test

also showed that the data violated the assumption of homogeneity of variance. The variance of both groups was examined and the larger group had slightly larger variance (1.12 compared to 0.77). The implications of this type of violation of the assumption of homogeneity meant that the ANOVA would be more conservative (i.e. there was a risk of calling an effect not significant when it was significant). This risk was viewed as acceptable and the ANOVA was conducted. These results were statistically significant (ANOVA: F = 25.2, df = 13, p >0.001, Table 12). The indicators separating these two scores indicate significant differences between the two types of communities (Figure 17). These include a change from one or two fishing trips per week to up to six trips per week and a change from a mostly subsistence fishery to a fishery where 50% percent of fish are sold or bartered.

Table 12. Results of Nested ANOVA Test for Whether Communities with Traditional Closures have Different Mean Dependence on Marine Resources Scores than Communities without

Source	Type III Sum of Squares	df	Mean Square	F	P
Corrected model	190.1	13	14.6	25.2	0.001
Intercept	268.4	1	268.4	462.7	0.001
Traditional closure	53.1	1	53.1	91.6	0.001
Village nested in traditional closure	148.3	12	12.4	21.3	0.001
Error	276.7	477	0.6		
Total	709.0	491			
Corrected total	466.8	490			

[a] R Squared = .407 (Adjusted R Squared = .391)

Figure 17 reveals an anomaly. The village of Ahus has a much higher dependence on marine resources than any of the other communities with traditional closures. This anomaly becomes particularly interesting when we note that the type of closure that Ahus operates is considerably different from the other closures. Ahus employs a gear restricted area, where only nets and spears are prohibited but line fishing is allowed- a strategy that would have considerably less social and economic impact on a community highly dependent upon marine resources than a no-take zone. The other communities employ periodic closures, where resources are closed from extractive activities for limited periods of time. This suggests that grouping all traditional closures together may be less

informative than examining the socioeconomic characteristics of communities that employ specific types of closures. Unfortunately, there is only one case of gear restricted areas in this sample, so a group of communities that employ this strategy cannot be formed to explore this quantatively. Therefore, the following chapter will use a detailed complimentary case study of each type of closure to examine how these strategies may be influenced by social factors in the communities that employ them.

When Ahus is excluded from the analysis, the mean dependence on marine resources score for communities with periodic closures (-1.36 + 0.07) is almost a logit lower than communities without traditional closures (-0.46 + 0.06). This suggests that periodic closures are a strategy employed in communities with low dependence on marine resources.

Social Capital and Occupational Mobility

The social capital and occupational mobility variable was developed by aggregating participation in decision-making, participation in community groups, involvement in informal economic activities, the number of occupations/livelihood strategies, and immigration indicators (see Table 9). High social capital and mobility were associated with involvement in a high number of community organisations, a high number of occupations, and ranking informal economic activities as highly important (Figure 18). Alternatively, low social capital and mobility was associated with being an immigrant, having passive involvement in community decision-making, and being involved in few occupations.

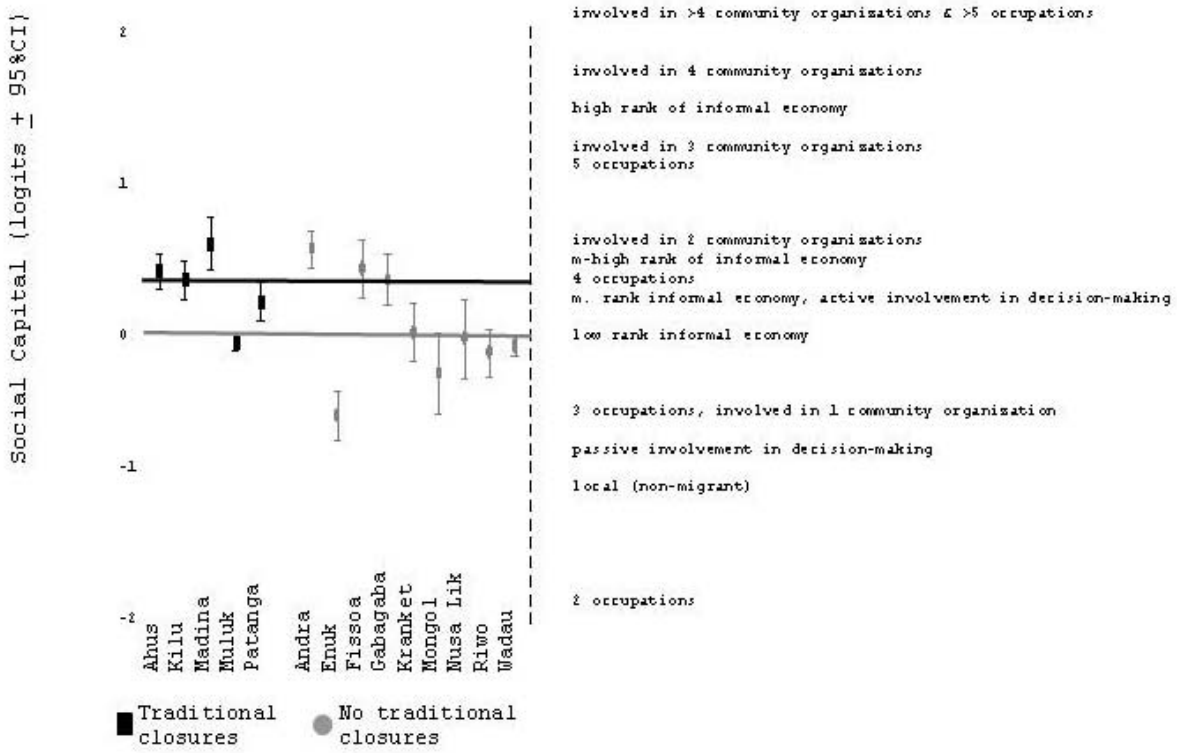

Figure 18. Comparison of Social Capital and Occupational Mobility in Communities with and without Traditional Closures. Social capital is measured along the y axis measured in logits. Indicators on the right hand side were used to construct the social capital variable. Error bar charts on the left-hand side of the figure represent each community's score on the variable + 95% confidence interval. The mean social capital score for all communities with traditional closures is indicated by the black horizontal line and the mean score for all communities without traditional closures is indicated by the grey line. The indicators on the right-hand side of the graph that lie in between the black and grey line are what likely separates the two groups of communities in terms of their degree of social capital.

Social capital and mobility was found to be higher in communities with traditional management. Communities with traditional management had a mean social capital and mobility score of 0.23 (± 0.09) logits, compared to a mean of 0.0 (± 0.08) for communities without traditional management. The indicator associated with a social capital score of 0.05 is a low rank of the informal economy and the indicators associated with a social capital score of 0.23 are a medium rank of the informal economy (a change of 2 ordinal categories from low to medium-low, then medium-low to medium) and high involvement in decision making. Therefore, the communities with traditional management are more likely to be more involved in the informal economy and active in village decision-making. However, the distance separating the means of the two groups is

relatively small (0.23 logits). The probability of communities with traditional management having these two indicators is only 6% higher, suggesting that the practical difference in social capital and mobility between these groups of communities is very slight. These results were tested for statistical significance with a nested ANOVA. As with the modernisation and dependence on marine resource constructs, tests indicated the data were non-normal, but Q-Q plots showed a distribution that was close to the expected distribution. The Levene's test indicated that the variances were homogeneous, so the nested ANOVA was run. The ANOVA indicated that the difference in social capital and occupational mobility between groups was statistically significant (F = 10.5, df = 13, p >0.001, Table 13).

Table 13. Results of Nested ANOVA Test for Whether Communities with Traditional Closures have Different Mean Social Capital and Occupational Mobility Scores than Communities without

Source	Type III Sum of Squares	df	Mean Square	F	P
Corrected Model	48.5	13	3.7	10.5	0.001
Intercept	4.9	1	4.9	13.7	0.001
Traditional closure	7.8	1	7.8	22.0	0.001
Village nested in Traditional closure	42.3	12	3.5	9.9	0.001
Error	174.0	489	0.4		
Total	226.9	503			
Corrected Total	222.5	502			

[a] R Squared = .218 (Adjusted R Squared = .197)

Communities with traditional management have a higher average social capital and mobility score, but there are communities with high scores that do not have traditional management (Figure 18). This suggests that communities with traditional management have high social capital and mobility, but that high social capital and mobility does not necessarily mean a community will have traditional management.

Perceptions of the human-environment interaction

The perceptions of the human-environment interaction variable was developed by aggregating responses to open-ended questions regarding what can affect fisheries and

what could improve fisheries (see Table 9). Respondents with low scores on the variable were likely to mention obvious factors that could affect the fishery, such as the use of destructive fishing techniques (i.e., bombs and poison) (Figure 19- right hand side). They were also likely to mention that the condition of the fishery could be improved by the use of traditional reef closures. This suggests that the use of closures to improve the condition of marine resources is an obvious response for many coastal people in PNG. Respondents with high scores on the variable were more likely to mention that abstract issues such as social and political factors could influence the condition of marine resources. They were also likely to mention that the use of nets could negatively affect the fishery.

Communities with traditional closures had a slightly lower mean perception of the human-environment interaction score (-1.44 $\pm$ 0.12) compared to communities without traditional closures (-1.22 $\pm$ 0.12) (Figure 19). The range of the 95% confidence intervals is larger than the difference in means, suggesting that there is no measurable difference between the two means. Figure 19 indicates that there is also considerable variation in the mean responses for communities without traditional closures, and no clear pattern is evident. The difference between these scores encompasses only one indicator: the belief that resource conditions could be improved with reef closures (Figure 19). Contrary to expectations, the odds that communities with closures endorsed this indicator were 5% lower than communities that did not. This difference between these two means was deemed to lack practical significant because difference was very slight (only 0.22 logits) and encompassed only one indicator. Thus, it was not necessary to test this variable for statistical significance.

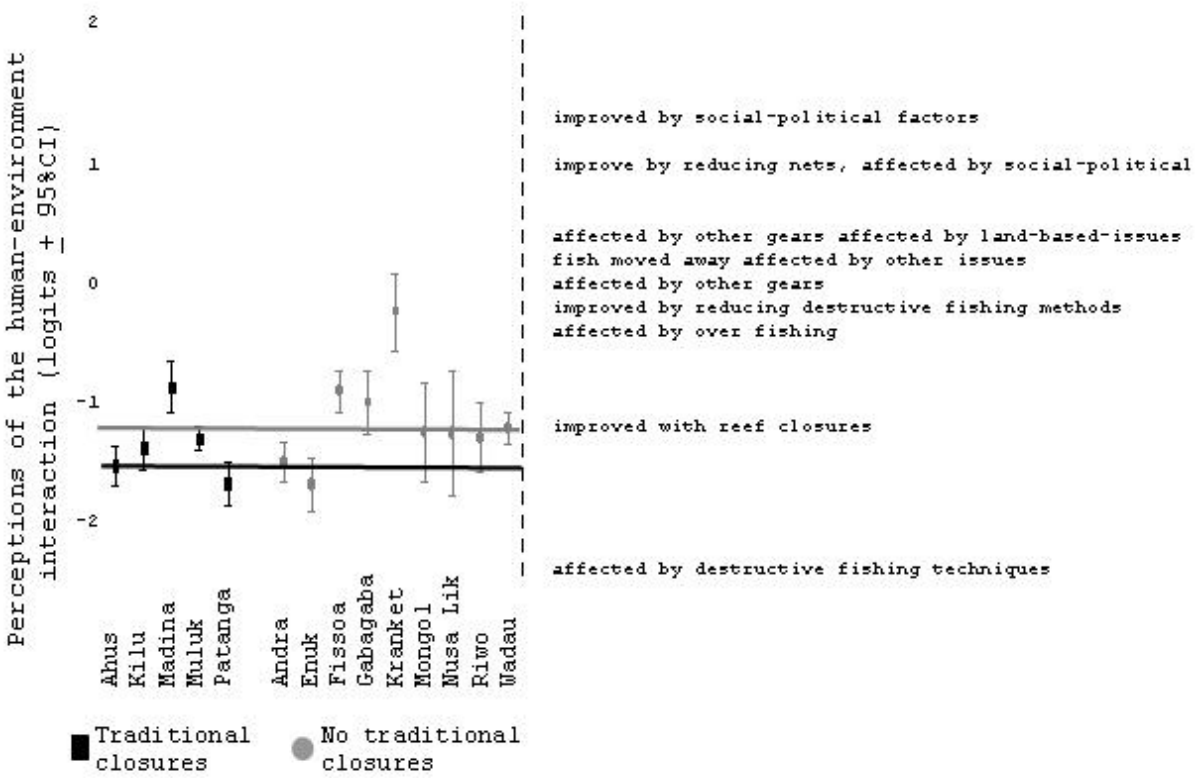

Figure 19. Comparison of Perceptions About Human-Environment Interactions in Communities with and without Traditional Closures. Perceptions about human-environment interactions are measured along the y axis in logits. Indicators on the right hand side were used to construct the perceptions of the human-environment interaction variable. Error bar charts on the left-hand side of the figure represent each community's score on the variable + 95% confidence interval. The mean perceptions of the human-environment interaction score for all communities with traditional closures is indicated by the black horizontal line and the mean score for all communities without traditional closures is indicated by the grey line. The indicators on the right-hand side of the graph that lie in between the black and grey line are what likely separates the two groups of communities in terms of their perceptions of the human-environment interaction.

Perceived condition of the environment

The perceived condition of the environment variable was constructed by examining respondents' perceived past, present, and future condition of the environment based on responses to Likert scale questions (see Table 9). In Chapter III, it was shown that the indicators used to construct this variable relate to the perceived trend in the condition of the resource from the past until present (called past) and the present to future (called future) for both fisheries and corals. A high ordinal rank of the indicator (e.g., 9) indicates perceived improvement the condition of the resource, whereas a low score (e.g., 1) indicates a perceived decline in the condition of the resource. Thus, respondents with

high scores on the perceived condition of the environment variable were likely to perceive an improvement in fish and coral for both past and future time periods (Figure 20, right hand side). Alternatively, respondents with low scores on the variable were likely to perceive a decline in the condition of fish and coral resources for both time periods.

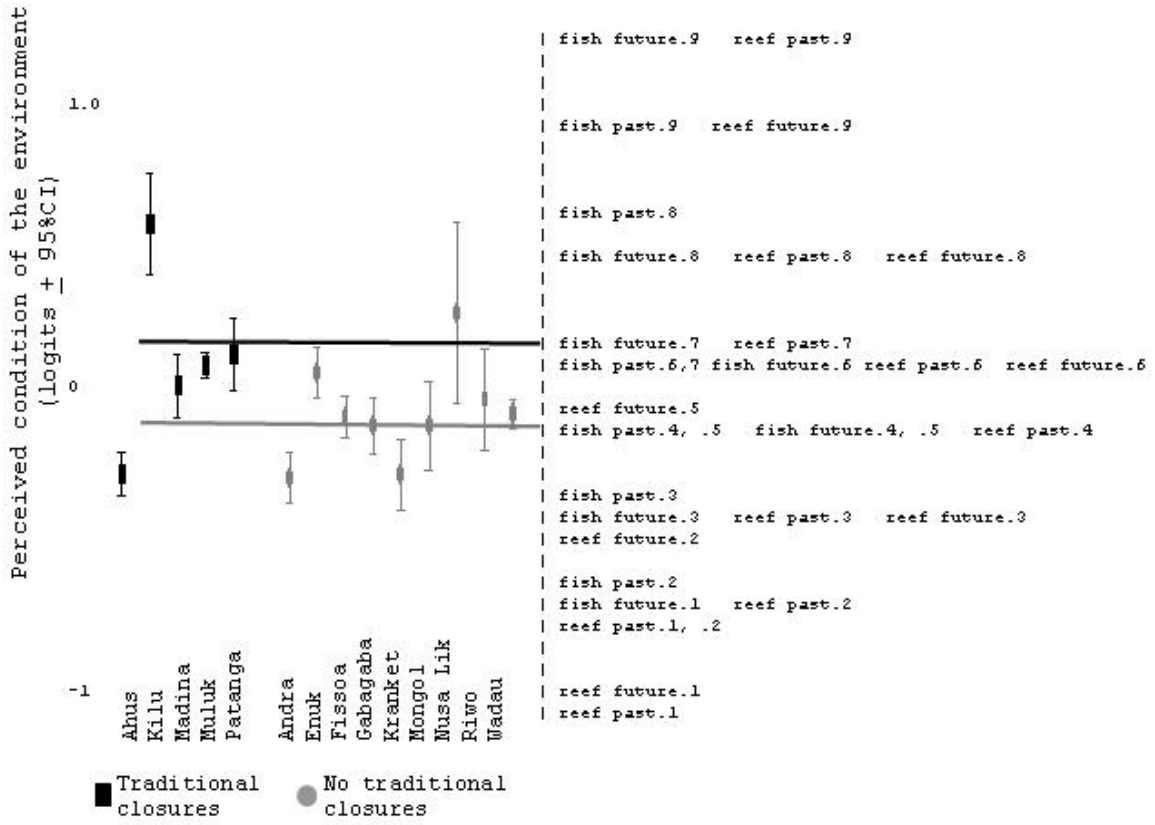

Figure 20 Comparison of Perceived Condition of the Environment in Communities with and without Traditional Closures. Perceived condition of the environment is measured along the y axis in logits. Indicators on the right hand side were used to construct the perceived condition of the environment. The numbers to the right of the indicator represent the particular threshold for that indicator. There were 9 thresholds, with one as the lowest and nine as the highest. Thus "reef past.1" indicates that the condition of the reef from five years ago has declined dramatically and "reef past.9" indicates that the condition of the reef over the past five years has improved dramatically. Error bar charts on the left-hand side of the figure represent each community's score on the variable + 95% confidence interval. The mean perceived condition of the environment score for all communities with traditional closures is indicated by the black horizontal line and the mean score for all communities without traditional closures is indicated by the grey line. The indicators on the right-hand side of the graph that lie in between the black and grey line are what likely separates the two groups of communities in terms of their perceived condition of the environment.

There were only marginal differences in the perceived condition of the environment scores in communities with traditional management (0.08 $\pm$ 0.09) and communities without (-0.1 $\pm$ 0.05) (Figure 20). Figure 20 shows Kilu has a very high perceived condition of the environment compared to other communities and this is appears to be pulling the mean score for communities with traditional closures higher. This may be partially due to the presence of a local NGO (Mahonia Na Dari) that is engaging in community conservation efforts. These differences were not deemed to be practically significant because they were very slight (only 0.18 logits) and appeared to be driven by a single community and thus were not tested for statistical significance.

Village-Level Socioeconomic Factors Related to Traditional Management

None of the village-level factors were significantly different in sites with traditional closures compared to sites without (Table 14). This was likely due to the relatively small sample size of 14 communities. However, the section on dependence on marine resources (pages 105-108), demonstrated that dependence on marine resources was most similar for communities employing periodic closures. A similar test was conducted to determine whether village-level socioeconomic conditions in communities with periodic closures were different to those in communities with no closures. This analysis showed that communities with periodic closures were significantly more likely to have dispersed settlement patterns in the communities ($p= 0.095$). This finding may result from higher engagement in agriculture in these communities, which can lead to dispersed inland settlements near the agricultural lands.

Table 14. Results of Mann-Whitney U Test Examining Mean Village-level Characteristics for Communities With and Without Traditional Management

	Traditional closure		Periodic closure	
Village-level factor	Z	P	Z	P
Distance to market[a]	-1.13	0.30	-1.13	0.30
Population[a]	-0.47	0.70	-0.28	0.84
Reef area in tenure[a]	-0.17	0.93	-0.28	0.86
Conflicts[b]	NA	.406	NA	.746
Settlement pattern[b]	NA	.203	NA	.095*

*statistically significant at $\alpha = 0.10$
[a]determined with Mann Whitney U test
[b]determined with Fisher's Exact test
NA= not applicable because the Fisher's Exact test does not use Z scores to determine probabilities

Summary of Socioeconomic Factors Related to Traditional Management

By comparing the socioeconomic conditions in communities with and without traditional reef closures, this chapter showed that communities with traditional closures have different socioeconomic characteristics than communities with out. Communities with traditional closures had lower dependence on marine resources, slightly lower modernisation, and negligibly lower perceived human-environment interaction scores but slightly higher social capital and negligibly higher perceived condition of marine resources (Table 15). Many of these differences were only slight and the practical significance was questionable, particularly for perceptions of the human-environment interaction and perceived condition of the environment. Social capital and modernisation showed slight, but statistically significant differences and dependence on marine resources was appreciably lower in communities with traditional closures. Only testing for statistical significance, which is all that is possible with other analytical techniques, would have shown all three results as very significant. By using Rasch analysis, this thesis was able to make intuitive sense of these results and determine that despite being statistically significant, the practical significance of modernisation and social capital and occupational mobility was very slight. This technique helped to prevent erroneous conclusions about the practical or substantive importance of these factors.

Table 15. Summary of Socioeconomic Factors Influencing Traditional Closures

Factor	Direction[a]	P[a]	Difference (in logits)	Practical significance[a]
Modernisation	-	0.001	.3	Slight
Dependence on marine resources	-	0.001	.6	Appreciable
Social capital	+	0.001	.23	Slight
Perceptions of the human-environment interaction	+	Not tested	.22	Not practical
Perceived condition of the environment	+	Not tested	.18	Not practical
Distance to market	NA	NS	NA	NA
Population	NA	NS	NA	NA
Reef area in tenure	NA	NS	NA	NA
Conflicts	NA	NS	NA	NA
Settlement pattern	NA	NS*	NA	NA

[a]Reflects whether the trait was higher (+) or lower (-) in communities with traditional management
[b]Probabilities determined by nested ANOVA
[c]Practical significance is a qualitative judgment determined by considering the number of logits separating the groups and the importance of the specific indicators that separate the two groups.
NA = not applicable
NS = no significant differences between differences with traditional closures and those without.
NS*= communities with periodic closures were more likely to have dispersed settlement patterns (p <0.1)

Several trends were also noted by examining error bar graphs of the different communities. The most important finding of the study is that there may be certain strategies that are better suited to certain types of communities. For example, Ahus had a traditional closure, but had a much higher dependence on marine resources score than the other communities with traditional closures. The type of closure employed in Ahus was very different from those employed in other areas: Ahus's closure was a gear-restricted area with the purpose of providing fish for occasional feasts. In the following chapter, detailed case studies are used to explore this issue in greater detail.

Secondly, differences exist in the socioeconomic conditions of communities with and without traditional management, but these differences are not clear cut. Communities with traditional management appear to have slightly higher social capital and perceived condition of the environment scores, and slightly lower modernisation and dependence on marine resources scores. However, in all of these cases, there are communities without traditional management with similar scores. This suggests that threshold levels of social

and economic conditions may determine whether a community can employ traditional management strategies, but a high or low score on any one particular variable does not necessarily mean that a village will have traditional management.

Other conclusions were that the village-level socioeconomic characteristics of communities with traditional closures did not differ significantly from communities without traditional closures. However, communities with periodic closures had dispersed settlement patterns. This factor is likely related to the lower dependence on marine resources exhibited by communities with periodic closures.

Discussion about Differences in Socioeconomic Characteristics between Communities that Have Traditional Management and Communities That Do Not

This chapter examined whether communities with traditional management had different socioeconomic characteristics than communities without these practices. This was tested by comparing the socioeconomic characteristics of 14 coastal communities, five of which had traditional management. This is a slightly higher percentage than the 27% of communities Harkes and Novaczek (2002) found with traditional marine restrictions in Muluku, Indonesia (the number of communities of closed areas in their study was not stated). This thesis showed an appreciable difference in dependence on marine resources and slight differences in modernisation and social capital and slight differences in settlement patterns when Ahus was removed from the analysis. Several of the factors expected to be related to the presence of traditional management did not demonstrate significant relationships. In particular, differences between communities that employed traditional closures and those that did not were not detected in perceptions of the human environment interaction, perceived condition of the environment, and any of the other village-level indicators such as population.

In a review of the factors influencing the sustainability of common property institutions, Agrawal (2002) notes that debates concerning the effect of population on common property institutions are highly polarized, with some findings indicating population has a large effect on how commons are managed and other finding the effects considerably more muted. The possibility exists that, since this was a village-level indicator, the sample size used (n = 14) was too small to detect differences. More interestingly, though is the possibility that the populations in the communities studied in this thesis were too small to detect any effect. Although population was not found to be significant in this study, the largest population of any community tested was 1,700 residents (note that that the pilot site, Tubusereia, had 5000 people and did not have traditional management). Harkes and Novaczek (2002) found that traditional management in Indonesia (called Sasi) dies out in villages greater than 3000 people. However, Evans et al (1997) noted that Sasi was present in a community larger than 14,000 people. Therefore, based on previous research, the critical population size at which traditional management may cease to function effectively may not have been reached in my study. The population levels of many of my study sites were similar to many rural coastal areas in the provinces studies (e.g., National Statistics Office, 2002a, 2002b), however, urbanized areas such as Lae and Port Moresby with high populations were not examined. An interesting area of further inquiry would be to examine whether or how communities with tens of thousands of residents could support traditional closures.

Aswani (2002) and Aswani and Hamilton (2004) speculated that nucleated and dispersed settlement patterns influenced whether and how communities in the Solomon Islands could develop and maintain marine tenure regimes. This thesis was not able to explore the in-depth ethnographic accounts of settlement histories used by Aswani (2002), but no relationships were found between basic settlement patterns and the presence of traditional closures. In a closely related study, Cinner (in review) also found no relationship between settlement patterns and the implementation of highly exclusive marine tenure regimes in 21 communities in Papua New Guinea and Indonesia. These results suggest that, in the broader context, whether communities are nucleated or dispersed may be less important than other socioeconomic factors in maintaining traditional management regimes,

however the following chapter will discuss how historical aspects relating to settlement may be somewhat influential.

The lack of convincing significant findings for these or other village-level indicators is not surprising given the moderate sample size at the village scale (n=14). At this level of power, differences in these indicators between communities with traditional closures and communities without would have to be rather large to be statistically significant. Given that the differences found with the more powerful analysis of household-level variables were quite small, it would likely require a much larger sample size to detect significant differences in village-level indicators. A larger sample of communities was unattainable given the time and resources available. It is important to note that not finding significant differences does not suggest that these indicators do not influence traditional management. It simply means that given the sample size used, these relationships could not be confirmed.

A significant body of literature suggests that people's relationship with their environment is determined largely by their perceptions of natural resources (Carrier, 1980; Cinner & Pollnac, 2004; Nazarea et al., 1998; Pollnac, 2000; Pollnac & Poggie, 1991). Johannes (2002d) suggested that the increase in traditional management over the past two decades may be partially in response to growing perceptions of resource scarcity. Although this study found that communities with traditional management had a slightly higher mean perceived condition of the environment and perceptions of the human-environment interaction score, these differences were not practically significant. Thus, it could not be established that community perceptions of the environment had any bearing on whether the community employed a traditional closure or not. Perhaps on a smaller scale, these variables may be important, particularly for the community leaders and others that are responsible for implementing traditional closures. Also, on a larger scale, such as cross-culturally, perceptions may have a lot to do with the implementation of traditional closures. Societies that do not believe that human actions can influence environmental conditions may be much less likely to implement traditional closures (i.e., there is no point in closing a reef off for 6 months so that fish stocks can be built up and

subsequently harvested for a feast if a community does not believe that not fishing will have any bearing on the condition and subsequent harvest of a fishery). Over the spatial scale examined in this thesis, perceptions did not appear to play a large role in the development or maintenance of traditional closures.

The mean modernisation and social capital scores were slightly, but significantly different for communities that had traditional management compared to communities that did not. The direction of these differences conforms to theory and expectations (that communities with traditional management have higher social capital and occupational mobility and lower modernisation), but the magnitude of the differences is not impressive enough to really confirm existing theories. Differences of at least ½ logit are required for two Rasch analysis scores to be considered appreciably different (pers. comm. T. Bond, 2004)

Social capital has become an important focus of common property research (Pretty, 2003; Pretty & Smith, 2004; Pretty & Ward, 2001; Uphoff & Wijayaratna, 2000). Consistent with this current research, communities with traditional management also had slightly higher social capital and occupational mobility scores. Unfortunately, the occupational mobility indicators had to be integrated with the social capital indicators to produce a combined variable that measured both characteristics. There were not enough separate indicators to develop a viable Rasch model scale for both variables. Future research should incorporate more indicators of each latent trait so that each variable could be examined separately. Because the difference was slight, it is hard to tell whether this is because the two latent traits were combined or because social capital is only having a marginal effect on the presence of traditional closures.

Modernisation has been cited as a factor in the decline of traditional management in both the literature (Evans et al., 1997; Harkes & Novaczek, 2002) and interviews with community leaders throughout PNG. As expected, communities with traditional management had lower mean modernisation scores than communities without, but again this difference was only slight. This difference in mean scores may have been driven by

the extremely high modernisation score of Gabagaba (without traditional closures) and the low score of Muluk (with traditional closures). There also appeared to be higher variability in modernisation in communities without traditional management, which suggests that there are individuals with highly modernized lifestyles in these communities, but overall, there were not enough of these individuals to significantly influence the overall community mean.

The most significant finding of this study is that dependence on marine resources appears to be an important factor in determining whether a community has traditional closures. Dependence on marine resources showed the most convincing pattern of any of the variables examined in this study and was appreciably lower in communities with traditional management than without. Dependence on natural resources has received comparatively little attention in the common property literature to date. While some studies make passing mention of dependence on marine resources (e.g., Naylor et al., 2002; Siar, 2003), there were very few studies that examined dependence on natural resources as a factor in common property governance. Furthermore, most of these studies had little to do with the fishery sector.

Lise (2000) quantitatively explored the socioeconomic factors that contributed to participation in common property forest management in India. Contrary to the results from this thesis, Lise found that participation in common property forest management was positively related to dependence on the forest. More closely related is a study by Zanetell and Knuth (2004) on willingness to participate in common property river fishery in Venezuela. Similar to this thesis, Zanetell and Knuth derived a quantitative variable for dependence on the fishery and found that dependence was the main factor in a predictive model explaining willingness to participate. However, like Lise (2000), Zanetell and Knuth (2004) found that dependence on the river fishery was positively related to participation in common property management (or at least their willingness to participate in it). Agrawal (2001) also suggested that high dependence on resources was likely to result in increased success of common property institutions.

If other empirical studies found dependence to be positively correlated with involvement in common property institutions, why then might the communities with low dependence on marine resources be the ones to implement closures in PNG? The reason for this may lie in the specific type of common property institution investigated in this study. The empirical results of Lise (2000) and Zanetell and Knuth (2004) were concerned with a much more generalized participation in common property institutions. There is nothing in the results of this thesis that suggests that highly dependent households or communities do not participate in or are unwilling to participate in common property institutions. Indeed, using many of the same study sites as in this thesis, Cinner (in review) found that communities in PNG and Indonesia with high dependence on marine resources were more likely to employ highly exclusive marine tenure regimes whereby outsiders were not permitted to access marine resources. Interestingly, high dependence on resources was related to a specific type of common property institution (exclusive marine tenure), but low dependence was related to another (traditional periodic closures). This suggests that the conditions that result in restricting self use may be very different from those that seek to restrict others. Common property institutions may emerge for a number of reasons, including conflict resolution, livelihood security, and/or providing the community with other benefits (see next chapter). Common property institutions may have emerged in communities with high dependence on resources to meet issues such as of conflict resolution and/or livelihood security, but in communities with low dependence for other reasons. The following chapter examines how factors such as high and low dependence may influence the specific common property regime that a community implements.

From a conservation standpoint, the implications of this thesis' main finding have a sad irony to them: the reefs which are probably in the least need of protection are the ones receiving the traditional management and the communities that are most dependent on marine resources and are most in need of resource management are the ones that are least likely to have traditional mechanisms to protect them. It would suggest that implementing conservation initiatives based on traditional closure systems would be more likely to work in communities with low dependence on marine resources. However, there is an

anomaly in this pattern- Ahus Island had a very high dependence on marine resources but implemented a traditional closure. This suggests that periodic closures may be better suited to communities with low dependence on marine resources, but that Ahus' strategy may be well suited to a community highly dependent on marine resources.

Summary

This chapter analysed whether communities with traditional closures had different socioeconomic conditions than communities without. Results showed that many of the factors examined were not different between these groups of communities. There were statistically significant differences in the constructs of social capital and occupational mobility, modernisation, and dependence on marine resources between communities with traditional closures and without. The use of Rasch analysis allowed an intuitive judgement to be made about the practical significance of these factors. Results showed that despite being statistically significant, the practical significance of modernisation, social capital and occupational mobility was very slight. The use of this analysis tool helped to prevent erroneous conclusions about the strength of the relationship between these factors and the presence of traditional closures. Communities with periodic closures were also more likely to have dispersed settlement patterns.

The results of this study also showed that communities with traditional closures had appreciably lower scores on the dependence on marine resources construct. However, one community with a closure had a very high dependence on marine resources score. To exemplify and discuss this anomaly, the next chapter presents two case studies of communities with traditional closures- one from Ahus Island with high dependence on marine resources and one from Muluk village with low dependence on marine resources. These case studies illustrate how these strategies are particularly well adapted to the socioeconomic conditions in their respective communities.

CHAPTER VI. HOW TRADITIONAL MANAGEMENT SYSTEMS REFLECT THE SOCIOECONOMIC CONDITIONS OF THE COMMUNITIES THAT IMPLEMENT THEM: CASE STUDIES FROM AHUS AND MULUK

The previous chapter looked at whether differences in socioeconomic conditions exist between communities with traditional closures and communities without. A comparative approach was used to examine whether broad patterns existed in how the implementation of traditional reef closures was related to socioeconomic conditions. Communities with traditional closures demonstrated appreciably lower dependence on marine resources, slightly lower modernisation and slightly higher social capital and occupational mobility.

This chapter explores the following research question: "How do traditional management systems reflect the socioeconomic conditions of the communities that implement them?" by using two case studies to explore social, economic, and cultural aspects of traditional closures in Papua New Guinea. Qualitative results are presented that reinforce the quantitative patterns demonstrated in the previous chapter. These two case studies will be used to illustrate the possible ways the closures may be well suited to local socioeconomic conditions. These case studies are synthesized from Cinner et al. (in review-b) and Cinner et al. (in review-a). These publications are collaborative and multi-disciplinary, incorporating aspects of both social science and coral reef ecology. The other co-authors on these papers worked on the ecological aspects.

Background

Before commencing on this type of investigation, it is important to first put this question of why a locally devised resource management strategy might reflect the local socioeconomic conditions into a broader theoretical perspective. In the 1950s the

emerging field of cultural ecology focused attention on how relationships between social and environmental systems may cause them to adapt or change over time (Davidson-Hunt & Berkes, 2003 citing Steward, 1955). Empirical and theoretical commons literature suggests that common property institutions may also adapt and change over time in response to social and economic conditions (Aswani, 2002; Berkes, 1989a; Davidson-Hunt & Berkes, 2003; De Castro, 2002). For example, De Castro (2002) presents an historical analysis of how common property institutions in the Amazonian floodplain shifted focus from cultural to political prescriptions on resource use over the course of immense socio-political change. De Castro (2002) states

> "Broader social and ecological processes directly influence how users shape their local management by formulating and adjusting the rules-in-use." Furthermore, De Castro claims that "given the complex environment in which [local management institutions] may operate, changes in their structure and organisation over time are to be expected. Prescriptions are replaced and refined according to how incentives for and goals of resource management modify through time. As a result, they are better described as mosaics of prescriptions created throughout the history of users according to a range of incentives and goals.

Thus, when examined through the lens of cultural evolution, the idea of long-enduring common property systems such as traditional management being continually refined and adapted over time to meet and reflect changing social goals and socioeconomic conditions makes conceptual sense. Practices that could no longer fulfil social goals or were poorly adapted to changes in socioeconomic conditions would either be dropped over time or adjusted to fit the circumstances. Berkes, Colding, and Folke (2003) state "local and traditional knowledge and management systems should be seen as adaptive in a place-based context and a rich source of lessons for social-ecological adaptations." It can be expected that over time, a traditional closure would have been adapted and refined to reflect the local socioeconomic circumstances.

There are many examples of traditional management systems adapting to changes in socioeconomic conditions (e.g., Aswani, 2002; Baines, 1989; Hviding, 1996, 1998). For example, Baines describes how the colonial administration weakened customary land and sea tenure in Fiji by neglecting the roles of traditional custodians, but these systems have adapted to the changes in the administrative systems and remain an important component

of inshore marine resource governance (Cooke et al., 2000; Dulvy et al., 2004; Johannes, 2002d). One might expect traditional management regimes to reflect socioeconomic conditions more so in situations where the practices were somewhat adaptive in nature (e.g., restricting an area of reef when resource users perceived a change in ecological conditions) than in circumstances where the practices were viewed to be prescribed by supernatural powers (e.g., species taboos or sacred groves described in Colding and Folke, 2001 and McClanahan et al., 1997). The former situation is the case for the closures examined in this study.

This chapter examines two case study communities and describes whether and how the governance institutions appeared to reflect local socioeconomic conditions. Specific aspects of the closures are examined (including closure size/shape, duration, and goals of the closure) to explore whether and how they may reflect the occupational structure and resource use patterns (number and types of fishing trips) of the communities. Two aspects of resource use appeared particularly important to understanding whether and how the closures might reflect resource use patterns: 1) examining the proportion of total fishing effort by gear type to see what proportion of the fishing effort may potentially be affected by the traditional closures; and 2) examining whether individual fishers used multiple gear or a single gear type to understand whether specific user groups (i.e., those using the gear that were restricted) were being disenfranchised by the closure or whether the burden was shared equally among resource users. Furthermore awareness and compliance with the closures are examined to see whether there are specific aspects of the reserve that may help to promote compliance with reserve rules.

Although the theoretical rationale suggests that governance institutions could be adapted to reflect socioeconomic conditions, and the previous chapter showed quantitatively that communities with traditional closures have different socioeconomic characteristics, it was not in the scope of this research to determine causal relationships or historical patterns. Therefore, the reader should interpret this chapter with the understanding that the relationships postulated are exploratory in nature.

Methods

The case studies presented in this chapter contain data largely synthesised from Chapters IV and V. A brief summary of data collection methods is presented here, but more detailed data collection methods were presented in Chapter II. A combination of household surveys, key informant interviews, oral histories, and participant observation in resource use activities was used to gather information on fishing pressure, occupational diversity, emigration, governance of coastal resources, and awareness of and compliance with closures.

Socioeconomic conditions

A combination of household surveys, key informant interviews, oral histories, and participant observation in resource use activities was used to gather information on fishing pressure, occupational diversity, emigration, governance of coastal resources, and awareness of and compliance with closures. The methods described in Henry (1990) were used to systematically sample 51 out of the 105 households in Ahus and 41 of the 50 households in Muluk. Participant observations, key informant interviews, and oral histories were also used to verify the accuracy of household survey responses and to gain a better understanding of the context of coastal resource use and management. Questions in household surveys were directed towards the head of the household (male, female, or both depending on who was present at the time of the interview). Participation in fishing, agriculture and other occupations was determined by having household respondents rank the occupations their household engaged in from most important to least important (Pollnac & Crawford, 2000).

Fishing pressure was estimated by asking household respondents the average number of days per week that each member of the household was engaged in specific fishing activities (i.e., the number of fishing trips per gear type was recorded) in both the high and low season. Resource users were asked about the gear types they used and asked to rank each gear type used in order of perceived importance (for example, if a fisher used nets and spear guns, the fisher was asked to rank which was more important). It should be

noted that importance was not always synonymous with frequency of use and that select activities may be seasonal (thus not used as often), but may contribute more to income, subsistence, or prestige.

Governance, awareness of regimes, and compliance

Information about resource use and governance in these communities was obtained through interviews with resource users, traditional leaders, and elected officials (see Chapter III). Resource users showed the approximate boundaries of the closures using obvious landmarks or reef features as guides. The area of the traditional closures was calculated by analyzing 1:100,000 aerial photographs with the UTHSCSA Image Tool 2.0 (University of Texas Health and Science Center, San Antonio, USA). It should be noted that only the shallow-water portion of the closures and fishing grounds (i.e. reef, sand, and seagrass) were calculated. The edges of the reef (which corresponded approximately to the 10m depth contour) were digitally traced and the shallow-water reef area was then calculated with the image analysis software.

Awareness of restrictions or closures was determined by asking a subset of the population (fishers) if there were places where people were not supposed to fish. For the purposes of this question, respondents were considered fishers if they ranked fishing among their household's three most important occupations or livelihood strategies. If respondents suggested there were places where people were not supposed to fish, they were asked to elaborate their response and describe where and when.

To assess compliance with the closure, fishers were asked if people still fished in the area they were not supposed to. Their responses were grouped into the following four ordinal categories; nobody fishes there, a few people fish there, many people fish there, almost everybody fishes there. It should be noted that this question was designed and tested for permanent closures and proved somewhat problematic for the periodic and gear restricted areas examined in this thesis. The retrospectively obvious problem with the question in the context of the periodic closures and gear restricted areas was that people can still fish there without breaking the rules (when the periodic closure is lifted and by using hook

and line on the gear restricted areas). Unfortunately, significant research had already been conducted by the time the problematic nature of this question in these contexts was revealed, so changing the question would have compromised the comparability of these data to previous sites. This comparability to other sites was a research priority for the Wildlife Conservation Society (WCS) and was one of the compromises (discussed in Chapter III) that had to be made. Responses from this question will be presented, but are probably an underestimate and should be interpreted guardedly. Fortunately, data were also collected by the ecological team that objectively examined the amount of discarded fishing gear (broken bits of net, spears that had been lost, etc.) inside compared to outside these areas (Cinner et al., in review-a; Cinner et al., in review-b). This appeared to be a relatively consistent measure of compliance with regulations throughout Papua New Guinea and Indonesia (McClanahan et al., in review).

Results

Governance

Both closure systems were located in close proximity to the villages and popular fishing sites. The high visibility of the closures may have served as a deterrent to violating the closures. The two closure systems had very different layouts: Muluk's closure was a single, large closure while Ahus' was a system of smaller closures (Figure 21). The coral reefs and lagoons surrounding Ahus and the neighbouring, uninhabited Onneta Island, (also under Ahus ownership), encompass approximately 550 ha. Fishing activities were restricted within six reef areas, together encompassing 33.2 ha (5.8% of the total reef area surrounding Ahus and Onneta). Spear and net fishing within the restricted areas were generally prohibited, but line fishing was permitted. Up to three times per year, the restricted areas were collectively harvested with spears and nets to provide fish for occasional feasts.

At Ahus, the reef closures operated within the context of a complicated customary marine tenure system that regulates access to specific reef areas, target species and harvesting

methods, similar to that described for neighbouring Ponham Island by Carrier (1987) and Carrier and Carrier (1991). Ahus Islanders claim exclusive rights to all marine resources on the reefs surrounding their island, as well as the neighbouring, uninhabited Onetta Island, and reefs between Ahus Island and the coast of Manus Island (although they acknowledge that the latter was difficult to enforce and that people fished there). Ownership rights can help to create an economic monopoly on marine resources among fishing communities (Malinowski 1935). The reefs surrounding Ahus Island are divided into areas owned by specific social units (e.g., clans, families, individuals). It is through this lineage-based ownership of delineated reef areas that the traditional closures are maintained and enforced. Some families also own the rights to harvest certain species (including turtle, coral, and sea cucumbers) or harvesting technology (such as traditional nets), which are not spatially restricted.

Muluk had traditional tenure over the entire coastline adjacent to both Muluk and the neighbouring village of Wadau- approximately 92 ha. Access to marine resources was more centralised than in Ahus, as key informants claimed that villagers had equal access to reef-related resources. Muluk practised a system of closing approximately 58 ha of reef adjacent to their village for 1-2 years whenever the village chiefs noticed the fish catch declining. The decision to close the reefs was reached through a consensus between the three clan chiefs. The reef closure in Muluk generally occurred 2-3 times within a 10-year span. At the time of the research, their reef had been closed for approximately 6 months. A summary comparison of closure characteristics can be found in Table 16.

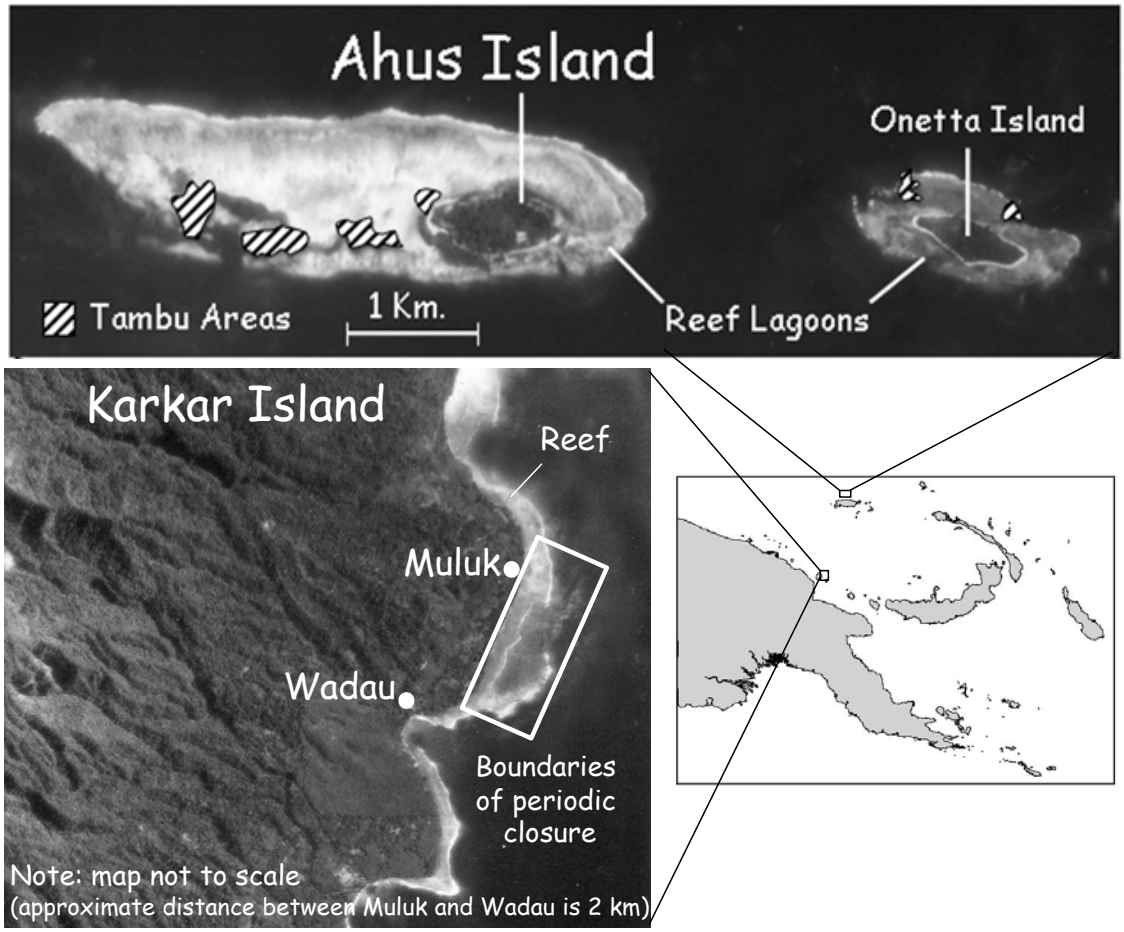

Figure 21. Comparison of Muluk and Ahus Reef Closure Systems. Ahus' system is comprised of six small reef closures while Muluk's is a single larger closure.

Table 16. Summary of Closure Characteristics

Closure characteristic	Muluk	Ahus
Size (deep water parts not included)	58 ha (63% of total reef area)	33.2 ha (5.8% of total reef area)
Configuration	Single large area in front of village	Six small areas owned by different clans
Restriction	All extractive activities	Net fishing and spear fishing
Duration	6-12 months	Permanent
Periodicity	Put in place every 6-24 months	Harvested 1-3 times per year

Occupations

Ahus Islanders were highly dependent upon fishing (Chapter V). Because of the remoteness of the island, opportunities to engage in other economic sectors were few. For

example, land shortages and poor soil led to minimal engagement in agriculture, mainly restricted to small patches of copra. While 21% of the community was engaged in agriculture (mainly coconut oil production and fruit), none of the respondents listed it as the primary occupation (Figure 22). There was a mean of only 2.7 (± 0.25 95% CI[6]) occupations per household, which is relatively low compared to an average of 3.2 (± 0.1 SE[7]) for the 13 other coastal communities in PNG.

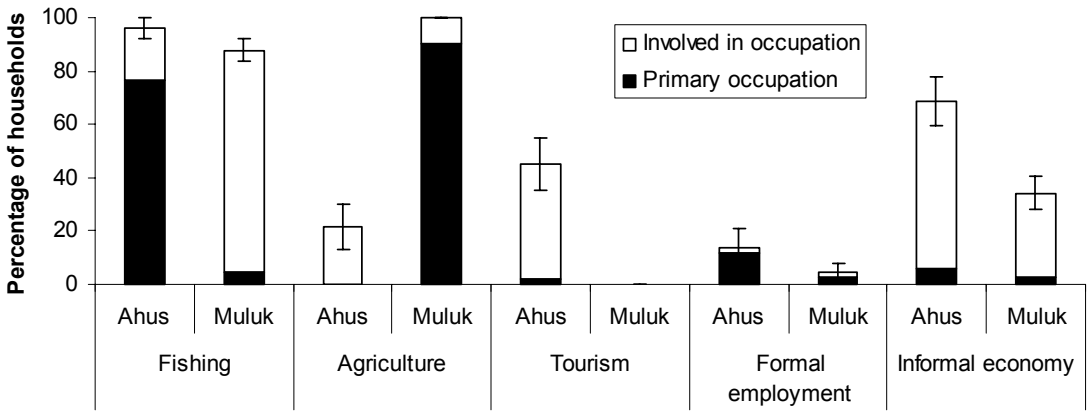

Figure 22. Percentage of Households on Ahus and Muluk Involved in Different Occupational Categories

Alternatively, in Muluk, fishing is an important supplementary activity, but few community residents ranked it as a primary source of income or subsistence (Figure 22). Agriculture, including subsistence farming and cash crops such as copra, was the most important occupation in Muluk. There was no involvement in tourism, and minimal involvement in salaried employment, such as government work or teaching. Informal economic activities, such as owning a small shop, carpentry, and transportation, played an important secondary role in livelihood strategies. Individual households engaged in a range of occupations; Muluk averaged 3.3 (± 0.1 95% CI) occupations per household.

[6] Confidence interval

[7] Standard error

Resource Use

Ahus islanders conducted an estimated 658 (±134 95% CI) fishing trips per week resulting in approximately 1.2 fishing trips/week/hectare of reef lagoon (including shallow reef, sand and seagrass). Line fishing and spear fishing accounted for 97% of Ahus' fishing pressure (Figure 23). These were almost evenly divided between line fishing (accounting for 51% of fishing effort at Ahus) and spear fishing (accounting for 46%). There were only 200 (±24 95% CI) fishing trips per week at Muluk, but due to the smaller reef area, this resulted in 3.5 fishing trips/week/hectare. Spear guns, spears (hand spears), and line fishing comprised the majority of fishing activity in Muluk (Figure 23). Line fishing and spear fishing (with spear guns) each accounted for more than 1/3 of total fishing effort. Hand spears accounted for an additional 23% of fishing effort. Chapter IV noted that hand spears were used to target flying fish at Muluk, which are not reef associated and this type of fishing occurs in the deeper water beyond the reef edge (thus not affected by the closures) and that an initiation was required to be involved in this fishery.

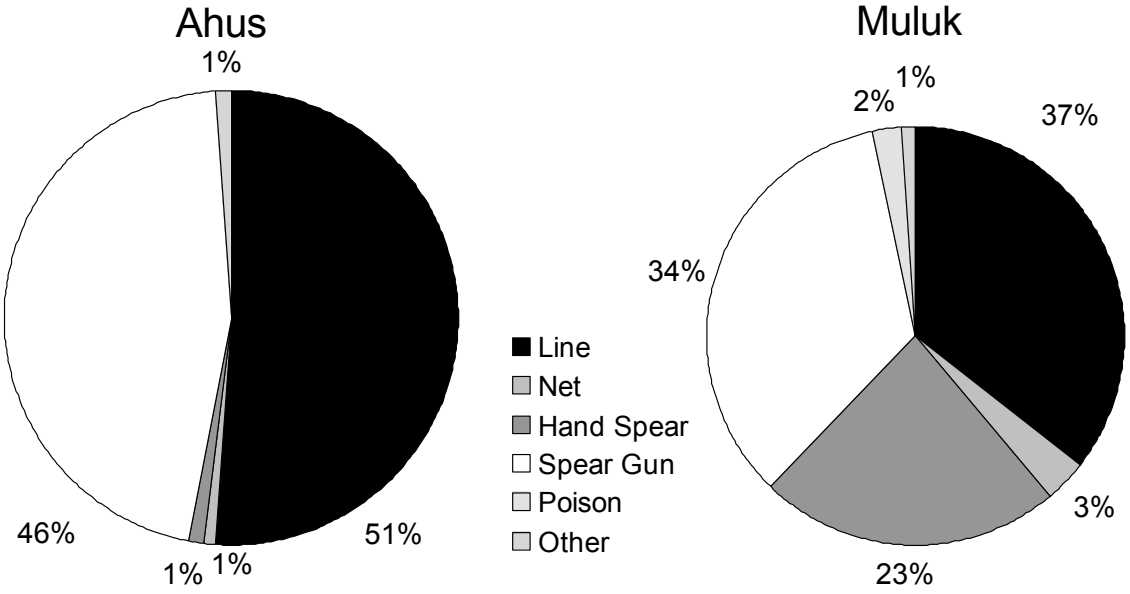

Figure 23. Proportion of Community Fishing Effort Devoted to Different Gear Types

The majority of fishers in both communities reported using multiple gear types. In Ahus 84% of households that were engaged in fishing used more than one fishing gear, compared to 65% in Muluk. Figure 24 shows the proportion of households that use certain fishing gear and highlights the proportion that ranked each gear type as the most important gear. This shows the diversity of fishing gear practised by each community and also illustrates which gear are most important and which are supplementary. Figure 24 shows that individual households in both communities engage in multiple fishing strategies. If fisheries were more segregated (i.e. a household only used a single gear type- as is common in some parts of the world) one would see very little white portions of the bar graphs. At Ahus, 86% percent of the households were involved in line fishing, 88% in spear fishing (Figure 23a), and 80% used both. At Muluk, more than 50% of households are engaged in both line fishing and spear fishing, but 51% are also engaged in using hand spears.

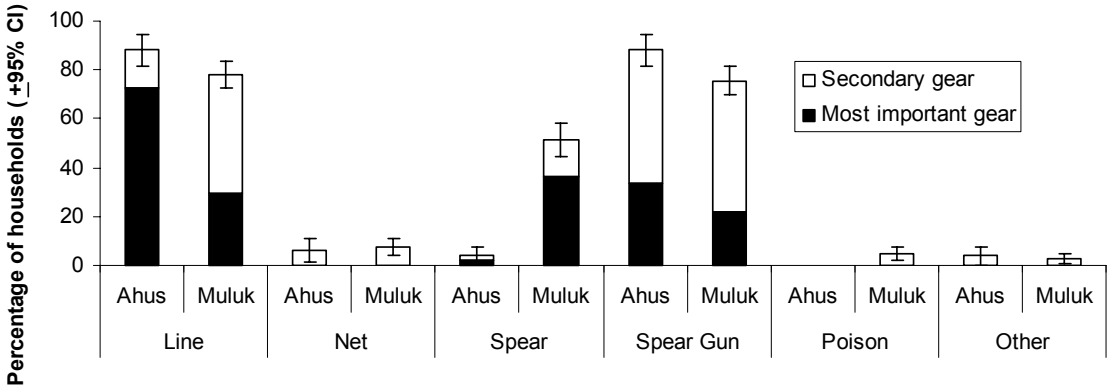

Figure 24. Percentage of Households that Use Different Fishing Gear, Highlighting the Proportion that Rank Each Gear as the Most Important Gear for the Household

Awareness and Compliance

Awareness of the closures in Ahus and Muluk was high; 73% of Ahus fishers and 79% of Muluk fishers mentioned that there were traditional spatial restrictions. Cinner et al. (in review-b) and Cinner et al. (in review-b) reported a lower incidence of broken or lost fishing gear inside both closures compared to outside the closures, indicating that there is less fishing pressure inside the closure. Reported compliance was also examined, but as

previously discussed, the question was not particularly effective because people were allowed to fish there using hook and line. Reported compliance was low: only 43% of Ahus fishers and 46% of Muluk fisher suggested that few or no people fished there.

Discussion

How Traditional Management Systems Reflected the Socioeconomic Conditions in the Communities

The specific type of closure system that Ahus practised (restricting nets and spear guns throughout most the year but allowing line fishing) was a fundamentally different strategy than the periodic closures practised by Muluk and the other communities. By exploring the socioeconomic context within which the traditional closures at Ahus and Muluk operated, each community's closure appeared to reflect the local social, economic, and cultural conditions in at least four ways: meeting diverse goals; minimising social costs, designs that reflect the scale at which marine resources are governed, and incorporating locally appropriate mechanisms that help to promote compliance.

Diverse goals

The socioeconomic conditions in the two communities were very different, so it is not surprising that the goals of the two communities' closures were also different. At Ahus, the restricted areas appeared to be an important component of maintaining local customs and economic vitality. Fishing restrictions on specific reef areas provided the community with a "bank account" of natural resources that could be accessed during special occasions. Although maintaining fish stocks within the restricted areas is clearly the goal of the restrictions, conservation in the Western sense appears to be just a by-product of other cultural and economic needs (Ruttan 1998). For example, ceremonial occasions such as the opening of a clan house (*haus boi*) are important in Ahus Island because they

not only affirm the status and position of the clan holding the ceremony, but may also help to maintain critical trade relations with neighbours.

Although Ahus Island is well-integrated into a cash economy, access to terrestrial resources such as firewood, timber, and vegetables is still quite reliant on good trade relations with neighbouring mainland villages (Carrier and Carrier 1991). Through customary marine tenure rights that restrict villages on the mainland from accessing reef-related resources, Ahus islanders create a demand for marine products, which helps to ensure that they have desirable goods to sell or trade. However, if exchange relationships with neighbouring communities become strained, Ahus Islanders could have difficulty accessing essential resources.

In, PNG, feasts can be used as an opportunity to reconcile or maintain exchange relationships (Schwimmer, 1973). During the ceremony witnessed at Ahus, neighbouring communities contributed pigs, dugong, shark, sting ray, and turtles (Figure 25). These contributions were likely given to affirm that current trade relationships were acceptable and to help promote a cycle of competitive exchange which facilitates future trade relations. Formal tallies of all contributions were kept in the expectation of at least equal reciprocity at a later date, thus providing incentives to maintain good relations. Participation in semi-regular feasts may also serve as cultural internalisation mechanisms that help to remind resource users of the rules and benefits of the closures.

On the other hand, Muluk's closure is very different in practice and intent from the strategy practised in Ahus. The explicitly stated reason for closing the area was so that the fish would become easier to catch, particularly while spear fishing. Resource users explained that when heavily fished, reef fish changed their behaviour so they stayed farther away from fishers and were more difficult to catch. Carrier (1982) noted that Ponham islanders also perceived declines in fish to be alterations in fish behaviour, rather than declines in abundance. By periodically closing the resource to extractive activities for up to one year, reef fish would become 'tame', allow fishers to get closer, and hence,

be easier to catch. Despite these differences, both closures appeared to focus on providing the community with benefits, rather than intrinsic conservation value (Ruttan, 1998).

Figure 25. Stingrays, Sharks and Dugongs Provided by Neighbouring Villages for Ceremonial Feast

Minimal social costs

Although the social role of the closures was very different in the two communities, each type of closure could address utilitarian goals without appearing to cause excessive social burdens. Additional long-term research would be required to quantify the social costs and benefits of specific closure strategies, which was beyond the scope of this study (see "future research directions" in Chapter VII). However, enough information was obtained to speculate on how these different strategies may impact the community.

Ahus' closures were able to provide a "bank account" of natural resources in ways that appeared to minimize social cost to the community. Ahus is highly dependent upon marine resources, so strategies such as permanent no-take zones or periodic closures, where significant portions of the reef are closed off for years at a time, could potentially create significant economic displacement and disadvantages. Despite the high dependence on marine resources, community members did not appear overly burdened by the regulations because most fishers practise multiple fishing techniques (Figure 23 b). By allowing line fishing throughout the year (which accounts for approximately half of the Ahus fishing effort, Figure 23), the regulations did not appear to alienate or displace specific user groups. If the Ahus fishery were such that each fisher typically employed only one gear type, the restricted areas would displace spear fishers and net fishers. Instead, the restricted use closures at Ahus appeared to reflect the ways in which resources were used.

At Muluk (and the other communities that employed periodic closures), dependence on marine resources was low (Chapter V) enough so that a temporary ban on fishing activities would not appear to severely threaten community members' livelihoods. At Muluk, fishing was a supplemental activity and residents practised multiple livelihood strategies, so switching to other occupations when the closure was in place would not have affected primary livelihood strategies. Furthermore, 51% of Muluk households used hand spears to catch flying fish in the deeper water, which meant that almost a third of the fishing effort was not affected by the closure. In addition, Muluk owned rights to fishing grounds in front of the neighbouring community of Wadau, so they were able to use those fishing grounds. Therefore, the periodic closure may have imposed an inconvenience on fishers, but did not prevent fishers from accessing marine resources.

Designs that reflect the scale at which marine resources are governed

It is not only the specific strategy, but also the design of the closures that appeared to reflect the local socioeconomic conditions. In particular, the design of the closures reflected the scale at which customary marine tenure operated in the communities.

Muluk's single large closure was well suited to the prevailing conditions there, while the six small closures reflected the governance situation at Ahus.

In Muluk, the three clans made a collective decision to close a large contiguous patch of reef, reflecting the highly communal nature of the existing marine tenure regime there. Closing off a large contiguous area appears equitable in Muluk because everyone shared the burden and switched to alternative occupations or fished outside the closure. Alternatively, at Ahus, most clans had their own closure which they were responsible for administering. Ahus' reef lagoon was much larger and customary marine tenure regimes were more decentralized. Because of the highly decentralized nature of the ownership rights arrangements at Ahus, a single large closure would be a source of inequity and internal conflict. Depending on where it was placed, specific families or clans would bear the entire burden of sacrificed production and associated income over all of their area and others would continue to harvest unabated. The design of several small closures spreads out the burden, so that each clan could decide whether and how much reef area and production they wish to sacrifice. Each clan's benefits were proportional to the sacrifices they made.

Incorporating locally appropriate mechanisms that help to promote compliance

Both closures appeared to reflect the communities that employed them in ways that not only reduced the social cost of resource management, but also in ways that may have helped to promote compliance with reserve rules. Compliance with externally-driven community-based protected areas can be low, particularly in areas where surveillance is difficult (Crawford et al. 2004) and where external assistance is lacking (Pollnac et al. 2001a). The chance of being caught violating fisheries management regulations is typically less than one percent, suggesting that when compliance with fisheries regulations does occur, it is largely driven by factors such as perceived legitimacy of the process and authorities, perceptions of how just and moral the regulations are, and social influences such as peers' opinions (Sutinen & Kuperan, 1999). Reportedly high awareness and compliance combined with a significantly lower abundance of discarded fishing gear on closed reefs than on reefs with no fishing restrictions (Cinner et al., in

review-a; Cinner et al., in review-b) indicates reasonably strong compliance with management regulations at Ahus and Muluk. Although sanctions did exist for violations of the traditional closures in Muluk and Ahus, there were no active patrols to enforce regulations, suggesting that compliance in these locations was likely related to intrinsic motivations. Compliance with the closures at both locations may have been facilitated by several locally relevant socioeconomic factors, including social mechanisms that embed the closures in the culture, legitimate exclusion of outsiders, appropriate sanctions, and the ease of monitoring the closures.

Periodically harvesting a small percentage of the fish within the Ahus *tambu* areas may also help to promote compliance by providing fishers and the wider community visible evidence that reef closures can help to improve fishery resources. Cinner et al. (in review-b) used a comparison of fish catch data from normal fishing activities with the fish caught during the periodic harvest to show that fish caught in the restricted area were significantly larger. Observations about the larger size of the fish caught inside the *tambu* areas were repeatedly made by fishers throughout the harvesting event. Therefore, this system of closure and brief, periodic harvest may provide a visual depiction to community members of the benefits of the closure for improving fish stocks. Key informants in Muluk suggested that they perceived direct benefits from the closures in the form of increased fish yields during periods when the area is open to fishing.

Both communities had strong traditional leadership and social mechanisms that embedded the closures into local traditions and customs. For example, at Ahus, motivations to comply may have been influenced by regular reminders of the restrictions through participation in harvesting events, feasts and celebrations (Berkes et al., 2000). Alternatively, at Muluk, reinforcement of rules and appropriate fishing behaviour were recited during initiation ceremonies. These types of cultural internalisation of traditional management regimes can help to reinforce awareness of and justification for the practices (Berkes et al., 2000).

In these communities, there was flexibility in governance coupled with the perceived legitimacy of excluding outsiders from accessing marine resources, which are important factors in compliance and commons governance (Dietz et al., 2003a; Sutinen & Kuperan, 1999). Perceived legitimacy of the practices and the traditional authorities may help to promote compliance with the fisheries management regulations with low enforcement and monitoring costs (Anderies et al., 2004; Sutinen & Kuperan, 1999). The closures were also placed close to the communities and were easily monitored by community members (Crawford et al., 2004). Sanctions were locally appropriate and graduated, so repeat offenders were fined more (Dietz et al., 2003a; Ostrom, 1990).

Are Traditional Closures Adaptive to Social and Ecological Conditions?

In both communities, decision-makers appeared to use qualitative social and ecological indicators in considering when and how long to either place the taboo or harvest the restricted area. For example, in Muluk, decision-makers claimed to use the perceived distance that fish would stay away from fishers as an indicator of when to open or close the reef. When the village chiefs felt that the fish catch was declining because the fish were remaining too far away from fishers (i.e., the resource reached a low baseline), they placed a taboo on the reef for an undetermined period. When they felt the fish were remaining closer, and thus easier to catch (i.e., the resource reached a high baseline), the taboo was lifted. Muluk's closure was instituted in response to perceived changes in the environment (i.e., perceived distance that the fish would remain from fishers). Figure 26 depicts a conceptual diagram of Muluk's cycle of adaptive management as having four components: 1) evaluating the condition of the resource, 2) placing the taboo, 3) observing the taboo, and 4) lifting the taboo. The thick grey lines represent the qualitative social and ecological baselines used to decide when to place the taboo.

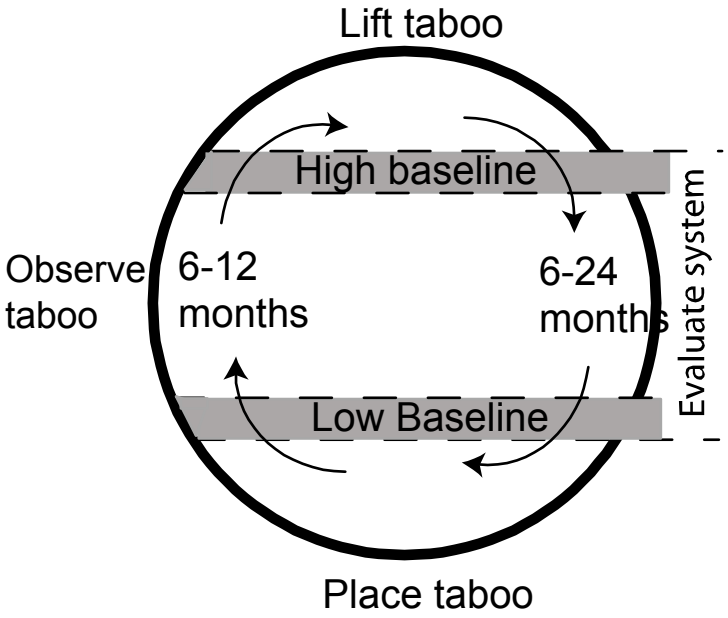

Figure 26. Conceptual Diagram of the Four Stages of Muluk's Traditional Management Cycle: Evaluating the Condition of the Resource, Placing the Taboo, Observing the Taboo, and Lifting the Taboo. Clan chiefs used qualitative indicators to decide when and how long to place the taboo (grey lines)

Implementing management in response to perceived changes in the social or ecological environment is what has been referred to in management and ecological literature as adaptive management (Berkes et al., 2000; Gunderson, 1999). Adaptive management is a process of adjusting management practices based on observed changes in social or ecological systems. Definitions of adaptive management can vary from a "learning by doing" approach (Bormann et al., 1999; Walters, 1997) to implementing resource management as experiments whereby managers incorporate the results of previous experiments to remain flexible (Grumbine, 1997). Most definitions agree that adaptive management involves responding to change.

It is more obvious to see how Muluk's system of closure was adaptive to the fluctuations in the environment, however, Berkes and Folke (2002) note that in resource management and sustainability issues, it is rarely possible to separate the social and ecological components. If the social and ecological components are examined as a socio-ecological system, then by using social baselines (i.e., examining social status, trade relations and time to have a feast) as cues for when to harvest their "bank account" of natural

resources, Ahus' system can also be viewed as adaptive to the social system. Thus, it is apparent that the resource governance institutions in the case study communities were characterized by flexibility. Both communities managed resources in ways that were adaptive to their social or ecological environment.

It has been argued that adaptive strategies are an important component of holistic ecosystem management (Berkes & Folke, 2002; Costanza et al., 1998; Holling, 2001), but few examples exist of adaptive management in Western coral reef fisheries (McManus et al., 1988). This may be, in part, because the ability to practice adaptive management may rely on the presence of specific social mechanisms which may be rare or unattainable in many locations. Thus, it is important to examine aspects of how socioeconomic conditions at the case study communities may have facilitated adaptive management strategies to better understand whether and how adaptive reef management may be applicable in other situations.

Adaptive management requires that management institutions must have the capacity to interpret and respond to changing conditions of resources, and both resource use practices and governance regimes must be flexible enough to allow for rapid changes and decisions (Gunderson, 1999). For example, the ability to place taboos as resource conditions declined or harvest resources as social conditions required may have been facilitated by flexibility and autonomy in the resource governance structure (Dietz et al., 2003a; Gunderson, 1999; Ostrom et al., 1999). In particular, the highly decentralized customary marine tenure regimes nested within (and recognised by) national and provincial authorities provided community leaders in both communities with the authority to develop and implement locally appropriate rules and sanctions virtually at will and with minimal bureaucracy (Hviding, 1998). However, there are also factors specific to each community that enabled adaptive management.

Summary

Traditional closures at Ahus and Muluk appeared to be adaptive strategies that were implemented in response to social and ecological conditions. The adaptive characteristics of these closures suggest that the strategies may have been adjusted through time to reflect socioeconomic conditions (De Castro, 2002). The specific closure strategies appear to be better suited to meeting the needs and goals of the communities based on their specific socioeconomic conditions in at least four ways: meeting diverse goals; minimising social costs, designs that reflect the scale at which marine resources are governed, and incorporating locally appropriate mechanisms that help to promote compliance. The following chapter will discuss how the results of the case studies in this chapter and the comparative analyses in Chapter V contribute to common property theory and to understanding the socioeconomic context within which traditional management operates.

CHAPTER VII. DISCUSSION AND CONCLUSION

Overview

Traditional management of marine resources is a foundation for marine conservation strategies in parts of the Pacific (Johannes, 2002d). However, debates exist as to whether and how these systems are compatible with the needs and goals of Western conservation. The literature review identified major debate threads in an overarching question of how traditional management of marine resources could fit into the modern conservation context. These debates focused primarily on three main questions: 1) Can traditional management regimes meet conservation goals? 2) How are traditional concepts and practices different from those of modern conservation? and 3) How are traditional conservation practices related to socioeconomic processes?

A careful review of the literature showed that although traditional management systems were not intended to conserve, they could act to improve the condition of select resources. However, the literature review found that there were considerable differences between traditional and Western management. In particular, traditional conservation was often practised and intended to meet the cyclical needs of Melanesian life, which contrasted strongly to the Western conservation strategies that seek to provide stable and consistent benefits to resource users or the environment.

The focus of this thesis was to contribute to the debate about the socioeconomic context within which traditional marine resource management operates. Chapter IV and Appendix II highlighted how fourteen coastal communities in PNG were very heterogeneous in a broad range of socioeconomic indicators and traditional management regimes. Then in Chapter V, the Rasch analysis technique was used to aggregate these indicators into thematic variables by which communities' dependence on marine resources, modernisation, perceptions about the complexity of human-environment interactions, perceptions about the condition of the marine environment, social capital

and occupational mobility were compared. Socioeconomic characteristics that vary primarily on a village scale were examined separately using non-parametric techniques. Chapter V then examined whether communities with traditional management had different socioeconomic characteristics than communities that did not and found that communities with traditional closures had slightly higher social capital and occupational mobility, slightly lower modernisation, and appreciably higher dependence on marine resources. The results were then discussed in the context of other theoretical and empirical research.

Then, Chapter VI examined how traditional management systems reflect the socioeconomic conditions of the communities that implement them by using two case studies to provide a more detailed examination on the most significant result of the Chapter V- that dependence on marine resources can affect the type of traditional management that is fitting for a community. One case study was from Ahus Island, where dependence on marine resources was extremely high. The other was from Muluk, where dependence on marine resources was low. These contrasting case studies helped to provide more detail into the socioeconomic context within which these traditional practices operated and how a community's dependence on marine resources may determine whether and how traditional closures may meet their goals. Results suggested that traditional closures were adaptive techniques that reflected the communities' patterns of resource use and governance, met distinct utilitarian goals, appeared to minimise social costs to the community, and incorporated locally appropriate mechanisms that may have helped to promote compliance.

This chapter moves to the application of these results by discussing how this study contributes to understanding common property systems and how these findings may shed light on traditional management's potential role in the modern conservation context. Finally, a brief review of some methodological concerns with the research and future research avenues are discussed.

Discussion

Contributions to Understanding Common Property Systems

This thesis used a common property theoretical framework to explore the role of socioeconomic factors in traditional management. The literature review examined why widely accepted common property theories such as Hardin's (1968) and Olsen's (1965) were not always appropriate in fishing communities. Then Ostrom's (1990) theoretical framework was discussed, which postulated that situational factors (such as the size of the resource and market influences), rather than individualized rational calculators were largely responsible for how and why individuals and communities could cooperatively engage in the collective behaviour required to govern common property resources. The literature review concluded that there was a significant gap in our understanding of how traditional management systems were related to the socioeconomic situation in particular communities and comparative research was required to address this issue.

This thesis showed that traditional common property institutions are influenced by socioeconomic conditions, which support the theoretical frameworks postulated by common property researchers such as Ostrom (1990), Agrawal (2001; 2002) and Wade (1994). Chapter V showed that socioeconomic factors (particularly dependence on marine resources, but possibly social capital and occupational mobility, modernisation, and settlement patterns) are related to the presence of traditional management, and discussed how these specific findings fit with other empirical studies of common property institutions. These results were found to validate the theoretical and empirical research of others in defining important variables to consider in comparing common property institutions (Agrawal, 2001, 2002; Harkes & Novaczek, 2002; Pollnac & Johnson, in press; Pretty, 2003; Pretty & Smith, 2004; Pretty & Ward, 2001).

The main contribution of this thesis to current common property theory is that it was able to tease out specific factors that appear particularly relevant to traditional management situations, specifically highlighting the importance of dependence on resources as a factor in whether or how traditional closures are implemented. It is clear from this study that

dependence on resources is an important consideration in whether traditional reef closures are implemented and should be considered in future comparative research on common property management institutions. Modernisation, social capital, and occupational mobility were also found to have slight, but significant relationships with the presence of traditional closures. However, the practical significance of results was very slight, so further research would be required before recommendations could be developed about where and how these factors might affect the implementation of traditional closures (this point is discussed further in the section on future research directions).

This thesis also contributes to the methodological aspects of common property research by introducing an analytical technique that addresses what Vaske et al. (2002) note as an important shortcoming of social science research to date: that the practical significance of findings based on constructed variables is difficult to determine and communicate. Many of the situational factors thought to influence common property systems are latent traits (e.g. social capital and dependence on resources, Ostrom, 2000) that require construct variables to measure and compare. Rasch analysis has hitherto been unused in this type of social science, but has implications for improving the interpretation of analyses based on constructed variables. Rasch analysis provided an analytical tool that helped to make intuitive sense of the results and prevented erroneous conclusions about the significance of certain factors that would have likely been reached using comparable analytical techniques. In particular, results showed that although modernisation, social capital, and occupational mobility were statistically significant, their practical significance was very slight. The adoption of Rasch analysis in similar studies may help to prevent erroneous conclusions about the importance of some findings based solely on statistical significance and allow authors to communicate the practical significance more easily.

Furthering Debates about the Role of Traditional Management in the Modern Conservation Context

As a result of this thesis, are we closer toward understanding whether and how traditional management should be part of coral reef management in PNG? Much of the evidence from this thesis and the associated publications that contain ecological data (e.g., Cinner, in review; Cinner et al., in press; Cinner et al., in review-a; Cinner et al., in review-b; McClanahan et al., in review) suggests that traditional management institutions are long-enduring systems that have been able to adapt and persist through time while meeting both social and ecological goals. The traditional closure systems explored in this thesis had many of the characteristics that theoretical studies covered in the literature review (e.g., Ostrom 1990, Becker and Ostrom 1995) defined as crucial for the long-term viability of common-property institutions. These were: 1) lineage-defined membership rights and traditional geographic boundaries were often defined (although sometimes challenged and frequently muddled by complexities of intermarriage) (Chapter IV); 2) the closures closely reflect the specific socioeconomic conditions of the communities, suggesting there was congruence between rules and local conditions (Chapter VI); 3) Community leaders were able to make and modify the rules (Chapter VI); 4) Although no formal monitoring systems were in place, closures were frequently located in areas that facilitated monitoring (Chapter VI); 5) Both traditional and legal conflict resolution mechanisms existed for dealing with conflicts (Chapter II, Chapter IV); and 6) Official recognition of customary marine tenure institutions provided resource users with the legal right to restrict access to marine resources and change these rules at will Chapter II, Chapter VI). This, in combination with the conclusions reached by Cinner et al. (in review-a, b) and McClanahan et al. (in review) that these systems can, in fact conserve biological resources suggest that traditional management may be a reasonable foundation for coral reef conservation in Papua New Guinea.

However, results from this thesis also urge caution in where and how traditional closures should be promoted as a basis for conservation. Indiscriminate application of traditional closures without consideration of socioeconomic factors may result in the development of a strategy that is incongruent with the needs, uses, and goals of the community. In

particular, this thesis showed that it is important to recognise that multiple types of traditional closures exist, some of which may be more appropriate for certain communities based on their specific socioeconomic conditions. For example, periodic closures may be more appropriate for communities with low dependence on marine resources and gear restricted areas may be more appropriate for communities with high dependence. Attempting to develop and implement a periodic closure in a community with extremely high dependence on marine resources may result in excessive burden on the community.

This thesis also showed that considerations of existing patterns of resource use and customary tenure are important in defining strategies that do not disproportionally disenfranchise a particular user group. Socioeconomic compliance theories suggest that not only do rules and authorities have to be perceived as legitimate (a traditional foundation may provide this legitimacy), but users must also perceive the rules to be equitable (Kuperan & Sutinen, 1998; Sutinen & Kuperan, 1999). If socioeconomic conditions such as resource use patterns and the scale of governance are not considered, opportunities to maximise perceived equity and legitimacy may be missed, and subsequent compliance with the management may suffer.

This thesis identified a range of other socioeconomic factors that should also be considered in whether and how traditional closures should be implemented. In particular, the case studies showed that different strategies were used to fulfil community goals that, although both utilitarian, were fundamentally different. Thus, a community's goals and/or previous experience with closures may influence the type of closure that is most appropriate for them. For example, Cinner et al. (2002) found that in Kilu (one of the study sites in this thesis with a traditional closure), compliance was extremely poor with a permanent no-take closure established adjacent to the community by external agents including The Nature Conservancy and a local NGO, Mahonia Na Dari. Cinner et al (2003; 2002) found that the community members did not understand the rationale behind the establishment of a no-take marine reserve and after several years of complying with the closure, community members claimed they began targeting the reserve as a primary

fishing spot. At first, this lack of understanding about the rationale of the closure seemed odd in the cultural context of the community because the villagers had been closing their reefs to fishing as part of traditional funerary rights rituals for generations (see Chapter III). When a person of stature in the community died, a portion of reef was closed for a period of 3-12 months and then opened to harvest fish for a feast to mark the end of the mourning period. However, this may in fact be contributing to the poor compliance because the prevailing perception of a traditional reef closure was that the goals were to build up fish stocks so they could later be exploited. The idea of a long-term no take reserve just for wilderness or conservation value was nonsensical in the Kilu cultural framework. Thus, the community's previous experience suggested that closures were temporary and their goals for the closure were utilitarian.

This study has helped to identify some of the characteristics that would help to discriminately apply specific traditional management strategies to appropriate locations for appropriate reasons. This thesis suggests that conservation organisations and/or government initiatives aiming to promote traditional closures as a basis for fisheries conservation should consider factors such as a community's dependence on marine resources, patterns of resource use, and scale of governance when selecting target communities and appropriate strategies. However, it is important to recognise that this thesis did not attempt to cover all the debates about whether and how traditional management should be applied to coral reef conservation in PNG and the wider Pacific. A number of considerations relevant to basing fisheries management and conservation on a traditional foundation have been brought up by other researchers that were not in the scope of this research to cover. For example, Foale and Manele (2004) describe how the scale at which customary marine tenure operates is generally too small to preserve fish recruitment and other ecological processes considered critical in the long-term viability of marine reserves, suggesting that there may be little long-term utility in basing fisheries management and reef conservation efforts on a framework of traditional management.

Speculation about the future of traditional management regimes

To explore the potential role of traditional closures in resource management in the Pacific, it is not only important to understand how socioeconomic factors are related to traditional management regimes, but also to speculate on whether these regimes will be resilient to changes in socioeconomic conditions. There has been considerable theoretical research into resilience in social-ecological systems (e.g., Dietz et al., 2003a; Folke et al., 2002; Gunderson, 1999, 2003; Holling, 1996; Ludwig et al., 1997). Resilience is described as the adaptive capacity of a social and/or ecological system to deal with fluctuations or perturbations before shifting to an alternate state. Alternate states, in the context of marine resource governance in Melanesia could include a shift from a system of customary marine tenure to an open-access system, as happened in Tonga following contact with Europeans (Johannes, 2002d). It is important to note that contemporary definitions of resilience do not assume the system to be static and that the system may adapt, refine, and change over time (Gunderson, 2003).

Traditional resource governance systems are dynamic institutions that, through adaptation to changing scenarios, have proven relatively robust to population pressures and aspects of economic and political modernisation (Baines, 1989; Hviding, 1998). The inherent flexibility of these systems, decentralised control over marine resources, and willingness to adapt and innovate suggest that these may be resilient systems (Davidson-Hunt & Berkes, 2003). However, there may be social forces that traditional governance regimes are unable to adapt to. Results from this study suggest that socioeconomic changes that will increase dependence on marine resources, decrease social capital, and increase modernisation may influence the ability of communities to employ or maintain traditional closures. Factors such as high in-migration to areas such as West New Britain to supply labour for the oil palm industry (Curry & Koczberski, 1999) and the development of live reef food fish trade which links community fisheries directly to high-price fish markets in Asia (field notes, Kavieng Province, 2002) may negatively influence the ability of communities to employ or maintain traditional management. Under these scenarios, conservation and development strategies that rely on traditional closures may become challenged at their foundation.

Difference between traditional and conventional management

In answering the research questions of this thesis, light was also shed on some of the other debates highlighted in Chapter II about the role of traditional management in the modern conservation context. In particular, the question of how traditional strategies differ from Western concepts and practices was touched upon. Highlighting the results of this thesis in this context here may contribute to the broader discussion on the role of traditional management in the modern conservation context.

Traditional closures differed dramatically from western conservation based on their intent and purpose: unlike western conservation techniques which seek to maintain ecological processes for the consistent economic benefits or the intrinsic value of biodiversity and wilderness, traditional management is focused on providing the community with tangible benefits to meet its cyclically changing needs. Indeed the cyclical and adaptive nature of these closures appears to strongly contrast with the linear-based Western conservation (Foale & Manele, 2004).

To illustrate this point, a conceptual model has been developed to contrast Western and traditional closures. The rationale behind Western resource management techniques generally fall into two categories: 1) promoting sustainable harvests (i.e., maintaining the point at which a fishery will replenish itself but excess production is harvested); and 2) protecting a core area whereby the benefits 'spill over' into outside areas. Western yield-based fisheries management techniques, such as minimum size regulations, gear restrictions, and temporary closures during vulnerable life stages seek to maintain fishing effort or fish population characteristics (e.g., enough breeding adults) to promote a sustainable linear population equilibrium of target species at a pre-determined level. For example, size restrictions and temporal restrictions during vulnerable life stages seek to ensure the breeding population is protected so the replenishment point (i.e., the point where the breeding population is maintained) can be sustained over time. The goal is then to harvest the excess stock above the replenishment point (Figure 27a). Likewise, marine reserves seek to maintain a stable climax community within the reserve. Surplus production inside the reserve theoretically results in spill over of adult fishes, which can

be harvested in adjacent fisheries (Russ et al., 2004) (Figure 27b). Although these conventional fisheries and marine reserve models seem very different at first glance, they are similar in the sense that resources are managed for equilibrium-based ecological stability (population climax for fully closed areas and the maximum sustainable yield for others) and excess production is harvested.

In contrast, traditional closures operate using very different principals. Traditional closures seek to build up a surplus of natural resources which can then be harvested. This can best be illustrated by revisiting the Muluk case study. The case study described how the closure was implemented when community leaders felt the resources were degraded (a low baseline) and then removed when they reached an acceptable level (a high baseline) (Figure 26). Figure 27c adapts the conceptual model presented in Figure 26 to compare the traditional system to Western systems. Rather than maintain a stable population state (and associated steady flow of benefits) as in Western resource conservation, in this traditional management model, resources continually oscillate between qualitative baselines.

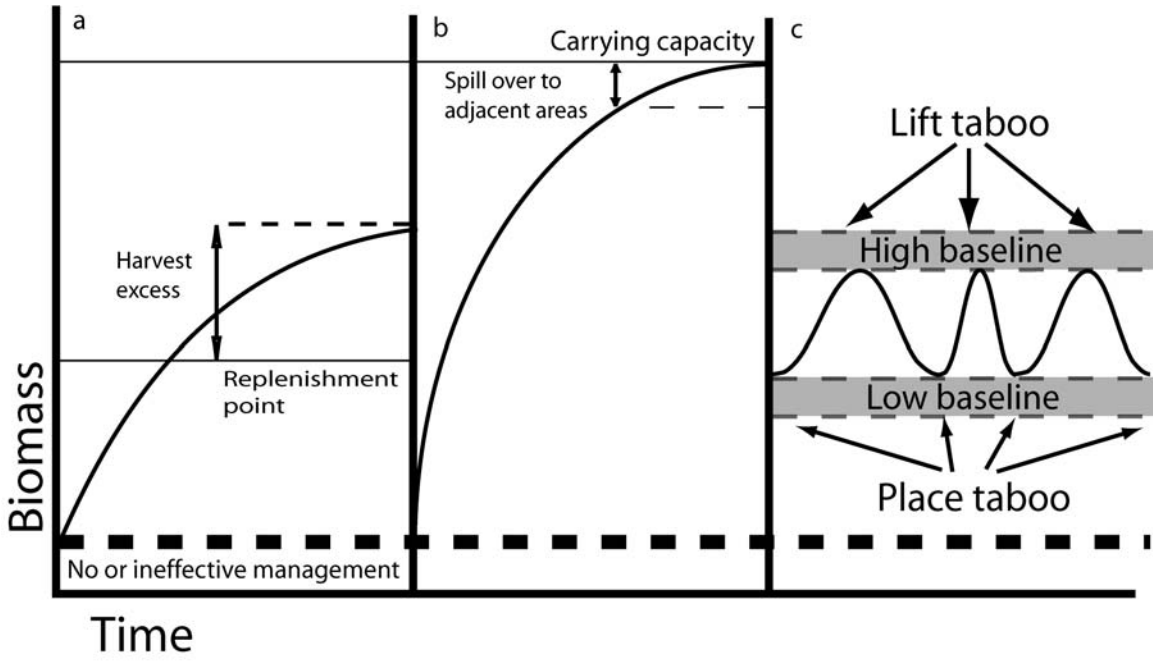

Figure 27. Comparison of Models of (a) Yield-Based Fisheries Management, (b) Closed Areas, and (c) Traditional Management Using Periodic Closures.

This would appear to confer very different benefits to both resource users and ecosystems than what has come to be expected from conservation and sustainable use. While yield-based fisheries and marine reserve theories attempt to consistently maximize economic and/or ecosystem benefits, traditional management aims to meet the cyclically changing needs of coastal communities. Any conservation effects are but by products of the means to meet social community needs. This cyclical system of receiving direct benefits from marine resource management initiatives, can lead to very different expectations between communities and conservationists on the purpose and duration of reef closures.

Without understanding how these systems differ from Western conservation, misunderstandings between communities and outsiders about the roles and expectations of marine conservation are likely. As a result of their utilitarian goals and cyclical nature, traditional management practices such as periodic closures are unlikely to conserve some of the ecological processes that fully implemented and observed closed areas do. However, the reality in many developing countries is that despite massive funding efforts by NGOs and development agencies, marine reserves often receive little community support and suffer poor compliance (McClanahan et al., in review). In these situations, management efforts are unlikely to significantly improve the condition of the resource and the potential benefits remain unrealized (McClanahan et al., in review). Even though traditional closures may never reach the theoretical potential that marine reserves attempt to, they can conserve some aspects of reef ecology and by providing the community with direct benefits, they can also garner community support without external financial assistance (Cinner et al., in review-a; Cinner et al., in review-b). Thus, one of the main lessons we can learn from studying traditional management systems is that conservation based on Western models may be ill-suited to meeting the specific needs, desires, and socioeconomic requirements of some communities in developing countries. In these areas, there is a need for a paradigm shift away from the largely unsuccessful biodiversity-based conservation toward developing pragmatic utility-based conservation of natural resources.

Conclusions

Lessons from Traditional Management for the Modern Conservation Context

I do not wish to perpetuate the myth of an 'ecologically noble savage' where indigenous communities are seen to be intrinsically inclined to conserve resources (Ruttan & Borgerhoff Mulder, 1999). On the contrary, in the traditional closure cases examined here, resources were managed for the social benefit of the community in ways that appeared to minimize negative impacts on community livelihoods. Since so many coral reef conservation initiatives fail for social reasons, studying the socioeconomic role of traditional management regimes that have been in place for generations may provide valuable lessons about the direction in which Western conservation theory may need to move to be applicable in the context of some developing countries. Johannes (2002d, citing Hviding and Ruddle, 1991) notes that the Pacific "has much to contribute to innovative thinking about small scale fisheries management worldwide." This thesis does not seek to advocate traditional management as a replacement for marine reserves or other marine conservation techniques. Instead, I seek to promote discussion about the direction of modern conservation theory and practice by examining what we can learn about conservation from systems that were not meant to conserve for the sake of biodiversity.

Historical arguments as to whether traditional management should play a role in the modern conservation context focused largely on the potential of traditional management practices to conserve resources (Johannes, 1978). However, increasing attention is now being focused on how resource management strategies can fulfil community goals. The long-enduring nature of these traditional closures also suggests that studying the socioeconomic conditions under which traditional reef closures operate may provide lessons that are applicable to where and how contemporary marine reserves could be designed to reflect local communities. Socioeconomic factors, particularly dependence on marine resources, may influence the type of strategy that a community is best able to employ. Indeed, the specific types of closures implemented in Ahus and Muluk reflected

the socioeconomic conditions of the communities in ways that allowed for conservation (Cinner et al., in review-a; Cinner et al., in review-b), but did not appear to create undue burdens on the communities. This should be carefully considered in conservation planning in areas with traditional management currently or historically in place and beyond. Understanding the types of communities where specific conservation strategies are more likely to work may help to improve the woeful success rate of coral reef conservation initiatives (Bryant et al., 1998; Burke & Maidens, 2004; Burke et al., 2002).

Christie (2004) notes how disproportional benefits or costs accruing to a particular set of stakeholders can cause resource management strategies to fail. This thesis highlighted how traditional closures reflected the scale at which resources were governed and used in ways which appeared to result in a relatively equitable distribution of benefits and costs. Further research is required to quantify the costs and benefits to individual resource users and the larger community, but these results suggest that contemporary marine reserves may be able to create more equitable costs and benefits among stakeholders by examining and reflecting the scales at which resources are used and governed. Reserves could also utilise locally appropriate mechanisms to promote compliance.

There is considerable debate about whether Marine Protected Areas (MPAs) should be large or partitioned into several smaller reserves (known as the SLOSS- Single Large or Several Small) (Dahlgren & Sobel, 2000; Halpern, 2003; Roberts et al., 2003; Sladek Nowlis & Roberts, 1999). Debates also exist about whether MPAs should be periodic or permanent in nature, particularly in temperate climates (Agardy, 2000 citing others). To date both of these have been purely ecological questions, but this thesis showed that these questions appear to also have important social determinants that are virtually absent in the literature about reserve design and information needs (e.g., Agardy, 2000; Roberts et al., 2003). Social science involvement in conservation planning has generally been an afterthought. For example, in a review of criteria for selecting marine reserves, (Roberts et al., 2003) claim that biological criteria should precede social criteria and that social input should not compromise biological integrity. However, this thesis showed that questions of reserve size and permanence should not be solely ecological debates, but

rather must be expanded to incorporate socioeconomic aspects of resource use and governance. This study reiterates the importance of involving social science in the forefront of conservation planning and suggests that understanding the socioeconomic context of a community should occur prior to attempts to develop or implement specific strategies (Christie et al., 2003; Cinner & Pollnac, 2004).

A Review of Some Methodological Concerns: Limitations that May Affect the Validity or Applicability of the Results

Comparative Research and the 'Snapshot Approach'

Case studies, particularly those of the Melanesian maritime ethnographers such as Malinowski (1922; 1935), Carrier (1987), and Hviding (1996) have provided in-depth explorations of the social context of common property institutions in particular locations. These thoroughly detailed examinations of localized genealogical use rights, developmental history, and transformations in the face of social and economic change help us to understand not only the complexities of traditional management systems, but also their potential applicability to the western conservation context. However, there have been relatively few comparative explorations of common property regimes to date, particularly in the Melanesian region. Ostrom (1990) and Rudd et al. (2003) have focused primarily on providing a broad theoretical framework upon which to compare common property regimes. Several other research frameworks and methodologies have been developed to compare fisheries management and reef governance systems. However, these either lack the depth to explore root causes of the management systems (i.e., Ruddle, 1991), are methodological protocol manuals that (by design) lack the broader conceptual framework (i.e. Bunce et al., 2000; Pollnac, 1998; Pollnac & Crawford, 2000), or are focused on determining resource sustainability (i.e., Pitcher & Preikshot, 2001). Despite the calls for studies exploring human-environment relationships in detailed comparative studies examining specific variables (Agrawal, 2001; Pollnac & Johnson, in press) relatively few authors have attempted this type of comparative

research (Aswani, 2002; Henrich et al., 2001; Muller et al., 2000; Pollnac et al., 2001a; Ruttan, 1998).

The lack of attention to comparative marine common property studies in Melanesia may be due, at least in part, to the relatively high financial resources required to conduct this type of field research. Alternatively, some authors, such as Hviding (1996) and McCay and Jentoft (1998), have theoretical criticisms of the development of a model to explain traditional management regimes. McCay and Jentoft (1998) suggest that in the context of common property research, an ethnographic approach is valuable because it can provide an extremely detailed exploration of causes and effects, tends to resist *a priori* definitions of causal relationships, and is unlikely to embrace over simplified and possibly misleading models. Hviding (1996) warns that customary marine tenure is an ever-evolving system whose empirical complexities "cannot be grasped, or delimited, by a formalized structural model." Hviding (1996) goes on to suggest that the abstractions required to develop a model of customary marine tenure are overly simplistic and "insensitive to the spatio-temporal variations that characterize marine tenure."

Hviding's concerns of oversimplification and misunderstanding apply to any "outsider" (whether conducting a long-term ethnographic case study such as his or developing a comparative model) who is limited by cultural conceptual bounds when attempting to understand and accurately portray complex institutions such as common property regimes. To explore how social and economic factors influence the types of common property regimes communities employ, this thesis compared specific socioeconomic variables and types of traditional management regimes across 14 communities in PNG and then presented two case studies to further explore the results of the comparative analysis. Although attempts to compartmentalize a wide range of traditional management regimes into comparable categories have undoubtedly led to overly simplistic interpretations of their true complexities, it is hoped that this will be outweighed by the ability to examine the variations in how traditional management responds to different social and economic factors that can be captured best through a comparative study.

Relatively few of the variables examined in the comparative analysis demonstrated convincing relationships with the presence of traditional management, however, the case studies highlighted a number of different ways in which traditional closures may reflect the socioeconomic conditions of a community (the scale at which resources are governed, resource use patterns, mechanisms that may help promote compliance, etc.). One might then ask whether the case study approach was more useful than the comparative analysis and whether comparative analyses should have any role in research on traditional management. Although few relationships were found in the comparative analysis, the comparative aspect of this study defined the scope of the case studies by highlighting an issue that warranted further investigation: communities with periodic closures all had low dependence on marine resources but the community with a gear restricted closure had high dependence. Thus, both the comparative and case study aspects of this study were important. This thesis showed that it is not a matter of conducting comparative or case study research, but rather demonstrates the advantages of utilizing both methodologies.

While the comparative approach used in this thesis offers the obvious advantage over case studies of being able to examine broader patterns, one of the significant weaknesses presented by the "snapshot" methodology (i.e., conducting research over a short temporal period) used in this study is that temporal factors are not easily considered. Historical events and processes can influence aspects of modern life such as rights to access resources and common property institutions (Aswani, 1999; Cinner et al., in press; De Castro, 2002). For example, De Castro (2002) found that evolution of local management institutions in the Amazonian floodplain involved complex historical processes. Historical processes and events may have influenced the governance institutions or socioeconomic conditions in the study sites in ways that are not immediately evident in a snapshot assessment. Therefore, it possible that historical factors may have influenced relationships between socioeconomic conditions and traditional management in ways that the methodological approach used in this thesis could not capture. For example, Chapter IV described how the community of Wadau was originally from the uplands of Karkar Island but was resettled to the coast by the colonial administration to provide access to government services such as school and health care facilities. Rights to marine resources

in Wadau are controlled by the historical owners, the neighbouring community Muluk. Thus, at Wadau the common property institutions that govern marine resources may be largely influenced by this historical event of re-settlement rather than the current manifestations of socioeconomic conditions such as the settlement pattern (which was operationalised as either nucleated or dispersed). The snapshot approach used in this thesis does not account for historical factors such as colonial resettlement, which may be important determinants in the presence of traditional management.

Numerous studies have shown that the management and health of common property resources can be affected by socioeconomic factors operating at the cultural (Atran et al., 2002), community (Aswani, 1999; Pollnac et al., 2000), clan or moiety (Carrier & Carrier, 1991), household , or even individual scale (Ruttan & Borgerhoff Mulder, 1999). This study looks specifically at how select household and village-level socioeconomic factors influence the presence of traditional reef management. Household-level factors were community characteristics that operated and varied primarily at a household level, such as dependence on fishing and modernisation. Village-level factors were community characteristics that operated and varied primarily at a village level (such as distance to market).

As a researcher, one of the biggest challenges of this project was accepting that not all of the relevant factors and scales could be actively investigated and incorporated given the time and financial limitations of this project. Since only one to three weeks were available per community to collect data, many of the complex processes that are played out at the clan or moiety level, such as lineage descent and associated rights, which often take ethnographers years to begin to unravel could not be adequately addressed. By not incorporating certain factors, in no way is it suggested that they do not have significant influences on the ways in which common property resources are used and governed nor dismiss their importance. Instead, this thesis seeks to make a contribution to our understanding of the complexities of how common property systems operate on varying scales by addressing specific household and village-level factors.

If potentially important factors such as historical events can not be considered, one might then ask whether it is useful to compare present day manifestations of socioeconomic factors. This thesis clearly showed that it was useful to investigate traditional management issues with a snapshot approach. Although this thesis was not able to investigate every potential factor and scale at which socioeconomic processes influence the implementation of traditional management, it was able to make clear contributions to our understanding of the socioeconomic context within which traditional management operates. In particular, this thesis was able to highlight the relationship between dependence on marine resources and the presence of traditional management and use the case studies to further explore how traditional management regimes reflected the local socioeconomic conditions. Despite their weaknesses, snapshot approaches have been a cornerstone of social science and development research for more than two decades (Chambers, 1983, 1994a, 1994b; Pollnac, 1998) and remain the best possible method to evaluate a large number of communities with limited resources and time.

Future Research Directions: Where To From Here?

As this thesis examined how socioeconomic factors influence the presence of traditional closures, it scratched the surface of a question that is relevant to the success of marine conservation initiatives around the world: Are certain types of conservation strategies better suited to communities with specific socioeconomic characteristics? At present, marine reserves are promoted by aid agencies and many NGOs as the marine conservation solution in any community, regardless of the existing socioeconomic characteristics or processes at play. The lack of understanding about the social conditions within which marine reserves can operate successfully has been reflected by the poor success rate of marine reserves (Burke & Maidens, 2004; Burke et al., 2002; Christie, 2004; Christie et al., 2003). This thesis highlighted the need for further research into the types of communities that specific conservation strategies can work in, which will help conservation planners target limited resources to the places that have the highest probability of success. Suggested research into this area includes:

1) Results on the modernisation, social capital and occupational mobility variables were only marginally significant and their influence on traditional closures was hard to discern in this study. It will be important for future studies to conduct more detailed studies on these factors. In particular, it will be important to collect information on more social capital and occupational mobility indicators so separate variable constructs can be developed.
2) Examining the socioeconomic factors that were identified in Chapter II but could not be addressed in the scope of this study also remains a high research priority. Examining factors such as leadership capacity, social structure, and resource variability may be appropriate topics for researchers that are embedded in communities for substantial lengths of time.
3) Other approaches to determining and quantifying the social and economic costs of different closure strategies of the closures would help to provide more information about the social burdens posed by certain strategies. Econometric methodologies may be appropriate to examining the costs and benefits associated with different closure strategies. This type of approach would also require longer-term studies that encompass detailed trade and exchange studies, quantification of social and economic value of target marine species affected by the closures, and multiple visits necessary to examine changes in resource use patterns (and associated costs) of periodic closures.
4) Conducting further comparative research into the types of communities that employ traditional closures. The methodological approach used in the comparative aspect of this study is replicable in both time and space. Temporal studies in the communities with traditional management using the same indicators could examine whether and how the traditional management regimes have responded to socioeconomic change. The study could also be conducted in other areas to determine whether the findings are applicable beyond the study sites in PNG. It would also be important to examine the socioeconomic conditions in communities with a broader range of closures. This will include examining a higher proportion of closures other than periodic closures (e.g., gear restrictions).

5) Examining the social characteristics of communities with successful marine conservation strategies. This research direction will involve conducting comparative research on the social characteristics of communities that can successfully cooperate in developing and maintaining marine reserves and other resource management strategies.

Summary

This thesis explored the socioeconomic context within which traditional management systems in PNG operate. The socioeconomic conditions in five communities that employed traditional closures were quantitatively compared with those in nine communities that did not. Many of the socioeconomic factors expected to be related to the implementation of traditional management institutions did not demonstrate practical or significant differences. Dependence on marine resources was the variable construct that had the best relationship to the presence of traditional closures. Two case studies were then used to demonstrate how specific aspects of traditional closures reflected the socioeconomic conditions of the communities that implement them. The results of this thesis were used to explore the role of traditional closures in the modern conservation context and explore what conventional conservation can learn about managing resources from traditional management systems.

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APPENDIX I. SURVEY FORMS

Household Surveys

I. DEMOGRAPHIC INFORMATION

Village_____

Date_____

1. Age_____ 2.Sex_____

2. Where are you originally from?_____

3. How long have you lived in XXX?_____

4. Why did you move to XXX?

Employment	Fish	Other work	Family & friends
Health/spiritual	Other		

5. How many people live in your house?

Adults	Children

II SOCIO-ECONOMIC INFORMATION

6. What jobs do you and other people in your house do that bring in food or money to your house?

Person	Activity	Days per week	Rank of Importance

7. Does anyone in the house collect shells, starfish, urchins, or sea cucumbers?

Invertebrate	Days per week	Hours per trip	dive	Walk on reef

8. If you garden, how many gardens do you have?

9. How long does it take you to arrive at the gardens?

III. Fisheries Information (If you fish)

10. How long have you been a fisher _____? 10b. What did you do before?_____

11. Did your father fish?

12a. When you or other household members go fishing, what equipment is involved?

Gear	Days per week	Hook size	Net length	Net gauge	Rank of Importance

12b. What do you do with your catch? %food_____ %market_____

14. Fisheries Management

Management type	Description	Trad.	Gov.	Do people still (go there, use that gear, etc)
Are there places where people are not supposed to fish?				
Are there certain times when people are not supposed to fish?				
Are there certain species that people are not supposed to catch?				
Are there certain gear that people are not supposed to use?				

IV. PERCEPTIONS ABOUT COASTAL RESOURCES

14. I am interested in how good or bad you think the fish catch has been over the past 12 months. How would you describe the fish catch over the past 12 months?

15. Over the past 12 months, where would the catch be on a scale of 0 to 10, if 0 is hardly any fish and 10 is lots of big fish? Five years ago? Where will it be in 5 yrs?

16. What can affect the number of fish in the sea?

Human activities	Fishing	*Number of fishers*	*Over fishing*	*Specific gear types*
dynamite	*Net*	*Poison*	*Sea cucumber*	Other
Fish moved/hiding	Supernatural	Land-based	Political/economic conditions	Social cohesion
Weather	Other			

17. What could be done around XXXX to so that there would be more fish in the sea?

18. How healthy are the corals around XXXX?

19. where would the corals be on a scale of 0 to 10, if 0 is all dead corals and 10 is very healthy corals? Where would they have been 5 years ago? In 5 years?

20. What can affect the condition of the coral?

Human activities	Fishing	*Number of fishers*	*Over fishing*	*Specific gear types*
dynamite	*Net*	*Poison*	*Sea cucumber*	Other
Fish moved/hiding	Supernatural	Land-based	Political/economic conditions	Social cohesion
Weather	Other			

21. What could be done around XXXX to make the corals healthier?

IV. MATERIAL STYLE OF LIFE

22. Do you own land? _____ if yes, hold title?_____ Rent_____

Other_____

23. Household items & facilities.

Generator	Electricity	Vehicle	Modern stove
Septic System	TV	Boat	Electric fan
Satellite dish	Agricultural animals What kind? how many?	Piped water	Water tank
Refrigerator	Radio/cassette player	Latrine	VCR
Motor (for boat)	Wood stove		

24. Roof material

Wood	Thatch	Insulated
Corrugated zinc	"Disposable" material	Tar paper
Other		

25. Floor material

Cement	Mosaic (tile)	Sand	Plank Wood	Bamboo/palm	Other

26. Wall material

Cement	Wood	Wood/Cement	Bamboo	"Disposable" Material	Other

27. Rooms

Bedroom(s)	Bathroom Indoor____ Outdoor___	Kitchen Indoor____ Outdoor___	Living room	Other

VI. COMMUNITY PARTICIPATION

28. Do you belong to any community organizations? How many?

29. If there is a decision to be made in your clan or in the larger community, are you involved in that decision? How?

VII. MORE SOCIOECONOMIC QUESTIONS

30. Religion 31. Languages 32.Ethnicity

33. What is the highest grade of education you have attained?

34. Last fortnightly expenditures

Store/market bought food	Other goods (soap, matches, etc)	Clothes	Transport (fares, fuel, repair)
Farming/fishing equipment	Rent	Special occasions (brideprice, etc.)	Other

Key Informant Interview

I. DEMOGRAPHIC INFORMATION

Village_____

Date_____

1. Do you live here?

Where are you originally from?_____

2. How long have you lived in XXX?_____

3. Why did you move to XXX?_____

Employment	Fish	Other work	Family & friends
Health/spiritual	Other		

4. How many days per month do you live in XXX?_____

5. What jobs to you do to bring in food or money to your house?

Activity	Season	Days per week	Rank of Importance

II. FISHERIES DATA

a) If fisher

6. Please list the types of gear that you use from most important to least?

Gear	Days per week	Hook size	Net length	Net gauge	Rank of Importance

7. Please list the importance of the species you catch, from most to least.

Species	Season	Rank

8. Did you used to use any other equipment? ____ Why did you stop?

9. Are there different groups of fishers? Describe

10. How has fishing changed around XXXX?

Size	Abundance	Species	Number of fishers
Fishing grounds	Gear	Other	

When did you first notice these changes and why do you think these happened?

B) If fish trader

11. Did you used to fish? _____ Why did you stop?

Age	Money	State of fishery	Other fishers
Supernatural	Regulations	Other	

12. Please list the importance of the species you sell, from most to least.

Species	Season	Gear used

C) If tourism operator

13. What types of tourism activities occur in the area?

Beach activities	Snorkel	SCUBA	Pleasure boating	Recreational Fishing	Reef viewing boat tours

14. How many tourists per week do you take out?

Beach activities	Snorkel	SCUBA	Pleasure boating	Recreational Fishing	Reef viewing boat tours

15. How has this changed over the past five years?

16. How many other operators are in the area?

17. What types of destructive tourism activities occur on the reef?

Walking on coral	Anchoring on coral	Depositing vessel waste	Collecting coral
Other			

III PERCEPTIONS ABOUT COASTAL RESOURCES

18. I am interested in how good or bad you think the fish catch has been over the past 12 months. How would you describe the fish catch over the past 12 months?

19. Over the past 12 months, where would the catch be on a scale of 0 to 10, if 0 is hardly any fish and 10 is lots of big fish? Five years ago? Where will it be in 5 yrs?

20. What can affect the number of fish in the sea?

Human activities	Fishing	Number of fishers	Over fishing	Specific gear types
dynamite	Net	Poison	Sea cucumber	Other
Fish moved/hiding	Supernatural	Land-based	Political/economic conditions	Social cohesion
Weather	Other			

21. What could be done around XXXX to so that there would be more fish in the sea?

22. How healthy are the corals around XXXX?

23. where would the corals be on a scale of 0 to 10, if 0 is all dead corals and 10 is very healthy corals? Where would they have been 5 years ago? In 5 years?

24. What can affect the condition of the coral?

Human activities	Fishing	Number of fishers	Over fishing	Specific gear types
dynamite	Net	Poison	Sea cucumber	Other
Fish moved/hiding	Supernatural	Land-based	Political/economic conditions	Social cohesion
Weather	Other			

25. What could be done around XXXX to make the corals healthier?

26. Corals (all)

What is coral used for?

Has it been used for anything different in the past?

27. Conflicts (all)

Are there any conflicts over fish or coral reefs?

Tourism operators/tourists_____ Other fishers_____

State/government_____ Other_____

If other fishers, why? gear-related? ____ origin-related ____ Other ____

IV. Fisheries Management (If fisher/fish trader/government)

28. Spatial Components

Where do people in this community fish?

Do they stay closer or go farther at other times of the year? When?

Are there certain places that people are not supposed to fish in or go to? How big are they?

How are the laws/rules enforced?

Do people still go there? Why?

Are there places that are considered dangerous or sacred?

Do people still go there? Why?

29. Time

When do people fish?

Are there certain times when people are not supposed to fish? Why?

How are the laws/rules enforced?

Do people fish during these times anyway?

30. Species

Are there certain species that people are not supposed to catch? Why?

How are the laws/rules enforced?

Do people catch them anyway?

31. Size

Do fish need to be of a certain size before they should be captured? Why?

How are the laws/rules enforced?

Do people catch them anyway?

32. Gear

Are there certain gear that people should not use? Why?

How are the laws/rules enforced?

Do people use them anyway?

33. TRADITIONS

Are there any fishing traditions that are no longer practised?

Women's Focus Group Interview

What are the main jobs that women here do to make food and money?

How would you compare the fishing today with 5 years ago?

What is affecting the number of fish in the sea?

What could be done to improve the number of fish in the sea?

How would you compare the reef today with 5 years ago?

What is affecting the reef?

What could be done to improve the health of the reef?

Do people respect the tambu area?

What could be done so they would respect it?

How are decisions made in the community?

Are women involved in the decisions?

What are some of the major issues facing the community?

What do you think would make life better for people in the community?

What are your hopes for the future of the community?

Community Leader Key Informant Survey

Population	
Number of houses	
Population growth rate	%
Infant mortality rate	

Services/facilities	present	absent	distance to
a. hospital			
b. medical clinic			
c. doctor			
d. dentist			
e. primary school			
f. secondary school			
g. piped water			
h. sewer pipes or canals			
I. sewage treatment facilities			
j. septic or settling tanks			
k. electric service			
l. telephone service			
m. food market			
n. pharmacy			
o. hotel or inn			
p. restaurant			
q. gas station			
r. public transportation			
s. hard-top road access			
t. banking services			
u. service/facilities index (sum a-t)			

How many clans are there in XXXX?

What are the main jobs that people here do to make food and money?

How many churches/mosques/etc. are there in the community?

How are decisions made in the community?

Are women involved in the decisions?

Are there any elected positions? If so, how many/what kind?

What kinds of groups are in the community?

How is land distributed throughout the community?

Are there conflicts or issues involving land?

Do people in this community have control over the adjacent ocean?

If so, is it owned by the larger community, individual clans, or individual households?

If so, are people from other areas excluded from fishing or going there? What is the penalty?

Are there any tambu or masali areas in the sea? If so, where? Do people still go there?

Are there conflicts or issues involving fish or reefs?

In your opinion, what are some of the major issues facing the community?

What are your hopes for the future of the community?

What do you think would make life better for people in the community?

APPENDIX II. SOCIOECONOMIC CHARACTERISTICS OF THE COMMUNITIES

This appendix summarizes the results of the quantitative community surveys by providing detailed descriptive statistics on the indicators that were used in the comparative analysis in Chapter V. The results presented in this appendix are largely descriptive in nature (i.e., community and sample means or totals, errors, etc.) and are necessary to provide the reader with an understanding of how socioeconomic characteristics vary on both household and community scales. This chapter incorporates photographs to illustrate the certain resource use activities. The results presented in this chapter are organized into the following sections: 1) a general overview of the fishing techniques used; Dependence on marine resources; 2) Modernisation; 3) Occupational mobility and social capital; 4) Perceptions of coastal resources; 5) size of resource and conflicts; 6)Distance to markets 7) Population and settlement pattern . The subsequent results chapter will present the analyses of how governance of coastal resources is influenced by the other factors.

Overview of fishing techniques

Fishers in PNG use a range of technology and techniques: spear guns, hook and line, hand spears, kite fishing, gill nets, hand traps, derris root, dynamite, weirs, and bamboo traps to harvest reef resources (Dalzell & Wright, 1990; Huber, 1994; Quinn, 2004). While a variety of gear types and techniques for using gear were noted, many of the gear types were highly specialized, used infrequently, and/or very localized. Four main gear types were predominant across the study sites: hook and line, spear guns, hand spears, and nets. Figure 28 illustrates the proportion of fishing trips allocated to four main gear types. Line fishing accounts for over half of all fishing effort and is clearly the most predominant fishing technique utilised in the study sites. Spear guns, hand spears and nets, respectively, show a lower level of use.

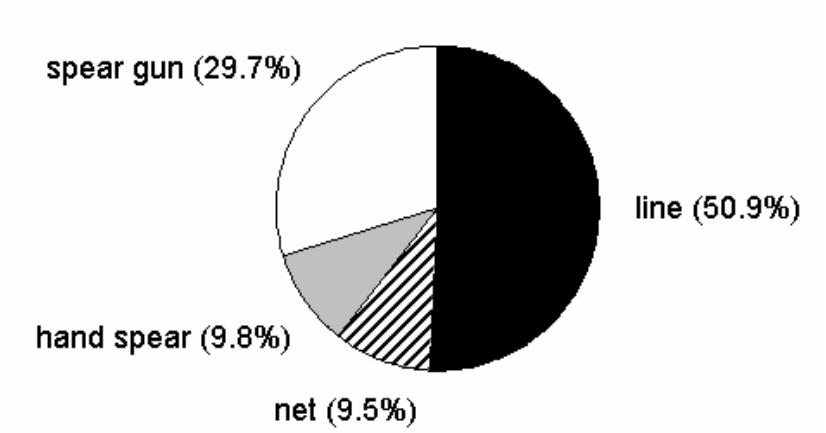

Figure 28. Proportion of Fishing Effort Allocated to Lines, Spear Guns, Nets, and Hand Spears for All Communities

Line fishing was very prolific in the study sites, and was used in a variety of techniques, including: trolling; bottom fishing on the reef from canoes or dinghies; throwing a small line from the shore, seawall, or groyne; and night fishing in the water column for mackerel. Both bait and homemade lures (including rice bag strips, feathers, and condoms) were used. Line fishing was conducted at all times of day and night, with certain communities occasionally specializing in specific techniques. For example, in Muluk and Wadau (Karkar Island), some residents used a line fishing technique involving a rock and a leaf. The leaf was wrapped around the rock, which sinker, and the hook was inserted in the stem of the leaf was used as a (Figures 29 a and b). When the rock hit the bottom, the fisher jerked the line, which made the hook tear through the leaf. The hook (which has a piece of string on it to attract fish) was then quickly pulled up. This technique prevented the hook from getting caught on the reef.

Figures 29 a and b Line fishing with Rocks and Leafs at Karkar Island; Figure 16a shows a leaf being wrapped around a rock to sink the line; Figure 16b shows a fisher retrieving the line.

Spear guns were frequently home made from wood, using a sharpened spoke or metal rod projected by a bicycle inner tube (Figure 30). Most projectiles were metal rods with no barb and occasionally had strings attached to the spear so the spear would not get lost. Some fishers had commercially manufactured tips with barbs. Spearfishing occurred at all hours, with night-time spearfishers mainly targeting parrotfish (*Scaridae*).

Hand spears were generally made of bamboo and had several prongs made from a palm wood. They were thrown by hand to catch flying fish, mullet, or longtoms. Hand spears were either thrown while standing in a canoe or while walking in shallow seagrass beds (Figure 31). In the Madang province, a specialized hand spear technique, called "*bom bom*," was used to catch flying fish at night from approximately November to February. The fisher would spear fish in the air as they were attracted to the light from a kerosene lantern.

Figure 30. Spear Fisher at Kranket Island, Madang Province

Gill nets were frequently set early in the morning or in the evening. Nets were generally set on the reef crest or in channels within a reef lagoon. In Kilu and Patanga (Kimbe Bay), net fishers frequently fished in the seagrass beds and in the Central Province, net fishers occasionally set nets in intertidal areas (Figures 32a and b). Participation in several net fishing trips indicated that net usage can be highly damaging to corals. When gill netting, it was common for 3-10 fishers to splash in the water, throw rocks, and break coral with sticks or other instruments to drive the fish into the net. Gill nets frequently became entangled in the coral and caused considerable damage to branching or plate corals when removed.

Figure 31. Hand Spear Fishing in the Seagrass Beds at Patanga

A variety of other gear were used in select study sites, including derris root, fish weirs, kites, explosives, basket traps and specialized nets (Figures 33a and b). These gear types were generally specialized in certain communities or regions and did not compromise a significant portion of fishing effort.

Figures 32a and b. Gill Netting in Seagrass Beds and Reef Flats in (a) Kimbe Bay and (b) Central Province

Figures 33 a and b. Alternative Fishing Methods such as (a) Preparing Derris Root in Kavieng and (b) Fish Weirs in Manus

Dependence on Marine Resources

Importance of Fishing

A total of 81% of the 506 respondents participated in the fishery (43.6% ranked the fishery as 1st or 2nd most important occupation for the household[8] and an additional 36.4% ranked it as 3rd or more). Figure 35 presents the percentage of each community engaged in fishing, and highlights the percent of the community with that ranked fishing as the primary or secondary occupation. The percent of households in each study community that were ranked fishing as important ranged from under three percent to over ninety percent. It is noteworthy that even in communities for which fishing was not highly ranked, (such as Patanga, Kilu, Fissoa, Madina, and Wadau), there was still a moderate proportion of the community (>57%) that engaged in fishing. It should also be noted that this measure does not include the importance of other marine resources such as reef gleaning or coral harvesting. Information about these activities was collected, but in the majority of cases, the relatively low engagement in these activities did not justify their inclusion as a key variable. However, the Andra community was heavily involved in coral harvesting for lime production. Details of this practice and its environmental effects can be found in Cinner et al. (in press).

[8] Recall from the methods section that data were collected about the relative importance of each occupation. For easier interpretation of the relative importance of each occupation, two categories were created based on the relative rank: One groups is for households that ranked the occupation as first or second in importance and the other group is for those households than ranked the occupation as 3rd or higher. These groupings were supported by participation in daily activities, interviews with key informants, and time line analyses which suggested that, in general, when occupations were ranked in order of importance, primary and secondary occupations were crucial to household survival, and activities ranked higher than third were supplementary.

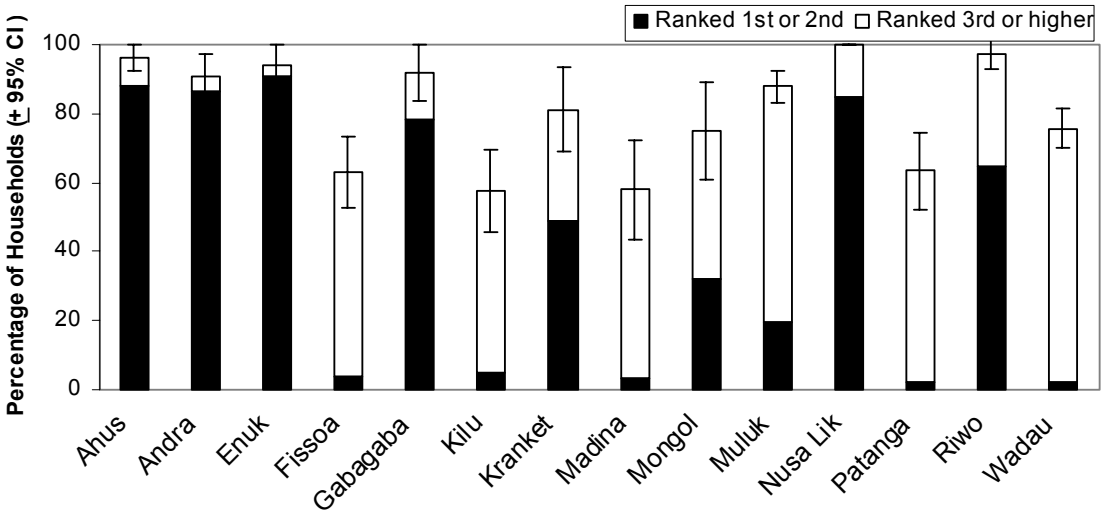

Figure 34. Percentage of Households Engaged in the Fishery, Highlighting the Proportions Ranked as 1st or 2nd in Importance [9]

Fishing Intensity

Households fished an average of 4.8 trips per week (standard error = 0.3). The maximum number of fishing trips per household was 59 trips per week, while the minimum was 0 (n = 494). Communities ranged from a mean of 79.8 (±27.3) fishing trips per week in Patanga to 1,644 (±739) in Gabagaba (Figure 35). The proportion of fishing effort devoted to specific gear varied considerably between communities.

[9] Confidence intervals were calculated using a finite population correction factors. A finite population correction factor allows the confidence interval to be adjusted based on the sampling proportion for a known population. Variance from the systematic sample was assumed to be equal to the estimated variance based on a simple random sample: see (Scheaffer et al., 1996).

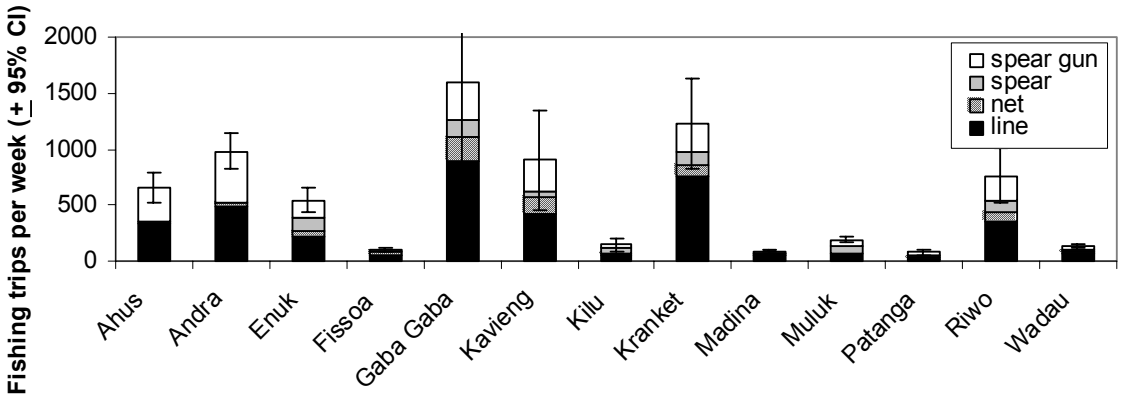

Figure 35. Estimated Fishing Trips per Week by Community, Highlighting the Proportion of Effort Allocated to Each Gear Type

Market Orientation

Across the study sites, fishing ranged from being a largely economic activity, where the majority of the fish catch was sold or bartered, to a largely subsistence activity, where the majority of the fish catch was consumed by the household. The percentage of fish catch sold or bartered ranged from a low of 9% in Madina to a high of 76% in Andra (Figure 36). The average percentage of fish catch sold or bartered for all households engaged in fishing (n=279) is 55.8 (standard error = 2.0) percent[10].

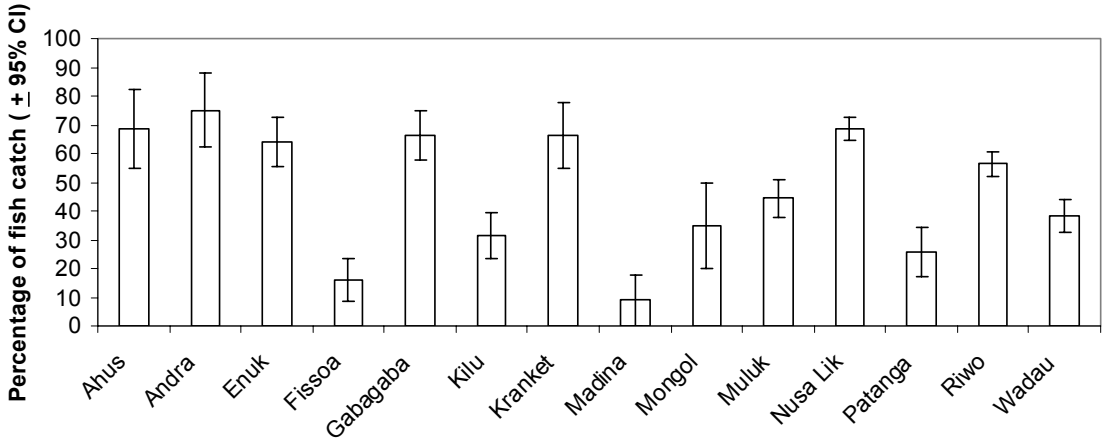

Figure 36. Percentage of Fish Catch Sold or Bartered (N=279)

[10] It should be noted that the estimates for Kranket were derived from non-random sampling of key informants rather than from systematic household sampling.

Importance of Agriculture

Participation in agriculture was high in most communities (Figure 37). The exceptions to this were the communities of Andra and Ahus, where agricultural activities were of relatively low importance. A total of 82% of all households surveyed participated in agriculture (71.3% were ranked it as 1st or 2nd in importance and 10.7% ranked it as 3rd or higher). Overall participation in both fishing and agriculture were similar (respectively 81% and 82% of respondents were engaged), but the percentage of respondents that ranked agriculture as 1st or 2nd in importance was much higher than that for fishing.

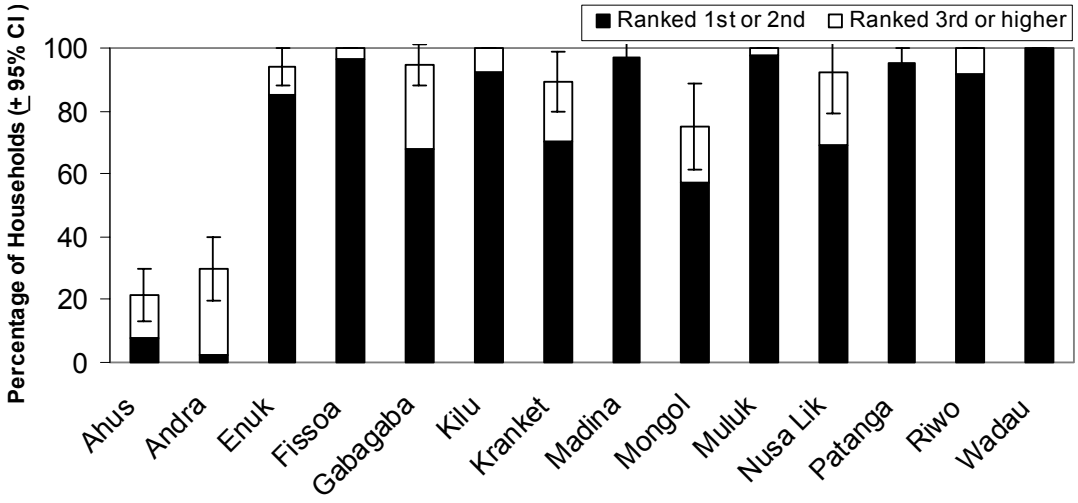

Figure 37. Percentage of Households Engaged in Agriculture, Highlighting the Proportions Ranked as 1st or 2nd in Importance

Modernisation

Formal Employment

Only 27% of all households surveyed participated in the formal economic sector (salaried employment). A total of 18.5 percent of households ranked salaried employment as the 1st or 2nd most important occupation, while 8.5% were engaged, but ranked it 3rd or higher. Across communities, involvement in the formal economic sector ranged from 5% of the community to 68% (Figure 38). As expected, participation in formal economic activities was highest in communities near commercial centres (Mongol, Kranket, and Gabagaba), and low in remote communities such as Muluk and Wadau.

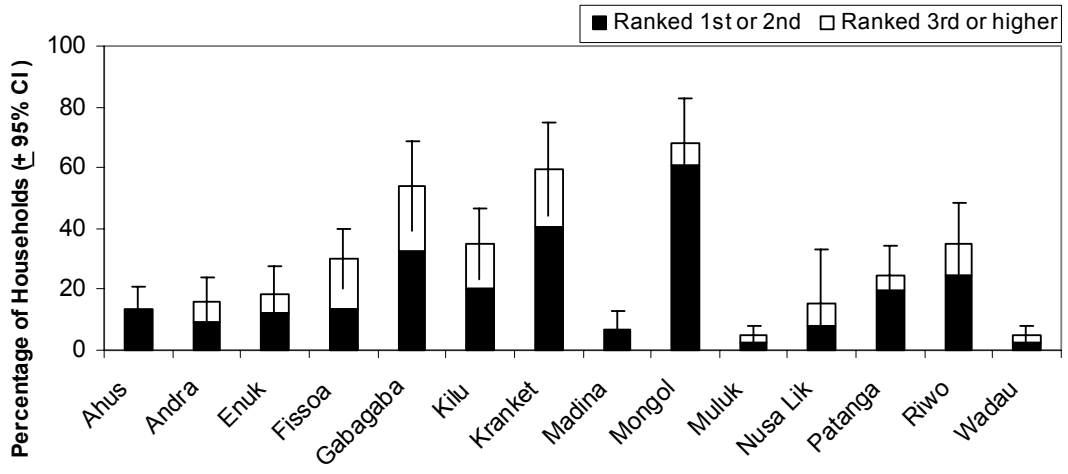

Figure 38. Percentage of Households Engaged in Salaried Employment, Highlighting the Proportions Dependent and Not Dependent

Education

Communities varied considerably in the mean years of education per household (Figure 39Figure 2). Gabagaba had the highest mean years of education. This was likely a result of the proximity to educational facilities in Port Moresby. Muluk had the lowest mean years of formal education of any of the study sites, with a mean of only 5 (±0.4) years. The mean for all households surveyed is 6.9 (standard error = 0.14) years, while the median was 6 years.

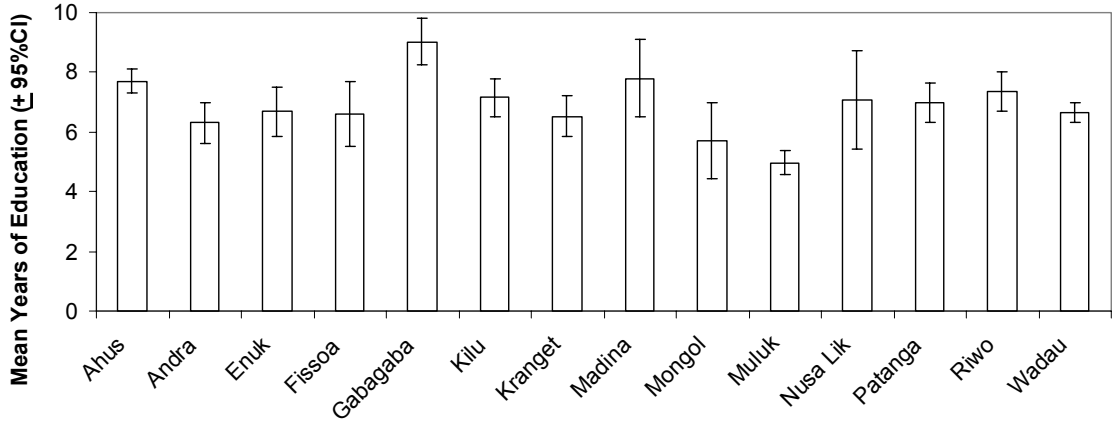

Figure 39. Mean Years of Formal Education (N=491)

Expenditures

The mean fortnightly expenditures for all households surveyed was USD$46.10 (standard error = 3.83), but the median expenditures was only USD$22.30. When examined across study sites, the mean fortnightly expenditures per household varied by almost an order of magnitude. Respondents in Wadau reported an average of only USD$13.80 spent in the previous fortnight, less than one half of the next lowest community, Enuk. Six communities, representing four of the five provinces studied, had very similar expenditures ranging from USD$42-48. The Central Province community of Gabagaba had considerably higher expenditures than all other communities with USD$93 ± 51 (95% CI) per fortnight.

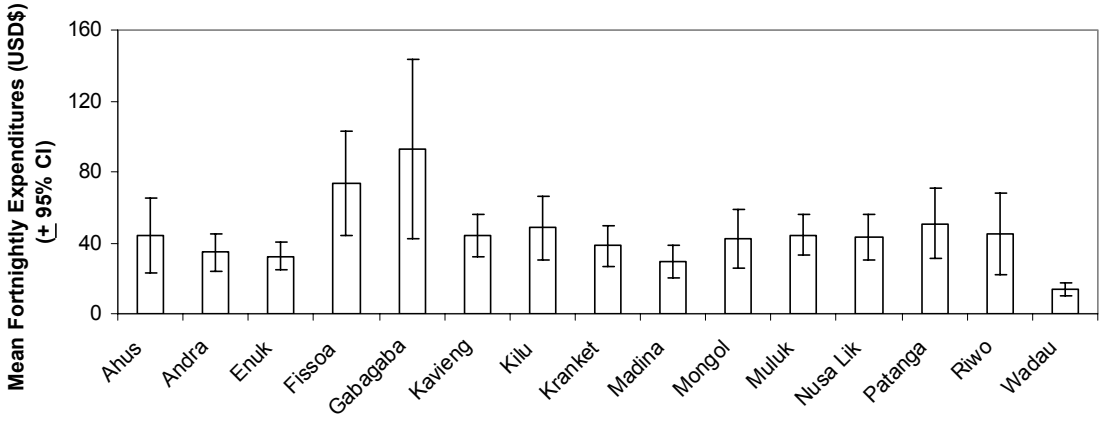

Figure 40. Mean Fortnightly Expenditures (in USD$) for Each Study Site

Material Possessions

The distribution of material possessions and quality of household structure varied considerably across communities (Table 17). Communities such as Gabagaba and Kranket had access to electricity and western goods such as TVs, and the households were generally constructed out of higher quality material such as metal roofs, plank or fibro walls, and plank wood floors. Communities such as Muluk and Wadau had relatively no access to electricity. Very few community members possessed luxury items such as modern stoves and the houses were typically constructed from bush material (thatched roofs & walls, bamboo or buai floors, etc.).

Table 17. Percentage of Households in Each Community with Specific Material Possessions and House Structure Items.

Item	Ahus	Andra	Enuk	Fissoa	Gabagaba	Kilu	Kranket	Madina	Mongol	Muluk	Nusa Lik	Patanga	Riwo	Wadau
Generator	0	4.5	3	6.7	0	15	10.8	11.1	7.1	9.8	23.1	14.6	8.1	4.9
Electricity	0	0	0	3.3	89.5	0	51.4	3.7	14.3	0	0	0	35.1	0
Vehicle	0	0	0	10	34.2	10	5.4	7.4	14.3	2.4	0	4.9	8.1	2.4
Modern stove	9.8	11.4	21.2	27.6	65.8	2.5	37.8	30.8	39.3	4.9	38.5	9.8	5.4	2.4
Septic system	0	0	0	0	2.6	0	8.1	0	7.1	0	0	2.4	0	0
TV	0	0	3	0	55.3	2.5	16.2	7.4	14.3	0	15.4	4.9	21.6	2.4
Boat	25.5	29.5	27.3	0	57.9	0	29.7	0	21.4	7.3	30.8	2.4	21.6	2.4
Electric fan	0	0	0	0	52.6	0	8.1	0	10.7	0	0	0	10.8	0
Antennae	0	0	0	0	47.4	5	0	3.7	10.7	0	0	2.4	10.8	0
Water tank	5.9	2.3	33.3	37.9	26.3	0	35.1	44	57.1	0	23.1	2.4	16.2	0
Radio	47.1	40.9	30.3	27.6	65.8	22.5	67.6	40.7	46.4	39	69.2	43.9	37.8	34.1
Latrine	0	0	12.1	44.8	44.7	0	86.5	56	0	0	30.8	0	13.5	17.1
VCR	0	0	0	0	26.3	2.5	2.7	3.7	7.1	0	0	4.9	8.1	0
Motor	21.6	29.5	24.2	0	57.9	2.5	18.9	0	17.9	7.3	23.1	2.4	13.5	7.3
Wood stove	100	100	97	100	89.5	100	78.4	100	100	97.6	92.3	97.6	100	100
Insulated roof	9.8	0	9.1	0	24.3	2.5	16.2	0	10.7	4.9	0	4.9	8.1	0
Thatched roof	21.6	77.3	30.3	37.9	0	57.5	54	46.2	17.9	90.2	30.8	41.5	62.1	92.5
Metal roof	80.4	22.7	81.8	75.9	100	65	48.6	52	89.3	14.6	76.9	68.3	37.8	17.5
Cement floor	13.7	7	12.1	23.3	0	2.5	11.1	23.1	10.7	2.4	23.1	2.4	10.8	0
Sand floor	56.9	41.9	21.2	23.3	0	5	0	28	0	0	30.8	0	0	0
Plank wood floor	23.5	51.2	45.5	50	100	70	72.2	38.5	67.9	4.9	30.8	48.8	64.9	2.5
Bamboo floor	5.9	2.3	27.3	0	0	25	13.9	7.4	25	95.1	15.4	48.8	24.3	97.5
Cement walls	3.9	0	9.1	16.7	0	5	0	11.5	7.1	0	0	0	5.4	0
Plank wood walls	7.8	2.3	12.1	34.5	24.3	25	13.9	33.3	10.7	5	15.4	17.1	8.1	0
Bamboo walls	72.5	84.1	48.5	34.5	0	70	69.4	36	39.3	95	53.8	78	70.3	100
Other wall material	0	0	42.2	37.5	75.7	0	16.7	18.9	17.7	13.6	42.9	38.5	0.0	3.3

Occupational Mobility

Occupational Diversity

Communities practised multiple economic and subsistence production strategies. The mean number of occupations per household varied from as high as 5.4 (± 0.3) in Fissoa to as low as 2.3 (± 0.2) in Enuk (Table 18). Enuk was a small island (1.05 km^2) and residents had limited access to agricultural land. Although there was a dive resort nearby Enuk, it was small and did not employ a large number of local residents. The mean number of occupations for all households surveyed (n= 506) is 3.3 (standard error =0.05).

Table 18. Mean number of Occupations per Household

Community	Number of Occupations	± 95% CI	Community	Number of Occupations	± 95% CI
Ahus	2.7	0.3	Madina	3.9	0.3
Andra	2.9	0.2	Mongol	3	0.4
Enuk	2.3	0.2	Muluk	3.3	0.1
Fissoa	5.4	1.1	Nusa Lik	3.7	0.6
Gabagaba	3.3	0.3	Patanga	3.8	0.2
Kilu	4.3	0.3	Riwo	3	0.3
Kranket	3.3	0.3	Wadau	3.2	0.1

Informal Economic Activities

Approximately half (57.2%) of all households surveyed were engaged in the informal economic sector (such as selling items at markets, driving taxis, etc.). A total of 27.1% of households were dependent on informal economic activities, while 30.1% were engaged, but not dependent (Figure 41). Participation in informal economic activities ranged from 15% to 93% of each community. It should be noted that Andra Island had the highest participation in informal economic sector. This was mainly the production and sale of lime powder manufactured from reefs used for consumption with betel nut.

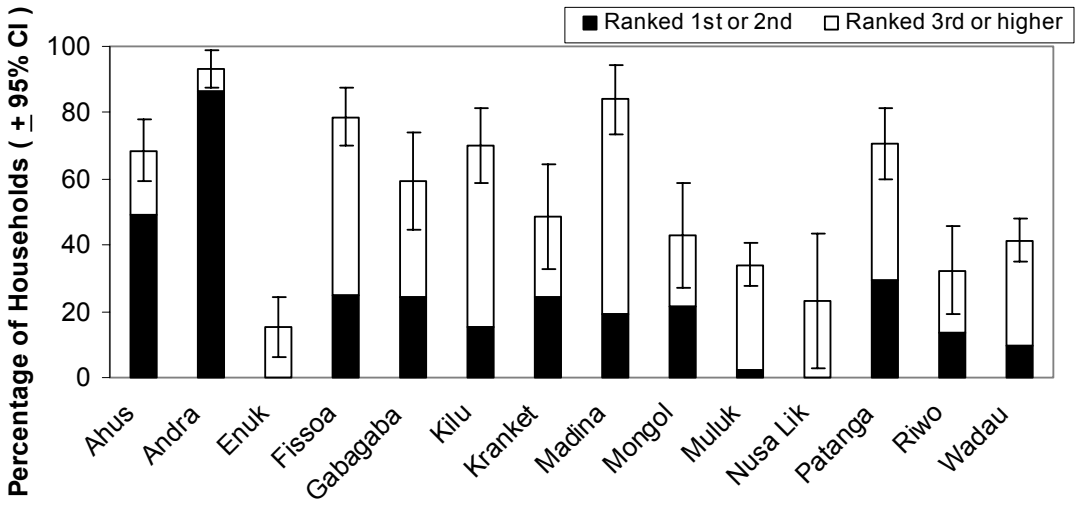

Figure 41. Percentage of Households Engaged the Informal Economic Sector, Highlighting the Proportion Ranked 1st or 2nd in Importance

Social Capital

Involvement in Decision-Making

At least two-thirds of each community was involved in decision-making (Table 19) (N = 498). The percentage of the community that was involved ranged from 66.7% to 89.5%. However, the percentage of the community that was actively[11] involved ranged from only 28.2% to 69.2%.

Involvement in Community Organisations

The majority of household in all study sites were involved in community organisations such as church groups and sports teams (Table 20). Involvement in the community organisations ranged from 57% in Riwo to just over 84% in Nusa Lik and Ahus. The mean number of community organisations per household varied from 0.8 in Riwo, Mongol, and Patanga, to 1.7 in Gabagaba (N=496).

[11] A household was considered actively involved in decision-making if they spoke at community meetings.

Table 19. Involvement in Community Decision-Making

Community	Percent of Households Involved in Decision-Making	± 95% CI	Percent of Households Actively Involved	± 95% CI
Ahus	84.3	2.6	58.8	2.2
Andra	88.6	3.1	63.6	2.6
Enuk	78.8	3.8	46.9	3
Fissoa	78.6	2.8	37.9	2
Gabagaba	89.5	4.5	50	3.4
Kilu	75	3.3	37.5	2.3
Kranket	67.6	4.2	43.2	3.4
Madina	60	2.6	50	2.3
Mongol	67.9	4.9	35.7	3.6
Muluk	82.5	1.9	57.5	1.6
Nusa Lik	84.6	12	69.2	10.9
Patanga	68.3	3	46.3	2.5
Riwo	86.5	4.2	61.1	3.6
Wadau	69.2	1.8	43.6	1.4

Table 20. Involvement in Community Organisations

Community	Percent of Households Involved in Community Organisations	± 95% CI	Mean Number of Community Organisations per Household	± 95% CI
Ahus	84.3	2.6	1.6	0.2
Andra	70.5	2.8	1.2	0.3
Enuk	69.7	3.6	0.9	0.2
Fissoa	75.6	2.7	1.4	0.4
Gabagaba	81.6	4.3	1.7	0.4
Kilu	82.5	3.4	1.5	0.2
Kranket	70.3	4.3	1.1	0.3
Madina	52	2.4	0.84	0.4
Mongol	64.3	4.8	0.8	0.2
Muluk	61.5	1.7	1	0.1
Nusa Lik	84.6	12	1.3	0.4
Patanga	73.2	3.1	0.8	0.1
Riwo	56.8	3.4	0.8	0.2
Wadau	61.5	1.7	1.0	0.1

Emigration

A total of 19.2% of all respondents of respondents had moved to the study sites from other locations. There was considerable variation in the percentage of migrants across study sites, ranging from 2.6% to 64.3% (Figure 42). Three of the four highest in-

migration rates were the New Ireland sites (Mongol, Nusa Lik, and Enuk). The lowest in-migration rates were in Gabagaba, Ahus, and Muluk. In total, 19.9% of all respondents (N=503) had emigrated. It should be noted that data about out-migration were not collected.

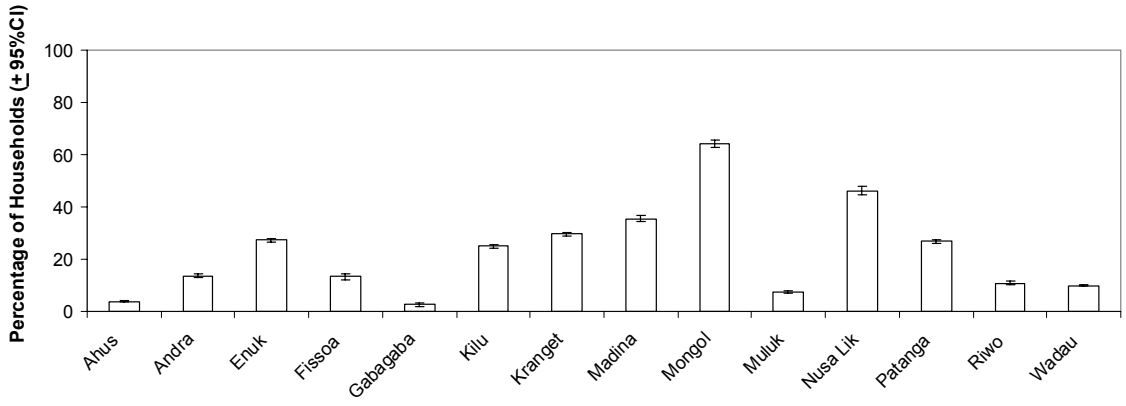

Figure 42. Percentage of Emigrants

Perceptions of Coastal Resources

Perceived Condition of the Fishery

Table 21 presents the Likert scale scores of perceptions of the condition of the fishery for two temporal periods (five years in the past and five years in the future) (N = 363). Overall, communities were pessimistic about their outlook of the condition of fisheries resources (i.e., the future score was generally less than the past score). All but one study site (Kilu) perceived a declining trend in the condition of the fishery from five years ago to five years in the future. The site with the highest population (Kranket Island) perceived the greatest decline in the condition of the fishery. Comparable estimates for Fissoa and Madina are not available.

Table 21. Perceived Condition of the Fishery

Community	Past Condition (5 years ago) [a]	95% CI	Present Condition	95% CI	Future Condition (5 years in the future) [a]	95 % CI	Past Trend [b]	Future Trend [c]
Ahus	7.9	0.3	5.9	0.4	3.8	0.4	-2	-2.1
Andra	8.3	0.5	6.2	0.4	4	0.5	-2.1	-2.2
Enuk	7	0.6	6.6	0.2	5.4	0.6	-0.4	-1.2
Gabagaba	7.9	0.6	6.4	0.6	5.2	0.9	-1.5	-1.2
Kilu	5.6	0.7	6.5	0.5	7.6	0.8	0.9	1.1
Kranket	7.7	0.7	5.3	0.5	3.1	0.7	-2.4	-2.2
Mongol	8	0.6	6.5	0.6	4.7	0.9	-1.5	-1.8
Muluk	7.3	0.3	7.2	0.3	6.4	0.4	-0.1	-0.8
Nusa Lik	8.2	1.1	7.2	0.9	7	1.3	-1	-0.2
Patanga	7.3	0.5	6.1	0.5	5.5	0.7	-1.2	-0.6
Riwo	7.6	0.6	5.6	0.5	4.7	0.9	-2	-0.9
Wadau	7.8	0.3	6.0	0.3	5	0.4	-1.8	-1

[a] These values are based on a 10 point Likert scale of 0 = worst condition to 10 = best condition.
[b] The past trend variable was calculated by subtracting the past condition from the present condition.
[c] The Future trend variable was calculated by subtracting the present condition from the future condition.

Community Perceptions of What Can Affect the Condition of Fisheries

Respondents were asked the open ended question "what can affect the number of fish in the sea?" Table 22 presents the percentage of each community that mentioned each response category. Respondents were able to mention more than one category, so column totals do not add up to 100%.

Table 22. Percentage of Households in Each Community that Mentioned Specific Factors that can Affect the Fishery

Response	Ahus	Andra	Enuk	Fissoa	Gabagaba	Kilu	Kranket	Madina	Mongol	Muluk	Nusa Lik	Patanga	Riwo	Wadau
# of fishers	31.4	20.5	3	20.7	10.8	2.5	51.4	25.8	22.2	10	7.7	2.4	13.5	44.7
Over fishing	47.1	18.2	9.1	37.9	10.8	5	13.5	28.6	14.8	2.5	15.4	2.4	13.5	5.3
Explosives	17.6	18.2	90.9	44.8	81.1	72.5	97.3	36.7	77.8	15	69.2	87.8	91.9	7.9
Nets	15.7	0	39.4	3.3	27.8	17.5	40.5	22.6	33.3	17.5	53.8	22	38.9	36.8
Poison	0	9.1	69.7	64.3	40.5	92.5	56.8	60.7	66.7	87.5	69.2	92.7	73	89.5
Gleaning	3.9	6.8	18.2	6.9	5.4	12.5	2.9	3.3	22.2	7.5	7.7	9.8	0	7.9
Other gear	19.6	61.4	3	6.8	10.9	0	0	9.6	0.0	0	0.0	0	0	0
Land-based	5.9	9.1	6.1	39.3	32.4	52.5	51.4	30.0	22.2	2.5	23.1	17.1	16.2	2.6
Political/economic	7.8	20.5	6.1	6.7	2.7	0	27	9.7	3.7	0	7.7	4.9	2.7	0
Social cohesion	0	0	0	16.7	16.2	0	5.4	21.4	18.5	0	0	0	2.7	0
Fish moved	17.6	38.6	12.1	13.8	27	7.5	32.4	6.5	3.7	22.5	0	7.3	16.2	18.4
Supernatural	3.9	59.3	6.1	6.7	2.7	2.5	0	6.7	11.1	0	0	0	0	0
Other	15.7	9.1	9.1	23.3	37.8	0	35.1	12.9	18.5	2.5	46.2	4.9	18.9	13.2
Don’t know	2	2.3	0	0.0	0	0	0	0.0	0.0	0	0.0	0	0	0

Size of Resource and Conflicts

Ownership of fishing areas typically extended only to shallower areas (<20m deep) of sand, seagrass, or reef. The size of fishing areas owned by communities was largely dependent upon local geography, such as the types of reefs locally prevalent (i.e., large lagoons, narrow shelves, etc.), which varied considerably by region. Fishing grounds owned by communities ranged from only 0.23 km^2 in Mongol to 14.9 km^2 in Gabagaba (Table 23). For example, Muluk and Wadau had extremely narrow fringing reefs, which resulted in very small reef areas adjacent to the communities. Andra and Ahus had relatively large reef lagoons surrounding the islands. It should be noted that an Australian colonial administrative decision gave Andra Islanders rights to use the eastern portion of the much larger reef lagoon on neighbouring Ponham Island (Carrier & Carrier, 1989b). The exact boundary of this reef is under dispute and area estimates were not available, but could potentially be almost as large as the existing lagoon. Gabagaba had both fringing and offshore reefs which resulted in a large tenure area. Estimates of fishing ground size were not available for Madina and Fissoa, although the reef is fringing and only about 500 meters wide, so the area would likely be comparable to Mongol, Wadau, or Muluk. Four of the 14 communities reported significant conflicts over marine resources over the previous 12 months (Table 23).

Table 23. Size of Marine Tenure Areas and Presence of Conflicts Over Marine Resources

Community	Size of Tenure (km^2)	Conflict	Community	Conflict	Size of Tenure (km^2)
Ahus	5.52	Yes	Madina	No	Not available
Andra	5.55	Yes	Mongol	No	0.23
Enuk	9.93	No	Muluk	Yes	0.58
Fissoa	Not available	No	Nusa Lik	No	1.51
Gabagaba	14.90	Yes	Patanga	No	1.35
Kilu	1.22	No	Riwo	No	0.70
Kranket	0.89	No	Wadau	No	0.34

Distance to Market

The distance from each community to the nearest commercial centre (which was either the provincial or national capital) varied from approximately 100 m to 69 km. The mean distance was 25.4 km (standard error = 7.3) and the median distance was 18.5 km.

Table 24. Distance to Nearest Commercial Centre

Community	Distance to Market (km)	Community	Distance to Market (km)
Ahus	20.5	Madina	70
Andra	31.25	Mongol	0.1
Enuk	14	Muluk	69
Fissoa	85	Nusa Lik	1
Gabagaba	57.75	Patanga	20.4
Kilu	16.5	Riwo	7
Kranket	1.25	Wadau	66

Population and Settlement Patterns

Population of the study sites varied dramatically, from almost 2,130 residents to under 275 (Table 25). Kranket Island, located adjacent to Madang, was the largest community studied, with approximately 2,127 residents in 309 households. Nusa Lik had the fewest households with 273 residents in 45 households.

Two types of settlement patterns were evident across the study sites, “nucleated coastal” settlements and “dispersed inland/coastal” settlements. “Nucleated coastal” settlement patterns were areas where the community was situated largely along the coast with a very small (if any) inland section. Nine of the fourteen communities were classified as nucleated coastal settlements (Table 25). “Dispersed coastal/inland” settlement pattern were communities that had significant inland sections. Five sites were classified as dispersed inland/coastal settlements: Gabagaba, Patanga, Fissoa, Madina, and Kilu. Although Gabagaba was historically nucleated on the coast, substantial portions of the community were settled inland at the time of study.

Table 25. Population and Settlement Patterns

Community	Number of Households	Total Population	± 95% CI	Population relative to resource (people/ha of fishing area)	Settlement Pattern
Ahus	105	544	47	9.8	nucleated coastal
Andra	92	479	54	8.6	nucleated coastal
Enuk	66	272	34	2.74	nucleated coastal
Fissoa	47	277	14	NA	dispersed coastal/inland
Gabagaba	206	1708	256	11.5	dispersed coastal/inland
Kilu	93	584	48	47.8	dispersed coastal/inland
Kranket	310	2127	309	238.9	nucleated coastal
Madina	92	564	14	NA	dispersed coastal/inland
Mongol	92	493	87	246.5	nucleated coastal
Muluk	50	333	19	57.2	nucleated coastal
Nusa Lik	45	273	53	34.6	nucleated coastal
Patanga	90	421	38	31.1	dispersed coastal/inland
Riwo	124	1136	175	162.2	nucleated coastal
Wadau	50	324	15	95.3	nucleated coastal

NA = not available

Summary

This appendix examined how socioeconomic and resource governance conditions varied in the 14 study sites. Study sites displayed a high degree of variability in most socioeconomic indicators examined. Communities also displayed a diversity of resource governance regimes, including marine tenure regimes and traditional management practices.

APPENDIX III. MECHANICS OF THE RASCH MODEL

The following description and interpretation of Rasch analysis relies heavily on Bond and Fox (2001) and personal communications with T. Bond. Bond and Fox (2001) provide a non-technical synthesis of how Rasch analysis can be applied to a wide range of social sciences. More technical discussions of Rasch analysis can be found in Rasch (1980), Wright and Masters (1982), and Andrich (1988). The purpose of this introduction to Rasch modelling is to provide some background information on the concepts and interpretation of a technique that has not yet been applied in the fields of common property theory or natural resource management.

Mechanics of the Rasch Model

Measuring and comparing latent traits relies on the basic assumption that people with more of a latent trait will have indicators in their life that are indicative of high levels of this latent trait. Depending on the latent trait we are measuring, this might be certain beliefs, attitudes, or possessions. For example, a person with higher intelligence will be able to correctly answer more difficult questions than someone with low intelligence. Likewise, someone that lives a modernized lifestyle will have more modernized household possessions (such as a TV, a metal roof, a vehicle) than someone living an unmodernized lifestyle.

The Rasch model operates on the principal that some indicators are representative of different levels of a latent trait. Just as some questions on a test may be more difficult (i.e., only a more intelligent person could answer them correctly), some indicators of other latent traits may be more difficult someone to attain. For example, a TV may be indicative of a modernized lifestyle, but a satellite dish may be indicative of a more modernized lifestyle. Thus some indicators are more difficult to attain than others. The amount of a latent trait that someone possesses can be assessed by examining both the quantity and type of indicators the respondent possesses. The term used in this thesis for whether a respondent has a particular possession or a particular belief consistent with the

latent trait being measured is that the respondent provided a response "supportive" of the latent trait being measured.

Rasch analysis is based on a probabilistic relationship between the likelihood of a respondent providing a response supportive of the latent trait being measured[12] (e.g., continuing with the modernisation example, this would mean that the respondent possessed a TV), and the proportion of questions the respondent answered supportively (i.e., the amount of the latent trait the respondent possesses) (Bond & Fox, 2001). Bond and Fox (2001, p. 199) note that underlying logic is quite simple: Respondents with more of the latent trait have a higher probability of supporting indicators that are more difficult than respondents with less of the trait. For example- continuing with the modernisation example from above, a more modernized respondent will have a higher probability of possessing a TV, concrete home and expensive metal roof than a respondent living a less modernized lifestyle.

Dichotomous and polytomous Rasch models exist. The polytomous partial credit model (which will be used in this thesis) can be expressed mathematically as follows:

$$\ln\left(\frac{P_{nik}}{1-P_{nik}}\right) = B_n - D_i - F_k$$

Where ln is the natural log, P_{nik} is the probability of respondent *n* choosing a specific ordinal category (threshold) *k* on indicator *i* (for example, ranking fishing as the most important occupation instead of the second most important occupation), B_n is the proportion of answers the respondent supported[13] in a manner consistent with the latent

[12] Note that the term "supportively" in this context refers to a response that conforms to our notion of the latent trait we are measuring. Thus, from the modernisation example from above, the respondent possessing a TV would be a supportive answer and the respondent not possessing a TV would be a unsupportive answer. The terminology frequently used in Rasch analysis is "endorsed".

[13] Again, note that in the context of how the Rasch Analysis is used in this analysis, a supportive or correct answer is whether they agreed with or possessed particular indicator.

trait being measured (generally referred to as a respondent's "ability" in the latent trait), D_i is the proportion of respondents that correctly answered indicator *i* (generally referred to as an indicator's "difficulty"), and F_k is the proportion of respondents that answered the given threshold *k* estimated across all indicators.

Estimates of how "difficult" it was to answer a specific indicator are derived from the log odds of the probability the question was answered correctly or positively. For example, if only 25% of the respondents positively answer an indicator (say, 25% of people own a TV), its difficulty estimate will be $\ln\left(25/75\right)$= -1.38. Estimates of a respondent's ability or aptitude in the trait we are measuring (i.e., how much of the trait does the respondent possess) are essentially derived the same way (i.e., $\ln(\text{percentage of correct answers /percent incorrect answers})$). A logarithmic scale is then constructed based on the probabilistic relationship of how difficult each indicator was for respondents to correctly answer and how much of the trait each respondent possessed. Each respondent receives a score based on the difficulty of the indicators he or she correctly answered. It is by comparing these scores that we can look for differences in the latent traits among individuals or groups. Each indicator also receives a score based on how difficult it was for respondents to correctly answer. The logarithmic transformation converts data from nominal and/or ordinal into interval data, so it is even possible to use parametric statistics to further analyse the resulting scores.