Multidisciplinary Appraisal of the Effectiveness of Customary Marine Tenure for Coral Reef Finfish Fisheries Management in Nggela (Solomon Islands)

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Thank you so much

Abstract

The failure of centralised fisheries management systems to prevent the overexploitation of coral reef resources has led many scholars and conservation practitioners to promote the use of customary marine tenure (CMT) as an alternative devolved means of fisheries management. The effectiveness of CMT for fisheries management is debated; some scholars argue that CMT is embedded within particular historical, socio-economic and political contexts and that unless it evolves to changing circumstances, its effectiveness for fisheries management will wane under external influences and changing exploitation patterns. Each CMT regime is unique; hence its response to changing circumstances may vary. A better understanding of the circumstances under which a CMT regime is likely to succeed is important if it is to be effectively used for fisheries management.

This research is posited on the DPSIR (Driver, Pressure, State, Impact, Response) model and employs multidisciplinary methods to investigate the effectiveness of CMT for reef finfish fisheries management. The aims of this thesis are: (1) To investigate the role of markets and subsistence as driving factors for fishing; (2) To investigate fisher spatial allocation of fishing, methods and target taxa (as proxies for pressure and impact); (3) contribute to the biological knowledge of a prominent vulnerable species (*Plectropomus leopardus*) by investigating aspects of its demography and reproduction (as a proxy for state); and (4) Investigate relationships between the Nggela CMT governance system and modern governance system (as a proxy for response), to improve understanding of how this knowledge may be applied to enhance small-scale fisheries management.

The role of markets and subsistence as driving (D) factors for fishing was investigated using the sustainable livelihoods approach (SLA). Ninety three (43 from the western zone and 50 from the eastern zone) household surveys were conducted in 10 (5 from the eastern zone and 5 from the western zone) randomly selected villages in Nggela to determine the contribution of different livelihood activities to fisher livelihoods. The reason for comparing the eastern and western zone was to determine the role of available natural land capital as one contributing factor (besides markets) to fishing drivers. Quantitative data generated from the household surveys were analysed using the statistical package SPSS. Additional key informant interviews to generate qualitative data to support the quantitative data were also conducted.

Spatial allocation of fishing and target taxa was investigated using household surveys (the same household survey mentioned above but with questions to address the issue of spatial allocation and fishing methods used), participative fishing with fishers to confirm spatial allocation of fishing and fishing methods employed and recording of landings data to determine the types of fish taxa targeted.

One of the initial aims of studies on *P. leopardus* was to compare the age-based demographic parameters of *P. leopardus* between CMT areas and offshore sub-tidal areas, the hypothesis being that if CMT was effective age-based demographic parameters would reveal the non vulnerability of *P. leopardus* in CMT areas. Such a comparison was not possible as only 4 specimens were obtained from inshore CMT areas compared to 116 specimens from offshore sub-tidal reefs. To determine the age-based demographic parameters of *Plectropomus leopardus*, fish total lengths (mm) and otoliths of fish were collected in the field, this was followed by otolith annuli counts of ages (tagged to a particular fish of certain total length) at the laboratory. A von Bertalanffy growth curve was then fitted to the fish total length data and to the age data to determine asymptotic length, Brody growth coefficient and theoretical age at length zero. Total mortality rate was determined by generating catch curves where the frequency of fish in each age class was regressed against age. Longevity was determined by calculating the mean age of 10% of the oldest individuals. Demographic parameters of *P. leopardus* in Nggela were also compared to those of Australian locations to determine variations in age-based demography. *Data analysis of P. leopardus* data was done using the statistical software R and Microsoft Excel 2003. Reproductive aspects of *P. leopardus* were determined from the fish gonads collected from the field. Fish gonads were used to determine different sexual reproductive stages. Data on the different sexual reproductive stages was used to determine sexual maturity and sex change.

The relationship between CMT governance and modern governance and how they may be combined for an effective reef finfish fisheries management was investigated using literature research, key informant interviews and dynamite fisher interviews.

Investigations of livelihoods show that Nggela fishers were engaged in more than one livelihood activity for their livelihoods. Subsistence gardening was the most important livelihood activity. While finfish was important for subsistence purposes, accessible markets and the role of middlemen in the villages made it especially important for income generation. A comparison of the role of fishing between eastern and western zone showed that available natural land capital was also an important driver for fishing; fishing was higher in the western zone where there was a narrow natural land capital.

Fisher perceptions indicate a declining trend in fisheries resource abundances within CMT areas; such decline has resulted in changes in the spatial allocation of fishing with a shift in fishing to offshore sub tidal reefs. Although some spatial closures were observed, fishing within the CMT areas is flexible. Three MPA's currently existed in West Nggela and fishing prohibitions within the areas were observed mainly because people thought that the MPA's were underscored by the government. Line fishing from dugout canoes remains the main method of fishing. Median trophic level of fish catch was between 2 - 3.84 while median standard length of catch was between 19 - 24 cm.

Age-based demographic studies show that the Brody growth coefficient of Nggela *P. leopardus* was 0.13 yr^{-1}, longevity was 12.9 years, maximum age was 15 years and mortality rate was 0.22% yr^{-1}. Female sexual maturity of Nggela *P. leopardus* began at 2 years of age with 50% sexual maturity achieved at 3.22 years. Sexual transition from female to male began at 3 - 10 years of age with 50% sex change achieved at 11 years. Mature female to male ratio was 3:1. The age-based demographic parameters of *P. leopardus* in Nggela were similar to those in Swain and Lizard Island in Australia. For Swain reef, growth coefficient was 0.17 yr^{-1}, longevity was 10.1 years, maximum age was 14 years and mortality rate was 0.39% yr^{-1}. For Lizard Island, growth coefficient was 0.26 yr^{-1}, longevity was 7.2 years, maximum age was 10 years and mortality rate was 0.59% yr^{-1}. Age-based demographic parameters of *P. leopardus* in Nggela were different to locations in Western Australia – Scott and Abrolhos reefs. For Scott reef, growth coefficient was 0.42 yr^{-1}, longevity was 6.4 years, mortality rate was 0.30% yr^{-1} while the maximum age was 8 years. For Abrohlos reef growth coefficient was 0.08 yr^{-1}, longevity was 13 years, mortality rate was 0.24% yr^{-1} and maximum age was 18 years. Sea temperature may be one contributing factor to regional variations in age-based demographic parameters.

The current CMT governance system has undergone changes which has rendered it ineffective as a coercive force for reef finfish fisheries management. While CMT is recognised by the modern governance system through National legislations, necessary ordinances at the provincial level are absent which prevent the effective use of CMT for fisheries management. For CMT to be effective it requires empowerment at the provincial government level.

Positioning the above results within the DPSIR model, markets and narrow natural land capital are important drivers within the Nggela finfish fisheries. The main pressure within the Nggela finfish fisheries are increase in population growth and use of improved fishing technology some of which are destructive, this has resulted in the demise of the state of finfish fisheries (as revealed by fisher perceptions and low catch of *P. leopardus* in inshore areas), hence a shift in pressure to offshore sub tidal reefs. CMT as a policy response system is currently unable to effectively manage reef finfish fisheries; it needs to be empowered by the modern governance system to be effective for reef finfish fisheries management.

Knowing how best to manage fisheries in an effective and sustainable way remains arguably equivocal around the world. Contemporary debates on fisheries governance increasingly highlights the importance of examining drivers of marine resource users' behaviour and policy responses, as these information are considered essential for developing management goals that are more likely supported by those targeted. The research presented herein makes an original contribution to current thinking on the governance and management of coral reef finfish fisheries in locations where CMT is practiced.

Acknowledgement

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List of Acronyms

CMT	Customary Marine Tenure
CPR	Common Property Resources
CPUE	Catch Per Unit Effort
CRF	Coral Reef Fisheries
CST	Customary Sea Tenure
DPSIR	Driver, Pressure, State, Impact, Response
PICs	Pacific Island Countries
PSR	Pressure, State, Response
SBD$	Solomon Islands Dollar (£1 = SBD$14)
SIG	Solomon Islands Government
SLA	Sustainable Livelihoods Approach
SSF	Small-scale Fisheries
SSFM	Small-scale Fisheries Management
TEK	Traditional Ecological Knowledge
TURF	Territorial Use Rights in Fisheries
VBGF	von Bertalanffy Growth Function

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CHAPTER 1

GENERAL INTRODUCTION

Abstract

This chapter reviews relevant literature on customary marine tenure (CMT); presents a model developed for investigating the thesis aim – to examine the effectiveness of CMT to manage coral reef finfish fisheries; discusses the methodological approach used; and provides a background to the study site. The findings of the literature review are: CMT systems are considered common property regimes; the use of CMT for small-scale fisheries management is a bone of contention, some scholars argue that it has a role to play in fisheries management while others argue that the changes it has undergone due to external factors (colonisation, introduction of new laws, Christianisation, market forces etc.) has diluted its effectiveness for fisheries management; CMT systems are present in Solomon Islands and have been a subject of previous research, although they share similar general principles, the modus operandi and successful use for small-scale fisheries management varies between locations. The Driver, Pressure, State, Impact, Response (DPSIR) model was used in this research to appraise the effectiveness of CMT as a policy response for reef finfish fisheries management. A multidisciplinary approach was adopted and social science methods employed included ethnographic methods (participant observations and interaction), 93 face to face semi-structured fisher interviews, and 20 key informant interviews. Other empirical data was based on recording of fish catch data and collection of otoliths and gonads from 120 Plectropomus leopardus specimens. Empirical data for P. leopardus from Australian locations was obtained from the Western Australia Department of Fisheries and CRC Reef Research Limited, Australia. Nggela where this research was conducted is located within Central Solomon Islands in the Southwest Pacific. Field research was conducted between December 2007 to May 2008.

1.1 INTRODUCTION

Gordon (1954:135) postulated that fisheries resources being common property can be subjected to unregulated use due to the absence of control over access to them. This idea was extended by Scott (1955) to take dynamic fishing behaviour into account (Feeny et al. 1996); using fishing boats as an illustration, Scott (1955) argued that an unified management regime will not necessarily solve the problem of common property resources; sole ownership of resources is required. These ideas later became widely known beyond

fisheries-related disciplines through Hardin's (1968) 'tragedy of the commons' which contended that unregulated use of common resources leads to resource mismanagement and environmental degradation resulting in detrimental impact to everyone. Hardin (1968) contended that the only way to avert this scenario is by State intervention. The Gordon (1954), Scott (1955) and Hardin (1968) theories referred to collectively as the 'theory of common property resources' (Ciriacy-Wantrup and Bishop 1975), were not new as they in fact originated in the 1800s (Eswaran and Lewis 1984; Hardin 1994).

Some Scholars (Ciriacy-Wantrup and Bishop 1975; Bromley 1992; Feeny et al. 1996; Wagner and Talakai 2007) on common property resources (CPR) rights however, have identified inadequacies in the theory of common property, both the erroneous use of the term 'common property resources' and the fallacy that common property regimes are fated to environmental resource mismanagement and demise. Common property is not everybody's property (Ciriacy-Wantrup and Bishop 1975:715); Bromley (1992:2) argued that there is no such thing as a common property resource – there are only resources controlled and managed as common property, or as state property, or as private property or there are resources over which no property rights have been recognised and are therefore called open access resources. Bromley (1992) urged that the term property regime be used rather than common property. Users of resources in a common property regime are not always altruistic; while there may be a few free riders (these are people who do not contribute to the well being of the resources or do not have rights to exploit the resource in the first place), the majority of users may be aware of likely effects of their actions and may take actions such as forming coalitions, establishing institutions and enforcement mechanisms to regulate rates of harvesting and ensure viability of resources (Feeny et al. 1996; Cudney-Bueno and Basurto 2009). Feeny (1996) used the collapse of the Pacific sardine (*Sardinops sagax*) fishery to illustrate that State intervention advocated by Hardin (1968) does not always result in the sustainable exploitation of resources. While there are failures in State intervention to effectively manage resources, there are also successes. Examples where State intervention has resulted in sustainable fisheries include: the New Zealand lobster fishery, Chilean artisanal fisheries and the Western Australian rock lobster fishery (Hilborn et al. 2005). Like State property regimes, common property regimes can be effective in regulating and

managing resource use and access in some cases but cannot in others (Berkes 1985; Bromley 1992; Aswani 1999; Acheson 2006). An aspect of common property regimes which has received attention from fisheries management disciplines in the last 4 decades is territorial use rights in fisheries-TURF (Christy 1982; Pollnac 1984) which are common in Asia and the South Pacific and have been a main focus of studies in small-scale fisheries (SSF) and resource management since 1970s (Johannes 1978; Johannes 1981; Berkes 1985; Ruddle 1996b; Lida 2005).

Within the South Pacific other terms used to refer to TURF are: customary marine tenure (CMT); traditional marine tenure (TMT); customary sea tenure (CST); or traditional in-shore fishery management systems. These terms will be used interchangeably in this thesis. CMT is a situation in which particular groups of people (e.g., individuals, clans, tribes, etc.) have informal or formal rights to coastal areas and in which their historical rights to use and access marine resources are, in principle, exclusionary, transferable, and enforceable either on a conditional or permanent basis (Ruddle 1996b; Aswani 2005:287). CMT systems are inextricably linked with the wider social and cultural contexts from which they emerge (Hviding 1994:91). Hence they are tightly embedded within a society's traditional ecological knowledge, traditional beliefs, social/governance structure and customary practices (Hviding 1994; Ruddle 1994; Foale 1998b; Berkes et al. 2000; Hickey 2006). According to Maenu'u's (1981) depiction of the embedded nature of the CMT system, people are connected to land/marine ownership (and rights) and to the gods they are associated with via the tribes or clans they are affiliated with (Figure 1.1).
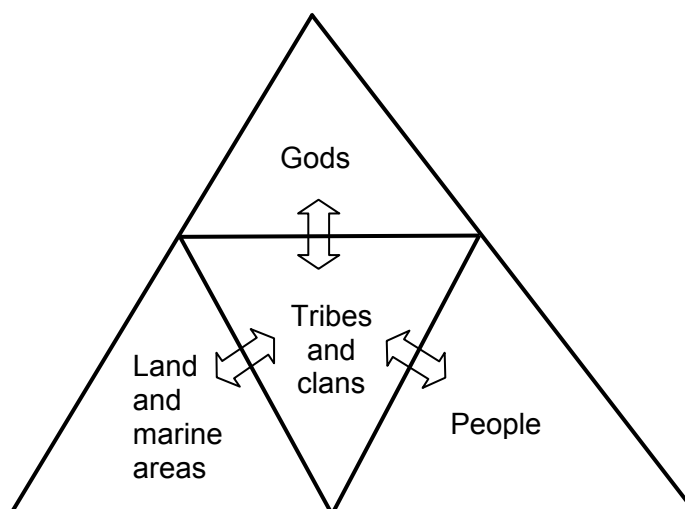
Figure 1.1: Representation of the embedded nature of the CMT system modified from Maenu'u (1981). Arrows are added to emphasise links.

Under the CMT system, marine areas (reefs, lagoons and transitional zones like mangrove swamps, littoral zones and low lying coral islets and inshore fishing grounds) are owned by social groups, in some societies at the tribe level while at the clan level in others. One has the right to access and use marine resources as a result of being a member of a certain clan or tribe. These rights are usually inherited patrilineally (rights inherited through the father), matrilineally (rights are inherited through the mother) or by ambilineal cognatic descent (rights are inherited through both the father and the mother). Different levels of rights exist, and rules governing these rights vary with locations where CMT is practiced. Primary rights-holders exercise decision rights (besides access and use rights). Secondary rights refer to where a person has rights to access and use, however s/he does not have decision making rights over the land/marine area. Usufruct rights are where a person has the right to use resources over the marine areas even though s/he may not have direct rights to them, however usufructory rights are usually more limited than those of the secondary rights-holder and are usually restricted, for example usufruct rights-holders may exploit marine resources for consumption only (and may be restricted to certain amounts only) but not for commercial purposes (Hviding and Baines 1994). Figure 1.2 shows a conceptual model of how a traditional CMT system may have operated in the past and extends the simple model depicted in Figure 1.1.

In the embedded nature of the social, governance and property structure, the tribe or clan is the central connecting structure which holds people, land/marine tenure rights and belief systems together (Figure 1.2, top triangular structure which was from Figure 1.1). This structure dictates different land and marine resources use rights (Figure 1.2, unfilled arrow from the triangular structure to `land/marine tenure rights') which are mediated by rules and enforcement processes (Figure 1.2, filled arrows from `rules and enforcement mechanisms to above 'land/marine tenure rights'). Note that rules and enforcement mechanisms descend directly from the triangular structure as well (Figure 1.2, unfilled arrow connecting triangular structure to rules and enforcement mechanisms). To illustrate, the main form of land rights ownership is through inheritance, however rules exist which also allow transfer of use rights. Land/marine use rights dictate resource use patterns and conservation strategies (Figure 1.2, unfilled arrow from `land/marine tenure rights' to

resource use patterns and conservation strategies). However use patterns and conservation strategies are mediated by traditional ecological knowledge (which can be a production system or a conservation mechanism) and tribal/clan beliefs (Figure 1.2, filled arrow from traditional ecological knowledge/tribe clan beliefs to below land/marine tenure rights); for example, clan beliefs can dictate the types of organisms that can or cannot be eaten. Rules and enforcement mechanisms also continue to play a mediating role in resource use patterns and conservation strategies (Figure 1.2, filled arrow from rules/enforcement mechanisms to below land/marine tenure rights). Resource use patterns subsequently have an effect on resource status, traditional livelihoods and the micro-economy (Figure 1.2). External factors can dictate resource abundance which in turn can have an effect on traditional economy and livelihoods. For example, seasonal patterns in the availability of resources result in subtle changes in livelihood patterns between different seasons. Droughts can result in a shift from a livelihood dependent on land to one which is dependent on marine resources.
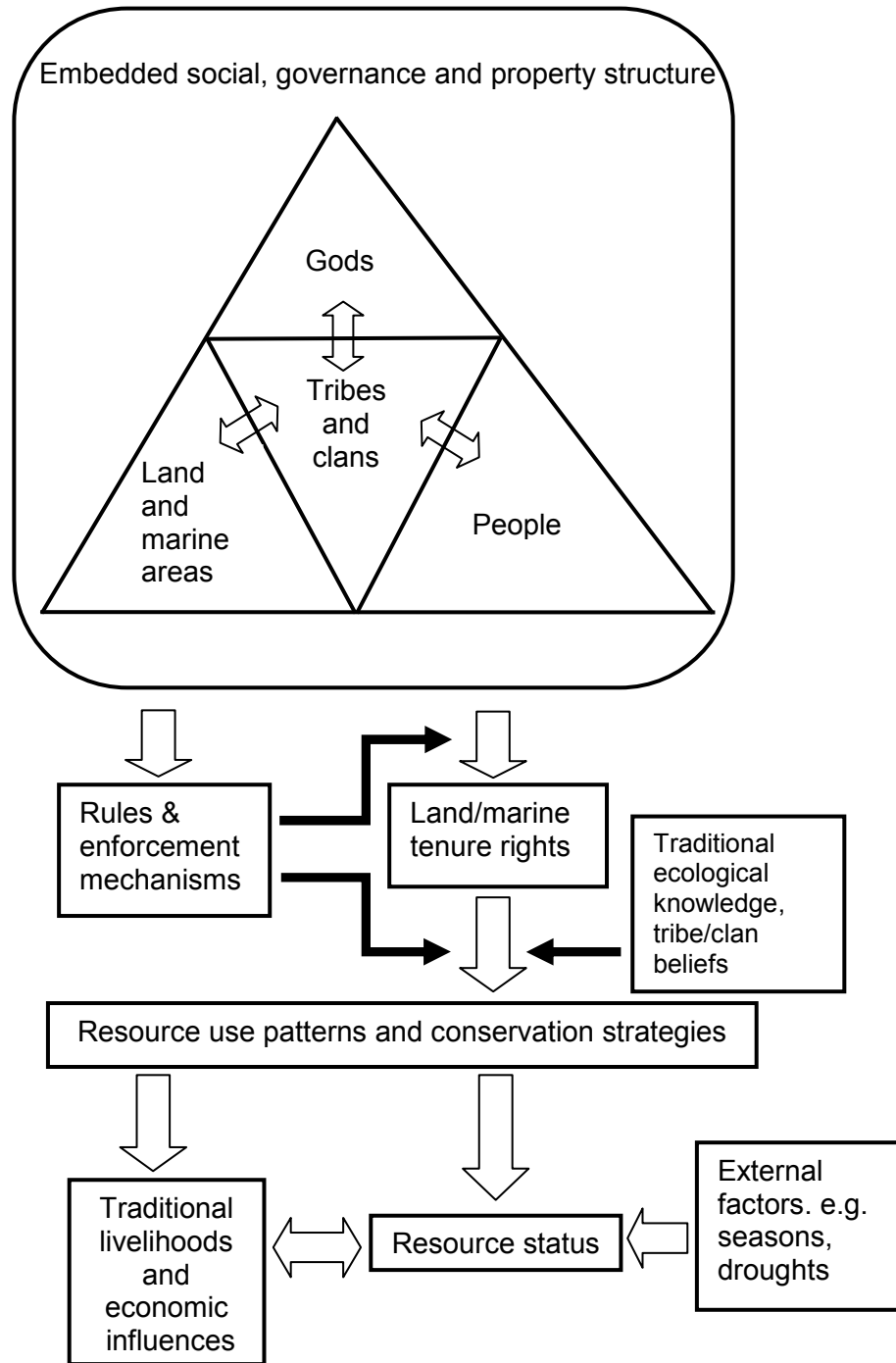
Figure 1.2: A conceptual and simplified model of how the CMT system operated in the past. (Note: Triangular structure at the top which depicts the embedded social, governance and property structure is from Maenu'u (1981) with modifications)

1.2 BACKGROUND ON RELEVANT CONCEPTS

Concepts which will be referred to in this thesis are: governance co-management and adaptive management. It is therefore important that they be defined at this juncture.

1.2.1 Governance

Governance has been defined as the formal and informal institutions through which authority and power are conceived and exercised (Larson and Soto 2008:214). In the context of marine resources, Vallega (2001) defines management as the undertaking of actions which are needed to achieve a goal, while governance is defined as an organising system (that exercises power and authority) towards a target. Following Vallega (2001), fisheries management therefore is the goal of sustainably utilising fisheries resources, while governance is the organising system to achieve that goal. Three modes of governance have become commonplace in recent fisheries management literature: hierarchical, market and participative (Korda et al. 2008).

Hierarchical governance is the most common mechanism through which fisheries management regimes are implemented. It is centrally administered by the State in a coercive top down manner, and is characterised by bureaucracy, scientific elitism, and sense of public responsibility. Market governance is underpinned by the forces of supply and demand and assumes that the unhindered quest of rationale self-interest by independent individuals will maximise the economic return from natural resources. Participative governance involves shared decision making processes in a spirit of compromise between stakeholders. Management decisions (and actions) in participative governance are sought through negotiations and consensus (Korda et al. 2008) rather than through coercion as in hierarchical governance or through market forces as in market governance.

1.2.2 Co-management

Co-management as used in this thesis is as defined by Kuperan and Abdullah (1994:310) where resource owners, local-level governance institutions, Non-Government organisation (NGOs) and the State agencies

share responsibilities for resource management functions. The state formally recognizes regulations which are enforced by the resource owners and local-level governance institutions. NGOs serve advisory roles in co-management arrangements (Pomeroy 1995), as they can offer technical advice on fisheries management and conservation. These roles by the NGOs are necessary as technical skills are usually scarce, particularly in developing countries.

1.2.3 Adaptive management

Adaptive management which was first articulated by Holling (1978) refers to the application of experimentation to the design and implementation of natural resource and environmental management policies (Halbert 1993; McLain and Lee 1996). The central tenet of adaptive management is that knowledge about the dynamics of an ecosystem and associated social factors (collectively referred to as a social-ecological system) is limited and never fully known; as further knowledge is gained, management will evolve and improve.

Define the problem: management objectives, indicators of success, options for action, assumptions, key uncertainties, alternative hypothesis

Design actions to test hypotheses; predict outcomes based on current knowledge

Implement the actions designed

Monitor implementation (any deviations from design?), and effectiveness (were the objectives achieved?)

Evaluate the results: which actions were most effective, and which hypotheses to accept/reject?

Revise uncertainties and hypotheses and repeat; share what has been learned

Figure 1.3: The adaptive management cycle (Murray and Marmorek 2004:2)

Adaptive management is appealing both to scientists and policy makers on the basis that it takes into account both technical (in the dynamics of the resources being managed) and social (in the dynamics of the institutional, economic and political) uncertainties, rather than having to rely on basic research for a complete understanding before management is instituted (Halbert 1993). Furthermore, the approach encourages continuous learning through experimentation and management flexibility under various conditions: for example, different traditional management systems (Armitage 2003), different adaptive capacity of social and ecological ecosystems (Armitage 2005) or merging with co-management arrangements (Armitage et al. 2009). There are different stages of the adaptive management cycle (Figure 1.3).

1.3 SMALL-SCALE FISHERIES MANAGEMENT (SSFM) AND CUSTOMARY MARINE TENURE

The definition of small-scale fisheries (SSF) can be very context specific as what is defined as small-scale in one country may be classed as large scale in another country (Charles 2001). The Food and Agriculture Organisation (FAO) of the United Nations Working Group on SSF agreed that the dynamic and diverse nature of SSF eludes any meaningful and appropriate universal definition. Hence SSF was described in terms of characteristics rather than defined (Béné et al. 2007). The FAO-endorsed characterisation of SSF is as follows:

SSF is characteristically dynamic and evolving. It involves labour intensive harvesting, processing and distribution technologies to exploit marine and inland water fishery resources. Activities may be conducted fulltime, part time or on a seasonal basis both for subsistence consumption or to supply local and domestic markets, although there has been a shift to export–oriented production in the last two decades due to market integration and globalization. While men are typically engaged in the capture process and women in processing and marketing, women are also involved in near shore harvesting and men being involved in marketing and distribution. SSF operates at different organisational levels ranging from self-employed single operators through informal microenterprises to formal sector business. SSF is very heterogeneous across countries and regions. Technological dimensions of

SSF are that: they operate in-shore, target multiple species and use a range of different fishing gear and techniques, some which may be relatively simple (FAO 2004; Béné et al. 2005).

SSF make important but undervalued contributions to third world developing countries; they are sources of animal protein where food security is a problem and sources of income, where income sources are usually scarce (Béné et al. 2007). In the Solomon Islands 90% of animal protein derives from fish, in the urban areas it is 83%, while in the rural areas it is 94% (Bell et al. 2009) and globally more than 200 million people depend on SSF and associated activities for their livelihoods (Andrew et al. 2007:228). SSF have come under threat from overfishing, excess capacity and external factors such as markets (Andrew et al. 2007) which may compromise their (SSF) sustainability. The use of centralised SSF management techniques in developing countries is compromised by: sparse data, limited expertise and lack of funds to do monitoring and enforcement of management rules (Andrew et al. 2007).

CMT systems in the Solomon Islands and the wider South Pacific have considerable potential utility for SSF management (SSFM) (Dahl 1988; Ruddle et al. 1992; Ruddle 1996b; Adams 1998; Hviding 1998; Johannes 1998; Johannes 2002a; Johannes 2002b; Aswani 2005; Aswani et al. 2007; Cinner and Aswani 2007), because ownership is viewed as an incentive to undertake fisheries management where the cost of over-exploitation will otherwise be borne by the resource owners (Johannes 1981; Aswani 2002; Johannes 2002a; Cinner and Aswani 2007). CMT ownership is governed by rights which are protected by customary law and practice. Customary law and practice not only legitimise these rights (i.e. rights to the exclusive use of resources within a defined marine territory) as exclusive but also provide rules and penalties for violating these rights; hence the right of enforcement, and in particular the right to exclude the free-riding outsider (Ruddle 1996b). CMT employs fisheries management practices such as: spatial restrictions, temporal restrictions, gear prohibitions, effort control, species specific bans and total allowable catch quotas (Johannes 1978; Hviding 1994; Aswani 2005; Cinner and Aswani 2007), which are similar to modern fisheries management practices. The use of CMT for fisheries management is particularly relevant for the South Pacific governments which are ill equipped both in human resources and finance to

carry out centralised forms of fisheries management (Johannes 1978:360). Examples of CMT being embraced for SSFM are the Cook Islands (Hoffmann 2002), Solomon Islands (Aswani and Hamilton 2004; Aswani and Lauer 2006; Aswani et al. 2007), Vanuatu (Johannes 1998), Fiji (Veitayaki 1998; Cooke et al. 2000; Clarke and Jupiter 2010) and other parts of the South Pacific (Johannes 2002b).

Although CMT offers advantages for SSFM, exogenous factors have also weakened CMT's effectiveness for fisheries management (Ruddle 1993), these exogenous factors include: socio-economicc changes and the influence of markets (Johannes 1978; Akimichi 1991; Jennings and Polunin 1996; Foale 1998a; Cinner and McClanahan 2006b; Cinner et al. 2007), changing demographic and consumption patterns (Aswani 2002), colonialism, neo-colonialism, economic development, technological innovation, indigenous cultural changes, impacts of Christianity, contemporary government policy (Johannes 1978; Johannes 1981; Ruddle 1994; Mantjoro and Akimichi 1996) and the replacement of traditional local authority (Johannes 1978; Graham and Idechong 1998; Muehlig-Hofmann 2007). Some colonial rulers introduce laws that removes CMT and under market forces some communities have forgone CMT based rules and have over exploited their resources to generate cash income (e.g. Johannes 1978; Ruddle 1993). Despite such pressures weakening its utility for effective fisheries management, CMT systems are dynamic and flexible, hence the external challenges and transformations CMT undergoes are not one sided (Hviding 1998). Certain modern pressures may lead to organizational innovations and reinforce the utility of CMT for effective fisheries management (Hviding 1998). For example, the realisation that resources are declining in the face of market forces has led many communities to enforce CMT-based fisheries management regimes (Ruddle et al. 1992; Hoffmann 2002; Johannes 2002b). Furthermore, a better understanding of: (1) how external factors (markets, new laws and legal systems, new forms of religion, new governance systems) impact CMT and, (2) how the differences and congruencies between CMT and modern methods of fisheries management can facilitate or inhibit adaptive hybrid management systems that are highly flexible may help towards conserving resources and meeting community goals (Cinner and Aswani 2007). For example, an Individual transferable quota (ITQ) system has been successfully employed in the

Aitutaki trochus (*Trochus niloticus*) fishery in Cook Islands (Adams 1998). CMT will have a role to play in modern day fisheries management in some cases but not in others, its greatest potential for fisheries management however is in forms of co-management (Ruddle 1993; Aswani 1997b).

1.4   OVERVIEW OF CMT-SSFM STUDIES IN SOLOMON ISLANDS

Although CMT is the main form of marine property ownership system in the Solomon Islands, studies have been conducted in only a few locations: Lau lagoon, Malaita (Figure 1.5) (Akimichi 1978; Akimichi 1991), Marovo Lagoon, New Georgia (Figure 1.5) (Hviding and Baines 1992; Ruddle et al. 1992; Hviding 1993; Hviding and Baines 1994; Hviding 1996; Hviding 1998; Lidimani 2006), Roviana and Vonavona Lagoon, New Georgia (Figure 1.5) (Aswani 1997a; Aswani 1997b; Aswani 1998a; Aswani 1998b; Aswani 1999; Aswani 2002; Hamilton 2003; Aswani and Hamilton 2004; Aswani 2005; Aswani and Lauer 2006; Aswani et al. 2007; Aswani and Sabetian 2009) and West Nggela (Foale and Day 1997; Foale 1998b; Foale 1998a; Foale 1998c; Foale 1999; Foale and Macintyre 2000; Foale 2002).

In Lau lagoon, CMT rights within clearly defined boundaries inshore are owned by collective groups not individuals, primary rights are patrilineally inherited and secondary and usufructory rights exist. Shallow areas which are limited in resources and the deep seas in Lau are subject to de facto open access use by the community, and were usually reserved for those who had no marine tenure rights. Akimichi (1991) described the Lau CMT system as tightly interwoven with the local traditional economy and local ecological knowledge. The main measures used for fisheries management were spatial closures (certain areas were closed off due to traditional beliefs) and temporal closures (fishing areas were closed for several months during the death of a chief or traditional religious priest). The advent of the market economy however has transformed the Lau CMT system, weakening the closure system and significantly increasing the harvest rates resulting in the decline of resources in Lau lagoon (Akimichi 1991).

Ownership of *puava* (marine areas) in Marovo lagoon is through collective groups called the *butubutu* via ambilineal cognatic descent. While the puava is a geographical space that has clearly defined boundaries, the

butubutu on the other hand is fluid in nature as marriages and inter-relationships contextually define and re-define social boundaries, which ultimately affect rights and access people have over the puava. Life in Marovo was tightly interwoven with the sea as indicated by Marovo fishermen's fishing practices and extensive knowledge about marine species and their behaviours (Hviding 1996; Johannes and Hviding 2001). The Marovo CMT system employs several fisheries management methods, for example closures which are similar to modern methods of fisheries management (Hviding 1994). The Marovo CMT system is a flexible system that is rooted in the past but has evolved to adapt to the changing ecological, social and economic circumstances (Hviding 1993; Hviding 1998). Hviding (1998) provided examples where the CMT system has successfully adapted to economic and development pressures such as mining, logging and industrial fishing. Leadership and governance aspects of the Marovo CMT systems were not given as much attention by Hviding (1996), although some aspects of this however were taken up by Lidimani (2006) who examined the nexus between the traditional governance/CMT system and the modern governance/legal system for effective fisheries management at Marovo. The gist of Lidimani's (2006) work is that relevant governance and legal structures are currently in place that can allow for hybridisation between CMT and modern governance/legal structures for effective fisheries management; however these structures are generic and application at any location needs to take a case specific approach and must consider local circumstances and contexts.

The CMT system in Roviana and Vonavona lagoon is also based on collective ownership (based on tribes) of marine tenure rights that are inherited through ambilineal cognatic descent (Aswani 1999). Primary, secondary and usufruct rights also all exist within the Roviana and Vonavona CMT system. Endogenous factors, which are historical in nature have contributed to subtle local regional differences in the types of CMT regimes in Roviana and Vonavona. Endogenous factors include: local regional settlement patterns (historical movement of people within the local region as a result of marriages, political coercion or other social factors) and local historical processes of political expansion and contraction (as a result of internal political friction within a society, inter-tribal warfare and conquests) (Aswani 1999). In addition, exogenous factors aiding the afore-mentioned endogenous factors are

changes in consumption (shift from subsistence economy to a reliance on cash to buy imported foods like rice, flour, tinned foods etc) and demographic (differences in population and ethnic composition as a result of inter-marriages with people from different islands and countries) patterns (Aswani 2002). Three types of CMT regime currently existing in Roviana and Vonavona due to endogenous historical processes and exogenous factors are: the territorial-enclosed entitlement regime, the mosaic-entitlement regime and the transitory-estates regime (Aswani 1999).

In a territorial-enclosed entitlement regime, territorial boundaries are circumscribed, jurisdictional power over territorial matters is centralized, and marine tenure entitlements are regionally recognized. The territorial-enclosed entitlement regime consists of various tribal groups dispersed in several villages under a single administrative authority. Members within the polity (the geographical area and the various tribes which fall under a single central chiefly authority) jointly use and manage marine resources. Territorial perimeters are well defined, and participants in the commons conceptualize their tenure rights as inalienable (not being transferred to others and needing to be inherited) (Aswani 1999:438). In the mosaic-entitlement model, territorial boundaries are disputed, authority over estates is decentralized and contested, and entitlements are regionally scattered across several polities (different chiefly authorities who oversee different territories). Participants in the mosaic-entitlement regime conceptualize their entitlements as incorporating other regional claimants' subsistence usufructory rights, but assert exclusive custodianship over their marine areas (Aswani 1999:442). The transitory-estates regime is a hybrid between the territorial-enclosed and the mosaic-entitlement regimes. Jurisdiction to marine areas is being conveyed and renegotiated as intermarriages between different polities occur, changing the flow of entitlements and claims (Aswani 1999:446). The subtle local regional differences in the 3 CMT regimes described above has different consequences in their role in SSFM (Aswani 1999; Aswani 2005); the most effective one for SSFM is the territorial-enclosed entitlement regime (Aswani 1997b). Territorial disputes in the mosaic entitlement regime and in the transitory estates regime cause social instability which subsequently results in environmental degradation (Aswani 1997b; Aswani 1999). Roviana and Vonavona culture is tightly inter-woven with the sea; fishers possess extensive indigenous

ecological knowledge about the marine environment and marine species and their behaviour, which are useful in fisheries management (Aswani and Hamilton 2004; Aswani 2005; Aswani and Lauer 2006; Aswani et al. 2007).

Foale (1998b) employed anthropological and fisheries management methods to investigate CMT in west Nggela (Nggela) and provided a description of the CMT property system (based on matrilineal inheritance - described in section 1.9.4) and the indigenous marine ecological knowledge of Nggela (Foale 1998c; Foale 1999). The very attractive market prices for trochus (*Trochus niloticus*) have overwhelmed the ability of CMT to conserve trochus resources; despite the existence of CMT which facilitated restricted access and the practice of serial prohibitions (closures only for short periods during the year) reefs were over-fished of trochus (Foale 1998b). This was especially accentuated in reefs where control was non-existent due to disputes over access rights by different social groups (such disputes usually arise due to increase in the perceived value of property or resources) or those reefs which were too remote from villages for any effective continuous enforcement of prohibitions by the resource owners. Furthermore, inherent gaps which exist between local knowledge and modern scientific knowledge constrain the use of indigenous ecological knowledge for SSFM; fishers at West Nggela were aware of subtle increases in abundance of trochus at particular points in the lunar cycle. However, while they identified these times as good occasions to harvest trochus, they were oblivious to the fact that the trochus were spawning at these times. They were not making any connection between spawning stock density and the capacity of the trochus population to renew itself, resulting in recruitment failure (Foale and Day 1997; Foale 2006).

Foale and Macintyre (2000) argued that one of the factors affecting the use of CMT for SSFM in west Nggela is the dynamics of personal power and local-level politics. This usually occurs where people who have achieved influential social status within the community (either through education or the church) attempt to abuse the local land court system to acquire marine access rights through processes which contravene customary rights of acquisition.

Although the general principles of CMT are the same across the different locations in the Solomon Islands where CMT has been studied the *modus operandi* of CMT varies between locations, and may do so within them (e.g.

Aswani 1999). Each instance of CMT is embedded within particular historical, socio-economicc and political contexts and is unique. Hence, applications of CMT to fisheries management and responses therefore may vary between locations. A better understanding of the circumstances under which a CMT regime is likely to succeed is important if it is to be effectively used for SSFM.

Even though all the above studies attribute market forces as a major contributing factor to the weakening of the CMT system for SSFM, only Aswani (2002) has taken a quantitative approach to this extent by comparing how different consumption patterns affect CMT and ultimately resource status. As yet a livelihoods approach has not been taken to addressing this question. While Aswani (1998a) had investigated whether fisher behaviour was dictated by conservation ideals or optimal foraging, none has investigated the spatial extent of CMT and resource exploitation. This understanding is important, because the use of CMT may be advocated for conservation in locations where exploitation has shifted from CMT areas to de facto open access areas.

The effectiveness of CMT for fisheries management depends on the governance structure on which it is based (Graham 1994a). Understanding how the CMT governance system can be effectively hybridised and integrated with the modern governance system is important for SSFM (Cinner and Aswani 2007); only Lidimani's (2006) study has sought to address this by conducting such a study at Marovo. Due to the uniqueness of each CMT system, further studies are required elsewhere. No study has yet looked at how CMT has evolved within changes in contemporary governance in the Solomon Islands.

While Foale (1998b) has already studied CMT system in Nggela, gaps remain. These are the need to better understand: (1) driving factors which through livelihoods affect resource exploitation; (2) the spatial extent of resource exploitation and the spatial extent of CMT influence; and (3) the history of the current CMT system, in order to contextually situate the current local political/governance dynamics and how it can be effectively hybridised with contemporary methods of SSFM. Foale and co-workers (Foale and Day 1997; Foale 2006) have highlighted the need for appropriate scientific information on/about exploited species for effective SSFM; in contrast to trochus, the biology of important exploited species in the Nggela finfish fisheries is poorly understood especially so for finfish.

1.5 THE RESEARCH MODEL

The Driver, Pressure, State, Impact, Response (DPSIR) framework (Figure 1.4) inspired the conceptual model for this research. The central tenets of the DPSIR framework (also referred to in this thesis as the DPSIR model) are that socio-economic drivers (D) exert pressure (P) on the environment through natural resource extraction resulting in the alteration of the state (S) of the environment and subsequently impacting (I) society and the environment. Society then makes a response (R) by trying to influence the driving forces (D) or pressure (P) (Cave et al. 2003; Jennings 2005; Mangi et al. 2007). The DPSIR model has been used to analyse coastal reef fisheries in Kenya (Mangi et al. 2007) and in other studies relating to the management of the marine environment; for example nutrient inputs into the environment (Turner et al. 1999; Langmead et al. 2009), wind power generation (Elliott 2002) and integrated coastal management (Turner et al. 1998; Cave et al. 2003).

The DPSIR model is a modification of the original PSR (Pressure, State Response) model which was focused on anthropogenic pressures and responses (Bowen and Riley 2003). Modification and extensions of the PSR model to create the DPSIR model was necessary to expand the concept of 'pressure' to incorporate social, economic, institutional and natural systems pressures, as well as examinations of human motivations for responding to the environmental conditions (Bowen and Riley 2003). Whether the DPSIR or the PSR model is more appropriate is debatable; Jennings (2005) argued that the combination of pressure, response and state would be sufficient to provide guidance for resource management. This thesis concurs with Bowen and Riley (2003) that understanding social conditions (Drivers) is necessary to inspire meaningful change in resource management. The DPSIR framework is a more appropriate model linking changes in the environment to the social and economic drivers and political responses (Mangi et al. 2007) than the PSR model; hence the DPSIR model is used in this thesis to develop the research framework.

The DPSIR model can be effectively used to integrate links between drivers, pressures, environmental states, impacts and responses on fisheries resources within the Nggela CMT system. In order to clarify the use of the DPSIR model to analyse the effectiveness of CMT for fisheries management a

description of the drivers, pressures, states, impacts and responses within the Nggela fisheries systems is necessary. The DPSIR framework used (Figure 1.4) is adapted from Mangi et al. (2007) based on Cave et al. (2003).
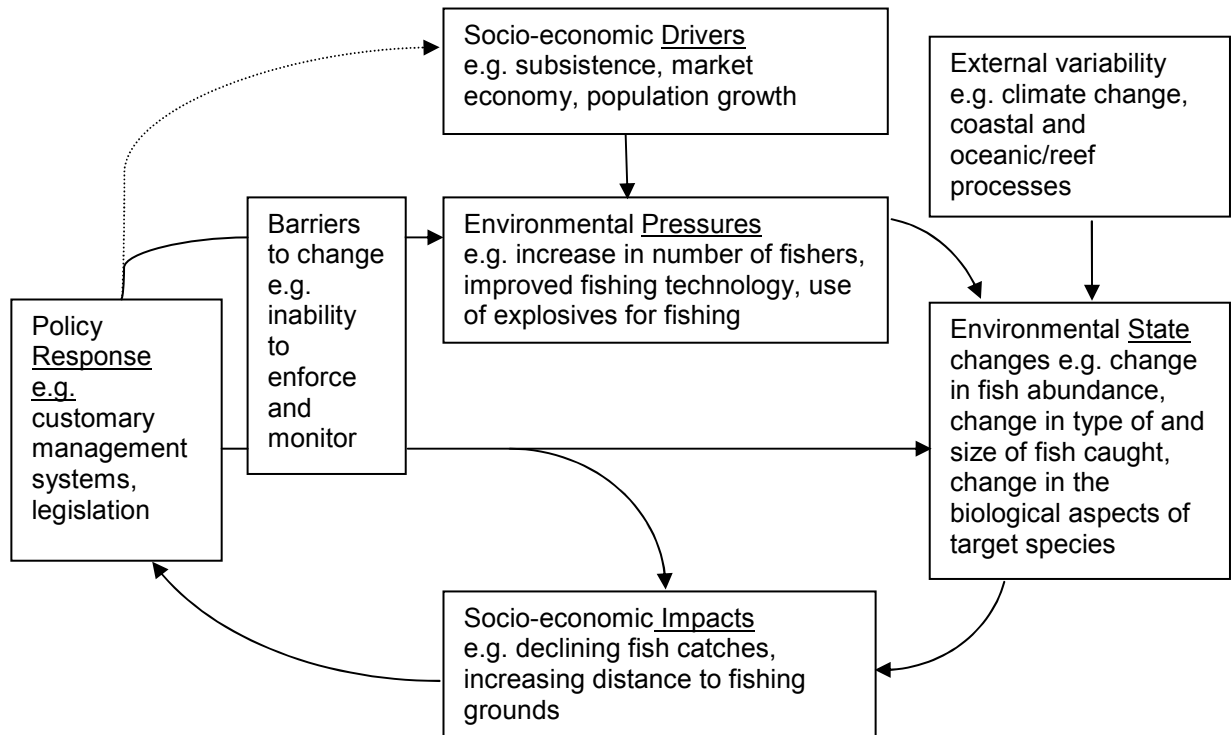
Figure 1.4: The DPSIR framework (adapted from Mangi et al. 2007:466)

1.5.1 Social Drivers

1.5.1.1: Population growth

Population growth has been an important social driver on fisheries resources in Nggela. The total population in 1999 was 13,660 persons (SIG 1999) while the 2006 estimate was 15,503 persons (SIG 2006). Although the annual population growth rate specifically for Nggela was not provided in the 1999 census report (this was the latest census record available), the annual population growth rate of Central Province (in which Nggela falls) based on the 1986 and 1999 census data was 2% per annum (SIG 1999); the best estimate for the annual population growth rate for Nggela therefore would be approximately 2% per annum (Solomon Islands Demographic and Statistics

Office, pers.com.). Increase in population has resulted in the increased number of people utilising coral reef resources both for subsistence and income generation. Increase in population has also resulted in increased competition for resources which has resulted in the use of improved fishing technology and destructive fishing gear by fishers.

1.5.1.2 Increased influence of market economy in livelihoods

The increased influence of the market economy has shifted livelihood patterns from a subsistence economy to a market economy. Reliance on products produced externally (e.g. fuel for lighting, clothes, food items, tobacco, alcohol, household items etc) requires income to participate in the market economy. In a society which is in close proximity to markets and where only few people are in paid employment, the need for income has become an important driver (D) which has resulted in the increased exploitation of resources, break down in traditional management regimes and degradation of resources (Aswani 2002).

1.5.1.3 Demise of traditional regulatory systems

Traditional regulatory systems such as taboos, prohibitions, belief systems, traditional ecological knowledge and traditional leadership/governance systems were part of the CMT system which helped curb exploitation drivers (Johannes 1978; Berkes et al. 2000; Ruddle 2000; Hickey 2006) as they dictate who, where, when and how resources can be exploited through social control and controlled access to common pool resources. The demise of traditional regulatory systems has removed previous controls and constraints on drivers.

1.5.2 Environmental Pressures

1.5.2.1 Increase in fisher numbers

Population increase, shift in livelihood patterns from subsistence to a market economy and the demise of traditional regulatory systems have

removed barriers which previously controlled access and exploitation of fisheries resources. Population increase results in increased pressure on resources due to the increase of local fishers; this is further compounded by the entry of outside fishers due to the absence of access barriers.

1.5.2.2 Use of improved fishing technology

The shift to the use of motor powered boats and improved fishing technology (e.g. FAO Samoan reel, night spear fishing using efficient spear guns and bright torches) by enterprising rural fishers in the last 10 years has added to pressure on coral reef fisheries resources. This is further exacerbated by Solomon Islands government and aid (particularly European Union and Japan) projects which provided motor powered boats and improved fishing technology (along with other infrastructure such as ice making and fish storage facilities at the rural level) to rural fishers under rural development projects aimed at stimulating income generation in the rural sectors through fisheries development. There are also anecdotal reports of industrial fishing boats fishing within inshore areas (interviewed fishers pers.comm.)

1.5.2.3 Use of destructive fishing gear

Increased demand (usually from urban markets) and the desire for low-cost fishing methods which have the ability to catch large volumes of fish within a short time period have led many fishers to employ destructive fishing practices which cause damage both to coral reef fish stocks and coral reef habitats. The most common destructive fishing method employed in Nggela is the use of explosives (other local terms used to refer to this fishing method are `dynamite fishing' or `bomb fishing') constructed from left-over World War II ammunitions.

1.5.3 Environmental state changes

1.5.3.1 Fish size and abundance changes

Literature on the ecology and dynamics of coral reefs in Nggela and Solomon Islands generally is lacking so tracking temporal changes in the abundance and size of fish is difficult. The only comprehensive survey was that by Green et al. (2006). Fish species which were targeted for consumption and the aquarium trade were generally in lower abundance in Nggela compared to other parts of the Solomon Islands (Green et al. 2006). A major contribution to this decline can be attributed to market demand due to the proximity of Nggela to the main capital (Brewer et al. 2009). Increased consumption and market demands have been important social drivers leading to increased pressure and the decline of coral reef finfish resources.

1.5.3.2 Live Coral cover changes

The general absence of studies on the ecology of coral reefs in Solomon Islands does not allow any temporal comparison of coral cover changes, however evidence of the use explosives for fishing in Nggela (Green et al. 2006) is linked with damaged coral cover on the reefs there compared to other parts of Solomon Islands.

1.5.4 Socio-economic impacts

1.5.4.1 Declining fish catch and increasing distance to fishing grounds

Damage to reefs and decline in fish catches in inshore areas has forced fishers to travel greater distances to offshore reefs for fishing (based on fisher interviews for this study). Three of the interviewed fishers expressed that high energy expenditure through long hours of paddling has resulted in near-death tragedies and physical injuries to some fishers. On several occasions fishers have had to be towed back to the village by fellow fishers as they had suffered from hunger, thirst and exhaustion due to the long paddling distances to fishing grounds. The dugout canoes used are usually very small to carry water (or

food) sufficient for the distance travelled. Intense sun results in fishers quickly exhausting their drinking water supplies for the day.

1.5.4.2 Livelihoods compromised

The increased importance of fishing to livelihoods, particularly for income generation for the Nggela fishers has resulted in over-fishing and the use of destructive fishing methods (e.g. dynamite fishing). Damaged reefs and decline in fish catches may compromise fishers' livelihoods, especially in locations where land-based livelihood options (e.g. small islands, hence limited land area for agricultural activities) are limited.

1.5.4.3 Increased conflicts

Increased numbers of fishers competing for declining resources have been reported to increase conflict among fishers in many countries, for example, reef users in Kenya (Mangi et al. 2007). Although Nggela fishers expressed concern during the interviews about fishers from nearby Langalanga (Malaita), recent migrants into Nggela and fishers from the main capital Honiara, the fishers expressed the view that they were still at a stage where no conflicts had occurred. This however may not be the case in the future; changes and further declines in coral reef fisheries resources may result in conflict among fishers and other users of coral reefs as reported in Kenya (Mangi et al. 2007).

1.5.5 Policy Response

1.5.5.1 Legislation

At the national level, legislations which provide protection, conservation and/or sustainable utilisation of coral reefs are the *Fisheries Act 1998*, and the *Protected Areas Act 2010.* Unlike other provinces in Solomon Islands, there are no ordinances protecting coral reefs at the provincial level in Central Islands Province in which Nggela sits. Compliance with regulations associated with the *Fisheries Act 1998* and the *Protected Areas Act 2010* is usually poor,

mostly due to lack of enforcement as well as ignorance by fishers about the legislations and regulations (based on interviews for this thesis). For example it is generally known (pers. Obs.) that use of explosives or poison for fishing is illegal yet most fishers still employ these methods due to poor (or no) enforcement. Some fishers continue to harvest fish below minimum size limits to sell at the local markets as they are unaware that it is illegal to do so; lack of market inspection by the relevant authorities further sustains the practice (pers.obs). General awareness among marine resource users in Nggela, especially fishers on topics such as management measures, rules and policies can be concluded as poor based on personal experience and interviewees' responses to the questionnaire (described in detail in Chapter 3).

1.5.5.2 Renaissance of community-based marine resource management and customary marine tenure systems

Awareness about resource declines and a sense of responsibility to avert them has led many South Pacific (Oceania) communities to re-introduce community-based resource management through the customary marine tenure system (Johannes 2002b). Since 2005, education and awareness initiatives of NGOs have led several communities in Nggela to establish community marine protected areas based on CMT systems.

1.5.5.3 Education and awareness

Education and awareness initiatives are important components of any intervention intended to halt or abate reef decline, because if performed effectively, then a better understanding amongst users to develop a willingness to change is more likely to be achieved (Mangi et al. 2007). Furthermore, increased awareness may lead to informed compliance among users due to better understanding of the rationale for the fisheries regulations or of the biology and ecology of exploited species and the role of humans in conserving them or exacerbating their demise (Foale 2006). Education and awareness therefore need to be important components of any coral reef management initiative (Mangi et al. 2007). The two major players in environmental education and awareness in Nggela are the NGOs, Solomon Islands Development Trust (SIDT), and the Foundations for the People of the South Pacific International

(FSPI) through the Locally Managed Marine Areas (LMMA) network. The Fisheries Department (both at the national and provincial level) has recently become active partners in this education and awareness initiative. As a result, several communities in Nggela have established marine protected areas in order to protect coral reefs.

1.5.5.4 Strengthening and empowerment of local governance structures

Effective community governance institutions are an integral part of effective resource management (Acheson 2006) as effective governance institutions can more effectively ensure compliance and penalisation of those who violate resource management or conservation rules (Aswani 1997b). The main form of governance at the community level in Nggela is the traditional governance system. However modernisation and Christianisation has eroded some of the practices, norms and values which hold such governance systems together, rendering the more traditional system increasingly ineffective for resource control and management. According to Wairiu and Tabo (2003), taboos by chiefs over marine resources are no longer respected and use of explosives for fishing is widely practised in Nggela, despite strong protests by chiefs and members of the communities. In an effort to reverse this trend the NGOs SIDT and FSPI has recently been engaging with communities and the provincial government to strengthen and empower community-level governance structures so as to ensure effective resource management and conservation is restored. Some aspects of governance and small-scale fisheries management in Nggela will be discussed in Chapter 5.

1.5.6 Barriers to Change

1.5.6.1 Lack of studies

Solomon Islands is the eastern most range of the coral triangle, the global epicentre of marine biodiversity (Veron et al. 2009). Yet, very few studies have been conducted on the ecology and biology of Solomon Islands coral reefs. Existing studies are usually short term (e.g., Green et al. 2006) or a few postgraduate thesis (mostly by foreign students) and targeted at

international peer reviewed journals rather than local policy makers and resource managers. Thus much of the information collected from research on marine resource management issues remains unknown or difficult for local relevant stakeholders to acquire. Beach recording programmes (P. Berggren, pers.com) where coral reef species targeted by the local fishers are recorded at the landing sites (e.g. Kenya; Mangi et al. 2007; McClanahan et al. 2008) is absent in Solomon Islands. The Fisheries Department of the government only maintains a statistical record of exported coral reef organisms (mostly aquarium species, *Trochus niloticus*, sea cucumber and a few coral reef fish species). These statistical data are usually collected from the commercial exporters. The dearth of detailed scientific knowledge and the availability of only a few relevant studies impede informed management of coral reef resources. Thus the findings herein are particularly timely and help address the current gap in understanding on the effectiveness of CMT on coral reef finfish in Nggela, the main aim of this thesis. An outcome of the literature review presented in this chapter and building on the afore-mentioned constraints, highlighted how the role of more formal governance, defined as the principal way in which decisions are made by decision-makers, for example, policy makers formulating legislation and regulations is influencing marine resource users' behaviour. This is reviewed in the next section.

1.5.6.2 Lack of political will

Although the Central Islands Province where Nggela is situated has a Fisheries Department, its role is more in fisheries development (through maintenance of ice-making facilities at the provincial headquarter in Tulagi and selected sub-centres) rather than active fisheries management. There are currently no provincial environmental ordinances which protect coral reefs. While equipment such as outboard motors and boats are available to conduct enforcement patrols (particularly against the use of explosives for fishing), no financial resources are made available to purchase fuel to enable such patrol activities. At the national level very limited resources are provided by the central government for monitoring and enforcement activities. Until or unless politicians see the importance of managing coral reef fisheries, the lack of political will to enact required provincial ordinances (to protect coral reefs) at

the provincial level and to make resources available at the national and provincial level for monitoring, enforcement and management will continue to be a barrier to the successful management of coral reefs in Nggela. Several NGOs and aid donors have been working with the provincial government since 2007 to raise the importance of provincial and local level government involvement in coral reef resource management. In January 2011, a 3 year coral reef conservation joint work plan for Nggela was established between the Central Province government, some local communities and the NGOs World Fish Centre, Foundations for the People of the South Pacific International (FSPI), Solomon Islands Development Trust (SIDT), World Wide Fund for Nature (WWF) and The Nature Conservancy (TNC). Such an initiative and increased involvement from additional NGOs other than the two initial main players (FSPI and SIDT) hopefully may be the impetus to garner greater political interest and support for coral reef management.

1.5.6.3 Inability to enforce and monitor

Despite the *Fisheries Act 1998* and *Protected Areas Act 2010,* lack of financial and human resources prevents resource monitoring and enforcement of relevant legislations and regulations. Under the *Fisheries Act 1998* the provinces are mandated to manage inshore resources, yet lack of financial and human resources and political will at the provincial level impedes enforcement and monitoring activities. Enforcement of some closed areas and prohibited fishing gear in some cases could theoretically be done through the CMT system. However the breakdown of some parts of the social structure and value systems which supports the CMT inhibits the use of CMT for coral reef resources management. Furthermore, some of the penalties under the CMT system contravene modern laws of Solomon Islands for example, corporal punishment or confiscation of boats and fishing gear.

1.6 THESIS AIM AND OBJECTIVES

The main aim of this thesis is to investigate the effectiveness of customary marine tenure (CMT) to manage coral reef finfish fisheries. This is examined through a multidisciplinary study and by addressing the following

objectives: (1) To investigate the role of markets and subsistence as driving factors for fishing; (2) To investigate fishers' spatial fishing behaviour, fishing methods employed and species targeted; (3) To contribute to the biological knowledge of a much sought after vulnerable species (*Plectropomus leopardus*) by investigating aspects of its demography and reproduction; and (4) To investigate relationships between the traditional Nggela CMT governance system and emerging modern governance system, to improve understanding of how past and present knowledge may be applied to enhance future small-scale fisheries management (SSFM).

1.7   THESIS OVERVIEW

This thesis draws inspiration from the DPSIR model (described in Figure 1.4) to appraise the effectiveness of CMT as a policy response (R) to coral reef finfish fisheries management needs. Hence it is systematically arranged in an order that will flow according to the model (i.e. begin with drivers (D) and end with response (R)). However the scope of the research presented herein is necessarily confined to selected components of the DPSIR model due to constraints in time, resources and logistics.

Chapter 2 investigates the role of subsistence and markets as driving factors of fishing using the sustainable livelihoods approach (Scoones 1998; Allison and Ellis 2001). Studies on livelihood strategies present an opportunity to investigate aspects of the dynamics of social-ecological relations people have with their environment. CMT was devised under a 'primitive economy' that was centred on kin group production and distribution (which was predominantly subsistence and exchange). Resource and property access was closely related to kinship groups and the economic structure was expressed in part through property relations; the social and economic roles of property were tightly interwoven (Dahl 1988).

The advent of the modern market economy and the introduction of modern currency however changed this relationship (Johannes 1978; Dahl 1988). According to Dahl (1988), modern currency facilitates the calculation of any benefits derived from an exchange event such that it does not need to be bound by relationships between actors and the degree to which they can trust each other. *"The level and scope of exchange can thus increase"* (Dahl 1988 :

44). Dahl (1988) further argued that the predominance of subsistence and exchange in the primitive economy limits the efforts applied to resource extraction, as the benefits of production lie entirely in their first use rather than as an access to a broader range of goods and services in the market. Hence, needs were limited which in turn limits the desire to exploit beyond what was immediately needed. In contrast, the availability of cash allows value to be transferred through space and time for future control of more effective means of production, for example capital can be accumulated to buy a motor or hire labour for fishing. This allows fishing effort to increase as resources needed to catch fish – technology and labour - can be more effectively brought together in space and time. Further shift into a cash economy facilitates a desire to trade natural resources for access to new and a wider range of goods and services (which are usually produced externally), resulting in increased exploitation of marine resources.

Understanding individuals' choices about livelihoods, especially fishing which can impact the health of marine environments, is important for proactively developing management that reflects local conditions and needs. Management regimes which are premised on an incomplete understanding of livelihoods can result in management actions incompatible with both resource conservation and the social and economic goals of management (Allison and Ellis 2001).

Chapter 3 examines pressure (P) and the state (S) of the coral reef finfish fisheries by investigating fisher behaviour and target taxa (Figure 1.4). It is important to pay attention to the behaviour of fishers who utilise the resources, for they ultimately affect the sustainability of resources (Aswani 1998a). Behavioural decisions underpin where, when, how and what fishers fish (Salas et al. 2004; Abernethy et al. 2007). Understanding of fisher behaviour and target taxa is essential for effective fisheries management (Salas and Gaertner 2004; Hilborn 2007). It will help in the formulation of relevant and efficient regulations (Béné and Tewfik 2001), that consider the spatial and temporal patterns of fishing effort and the impacts of effort and gear on species (Pet-Soede et al. 2001; McClanahan and Cinner 2008; Cinner et al. 2009b; Jones et al. 2009). Furthermore, understanding the spatial allocation of fishing is important due to the fact that a successful CMT system based on territory requires clearly defined boundaries (Dahl 1988).

Specifically, pressure (Figure 1.4) was examined by investigating spatial behaviour of fishers, fishing methods used and fish taxa targeted. The state of coral reef finfish fisheries was investigated through fishers' perceptions of resource abundance changes and causes for the changes. The use of fisher perceptions to assess the state of reef finfish fisheries was necessary due to the absence of historical data on fish landings or sizes. Underwater visual census (UVC) to compare finfish abundance in inshore and offshore areas with a view to triangulating this information with fisher perceptions on the state of reef finfish fisheries could not be done as most of the fishing areas in offshore reef areas were deeper than 20m (20m is the accessible safe SCUBA depth, initial attempts to do SCUBA in offshore tidal reefs also proved unsafe due to strong currents in those areas).

Chapter 4 is a case study of the age-based demography of one of the most sought-after locally exploited species, *Plectropomus leopardus* and explores related aspects of the reproductive biology of this species. Relationships between body size, demographic parameters and their trade-offs are important in understanding within and between species effects of fisheries exploitation (Jennings and Beverton 1991; Jensen 1996; Jennings et al. 1998; Stamps et al. 1998; Jennings et al. 1999; Graham et al. 2005) and impacts of extrinsic factors such as temperature (Pauly 1980; Helser and Lai 2004; Winemiller 2005; Kimura 2008). Demographic parameters have proved to be reliable measures of exploitation and effects of environment on a species (Russ and Alcala 1998; Reynolds et al. 2001; Reynolds et al. 2005). This age-based finfish demographic approach was useful for this thesis after finding that the deeper water depths prevented use of UVC.

Plectropomus leopardus was chosen as a species to investigate its age-based demography and reproductive biology because: (1) it was one of the species which commands a high price at the Honiara market, being targeted by fishermen when it aggregates to spawn; (2) it is currently listed as near threatened on the IUCN red list and (3) the use of otoliths to determine its age has already been validated by Ferreira and Russ (1994). Besides the aim of determining the age-based demographic parameters and doing a latitudinal comparison with Australian locations, the other initial aim was to triangulate fishers perceptions on the state (S; Figure 1.4) of the finfish fisheries by comparing the reproductive and demographic parameters of *P. leopardus* at

the local scale (between CMT areas and the sub-tidal offshore reefs which are de facto open access) to determine the effectiveness of CMT in protecting the species. The hypothesis was that if CMT was effective then average *P. leopardus* size and age range in CMT areas should be higher than those in open access areas and mortality rates in CMT areas should be lower than those in the open access areas. In the event, only 4 specimens were obtained from CMT areas; hence such local scale comparison could not be made with such a small sample size (*P. leopardus* were probably over exploited in CMT areas inshore).

Chapter 5 investigates the effectiveness of the CMT system as a policy response (R; Figure 1.4) for management of coral reef finfish fisheries from a governance perspective. Governance is defined here as the principle mechanism in which decisions are made formally (e.g., legislation, policy or regulations) or informally (e.g., community based actions). Governance was explored by examining the history of the present CMT governance system to understand the historical contexts contributing to the changes it has undergone, therefore the role of those changes and the place of CMT governance within the present local level governance system; secondly, dynamite fishing was used as a case study to determine some of the reasons for the inability of CMT to enforce fisheries management rules. Any fisheries management regime requires a governance structure whether formal and/or informal which can create and enforce rules; such a structure is present within CMT systems. CMT was devised under social and governance conditions which were different from those existing at present; in situations where CMT systems are undergoing changes, the effectiveness of such a structure needs to be re-examined, for it is only from a complete understanding of this governance structure that CMT regimes might be effectively hybridised with contemporary SSFM (Cinner and Aswani 2007).

Chapter 6 is an overall synthesis of the thesis. A summary of the findings from the different chapters is presented, followed by important lessons learned from the thesis in general; a model on how CMT can be used for modern fisheries management is presented before the thesis is concluded.

1.8 METHODOLOGICAL APPROACH

Modern fisheries science and management initially evolved as a population biology discipline, with an emphasis on reducing or maintaining fishing mortality via controls on fishing effort (both input and output controls), such that the population of an exploited species would be maintained at a sustainable level (Daw 2008). Such a management regime which focuses solely on fisheries science has however not been successful in managing fisheries (Hilborn et al. 2003; Daw 2008). It is now commonly held that for fisheries management (or any conservation or resource management regime for that matter) to succeed, it requires a multidisciplinary approach which involves natural science (biology, ecology, oceanography etc) and the different social science disciplines (political science, anthropology, economics, psychology, sociology, geography, legal studies etc.) (Mascia et al. 2003; Daw 2008; Cooke et al. 2009; Lowe et al. 2009). According to Mascia (2003:649), "*The disconnect between our biological knowledge and conservation success has led to a growing sense among scientists and practitioners that social factors are often the primary determinants of success or failure*". While Ludwig et al. (2001:482) wrote: "*Clearly scientific understanding, and particularly ecological understanding, is an important tool for dealing with environmental problems. Now it is also clear that scientific knowledge will never be enough. Somehow that knowledge must be integrated with political, economic, social, ethical and religious insight*".

The question that arises is how does one navigate the methodological divide between natural and social science when evaluating the social aspects of coupled social-ecological systems, specifically for this thesis, CMT systems? The question arises whether the social world can and should be studied according to the same principles, procedures and ethos as the natural sciences in a positivist approach which emphasises objective enquiry (Bryman 2004), as opposed to a social science approach which posits that complete personal detachment from a studied subject is impossible (Phillipson et al. 2009).

According to Pollnac and Johnson (2005), studies on CMT were previously based on anthropological methods because CMT lay in the domain of anthropological studies. It was catapulted into fisheries science and

management by Johannes' (1978; 1981) seminal papers on traditional fisheries management in Polynesia, and has impacted in its use and in debates on conservation and fisheries management because Johannes was a marine scientist and was read by other marine scientists. The methodological considerations of Pollnac and Johnson (2005) for folk management and marine conservation research were incorporated into the design of the present study. These were: (1) information should be collected from several villagers, interviewed apart, not as a group with the interviews taking place in as brief a time span as possible to reduce the chances of sharing post-interview information. This approach helps in cross validation of the information collected from fishers; (2) leading questions should not be asked and the interviews should not be ceased just because responses reflect or conflict with the researchers ideological view points; (3) key informants should be those who have had the least contact with marine scientists or conservationists, because those who have had such contact will have acquired marine scientist and conservationist understanding that can be fed back to unsuspecting researchers; (4) sufficient time should be spent at a site to allow for in depth observation and triangulation of responses because respondents may respond in a way to either please the interviewer or make themselves look good. In addition to the considerations, an empirical approach is also desirable in order to quantify the investigated variables. Qualitative and quantitative data can help to inform each other and facilitate a better understanding of the issues being investigated (Bryman 2004). Aswani (1998b; 2002; 2005), Foale (1998a) and Cinner and co-workers (Cinner 2005; Cinner and McClanahan 2006b; Cinner et al. 2007) employed both a qualitative and quantitative approach in investigations of CMT in Oceania and this approach served as models in the methodological approach taken in this thesis.

The present study relied on quantitative, qualitative and ethnographic methods to understand the socio-economic circumstances and drivers of fishing; fisher behaviour and target species; demographic parameters of an exploited finfish species; and CMT and governance in the management of fishfish fisheries in Nggela.

The livelihood variables which were based on the livelihood frame work of Allison and Ellis (2001) were collected using a semi-structured questionnaire that was designed based on those of Cinner and co-workers (Cinner 2005;

Cinner and McClanahan 2006b; Cinner et al. 2007). This was used to better understand the role of livelihoods in fisheries, particularly the increasing importance of fish for income generation in an economy that is currently a mix of both subsistence and cash. Variables of fishing behaviour used to understand fishing patterns were perceptions of fisheries and spatial allocation of fishing, fishing methods currently being used and fish families being targeted. Perceptions of fisheries were investigated using a closed questionnaire; spatial allocation of fishing patterns was investigated using an open questionnaire and then triangulated by accompanying fishers during fishing trips and asking fishers from neighbouring villages where fishers in a particular village were fishing; targeted fish families were investigated by recording fish catch data. Fishing spatial behaviour was investigated to determine whether fishing was dictated by CMT rules or not. Variables used to investigate the demographic parameters of an exploited species were size and age structure, longevity, mortality and aspects of reproductive biology and thus a purely quantitative approach was adopted (see Chapter 4). Collection of data to understand CMT and governance in the management of reef finfish fisheries departed significantly from a natural science or positivist approach to embrace social science methods; it relied heavily on historical accounts based on literature and qualitative data based on key informant interviews.

This research was conducted in a society where I was born and raised. Although I have been educated and had relocated and lived in an urban area for 10 years, I still interact with the studied society and spend several weeks each year in the village for holidays or other cultural obligations and activities. This PhD research was not the first time that I was dealing with the issues of CMT and resource management. Growing up within the society, I was aware of the Nggela CMT system. During my employment as a conservation officer in WWF and as a fisheries officer in the Solomon Islands Fisheries Department I had also dealt with CMT and inshore fisheries. I was therefore an insider with inside knowledge of CMT and of the culture, language and social setting of the study site. This inside knowledge helped in the research process, particularly in: conducting research in a manner that is sensitive to the local culture and practices; using the local language which overcomes communication barriers; and in the ethnographic process seeing issues and concepts through the lenses of those being researched. My experience of working in WWF and the

Fisheries Department provided some background knowledge on the researched issues and in orienting my investigations to extract as much data as possible within the season for which I was in the field. For example when conducting interviews, questions would be asked to provide perspectives on the entire year; fishers would be asked to state their fishing frequency in terms of the main seasons of the entire year rather than just during the season involved. Full factoring in of season however was not possible across the entire study, for example the landings data and the data on *P. leopardus* were only for one season because time and funding constrained this study.

While inside knowledge was of immense help in the research process, I was aware from the beginning that without due attention 'cultural closeness' might cloud my objectivity when collecting and analysing data; particularly being afflicted by the 'going native' phenomenon when utilising ethnographic processes. 'Going native' refers to the plight of researchers who lose the sense of being a researcher and become wrapped up in the world view of those being studied (Bryman 2004). Being a former fisheries officer also had its disadvantage in some instances, for example dynamite fishers refused to be interviewed thinking that I was still a fisheries officer in the Fisheries Department and this affected the number of dynamite fishers interviewed. While I cannot claim a fully objective, neutral and value free approach in the research process, I sought to control any personal biases and as much as possible tried to maintain objectivity at all times during the collection and analysis of data.

1.8.1 Background to field work

There were insufficient funds initially for field work as only one return flight (UK-Solomon-UK) and £600 were provided by the Commonwealth Scholarships Commission towards field work. Only 6 months could be spent in the field, and any additional months had to be undertaken with no stipend paid. Factoring in seasonality and planning more than one field visit therefore could not be considered.

After developing thesis topic ideas, research grant proposals were submitted to several funding agencies. These were successful from the University of the South Pacific (USP) (£3333), the Rufford small grants

Foundation (£5000) and the Newcastle University School of Marine Science and Technology (£1200).

The USP funding was used for field reconnaissance during the months of April and May 2007, however my father passing away during this period meant field reconnaissance was postponed for 10 days for funeral and associated activities. Hence the reconnaissance and piloting extended into June 2007. The Rufford Foundation money was used for field work during the period December 2007 to May 2008. Two months (June - July 2008) were spent at James Cook University (Australia) to process and analyse the otolith and gonad samples of *P. leopardus*.

1.8.1.1 Reconnaissance and piloting

The purpose of reconnaissance and piloting was to acquaint myself and forge links with contacts whom I might encounter during the field work – I was able to introduce myself and my project to the Fisheries Department, Department of Environment and to the NGOs who were doing work on Nggela; investigate the availability of relevant historical/secondary data that might be available at the relevant government departments (particularly Fisheries, Environment, and Statistics department) and NGOs and pilot the field methods and survey questionnaire (Bunce et al. 2000) .

It became evident during the reconnaissance that there were no landings data on coral reef finfish fisheries at the village/community level or at the urban markets. The only data that were available at the Fisheries Department were: unpublished project reports of previous fisheries development projects (in particular a European Union rural fisheries project (which were mostly short field reports for 1998 to 2000) and a Japanese funded inshore fisheries project (Oreihaka and Ramohia 2000), both aimed at developing the deep sea snapper fishery); export data of beche-de-mer (several species of the genus *Holothuria*), trochus (*Trochus niloticus*), aquarium species (corals, several invertebrate species and aquarium fish species), shark fins and miscellaneous marine products which were usually submitted by exporters of marine products; and landings data for the tuna fisheries. The availability of only such data at the Fisheries Department was not surprising given Adam's (1998) observation that South Pacific Fisheries Departments are usually under

pressure from their government central planning offices to concentrate their efforts on the development of commercial fisheries and the encouragement of foreign investments/revenues, rather than being involved with community based fisheries which are mainly for subsistence purposes. The data available at the government Statistics Department were the 1999 national census report and the 2006 national household income and expenditure survey which were bought for SBD$100.00. The only secondary fisheries data found useful were the European Union and the Japanese projects referred to. These reports provided some background knowledge on reef finfish fisheries in rural Solomon Islands, while census report provided useful information on the human population of Nggela.

Preparation for research in a particular village would begin with identifying a contact of a particular village in Honiara. The best place to do this was at the Honiara main market where villagers would come to sell their marine or farm products. Upon identification of a contact, a written letter addressed to the village chief was given to the contact to take back to the village to be delivered to the chief. The letter introduced the researcher, intent to conduct research at the particular village hence a request for permission to do so, and the tentative dates when I wished to be at the village. A week would normally be allowed to pass after which I would re-visit the market to get a verbal reply from other people from the particular village coming to sell their produce.

Piloting of field work methods (details in section *1.8.1.2* below) and questionnaire (Appendix 1) was conducted in two villages - my own village and another village which was not later used as a study village. During the piloting I found out that it was very difficult to conduct research at my own village owing to the fact that I knew too much about the village. Furthermore, eliciting acceptable responses during the interview was difficult. Relative ease for an interviewee to confiding in a stranger than in one who is known to the interviewee (Fielding and Thomas 2001) may have been one reason I had difficulties conducting research in my own village. The decision was thus made not to conduct the main field work in my own village or neighbouring villages in order to prevent personal bias and reduce interviewer effects as a result of close personal relationships

Piloting of the questionnaire also revealed that some questions were culturally sensitive with respondents finding them uncomfortable to answer (e.g. questions on material wealth and wealth ranking which asked if a respondent had a television set, stereo set, bicycle, type of toilet used, etc); these questions were subsequently removed from the questionnaire.

1.8.1.2 Main field work

Selection of villages for research was based on the plan to sample 5 villages each from the eastern and western zones of Nggela on a random basis. Random selection of villages was achieved by writing the names of villages in a particular zone (excluding my village, its 3 neighbours and the pilot village) on pieces of paper and put together into a bucket from which 5 were drawn. Villages thus drawn from the western zone were Naghotano, Soso, Ravu sondu kosi, Ravu sondu ulu and Haleta and from the eastern zone were Vura, Rara, Salesapa, Ghole and Ghumba. Initial contact with the villages were as described previously where inhabitants of a certain village were sought out at the Honiara market to act as my letter couriers and replies were subsequently sought at the market one week later after the letters were distributed. Positive replies were received from all the villages.

On arrival at a village, first contacts were made with the village chief. After introductions my two research assistants and I would be led to the village rest house where we were accommodated, SBD$100 was usually paid as good will payment contribution to the village church funds for the use of the rest house. A general village meeting was held either on the evening of arrival or the first morning after arrival where we would meet other village leaders, church leaders and community members. During the meeting, I introduced myself to the community and told them that I was a student doing research on a marine related theme. Such introductions and clarification were necessary so that the villagers did not confuse the researchers for government officers or aid donor officers, thereby reducing any expectations of government or donor projects and assistants that might be expected from the researcher. Following the introductions, I then informed everyone that I would be doing interviews with fishers, record fishers landings data, collect otoliths and gonads of *P. leopardus* and that I would participate in some village day to day activities,

including accompanying fishers or other community members (if allowed) on some of their fishing trips or when they visited their gardens.

Mixed methods (Bryman 2004) employed in the field research were: village transect walks and observations; household interviews of fishers using a semi-structured questionnaire; key informant interviews by use of an open questionnaire, interview of fishers of a neighbouring village; and informal conversations. These methods were used in a complementary manner in the field. No focus group interviews were conducted as recommended by Pollnac and Johnson (2005). A brief explanation of each of the methods follows.

The first week at the village involved: (1) transect walks through the village with one of the villagers to help understand the village arrangement and other issues e.g. location of water source and food gardens, nature of social structure and strata, influential people and significant facilities e.g. school, clinic which were available in the village or distance from the village if they were unavailable in the village; (2) household counts; (3) acquaintance of community members; (4) determination of village population from church records; (5) determination of the fishers within the village; (6) starting recording of landed catch by fishers and collecting otoliths and gonads of *P. leopardus* if they were caught.

Sundays were usually free days in the villages when people visited relatives in neighbouring villages after the church service. I would accompany some members of the study village on the first Sunday of my stay at the village during these 'Sunday walkabouts' (*ole ole Sunday*) when I would make acquaintance with community members of the neighbouring village; usually the members of the neighbouring village would have already heard about the researcher after the first week so these meetings/encounters were usually not a surprise. Acquaintance with neighbouring villages was necessary for subsequent triangulation interviews.

Semi-structured interviews were conducted in the second week (i.e. after familiarisation with the village and identification of fishers, hence total number of fishers at the study village). Table 1.1 shows the village populations, numbers of fishers, numbers of households engaged in fishing for the study villages and numbers of fishers interviewed (which was in effect number of households interviewed) in the study villages. The number of households

engaged in fishing in a study village was 40-70% in the eastern zone and 30-100% in the western zone. I tried to interview at least 20% of the fishers in a village, particularly selecting those 30-46 years of age; the purpose of selecting fishers within this age bracket being to select experienced fishers who could give reliable first-hand information (Johannes et al. 2000; Turner et al. 2007) and avoid the shifting baseline syndrome (Pauly 1995; Saenz-Arroyo et al. 2005a; Saenz-Arroyo et al. 2005b; Bunce et al. 2008; Mee et al. 2008). In previous studies Cinner and McClanahan (2006a) had a sample size of 6-100% of fishers per study community (overall sample size 38% of fishers) while Turner et al. (2007) had a sample size of 9-14%. Thus a sample size of ≥ 20% of fishers was considered adequately representative and was generally possible, except for Naghotano where some fishers within the 30-46 age group were either unavailable or absent at the time of research; a large proportion of fishers in Naghotano were below the age of 30 with some as young as 12. The semi-structured interviews were conducted in the Nggela language and at a time that was convenient for the respondents; hence in the morning, during the day or in the evening. The respondents were not paid or given any reward to be interviewed. A total of 109 semi-structured interviews were conducted, however after cross validation and triangulation from key informant interviews and informal conversations, 16 were considered inaccurate and unusable, hence only 93 were deemed appropriate for analysis. Key informant interviews were usually conducted in the second and third weeks of stay at the village. Interviews with fishers from the neighbouring village to triangulate some of the information (number of fishers and spatial fishing behaviour by fishers of the study village) were done in the third week. If the neighbouring village was also a selected study village then household interviews would also be conducted besides triangulation interviews, in which case a little more than 3 weeks would be spent between the two villages, for example a total of 3.5 weeks was spent doing research at Ravu sondu ulu and Ravu sondu kosi.

Table 1.1: Village population size (number), number of fishers per village and number of fishers interviewed in each of the sampled villages

Village	Village Population	Households	Households engaged in fishing	Total Fishers	Fishers interviewed
Eastern Zone					
Ghole	277	50	20	34	9
Ghumba	483	87	60	63	15
Salesapa	503	66	30	35	13
Rara	130	12	8	12	3
Vura	200	35	15	18	10
Western Zone					
Naghotano	347	43	43	96	7
Soso	96	12	12	34	5
Ravu sondu kosi	205	37	16	19	7
Ravu sondu ulu	243	38	12	17	7
Haleta	612	66	35	40	17

Informal conversations served as an important means to access more in-depth knowledge which complemented, enhanced or filled the knowledge gaps from the semi-structured interviews. These informal conversations occurred when community members visited me in the evenings (when I was not conducting interviews) or during participatory activities when I accompanied the fishers and other community members during fishing or food garden trips. The absence of a stressful environment that may be posed by an interview situation usually relaxed people such that they usually expressed themselves freely, although I tried to make the interviews as relaxed as possible. These informal conversations also served to triangulate some of the data collected during semi-structured interviews. For example, during these informal conversations I was able to determine how much could be earned from certain livelihood activities and this helped in the triangulation of interview responses; some of the interviews that were discarded before the final data analysis involved over-estimation of income that could be obtained from certain livelihood activities.

I had two research assistants who mainly helped with collecting landings data, measurement of water depths where fishers were fishing and the extraction of otoliths and gonads from *P. leopardus* specimens. All the interviews were conducted by me, the main reason being that I was unable to hire someone sufficiently qualified and fluent in the Nggela language to assist.

The research assistants had only high school education. Doing all the interviews myself reduced interviewer variability and I was able to probe answers to the interview questions in a similar manner for all the interviews.

Although consultations with supervisors and other learned persons were done, all data analysis and writing of the chapters were done solely by the author of this thesis – I can claim first author if any of the chapters were to be published. There was no collaborative writing on any of the chapters. Drafts of the chapters however were given for critique and review by the supervisors and other learned persons when completed.

1.9   BACKGROUND TO STUDY SITE

In order to provide a broad context of where this study is conducted, this section provides a brief and general description of the Solomon Islands, its coral reefs and its history. The information about Nggela society, especially its social structure as it relates to CMT, is provided here in order to contextually situate this study right from the beginning.

1.9.1 The Geography of Solomon Islands

The Solomon Islands are the northern group of a huge arc of islands delimiting the northeast boundary of the Coral Sea. The archipelago, oriented southeast to northwest, stretches about 1700km between Papua New Guinea and Vanuatu. The six main islands are: Choiseul; Santa Isabel; New Georgia; Guadalcanal; Malaita; and Makira (San Cristobal). They are arranged roughly in a double chain with the two 'strands' enclosing a relatively sheltered sea area comprising New Georgia Sound and Indispensable Strait (Figure 1.5). The land area of 28,370 km^2 makes the Solomon Islands the second largest island nation in the South Pacific, after Papua New Guinea. The 200 mile EEZ encloses 1.34 million km^2, the 12-mile zone 0.3 million km^2; the latter is where most of the coral reefs occur and is the domain of the inshore small-scale fisheries.

There are about 1000 islands (comprising small islands, atolls and islets) which are mostly raised volcanic islands with the reefs predominantly fringing

on the steep slopes (Maragos 1998). The six largest islands, rise steeply from the sea and each has a central mountain spine with peaks up to 2450m. The Solomon Islands is within the 'Pacific Ring of Fire' belt, it still has active and dormant volcanoes and earth quakes still occur frequently.

The coral reefs are mainly fringing and intermittent around all of the islands, and although certain areas appear to be coral-free on the map, e.g. the northern and southern coasts of Guadalcanal, even those coastal tracts usually support a narrow fringing zone of corals on the steeply sloping seabed (Stoddart 1969c; Stoddart 1969b; Stoddart 1969a). The only areas devoid of corals are near major river mouths. In Nggela, coral reefs are mainly fringing with several sub-tidal reefs occurring offshore. Some of the largest Solomon Islands coral reef areas occur where there are large lagoon complexes variously protected by volcanic islands, raised islands, sand cays or barrier reefs. Significant areas are: around the Shortland Islands near Bougainville; inside barrier reefs along the northeastern shore of Choiseul; on either side of Manning Strait between Choiseul and Santa Isabel Islands, and extending along the southwestern shore of Santa Isabel; in the Ghizo–Vonavona lagoonal area on New Georgia's southern shore; encircling Vangunu in southeastern New Georgia and along the northeastern coast area (Marovo Lagoon); in the north at Lau Lagoon and west at Langalanga Lagoon in Malaita; and in eastern Guadalcanal (Marau Sound).

Long (e.g. 10s of km) submerged barrier reefs (e.g. like the Great Sea Reef in Fiji) are rare in the Solomon Islands; although there are smaller examples including: along the northeast coast of Choiseul; near Ghizo and near Munda in New Georgia; off Star Harbour in eastern Makira (San Cristobal); northeast of the Russell Islands; across the entrance of Kangava Bay on the south coast of Rennell; and around Utupua Island in the easterly Santa Cruz Islands. In the Reef Islands, a line of 4 reefs stretches westwards for 21km, and the Great Reef slightly further north is about 25km long.

Atolls are relatively uncommon. The only large atoll is Ontong Java, a northern outlier, which is 70km long and 11-36km wide. Sikaiana Atoll (Stewart Islands), about 200km northeast of Malaita, is a small triangular atoll about 10km wide with a 45m tall remnant of the original volcano. The surrounding reef drops steeply to great depths, so the band of coral is narrow. Far to the

west in Bougainville Strait is Oema Atoll. Rennell and Bellona are raised atolls with coastal cliffs and fringing reefs. There are also several mid-ocean reefs, infrequently visited, but covered with coral. These include Roncador and Bradley reefs lying south of Ontong Java, Indispensable Reefs south of Rennell, and several small shoals north of the Santa Cruz Islands.

1.9.2 Human history of Solomon Islands

Melanesians (dark skin colour) first settled the Solomon Islands 4000-6500 years before present, with the Polynesians (lighter skin colour like the Tongans and Samoans) settling in the outlying islands and atolls about 2000-3000 years ago. The indigenous people of the Solomon Islands are diverse and speak about 87 languages and dialects. The common language is Pidgin, and English is the official language used in government and business. The population consists of Melanesians (95%), Polynesians (4%), Micronesians (2%) and Chinese or Caucasian (1%), the population estimate in 2006 was 533,672 persons (SIG 2006).

European 'discovery' of Solomon Islands was a hit and miss affair. The Spanish, who came from Peru, hit upon Santa Isabel in 1568, and over a period of six months found the other large islands. Returning in 1595 to start a colony, they missed the main islands, so tried unsuccessfully to colonise the much smaller Santa Cruz Islands. A second colonisation attempt in 1606 found only the minuscule Duff Islands and went on to attempt to colonise Espiritu Santo in Vanuatu – again unsuccessfully. This was probably because mapmakers plotted the Solomon Islands far to the east of their correct position. The next European contact was in 1767 when a British sea captain, Philip Cataret, found Santa Cruz and Malaita, followed by other British, French and American explorers. Traders, missionaries and territorial claims in the north by Germany and in the south by Great Britain followed. Germany ceded the northern claims in 1897 to Great Britain in exchange for Britain relinquishing its claims to Western Samoa. Bougainville, naturally part of the Solomon archipelago was left in German control, and so today is part of Papua New Guinea. The British administered the islands as a Protectorate; but development was minimal. During World War II the fight for control of an airstrip on Guadalcanal was a major turning point of the war. After the war,

Britain continued to administer the Protectorate until independence in 1978. Solomon Islands was one of the last British colonies to become independent. It is now a democratic state with a unicameral form of Westminster government and the British Monarch as Head of State. Politically the nation is divided into 9 provinces: (1) Temotu (Santa Cruz Islands); (2) Makira (San Christobal); (3) Guadalcanal; (4) Central (Nggela, Russell and Savo); (5) Malaita (includes Ontong Java and Sikaiana); (6) Santa Isabel; (7) Western (Shortland, Kolombangara, Vella Lavella & New Georgia); (8) Choiseul and (9) Rennell & Bellona; in addition to the Honiara Town Council.

1.9.3 Nggela (Florida Islands)

Nggela (other variation in spelling is Gela) also known as the Florida Islands lies in the centre of the Solomon Islands. Nggela is composed of 4 islands: Nggela Pile, Nggela Sule, Sandfly and Buena Vista (Figure 1.6). It is approximately 45km in length and 11km in width, the total land surface area is approximately 510 km^2. In 2008 there were a total of 60 main villages in Nggela (the 10 villages shown in Figure 1.6 are only those of study sites); the estimated population in 2006 was 15,503 persons (Gagahe 2006), making the population density of Nggela about 30 persons per km^2. The Nggela language is spoken throughout the whole island with some word variations between different locations; Soso, Naghotano and Thadi on the western end of the group also speak the Santa Isabel language *Bughotu*. Nggela was the first location of Anglican missionary contact in 1862 (Fox 1958), 99% of the present population are Anglicans. From its establishment up to now the church has played an important political role in the life of Nggela (Fox 1958; Foale 1998b).

All the study villages (Figure 1.6) where this study was conducted were all similarly rural in character with 99% of all the houses consisting of palm-leaf thatched roofs and other natural materials. Figure 1.7 shows a typical Nggela village setting. The Nggela language was spoken in all the villages and they all practised the Anglican faith. Study village sizes ranged from 12 - 87 households with village populations of 96 - 612 people.

Nggela is host to the provincial headquarters of the Central province; situated on Tulagi, it could be described as semi-urban. The nearest main urban centre is the national capital, Honiara which is situated on the island of

Guadalcanal. Nggela is 30 nm from Honiara and is accessible by either a 3-5 hour inter-island vessel or by outboard motor which takes 1 – 2 hours, depending on the location within Nggela.

1.9.4 Nggela social organisation and land/marine tenure

Early descriptions of the social organisation and land/marine tenure system of Nggela were by Hogbin (1937), Belshaw (1945) Allan (1957) and Foale and Macintyre (2000). Nggela society is composed of only one tribe, the Nggela tribe (*Vinahuhu ni Nggela*) (Figure 1.8). The tribe is further divided into 4 clans (*kema*); each of the 4 clans contains 7 sub clans (*vike*). Numerous family units (b*inaboli*) fall under the vike, an individual connecting to the overall social structure through the binaboli. Each clan is associated with a totemic creature. Associations with a spiritual being (god) occur at the vike level with each sub clan having its own god (k*iramo*), associated sacrificial/ritual sites and land and marine tenure entitlements.

Clan affiliation is matrilineally inherited; it is quite common for people to know their unilineal matrilineages (*susu*) for up to 7 or 8 generations. Land and marine tenure rights ownership is inherited matrilineally through the clans and sub clans. Alternative means of acquiring land and marine tenure rights patrilineally, as a gift or for other significant transaction processes between kema and vike is through the *huihui* process, the closest meaning of *huihui* in English being 'unhook' or 'unlock'. In a huihui, those who are acquiring rights prepare food, pigs and traditional money (nowadays also modern cash and goods) and present them to those who own the land and marine tenure rights. On receipt of the goods at a public ceremony that must be witnessed by chiefs, the primary owners relinquish their rights. Land and marine tenure rights acquired through huihui are valid for only 3 generations through the patriline (3 generations of men). Unless another huihui is carried at this stage, land and marine tenure rights revert to the original kema and vike. After huihui land/marine ownerships rights can then be inherited matrilineally. Kema and vike membership are fixed, there are no social processes to change clan and sub clan membership.

Marriages usually results in people living in locations away from where they have primary land and marine tenure rights. This distance ranges from the

next village (≥ 1km) to other parts of Nggela (maximum 45km). Relocation due to marriages could now also be to other islands in Solomon Islands or to urban areas. This arises because marriages normally involve the presentation of bride price by the groom to the bride's family, after which a bride relocates to her husband's village (viri-patrilocal residence). Descendents also end up living in a location away from where they have ownership rights; it is quite common for descendents to relocate back to their mother's former residence (if more than 3 generations, may be subjected to proof, by knowledge of the unilineal matrilineage). There are cases however where the husband moves to the bride's village (uxorilocal residence), hence avoiding such problem.
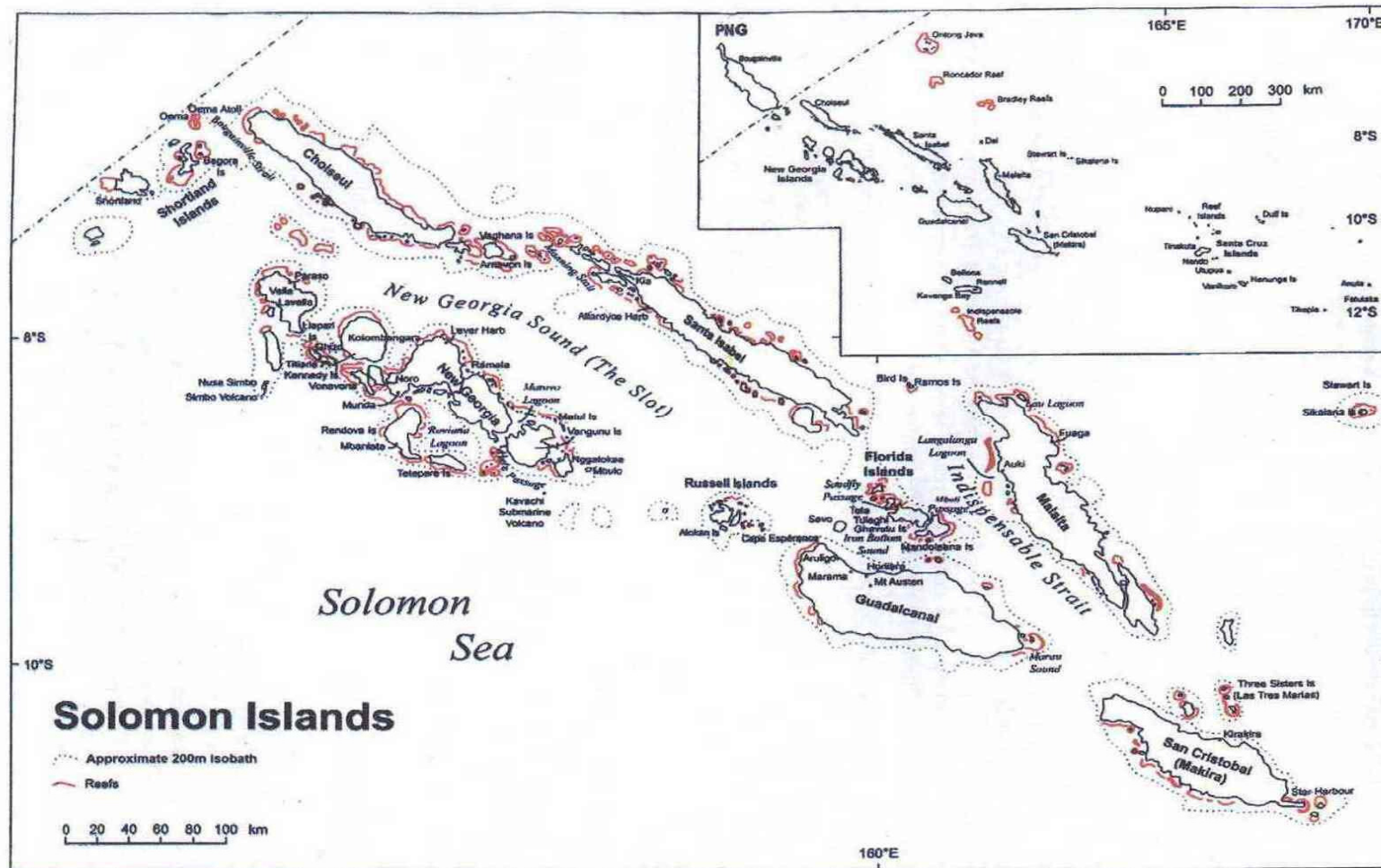
Figure 1.5: Map of Solomon Islands (from Sulu et al. 2000)
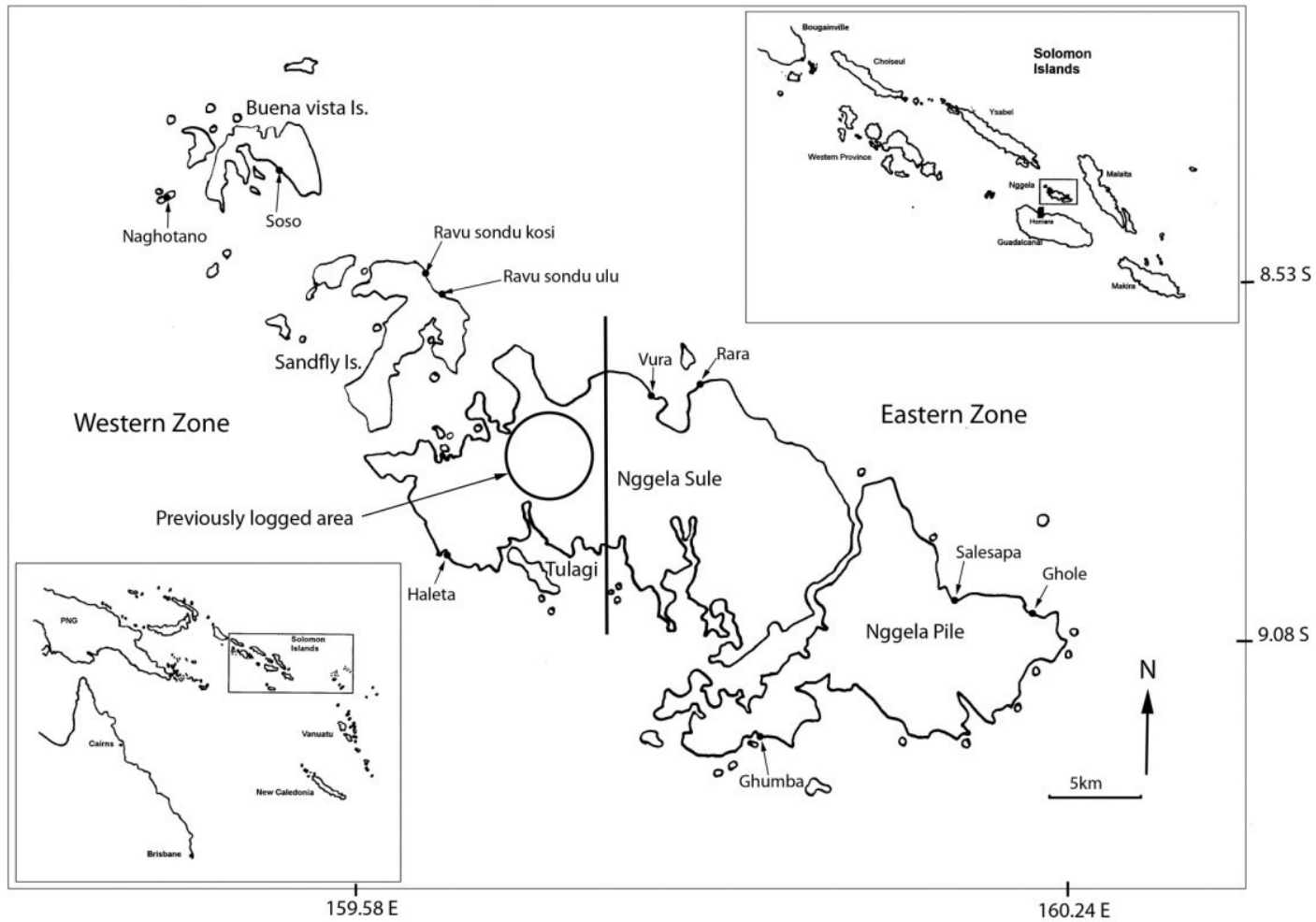
Figure 1.6: Map of Nggela, inserted maps showing Solomon Islands in relation to East coast of Australia and Nggela within Solomon Islands (Foale 1999). Vertical line is demarcation of Western vs Eastern Zone of Nggela.

Figure 1.7: A typical Nggela thatched roof house at Ghole village.
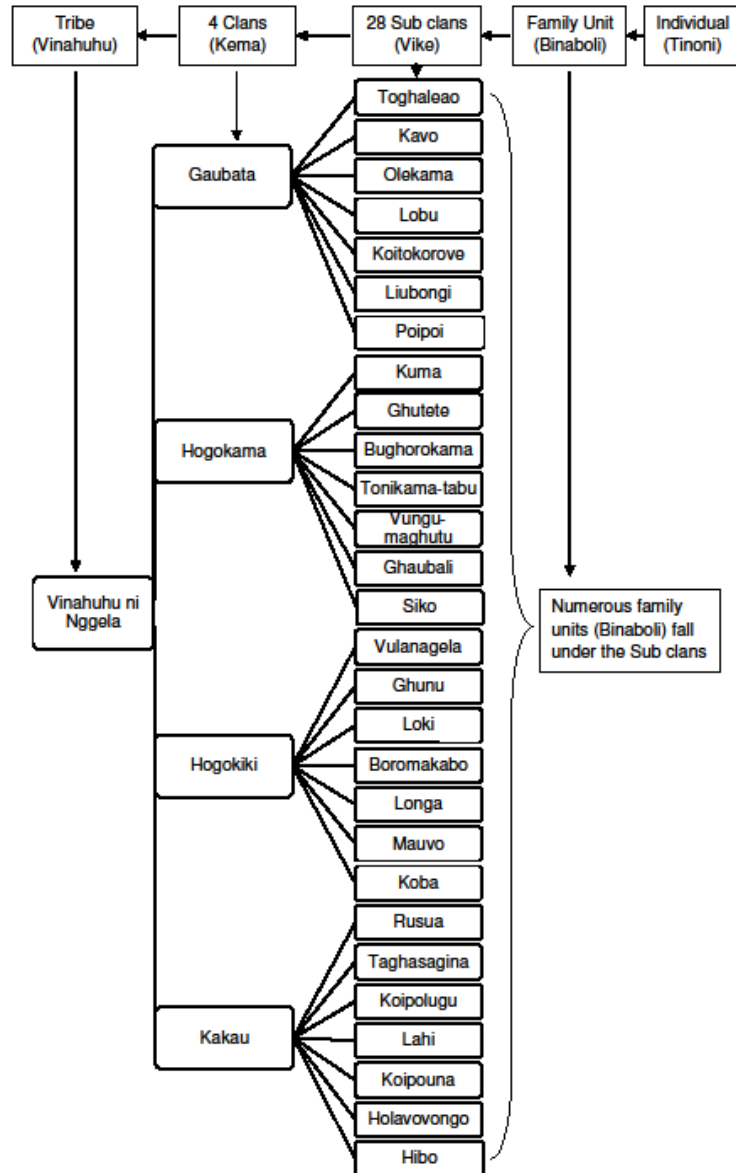
Figure 1.8: Social structure of Nggela society

CHAPTER 2

FISHERIES AND LIVELIHOODS AT NGGELA

Abstract

The sustainable livelihoods approach was used to investigate the social drivers of fishing activities in Nggela. Among the many livelihood activities (e.g. subsistence gardening, fishing, selling of betel nut etc.) that fishers were engaged in, subsistence gardening was the most important, 100% of sampled households were engaged in subsistence gardening. Although fishing was important for subsistence purposes, the enhancing role of the esky operators who act as middlemen in the villages made fishing especially important for income generation. The income generation role of fishing was an especially important driver for fishing in the western zone of Nggela where available natural land capital was narrower than in the eastern zone.

2.1   INTRODUCTION

Coral reef fisheries (CRF) play an important role in the livelihoods of South Pacific coastal communities for subsistence and income generation (Dalzell et al. 1996; Gillett 2000; World-Bank 2000; Gillett and Lightfoot 2001; Kronen 2004; Kuster et al. 2005; Labrosse et al. 2006; Sabetian and Foale 2006; Kronen and Bender 2007; Bell et al. 2009). High socio-economic dependence on fisheries is common and can have dire consequences for coral reef ecosystems, (Veitayaki and South 2000; Bellwood et al. 2004; Newton et al. 2007) impacting their ability to sustain the quality and quantity of ecosystem goods and services they provide (Moberg and Folke 1999). A majority of interviewees in Fiji, Palau, Samoa, Solomon Islands and Tonga, perceived a declining trend in the CPUE of marine resources productivity between 1989 and 1999, this was attributed to increased livelihood demands and the need for cash income (World-Bank 2000). These communities expressed a desire for external assistance in the management of their resources (World-Bank 2000). Effective management requires an understanding of the way people interact with their natural resources through their livelihoods. Management regimes which are premised on an incomplete understanding of livelihoods can result in management actions incompatible with both resource conservation and the social and economic goals of management (Allison and Ellis 2001). It is

therefore important to understand the way societies interact with their environment besides an ecological understanding of the exploited species (Hughes et al. 2005). Interactions with fisheries resources through livelihoods may differ significantly between locations and for many societies it is still poorly understood (Hughes et al. 2005; Cinner et al. 2009a).

Within the South Pacific, the level of dependence on small-scale fisheries varies between locations and is affected by factors such as: (1) the availability of cultivable land (Foale 2005; Kronen and Bender 2007); reliance is high on small islands which do not have sufficient land to develop significant agricultural activities (Cinner et al. 2005a; Foale 2005; Labrosse et al. 2006) while it is lower on larger islands with sufficient agricultural land (Huber 1994); (2) access rights and rules governed by local social and cultural institutions (Aswani 2005; Cinner et al. 2005b; Bender 2007); (3) local social dynamics and expectations (Bender et al. 2002); (4) local demographic dynamics (Kuster et al. 2005) and (5) access to market and trade opportunities (Jennings and Polunin 1996; Cinner and McClanahan 2006b; Turner et al. 2007). Studies to date in the Solomon Islands have highlighted the role of changing livelihoods and the influence of markets (Aswani 2002; Brewer et al. 2009) as factors contributing to finfish resource decline, but no studies have quantified the role of finfish as food and as income generating commodity as drivers of fishing using a livelihoods approach.

A livelihood may be defined as a process which seeks to draw together *"the critical factors that affect the vulnerability or strength of individual or family survival strategies"* (Allison and Ellis 2001). These comprise of the assets owned by people, *"the activities in which they engage in order to generate an adequate standard of living and to satisfy other goals such as risk reduction, and the factors that facilitate or inhibit people from gaining access to assets and activities"* (ibid:379). 'Livelihood strategies' are a suite of possible different activities that generate the means of household survival (Ellis 2000) while 'livelihood diversification' describes *"the processes by which households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living"* (Ellis 2000:15).

The complex and dynamic nature of livelihoods requires a robust and transferable analytical framework to integrate and assess a wide range of

issues associated with it (Smith et al. 2005). Allison and Ellis (2001) suggest the use of the sustainable livelihoods analysis (SLA) framework. According to Bene (2003) the SLA in its current form was devised by Scoones (1998). The SLA has been commonly used in development and poverty studies to analyse livelihoods. It has seldom been applied to fisheries studies (Allison and Ellis 2001; Charles 2001), however its versatility in generating in-depth understanding of social-ecological interactions (especially with regards to understanding the interplay between socio-economicc status, adaptive livelihood strategies and fishing patterns) has seen its recent wide use in small-scale fisheries research (e.g. Allison and Ellis 2001; Allison and Mvula 2002; Neiland and Bene 2004; Smith et al. 2005; Allison and Horemans 2006; Brooks et al. 2008; Béné and Friend 2009; Béné et al. 2009). The SLA approach is based on the understanding that individual or household assets are linked to the activities they are engaged in by mediating processes which govern their access to assets and alternative livelihood activities. The framework as adapted for use in this chapter for the analysis of fisher livelihoods is taken from Allison and Ellis (2001) and is shown in Table 2.1.

The conventional view originating from FAO (Béné 2003) which has existed in small-scale fisheries literature (e.g. Panayotou 1982; Pauly 1994; Pauly 1997) for the last 35 years is; 'fishing is an occupation of last resort' engaged in by 'the poorest of the poor' who are illiterate, lack land, capital and skills and have no other livelihood alternatives. Against this backdrop and coupled with the breakdown of traditional management regimes (which were previously barriers to open access) the poor turn towards an open access property, the sea, for their livelihood. Over time, increased population growth through offspring, new entrants from many landless farmers (Pauly 1994) and natural disasters such as droughts which reduces soil fertility and land productivity (Bunce et al. 2009) further increases the small-scale fisher population. Lack of alternatives, declining catches, poverty entrapment and occupational and geographical immobility, subsequently lead these fishers to introduce wholesale destructive fishing practices in their effort to maintain catches and income - a situation termed 'Malthusian overfishing' (Pauly 1994). The popular rhetoric is that 'fisher equals poverty' and fishers are fishers because they are poor and furthermore are poor because they are fishers,

perceptions described by Béné (2003) as the 'old paradigm' on poverty and small-scale fisheries.

Several authors (Béné 2003; Smith et al. 2005; Allison and Horemans 2006; Béné 2009; Béné and Friend 2009; Béné et al. 2009) however have recently disputed this view in the light of recent research and changes in the way poverty is defined and measured. These authors argue that it is erroneous to think that there is a direct linear relationship between poverty and fishing. Fishers do live in areas that bear all the characteristics of being poor (Béné 2003). However their poverty may not necessarily be related to fishing. Poverty is a complex phenomenon which encompasses demographic, non demographic and other social factors (Sunderlin 1994; Béné 2003; Smith et al. 2005).

Fishers are not confined to fishing only but are involved in a diversity of livelihood activities (Geheb and Binns 1997; Allison and Mvula 2002; Béné and Friend 2009) which involves switching between occupations seasonally or between years or maintaining a portfolio of livelihood activities involving different members of the household (Panayotou and Panayotou 1986; Teitze et al. 2000; Allison and Mvula 2002; Turner et al. 2007). Fishers have responded dynamically to reduced opportunities in fishing and have undertaken occupational and geographical mobility to take advantage of income differentials and opportunities (Panayotou and Panayotou 1986; Teitze et al. 2000; Allison and Mvula 2002). Fishing may enhance the livelihoods of members of poor communities, either through provision of much needed nutrition and income or as a buffer against livelihood shocks (Brooks et al. 2008; Bell et al. 2009; Béné and Friend 2009; Béné et al. 2009).

Nggela offers several opportunities for studying relationships between livelihoods and fisheries. The eastern zone of Nggela generally has more cultivable land for cash crops and other farming activities with a lot more forested areas offering a much broader natural resource base (i.e. broader livelihood platform in terms of natural capital, Table 2.1) for livelihood strategies than in the Western zone. The western zone of Nggela is quite hilly which restricts available land for cash crops like cocoa (*Theobroma cacao*) used in making chocolates and coconuts for copra production. Logging operations also occurred in the western zone of Nggela in 2000 - 2002,

removing what is left of the original forest trees, and eliminating possible reliance on forest products for livelihood. Land is even more restricted on the smaller islands of Sandfly and Buena Vista (part of the western zone of Nggela) and there is very limited forest area. Because of land restrictions, what is left of the available land on the western zone of Nggela is generally restricted to subsistence agriculture and other traditional crops like betel nut and fruit trees, the only exception being the few families (less than 5% of the population) who have more land than the general western zone populace.

Table 2.1: A framework for micro policy analysis of rural livelihoods (Allison and Ellis 2001:379)

A	B	C	D	E	F
Livelihood platform	Access modified by	In context of	Resulting in	Composed of activities	With effects on
Natural capital e.g. land, water, fish stocks, forest.	**Social relations** Gender Class Age Ethnicity	**Trends** Population Migration Technological change Relative prices Macro policy National economic trends World economic trends		**Natural resource based activities** Fishing Cultivation (food) Cultivation (non-food) Livestock Nonfarm natural resources	**Livelihood security** Income level Income stability Seasonality Degrees of risk
Physical capital e.g. infrastructure, tools, boats, building.					
Human capital e.g. skills, knowledge, health.	**Institutions** Rules & Customs Land & sea tenure Markets in practice		**Livelihood strategies**		
Financial capital e.g. income flows, savings, credit.		**Shocks** Storms Recruitment failures Diseases Civil war		**Non natural resource based activities** Rural trade Other services Rural manufacture Remittances Other transfers	**Environmental sustainability** Soil and land quality Water quality Fish stocks Forests Biodiversity
Social capital e.g. kinship networks, association, trust and access to wider institutions.	**Organisations** Associations NGOs Local administration State agencies				

Nggela is comparatively homogeneous vis-à-vis traditional governance, customary practices, land and marine tenure system, farming practices, religion (99% are Anglicans) and language. This homogeneity means that social-cultural influences on any spatial differences on livelihood strategies are likely to be relatively small.

The aim of this chapter is to investigate the way people interact with coral reef finfish fisheries and hence the factors driving fishing through analysis of livelihoods of small-scale fishers in Nggela (Solomon Islands). The specific objectives are: (1) To document and quantify the contributions of reef finfish fisheries in the economy and livelihoods of small-scale fishers; and (2) To investigate the roles of fish as food and as an income generating commodity, drivers of fishing, by comparing livelihood strategies between the eastern and western zone.
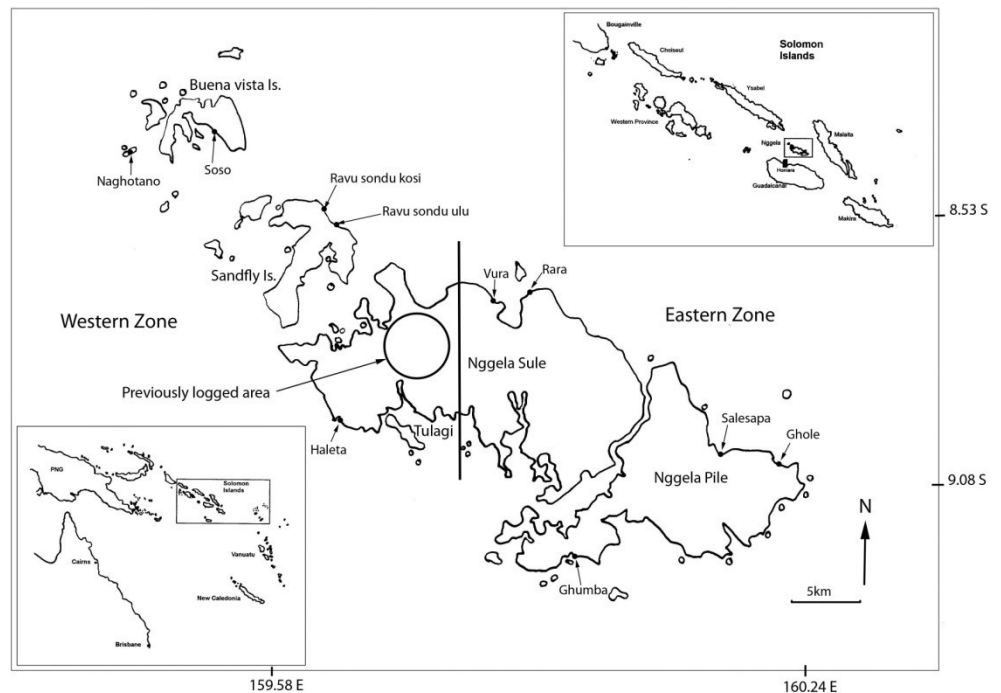
Figure 2.1: Diagrammatic map showing the 10 villages where interviews were conducted in Nggela. No interviews were conducted at Tulagi.

2.2 METHODOLOGY

2.2.1 Household surveys and key informant interviews

Fisher household surveys and key informant interviews were conducted in 10 randomly selected communities in Nggela (5 from the eastern and 5 from the western zone, Figure 2.1), Solomon Islands between 27 November 2007 and 30 April 2008. The fishers were selected based on the recommendations of village elders as well as by snowball sampling (Cinner and McClanahan 2006b) based on respondents recommended by the interviewees. The questionnaire (Appendix 1) was designed to collect information on the different possible livelihood activities and expenditures as listed in Table 2.2. In addition other household information collected was: household composition and size and whether the fisher was originally from the community concerned. Interviews were conducted at any time of the day whenever the interviewees were available. All interviews were conducted in the local language (Nggela), with the head of households (who were all males) and where possible in the company of their spouses who also contributed to the responses. A total of 93 fisher interviews were conducted (27% of all the fishers in all the 10 sampled villagers); 50 were from the eastern zone (30% of fishers in the 5 eastern zone villages) and 43 were from the western zone (21% of fishers in the 5 western zone villages) of Nggela (Table 1.1).

The level of reliance on the percentage of fish catch which was consumed was calculated from the data on fish catch proportions consumed and sold; self consumption rate was the proportion of catch consumed. Dependence levels on fishing for income were determined by calculating the proportion of total weekly fishing income as a percentage of total weekly household income (%), based on methods of Béné et al., (2009). The measure of central tendency used for measuring absolute income was median rather than the mean weekly income because Solomon Islands income data were expected to be asymmetrical and non-normally distributed; median would be a better reflection of income central tendency than the mean. The use of the mean would inflate average income above what was normally the average rural income in Solomon Islands as it was skewed towards the higher levels by the few 'rich people' (Solomon Islands Demographic and Statistics Office pers.com). For all other measures besides absolute income (e.g. household

sizes, labour distribution, income dependence levels (%) on fishing, etc) median was also used as a measure of central tendency due to the non-homogenous and non-normal nature of the data.

Besides the fisher household interviews, an additional 20 key informant interviews were also conducted with elderly members of the communities to generate background information on the social, economic and institutional characteristics of the communities and the seasonal organisation of fishing and other livelihood activities (Table 2.3).

Table 2.2: Information collected from fisher household interviews
-Types of livelihood activities engaged in
-Frequency of engagement in the activity per week, in the case of fishing frequency in months per year as well.
-Number of household members involved in the respective activity
-Weekly income derived from the activity if it generates income
-Proportion consumed also called self consumption rate (in the case of fishing and farming products, includes giveaways to relatives for consumption)
-Proportion sold (in the case of fishing and farming products)
-Household fortnightly expenditure (food, energy, clothing, tobacco, occasional family obligations, school, fishing and farming inputs, transport, community/church contributions and alcohol)

Table 2.3: Information collected from key informants
-What is the total population of this community
-How is the community organised and what social institutions exist in the community
-Where is the nearest school or health centre
-Who are the fishers in the community
-What are the main seasons in the year and how is farming, fishing and other activities organised generally around these seasons
-What are the main livelihood activities that could be considered as general for the community
-How accessible is it for people in this community to get to the main capital, Honiara to sell fish or farm products.

2.2.2 Statistical analysis

The statistical package SPSS was used to analyse quantitative data (e.g. household incomes). Levene's test and Q-Q plots were used to test for homogeneity of variance and normality. Since the data were non-homogenous and non-normal, non-parametric procedures were employed. The Kruskall-Wallis test was used to compare, number of household occupations, income between the different occupations and income groups. The Mann-Whitney U test was used as a post hoc test. Statistical significance level of $p < 0.05$ was used to detect differences. Bonferroni correction was applied to multiple tests to reduce the chance of type 1 error (Cinner et al. 2005b; Turner et al. 2007).

2.3 RESULTS

2.3.1 Livelihood seasons and resources.

Fishing and livelihood activities are organised around two main annual climate systems affecting the island group; the southeasterly trade winds (*Ara*) that blow from April to August and the northwesterly monsoon winds (*Koburu*) that blow from September to March. According to fishers the Koburu period is the main fishing season. During this period, the weather is generally calmer, the sea is generally darker and microalgae *(lumi)* sticks on to the paddles. Fishing frequency is especially high during Koburu and more especially when middlemen operate in the villages to buy fish to be sold in Honiara

Farming practice employed in Nggela is swidden agriculture. The food gardening season (GDN) is between May-August. Normally two sets of food gardens are made per year; the first set of gardens are cleared and planted in May/June and harvested in December, while the second set of gardens is cleared and planted in July/August and harvested in March/ April; harvesting normally occurs over 2-3 months rather than as a single harvest. The first staple crops planted are the yams *Dioscorea alata (uvi)* and *Dioscorea esculenta (pana)*. After the first harvest, the gardens are replanted with yams and following the second harvest the third crops planted are either sweet potatoes (*Ipomoea batatas*) and/or cassava (*Manihot esculenta*). Following the third harvest, the cleared land is left for fallow. Other food crops which are also

cultivated together with the staple crops are: several varieties of bananas and plantains (*Musa* sp.), pineapple (*Ananas comosus*), taro (*Colocasia esculenta*) and bush hibiscus spinach (*Abelmoschus manihot*).

Marine resources which occur in seasons and were also relied upon when in season for consumption and income generation are: polychaete worm *odu* (*Eunice viridis*) which occurs during October/November and the land crab *kakau* (*Cardisoma hirtipes*) which is harvested when it migrates for spawning in December and February. Fruits which come into season between October and February which are either consumed or sold for income are; the native apples *sagau* (*Syzygium samarangense*), mangoes locally called *kola*, (*Mangifera indica*) and golden apples locally called *kaio* (*Spondias dulcis*). The nut tree locally called *ngali* (*Canarium indicum*) a traditionally important nut for traditional cuisines has become an important cash crop in recent years. Commonly cultivated cash crops are coconuts (*Cocos nucifera*), betel nuts (*Areca catechu*) and cocoa (*Theobroma cacao*). Copra and cocoa are produced and sold all year around. The main betel nut harvesting and selling season is November/December and April/May with smaller quantities harvested and sold all year around.

2.3.2 Livelihood strategies of fishers on Nggela

Fishers relied on a minimum of 2 up to a maximum of 7 livelihood activities per household (Figure 2.2). The different livelihood activities were subsistence agriculture (GDN), fishing (FSH), selling of betel nut (BTL), seasonal employment (EPL), mixture of seasonal/opportunistic activities (OTH), production of copra (CPR), village store trading (STR), selling of trochus (*Trochus niloticus*) (TRK), timber lumbering (TMB), selling of cocoa (COA) and selling of Beche-de-mer (BDM). Median number of occupations per household in the eastern zone was 4 while in the western zone it was 3. The number of occupations was significantly greater in the eastern zone than the western zone (Mann-Whitney U test P = 0.024). According to the western zone informants, cocoa (COA) and copra production (CPR) were uncommon activities in the western zone. These livelihood activities were engaged in by a very small number of families who had surplus land to accommodate the crops

involved. Timber lumbering was not done in the western zone due to the limited availability of rainforest trees to support it.

For both the east and western zone, subsistence agriculture and fishing were the main livelihood activities and ≥80% of the interviewed households relied on them (Figure 2.3). More than 58% of households in both zones also depend on the sale of betel nut. Forty percent of households were employing an array of activities categorised as others (OTH), which though not regular were opportunistic and seasonal in nature to support households either as a source of food or income. Examples of such activities were: carving; sale of terrestrial wildlife such as birds (several species) and reptiles (snakes, lizards and skinks); production and sale of lime (produced from burning of Acropora corals and used in chewing betel nut); sale of seasonal resources such as land crab (*Cardisoma hirtipes*), nuts or fruits; petty trade of commodities such as noodles bought from urban centres; sale of shark fins obtained during fishing trips and occasional selling of home baked buns, doughnuts and bread. The proportions of households participating in the sale of beche-de-mer or trochus and conducting store trade were relatively similar between zones (Figure 2.5).
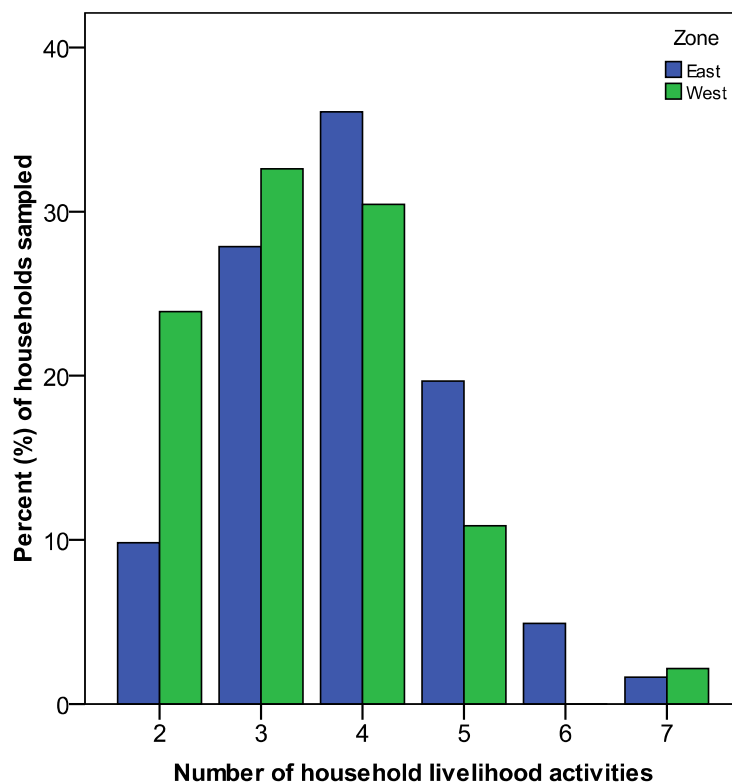
Figure 2.2: Histogram showing number of livelihood activities per household in the eastern and western zones of Nggela (East-n=50, West-n=43).

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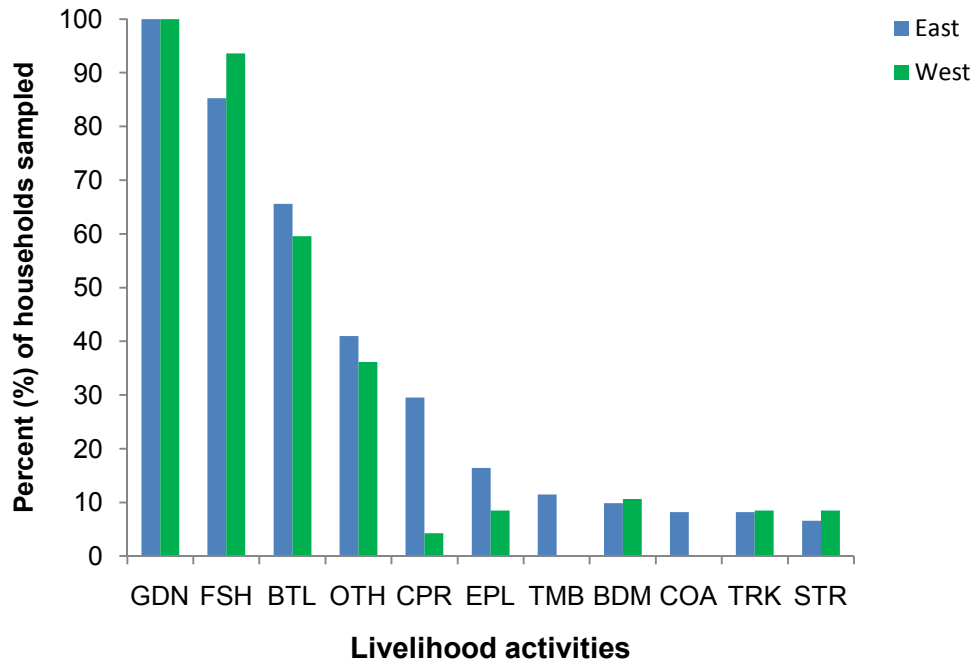
Figure 2.3: Histogram showing household participation in the different livelihood activities. GDN=Subsistence agriculture, FSH=Fishing, BTL= Sell betel nut, EPL=Seasonal employment, OTH=Mixture of seasonal/opportunistic activities, CPR=Copra, STR=Store trading, TRK=Sell trochus, TMB=Timber lumbering, COA=Cocoa, BDM=Beche-de-mer.

2.3.3 Household labour distribution between different livelihood activities

Household sizes ranged from a minimum of 2 to a maximum of 11 people (see Figure 2.4). Median household size in the eastern zone was 6 and in the western zone it was 5, which did not differ (Mann-Whitney U test P>0.05). Household membership composition was as follows: (1) small households comprising only two people who were either a newly married couple or an elderly couple whose children had established their own households or had moved to another location (mostly urban centre to work); (2) households of 3-11 people composed of: one adult and his/her children (where the spouse had died), two adults and the remaining being their children, or parents with their married children and grandchildren still living with them, or a family headed by an adult with his wife, children and elderly parents (or parent) living with them. Household members might not all be necessarily living in the same house. Single men, elderly parents or recently married couples were usually living in

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separate houses, but were engaged in common activities such as food gathering and eating meals together.
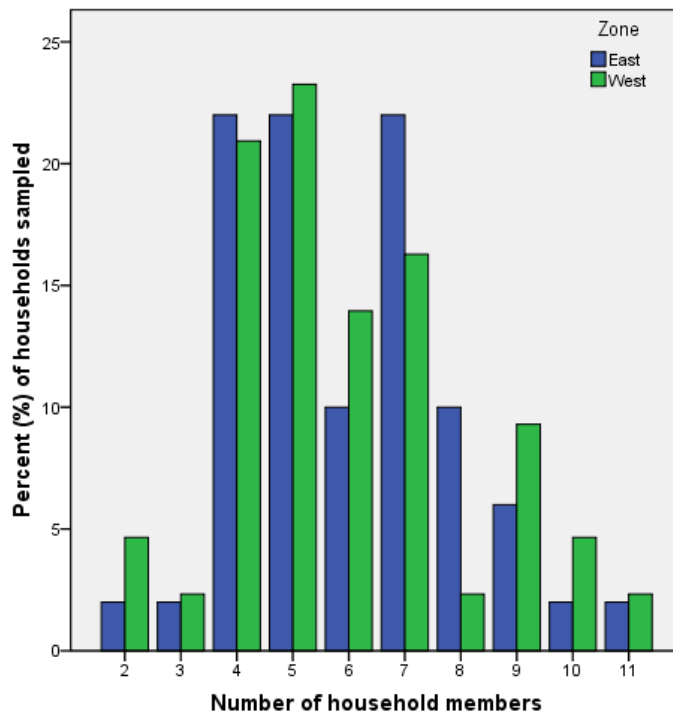
Figure 2.4: Histogram of household size (adults and children) in the eastern and western Zone.
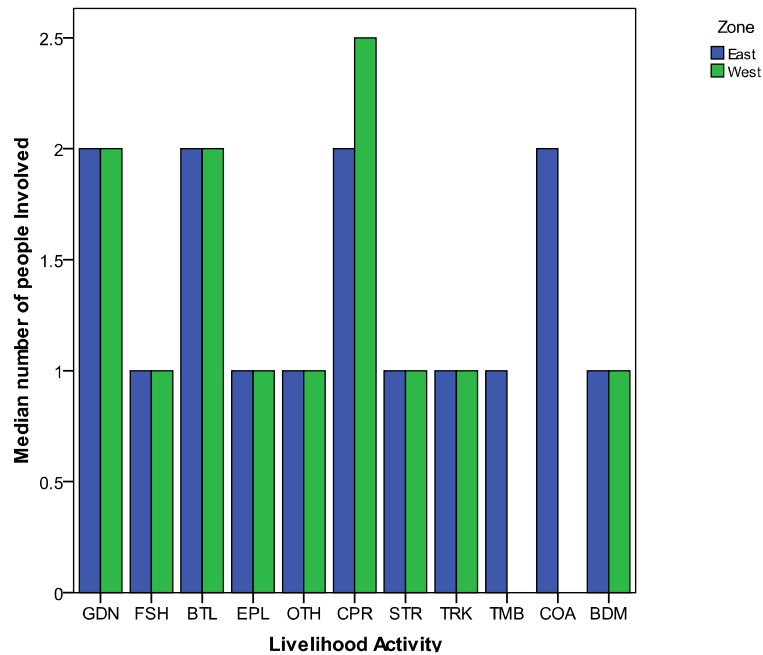
Figure 2.5: Histogram of median number of people involved per livelihood activity in Eastern and Western zone. GDN=Subsistence agriculture, FSH=Fishing, BTL= Sell betel nut, EPL=Seasonal employment, OTH=Mixture of seasonal/opportunistic activities, CPR=Copra, STR=Store trading, TRK=Sell trochus, TMB=Timber lumbering, COA=Cocoa. BDM=Beche-de-mer

There was greater allocation of household labour effort to land-based activities than to fishing or other marine-related activities. Subsistence agriculture had the highest median labour allocation with a median involvement of 2 people per household in both the zones (Figure 2.5). Other activities with similar levels of labour allocation were harvesting and sale of betel nut for both regions, and for the eastern zone only, cocoa and copra production. The number of people in any particular activity did not differ significantly between zones (Chi square test P>0.05)

Subsistence agriculture involved the participation of both male and female members of the household, albeit in gender specific roles. Men were more involved in the clearing and sowing phase of subsistence agriculture during May - August, after which they shifted their efforts to other land-based activities such as tending cash crops, income generating activities such as lumbering, other household activities or fishing. The women were involved in the sowing, maintenance and harvesting.

For both zones, fishing related activity was on average conducted by only one person per household. In 9 out of the 10 sampled communities, fishing was restricted to males. The only exception was the village of Naghotano on the western zone which is situated on a $0.12km^2$ (600 x 200m) island, where females and individuals as young as 12 years were also actively participating in fishing activities. Compared to other communities, in Naghotano there are at least 2 fishers per household.

2.3.4 Contribution of different livelihood activities to household cash economy

Weekly individual household income for both zones in the study site varied widely from a minimum of SBD$30 per week to a maximum of >SBD$2000 per week (Table 2.4). Median weekly household income in the eastern zone was SBD$240 per week while in the western zone it was SBD$172 per week, however these did not differ significantly (Mann-Whitney U test P=0.094). All sampled households (100%) depended on subsistence agriculture as the main food source; 38% of households in the eastern zone and 37% in the western zone were reserving farm products (mostly yams and

sweet potatoes) for household consumption only, not selling them to generate income. Sixty one percent of the households in the eastern zone and 63% of households in the western zone were farming for consumption as well as sale of farm products to generate income. Median weekly income from sale of farm products was lower than for other livelihood activities in both zones (Table 2.5 and 2.6) as it was mostly surpluses that were being sold. Median weekly income from farm products in the east was SBD$12.5 and the western zone SBD$10.0 which did not differ (Mann-Whitney U test P=0.15). However, the income from farm products in the eastern zone was much more dispersed (the range of income in the eastern zone was greater than in the western zone), with the maximum income being 3 times greater than in the western zone. In both zones, the proportion of those who were fishing for consumption only was much lower than those farming for consumption only; indicating that fish was possibly playing a more important role in the cash economy than farm products. Twenty four percent of households in the eastern zone fished for consumption only while 76% fished both for consumption as well as to generate income. In the western zone, only 7% of sampled households fished for consumption only, while 93% fish both for consumption as well as to generate income (Table 2.7).

The number of months per year per household allocated to fishing was similar between the two zones (Mann-Whitney U tests P=0.33). Respondents in both zones stated that they normally increased their fishing effort during the *Koburu* season (September – March). While fishing may be conducted outside this period (the *Ara* season), it does so on a reduced level due to diversion of efforts into agricultural activities, the sowing period being May-August. Furthermore, according to respondents, favourable weather conditions for fishing were also reduced outside the *Koburu* period. However when considering the average fishing days per week, there was a difference (Mann-Whitney test, P=0.021) between the zones; fishers in the western zone were fishing more frequently (mean 3.5 d per week) than fishers in the eastern zone (mean 2.8 d per week).

Fishers in the western zone were selling larger proportions of their catch (Table 2.7) than eastern zone fishers (Mann-Whitney test, P<0.05). Median weekly income from fishing for both zones was SBD$100 per week (Mann-Whitney U tests P=0.167) (Tables 2.5 and 2.6), which was the highest among

the different livelihood activities. Most fishers in the villages were selling their catch to village middle men (the esky operators – see Figure 2.6, 'esky' is the pijin english term for insulated ice cooling boxes used to store and transfer fish from villages to fish markets in urban areas) who fish as well as buy fish in the villages to resell in the main capital. The maximum incomes of SBD$1500 - 2000 per week for fishing (Tables 2.5 and 2.6) were those of esky operators.

Median weekly income from betel nut sales and opportunistic/seasonal activities (OTH) was similar between the zones. Sale of betel nut for both zones generated a median income of SBD$20 per week while that of 'Others' (OTH) was SBD$15 per week. The highest weekly median income of SBD$500 for 'Others' in the western zone was by a farmer-fisher/esky operator who was also actively involved in the sale of wild reptiles and birds.

Seasonal employment in the construction industry in the main capital Honiara contributed a median income of SBD$60 per week for the eastern zone (Table 2.5). In contrast, the contribution of seasonal employment to household income was lower (SBD$20 per week) in the western zone, only one respondent being involved in seasonal employment which involved building of houses in the local community (Table 2.6). Timber lumbering (eastern zone only) and trade store (for both zones) commanded higher incomes, however, household participation in these activities was low (Table 2.5 and 2.6). The requirement of capital was an entry barrier, timber lumbering requiring the purchase of a chain saw which costs approximately SBD$23,000. Trade store ownership normally requires more capital than most fishers can afford, to pay for the costs of a provincial trading licence and goods for sale. The returns from copra, although seemingly high (median income SBD$47 per week), attracted only modest household participation. Respondents stated that the returns from copra were quite low for the considerable amount of effort required to produce them. At the time of research copra prices were declining (from SBD$3.50 to 2.00 per kg), some respondents in the eastern zone stating that they had abandoned copra production and had spent more time fishing to generate income.

Although they command high prices at the urban centre beche-de-mer and trochus involved only 9-11% of households and generated weekly median income contributions of SBD$10-20 per week (Table 2.5 - 2.6). According to

respondents, these commodities were generally depleted in accessible reefs hence they were being sold only in small quantities by skilled breath-holding free divers who were able to collect them from deeper reef areas.

In the eastern zone, median weekly income from fishing (SBD$100) was generally similar to that for all other activities (SBD$113) combined (including beche-de-mer and trochus). However in the western zone, median weekly income from fishing (SBD$100) was twice that from all activities combined (SBD$56).

Table 2.4: Weekly household income (SBD$) for fishers in Nggela

Zone	Median	Minimum	Maximum	Range	Standard Deviation
East (N=50)	240	30	2000	1170	376
West (N=43)	172	50	2575	2525	507

Figure 2.6: An esky operator (centre) at Haleta village packing fish with ice while other community members look on.

Table 2.5: Weekly household income contribution from different livelihood activities in the Eastern zone (n=50).

Livelihood activity	% of sampled households engaged	Median weekly income (SBD$)	Mean weekly income (SBD$)	Minimum Weekly income (SBD$)	Maximum Weekly income (SBD$)	Standard deviation (SBD$)
Agriculture	100	12.5	60.3	0	300	82.4
Fishing	100	100	181.3	0	2000	320.5
Betel nut	66	20	41.1	2	192	44.9
Others	34	15	37.4	3	153	45.4
Copra	32	47	46.2	8	129	30.8
Employment	14	60	145.6	4	500	176.9
[1]Bch-d-mer	12	21.5	23.6	5	58	19.5
Timber	12	96	245.2	50	769	288.4
Trochus	8	15	30.6	2	100	39.7
Cocoa	6	15	20.3	8	38	15.7
Trade store	4	275	275	50	500	318.2

Table 2.6: Weekly household income contribution from different livelihood activities in the Western zone (n=43)

Livelihood activity	% of sampled households engaged	Median weekly income	Mean weekly income	Minimum Weekly income	Maximum Weekly income	Standard deviation ($SBD)
Agriculture	100	10	19.4	0	125	25.8
Fishing	100	100	225.8	0	2000	367.9
Betel nut	58	22	34	2	100	29.9
Others	37	15	80.5	2	500	139.8
Bch-d-mer[1]	11.6	70	52	10	80	34.2
Trochus	9.3	9.5	12.8	2	30	12.4
Trade store	6.9	400	333.3	100	500	208.2
Copra	4.7	48.5	48.5	40	57	12.0
Employment	2.3	20	20	20	20	0

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[1] This should be Beche-de-mer, it was shortened so that the table is not distorted

Table 2.7: Proportions of fish catch sold and consumed

	East (n=50)	West (n=43)
Percentage of households selling part or all of their catch (%)	76.0	93.0
Median (±SD) proportion of catch sold (%)	70.0 (±34.6)	90.0 (±22.67)
Median (±SD) proportion of catch self consumed (%)	30.0 (±34.6)	10.0 (±22.67)

2.3.5 Livelihood diversification and household cash income

Analyses were conducted to determine how the degree of livelihood diversification was related to household cash income and household income dependence on fishing. Since there was no significant difference (Mann-Whitney test P=0.094) detected in the total weekly household income between zones, the data for both zones were pooled. Household median weekly income (Table 2.8) was significantly different among the number of livelihood activities (degree of livelihood diversification) (Kruskal-Wallis test, $H_{(4)}$=16.6, P<0.05). Jonckheere-Terpstra test for trends revealed a significant trend in the data; the degree of livelihood diversification (number of livelihood activities) was positively related to household income (J=1877, z=1.77, r =0.18), however household income dependence on fishing was negatively related to livelihood diversification (J=1621, z=-6.48, r=-0.67). Those with lower livelihood diversity had a higher dependence on fishing for their household income and vice-versa (Figure 2.7). Dependence of household income on fishing differed between degrees of livelihood diversification (Kruskal-Wallis test, H(4)=37.5, P<0.05).

Table 2.8: Household median weekly income grouped by number of livelihoods

	Number of livelihood activities				
	2	3	4	5	6+
East					
Group size (n)	5	13	18	10	4
Median weekly income (SBD$)	200.0	315.0	208.0	255.5	692.5
West					
Group size (n)	10	14	13	5	1
Median weekly income (SBD$)	137.5	178.0	152.0	302.0	622.0
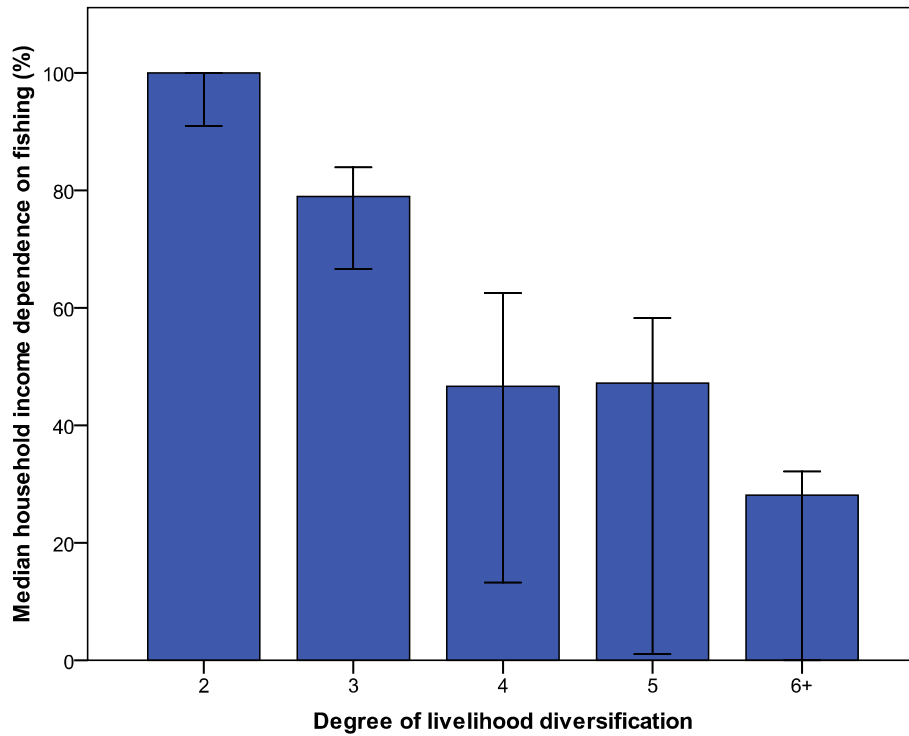
Figure 2.7: Histogram of number of livelihood activities against household dependence on fishing for income

2.3.6 Relationship of fishing to household cash income

To determine the role of fishing on household cash income and fish subsistence, households were grouped according to income quartiles; Q1 being the lowest income quartile and Q4 the highest income quartile. There was no difference in income quartiles between zones (Chi-square test P=0.258), hence data for both zones were pooled for the analysis. Weekly income differed between the 4 income quartiles (Kruskal-Wallis test, $H_{(3)}$=86.23, P<0.05), however there was no significant difference in the dependence of household income on fishing between income quartiles (Figure 2.8) ($H_{(3)}$=0.74, P=0.87).

2.3.7 Household expenditure

Household expenditures did not differ significantly between zones (Mann-Whitney test, P=0.22) hence expenditure data for both zones were pooled. Half the household expenditure was on basic necessities such as food items, fuel energy (kerosene for lighting and batteries for torches and transistor radios)

and clothing (Figure 2.9). The next 40% of household expenditure (after basic necessities) was quite equally divided between school expenses, occasional social obligations, tobacco, transport costs, household items, fishing and farming inputs. Alcohol on average constituted 4%, while community and church contributions amounted to 3% of the household expenditure.

Those in the lowest income bracket (Q1) spent relatively more of their expenditure on basic necessities (food, energy costs and clothes), tobacco, household items, farming & fishing inputs, compared to the higher income brackets (Table 2.9). The higher income quartile groups spent a higher proportion on education (school) compared to the lowest group (Q1). Transport expenditure increased positively with increased income (Table 2.9). Major components of these costs were: (1) outboard motor fuel for fishing and transporting fish to be sold in Honiara and, (2) inter-island boat fares and freight. Since these transport costs were associated with income generation, then they could be considered to be investment costs and hence, 18% of expenditure for the highest group (Q4) spent on transportation was invested on income generating activities. For the lower groups (Q1-Q3), transport costs were limited to essential travel, usually to seek medical assistance at the provincial centre clinics or Honiara.
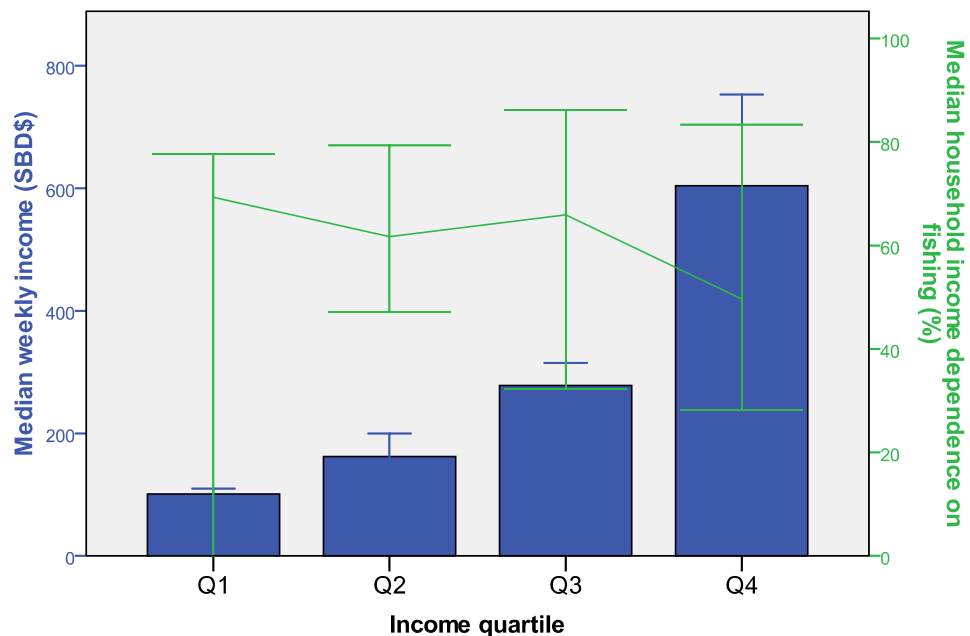
Figure 2.8: Percentage contribution of fishing to total household income per income quartile (n=93). Q1 = lowest quartile, Q4 = highest quartile

There appears to be different investment strategies between those in the lower income quartiles (Q1-Q2) and those in the higher income quartiles (Q3-Q4). Those in the lower income quartiles were spending more in farming and fishing input to enhance income generating potential, the income being then diverted to purchase household items (bedding, utensils and implements) to better their quality of life. Possible factors contributing to the relatively low expenditure on education (school) by those in the lowest income quartile (Q1) were labour requirements for farming and the non-availability of surplus cash to pay for school fees. The richer households were more able to afford the costs of education. Furthermore, the richer households who already had the necessary tools and equipment spent relatively little on 'household items, fishing & farming inputs' and more on the running costs of livelihood activities such as fishing, in order to maintain or enhance the ability to generate household income.

Besides the basic necessities and investments (either directly as running costs in a livelihood activity, future potential in the case of education or social insurance via contributions to family or community obligations), tobacco was consuming an average of 9% of the household expenditure across all income quartiles. Tobacco expenditure could be an important driver for income which in turn could be a driver for fishing. Some respondents expressed that on many occasions they fished purposefully to get income to be able to buy tobacco.
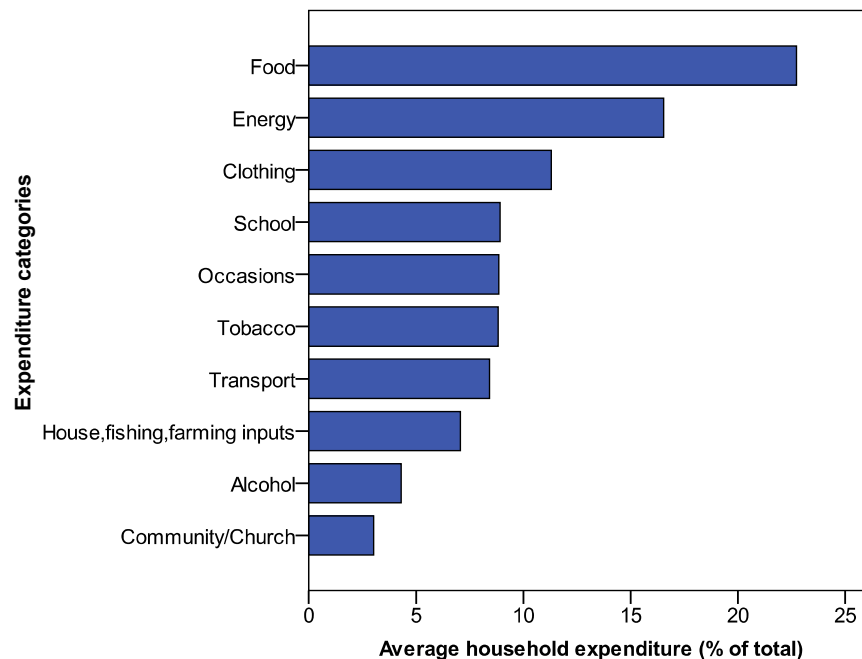
Figure 2.9: Aggregated household expenditure patterns (n=93)

Table 2.9: Average household expenditure (% of total) by income quartile

	Income quartiles			
	Q1 (n=23)	Q2 (n=23)	Q3 (n=24)	Q4 (n=23)
Food	24.0	22.5	23.0	21.4
Energy	19.2	16.6	16.2	14.2
Clothing	14.5	8.9	11.7	10.1
School	6.0	11.5	8.1	10.1
Occasions	9.0	7.7	11.5	7.0
Tobacco	11.3	8.9	8.9	6.4
Transport	2.7	6.1	6.9	18.0
Household, fishing & farming inputs	8.8	7.8	7.1	4.6
Alcohol	1.0	7.1	3.4	5.6
Community/Church	3.5	2.9	3.2	2.6
Total	100	100	100	100

2.4   Discussion

The Nggela economy is predominantly a subsistence economy; those who engage in small-scale fishing, undertake it as one among a diverse set of livelihood strategies. Subsistence agriculture (farming) is the most important activity as it provides the most secure source of food; not only for daily subsistence needs but for traditional activities, ceremonies and social reciprocal exchanges and obligations. This was revealed by a high household participation in subsistence agriculture compared to other livelihood activities and much higher household labour allocation. Fishing and other livelihood activities where they were ranked as the most important were usually positioned alongside farming. Hence, Nggela fishers could be more appropriately called 'fishing-farmers' (Geheb and Binns 1997; Béné et al. 2009).

Besides serving subsistence purposes, fishing was especially important for income as it generated higher weekly income compared to farm or forest products. In addition, there was a high percentage of households fishing for 'consumption and income' than to those fishing for 'consumption only', and a relatively high proportion of catch (70%) sold. In fact fishers sold all of their catch where possible and only retained for consumption the small fish or those that were not marketable. All the key informants (100%) expressed the view that the facilitating role of the 'esky operators' who serve as middlemen in the villages has resulted in the shift from purely subsistence fishing to artisanal fishing, hence an increasing role of fish as a cash commodity. This would be consistent with other areas in the Solomon Islands (Sabetian and Foale 2006) and the South Pacific (Jennings and Polunin 1996; Cinner and McClanahan 2006b).

The role of fish as an important cash commodity is enhanced by several factors. Firstly, accessibility of the markets in the main urban centre (Jennings and Polunin 1996; Brewer et al. 2009) and the role played by the 'esky operators' have made it possible for ordinary fishers without capital to participate in the activity. Hence, fishers without capital but able to buy hook and fishing line and having a dugout canoe (usually borrowed from relatives if it is not owned) can participate in fishing for immediate income. The participation of other fishers is also beneficial for the esky operator as s/he will be able to fill an esky within a short period of time (usually 1-4 days) and be able to sell fresh fish at a higher price in Honiara. Brewer et al (2009) stated that price is independent of species, freshness being the main determinant of price. However, I observed that freshness being equal prices varied among finfish species; the Serranidae species and *Scomberomorus commerson* (king fish) commanded higher prices followed by Lutjanidae species, Lethrinidae, Scaridae and then other species. The Carangidae usually commanded the lowest prices.

A second factor increasing the importance of fish as a cash commodity in the face of market accessibility is its lower seasonality compared to land-based products which generate income only intermittently. Peak farm harvests were restricted to December, March and April when surplus could be sold, at other times most farm products were retained for household consumption. Land crab (*Cardisoma hirtipes*) migration occurs between late October and December

(Foale 1999), hence the consumption or sale of crabs for income only occurs within this period. Foale (1998a) also reported that the sale of trochus is an important income generating activity in the western zone as it yields the highest cash return per unit effort, however the ease of obtaining trochus also contributes to its general scarcity on the reefs (Foale and Day 1997), lower total return (in terms of derived cash income) per individual shell per year (Foale 1998a), hence lower contribution overall to household income. Although fishing or marketing of garden produce was more effort intensive (in terms of labour input) than trochus it provided a consistently higher return during the year hence involved a higher participation as a livelihood activity (Foale 1998a), an observation that is consistent with the findings of this study. Fruit trees (mangoes *Mangifera indica*, local apple *Szygium samaragense,* golden apple *Spondias dulcis*), pineapple (*Ananas comosus*) and local nuts (*Canarium indicum*) seasons are usually between late October and late January. The main betel nut (*Areca catechu*) harvesting and selling season is November/December and April/May with smaller quantities harvested and sold all year around. According to respondents, the over-supply of land-based products when in season results in lower prices for these commodities compared to fish which has a more stable price over the year. Seasonality of fishing was alluded to above when making comparison of fishing frequency between *Koburu* and *Ara* seasons, fishing however was more continuous over the entire year compared to supply of land-based products. Hence, even when committed to agricultural activities during the sowing season that coincides with the *Ara* period, fishers still fished in the evening or selected days when weather permitted. Fish therefore offers the capacity to generate income on a daily basis all year around in contrast to land crops.

A third factor increasing the importance of fish as a cash commodity is the common property nature of fish and fishing areas. Customary tenure restrictions only apply in reef areas with a maximum distance of 50m from adjacent land or on reefs surrounding claimed islands (details in chapter 3). According to respondents, most of the reef areas adjacent to land have been over fished. Inshore reefs in Nggela have lower fish biomass compared to inshore reefs of other parts of Solomon Islands which are far from urban centres (Green et al. 2006; Brewer et al. 2009), which is consistent with observation by Cinner and McClanahan (2006b) in Papua New Guinea.

Fishing therefore occurs in more productive outer areas outside any particular social group's claims, allowing those who can to participate.

The role of fishing as an income generating commodity is more pervasive when considered in the light of available livelihood activities. Fishing frequency was high in the western zone where the number of livelihood activities was lower. Furthermore, a higher proportion of fishers in the western zone (compared to the eastern zone) were fishing for income and consumption than those fishing for consumption only. These observation indicate that: (1) fish is important for generating cash income to make up for income foregone from farm products reserved only for consumption, (2) fishing complements low land-based income generating activities, (3) fishing makes up for income shortfall in the face of a narrow land-based livelihood platform.

All fisher income groups were reliant on fishing for at least 50% of their household income. In absolute terms, this is especially important for fishers in the lower income quartiles with regards to being able to access cash income with only limited capital requirements. Expenditures reveal that although the Nggela economy was and is predominantly a subsistence economy, there was a strong reliance on the external economy for basic necessities like clothing, fuel energy, manufactured goods, food items, education and addictive items like tobacco. Modern cash is an important exchange medium in a lot of the cultural exchanges, activities and social obligations. Income acquired through fishing gives even the 'poorest people' access to income to meet the basic necessities, make improvements in their lives or participate in cultural activities and obligations. Furthermore, the low capital requirement mean that fishers (except the esky operators) can move in and out of fishing activity as a livelihood diversification strategy to reduce risk and take advantage of other favourable activities as they occur (Allison and Ellis 2001).

The total sample size for these data coupled with the fact that data were obtained mainly from interviews were possible contributing factors which may compromise the data used in this chapter. Ideally a larger sample size and corroboration of the data through recording of actual fisher household income and expenditures as and when different livelihood activities were conducted (this could have involved tracking of livelihood activities and income and expenditures of a sub-sample of interviewees over a longer time period,

possibly a year) would have given greater representation and thus confidence in the inferences. However, time constraints of this project did not allow more in-depth data to be collected over a longer period of time. Previous research with a similar approach (e.g. Bene et al. 2003; Béné and Friend 2009; Béné et al. 2009) on livelihoods has mainly relied on interview data and reported its reliability. The different social science survey methods employed (key informant interviews, informal conversations and my inside knowledge of the society), and the resultant data from different sources allow triangulation of the findings which provide a certain level of confidence that, the livelihood information was representative of rural fisher livelihoods. Regardless of the small sample size, the data provided an invaluable insight into the role of fishing in the livelihoods of fishers at Nggela.

Within the diversified livelihood strategy of Nggela fishing-farmers, fishing is employed as an income generating activity, to complement other low income earning activities and the subsistence role of farming. The role of fishing for income as well as for subsistence is more pervasive among low income members of the population and in locations where there is a narrow land-based livelihood platform. The lives of the people are entwined with the global economy through their basic needs (they require clothes, food items etc which are imported from other parts of the world); hence required income to purchase clothes, fuel, food items etcetera besides engaging in a purely subsistence economy. In a location where the majority of the population live in the rural areas with good access to market, fish is an important cash commodity. This is in contrast to other South Pacific Islands, for example Tonga where limited market potential coupled with a high influx of remittances from a large overseas working population (Kronen and Bender 2007) reduces the economic value of fish for predominantly subsistence purposes. The results of this study are consistent with Béné et al. (2009), fish being a cash commodity in small-scale fisheries, especially in areas close to market (Jennings and Polunin 1996; Cinner and McClanahan 2006b). The subsistence role of fish especially among low income earners and the increasing role of fish as a cash commodity in the face of market accessibility and low capital requirements are important drivers for fishing on Nggela.

The central aim of this chapter was to investigate the role of fisheries in livelihoods on Nggela using the SLA framework by Allison and Ellis (2001);

Based on the findings here what can be said about the social-ecological relationships in terms of the SLA frame-work of Allison and Ellis (2001)? The differences in livelihood platform, in particular land-based natural capital between the eastern and western zone of Nggela, influences livelihood strategies and this in turn has an effect on marine resource exploitation. The eastern zone had a broader land-based natural capital; hence there is a greater reliance on land-based livelihood activities. For example besides cultivation for food (subsistence agriculture) as a natural resource based activity there is also the cultivation of non-food items e.g. cocoa (*Theobroma cacao*), coconuts (*Cocos nucifera*) for copra production and the extraction of forest products (lumbering) to generate income. The broader land-based livelihood platform in combination with fishing (and other marine-based resource extraction) provided a more diverse livelihood portfolio for the eastern zone. The comparatively narrow land-based natural capital in the western zone resulted in fishers engaging more in marine-based natural resource extraction in order to increase the number of their livelihood activities. This was especially evident in the village of Naghotano which was situated on a small island; on average there were two fishers per household in Naghotano compared to an average of only one fisher per household for other study villages. An informant from Naghotano made the following comments about the role of fishing in the livelihoods of Naghotano villagers:

"Almost everyone in this village fishes, men, women and children who are old enough to fish. People fish, they sell their fish to the esky operators and then buy rice flour or buns (home baked bread) to feed their families. Some people don't work the land, they need to fish all the time to buy food and they feel it (meaning that these people go hungry) *during prolonged bad weather conditions which prevent them from fishing. I have a little bit of land so I can alternate between fishing, working the land, diving for trochus and selling copra".*

An informant at Haleta made the following comments about the livelihood disparity between the eastern and western zone:

"We are not like you people on the other side, (meaning the eastern zone and referring to the fact that the researcher was from the eastern zone) *you people have more land so you can plant cocoa and copra to generate income,*

we here have to endure the discomforts of sitting under the sun all day in the canoe or faring bad weather conditions to fish more often than we like in order to make money. There is good money in fishing, but it is also hard work; humans are things of the land you know, there is only a certain extent to which we can endure the sea. If I had the choice I would prefer to make money from land activities and fish only for consumption. You put something down on the land (meaning you plant something) *you know it's yours you can always come back for it; the sea, it belongs to everyone, sometimes you are lucky, sometimes you are not".*

The availability of new livelihood opportunities offered by the commodification of marine resources under circumstances where land-based natural capital is limited can be an important driver of fishing, especially within what Allison and Ellis (2001) described as *"the context of national economic trends"* (in this case the increased influence of markets). Livelihood security (through activities such as the extraction of marine resources) under enabling circumstances (narrow land-based natural capital, the availability of human capital by way of skills, knowledge, health and increased livelihood opportunity offered by markets) can have consequences for natural resources. Such drivers can increase pressure and disputes over resources which in turn can result in the breakdown of resource management practices (Foale and Macintyre 2000) and ultimately degrade/reduce the sustainability of resources (Foale and Day 1997; Foale 1998a) .

CHAPTER 3

FISHER BEHAVIOUR AND FISH TAXA TARGETED IN THE NGGELA REEF FINFISH FISHERIES

Abstract

This chapter investigated fisher behaviour and which taxa of reef finfish fisheries is targeted in Nggela through 93 fisher interviews, participatory fishing and analysis of landed catch data. The findings demonstrated that spatial allocation of fishing is influenced more by perceptions of fishers on the health of finfish fisheries resources than by spatial, temporal species or gear prohibitions (or awareness of such prohibitions or restrictions). Three MPAs currently existed in West Nggela and fishing prohibitions within the areas were observed mainly because people thought that the MPAs were underscored by the government. The majority (80%) of fishers perceived that inshore areas which are within 0.5 to 1 km from the village contain less finfish fisheries resources due to dynamite fishing than offshore sub-tidal reef areas which are more than 1km from land. Thus, while fishing activities occurs in inshore areas, offshore sub-tidal reefs were the domain of finfish fisheries. The main method of fishing (90%) was line fishing from dugout canoes with the main fish families targeted being Lutjanidae, Lethrinidae, Serranidae and Carangidae. Median trophic level of fish catch was between 2 - 3.84 while median standard length of catch was between 19 - 24 cm.

3.1 INTRODUCTION

Small-scale artisanal fishers contribute to the demise of coral reef health (Hawkins and Roberts 2004a; Cinner and McClanahan 2006b; Wilson et al. 2008; Lokrantz et al. 2009) especially in locations close to urban areas (Sabetian and Foale 2006; Aswani and Sabetian 2009) where the main factor driving fishing are income generation and human population growth (Huber 1994; Jennings and Polunin 1996; Brewer et al. 2009). Mitigating coral reef degradation requires an understanding of the biological dynamics of fish stocks combined with fishing behaviour (Béné and Tewfik 2001), because behavioural decisions underpin where, when, how and what fishers fish (Salas et al. 2004; Abernethy et al. 2007).

Fishing strategies and tactics are usually developed in response to the constraints they encounter, and their intended objectives, given their particular human, social, cultural, ecological and economic context (Béné 1996; Salas

and Gaertner 2004; Abernethy et al. 2007). For industrial fishers, the main objective may be to maximise economic returns under constraints such as resource dynamics and market demands (Béné 1996; Robinson and Pascoe 1997; Salas and Gaertner 2004). In small-scale fisheries, particularly in developing countries, the objectives may include economic maximisation, as well as other considerations, for example, subsistence needs. Constraints may not be only resource dynamics and market demands but also: socio-economic circumstances; local values and social status (Béné and Tewfik 2001); social norms and relationships (Salas and Gaertner 2004; Kronen and Bender 2007); and the physical ability of fishers (Béné and Tewfik 2001; Abernethy et al. 2007) since resource extraction is labour intensive.

Understanding relationships between fisher behaviour and target species is essential for effective fisheries management (Salas and Gaertner 2004; Hilborn 2007) as it will help in the formulation of relevant and effective regulations (Béné and Tewfik 2001). The spatial and temporal patterns of fishing effort and the impacts of effort and gears on species should be considered (Pet-Soede et al. 2001; McClanahan and Cinner 2008; Cinner et al. 2009b; Jones et al. 2009). Management failures usually result from ignoring the complex dynamics of fishing and associated behaviour (Salas and Gaertner 2004). Most major fishery problems in the world are due not to poor understanding or biological management of fish but to problems with fishers (Hilborn 1985). Current understanding of fisher behaviour, particularly in small-scale fisheries, is at best rudimentary (Abernethy et al. 2007) and this is particularly so in the South Pacific. Although numerous studies have been conducted on the social aspects of Pacific Island small-scale fisheries, few have dealt specifically with human-marine environment interactions (Aswani 1998b). During the period 1998 - 2009 the only studies published on this subject were those in Tonga (Kronen and Bender 2007) and in the Federated states of Micronesia (Sosis et al. 1998; Sosis 2001; Sosis 2002). For the Solomon Islands in particular, no study of fishers' fishing strategies has been conducted since that by Aswani (1998a). This chapter gives a contemporary insight into fishers' behaviour in Nggela.

3.2 FISHING EFFORT ALLOCATION AND THE COMPLEXITIES OF FISHER BEHAVIOUR AND FISHING STRATEGIES

From a methodological perspective, fishing effort distribution can be understood through two steps: (1) description of the patterns of fishing effort, and (2) identification of the 'rationale' which governs the allocation of fishing effort (Béné and Tewfik 2001:158). Patterns of fishing effort represent changes in fishing effort allocation, which reflects some degree of periodicity, seasonality or regularity. In a single species fishery (e.g. lobster fishery on the Northumberland coast in UK), these patterns have spatial and temporal dimensions while in a multi-species fishery (which is typical of small-scale multi-species fisheries in the South Pacific) there are spatial, temporal and inter-species components to consider. 'Rationale' refers to the rule or rules that influence fishers decision making processes which ultimately underpins how or where fishing effort is distributed (Béné and Tewfik 2001).

In general, fishing effort distribution is the result of multi-component choices that includes fishers' traditonal fishing patterns, risk-taking or risk-averting factors, cost and catch expectations, available technology, management regulations, biological availability of stock, general market conditions, weather and seasonal cycles (Béné and Tewfik 2001). For example, for fishers in southwestern New Georgia in Solomon Islands, seasonal tidal cycles which untimately affect catch rates determine fishing effort distribution between different patches (Aswani 1998a). In the Spermonde Achipelago (Indonesia), variable catch rates make it difficult for small-scale fishers to detect trends, and hence harder to contrast catch rates between locations. This, coupled with the aim to minimise physical and economic risks, resulted in fishers selecting suitable habitats close to their village, rather than attempting to maximise catches by switching between gears and locations (Pet-Soede et al. 2001). For Anguillan fishers, different competitive abilities, imperfect knowledge and changing accuracy of resource abundance perceptions with distance from port play a role in effort distribution; fishers were faithful to sites where they felt their needs were met the most (Abernethy et al. 2007).

3.3   SOUTH PACIFIC SMALL-SCALE FISHING STRATEGIES

Gain maximising objectives under constraints imposed by resource dynamics and market demands (e.g. Béné 1996) have been reported by researchers (Huber 1994; Jennings and Polunin 1995; Jennings and Polunin 1996; Sosis 2002; Foale 2005; Brewer et al. 2009) in the South Pacific. However, religious beliefs also impose constraints on when and what fishers fish; for example most Christians do not fish on Sundays (Jennings et al. 2001), and some tribes prohibit the consumption of certain species (McGoodwin 2001), (e.g. octopus in Lau lagoon, Solomon Islands). Seasonal cycles also influence fishing strategies, thus the daily variation in tidal cycles coupled with other factors within the tidal seasons, such as the lunar cycle and the prevailing winds, determine the times fishers go fishing and the habitat types targeted (Aswani 1998a). During the 'day high-night low' (*odu rane-masa boni*) season, drop line methods were used in New Georgia to target pelagic species in the lagoon passages and along outer lagoon reef drops during the day, resulting in a simultaneous drop in fishing in inner lagoon reefs. The Inner lagoon reefs were targeted during the late evening when the tide ebbs (Aswani 1998a). During the tidal transition period (*vekoa kolo*), the frequent changes of water in and out of the lagoon attracts baitfish *Herklotsichthys quadrimaculatus* into the lagoon passages; this results in the intensification of trolling and angling in the lagoon passages for pelagic species that come in to feed on the baitfish (Aswani 1998a). During the 'day low-night high' (*masa rane-odu boni*) season, the drop in water results in fish moving away from seagrass beds and mangroves to the inner lagoon reefs during the day, resulting in the intensification of angling in the inner lagoon areas and employment of methods such as fish drives, netting and the use of organic piscicides (Aswani 1998a).

Local values and norms also play an important role in fisher fishing strategies. In Tonga, fishers' fishing strategies do not follow gain maximising objectives (Kronen and Bender 2007). Rather, fishing strategies were driven by the need to serve subsistence purposes, social obligations and the choice to maintain fishing as a life style, and as part of traditional livelihood and social institutions (Kronen and Bender 2007).

One aspect of social institutions which has received significant attention from researchers in the South Pacific is customary marine tenure (CMT)

(Johannes 1978; Hviding 1996; Foale 1998b). As an ownership regime over marine areas or fishing methods, CMT influences fishers' fishing strategies by imposing constraints on where fishers can or cannot fish (Aswani 2002; Aswani 2005) and how they may conduct their fishing activities (Carrier and Carrier 1983; Carrier 1987). This requires clearly defined boundaries where appropriation rules like exclusive use and temporal, spatial, species or gear restrictions/prohibitions can be enforced (Dahl 1988; Ostrom 1990). The ways CMT maritime boundaries are defined varies, and are usually vague; for example where a marine area is an extension of the land as in the case of fringing reefs or within sight of a claimed piece of land then land boundary markers are used (Dahl 1988; Foale 1998b; Hviding 1998). Cases occur where the owner of a piece of land and adjacent reef are not the same (Rutley 1987; Hviding 1998). The seaward outermost boundaries of customary tenure are unclear in the Solomon Islands (Lidimani 2006) with a lot of variations in the distances claimed or where rights are exercised (Rutley 1987). Outermost seaward boundaries may be marked by oceanic features or coral heads (Hviding 1998), but rarely include mid-ocean delimitations or floating boundaries that run right through open waters (Lidimani 2006). Boundaries in CMT systems are further complicated by social boundaries which define different user rights. Related to this are the different ways in which marine territory and ownership are perceived compared to those of land. Aswani (1999), characterises land as a physical territory that can be worked, transformed and claimed by individuals through its physical modification at an intra or inter kindred level. In contrast, the sea cannot be physically modified and individually claimed, hence it remains a common property shared by all members and in the case of CMT may be under the jurisdiction of a chief (Aswani 1999). Interactions of these different types of boundary and differences in how ownership rights over marine and land are perceived, pose social challenges in multi-species and multi-gear coral reef fisheries management (Ruddle 1996a).

Researchers on the social aspects of fisheries in the South Pacific have indicated that CMT has the potential to be used for effective littoral fisheries management and conservation, either directly or as an unintended product of other social processes (Ruddle et al. 1992; Johannes 1998; Johannes 2002b; Aswani and Hamilton 2004; Cinner and Aswani 2007). A strength of CMT is the

unwritten and non-codified nature of its long standing general principles which enable it to be contextually adaptable to changing circumstances (Hviding 1998; Aswani 2002; Johannes 2002b). However, under the strains of population growth, economic development and social changes, the CMT system can decay to a regime where enforcement of the exclusivity to resource access is weak, even to the extent of an open access regime (Johannes 1978; Ruddle 1993; Cinner 2005; Cinner et al. 2007). Even where enforcement of exclusivity to resource access is effective, unrestrained exploitation by resource owners themselves (Polunin 1984) especially in a cash economy environment can still result in resource overexploitation (Foale 1998a; Sabetian and Foale 2006), hence rendering CMT ineffective for fisheries management and conservation. A further limitation to the use of CMT for fisheries management is that the spatial scale at which it operates can be less than the spatial scale at which resources are exploited. This can pose a challenge to the management of more mobile species like finfish which have a distribution range beyond CMT areas.

The aim of this chapter was to answer the following objectives: (1) What are the fishers' perceptions of resource abundance within CMT areas, do they think there are more or fewer resources within CMT over non-CMT areas and what do they think are the causes for any such differences; (2) are there any rules or prohibitions such as closed areas, prohibitions on species or fishing methods; (3) do fishers confine their fishing activities only to their own CMT areas, employ only approved fishing methods and target only approved species; (4) What methods of fishing are currently being employed and what fish sizes, trophic levels, functional groups and families are targeted?

3.4 METHODS

3.4.1 Fisher interviews on perceptions of resource abundance changes and causes for these changes

To address objective 1, a semi-structured questionnaire was used to interview 93 fishers from 10 randomly selected communities in Nggela (Solomon Islands) between 27 November 2007 and 30 April 2008 to determine: perceptions of fish abundance, changes in fishing methods, any changes in the size or type of fish caught and factors which might have

affected fish abundance in the previous 5 years (before 2008). Table 3.1 shows the questions that were asked. The fishers were selected based on the recommendations of village elders as well as by snowball sampling based on recommended respondents by the interviewees.

Table 3.1: Information collected from fisher interviews on resource abundance

-Are there more or less fish in the sea now compared to 5 years ago?

-Which areas have more fish and which areas have less fish?

-How do you know this?

-What affects fish abundance and how does it affect fish abundance?

-Has the size of fish caught increased, remained the same or decreased in the last 5 or more years and is there a change in the type of fish caught?

-What fish do you catch 5 yrs ago and what fish do you catch now?

3.4.2 Gear, species and area prohibitions

To address objective 2, a semi-structured questionnaire was used to interview 93 fishers on any prohibitions with regards to gear, species, areas of fishing or temporal prohibitions. Each fisher was specifically asked to list whether: (1) there were any temporal prohibitions/restrictions, (2) there were areas prohibited to fishing, (3) there were any fishing gears which were prohibited from being used within their community and (4) any particular species which were prohibited or restricted. In addition to the semi-structured interview, unstructured interviews were also conducted with key informants to ascertain CMT areas, CMT boundaries and ownership, exclusivity in the use of CMT and ability to enforce exclusive use of CMT areas. Additional unstructured interviews on the enforcement of closed areas were also conducted at the 3 villages in Nggela that had marine protected areas on reefs in front of their villages. These 3 villages were not part of the designated study villages as they were not picked during the random selection of study villages. These were the only MPAs in existence in Nggela (joint partnership between CMT owners, provincial Fisheries Department and NGOs).

3.4.3 Spatial allocation of fishing

To determine fishing areas (objective 3) used by fishers of a particular village and distance to the fishing areas, interviewees were asked to draw their fishing areas on a map. Several fishing area maps by fishers of a particular village were then coalesced using the geographical information systems software ArcGIS (version 9) to give the overall fishing area of a particular village. Fishing areas reportedly fished by interviewees were checked through triangulating spatial fishing patterns observed by the researcher by accompanying fishers on their fishing trips and recording the GPS (global positioning system) data on the fishing areas. These coordinates of actual areas fished were then compared with the positions indicated by the fishers from the interviews. During these trips fishers did not travel in a straight line from their villages to their fishing grounds but visited different patches and employed different fishing methods (or different variations of a fishing method) on their way to and from the most distant fishing ground, hence the actual fishing distance was greater than the linear distance from the village. Since my aim was to show that fishing space was not confined to CMT areas, the linear distance from the villages was sufficient for my purposes and used in the data analysis. The linear distance was measured on a marine chart (determined from the scale on the marine chart using a pair of dividers and a ruler) as a direct distance from the village to the fishing areas. Further triangulation of fishing areas fished was done by asking fishers of neighbouring villages where fishers of a particular study village were fishing. In addition, fishers were asked if the fishing location they fished within was owned by anyone and if it was owned, who the owners were. Due to a short period (usually a maximum of 3 weeks) spent at each village, seasonal patterns of the spatial allocation of fishing or patch choice dynamics were not investigated.

3.4.4 Fishing methods and catch analysis

To address objective 4, a semi-structured questionnaire was used to interview fishers on: the types of primary gear used, fishing areas where the gear was used and details of other fishing gear that was also used by the fisher.

In addition to the semi-structured interview, participatory fishing methods with the fishers was also conducted (i.e. I accompanied fishers on their fishing trips) to ascertain fishing locations and depths (measured using a calibrated line), gear use and fishing duration. In addition, finfish species landed and fish standard lengths (mm) were also recorded. Fish standard lengths *(L)* were subsequently converted to fish mass (*W*) using the power function Eq 3.1.

$$W = aL^b \tag{Eq 3.1}$$

Where *L* is standard length of fish in mm and the constants *'a'* and *'b'* are length-mass constants for a particular fish species, the constants *'a'* and *'b'* for a particular species were obtained from Fishbase (Froese and Pauly 2009).

In cases where I was unable to participate in the fishing activities, fishing duration and catch data were also collected from fishers at the landing sites in the villages. For the entire study, a total of 103 fish catch surveys were recorded where a total of 1018 fish specimens were recorded and their standard lengths measured. Data on fish catch composition were used to: (1) determine fish families, species diversity and percentage mass composition for different fish families for each of the gears, (2) calculate the median lengths of catch for the different gears, (3) calculate the trophic level of the different gears and (4) determine the functional groups caught by the different gears. Family and species diversity was calculated as a mean modified Simpson's index of diversity (*D*) using:

$$D = 1 - \sum \frac{ni}{Nt}, \tag{Eq 3.2}$$

Where; n_i is the total number for a particular species and N_t is the total number of all fishes sampled for the particular gear (Cinner and McClanahan 2006b).

The trophic level (*TL*) of each species was obtained from Fishbase (Froese and Pauly 2009) and used to calculate the trophic level of catch of each gear using:

$$TL = \sum_{i=1}^{m} Yik \, TL / \sum_{i=1}^{m} Yik, \tag{Eq 3.3}$$

Where; *Yik* is the catch of species *i* by gear *k* and *TL* is the trophic level of species *i* for *m* fish species sampled by a particular gear (Pauly et al. 2001;

Cinner and McClanahan 2006b; Jones et al. 2009). Where a trophic level for a species was not available, trophic level for a similar species within the same genus was used.

A further analysis was conducted to determine the functional groups and whether the targeted fish families and species (from the catch data) were reef associated. This was done by sorting fish species from the catch data according to the different functional groups and reef associations based on the table compiled by Cinner et al., (2009b) from published literature. This table is available at: http://onlinelibrary.wiley.com/store/10.1111/j.1365-2664.2009.01648.x/asset/supinfo/JPE_1648_sm_TableS1.xls?v=1&s=65830df 4cf8caf9fdd6af2ce1d3419f3637c65dd.The A histogram of the different functional groups or reef associations (as a catch composition percentage) for each of the gears was then plotted as per Cinner et al. (2009b). All data manipulations were done using the software packages SPSS and Microsoft Excel 2007. Understanding of fish functional groups and reef associations are important as certain functional groups are important for reef health or recovery (Bellwood et al. 2004; Lokrantz et al. 2009).

3.5 RESULTS

3.5.1 Resource abundance perceptions and causes of changes

All of the 93 fishers who were interviewed perceived that in general, there had been no change in the type of fish caught over the 5 year period between 2003 and 2008. However there had been a change in location with regards to the types of fish caught. Species which were specifically mentioned by 59 (62%) interviewed fishers as not being caught within or near CMT areas were: *Lutjanus bohar, Lethrinus olivaceus*, *Lethrinus nebulosus, Plectorhincus lineatus* and species within the subfamily Epinephelinae. Sixty five percent of interviewed fishers perceived fish sizes to have declined near villages or within CMT areas in the last 5 years, 26% perceived sizes of fish caught in the last 5 years near villages or within CMT areas to have remained the same, while 9% perceived that fish sizes near villages or within CMT areas varied with seasons. All of the fishers interviewed stated that the primary gears that they used had not changed in the last 5 years. Eighty percent of the interviewed fishers perceived the abundance of finfish resources near villages or within CMT had declined in the previous 5 years (see Figure 3.1); 10% perceived it to have remained the same while 5% perceived it to have increased.

Fifty percent of respondents perceived the primary cause of resource abundance changes near villages and within CMT areas to be the use of explosives for fishing (Figure 3.2), 21% said that it was due to a combination of the increase in the number of fishers and over-fishing. Seven percent attributed abundance changes to fish behaviour, such behaviour includes fish becoming 'wilder' and migrating to deeper places (or sub-tidal reefs) due to being constantly chased through fishing'. A further 7% attributed decline in resource abundance to other effects of gear, particularly when fishing line methods such as '*strike'* and *kurakura* (described in detail below) were employed. Fishers perceived that when '*strike*' is employed the continuous jerking of the line up and down resulted in the steel rod used as sinker pounding on the corals, destroying them in the process; fish therefore moved away due to the destruction of their 'houses'. Similarly fishers reasoned that the significant number of stones dropped onto the inshore reef when *kurakura* was employed also destroyed corals 'fish houses', resulting in fish 'moving away'. Other reasons given by fishers as the primary causes of resource abundance

changes were: fish reproduction and life history stages, changes in season, industrial fishing, supernatural factors, marine pollution, poison, gillnet and unknown causes (they don't know the causes).
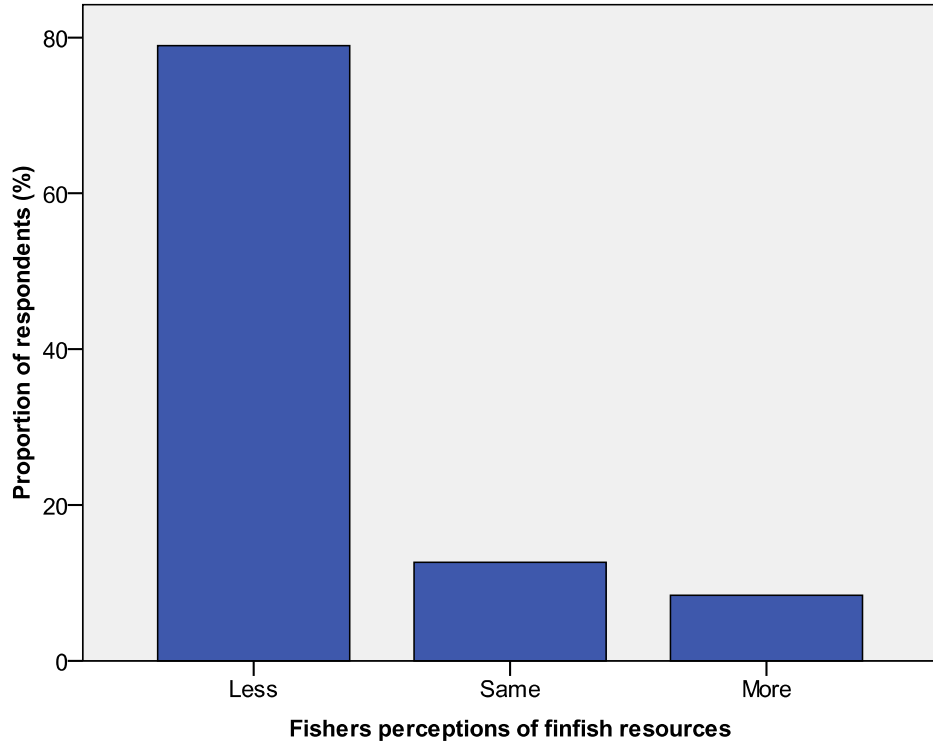
Figure 3.1: Fishers' perceptions of state of finfish fisheries near villages or within CMT areas in 2008 compared to 2003 or earlier.
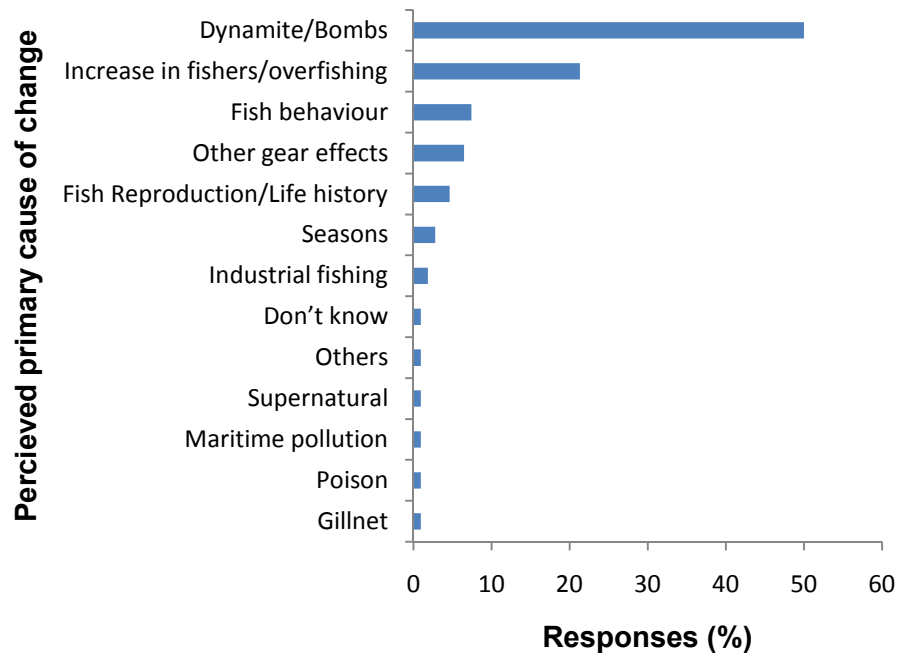
Figure 3.2: Histogram of fishers' responses for a question about primary causes of finfish decline near villages or within CMT areas.

3.5.2 Gear, species and area prohibitions

Temporal prohibitions/restrictions

There were no regular temporal prohibitions or restrictions instituted in any of the communities where interviews were conducted. One respondent from Naghotano village stated that the only form of temporal restriction was when people did not fish during lent (prayer period in the Anglican calendar which begins on Ash Wednesday and ends on Easter Sunday) as a form of penance. Two respondents; one from Ravu sondu kosi and another from Salesapa stated that the only form of temporal prohibition they were aware of within their communities was when schooling fish species such as *Hypoatherina* sp*., Herklotsichthys quadrimaculatus*, *Selar crumenopthalmus and Selaroides leptolepis* aggregate inside bays near villages or within CMT areas; reef owners could prohibit or restrict people from exploiting these resources. Since such schooling aggregation occurs 2-3 times per year, temporal restrictions may coincide with these schooling aggregations. Not all schooling aggregations however were always protected.

Area prohibitions/restrictions

All of the respondents in the 10 villages stated that there were no long-term designated restrictions or protected areas in their villages. The only prohibitions at the study villages were temporary and periodic closures for invertebrates such as trochus (*Trochus niloticus*) and sea cucumber (several species from the genus *Holothuria*), or areas closed to 'accumulate' fish for church feasts. These temporary closures in most cases were in the form of conditional spell taboos instituted by an Anglican priest or a traditional medicine man. In some cases, these invertebrate closures did not include prohibition of line fishing from dugout canoes which might therefore still occur within the areas. Spear diving for fish however was always prohibited in 'invertebrate closed areas' for fear that divers might collect trochus or sea cucumber under the pretext of spear fishing.

Respondents however were aware of the 3 MPAs (see Figure 3.5) at the villages of Sisili, Salavo and Maravaghi that were not among the 10 study villages; these had been established with the assistance of local (SIDT) and

international (FSPI) NGOs and the Central Province Fisheries Department. According to Joan Pita (FSPI staff, pers.com), the processes involved in creating and managing the MPAs followed those of the Locally Managed Marine Areas (LMMA) network (Margoluis and Salafsky 1998; Govan et al. 2008:6) (Figure 3.3).
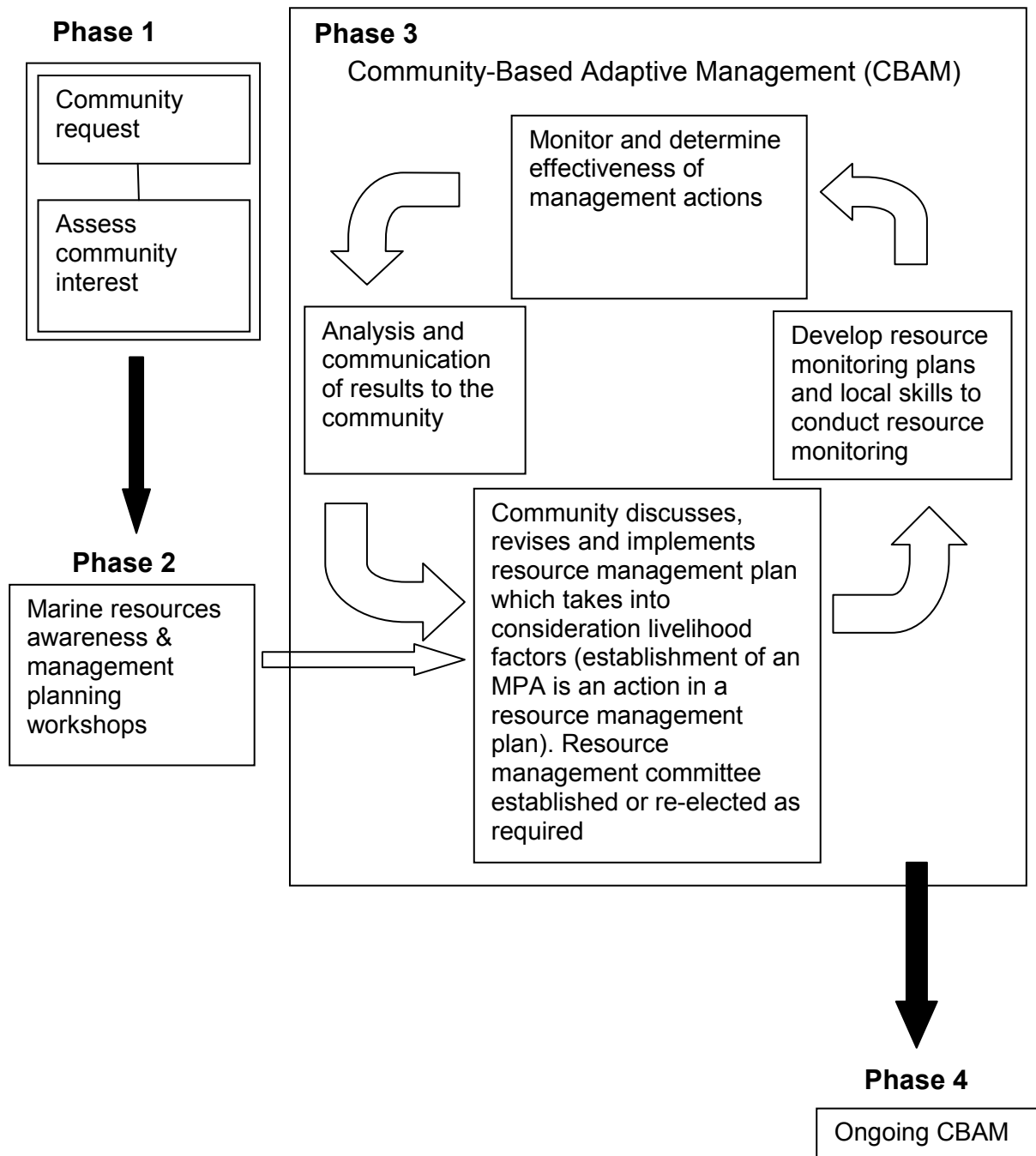
Figure 3.3: A schematic diagram of the processes used in establishing and managing the MPAs at Sisili, Salavo and Maravaghi (based on Margoluis and Salafsky 1998).

The process of establishing the 3 MPAs began with a request from the communities to the NGOs (Figure 3.3, Phase 1), which in association with the Provincial Fisheries Department conducted a scoping exercise to assess interest at the community level and to identify threats or issues that might hinder the establishment of the MPA. This was followed by awareness seminars on marine resources, basic MPA science and resource management planning workshops (by the NGOs and Provincial Fisheries Department for the communities) (Figure 3.3). The communities (Sisili, Salavo and Maravaghi) were then allowed to devise their resource management plan and elect an MPA committee (Includes, elders, youths and women) who would be involved in monitoring and enforcement. Youths (16-21 years of age) were particularly interested in resource monitoring and hence were involved in this while the older folk (≥21 years of age) were involved in enforcement. After the establishment of the MPA, the NGOs conducted training to develop community skills in resource monitoring (UVC to assess fish abundance, line intercept transect to asses coral cover etc). The results of resource monitoring were then communicated to the community (by the NGO, provincial Fisheries Department and youths involved in resource monitoring) and used to determine the effectiveness of the MPA. Following communication of results, the MPA committee in association with the community then revised the management plan (and any rules pertaining to the MPA) as required based on results of resource monitoring.

The MPAs were not fully closed areas as trochus was still harvested annually with the proceeds shared among the tenure rights holders. According to the FSPI staff (pers.com) such trochus harvests were important to generate benefits (as long as harvesting did not occur to the level where recruitment failure or recruitment overfishing occurs), considering that these MPAs were fully integrated with livelihoods. "*Furthermore, deriving benefits from the MPA should reinforce the interest to keep the MPA going*" (FSPI pers.com).

The MPA at Sisili occupies a total area of 0.068 km^2, the Salavo MPA occupies a total area of 0.365 km^2 and the one at Maravaghi occupied a total area of 0.154 km^2 (FSPI pers.comm.). All these MPAs were established based on tenure rights with the primary rights holders making the initial request (to the NGOs and Provincial Fisheries Department) and playing a leading role in establishment, ongoing management and enforcement. At the time of research

these MPAs were in the process of forming an umbrella body (which they called the resource owners association) with the intent to solicit support from the provincial government in the enforcement of MPA regulations, technical support in resource monitoring and assistance to integrate these MPAs in income-generating activities (e.g. eco-tourism activities such as snorkelling, SCUBA diving and manta ray and dugong watching).

Interviewed fishers (all 93 fishers interviewed) perceived that the MPA rules were underscored by the provincial government, because of the involvement of the provincial fisheries officer. All fishers at Ravu sondu ulu and Ravu sondu kosi (which are closest to the 3 villages with MPAs) stated that enforcement within the 3 MPAs was effective and they did not fish within or near the MPA areas. Two fishers at Ravu sondu ulu had marine tenure rights over the MPA at Salavo. However they had not been fishing or collecting invertebrates there, one of them made the following comments:

"I used to collect corals there to burn into lime and also dive for trochus, but since my uncle had this arrangement with the gavmane (government), *I don't collect corals or dive trochus there anymore, one does not want to get into trouble with the law. In a way the MPA is good, it makes the fish and everything on the reef come back. Last time it was not only us who were using it, all sorts of people were diving and fishing there; now it's under the law it helps us stop all sorts of people going in there – that's one good thing about it".*

(Respondent Ravu sondu ulu)

Gear prohibition/restrictions

Eighty four percent of respondents stated that they were aware that dynamite fishing was prohibited by government fisheries regulations and that such prohibition was welcomed within their communities. However regardless of such prohibitions it was still a fishing method commonly used in inshore reefs and within CMT areas by villagers and non-Nggela fishers because of its convenience. During the study period I witnessed 2 incidents of dynamite fishing outside of Ghumba village.

About 9% of respondents stated that nets had been prohibited within certain reefs by reef owners. Over 2% of respondents stated that the use of

poison had been prohibited in some CMT areas, a further 2.5% stating that night diving had been prohibited in some CMT areas, while 1.6% stated that *kurakura* line fishing had been prohibited.

Species restrictions

Respondents were generally aware of some national fisheries regulations (Figure 3.4), those regulations most commonly known were size restrictions and the protection of sea turtles. Regardless of this awareness, no species prohibitions or size restrictions were being enforced in any of the study villages.
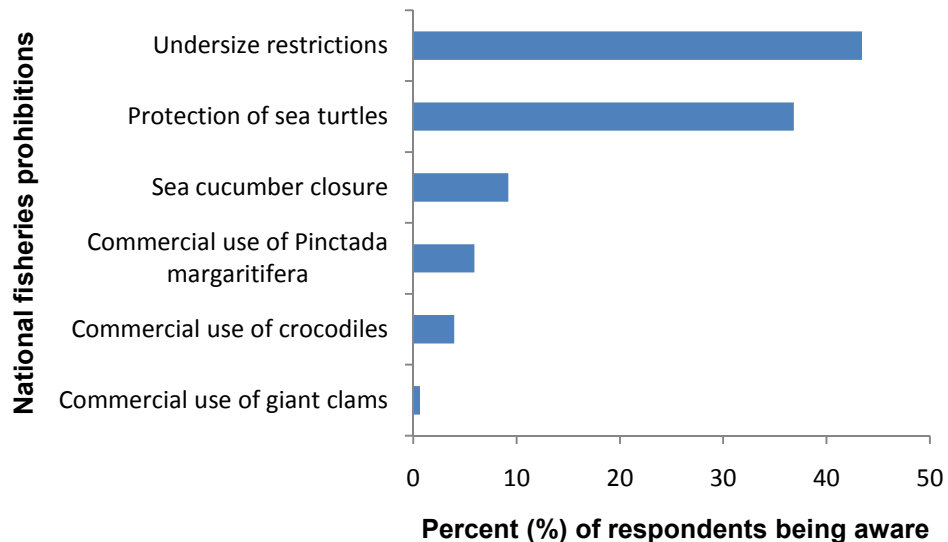
Figure 3.4: Awareness by respondents of national fisheries regulations

3.5.3 Spatial allocation of fishing

During participant observation of fishing practices undertaken by accompanying the fishers on their fishing trips it was recorded that the fishers identified their spatial position in the sea using land reference marks (mountains and islands), 2-3 land reference points being used to identify distance and position from land. The fishing space of a village stretched beyond the village itself with fishing space often overlapping between villages (Figure 3.5). Based on 85 dugout canoe fishing trips, mean linear distance from the villages to the fishing grounds was 4.4km (±SD 2.1); minimum

distance was zero where fishing occurred on the village fringing reefs and the maximum linear distance recorded was 9km from the village (Figure 3.6). Distances of 0-2km could be either along the coast or to offshore areas, however distances >2km were usually to the offshore sub-tidal reefs. More than 70% of dugout canoe fishers (Figure 3.6) were fishing in offshore sub-tidal reefs. For 5 outboard motored fishing trips, mean linear distance from the village to the fishing ground was 17.9 km (±SD 7.2), (range 10-28km). All areas targeted by the outboard motor boats were offshore sub-tidal reefs (e.g. Rua dika, Tenapari reefs and Hitchcock shoal, Figure 3.5).

All interviewed fishers stated that the way they distributed their fishing effort within the fishing space varied. Regions of the fishing space which are >6km from the base were targeted during favourable weather conditions while closer areas and inshore regions were targeted during unfavourable weather or when schooling species aggregated there. The purpose of fishing also influenced spatial allocation; fishing for commercial purposes (selling to esky operators) was conducted in offshore areas, while that for consumption where fish types or sizes did not matter was carried out inshore. According to fishers, *'bigger and better types of fish'* desired by the esky operators could only be obtained in the offshore regions of the fishing space.

All sub-tidal reefs which are ≥0.5km from land were considered to be common property (*Lologho ni mavitu*) and everyone was entitled to fish within these reefs. In contrast, all fringing reefs at the end of the villages, around islands (blue areas in Figure 3.5) or within the vicinity of a claimed land were owned under the CMT system by kinship groups. Views about what constituted 'vicinity to claimed land' varied, but the range of distances given by informants was between 20 and 50m from land or the edge of a fringing reef. Access to fish within CMT areas was usually flexible; unless there was a taboo placed on it for certain purposes e.g. periodic closures or the 3 village MPAs mentioned above.
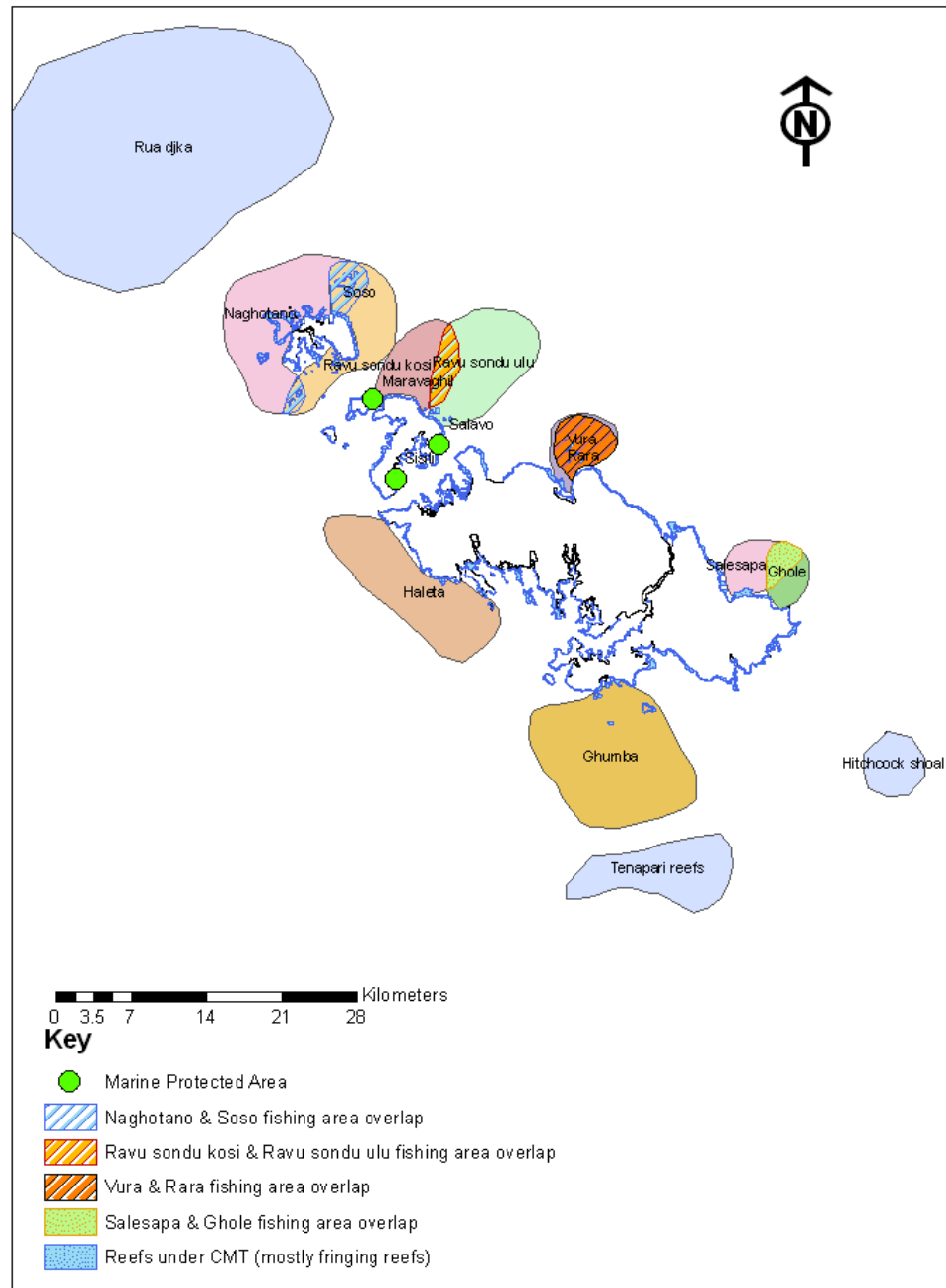
Figure 3.5: Map showing spatial range of fishing activity for the 10 study villages and the overlaps in fishing space. Rua dika, Tenapri reefs and Hitchcock shoal are offshore sub-tidal reefs which were de facto open access. (This map was produced by coalescing fishing area maps provided by interviewed fishers of each study village)
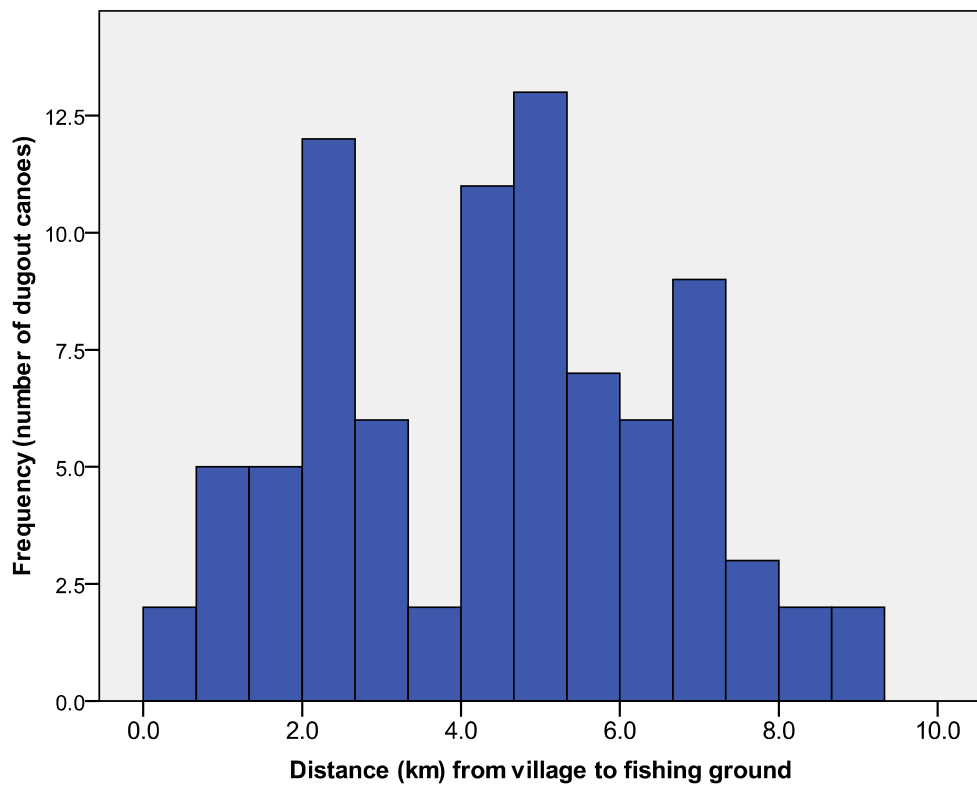
Figure 3.6: Distribution of fishing distances of 85 dugout canoe fishing trips

3.5.4 Fishing methods and catch analysis

Gear use

Eighty seven percent of the fishers (both zones combined) used unmotorised dugout canoes for fishing while 13% used boats powered by outboard motor engines of 15 - 40 horse power. Boats had a fibreglass hull, 5 - 7m long and 1.5 - 2m wide. Ninety percent of fishers interviewed listed line fishing (Figure 3.7) as their primary fishing gear. Line fishing had several possible variations; (1) d*augulu* involved baiting a single or several hooks on a line attached to a sinker (sinker is usually a construction steel rod 20 - 26cm in length and 1.5 - 2cm in diameter) (2) *strike* involved the disguise of a hook among chicken feathers which are held together by being inserted into a plastic drinking straw, the disguised hook being tied to a line and sinker and then deployed. When the sinker reached the bottom, the line were jerked up and down so that the lure mimicked the upward and downward movement of small marine organisms within the water column which attracted fish to the lure, (3) *ariari* was horizontal trolling, namely the towing of a hook on a line on or just below the water surface behind a paddled canoe or motor powered boat; (4)

kurakura was vertical trolling where a single hook attached to a coconut frond that was tied to a stone 300-500g in weight and this was allowed to sink with the attached hook. When the stone had reached the bottom, the line was tugged to free the hook from the coconut frond and then retrieved very rapidly into the canoe, the retrieval mimicking the rapid horizontal movement of small marine organisms through the water column, attracting fishes to chase and bite the lure. Line fishing was normally conducted at 36 - 182m depth (Table 3.2), although horizontal trolling occurred at the surface.

Other fishing methods employed were: (1) use of a spear when diving which is either hand held or propelled using hand stretched elastic rubber or spear gun. Spear diving was normally conducted at depths of 3 - 6m, (2) use of gillnets on shallow reefs, or seagrass beds, usually deployed at depths of 2 - 3m, (3) use of explosives constructed from left over second world war ammunitions usually conducted at 2 - 6m. Fishers also stated that traditional poison methods were also used; however such methods were very infrequent. Sixty nine percent of interviewed fishers employ only one type of fishing gear, 26% employed two types of fishing gear, while 5% employed three types of fishing gear (Figure 3.8).
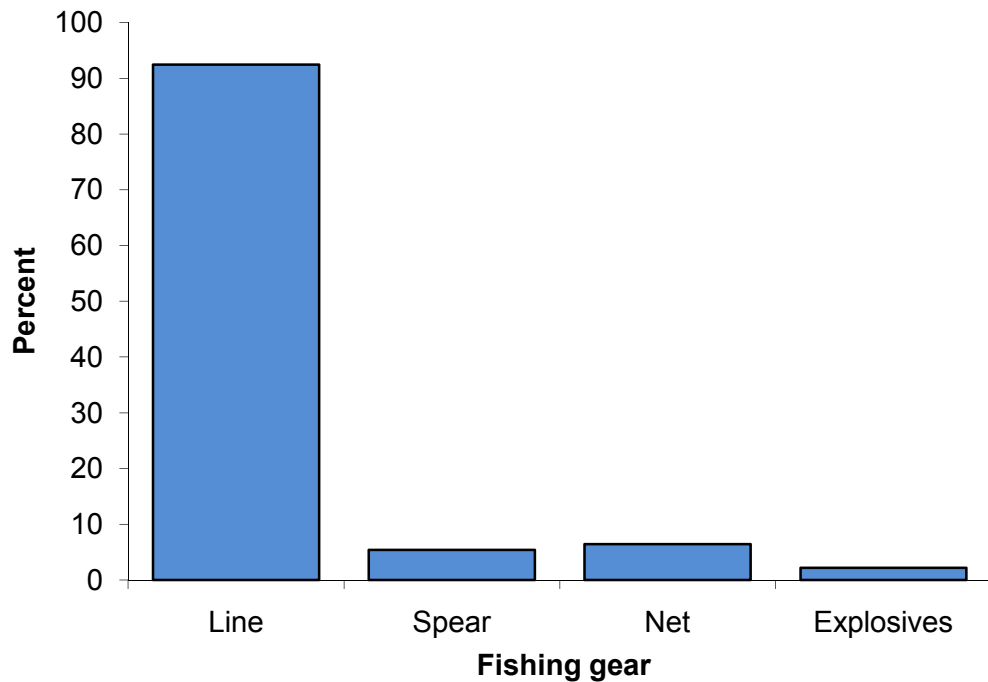
Figure 3.7: Histogram showing the distribution of primary fishing gears used by fishers

Number of gears used by a fisher
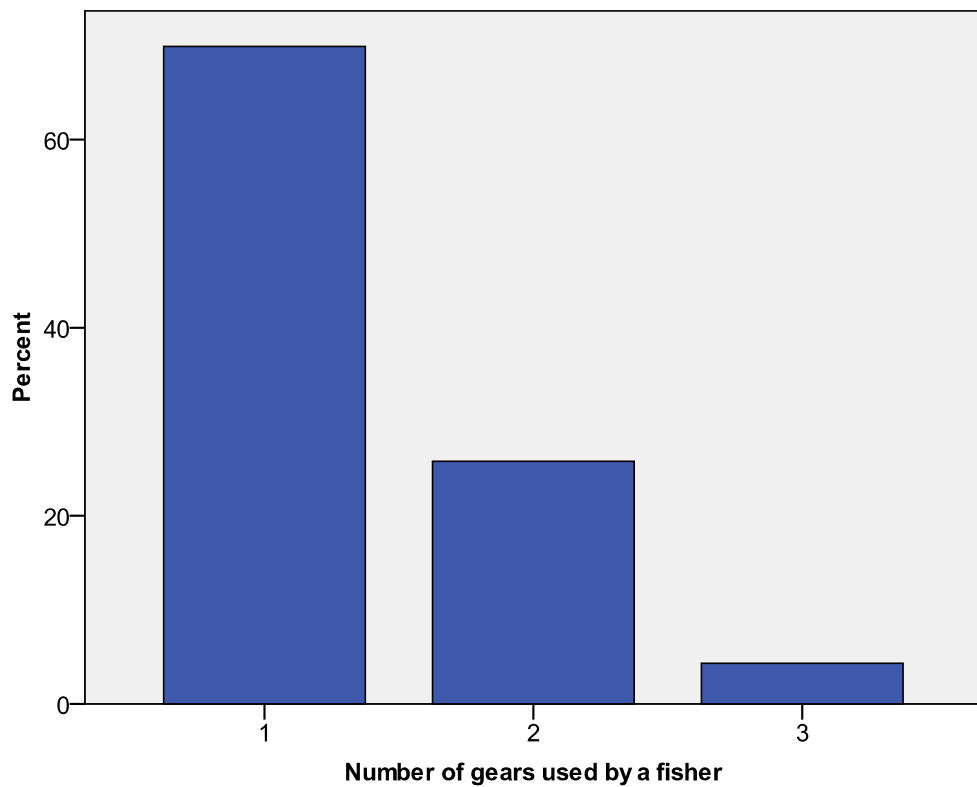
Figure 3.8: Histogram showing the distribution of multiple gear use by fishers

Table 3.2: Fishing depths (m) for the different gears used by Nggela fishers

Gear	Minimum depth (m)	Maximum depth (m)	Mean depth (m)
Line (n=95)	36	182	108
Spear (n=5)	3	6	4
Net (n=3)	2	3	2.6

Catch analyses

Fishers using dugout canoes spent 2- 5 hours fishing while fishers using motor powered boats spent 7-19 hours fishing. Median CPUE (kg/person/hr) for line fishing was 1.02, for gillnet it was 1.45, while for spear fishing it was 0.8; there was no significant difference in CPUE between the different fishing methods (Table 3.3). The four most commonly targeted fish families were Lutjanidae, Serranidae, Lethrinidae and Carangidae (see Figure 3.9) (Appendix 2 shows complete list of target fish species). Line fishing targeted more species than gill nets and spear (see Table 3.3); sample sizes of the last two were small. Median trophic level of line fishing was 3.84 and represented a high proportion of piscivorous/macro-invertivorous, invertivorous and piscivorous species (see Figure 3.10). Median trophic level of gill net and spear

fishing was 2.0 and 2.38 respectively (Table 3.3) comprising mostly scrapers/excavators, grazers, planktivorous and piscivorous/macro-invertivorous species (Figure 3.10). Median trophic level and standard lengths of fish targeted by line fishing were greater than for gill net and spear, although sample sizes of gillnet and spear were small. Species which were targeted had low or medium association with coral reef (see Figure 3.11), only a very small proportion targeted by line fishing (mostly Serranidae) being strongly associated with coral reefs.
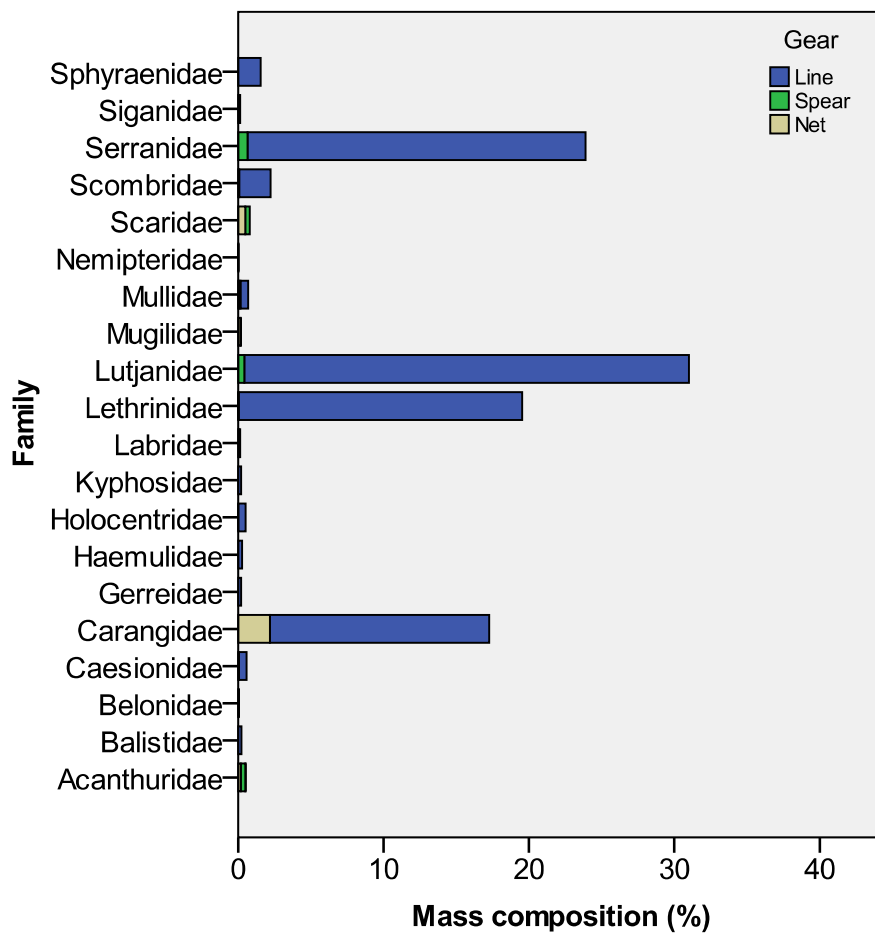
Figure 3.9: Histogram showing mass percentage composition of the different fish families according to the different gears used by fishers.

Table 3.3: Families, species diversity, median trophic level and standard lengths of fish catch for the different gears.

	Line fishing			Gill net			Spear fishing			Kruskal-Wallis	Mann Whitney tests
	N	Median	SD	N	Median	SD	N	Median	SD	P	
Count of families	18	*	*	8	*	*	9	*	*	*	*
Count of species	89	*	*	19	*	*	17	*	*	*	*
Simpson's diversity index	0.95	*	*	0.86	*	*	0.93	*	*	*	*
Median trophic level	1018	3.84	0.41	54	2.00	0.91	36	2.38	0.88	0.00	Line>Spear Line>Net Spear=Net
Median standard length (cm)	1018	24.00	10.1	54	21.00	9.6	36	19.00	7.7	0.00	Line>Spear Line=Net Net>Spear
Median CPUE (kg/person/hr)	95	1.02	3.3	3	1.45	2.64	5	0.80	0.61	0.83	nsd

* Not Applicable; nsd – no significant difference in CPUE when doing pair wise post hoc tests using the Mann Whitney U tests
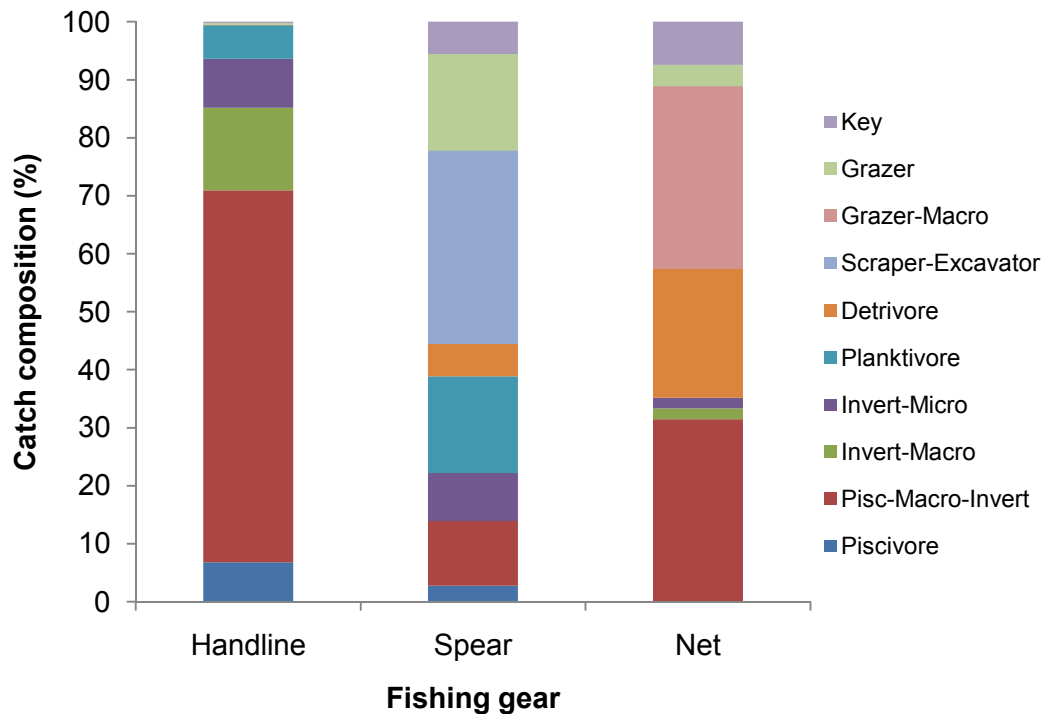
Figure 3.10: Fish catch by gear as a proportion of functional groups.
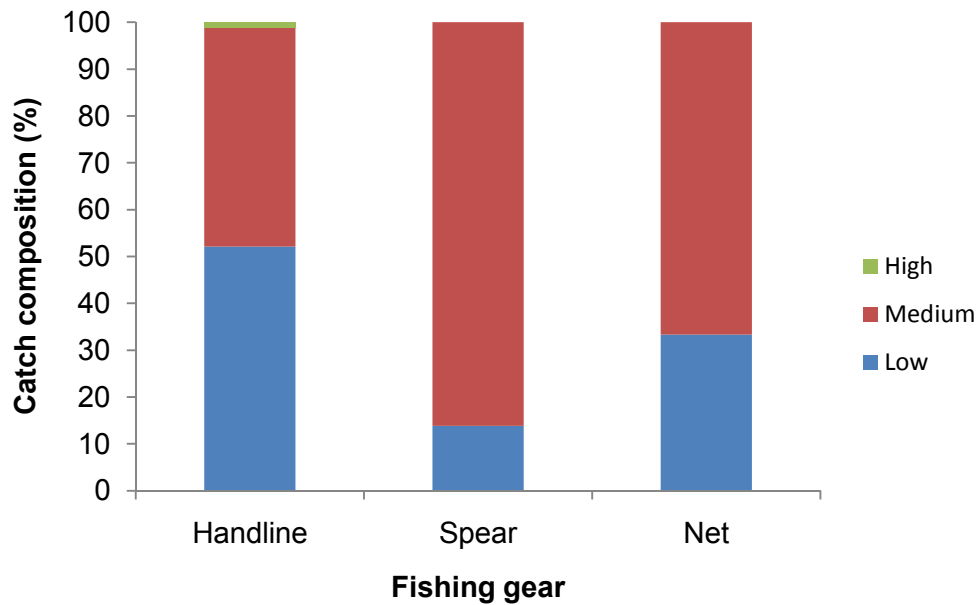
Figure 3.11: Fish catch by gear as a proportion of the level of reef association.

3.6   DISCUSSION

Finfish fishers of Nggela did not confine themselves to fishing within CMT areas; rather, their exploitation range stretched to offshore sub-tidal reefs and deeper zones of the sea which do not fall under the ownership of any kinship group. A contributing factor to such a large extent of the exploitation range was perceptions of resource abundance; fishers perceived inshore areas to contain fewer/smaller finfish resources and were targeting off shore areas that they perceived to contain more abundant resources. Healthy populations of reef food or aquarium fishes were not encountered at 10m depths on Nggela (Green et al. 2006). The biomass of snappers (Lutjanidae), emperors (Lethrinidae) and parrotfishes (Scaridae) was low at 10m depth on Nggela compared to other parts of the Solomon Islands (Green et al. 2006). Possible old damage from destructive fishing practices' on reefs has been reported by Green et al.(2006). Empirical evidence collected for this thesis showed that Lutjanidae, Lethrinidae and Serranidae species still composed a major part of the fishers' catch in 2008 and indicates that fishers were targeting Lutjanidae, Lethrinidae and Serranidae species at offshore sub-tidal reefs and deeper zones further from the villages and CMT areas. Further support for this observed trend is provided through the high trophic level of the catch data and an observed low or medium reef association of the target species.

The small contribution of Acanthuridae and Scaridae species to the catch data may well be due to the fact that these species were not vulnerable to the predominant gear used (hook and line fishing), but more importantly, probably due to the low abundance of these species due to a combination of overfishing and the use of explosives for fishing. Acanthuridae biomass was low at sites ≤0.86 km from communities, but higher at sites >0.86km away, while Lethrinidae biomass was low at ≤3.7km from a community, but higher at >3.7km away (Brewer et al. 2009). Scaridae biomass distribution was significantly influenced by market proximity and distance to provincial and main capitals; distances <58km from a provincial capital or at least 487km from the national capital exhibited low Scaridae biomass (Brewer et al. 2009). Nggela is only within 49km from the main capital, a site where Scaridae are facing the highest threat from exploitation (Brewer et al. 2009); Scaridae species may be already overexploited on the inshore reefs. Resource declines and hence shifts in fishing zones are probably major factors dictating the kind of fishing gear used by Nggela fishers. Hook and line fishing was more feasible in the offshore sub-tidal reefs and deeper zones than spear diving or the use of nets.

The overlap in fishing space at distances of >0.5km from land (or the end of fringing reefs) is attributable to these areas being outside the ownership of anyone and everyone was free to exploit resources there. Other researchers (Rutley 1987; Foale 1998b:56) however have reported claims of sub-tidal offshore reefs >0.5km from the end of a fringing reef because they are still seen from the land (i.e. 'within the vicinity of land'). Although respondents stated that some form of gear prohibitions or area closures were practised during field work (2007-2008), no such prohibitions or closures was enforced when I was in the villages. It is unclear why there are no exclusions or prohibitions in the tenured areas in the study villages. With the exception of periodic closures (and the 3 MPAs established with external assistance), there was no closed area and no prohibition of gear or species. Firstly, it is likely that the low abundance of reef finfish resources inshore may offer a dis-incentive to prohibit others fishing in these areas (Dyson-Hudson and Smith 1978). Furthermore human population growth and increased competition for finfish within inshore waters even within kinship groups may have led to a loss of enforceability of CMT rules and in territoriality over time (Bishop 1970; Cinner et al. 2007). While resource scarcity and unpredictability may otherwise lead to

greater territoriality (Cashdan 1983; Dahl 1988), offshore sub-tidal reefs and fishing zones have offered alternative areas to exploit. Secondly unlike trochus and sea cucumber, fish move between and beyond owned areas and people may be disinclined to claim ownership over fish. Trochus and sea cucumber are semi-sedentary, hence can remain on a reef and gain can be maximised from them. The cost of defending fish is greater than the gain that will be derived from such actions, while for trochus and sea cucumber derived benefits likely exceed the cost of defending the resources (Ruttan 1998). This view is summarised by the statements of one of the respondents:-

"Restricting people to fishing within CMT areas just because a person owns the reef, is unreasonable as it may unduly affect the livelihoods of other people, everybody needs to live. Fish move around all the time, they are not fixed to a reef, they may be on your reef today but on another person's reef tomorrow, fish is a shared resource. Trochus and sea cucumber are different; they can be fixed on a reef hence a taboo can be placed on them when needed to meet financial commitments. Taboo should be instituted only when needed or it is a reasonable thing to do, not just because one can. For example, permanent taboo on practices like dynamite fishing should be instituted as they destroy the reefs which are houses and food for the fish" (Respondent, Naghotano).

The third possible reason for non exclusions and prohibitions within CMT areas is due to the inability of kinship groups to enforce prohibitions or exclusions within owned reefs, due to the overall break down of the taboo system as a result of market forces (Cinner and McClanahan 2006b). Fourthly, an important factor which must also be considered in the overlap of fishing space between villages is that of reef ownership. Village of residence does not often equate to ownership of reefs in front of villages (Rutley 1987; Hviding 1998). This is due to the complexities of the tenure system where kinship affiliation and ownership rights are inherited matrilineally but residence patterns are mostly viri-patrilocal rather than uxorilocal (Foale 1998b). Hence, people travel to 'their' reefs in front of nearby villages to exploit marine resources. Regardless of this however, most of the fishers interviewed stated that they could still fish on 'others' reefs if there was no specific temporary closure or taboo and neither did they prohibit 'others' fishing in 'their' reefs if they did not have any specific commitments requiring periodic closures. This is attributable

to usufruct rights based on complex personal relationships as well as the sense of obligation to share, resulting in reciprocity and tolerated theft (Blurton-Jones 1987; Bird and Bird 1997). Similar observations have been reported in the western Solomon Islands (Aswani 1999). An informant summarised this process as follows:-

"It is our way of life that we always 'eat together' (vanga koukolu). You cannot always produce everything you need by yourself or always find them in your areas, one day you may need it from someone or someone's area, that's why we are flexible about where we can go fishing" (Respondent, Salesapa).

Over the years that I have lived in Nggela I have noticed that although there is flexibility about where people fish, when the need arises primary rights holders can come out in force to stake claims within boundaries that they consider theirs and can enforce and monitor such claims especially in relation to what they consider to be important commercial ventures such as tourism and commercial SCUBA diving and in relation to resources such as trochus and sea cucumber. A perceived increase in the value of resources or property can result in disputes over primary rights which ultimately have dire consequences for semi-sedentary resources like trochus (Foale and Day 1997; Foale 1998b; Foale 1998a; 2000). The main difference between this study and that of Foale and co-workers is that this study determines that resource use is not only restricted to inshore CMT areas but it extends out and beyond the CMT areas.

While the data presented here elucidate some broad aspects of exploitation of Nggela fishers and types of fish families they target when fishing, the surveys have not captured finer details of the interactions between the spatial and temporal patterns of exploitation and their relationship with social dynamics. Further considerations of these details would have added value to the understanding of the way finfish fisheries are exploited in Nggela. Time and logistical constraints did not allow a more in-depth investigation. The research findings demonstrated that finfish fisheries are targeted beyond CMT areas. Thus a recommendation for fisheries management is that fishers' spatial fishing behaviour be considered on a scale that goes beyond current CMT boundaries.

The complexities of different user rights besides primary rights, hence the flexibility to exploit resources in 'others' reefs, coupled with the important socio-economicc roles of sharing, reciprocity and tolerated theft has been reported elsewhere in the Solomon Islands (Ruddle et al. 1992; Aswani 1999), other parts of the South Pacific (Carrier and Carrier 1983; Kronen and Bender 2007) and in the Torres strait islands of Australia (Bird and Bird 1997). These socio-economicc aspects of resource exploitation and sharing coupled with population growth and modern market forces are important factors contributing to the shortage of finfish resources in inshore areas on Nggela. This therefore has shifted current finfish exploitation to offshore areas which are outside of CMT ownership. This has further implications for fisheries management and would be a major challenge to incorporate in any codification of CMT.

Despite fishers' flexibility to fish on reefs of others, the establishment of 3 MPAs in west Nggela and the fact that fishers living within the vicinity of these MPAs observe the rules of not fishing within them (MPAs) are indications that CMT can still be effective where empowered and enforced. Hence enforced CMT can still be a factor influencing fisher behaviour by regulating where they can fish. Unstructured interviews with fishers at the 3 villages where MPAs were established and at Ravu sondu ulu and Ravu sondu kosi indicated that fishers were not fishing in the MPAs out of the misconception that it was a government initiative with the primary tenure rights holders. Hence, they could get into trouble with the law if they violated the rules; similar observations were reported in Fiji (Clarke and Jupiter 2010).

The boundary limits of CMT are only within the fringing reef areas or at the most 0.5km from the fringing reef; current exploitation of finfish occurs at a scale much larger than CMT areas. Management of finfish species will require not only an empowered CMT but also co-management initiatives with external agencies like the government (Foale 2007) and NGOs (Kuperan and Abdullah 1994; Pomeroy 1995) that can consider the full spatial extent of finfish exploitation. How to approach such a co-management initiative in Nggela will be discussed in Chapter 5 and 6.

CHAPTER 4

SOME DEMOGRAPHIC PARAMETERS OF *Plectropomus leopardus* IN NGGELA AND THEIR REGIONAL VARIATION

Abstract

This chapter investigated age-based demographic parameters of P. leopardus in Nggela using the von Bertalanffy growth curve and age-based catch curves and compared these to trends observed in Australian locations. Reproductive biology was also investigated by examining different stages of gonad development. The growth coefficient of P. leopardus was 0.13 yr^{-1} with 10% longevity (based on 10% of oldest individuals) of 12.9 years. The oldest individual specimen collected was 15 years with a total length of 560mm. Total mortality rate of P. leopardus in Nggela was 0.22 % yr^{-1}. Age-based demographic parameters of Nggela P. leopardus were generally similar to those on Swain Reef and Lizard Island in Australia. For Swain Reef, growth coefficient was 0.17 yr^{-1}, 10% longevity was 10.1 years, mortality rate was 0.39 % yr^{-1} while the maximum age was 14 years at a total length of 535 mm. For Lizard Island growth coefficient was 0.26 yr^{-1}, 10% longevity was 7.2 years, while the maximum age was 10 years at a total length of 569mm. Mortality rate at Lizard Islands was 0.59% yr^{-1}. The age-based demographic parameters of Nggela P. leopardus were different from those in Western Australia (Scott Reef and Abrolhos Reef). For Scott Reef, growth coefficient was 0.42 yr^{-1}, 10% longevity was 6.4 years, mortality rate was 0.30 % yr^{-1} while the maximum age was 8 years at a total length of 400mm. For Abrohlos reef growth coefficient was 0.08 yr^{-1}, 10% longevity was 13 years, mortality rate was 0.24 % yr^{-1} while the maximum age was 18 years at a total length of 716mm. Sea temperature may be one contributing factor to regional variations in age-based demographic parameters. Female sexual maturity of Nggela P. leopardus began at 2 years of age with 50% sexual maturity achieved at 3.22 years. Sexual transition from female to male began at 3-10 years of age with 50% sex change achieved at 11 years. Mature female to male ratio was 3:1.

4.1   INTRODUCTION

Traditional ecological knowledge may be useful in providing information such as interannual, seasonal, lunar, diel, tide related, and habitat-related differences in behaviour and abundance of target species (Johannes et al. 2000; Silvano and Valbo-Jørgensen 2008); this information is important for fisheries management. Two examples of where such knowledge have been successfully applied are: (1) protecting grouper spawning aggregation sites in Palau (Johannes et al. 1999) and (2) conservation of bumphead parrotfish (*Bolbometopon muricatum*) (Aswani and Hamilton 2004), and the establishment

of marine protected areas (Aswani and Lauer 2006) in the Solomon Islands. Despite successes, inherent gaps in traditional ecological knowledge can fail to underpin fisheries management (Foale 1998a; Foale 2006) and scientific information is still required for effective fisheries management decisions at the village level, especially in an environment where traditional ecological knowledge is fast eroding (Johannes 1998).

Information complementary to traditional ecological knowledge is necessary for fisheries management and still originates from modern scientific methods. Types of information needed include knowledge of the demography (growth, longevity and mortality) and reproductive biology of highly targeted and vulnerable finfish species (Hilborn et al. 2005). To illustrate: understanding growth in fishes is important for devising specific management measures as it can be used to establish appropriate recommendations like size limits of target species that can be landed (Welsford and Lyle 2005). Furthermore, in a co-management arrangement, experts in Fisheries Departments or NGOs can use demographic and reproductive information to assist communities in resource management by calculating sustainable total catch quotas of a species. However, in the case of the Solomon Islands and many other developing countries such assessments are constrained by personnel, financial and infrastructure limitations. Such countries may have to rely on data that are generated elsewhere. In the Solomon Islands, fish size limits are obtained from Fishbase (http://www.Fishbase.org), these data usually originating from Australian, Caribbean, or Southeast Asian reefs, yet are used for local management. However the spatial plasticity of growth challenges the ease of applying growth data between locations for management purposes (Helser and Lai 2004) including that of reef fishes (Gust 2004). Such extrapolation can only be useful if there is an understanding of the systematic and random components of growth variability (Helser and Lai 2004) and reproductive plasticity. The literature is replete with growth studies of single fish populations, however comparatively few studies have undertaken robust quantitative comparison of growth among populations and even fewer have compared numerous populations of a given species over different spatial and temporal scales, possibly due to the sophisticated statistical analysis required (Helser and Lai 2004).

Reef fishes occur across areas with variable habitats and temperatures and exhibit different demographic patterns and structures (Meekan et al. 2001;

Gust et al. 2002; Ackerman 2004; Gust 2004; Trip et al. 2008) even over tens of kilometres (Gust 2004), yet studies of spatial variation in the age-based demography of reef fishes are few (Meekan et al. 2001; Choat and Robertson 2002). Some coral reef species for which population comparisons have been made (both at the local and large scale) are those within the family Acanthuridae, Scaridae (Choat and Robertson 2002; Gust et al. 2002; Choat et al. 2003; Robertson et al. 2005a; Robertson et al. 2005b; Trip et al. 2008), Lutjanidae (Kamukuru et al. 2005), Lethrinidae (Williams et al. 2003), Labridae (Ackerman 2004) and Pomacentridae (Meekan et al. 2001).

Beverton and Holt (1957; 1959) introduced the Ludwig von Bertalanffy growth function (von Bertalanffy 1938) to model growth in fish. It has since become one of the most used models in fisheries to analyse growth of fish, crustaceans and molluscs as well as for comparative growth analysis at intraspecific (between sexes, space or time) and interspecific levels (Choat and Robertson 2002; Gust et al. 2002; Kimura 2008). The von Bertalanffy growth function (VBGF) may be represented as follows:

$$L_t = L_\infty (1 - e^{-K(t-t_0)})$$
(Eq 4.1)

Where; L_t is Length at age t, L_∞ is the asymptotic length or the theoretical maximum length achievable by the species, K is the Brody growth coefficient and t_o is the theoretical age at length zero.

The VBGF has been criticised for its assumption of an upper limit to growth; L_∞ can be difficult to estimate when fitted data do not indicate an asymptote. In addition L_∞ can be construed as the maximum size in nature (L_{max}) when it is in fact a mathematical artefact (Knight 1968; Jensen 1996). Statistical analysis of the model is constrained by the interdependence of K and L_∞ and the inability to represent the sigmoid curve in a linear dimension (Knight 1968; Gallucci and Quinn 1979; Roff 1980). No term in the model has units of length per time as may be expected of a growth model; the unit of K is actually t^{-1} (Jensen 1996). The widespread use of VBGF has also resulted in its erroneous use (Gallucci and Quinn 1979; Francis 1988)

The VBGF nevertheless is an useful model if appropriately applied (Schnute 1981; Essington et al. 2001; Ackerman 2004). Although K is not represented as units of length per time, it has been an accurate proxy for growth rate for many species. The VBGF performs better than other growth models (Chen et al. 1992; Hearn and Leigh 1994). One of its main strengths has been its

flexibility and ability to accommodate a wide range of data (Roff 1980). The problems of statistical analysis by use of the least squares method (Roff 1980) have been overcome by the application of likelihood methods (Kimura 1980; Francis 1988; Cerrato 1990; Cerrato 1991) and the test of coincident curves (Chen et al. 1992). Faster computers now efficiently perform what were previously laborious iterative processes involved in solving the model (Misra 1980). Several researchers have also carried out reparameterisation (Ratkowsky 1986; Francis 1988; Cerrato 1991) and extensions (Kimura 2008) of the model that enhance its utility for growth analysis. The VBGF is still the most widely used model for growth studies in fisheries (Quinn II and Deriso 1999; Kimura 2008).

Coral reef Serranidae species (groupers) usually form a major component of subsistence-artisanal fisheries at the local level (Rhodes and Tupper 2007) and internationally (Sadovy and Vincent 2002), and are vulnerable to exploitation because of their inherent life history characteristics (Coleman et al. 2000). They have a pelagic larval period of 40-50 days (Wilson and McCormick 1999; Coleman et al. 2000) before settling onto reefs, are generally slow growing, mature late, have low natural mortality and are long-lived with some species living up to 25 - 40 years and achieving sizes of 1- 2m (Coleman et al. 2000). They form spawning aggregations at the same sites repeatedly which makes them easy fishermen targets. A protogynous reproductive strategy means that males are mostly large individuals that form a small proportion of the total population (Ferreira 1995; Ferreira and Russ 1995; Adams et al. 2000). Size selective fishing of even a few large individuals can decimate a population of the males required for reproduction. In wrasses, migration and knowledge of spawning site are a learned behaviour (Warner 1990), and this may also be true of groupers; the loss of large individuals may result in young individuals not knowing the spawning sites. The resulting sex ratio imbalance and social structure disruption resulting from removal of large individuals can therefore have dire reproductive consequences for a population and quickly lead to weak cohorts (Coleman et al. 2000).

Over-exploitation of groupers has resulted in the listing of several species under various categories on the IUCN red list, among them is *Plectropomus leopardus* which has been listed as near threatened (NT). Under this category, the species may be threatened without ongoing specific conservation attention. *Plectropomus leopardus* is moderately uncommon in the Solomon Islands compared to the Great Barrier Reef (IUCN 2009) where it is a common fishery

species. Yet, occasionally, *P. leopardus* can be abundant at local markets during periods the local fishermen call `*the season for it'* (personal observation) which were probably the spawning seasons when aggregations were targeted. At the time of conducting research for my thesis, *P. leopardus* was one of the highly priced species at the Honiara market commanding Solomon Dollars SBD$30.00 per kg (SBD$30 is about £2) compared to other species with a price range of between SBD$20 - 24 per kg. Hence, *P. leopardus* may be vulnerable to over-exploitation in Nggela, especially where it occurs close to the main urban markets. No studies on the fisheries, demography, reproductive biology or ecology of *P. leopardus* have been conducted in the Solomon Islands.

Reproductive and demographic studies of *P. leopardus* have been conducted on the Great Barrier Reef (Australia) and in New Caledonia. *Plectropomus leopardus* is generally long lived with a maximum life span of 19 years (Loubens, cited in Ferreira and Russ 1994). The mode of sexual development was previously described as monandric protogynous hermaphroditism (Ferreira 1995), however Adams (2003) describes them as diandric protogynous hermaphrodites. Reproduction normally involves the formation of spawning aggregations of up to 128 fishes at new moon within the period August - December (Samoilys 1997), with individual fish movements of 0.2 - 5km to the aggregation sites (Zeller 1998). Spawning behaviour involves elaborate courtship behaviour from the males culminating in spawning rushes between male and female pairs whereby gametes are released into the water column for fertilisation (Samoilys 1997). Zygotes develop into pelagic larvae which subsequently settle onto the reefs at juvenile sizes of 40 - 90mm (Light and Jones 1997). Juveniles feed on benthic crustaceans, with a shift to a predominantly piscivorous diet as adults (Kingsford 1992; St John 1999; St John et al. 2001).

Ferreira and Russ (1995) compared *P. leopardus* population structure and demographic parameters between fished and unfished sites on the Great Barrier Reef (Australia), however no broad latitudinal comparisons of *P. leopardus* have been made. The availability of *P. leopardus* age and size data from Abrolhos Reef, Scott Reef, Swain Reef and Lizard Island (all locations in Australia) presented a unique opportunity to make such comparison.

The objectives of this chapter are to: (1) determine certain age based demographic characteristics of *P. leopardus* in the Nggela finfish fisheries and (2) compare age based demographic parameters of *P. leopardus* between

Nggela and Australian locations. *Plectropomus leopardus* is currently not under any form of management in the Solomon Islands, except the prohibition of their exploitation inside a few marine protected areas. The findings may be useful for eventual management of the species, especially in the establishment of minimum and maximum harvestable sizes.

4.2 METHODOLOGY

4.2.1 Gonad Extraction and Processing

Gonads were collected from *P. leopardus* landed by fishermen at the landing sites around Nggela between 27 November 2007 and 30 April 2008. The total length (TL) and standard length (SL) was measured in millimetres (mm) before each fish was dissected to remove the gonads. A total of 120 individuals were collected, however 11 were already gutted by fishermen hence only a total of 109 individuals had gonads. The sample size was dictated by how many fish I could obtain from fishers thus was subject to availability. Since the IUCN list *P. leopardus* as near threatened and as relatively uncommon in the Solomon Islands, I did not wish to contribute to further depletion of the species; I therefore sought to rely on fisheries dependent data only, which were deemed appropriate (e.g. Williams et al. 2008) for the analyses and in addressing the main aim of this chapter.

Preservation and processing followed the methods by Ferreira (1995) and Samoilys and Roelofs (2000). Gonads were fixed and left in FAACC solution (4% formaldehyde, 5% acetic acid, 1.3% calcium chloride and 89.7% distilled water) for 5 months while in the field, until they were brought for processing at the laboratory. The 5 months in the FAACC solution did not affect the subsequent clarity of the stained sections even for the basophilic components of the stained sections. However, remaining samples left after histological processing were transferred to 70% ethanol for prolonged storage in case they were required for later re-examination and analysis. Samoilys and Roelofs (2000) reported deterioration of the basophilic components of some of their samples; this was possibly due to storage of their samples in FAACC solution for 6 - 18 months.

At the laboratory, the gonads were removed from the FAACC solution, damp dried with a paper towel and weighed on an analytical balance to determine mass in grams (to four decimal places). Sections 2 - 4mm in thickness were then taken from the middle of either the left or right lobes. Uniform

development has been reported between the left and right (Ferreira 1995) as well as longitudinally along gonad lobes (Adams et al. 2000; Samoilys and Roelofs 2000). The sectioned tissues were placed in a labelled tissue processing cassette and left for a minimum of 2 hours in 70% ethanol.

The tissue samples were then transferred to an automatic tissue processor for dehydration. The dehydration process in the automatic processor involved passing the tissues through 6 changes of ethanol, two changes of xylene and finally impregnated with liquid paraffin at a vacuum pressure of 50kPa to remove any water bubbles. The samples were then embedded in paraffin wax blocks using metal moulds. Tissue embedded wax blocks were left overnight to set properly.

On the following day, tissue embedded wax blocks were soaked in ice (or ice cooled 10% ammonia for the ripe gonads) for approximately 15 minutes before being mounted on a rotary microtome for sectioning. Soaking in ice (or 10% ammonia) facilitates obtaining finer sections during the cutting process. Ribbon sections of 5μm thickness were cut from the block and floated in a 40°C water bath. The sections were recovered on slides, placed on a rack to allow water to drip off before being put into a 60°C oven to melt the wax. Tissues were then subjected to a routine protocol of dewaxing and staining using Mayers haemotoxylin and Young's eosin erythrosin stains. Stained sections were mounted with a cover slip using DPex mounting medium, allowed to dry then examined under the microscope to determine reproductive stages of individual fish. Criteria for the determinations of reproductive stages were based on Adams et al. (2000, Table 4.1), a further category 'undetermined females' being used where it could not be resolved whether the sample was a immature female or mature resting female.

Table 4.1: Development stages of *P. leopardus* (from Adams et al. 2000: 1452)

Developmental stage	Histological description
Immature female	Ovary dominated by previtellogenic primary stage oocytes (stages 1 and 2). Thin gonad wall. No evidence of prior spawning in the form of postovulatory follicles, atretic cortical alveolus and (or) vitellogenic (stages 3 and 4) oocytes, brown bodies, or intralamellar muscle bundles in the gonad.
Mature resting female (prespawning and post spawning)	Ovary dominated by previtellogenic primary growth oocytes (stages 1 and 2) with a thick gonad wall (prespawning). Evidence of recent prior spawning indicated by presence of postovulatory follicles,

	atretic stage 3-4 oocytes and (or) brown bodies (post spawning). Intralamellar muscle bundles can be present in both prespawning and post spawning mature resting females.
Mature ripe/running female	Ovary in active vitellogenesis. Oocytes present in all stages of development; Cortical alveolus (stage 3) and vitellogenic (stage 4) oocytes dominate the ovary. Hydrated (stage 5) oocytes present in ripe/running females.
Transitional	Degenerating oocyte stages 1-4 in the presence of proliferating testicular tissue where spermatozoa have not yet proceeded to fill the peripheral sperm sinuses. Thin bands of primary and secondary spermatocytes, spermatid, and spermatozoa crypts present and often closely associated with peripheries of gonad wall.
Mature ripe male	Proliferation of testicular tissue has progressed to the point where spermatozoa are present in the peripheral sperm sinuses. Testis in active spermatogenesis where all sperm stages (primary and secondary spermatocytes, spermatids and spermatozoa) are present. Remnant ovarian central cavity visible in all males.

4.2.2 SAGITTAL OTOLITH EXTRACTION AND PROCESSING

The use of sagittal otoliths (sagittae) to age *P. leopardus* has been validated by Ferreira and Russ (1994) for Great Barrier Reef (Australia). Time and financial constraints did not allow such validation for the species from Solomon Islands; it was assumed that Solomon Islands otolith growth banding was similar to that of the Great Barrier Reef; previous studies (Ackerman 2004) on other species have shown that growth band characteristics between Solomon Islands and Australian locations are similar. Sagittae were removed immediately after the gonads, following methods of Secor et al. (1991). Gills and gill arches were removed and the inferior portion of the neurocranium was cleaned of connective and muscular tissues to expose the bulla portion of the prootic bone. A pair of pliers was then used to crack and pull away the bullae, exposing the sagittal otoliths which were removed with a pair of forceps. The otoliths were cleaned and stored dry in small labelled vials until processed at the laboratory. From a total sample of 120 individuals collected, otoliths from seven of the specimens were damaged during extraction; hence otoliths from 113 individuals were available for age-based studies.

At the laboratory, sagittae were weighed in grams to 4 decimal places. The primordial area on the distal surface of one sagitta was marked with a pencil before embedding in clear cast resin using rubber moulds and left to dry for 6 hours at 60°C. A diamond saw blade was then used to cut 0.3mm transverse sections through the primordium. The sectioned sagitta were placed on a slide and mounted with clear cast resin before being examined under a binocular microscope at x30 magnification. Annuli counts of ages (i.e. alternating pattern of translucent and opaque bands on the sectioned otoliths; the opaque bands being the annulus which were formed annually) was based on Ferreira and Russ (1994), annuli counts by the author were cross checked by Dr Lou Dong Chong of the otolith laboratory at James Cook University (Townsville, Queensland). Where readings differed, the reading by Dr Chong was used in recognition of his greater experience. Data-sets of size and age for *P. leopardus* from Lizard Island and Swain Reef were obtained from the CRC Reef Research Ltd, while the data for Scott Reef and Abrolhos Reef were obtained from the Western Australia Department of Fisheries, the annuli counts for these locations being those of Dr Chong.

4.2.3 Data Analysis

Age based demographic analysis and graphics were done using the FSA package (by Professor Derek Ogle) of the statistical software R (Version 2.9.2), except Figure 4.6, based on Microsoft Excel 2003.

Growth

The von Bertalanffy growth curves were fitted by nonlinear least squares regression of total length on age (Pears et al. 2006; Williams et al. 2008). The von Bertalanffy growth function used was of the form:

$$L_t = L_\infty \left(1 - e^{-K(t-t_0)}\right) \qquad \text{(Eq 4.1)}$$

where L_t is length at age t, L_∞ is the asymptotic length (L_∞ is also written as Linf in some of the graphics as I was not able to insert subscripts and the symbol '∞' in the software R) or L_{max}, K is the Brody growth coefficient and t_o (this is also written as 'to' in some of the graphics as I was not able to insert subscripts in the graphics in R) is the theoretical age at length zero. The von Bertalanffy growth curve was selected over other growth models such as the Gompertz curve because previous studies of *P. leopardus* had used the von Bertalanffy growth curve and its use here will enable comparison with these studies. Furthermore,

the Schnute's growth formulae (Schnute 1981) indicates the von Bertalanffy growth curve best describes the growth of *P. leopardus* over other growth models (Ferreira and Russ 1994).

Spatial comparison of growth curves used Kimura's likelihood ratio test (LRT) for the von Bertalanffy growth curve (Kimura 1980; Haddon 2001; Ye et al. 2003). Kimura (1980) proved that the least squares estimate is intimately linked to both the maximum likelihood under normal error assumptions (residuals are independent, additive, random and normally distributed) and the usual *F* test for testing significance of effects, hence classic nonlinear methods can be applied to the VBG function.

Further investigation to determine differences in growth curves between Nggela and Australian locations was also done by bootstrapping the data 5000 times (Haddon 2001; Welsford and Lyle 2005; Manly 2007) to detect any overlap in: (1) the 95% confidence intervals of the growth curves, and (2) cross sections of the probability distributions of the newly generated life history parameters.

To test the relationship between sea temperature and demographic parameters, temperature data were extracted from the World Ocean Atlas of the Asia-Pacific Data Research Center (CSIRO Atlas of Regional Seas (CARS2000) LAS http://apdrc.soest.hawaii.edu/w_data/clima3.htm); these data had already been ground truthed by use of floats under the Pacific Global Ocean Observing System (P-GOOS). Depths (hence their respective temperatures) were selected to straddle the depth range 3-100m over which *P. leopardus* occurs (Froese and Pauly 2009). Analysis was done in two stages; analysis of location temperatures followed by correlation of the temperature analysis output (β = harmonic regression coefficient) with demographic parameters as follows.

Relationships between season (months), sea depth (m) and temperature (°C) were investigated using mixed effect models with harmonic covariates for season and location modelled as a random effect. The model was of the form:

$$T = \beta \cos(\frac{2\Pi m}{12}) + \beta \sin(\frac{2\Pi m}{12}) + D + [D(\beta \cos(\frac{2\Pi m}{12})] +$$

$$[D(\beta \sin(\frac{2\Pi m}{12})] + L$$

(Eq 4.2)

Where: T = temperature, β = harmonic regression coefficient (which will be used later as a proxy for location temperature, also referred to as location

temperature coefficient elsewhere in this thesis), Π = pi, m = month, D = depth and L = location.

Harmonic effects model was fitted using the non linear mixed effects (nlme) package of the statistical software R (version 2.9.2). The assumption made with the model was that the response of temperature to season varied randomly with location. Harmonic regressions coefficients (β) derived from the harmonic regression were used as proxies for location temperatures, and these were correlated with the demographic parameters to determine the relationship between temperature and demographic parameters.

Longevity, mortality and survivorship

Longevity was calculated from the data as an average age of the oldest 10% of the sample (10% longevity). Instantaneous rate of total mortality Z was determined from age-based catch curves where the frequency of fish in each age class was regressed against age (Ricker 1975). The curve was fitted from the modal age of recruitment into the fisheries through to the oldest age (2-15 years). Mortality rates for different locations were compared by ANCOVA where age was a covariate (Williams et al. 2008).

Sexual maturity and sex change

Sexual maturity curves were generated by fitting a logistic function to the proportion of mature females in each age and 20mm length classes. The age and length at which 50% sexual maturity occurs (A_{50} and L_{50}) was estimated from the sexual maturity curve (Pears et al. 2006). Age and length at sex change was estimated using the logistic function:

$$P_s = (1 + e^{-ln\ 19\ (S - S50)\ /\ (S95 - S50)})^{-1} \qquad \text{(Eq 4.3)}$$

Where: P_s is the proportion of males in age or 20mm length class S, and $S50$ and $S95$ are the age or length at which 50% and 95% of the population were males (Williams et al. 2008). Undetermined females, transitional individuals and males were not included in the sexual maturity analysis, while undetermined females were not included in the sex change analysis.

4.3   RESULTS

4.3.1 Size and age structure of *P. leopardus* in the Nggela fishery

The minimum size observed was a one year old individual that was 215mm (all fish lengths are in total length (TL)) while the largest size observed was a 15 year old individual that was 560mm. Age and size frequency seems to indicate a single cohort; modal age range was 2-6 years old at a size range of 350-450mm (Figure 4.1). Mean sample length was 387.5 ($\pm$ 6.7) mm at a mean age of 6.4 ($\pm$ 0.3) yr. Females comprised 79% of the sample in the 215 - 470mm size range (mean 361.5mm), while males comprised 21% of sample in the size range 380 - 560mm (mean 460.2mm). Although the mean size of males was greater than that of the females, the 95% confidence intervals overlapped.

4.3.2 Growth, longevity and mortality of *P. leopardus* in Nggela

Longevity based on the mean age of 10% of the oldest individuals was 12.9 ($\pm$0.4) yr. The VBGF growth curve followed the expected asymptotic pattern (Figure 4.2). The growth coefficient K was 0.13 ($\pm$ 0.05) yr^{-1} with 80% of the asymptotic growth achieved at 9 years of age, the final asymptotic length (L_∞) was 520 ($\pm$44) mm (Figure 4.2). Mean total mortality was 0.22 ($\pm$0.04) % yr^{-1} (regression age range 2-15 years, Figure 4.3) with a survival rate of 0.80% yr^{-1}.
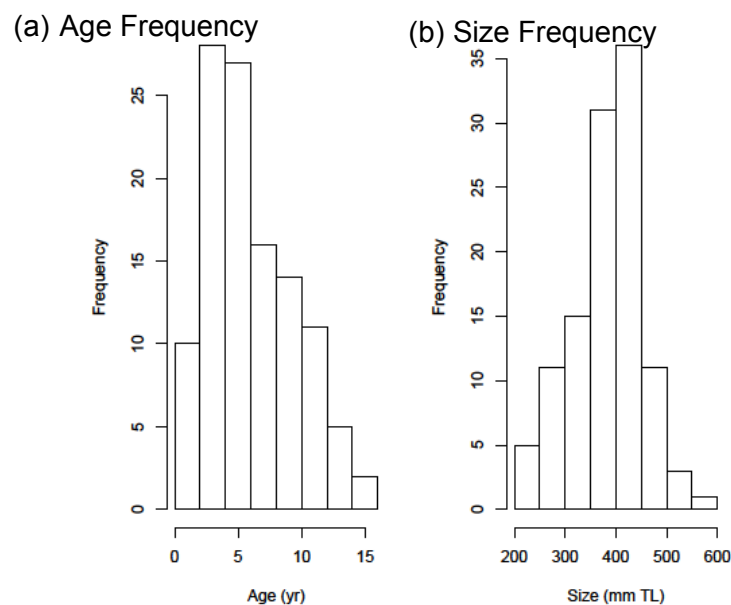

Figure 4.1: Age and size frequency of *Nggela P. leopardus* (n=113)
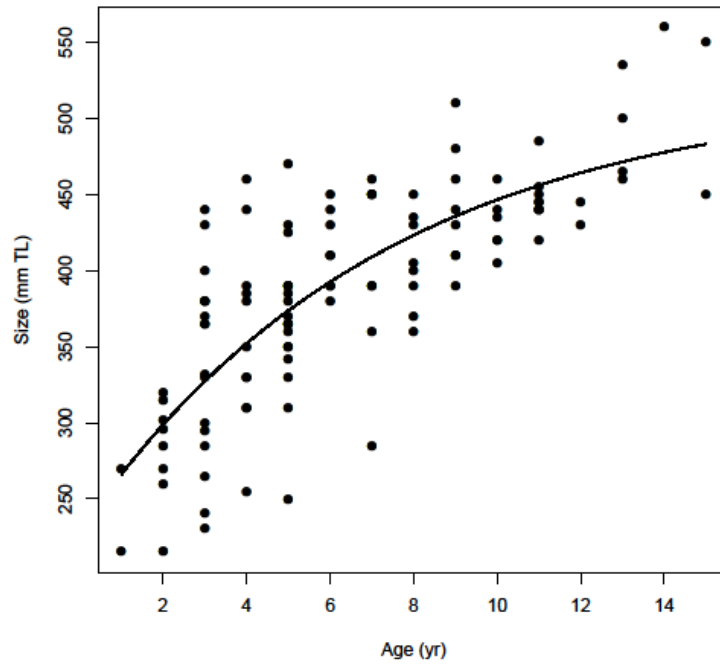
Figure 4.2: von Bertalanffy growth curve for Nggela *P. leopardus* (n=113)
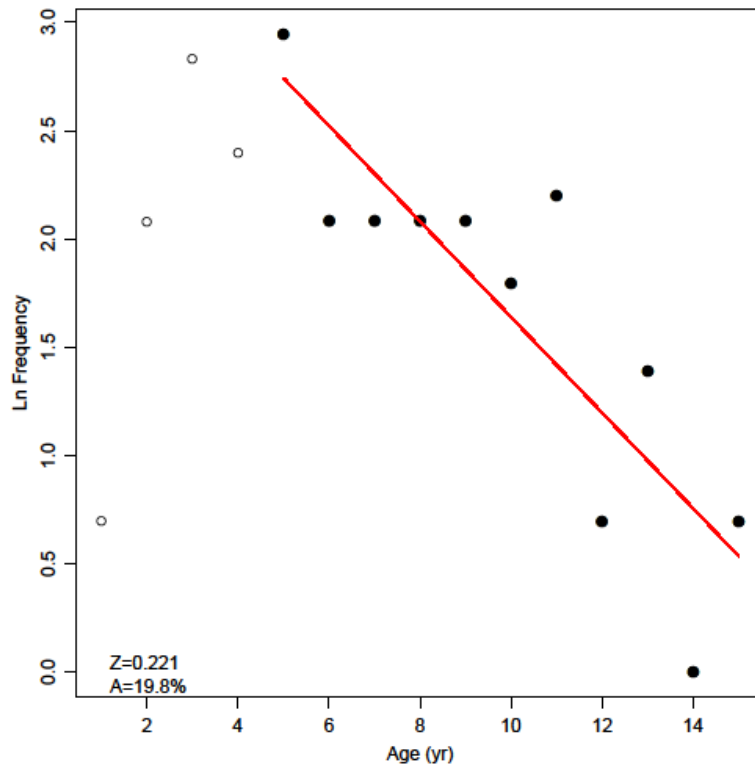
Figure 4.3: Nggela *P. leopardus* catch curve. Ln frequency of catch was regressed with age to determine mean total mortality (Z)

4.3.3 Reproductive biology of *P. leopardus* in Nggela

The characteristics of the different sexual stages of the Nggela *P. leopardus* are shown in Figure 4.4, they are similar to those of Adams et al. (2000). The Nggela sample had a female to male ratio of 4:1 and consisted of 20% immature females, 5% undetermined females, 53% mature females, 4% transitional individuals and 18% males. Mature female to male ratio was 3:1 (operational sex ratio, immature and transitional individuals not included), no primary males were observed. Female maturity began at 2 years of age (291mm), with 50% sexual maturity achieved at 3.22 years at TL of 327mm (Figure 4.5). Sexual transition from female to male occurred at 3 -10 years of age, 50% sex change from female to male was achieved at 11 years at TL 420mm (Figure 4.6). Males occurred in lower frequency compared to the females in the age range 3 - 11 years, with a relatively higher frequency at older ages (>11 yr) and larger sizes (>440mm) (see logistic curve on Figure 4.6). The oldest and largest individual was a male.
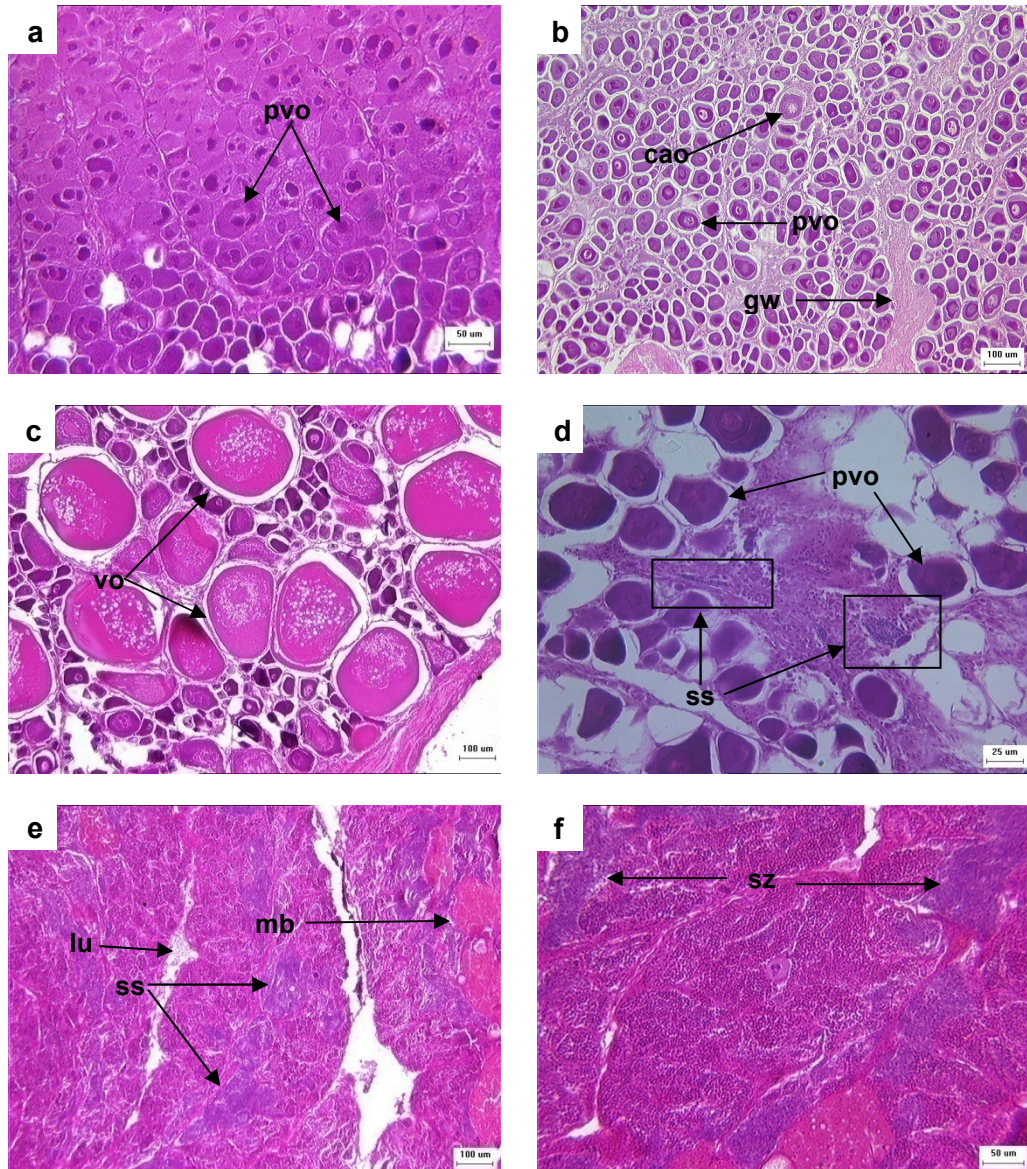
Figure 4.4: Reproductive stages of *Plectropomus leopardus*

(**a**) Immature female (**b**) mature resting female (**c**) ripe female (**d**) transitional individual (**e**) mature male (**f**) mature male enlarged to show spermatozoa. **pvo**-previtollogenic oocytes, **cao**-corticial alveolar oocytes, **gw**-gonad wall, **vo**-vitellogenic oocytes, **ss**-sperm sinuses, **mb**-muscle blocks, **lu**-ex-ovarian lumen, **sz**-spermatozoa
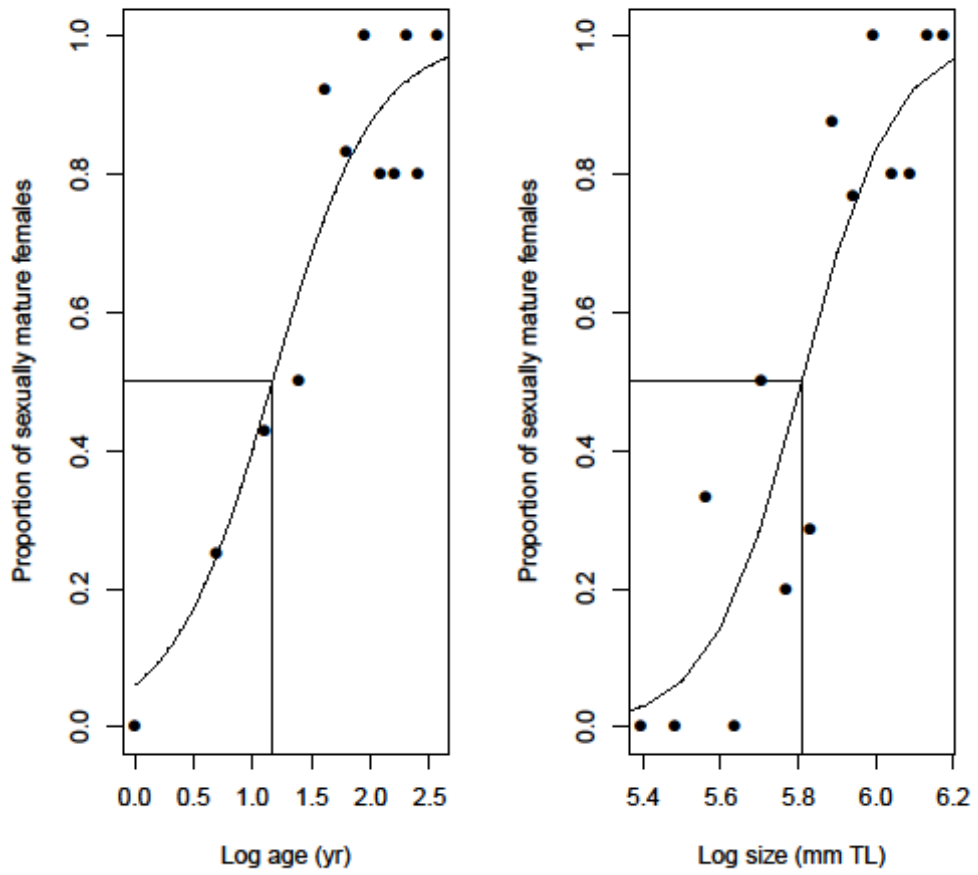
Figure 4.5: Sexual maturity ogive for Nggela *P. leopardus*
(Note: Log in above maturity ogive is Log$_{10}$.)
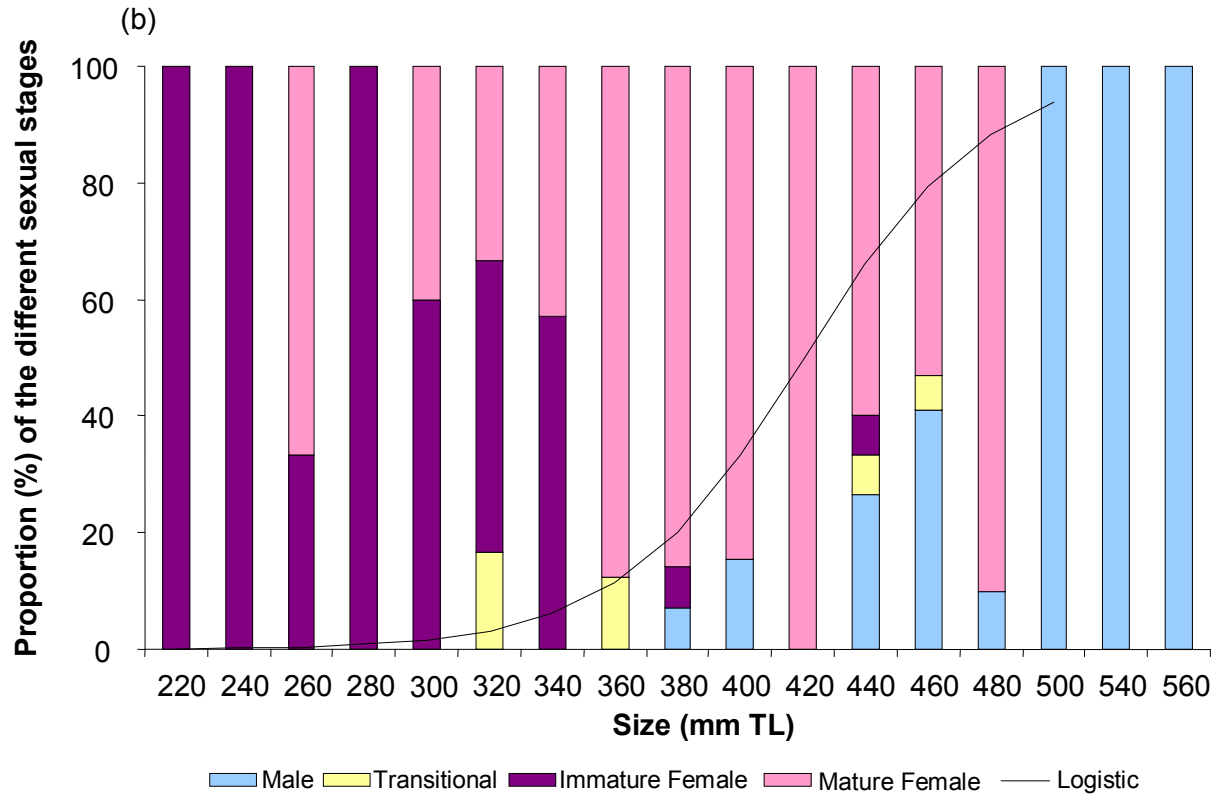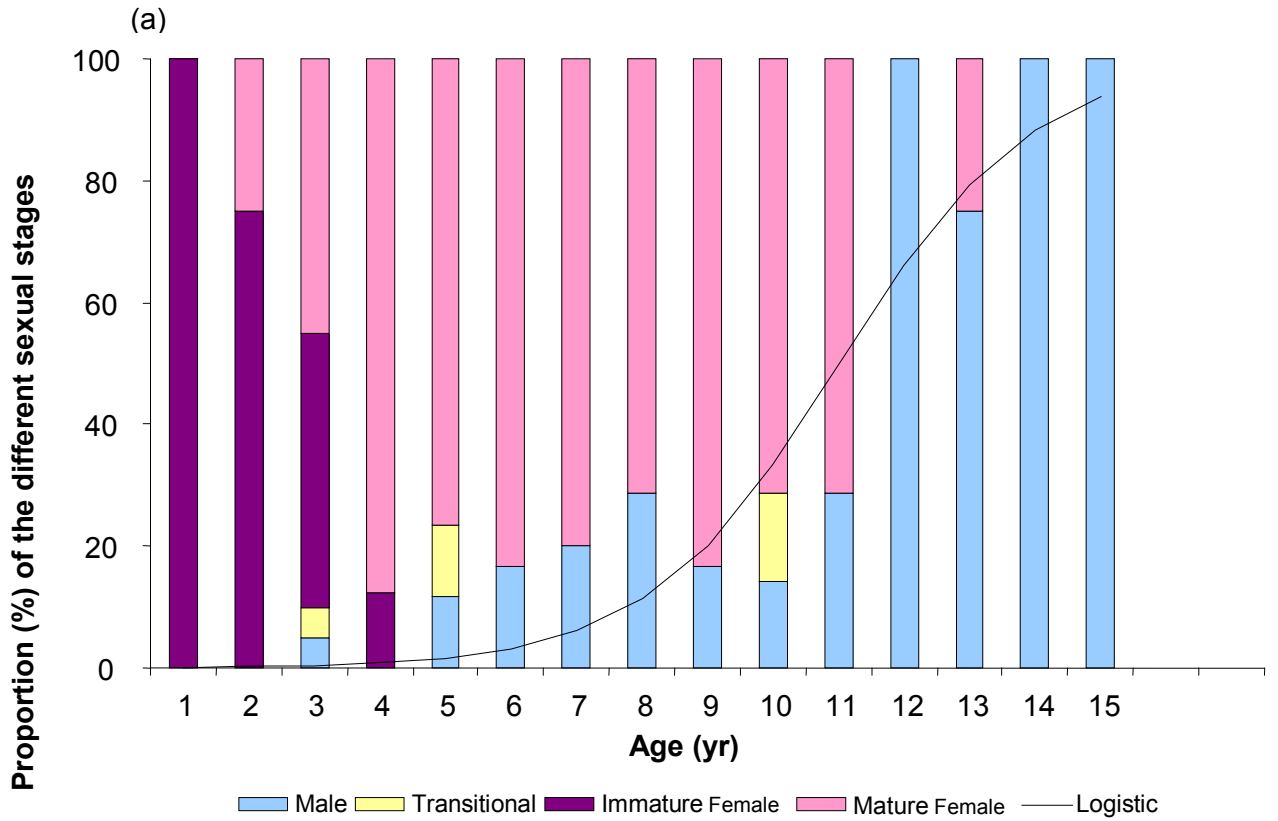
Figure 4.6: Proportion of the different sexual cstages according to (a) age and (b) size classes for Nggela *P. leopardus* (n=109)

4.3.4 Demography of *P. leopardus* from Australian locations

Age and growth

Modal size and age for Lizard Island, Swain Reef and Scott Reef in Australia were generally similar to those of Nggela, being TL 300 - 450mm at an age range of 2 - 6 years (Figures 4.7- 4.8). The size structure at Abrolhos Reef indicated modal size at 300 - 450mm total length as well; however most of this recruitment occurred at 4 - 6 years which tend to be later than for other locations. Furthermore the size and age structure shown by the Abrolhos data seems to indicate the presence of two cohorts.

The growth coefficient K of *P. leopardus* at Lizard Island reef was 0.26 (±0.10) yr^{-1}, 80% of asymptotic growth was achieved at approximately 4 years old, with an asymptotic length of 502 (±38) mm (Figure 4.9). For Swain Reef the growth coefficient K was 0.17 (±0.06) yr$^{-1}$, 80% of asymptotic growth was achieved at approximately 6 years of age with L_∞ of 535 (±39) mm. L_∞ at Scott Reef was the lowest at 385 (±7) mm and K was 0.42 (±0.06) yr^{-1}, 80% of the asymptotic length being achieved at about 3 years of age (Figure 4.9). The highest asymptotic length was observed at Abrolhos Reef which was 916 (±106) mm, with a K value of 0.08 (±0.02) yr^{-1}, 80% of asymptotic length being achieved at approximately 15 years of age (Figure 4.9).

Longevity and mortality

The greatest age of 18 years with a longevity of 13.0 (±0.84) yr was observed at Abrolhos Reef. For the other Australian locations, longevity at Swain Reef was 10.1 (±0.4) yr, at Lizard Island it was 7.2 (±0.4) yr, while at Scott Reef it was 6.4 (±0.4). Longevity of *P. leopardus* based on 10% of the oldest individuals differed significantly among locations, the lowest longevity being at Lizard Island and Scott Reef.

Total mortality at Abrolhos was 0.24 (±0.04) % yr^{-1}, for Swain Reef it was 0.39 (±0.03) % yr^{-1} while for Scott Reef it was 0.30 (±0.03). An expected high mortality at Scott Reef due to a very short life span was not evident from the catch curves. The highest mortality of 0.59 (±0.05) % yr^{-1} was observed at Lizard Island (Figure 4.10). There was a highly significant difference (ANCOVA, P <0.05, F = 8.5, df = 4) in the total mortality among the locations.
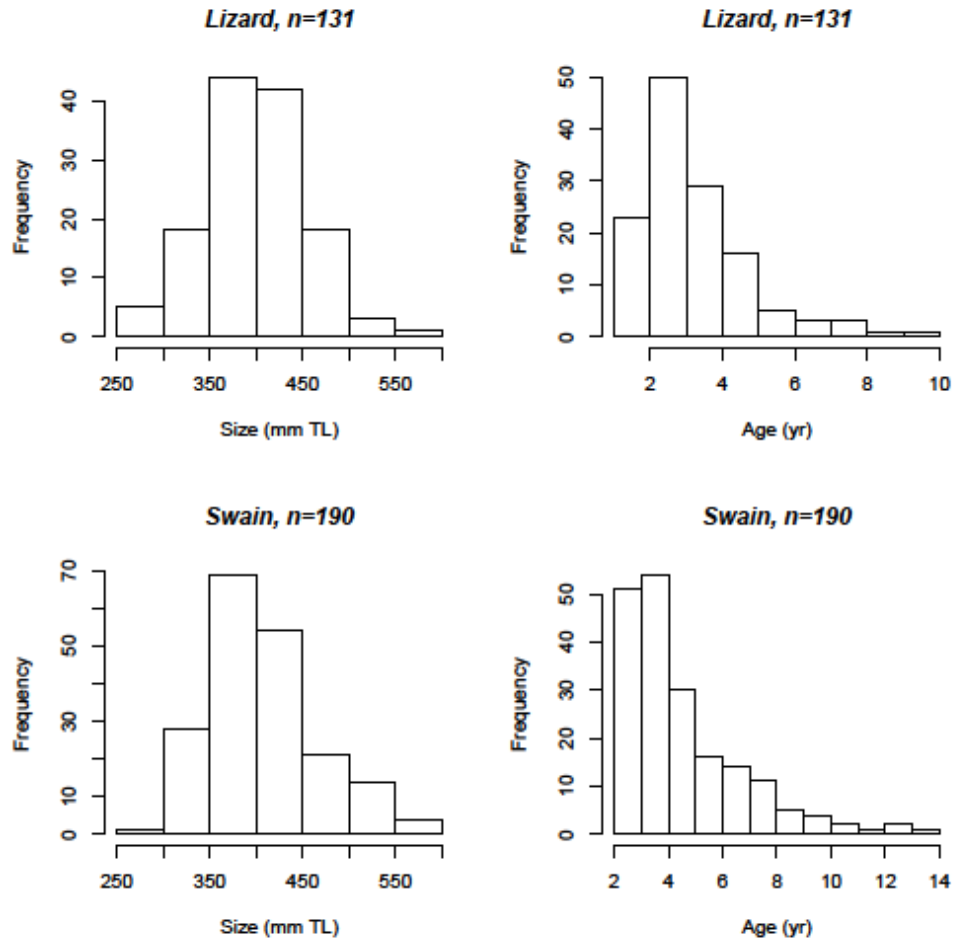
Figure 4.7: Size and age frequency of *P. leopardus* at Lizard Island and Swain Reef, Australia (Data from CRC Reef Research Ltd, Australia)
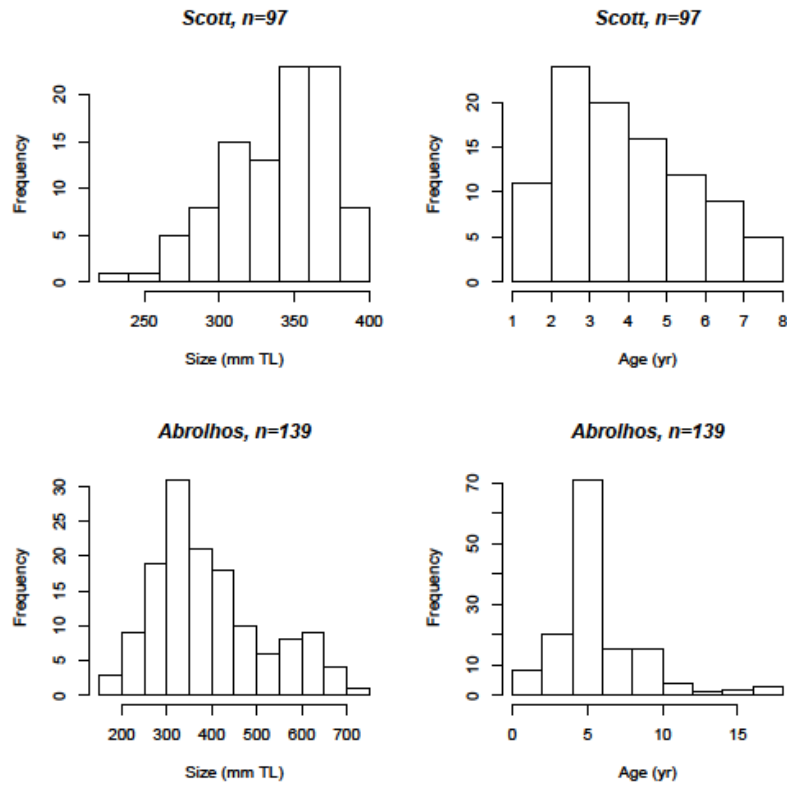
Figure 4.8: Size and age frequency of *P. leopardus* at Scott and Abrolhos Reefs (Data from Western Australia Department of Fisheries)
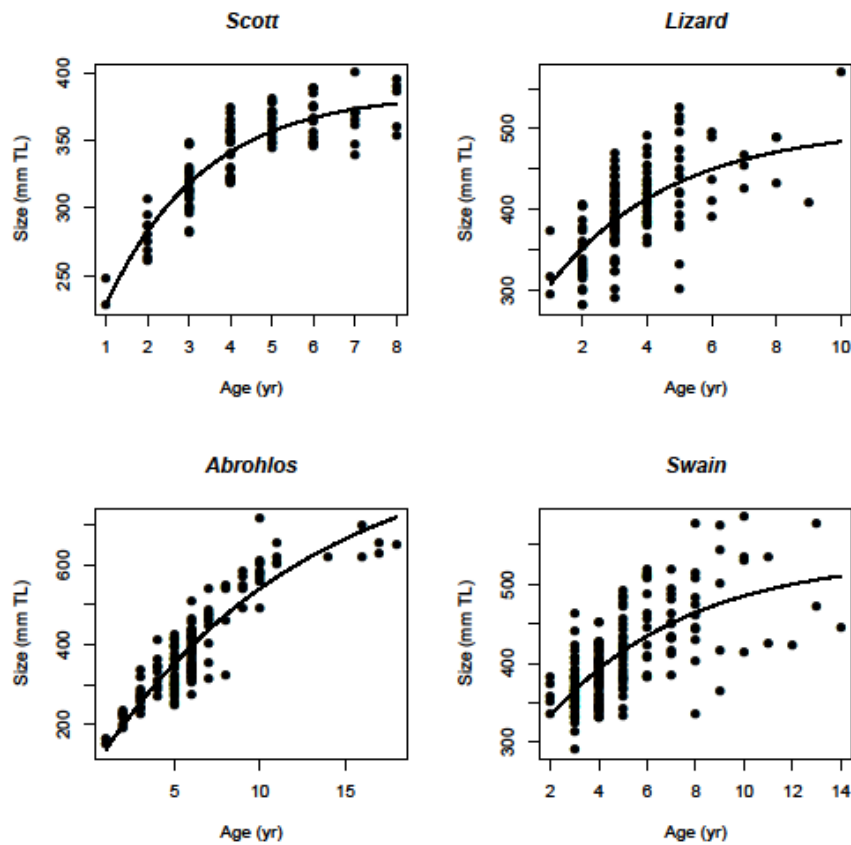
Figure 4.9: von Bertalanffy growth curve for *P. leopardus* at Australian locations
(Data from CRC Reef Research Ltd and Western Australia Department of Fisheries)
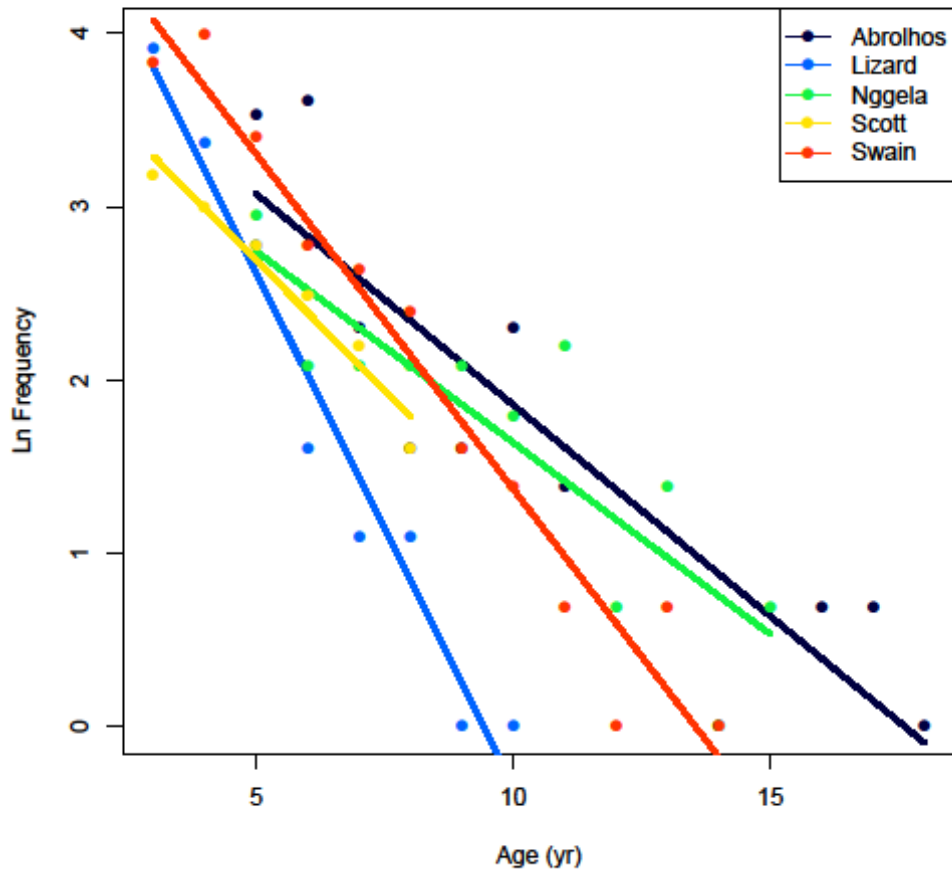
Figure 4.10: Catch curves for *P. leopardus* for all locations, Nggela included for comparison (Data for Lizard and Swain from CRC Reef Research Ltd and for Scott and Abrolhos from Western Australia Department of Fisheries)

4.3.5 Spatial variation of the age based demography of *P. leopardus*

The age-based demographic parameters of *P. leopardus* varied spatially (Table 4.2) as shown by non linear least squares regression of the bootstrapped age-length data (Figure 4.11) and likelihood ratio tests (Table 4.3). Likelihood ratio comparisons between Nggela and Scott showed that differences in the growth curve overall can be attributed to significant differences in L_∞ and K. For Nggela and Abrolhos, significant differences in the growth curves can be attributed to significant differences in t_o.

Cross sectional plots of the 95% confidence regions around the least square estimates of the bootstrapped growth parameters showed overlaps in the growth parameters between Nggela, Lizard and Swain (Figure 4.12); growth trajectories were not significantly different among these locations. Based on the

cross sectional plots, growth trajectories for Scott and Abrolhos were significantly different from Nggela, Lizard and Swain (Figure 4.12).

Temperatures varied non-linearly with season and depth among locations. L_∞ was negatively correlated with the harmonic regression coefficient β (Eq.4.2) of the locations (r=-0.82, P<0.05) and positively related to the Brody growth coefficient (r=0.36, P<0.05), (Figure 4.13), indicating that L_∞ was higher in cooler areas where growth was slowest while L_∞ was smaller in warmer areas where growth was faster.
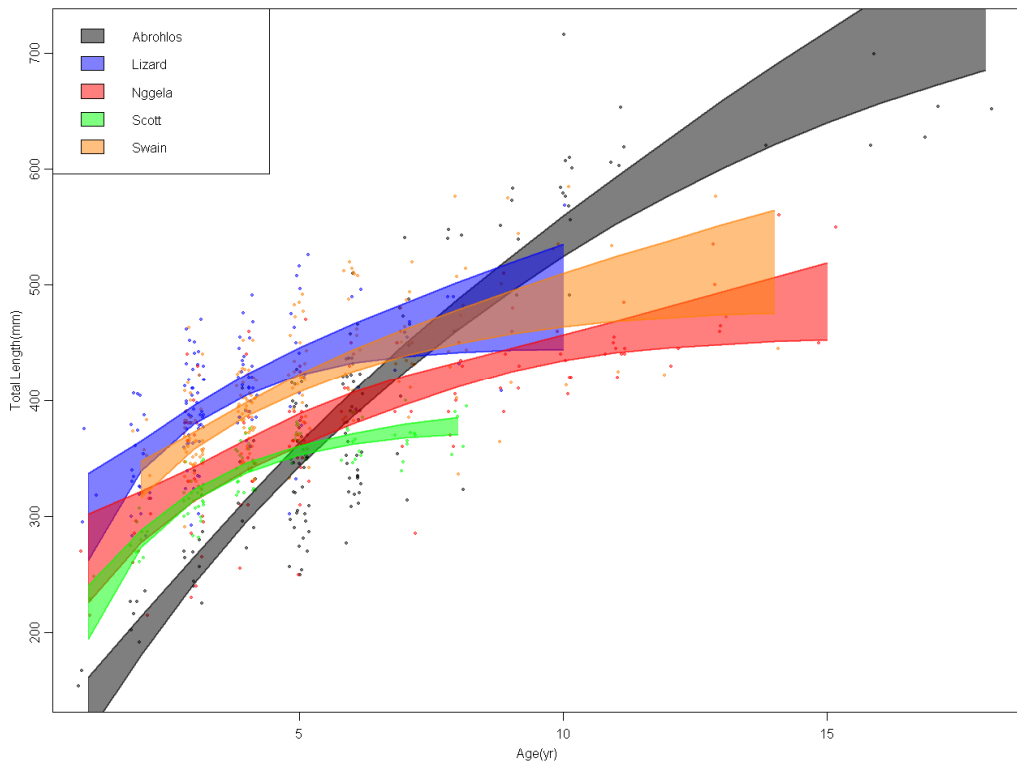
Figure 4.11: 95% confidence interval bootstrapped growth curves for Nggela and the four Australian locations (Data for Lizard and Swain from CRC Reef Research Ltd and for Scott and Abrolhos from Western Australia Department of Fisheries)

Table 4.2: Temperature range and β (in parenthesis) with age-based demographic parameters of *P. leopardus* from the 5 locations

Location	Temp range (^{o}C) at 3-100m depth and (β)	n	Age range (yr)	Size range (mm)	L_∞ (mm TL)	K (yr^{-1})	t_o (yr)	Z (%yr^{-1})	10% Longevity (yr)
Nggela 160.1^o , -9.1^o	24.5 - 29.7 (6.23)	113	1 - 15	215 - 560	520	0.13	-4.19	0.22	12.9
Lizard 145.4^o, -14.6^o	22.2 - 29.0 (4.15)	131	1 - 10	283 - 569	502	0.26	-2.64	0.59	7.2
Swain 154.2^o , -21.6^o	20.5 - 28.3 (3.02)	190	2 - 14	219 - 585	535	0.17	-3.61	0.39	10.1
Scott 121.8^o, -14.0^o	20.6 - 30.2 (4.27)	97	1 - 8	229 - 400	385	0.42	-1.12	0.30	6.4
Abrolhos 113.7^o ,- 28.7^o	18.6 - 23.7 (0)	139	1 - 18	154 - 716	916	0.08	-1.03	0.24	13.0

(Data for Lizard and Swain from CRC Reef Research Ltd and for Scott and Abrolhos from Western Australia Department of Fisheries)

Table 4.3: Results of likelihood ratio tests comparing von Bertalanffy parameters of *P. leopardus* between Nggela and the Australian locations

Locations compared	Hypothesis	Chi square	Degrees of freedom	P
Nggela-Lizard	$L_{\infty 1} = L_{\infty 2}$	0.23	1	0.632
	$K_1 = K_2$	1.27	1	0.260
	$t_{o1} = t_{o2}$	0.64	1	0.424
	$L_{\infty 1} = L_{\infty 2}, K_1 = K_2, t_{o1} = t_{o2}$	71.00	3	0.000*
Nggela-Swain	$L_{\infty 1} = L_{\infty 2}$	0.06	1	0.806
	$K_1 = K_2$	0.19	1	0.663
	$t_{o1} = t_{o2}$	0.06	1	0.806
	$L_{\infty 1} = L_{\infty 2}, K_1 = K_2, t_{o1} = t_{o2}$	48.17	3	0.000*
Nggela-Scott	$L_{\infty 1} = L_{\infty 2}$	7.19	1	0.007*
	$K_1 = K_2$	5.07	1	0.024*
	$t_{o1} = t_{o2}$	3.42	1	0.064
	$L_{\infty 1} = L_{\infty 2}, K_1 = K_2, t_{o1} = t_{o2}$	21.83	3	0.000*
Nggela-Abrolhos	$L_{\infty 1} = L_{\infty 2}$	2.84	1	0.092
	$K_1 = K_2$	0.75	1	0.386
	$t_{o1} = t_{o2}$	4.38	1	0.036*
	$L_{\infty 1} = L_{\infty 2}, K_1 = K_2, t_{o1} = t_{o2}$	98.35	3	0.000*

(Data for Lizard and Swain from CRC Reef Research Ltd and for Scott and Abrolhos from Western Australia Department of Fisheries)
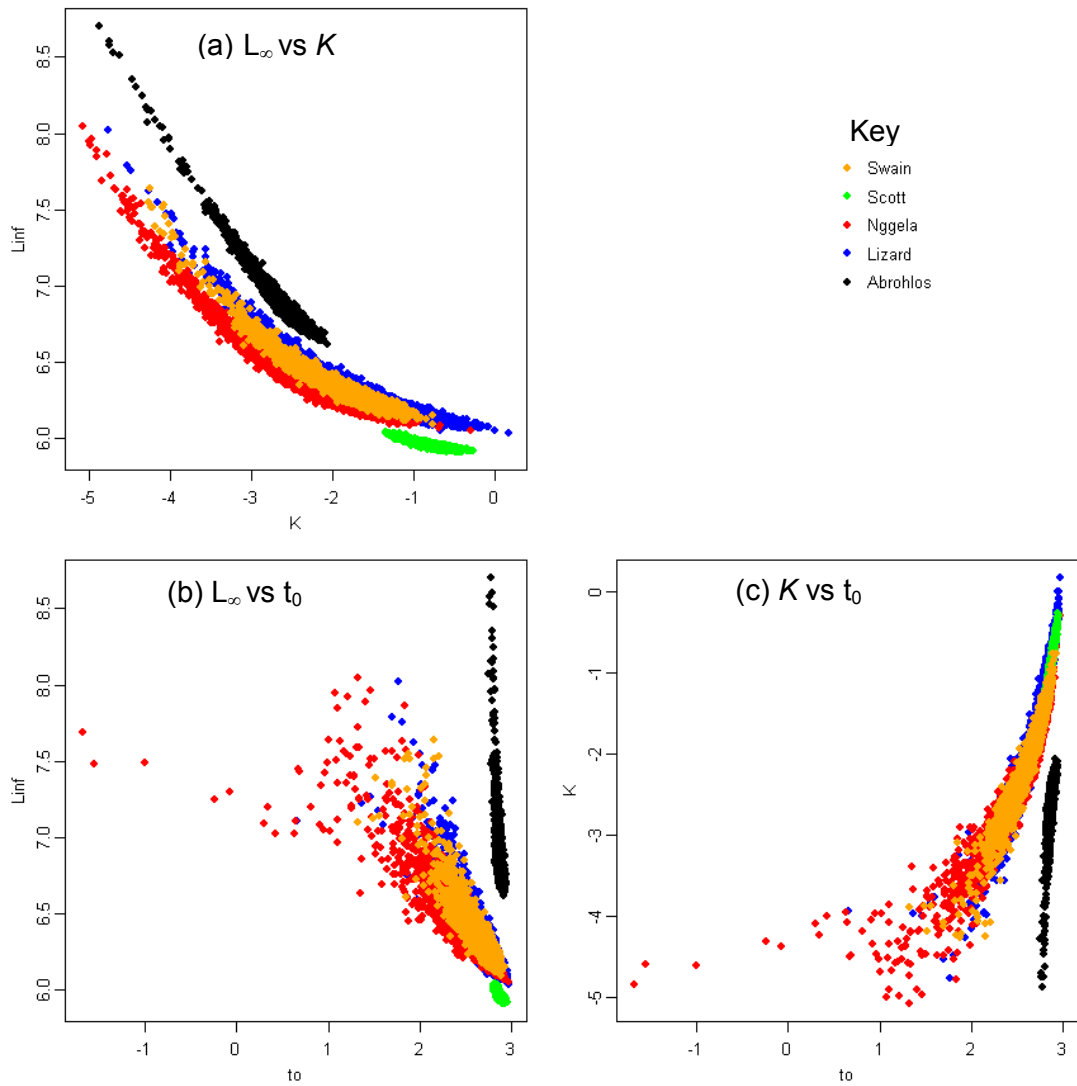
Figure 4.12: Cross sections of 95% confidence interval bootstrapped estimates of von Bertalanffy parameters for *P. leopardus* from different locations plotted on logarithmic axes for clarity. (Note: I was unable to add subscripts and the symbol ∞ in R, hence Linf = L_∞, to = t_0, K = *K*)

(Data for Lizard and Swain from CRC Reef Research Ltd and for Scott and Abrolhos from Western Australia Department of Fisheries)
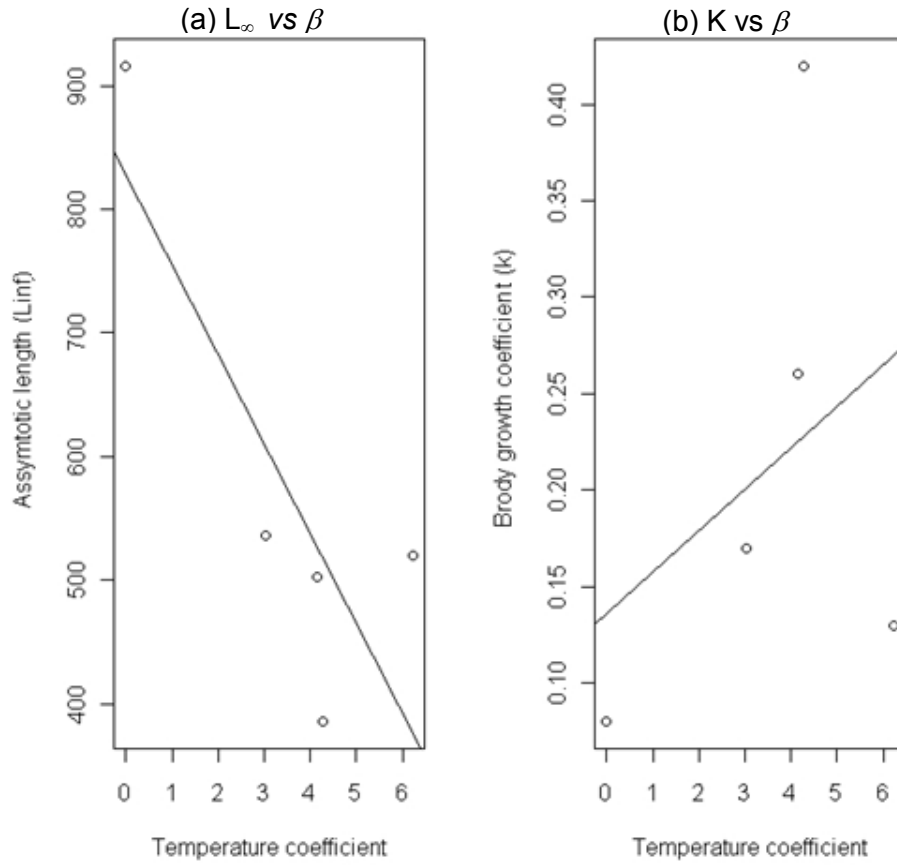
Figure 4.13: Plots of (a) L_∞ (Linf) in mm total length of fish and (b) K in t^{-1} against temperature coefficient (i.e. β = harmonic regression coefficient from Eq. 4.2, used here as a proxy for location temperature). Line through the data is a best fit correlation line for which the r is given in the text.

4.4 DISCUSSION

The data collected for this chapter and the resultant inferences are constrained by being representative only for one season, hence size and age structures refer to the season (koburu) when I was doing field research; modal progression of the cohorts of *P .leopardus* over several seasons or years could not be shown from the data analysed for this study. However, the size and age structures when considered together with reproductive data indicate that *P. leopardus* in Nggela is currently targeted within the size and age range of 50% female sexual maturity. The catch curves of *P. leopardus* in Nggela indicate a lower total mortality *(Z)* than for Australian locations. However, this low total mortality should be considered with caution for several reasons. Firstly, as mentioned earlier the sample of specimens collected was only for one season and a strong year class consisting of mostly large sizes present at that particular time during sampling may have resulted in the underestimation of the mortality rate. According to Ferreira and Russ (1995) the presence of a strong year class for a single sampling regime may inaccurately inflate or deflate mortality rate calculations. A second reason for caution is that, mortality rate calculations based on the Ricker's (1975) model assumed that all age groups had been recruited with the same abundance level (Ferreira and Russ 1995); this assumption could not be tested herein. The third reason is that the samples collected were fisheries dependent, fishers probably used hooks which select larger individuals and such bias may further contribute to underestimation of the mortality rate.

The sex ratio of *P. leopardus* in Nggela was as expected for a protogynous species (Allsop and West 2004). The size and age of first sexual reproduction in Nggela *P. leopardus* were similar to those for Great Barrier (Ferreira 1995). Fifty percent sexual transition occurred at a relatively old age and large size; the operational sex ratio was 3:1, compared to 2.0:1 for fished areas of eastern Torres Strait (Williams et al. 2008), 0.7:1 to 5.5:1 in 4 areas open to fishing and 0.3:1 to 2.7:1 in areas closed to fishing on the Great Barrier Reef (Adams et al. 2000). The present study and those of Williams et al. (2008) and Adams et al. (2000) were conducted under: (i) different sampling regimes, (ii) different sample sizes, and (iii) different reef closure regimes. My study was fisheries dependent, the total sample size collected over 4 months was 113, and fishing was at 65 - 120m depth. The Williams et al. (2008) study

was also fisheries dependent, however their total sample size was 456 over a much larger spatial area than at Nggela. The Adams et al. (2000) study was probably the most statistically rigorous as it was conducted between 4 open and 4 closed reefs with sampling times and depths controlled for; sample size for each reef was 80 giving a total sample size of 640.

Several studies and heuristic modelling (Huntsman and Schaaf 1994; Armsworth 2001; Alonzo and Mangel 2004; Hawkins and Roberts 2004b; Alonzo and Mangel 2005; Heppell et al. 2006; Molloy et al. 2007) have indicated that protogynous species are more sensitive to fishing than gonochoristic species and that preferential fishing of large individuals over a prolonged period can significantly affect sex ratio (McGovern et al. 1998). However the incomplete understanding of the plasticity of the sex changing strategies under different circumstances made it difficult to determine what the 'safe' sex ratio should be, in order to sustain a population. Adams et al. (2000) attempted to quantify the effects of fishing on sex ratios of *P. leopardus* between areas that were open and closed to fishing and concluded that there were no clear patterns in sex ratio, sex specific sizes and reproductive biology for *P. leopardus* between reef closure regimes. Taking into consideration previous studies and the limitations of my data, no conclusions can be made about what threat levels current sex ratios indicate about *P. leopardus* in the Nggela fisheries.

Plectropomus leopardus is an economically important reef finfish species not only for the local market but for the international live reef food fish trade (Ferreira and Russ 1994). Because of its importance, it has been a subject of previous (Ferreira and Russ 1994; Ferreira 1995; Ferreira and Russ 1995; Russ et al. 1996; Russ et al. 1998; Adams et al. 2000; Mamauag 2002; Williams et al. 2008) age-based demographic studies undertaken elsewhere. Ferreira and Russ (1994) reported an L_∞ (fork length) value of 522 mm, K value of 0.354 and a t_o value of -0.766 for Lizard Island. Mamauag (2002) who investigated the live reef fish trade at Coron and Guivan in the Philippines reported an L_∞ (total length) of 630mm and 505mm, K value of 0.08 and 0.13 respectively. Williams (2008) reported an L_∞ (fork length) value of 746mm, K value of 0.07 and a t_o value of -0.72 in Torres Strait Islands. These different studies and the Australian data analysed for this study show that age-based

demographic parameters vary with locations. The age based demographic parameters of *P. leopardus* in Nggela showed similarities to those previously reported for the Great Barrier Reef (Ferreira and Russ 1994; Ferreira 1995; Ferreira and Russ 1995) and to the data from CRC reef research limited for Lizard and Swain (both these reefs are on the Great Barrier Reef) which were analysed in this study. However, there were differences between Nggela and the Western Australian data. VBGF growth analysis can be constrained by small sample sizes, individual variability within age or sizes and/or the absence of certain age classes in the sample. For example in eastern Torres Strait, L_∞ was over estimated and K under estimated due to the absence of lower age classes in the sample (Williams et al. 2008). I attempted to overcome unequal sample sizes and under-representation of certain age classes in the Nggela data by bootstrapping to generate non-parametric probability distributions of the demographic parameters that were biologically representative and robust enough to allow for spatial comparisons.

The analyses herein show that seawater temperature of the location where samples were taken may have had an effect on the demographic parameters of *P. leopardus*; faster growth (e.g. 0.13 yr^{-1} for Nggela) and lower asymptotic length (e.g. 560mm for Nggela) were achieved in warmer areas while the reverse is true for colder regions (Brody growth coefficient in Abrolhos was 0.08 yr^{-1} while asymptotic length was 716mm). This is consistent with other general life history studies (Atkinson 1995; Belk and Houston 2002; Braaten and Guy 2002; Helser and Lai 2004; Kingsolver and Huey 2008). Phenotypic plasticity in the growth of *P. leopardus* under different temperatures may contribute more to these growth differences than genetic differences. This conclusion is suggested based on previous genetic studies of *P. leopardus* between Scott and Abrolhos Reef and other coral reef species generally (Doherty et al. 1995; Shulman and Bermingham 1995; Dudgeon et al. 2000). Using Lactate dehydrogenase-B (Ldh-B) which is known to be under thermal selection in *Fundulus heteroclitus*, Hillersoy (2007) investigated spatial genetic differences in the local thermal adaptation of *P. leopardus* between Scott Reef and Abrolhos Reef. There was no difference in the Ldh-B between the two locations; however the role of other thermo-regulatory genetic factors besides Ldh-B was not excluded. Based on microsatellite markers, Van Herwerden et al. (2009), reported that Scott Reef is the recruitment source for the Abrolhos

P. leopardus population. Coral reef fishes tend to be genetically homogenous over hundreds to thousands of kilometres (Doherty et al. 1995; Shulman and Bermingham 1995; Dudgeon et al. 2000). Variability of age-based demographic parameters due to other ecological factors such as competition (Jones 1987) and food availability (Hart and Russ 1996) etc) is also acknowledged. Data for Scott Reef were different from all the locations sampled as the *P. leopardus* found there were generally shorter lived (10% longevity was only 6.4 years) and smaller in size (asymptotic length was only 400mm). Similar observations of being short lived and smaller in size were also made by Ackerman (2004) for Scott Reef when making latitudinal comparisons of age-based demographic parameters of the moon wrasse (*Thalassoma lunare*). I acknowledge that this is an outlier I cannot explain from the analysis of data collected in this study, however, the role of over fishing could not be discounted as Indonesian fishermen have been reported to sail as far as Scott Reef to fish (Howard Choat pers.comm). More computationally robust data analysis techniques such as Bayesian hierarchical analysis (Helser and Lai 2004) or modifications to the VBGF (Sinclair et al. 2002; Kimura 2008) might have further elucidated the spatial differences here, however such robust comparisons were constrained by small sample sizes; the study by Helser and Lai (2004) was a meta analysis of 245 populations (no specific sample size was given) of the largemouth bass *Micropterus salmoides* to determine growth variability among geographically distinct populations, while Kimura (2008) used a sample size of 16,182 - 36,750 fish specimens in a study of 3 fish species to model how growth rates can be related to geographic, environmental and biological factors.

The present data indicate that *P. leopardus* is currently not under threat from current levels of fishing pressure in Nggela. This may well be true considering that 97% of the samples were obtained from offshore reefs which require time and effort to reach for the majority of fishers who were using dugout canoes. The relatively long distances (which is between 2-6 km) to these reefs may be offering *P. leopardus* some protection. However only 4 individual specimens of *P. leopardus* were obtained from inshore areas during the 5 months sampling period; *P. leopardus* may be over exploited in inshore reefs and fishers may be moving to offshore areas to target them. This lends support to fisher perceptions (Chapter 3, Figure 3.1) that finfish abundance in

inshore areas is lower than offshore reef areas. Although the age-based demographic data indicate that *P. leopardus* in offshore areas is currently not under threat, several factors suggest that this may not be the case. There are currently no management measures such as minimum and maximum harvestable sizes or protection of spawning aggregations of *P. leopardus*. In the absence of regulations, landed sizes may decline or if there is selective exploitation of large individuals, then the population's reproductive capacity may be compromised by the shortage of males. A further threat and possibly a major threat in the light of the generally low abundance of *P. leopardus* come from the practice of targeting spawning aggregations. If no management measures are in place, *P. leopardus* in the offshore reefs areas of Nggela may be heading in the same direction as in inshore areas, especially in an environment of increasing efficient gears and use of motor powered boats to access offshore reefs.

Further studies could build on the findings of this chapter to provide a more complete picture of *P. leopardus* status in Nggela. Sampling both inshore and offshore over several years could be used to determine the strength of the cohorts from year to year. This could be complemented by mark recapture surveys using traps to estimate abundance of the species. A reference location on an island that is further from markets has a low fishing pressure but with similar characteristics to Nggela such as the Russell Islands might be included in future studies. Market surveys similar to those of Rhodes and Tupper (2007) over at least one year could determine when *P. leopardus* is heavily targeted and might indicate the spawning periods. Working more closely with fishers would help identify the sites and assess abundances of spawning aggregations by using video methods as the depths at which they occur may be too great for underwater visual census.

CHAPTER 5

CUSTOMARY MARINE TENURE, MANAGEMENT AND GOVERNANCE OF REEF FINFISH FISHERIES IN NGGELA

Abstract

This chapter investigates the historical changes the CMT governance system in Nggela has undergone, the relationship of the CMT governance system to management of reef finfish fisheries, the Anglican Church and local level governance. Methods used were literature research, key informant interviews and participant observations. The Anglican Church played a significant role in the historical changes of the CMT governance system and at the time of the fieldwork continued to influence developments in local level governance and politics. Two levels of governance were identified to be operating above community level governance (which was present at the community level): the national government and the provincial government. Using dynamite fishing as a case study, the findings demonstrated that the CMT governance system is failing to support effective management of the reef finfish fishery because management structures do not appear to have coercive powers like those observed in more hierachial fisheries governance structures (e.g. Common Fisheries Policy in Europe). Such an ineffective governance system may affect fisheries management. Empowerment of the CMT governance system by the provincial governance structure is recommended to enable the use of CMT for effective small-scale fisheries management.

5.1 INTRODUCTION

One of the major factors determining the success of CMT for contemporary fisheries management is the ability of traditional authority (local governance institutions) to enforce resource management rules and sanction penalties under customary law and practice within the modern legal and governance environment (Graham 1994a). While modern governance institutions to an extent recognise traditional governance institutions (Graham and Idechong 1998; Care and Zorn 2001; Lidimani 2006), traditional authorities do not normally have formal authority to enforce management rules, and certain community sanctions may be a violation of modern criminal laws (Veitayaki 2000). Governance is defined herein as the principal mechanism in which decisions are made, either formally (e.g. governments making legislation, policies, rules and regulations) or informally (e.g. community based

actions). Ruddle (1996b:329-330) lists banishment, confiscation of boats and fishing gear, corporal and capital punishment as sanctions that may be applied. In the absence of 'real powers' for enforcement of compliance, the success of CMT or any community based management regime therefore depends on the level of authority and respect traditional authorities command (Johannes 1998; Cooke et al. 2000; Hoffmann 2002; Wairiu and Tabo 2003; Aswani 2005; Muehlig-Hofmann 2007; Aswani and Sabetian 2009; Clarke and Jupiter 2010). Acheson (2006) argued that, there is increasing consensus that a factor contributing to resource degradation is institutional failure, and that resource problems will need to be matched with governance institutions that are effective in achieving stated aims and objectives and specific management techniques, if resources are to be managed sustainably.

Within the context of moribund or transitional tenurial systems, the effective use of CMT for contemporary fisheries management, particularly the enforcement of management rules, requires a proper understanding of the traditional governance institutions and the nature of local politics and power relations (Graham 1994a; Thomas 2001). This understanding will allow prediction of whether a CMT system can be hybridised effectively with contemporary fisheries management methods (Aswani and Hamilton 2004; Aswani 2005). White (2007:1-2) made the following observations about the intersection between local cultural practices and state institutions in Solomon Islands:

"Despite a century of response and adaptation to State power, we know very little about the ways customary practices actually articulate with government institutions. One of the ongoing puzzles in Solomon Islands, for example, is the fact that traditional leaders "chiefs" have been a topic of national interest and debate for decades with almost no real political reform that brings them into the machinery of government. The lack of accommodation in this area signals deeper problems in linking indigenous practices with the apparatus of the State"

Dynamite fishing was a prohibited method of fishing in the 10 villages where this study was conducted, yet its prohibition could not be enforced by the village chiefs and clan leaders. Using dynamite fishing as a case study, the questions that this chapter seeks to answer are:

(1) why is the Nggela clan and village system as a governance structure not able to enforce the rules against dynamite fishing within CMT areas?

(2) how can the Nggela clan and village system as a governance structure be enabled to be effective, not only in enforcing management rules against dynamite fishing but also as an effective CMT fisheries management governance regime?

5.2 METHODS

The information on whether dynamite fishing is a prohibited fishing method was obtained from fisher interviews (n=93, Chapter 1, Table 1.1 – the same fishers who were interviewed for data in Chapters 2 and 3). Other qualitative data were collected through face to face unstructured interviews with village chiefs, clan chiefs within the villages, the paramount chief (who was the Diocesan Bishop of Nggela at the time of research) and the deputy paramount chief of Nggela. A total of 8 key informants were interviewed. The age range of the informants was 50-70 years. Interviews lasted 4-7 hours. Even though the interviews were unstructured, several guiding points were followed during the interview (Table 5.1).

Table 5.1: Guiding points for interview on traditional governance in Nggela

-What types of organisations exist in this community and under what main categories
do they fall i.e., religious organisations, traditional organisations, government
organisation, fishermen's organisation etc?
-What is the social/governance structure of the village and what roles do different
people/leaders play in the village social/governance structure?
-How are leaders in the community chosen?
-How are different communities on Nggela related in their social/governance structure?
-How is Nggela society socially/politically structured?
-What have been the historical changes in the leadership and governance structure of
Nggela over time based on your knowledge as it has been passed down through
generations?
-How are land/marine areas owned/possessed and transacted and what have been the
changes over the years?
-When land/marine area ownerships are contested, how are they resolved?

-What are the current main social concerns in the village?

-How effective are chiefs in instituting rules and do people in and outside community follow them?

-Besides the chiefs, what other authorities exist to create and enforce rules in the community?

Other sources of information used in the data analysis were: (1) interviews with 6 former dynamite fishers. An attempt to do a larger survey of the dynamite fishers to provide more quantitative data was not possible. Those who were listed as dynamite fishers by informants vehemently denied ever using dynamite for fishing when approached; a major disadvantage contributing to this was my background as a former fisheries officer. Although I had taken all the effort to explain that what I was doing had nothing to do with the Fisheries Department or the Police Department and that I had left that job, I was still viewed with a lot of suspicion by the dynamite fishers. I was only able to convince 6 former dynamite fishers hence the resultant small sample size. Employing other persons to do surveys on my behalf would still face the same obstacles given that the interviews would be done on my behalf. Dynamite fishers may fear that such researchers may ultimately disclose their identity inadvertently or on purpose. Some quantitative data to determine the extent of dynamite fishing were obtained from the police department at Tulagi; (2) interviews with leaders and family clan members of 3 existing MPAs on west Nggela; (3) the draft constitution of the Nggela house of chiefs (*Nggela Vale Vaukolu*); (4) the National Constitution of Solomon Islands; (5) the Provincial Government Act of Solomon Islands; (6) the 1998 Fisheries Act of Solomon Islands; (7) Literature on previous research on the subject of marine tenure and governance either on Nggela or generally in the Solomon Islands. Some of the information collected here was already introduced in chapter 1 (social organisation and land/marine tenure in Nggela).

An analysis was made of the structure of governance, the different tiers of governance within it, and how traditional governance institutions are recognised in Nggela. This was then followed by an analysis of the Nggela traditional governance structure and the different roles and responsibilities within it. Information from the chiefs and clan leaders was used to determine the effectiveness of the governance structure in coercing or persuading people

to follow rules. A final analysis of the traditional and modern governance institutions involved the examination of the links and interface between the two types of governance institutions to determine the opportunities and the challenges of hybridising them for effective CMT based fisheries management. The interview with the dynamite fisheries elucidates their perceptions about these two governance systems and which one they would prefer to follow if it instituted fisheries management or marine conservation rules.

5.3   BACKGROUND ON TRADITIONAL GOVERNANCE IN NGGELA

How South Pacific societies organised themselves during the pre-colonial period has been a subject of debate among scholars. Researchers argued that societies in Melanesia were usually organised into small homogenous societies usually within small geographical locales with complicated social and governance structures (Hogbin 1964; Nanau 1998:191; Care and Zorn 2001:51; Schoeffel and Turner 2003). The governance structures rarely occurred at an Island level and where they did occur this was only for the smaller Islands. Inter-island political/governance structures only occurred from the colonial era (Nanau 1998).

According to McLeod (2008) works prior to Sahlins (1963) always used the terms *Big Man* and *Chief* to distinguish two main types of political leadership in the South Pacific; Sahlins (1963) cemented their use and distinction (McLeod 2008). The Big Man system was predominant in the western parts of Melanesia (Papua New Guinea, Solomon Islands and Vanuatu) while the Chiefly system was predominant in Polynesia (Samoa, Tonga, Cook Islands, Hawaii and French Polynesia). In eastern Melanesia (Fiji and New Caledonia) which occurred at the intersection between Polynesia and Melanesia, political approximations of the Polynesian system (the Chiefly system) were common (Sahlins 1963).

In the Big Man system personal power is important, status is gained through demonstration of skills (magic, oratory, bravery etc), status is gained and maintained via generosity in the distribution of wealth and influence is over fluctuating factions. Hogbin (1964) described a Big Man in Guadalcanal, Solomon Islands, and stated that while there were important advantages in enjoying renown as a warrior, orator or magician, the prime qualification was

wealth in the form of vegetable supplies and pigs. In the Chiefly system power resides in the position, not the person, authority is normally over permanent groups, status is inherited and not achieved, and the chief has the authority to call upon the support of others without inducement. Sahlins (1963) further contended that the Chiefly system was evolutionarily more advanced and inherently more stable than the Big Man system owing to the fact that Chiefs possess power over large unfluctuating hierarchically organised political units compared to the Big Man who merely relies on the fluctuating support of followers from small segmentary groups.

Sahlins' (1963) typologies of leadership and broad geographical generalisations have been criticised by several scholars who argue that based on ethnographic data there were significant subtle difference in leadership practices which the Sahlins' leadership model failed to consider (Douglas 1979). Guiart (1983) further argued that Sahlins' argument that these political leadership types are evolutionary is erroneous and was probably new ways of justifying the old ideas of racial and intellectual superiority. Citing many examples from Papua New Guinea Roscoe (2000) argued that leadership achievement and ascription coexist in Papua New Guinea, e.g. Hau'ofa (1971). Sons or nephews of a leader would obviously have an advantage in becoming leaders as they were groomed by the reigning Big Man so a certain level of leadership inheritance occurred (Douglas 1979; Bolton 1998). Hereditary chiefs occurred in the central and far southern parts of Vanuatu where chiefs had total authority over people and land in their domain (Bolton 1998). Some Islands in the Solomon Islands like Tikopia, Anuta and Rennel and Bellona (all Polynesian societies), parts of Malaita and Ulawa (both Melanesian societies) practice the Chiefly system, while in Guadalcanal and Nggela (both Melanesian societies) it is the 'Big Man' system that prevailed (Allan 1957). According to McLeod (2008), the criticism against Sahlins' leadership model are true; its broad geographical categorisations and dichotomous distinctions failed to capture the social diversity, leadership permutations and gradations that characterise traditional political leadership types in South Pacific societies (Roscoe 2000). However if used with qualification they can assist in understanding the leadership variation that exists in the South Pacific (McLeod 2008) and when analysing intersection points between local cultural practices and modern governance institutions.

5.4   COLONIAL GOVERNANCE IN NGGELA

Although the first Solomon Islands-European contact was in 1568 through the Spanish explorer captain Alvaro de Mendana, the first actual interactive contact of Nggela with the outside world was through the British Anglican mission in 1862 (Fox 1958). It was not until 1883 that the British Anglican mission got a foot hold on Nggela owing mostly to the events of 1880 (Fox 1958; Hilliard 1978). A British survey ship the HMS Sandfly's whale boat was attacked by 'the Nggela natives' in Gaeta district, the eastern part of Nggela on the 15th October 1880, killing the captain Lieutenant Bower and three of his sailors. This infuriated the British so the HMS Emerald was sent on a punitive expedition through the Gaeta district burning down every single village, destroying properties and killing anyone who had not escaped. The only exception was a mission station then based at Lango. The influence of the Big Man among people and societies was significantly reduced after the HMS Emerald attacks. The first Big Man with all his followers submitted to the mission in 1883. The demise of the Big Man following the events of 1880 created a leadership vacuum in Nggela and this to an extent was filled by 'native converts' who acted as catechist/teachers or chiefs. The first form of Nggela-wide governance came in 1888 when the British Anglican Mission established 'the native parliament' which was composed of catechists/teachers and the remaining traditional Big Men then in existence who had converted to Christianity (Fox 1958; Hilliard 1978). At its establishment the Nggela native parliament was called the '*Vaukolu*' (Fox 1958) which translated into English means 'woven together' (my own translation based on my own understanding of the Nggela language). Establishment of the vaukolu shifted the traditional governance systems based on a few communities to one where there was a Nggela-wide traditional governance system with a paramount chief as the supreme chief of Nggela. According to Fox (1958:184) the Nggela *Vaukolu* was the first attempt at civil government in the Solomon Islands and it was held annually during 1880-1896 with attendance of up to 500 participants to discuss civil and church affairs. The establishment of the British protectorate in 1896 gave official recognition to the vaukolu and it was the governance structure through which the British colonial administrators initially governed Nggela. As the British colonial government increased in size and capacity in the early 1900's the role of the vaukolu within the British colonial government machinery

declined and ceased to be an official part of the modern governance structure. Nevertheless the vaukolu persists within the Nggela traditional political landscape since its inception by the missionaries. The absence of formal local community level governance, following independence in 1978 has seen revival of the vaukolu by Nggela traditional leaders as a structure to govern villages and communities according to local custom and practices.

5.5 POSTCOLONIAL GOVERNANCE IN NGGELA

5.5.1 Formal governance structure

At the end of colonial rule in 1978, Solomon Islands adopted a 3 tiered government system (see Figure 5.1, note that hierarchy descends as you go down the page) which was designed by the British colonial government. The first tier of government is the Central Government (Unicameral National Parliament). Seated at the main capital in Honiara, it is the highest governing body of the land with supreme legislative powers and consists of representatives elected via first past the post system from the 50 constituencies. At the National Parliament level two legislative agencies that have overlapping responsibilities for fisheries management and conservation are: The Ministry of Fisheries and Marine Resources and The Ministry of Environment, Conservation and Meteorology.

The second tier of government is provided for in the Constitution of Solomon Islands 1978 (S114) and the Provincial Government Act 1997 - the Provincial Assemblies. The aim of having the provincial assemblies was to bring governance decision making closer to the people through the devolution and decentralisation of authorities to the lower levels of government (Nanau 1995) and furthermore, due to the cultural diversity of the country, having provincial governments would enable governance matters to be dealt with at the local level in a manner that would be more relevant to local situations (Lidimani 2006). The provincial assemblies consisted of ward representatives (a ward consists of several villages) who are elected via a first past the post system. The executive power of the provincial assembly rests on the provincial premier and his provincial ministers who are answerable to the Minister of Provincial Government in the National Parliament.

The functions of the provincial government are: (1) managing and providing government services (health, education, justice and law enforcement, fisheries enforcement and development, physical planning etc); (2) acting as the national government's development agent pertaining to rural development and (3) enactment of provincial ordinances (subject to consistency with the national laws and the constitution) at the respective provincial levels as provided for by the national constitution and other national laws (*Acts*). Three national pieces of legislation which are relevant to the environment (fisheries management and conservation in general) and empowers provincial assemblies to enact provincial ordinances are: *The Provincial Government Act 1997, The Fisheries Act 1998* and *The Protected Areas Act 2010*. The *Provincial Government Act 1997* (s32 and s33) empowers the provincial government to enact any provincial ordinances that are relevant to and only within the jurisdiction and competence of the respective provincial assembly. The *Fisheries Act 1998* (s9(1)-s10(5)) gives powers to the provincial assemblies to manage reefs and inshore and freshwater fisheries resources at the provincial level only, including the enactment of provincial ordinances required for fisheries management, establishment of MPAs, the appointment of authorised enforcement officers, and the registration or recording of customary fishing rights, their boundaries and the persons or groups of persons entitled under those rights. Section 12 of the *Fisheries Act 1998* provides recognition for customary fishing rights. The *Protected Areas Act 2010* empowers the provincial assembly to make provincial ordinances pertaining to both terrestrial and marine protected areas. Seven provinces (Choiseul, Western, Isabel, Guadalcanal Malaita, Makira and Temotu) have enacted some form of environmental ordinance which related to the management, protection or recognition of freshwater, terrestrial or marine areas (McDonald 2007). However, Central Province under which Nggela falls and Rennell-Bellona Province have never enacted any environmental related ordinances (McDonald 2007). Violations of provincial ordinances and other national *Acts* such as the *Fisheries Act 1998* and *Protected Areas Act 2010* are prosecuted at the magistrate's court level and sanctions include fines and prison sentences.

The third tier of government was (has ceased to exist) the local area council (provided for under the *Local Government Act 1964*) which provided governance functions at a level lower than the ward (fewer villages than

contained in a ward, on average between 8-10 villages may form a local area council, 2-3 local area councils may fall under a ward). The local area council can make relevant micro-level byelaws relating to health (use of proper toilets, protection of drinking water sources), the penning of pigs and chickens, adherence to local norms and customs, and byelaws relating to the environment (when growing up, the only environmental byelaw of which I was aware was that to keep back yards clean and to dispose rubbish properly so that the village was clean). Violations of byelaws attract fines which must be paid at the provincial government level. The third tier of government was largely ignored at the national level soon after independence (Nanau 1998) mainly because it was too expensive to run the 3 tiered government system and this was probably the easiest one to ignore (Schoeffel and Turner 2003). The local area council was abolished in 1996/97 (Hegarty 2009). Hence, only a 2-tier system of government is currently operating in Solomon Islands. In the absence of a 'formal government', governance at the local community level has always been through the traditional governance system and the churches (Douglas 2005; White 2007; Keith and Beu 2008; McDougall 2008; Hegarty 2009).
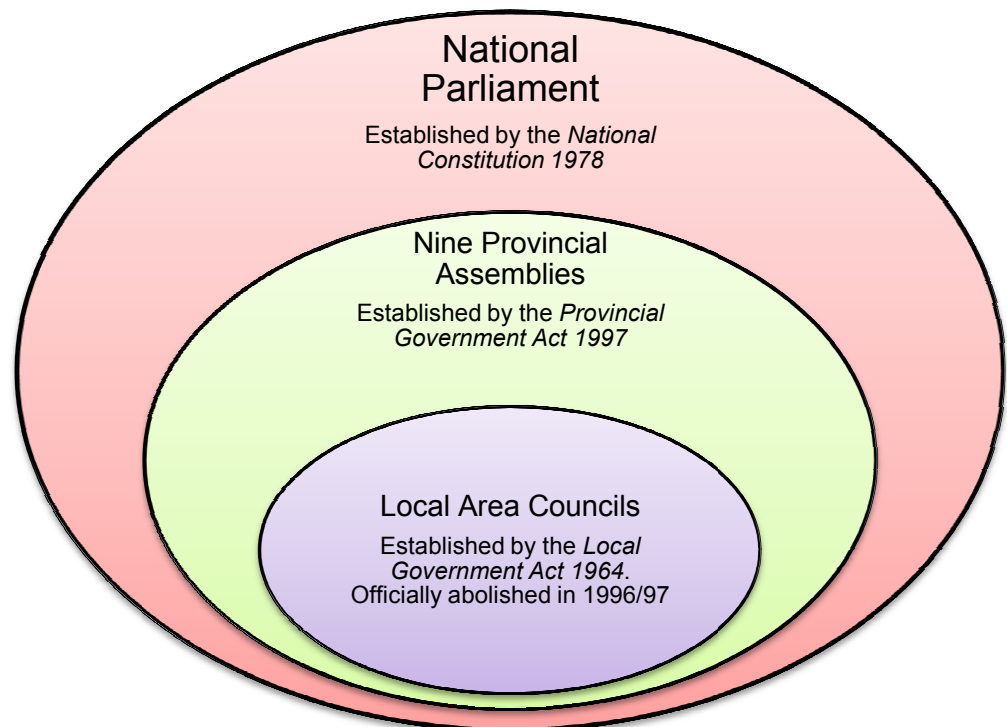

Figure 5.1: The 3 tiered modern governance structure of Solomon Islands up to 1996/1997

5.5.2 Results of interviews on local community governance

Three types of leaders are found at the community level. The first of these leaders is a village chief who is elected by everyone in the village to serve for two years. Assisted by village committees (usually including school, water, health & sanitation), the main role of the village chief is to run the affairs of the village, ensure that community members adhere to local customs and norms of behaviour and that order prevails in the village. A village chief can be any respected older member of the community and may even include people from another community (or island) who have married into and settled in the community. Besides the general customary rules and expected patterns of behaviour, the village (usually at the village meetings) may institute village byelaws; people who violate the byelaws are prosecuted in a public village hearing by the chief and selected village elders. If found guilty, a person may be ordered to pay fines into the village coffers, or compensate an aggrieved party if a disagreement is between two parties rather than against the village customary rules and byelaws.

The second group are the church leaders. A village may have one or two church keepers who are assisted by various church committees and church organisations (mothers union, youth, companions of the Melanesian brotherhood, Melanesian Anglican guild of service etc). The village church leaders and committees usually work with the parish priest (normally called the 'district priest'; several villages form a parish or district). The next level above the parish is the region. Hence parish priests are answerable to a regional priest and regional priests are answerable to the Vicar General who is based at the Diocese head quarters at the provincial capital. The Vicar General reports to the Diocesan Bishop, the Diocesan Bishop reports to the Archbishop of the Anglican church of Solomon Islands who is the overall head of the Anglican Church in Solomon Islands and is based in the national capital. Priests and church leaders do not only deal with the spiritual aspects of members of the society. They also exert a lot of leadership influence over the people and usually work closely with the village leaders and non-government organisations on other aspects of the society such as: health, schools, environmental issues and even attempt to assist the enforcement of prohibitions on use of explosives for fishing.

The third group of community leaders are the traditional leaders. These are clan leaders who are responsible for matters relating mostly to the cultural and traditional aspects of the community. One of their main functions is to sit in the state recognised local land courts to resolve land and marine area ownership disputes. This is the only state empowered and recognised function of traditional leaders, local courts relating to village rules and byelaws do not have state recognition. Clan leadership is strictly restricted to members of the respective clans; membership is by matrilineal inheritance. Village clan leaders are chosen by village clan members based on secret ballot for a term of four years (and this is the same for all other traditional leadership positions within the hierarchy up to the paramount chief). A person who is chosen should be one who is considered to have good knowledge of the clan's history, the clans land and marine ownership and the general Nggela culture, traditions and practices. There are 4 clans in the Nggela traditional structure so there can be maximum of 4 clan leaders in a community. Leaders of a particular clan in the district (parish) choose a district clan leader from among themselves (there are 11 districts in Nggela). The district clan leaders then choose a Nggela-wide clan leader. All the Nggela wide clan leaders (for all the 4 clans) and the district clan leaders choose by secret ballot 3 deputy paramount chiefs for the 3 regions of Nggela and the paramount chief of Nggela. A general scheme of the local community level governance is shown in Figure 5.2; note that there is an ascent in the hierarchy as you go down the page. It should be noted that the leadership selection is based on a modern democratic system where leaders can be voted in and voted out as desired by clan members.

Although the local level governance structure at the community level is described in a sectoral manner above, it should be clarified that it is a well integrated system; a person may be simultaneously involved at all the different parts of the structure. For example, a village chief can at the same time be a church committee chairman and a clan leader (subject to clan membership) at the community, district or island level.

5.6   RESULTS OF INTERVIEWS ON DYNAMITE FISHING AND GOVERNANCE IN NGGELA.

5.6.1 Current extent of dynamite fishing

Eighty four percent of interviewed fishers and all village leaders and key informants stated that dynamite fishing is prohibited in their communities. However it is still a fishing method in inshore reefs including CMT areas commonly used by villagers and non Nggela fishers. During the study period I witnessed 2 incidents of dynamite fishing outside Ghumba village. Thirty six incidents of dynamite fishing were apprehended by police in Nggela during the period January 2000 - May 2008, of which 15 were convicted, representing a 50% conviction rate over an 8 year period (Figure 5.3).

According to key informants, threats of the use of explosives on persons, coupled with the fact that village chiefs and elders do not have *'mana ni vetena'* (powers of the law) to arrest, nor the '*sasaro ni vetena'* (protection of the law) as law enforcement officers, prevent them enforcing prohibitions on the use of dynamite for fishing. The comments by a community leader from Ghumba illustrate what was commonly felt about dynamite fishing in the study villages:

"Dynamite fishing is prohibited, but people in this village as well outsiders who marry into this village or who just came in to fish use it like there is no law forbidding its use, it is used all the time. We can't do anything by ourselves, the most we have done now that we have mobile telephone signals reaching our village is to call the police or fisheries officers at Tulagi to come and arrest them when they are in the act of using dynamite. The police or fisheries officers need to see the act themselves as village people are usually afraid to testify as witness if it is reported later. We have had a few convictions in the past as a result of police intercepting dynamite fishers, but that is not enough and it has not stopped the practice."

According to the provincial police superintendent, dynamite fishing is more rampant in Nggela than anywhere in Solomon Islands, especially close to Christmas and New Year period when fishers are trying to generate income for Christmas shopping and school fees for the New Year. It is difficult to arrest and convict outsiders as they very quickly escape to Langalanga (Malaita)

where they come from. Furthermore there is the problem of evidence and custody of evidence where the actual act of dynamite fishing is not seen by police. Experts are needed to examine and testify in court that the fish were actually caught by dynamite and not by net; these experts are usually not available. For every incident apprehended and taken to court by police (Figure 5.3), there are about 40-50 other incidents which the police did not see and which never came before the courts. Financial resources to enable police to make frequent patrols have been a factor limiting efforts to curb the practice.

5.6.2 Key informant perceptions on governance and dynamite fishing

Key informants said that the effectiveness of traditional leadership had changed in their life time; community leaders had been more likely to be respected and followed thirty years ago than now. Cooperation at the community level had also declined; community leaders needed to exert greater efforts to get everyone's cooperation. The main concerns within the communities were: dynamite fishing, the abuse of marijuana, consumption of illegally produced beer (homebrew) and spirit (kwaso) which usually causes anti-social behaviour. According to informants, half of the dynamite fishing activities was undertaken by the few youths who did not know how to fish but required finance for alcohol consumption. While there were processes to prosecute and impose sanctions, village leaders had no power to ensure that the guilty persons paid the required compensation. According to one informant, in the past, a person might be subjected to public flogging if he does not pay up his/her compensation; that usually ensured that guilty persons pay compensation, however nowadays public flogging was now against the law.

Informants described the issue of dynamite fishing as a very complicated problem as it involved both locals and Malaita fishers who come in to fish in Nggela and move on to sell in Honiara. Previously locals who were found to use dynamite for fishing were prosecuted in village courts and ordered to pay compensation to reef owners and into the village coffers. Since 2000 community leaders had not bothered to prosecute the local dynamite fishers as they thought it unfair to punish 'their own sons' while outsiders who were not

part of the community (hence have no regard for community rules and are not subjected to community rules) went free.
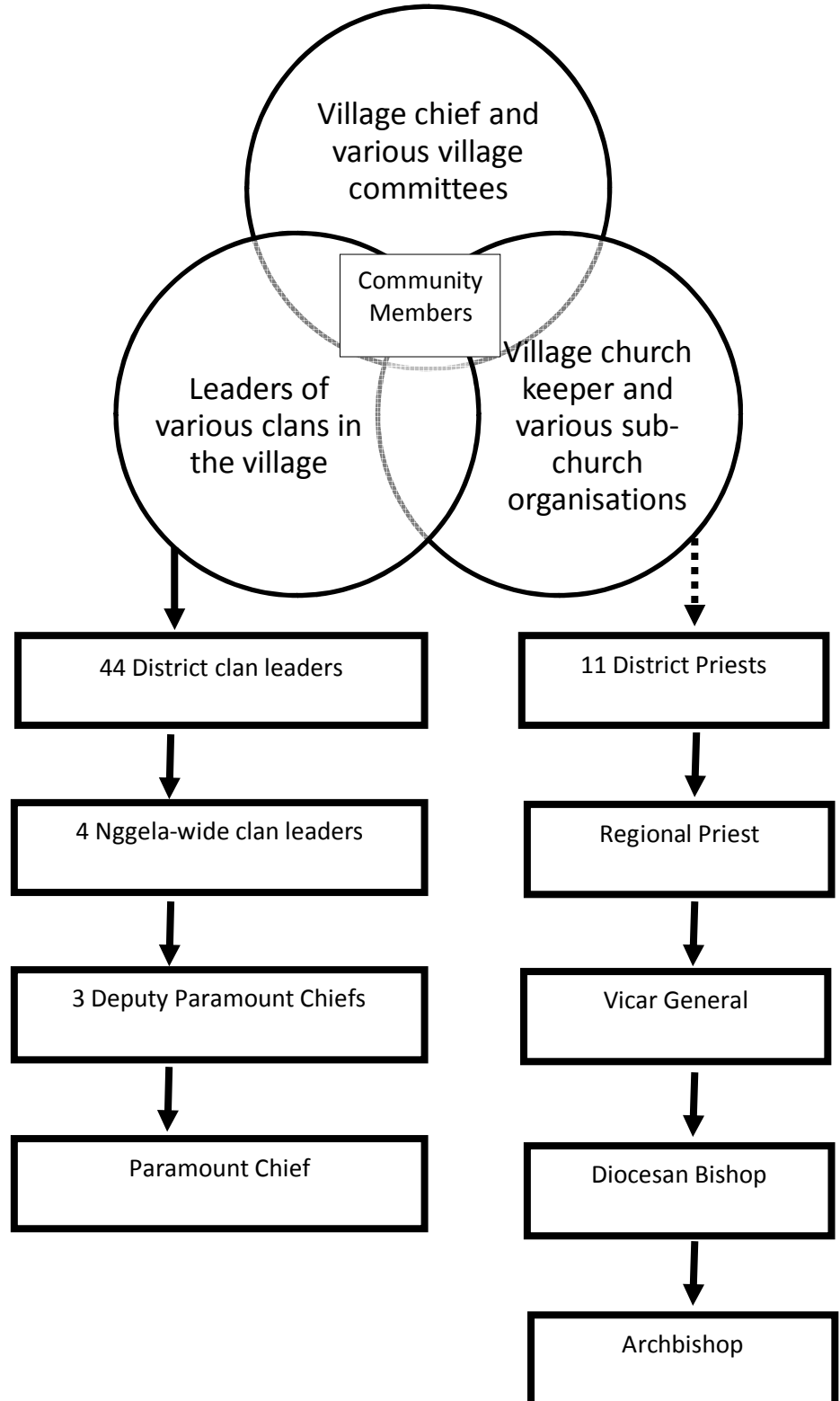

Figure 5.2: Local level governance structure of Nggela and relationship to church. Note that the dashed arrow indicates externality of church from 'traditional' governance system.
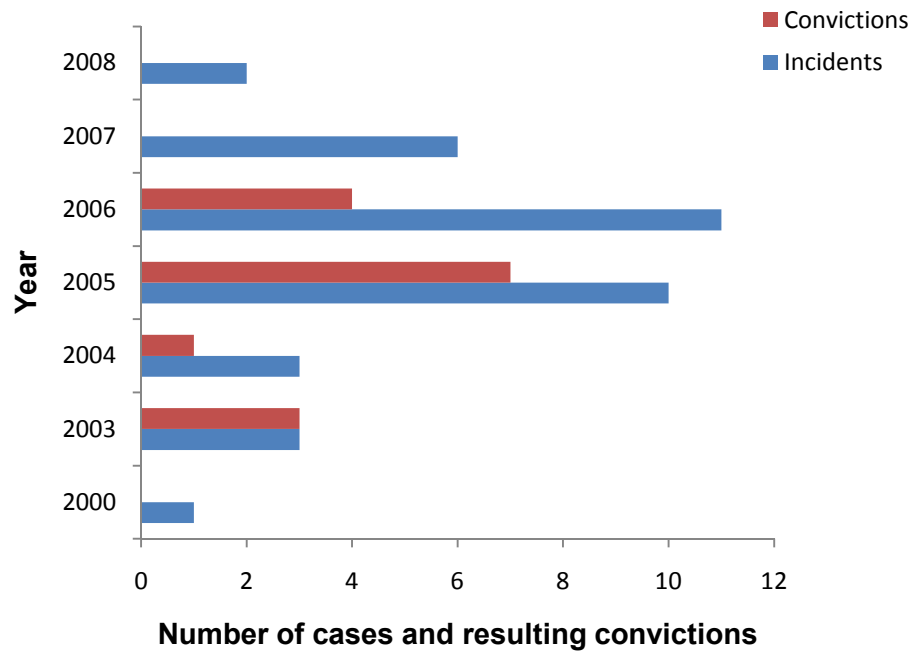
Figure 5.3: Histogram showing number of dynamite fishing incidents and convictions in 2000 – 2008 (source: Tulagi Police Department).

All main informants prefer that the case of dynamite fishing be handled by the police or Fisheries Department so that dynamite fishers both from within and outside the community could be dealt with equally. Prevention of dynamite fishing on any reef within CMT area was the personal responsibility of reef owners. All informants agreed that their influence depended only on the respect community member had for them; they did not have coercive powers to ensure that people followed rules that had been instituted. All informants stated that the majority of community members had regard for the community rules and norms, and were obliged to follow them. However, there were always a few community members who would do otherwise.

When asked whether any association with a formal system of governance would strengthen rules relating to fisheries management, all informants agreed that it would. Citing as example the three MPAs established on west Nggela, they stated that deviants and dynamite fishers had been deterred from attempting to poach within these areas as *'they were afraid that they will get into trouble with the law'*. This was confirmed by leaders and family owners of the 3 MPAs that association with the NGOs and the provincial Fisheries Department had been one reason for compliance with these MPAs. I cross checked with the provincial fisheries officer whether there was any

legislated recognition of these MPAs and was told that there was none, other than collaboration. Compliance was observed to be under the misconception that the reef owners had state support in the establishment of the MPAs.

5.6.3 Dynamite fishers' perceptions on the issue of dynamite fishing

Dynamite fishers were all fully aware that the use of dynamite for fishing was against village rules as well as against the laws of the country. However it was an easy method of fishing, and police and fisheries officers seldom made patrols and community leaders did not have powers to impose sanctions on them. When asked who they would be most fearful of when undertaking dynamite fishing, they stated that they would be more fearful of police, fisheries officers and reef owners than the community leaders. When asked why they were more fearful of police, fisheries officers and the reef owners, they stated that the penalties for prosecution by police and fisheries officers were very high. One informant who had been caught and prosecuted by police officers (and found guilty) stated that he had had to pay SBD$1000 fine and had his boat, outboard engine and ice-box (with all its fish contents) confiscated. Failure to pay fines can result in imprisonment of up to 12 months. Reef owners were feared because violent confrontations could occur. As far as the dynamite fishers were concerned, community leaders had not prosecuted or imposed sanctions on any dynamite fisher for a long time. There was a growing perception that compared to the formal governance structure, the traditional governance had lost its coercive powers, and hence it could not enforce rules. When asked what their response would be if the community leaders were given legal powers to arrest (like those of the police and fisheries officers) by the state, they stated that they would be fearful of the community leaders and would abide by the rules of not engaging in dynamite fishing.

5.7 DISCUSSION

The traditional governance structure of Nggela which the CMT system is based on has undergone changes primarily as a result of exogenous processes. The changes however do not completely transform the CMT system, rather, the changes were instituted and re-contextualised within the system. The traditional political structure has undergone transformation from isolated governance units to one where there is unification of isolated units to a Nggela-wide traditional political system. Furthermore, the church, an introduced institution has successfully merged into the political structure. Although the political aspect of the Nggela CMT system was re-contextualised, as a property institution it has not changed; property rights ownership is still either through matrilineal inheritance or the huihui process (see Chapter 1).

The changes which have occurred on Nggela are not unique to Nggela. Other researchers have reported similar cases in the neighbouring island of Isabel also involving the Anglican mission in the 1930s (White 2007) and on the Islands of Aneityum in Vanuatu in 1854 involving the Presbyterian church (Miller 1978; Bolton 1998), where Christian missionaries instituted local parliaments to fill the leadership vacuum created by the undercutting of the authority of traditional leadership due to changes brought by Christianity. The repercussion of these changes is that while the traditional political structure and leadership is still retained, there is a mismatch in the conception of these leaders by those within and those external to the society. For example, informants I interviewed said that the democratic model of selecting traditional leaders can give rise to the selection of people who do not have deep knowledge of traditions and cultures and social links. Hence viewed from outside there is a traditional leader, while from within, these leaders may not command respect from people as *"they did not achieve the leadership role in the proper way"*. The association with the church has also created some leaders who do not command respect as traditional leaders. It was noted during the field work that there were some elders who never held traditional leadership positions or played a public role, yet were more revered as chiefs (over the elected clan leaders) even by the most deviant youths of the society. Bolton (1998:182) made the following observation about contemporary traditional leaders in Vanuatu: *"Consistently, missionaries and Europeans looked for leaders in Vanuatu and found influential individuals who they*

described as chiefs. But the European notion of a chief rarely matched local conceptions of authority". Needless to say such differences in conception of leadership still exists today and need to be considered in any hybridisation of modern and traditional practices. Having 'one voice' through a respected leader (or leaders) is important if traditional structures and institutions are to be effective for fisheries management (Muehlig-Hofmann 2007). The current system of governance on Nggela is already a hybrid between traditional and formal systems with different power structures (having different origins) that coexist and overlap to a certain degree (White 1991; Foale and Macintyre 2000), although the formal governance system is less obvious in its amalgamation at the local level. In his study of the Baluan community in Manus (Papua New Guinea), Otto (1992) described three 'spheres of authority', *Kastam* (Papua New Guinea pijin for custom), *Gavman* (Papua New Guinea pijin for Government) and *Lotu* (Papua New Guinea Pijin for Church). Those who were not able to achieve leadership through *Kastam* do so via *Gavman* or *Lotu* and the overlaps between these different spheres of authority usually result in clashes. This is probably the reason some 'traditional' leaders (this study) were described by some respondents as: '*not achieving the leadership role in the proper way"*. This is an important factor to consider, because in the absence of 'one voice' (Muehlig-Hofmann 2007) compliance to rules may be hindered.

Chapman (1987:202) argued that the 'Big Man' political structure was always pre-disposed to fail when it comes to conservation on the basis that it is a short term authority that was never absolute nor unquestioned. The Big Man was merely a resource manager whose status was based in part on the accumulation of wealth for purposes of display and distribution; resources were only important to him after they had been harvested. Hence, he had little incentive to leave resources unharvested. The drive to exploit rather than preserve resources, in combination with the short term outlook, worked against the development of conservation attitudes towards natural resources. Other researchers who have argued along the same lines are Polunin (1984), Carrier (1987) and Foale and Manele (2004). Chapman (1987) argued that by contrast, the more permanent nature of the Chiefly political structure makes it such that the chief's role in resource regulation was for stewardship purposes rather than exploitation for personal gain. Since this stewardship was passed

to the next in line, there was a political interest to ensure long term continuation of resources over time. It is possible that these arguments may also be true of Nggela; the absence of an embedded conservation principle coupled with the short term nature of the village and traditional chiefs possibly prevents any sustained conservation ethic within the traditional governance political structure.

Regardless of the possible historical absence of a conservation ethic and the ambiguities of recognising the contemporary Nggela Big Man, the recent increase in local awareness of resource declines and the importance of marine resource management and conservation (principally due to the efforts of NGOs) have not just by-passed resource owners and local level leaders on Nggela. In fact this increased awareness has become an impetus for a desire to manage marine resources, as illustrated by current attempts to establish MPAs. Local level leaders are prepared to enforce rules against practices like dynamite fishing; the hurdle is the lack of power to sanction those who violate the rules. This requires the backing of the State through some means of codification. In the contemporary context, State support is important because even if communities adjust to institutional and environmental changes but if their rights are not underpinned by the state then encroachment by interlopers and poachers can undermine the effectiveness of local leaders to defend people's customary marine tenure rights (Grafton 2000). Codification of CMT has been debated among researchers. Johannes (1978) and Ruddle et al., (1992) argue that codification may fossilise CMT systems, eroding their adaptability and plasticity. But Graham (1994b:3) argued that *"where traditional tenure systems are collapsing because of the inability of traditional authorities to effectively arbitrate and enforce use rights, codification of traditional law can serve to replace or reinforce the power of traditional authorities";* such codification does not have to be rigid as the required flexibility can be allowed for during the codification process. Aswani (1997b:15) argued that codification in certain circumstances may be the only means to ensure CMT is an effective tool for fisheries resource management, and that any codification should be that of a middle down-middle up approach where the main role of the modern governance institution is to provide a unit of coercion (as per Bromley 1992) by empowering traditional leaders or local village chiefs to punish poachers, free riders and interlopers. Clark and Jupiter (2010) reported that the success of a

reserve in Fiji was largely dependent on respect for traditional chiefly authority and, to a lesser extent, a misconception that the reserve was protected under national legislation; this demonstrates that State backed coercion can ensure compliance in fisheries management regimes. The question then is what is there within the modern governance structure which can be harnessed to empower Nggela leaders and resource owners to defend their customary rights and ensure that a conducive environment for fisheries management exists?

Lidimani (2006:22) argued that whilst the Solomon Islands constitution defines power relations at the macro level to incorporate the provincial assemblies, it is silent on the decentralisation of power to the micro-level (the communities); an approach he (Lidimani) considered reasonable given the cultural diversity of the country, hence the difficulties in defining governance institutions below the provincial assembly level. The constitution (s75 and s114) recognises custom, traditional leaders and traditional institutions. Customary law is allowed to operate in parallel with modern law, unless there is a conflict then the modern law precedes customary law (Care and Zorn 2001). The shortfall however is that, regardless of this recognition, traditional governance systems have never been elevated to the formal governance structure (Lidimani 2006; White 2007). Past experiences (e.g. Foale 1998b) have shown that mere recognition has been insufficient to safeguard customary resources (Lidimani 2006). Despite the shortcomings in the formalisation of traditional governance systems by the highest governance institution (parliament and constitution) in the land, there are provisions within the Fisheries Act 1998, *Provincial Government Act 1997* and the *Protected Areas Act 2010* which devolves law-making powers to the provincial assemblies. These devolved powers could be articulated and ordinances could be enacted at the provincial assembly level to either formally recognise micro level governance or empower the Nggela local level governance system to create, enforce and sanction fisheries management rules. However there has never been any political will to do this in Central Province. The necessary link and important starting point to empower the Nggela local level governance structure for effective fisheries management is the enactment of necessary environmental and fisheries management related provincial ordinances by the Central Province to that effect. A particular point which should be considered during the ordinance enactment process is to specify particular actors within

the local governance structure who should be mandated to enforce the rules as per s10(2) of the *Fisheries Act 1998: "The Provincial Executive of a province may appoint by notice published in the Gazette an authorised officer for the purposes of enforcing the provisions of this Act in that province"*. The democratically elected village chief (this is the person in the top circle in Figure 5.2) should be given this role and he is to be assisted by a fisheries management committee selected by the village (the presence of other committees such as for water, school and health committee indicate that a committee to enforce resource management rules may also work), such that even if a village chief changed over time the mandate would rest on an institution not a person; the church leader or the 'traditional leader could be personal (based on the big man system) and any mandate to enforce rules might wane with their demise. The second reason for mandating a particular actor and to be assisted by a committee selected by the village to undertake this role is that the fisheries management rules enforcement would not suffer from any power struggles between the different 'spheres of authority'; such power struggles have occurred in Samoa (Fa'asili and Kelekolo 1999), although they were sorted resulting in a successful community based fisheries management arrangement where community fisheries management rules were empowered by the State. Following the enactment of the necessary provincial ordinances then a co-management arrangement between the resource owners, local level governance regime, NGOs and the State could be instituted.

Co-management as used here is as defined by Kuperan and Abdullah (1994:310) where resource owners, local level governance leaders, NGOs and the State agencies (at the provincial assembly level) share responsibilities for management functions. The State formally recognizes regulations which are enforced by the resource owners and local level governance leaders. NGOs can be important in co-management arrangements (Pomeroy 1995), as is the case of NGO actions in relation to the 3 MPAs in Nggela. The scope of management might not only include CMT areas but also coral reef outside CMT boundaries, albeit within the provincial waters. The *Fisheries Act 1998* stipulated that the provinces are responsible for the proper management of inshore fisheries resources within their waters (≤3 nautical miles from land). Co-management arrangements with Nggela users who exploit these areas

could support the province to this effect. Successful integration of traditional and modern methods of fisheries management has occurred elsewhere in the South Pacific (Adams 1998). Such integration may be the only hope for coral reef finfish fisheries in Nggela.

5.8   Conclusion

The Nggela governance structure on which CMT is based has undergone changes mainly from exogenous forces and this is not unusual; CMT systems always undergo changes and are often very different from those of even the recent past (Ruddle 1994). The governance aspect of the system has undergone a hybridisation with the church especially on the notions of democracy. There are however significant parts of CMT which are still very strong, this is its property institution aspect (i.e. property rights) unfortunately the role of the governance aspect of CMT system to defend these rights has been reduced and this is where the State is needed if the system is to be used for effective fisheries management. The formal governance structures of Solomon Islands through its legislations provide opportunities, which could be employed to empower the CMT system for fisheries management. The modified CMT system could be hybridised with formal notions of democratic government. The first important step required to undertake this, is to enact ordinances at the provincial level and then co-management arrangements among the resource owners, local level governance leaders, NGOs and the state.

CHAPTER 6

SYNTHESIS

Abstract

Drawing on the DPSIR (Driver, Pressure, State, Impact, Response) model and taking a multidisciplinary approach, this thesis appraised the effectiveness of customary marine tenure (CMT) as a policy response (R) in the small-scale fisheries management (SSFM) of coral reef finfish fisheries in Nggela (Solomon Islands). CMT was identified as potentially being an important prerequisite for SSFM in locations where it is practised but it is concluded that its effective use requires a multidisciplinary understanding of the social contexts in which it operates (Adams 1998; Hviding 1998; Johannes 2002b; Cinner and Aswani 2007). This chapter summarises the main findings of the preceding chapters, draws out key lessons from the study which are important for engaging CMT in small-scale-fisheries management and suggests ways in which CMT might in future be applied to small-scale coral reef finfish fisheries management in Nggela.

6.1 Summary of findings

Chapter 1 reviewed a range of literature relevant to CMT. Considering that CMT is a property regime, it began with the argument that no particular property regime (whether privately or commonly owned) is superior over another for successful fisheries management. Rather the success or failure of a property regime for fisheries management is dependent on the circumstances and contexts in which it occurs (or is applied). CMT is a common property regime that is based on kinship ties (Ruddle 1996b) with links to the wider social and cultural contexts in which it occurs (Hviding 1994).

CMT potentially has a role to play in small-scale fisheries management on the basis that ownership is supposedly an incentive to manage resources as the costs of not managing resources would otherwise be borne by the owners and secondly it is supported by social structures and mechanisms which allow the enforcement of such a management regime (Ruddle 1996b). CMT fisheries management methods share many similarities with modern forms of fisheries management methods and this provides an opportunity to hybridise them (Cinner and Aswani 2007). However, such a hybridisation is undermined by the social and economic changes CMT has undergone which challenge its effectiveness (Johannes 1978; Aswani 2002). A better

understanding of these challenges is necessary for a successful hybridisation of CMT with modern fisheries management methods. An overview of CMT studies in Solomon Islands reveal that the principles of CMT were generally similar between the different locations. However, the details of how each CMT system operates vary between the locations to the extent that there may be subtle differences even within a particular geographical area (Aswani 1999).

Based on the DPSIR model, CMT was considered as a policy response (R) for coral reef finfish fisheries management. A description of the finfish fisheries in general (for Nggela) within the DPSIR context was provided to contextually situate the study within the research model, followed by the methodological approach used in the study. Chapter 1 concluded with a background to the study site in order to set the scene for the entire thesis and allow the reader to understand the cultural context for the research undertaken for this thesis.

Chapter 2 investigated the drivers (D) of coral reef finfish exploitation using the sustainable livelihoods approach (SLA) of Allison and Ellis (2001). Nggela fishers relied on more than one activity for their livelihood, subsistence agriculture being identified as the main livelihood activity for food production. Fishing was found to be important for subsistence purposes; however, income generation is an increasingly important driver of fishing over subsistence purposes. Available natural capital has an effect on fishing activities; the western zone of Nggela which has a relatively lower natural capital has a higher level of fishing activity compared to the eastern zone where natural capital is higher.

Chapter 3 investigated aspects of pressure (P) and state (S) of the DPSIR model by examining fisher behaviour and fish taxa targeted by fishers. Perceptions of fish abundance seemed to be the main determinant of the spatial allocation of fishing effort by fishers rather than spatial, temporal, gear or species restrictions. Spatial restrictions could be complied with if they were perceived to be backed by the State. High median trophic levels, high median standard lengths and low reef association of fish caught can be inferred to indicate healthy offshore fishing grounds. The spatial scales of CMT ownership and hence its applicability are less than the spatial scale at which finfish exploitation occurs.

Chapter 4 was a case study of a near threatened species that sought to further explore aspects of the state (S) of the finfish fisheries. Several observations from this case study may lend support to fishers' perceptions of declining fisheries resources in inshore CMT areas (Chapter 3): a very low sample size of only 4 individuals obtained from inshore CMT areas compared to a total of 116 individuals from offshore areas during the 5 months sampling period; and fast growth and low mortality rates of *P. leopardus* indicated by the age-based demographic parameters (taking into consideration the geographic variations of these demographic parameters).

Chapter 5 investigated the ability of the CMT governance structure to enforce fisheries management rules if CMT is to be employed as a policy response (R) for reef finfish fisheries management. While the property ownership aspect of CMT still exists, the current CMT governance structure has undergone changes, such that it has lost its ability to coerce (or persuade) people to comply with fisheries management rules. For CMT to be effective, it requires empowerment and one approach to achieving this could be through adopting a more modern governance system such as the Common Fisheries Policy (CFP). Nonetheless, the CFP which is classed as a hierarchical governance system (Gray 2005) has received wide criticism especially from fishers in failing to support sustainable management of European fishing interests. Future work should consider other fisheries governance models from around the world to examine if lessons learned can be applied to the Solomon Islands.

6.2 Key lessons to consider when engaging CMT in finfish fisheries management in Nggela

Previous work (Polunin 1984; Carrier 1987; Aswani 1997b; Foale and Manele 2004; Clarke and Jupiter 2010) had argued that CMT on its own is not adequate for effective SSFM, and this thesis showed this is also true for Nggela; especially in the light of changing livelihoods under the burgeoning influence of markets and increased importance of fish as an income generating commodity (Chapter 2). Livelihoods in Nggela have undergone changes from one that is based on subsistence/exchange-based economy to a market economy where cash is a medium of exchange. The need for cash is

especially important in the light of the fact that some of the items required for livelihoods at present are produced externally (e.g. fishing gear, clothes, fuel for lighting, household items and implements, food items etc). Furthermore, modern cash is now an important medium of exchange in a lot of cultural activities and ceremonies (e.g. marriages, deaths, and even property transactions). Such engagement with the market economy has resulted in two important changes. Firstly, the level of effort applied to the resources within CMT areas has changed. In an earlier study where trochus stock assessments were conducted within CMT areas, Foale and Day (1997) reported that trochus levels within CMT were generally over exploited owing mostly to the low levels of effort required to harvest trochus and secondly the high cash returns per effort from trochus. Their observation is consistent with what I found in this study for finfish resources based on fisher perceptions (that resources within CMT areas were in decline) and previous assessments of finfish resources (e.g. Green et al. 2006; Brewer et al. 2009). Market forces under changing livelihoods coupled with the accessibility of CMT areas have driven over-exploitation of fisheries resources in CMT areas.

The second important change is in exploitation space. Aided and abetted by the market economy and market accessibility, cash has given an incentive to exploit offshore areas (when inshore fisheries resources are in decline) relative to exploitation for subsistence/exchange purposes; cash can buy a much wider range of goods and services (Dahl 1988). Furthermore, access to improved technology in terms of powered transport and cold storage equipment (either through the fishers own hard work or provided through government and aid donor projects and employed relatives in urban areas) has facilitated the ability to travel further and to increase fishing effort in order to increase fish yield which should subsequently increase cash returns. This is in contrast to what Kuster et al. (2005) reported for a remote location in Fiji where although there was a transition from the use of traditional outrigger canoes to outboard powered vessels with a resultant increase in catch rates, the result was a decrease in fishing effort rather than an increase in fisheries yield as the fishery was driven more by subsistence purposes. The change in exploitation space has important implications for managing reef finfish resources which are highly mobile. CMT is only applicable within 0.5km (and this is maximum, in some cases it may be less) from the end of fringing reefs or around islands,

while finfish exploitation occurs well beyond this range. Protection and management of finfish resources needs to consider the spatial extent of exploitation and finfish distribution. Even assuming effective enforcement of territorial delimitations under TURF (Territorial Use Rights in Fisheries), CMT cannot address this in Nggela, as the bulk of finfish exploitation is shifting to de facto open access areas.

Market drivers are especially of concern on the near threatened species, particularly those species which are currently vulnerable due to high demand from both the local and international markets. The generally low sample size of *P. leopardus* in inshore areas during the 5 months sampling period is a testament of the pervasive effects of markets on valuable finfish species which are vulnerable to exploitation in accessible inshore areas. Information on the reproductive biology and growth (Chapter 4) may help in the 'informed' establishment of appropriate size limits as a management tool (Welsford and Lyle 2005) to complement CMT based fisheries management. The Fisheries Department in the Solomon Islands usually relies on demographic data generated elsewhere (usually from Fishbase) to establish minimum and maximum harvestable sizes of vulnerable finfish species. This study has shown that while the data generated elsewhere may be relevant for local use (as shown by similarities in the demographic parameters of *P .leopardus* between Great Barrier Reef and Nggela - Chapter 4), in other cases they may be different (as shown by the difference in the demographic parameters of *P. leopardus* between Nggela and West Australia – Chapter 4), a better understanding of these variations could contribute to management initiatives that do not deprive fishers benefiting from these resources (for example where minimum sizes are set lower than they should) while at the same time protecting the fish species.

Natural mortality rates (Z) interact with fishing (Hilborn et al. 2005) and are important to determine species vulnerability (Pope et al. 2000). While the advanced nature of demographic parameters such as mortality rates do not lend themselves to be readily usable at the community level, they can be used by central fisheries agencies in devising management strategies that supports the management of vulnerable species at the community level. For example, such information has been useful in establishing nationwide long term closures on the beche-de-mer fishery in Solomon Islands by the government (Foale

2007), and the knowledge of the reproductive biology of groupers has resulted in the establishment of temporal closures of grouper exploitation in Pohnpei (Rhodes and Sadovy 2002).

Although the property institution aspect of CMT in Nggela is still very strong (i.e. customary rights to land and marine areas are still acquired only via inheritance through the mother or by the huihui process), its governance aspect has lost its effectiveness in defending TURF and in enforcing fisheries management rules. This was demonstrated by the general absence of exclusivity in the spatial use of CMT areas and non existence of temporal, gear and species prohibitions/restrictions reported in Chapter 3 and in Chapter 5 (specifically on the dynamite fishing issue). The loss in the effective governance aspect of CMT therefore reduces its potential as: (1) a coercive force to ensure compliance and; (2) a competent authority to impose sanctions on rule breakers.

Some aspects of the traditional CMT model (as per Figure 1.2) and its operation still exist; however it has undergone changes (Figure 6.1). Firstly the traditional gods and belief systems have been replaced by the new gods and belief systems through Christianisation. However the new gods remain external to the embedded social and property structure. The position of the gods within the original CMT model is now empty (Figure 6.1, dotted top triangle). Belief systems were in the past important to the effectiveness of CMT for fisheries management as they integrated with traditional ecological knowledge to form a knowledge-practice belief complex (Berkes 1999; Berkes et al. 2000). For example, the non-consumption of certain species may be based on belief systems but it has a conservation outcome. With the removal of a belief system, organisms previously prohibited from exploitation are now exploited. Spatial zones which were previously taboo sites for religious rites (and hence closed from entry and exploitation) are now open allowing people to exploit resources within the areas. In similar fashion Mgumia and Oba (2003) reported that terrestrial sacred groves in Tanzania had greater woody species richness and biodiversity than State managed forest reserves.

An external governance system has also been introduced which now interacts with the social and property system in a governing role, (Figure 6.1, unfilled double arrow connecting modern governance structure and embedded

social and property structure) with some overlaps between the two systems rather than complete integration. The modern governance structure is placed slightly higher than the 'embedded social property structure' to indicate it's more dominating role in overall governance. Rules and enforcement mechanisms in determining property access to rights are still strong; however the mediating role of the traditional CMT system with regards to rules and enforcement mechanisms in resource use patterns and conservation strategies is now diluted (Figure 6.1 dotted arrows connecting 'rules & enforcement mechanisms to below land/marine tenure rights). Traditional ecological knowledge and belief systems now also play a diluted role in mediating resource use patterns and conservation strategies (Figure 6.1, dotted arrow from traditional ecological knowledge & beliefs to below land/marine tenure rights). The modern governance structure has a strong mediating role in: (1) property rights by virtue of the role of the modern court system (from the local level to the court of appeal) in land/marine tenure dispute resolutions (Figure 6.1, filled arrow from modern governance structure to above land/marine tenure rights) and (2) resource use patterns and conservation strategies (Figure 6.1, filled arrow from modern governance structure to below land/marine tenure rights); for example, national fisheries regulations which prohibit sale and export of beche-de-mer can mediate resource exploitation by preventing a person from harvesting that resource even though he/she may have the right to do so in a particular area as there is no market for that product. Alternatively, the government can increase resource exploitation through rural fisheries development projects by providing boat and fishing equipment. The potential mediating role of the government extends over a continuum (due to the many departments and roles of the modern government) from being ineffective (e.g. unenforced regulations like dynamite fishing) to prohibition of trade of a particular species (e.g. crocodiles and beche-de-mer) which indirectly offers protection for a species. Furthermore, it can range from supporting resource management and conservation to not supporting conservation (especially in poorly thought-out development projects which emphasise economic rather than considered social, economic and ecological returns).

The external market and economy are now important in resource use patterns and conservation. The external market has a direct impact;

exploitation is not only for local subsistence and exchange purposes but for income generation as well. The external market can also cause changes in livelihoods (e.g. people less dependent on subsistence purposes but more on imported food items); this can lead to changes in the way resources are exploited and subsequently to an altered resource status (e.g. Aswani 2002). With the advent of the market economy, there is now an interaction between livelihoods and resource use patterns, rather than resources use and exploitation patterns dictating livelihoods. External factors which are outside of human influence continue to contribute to resource status.
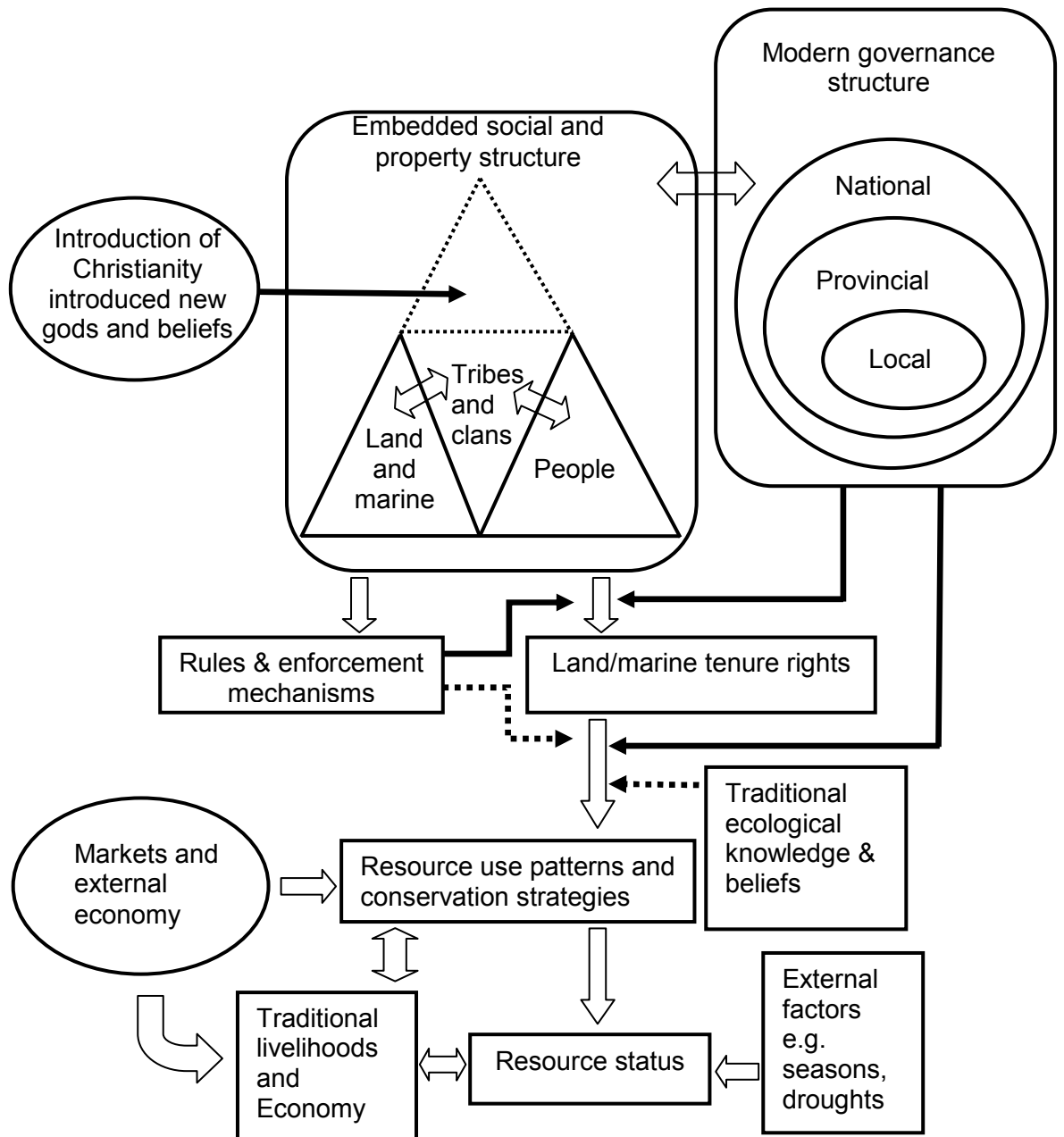
Figure 6.1: A conceptual model of how the CMT system operates at present. Triangular structure depicts the embedded social, and property structure of Maenu'u (1981)
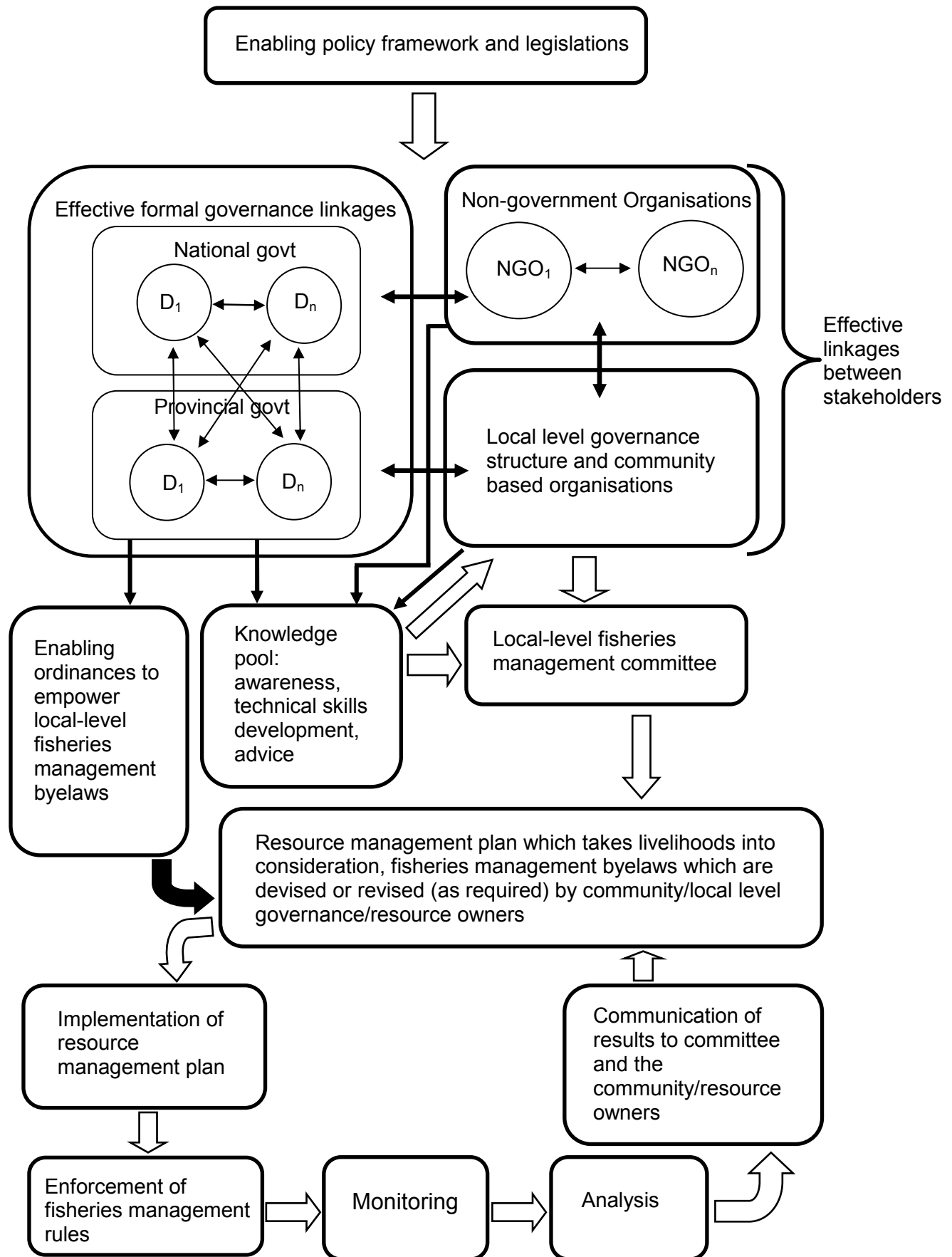
Figure 6.2: An adaptive co-management approach to enhance the effectiveness of CMT for small-scale finfish fisheries management

6.3 Way forward in engaging CMT in finfish fisheries management

Despite the current limitations of CMT, this thesis argues that CMT still has the potential to be successfully used for SSFM in Nggela. Two conditions are required to achieve this: (1) empowerment of the CMT by a more formal governance system (for example the modern Provincial Government system) and (2) employment of CMT in an adaptive co-management arrangement where the partnership is between the CMT rights-holders, NGOs and the government. Other researchers (e.g. Aswani 1997b; Virdin 2000) on CMT have emphasised the need for empowerment by formal governance system and co-management mechanisms to enable effective use of CMT. The continued existence of the MPAs at Sisili, Salavo and Maravaghi (2007 - 2010) which is a partnership between resource owners, local NGOs and the provincial Fisheries Department is a demonstration that CMT can be used for SSFM (I acknowledging that this may not always be the case).

What approach should be taken to empower CMT and facilitate its effective use for SSFM? This thesis suggests that an adaptive co-management approach (Figure 6.2) is required. The most important over-arching part of the proposed model (Figure 6.2) is the enabling policy framework and legislations. These are already present within the Solomon Islands through the legal recognition of CMT and related legislations (*Provincial Government Act 1997, Fisheries Act 1998, Protected Areas Act 2010*). Secondly, the model recommends effective linkages and communication within and between stakeholders (Figure 6.2 solid double-ended arrows); formal governance structure, NGOs and local-level governance structures and community-based organisations (e.g. tribes, clans, youth clubs, mothers unions etc at the community level). Since the formal governance structure can be substantial in size and complexity ('D_1' and 'D_n' in the model denotes different parts of the formal governance structure e.g. departments, ministries etc) and be made up of different layers (e.g. national or provincial level), effective linkages between the different parts of the formal structure (Figure 6.2 bold arrows) are needed for the different parts to complement roles in resource management and conservation (Carlsson and Berkes 2005). The formal governance structure through the provincial government (Fisheries Department), and NGOs contributes to the knowledge pool. This knowledge pool does not necessarily mean a repository; it could be a group of individuals who possess the

knowledge and are able to use and/or disseminate it. Local and community based-organisations (or individuals) also contribute to the knowledge pool by contributing their local ecological knowledge. What is contributed to the knowledge pool is used to build greater awareness in the community (Figure 6.2 unfilled single-ended arrow connecting 'knowledge pool' to 'local level governance and community based organisations). Information from the knowledge pool is also provided to the local-level fisheries management committee (Figure 6.2 unfilled single-ended arrow connecting knowledge pool to local fisheries management committee) who may use that knowledge in devising (or revising) the resource management plan, fisheries management byelaws and rules and development of required skills in the fisheries management process (e.g. resource monitoring). The provincial government will enact enabling ordinances (Figure 6.2 curved bold arrow) with coercive powers so that violators of local byelaws or rules can be prosecuted by the formal courts. The ordinances will empower the local level fisheries management committee and underscore the local resource management plan. (Note: At the time of revising this thesis in June 2011 the NGOs and the Central Province government are in the process of putting together relevant provincial ordinances for environmental management and coral reef protection, I will be making contributions to those ordinances). An important consideration in the enactment of the ordinances is that it should provide for flexibility that allows the adaptive application of CMT-based fisheries management rules over time. The process thereafter follows the community-based adaptive management process (Margoluis and Salafsky 1998) where the implementation of the resource management plan should be followed by enforcement of fisheries management rules; monitoring and analysis of monitoring data to determine the effectiveness of management actions; and use of results to revise the management plan as required, and provide feedback to the community on the performance of the plan.

The main emphasis of the proposed model (Figure 6.2) is on bottom up process, driven by the resource owners at the community level with the government and NGOs providing appropriate information and support (e.g. enabling policies and legislations and technical advice) in order to provide a rationale basis for local community CMT rights holders decision (Adams 1998). The CMT rights holders need to maintain a sense of ownership in the process

of governance and resource management as well as being involved in formulating rules (temporal, spatial gear or species restriction) designed for fisheries management purposes to increase likelihood of greater support from the end-users targeted; the question of ownership has previously been one of the incongruent factors between formal government and local-level communities in local level fisheries management (Adams 1998). Furthermore *"the will for action, if it comes from within the community, is far more likely to produce positive results than any external attempts to impose such values"* (Adams 1998: 137).

Livelihood demands and market influences will continue to impose on CMT-based finfish fisheries management. In illustrating the dilemmas faced by rural South Pacific fisher folks between conservation and livelihoods, Adams (1998: 140) noted that: *"the need to worry about keeping resources for a person's children in the future carries little weight when income from the fisheries resources could pay for the children's way out of the village, to school, then into a job in town, where the state of the fishery will not matter to them directly"*. As at June 2011, the Maravaghi and Salavo MPAs were still in existence with an additional 5 more village MPAs established in neighbouring villages. However the Sisili MPA was in the process of being opened in order to supply fish for the village church consecration feast. Such cases will inevitably occur especially when these MPAs were established with livelihood considerations in mind, although positive results from such harvests might be an impetus to close the area again afterwards. Periodic closures (2-10 years) will probably be the norm for CMT areas rather than permanent closures. Foale and Manele (2004) argued that permanent long-term closures of CMT areas to re-seed other reefs for the general good is typically impossible considering that the benefits of such sacrifice may not deliver accrued benefits, or if there are benefits then these may also accrue to those who gave up nothing. Foale and Manele (2004) suggested that the only way to circumnavigate this problem is to focus attention on zones which do not fall under customary ownership, such as offshore sub-tidal reefs which do not fall under any CMT ownership identified in this thesis. The findings from this research support the recommendation that adaptive co-management (Figure 6.2) should consider the spatial extent of resource exploitation. The seabed and marine areas which do not fall under CMT ownership are the property of the State (*Solomon*

Islands Delimitation of Marine Waters Act 1979 and 1986), hence the state (national or provincial Fisheries Departments) through the *Solomon Islands Fisheries Act 1998, the Provincial Government Act 1997* and *The Protected Areas Act 2010* can enter into a partnership with NGOs and fishers to establish fisheries management rules within these areas; the most appropriate would be temporal or long term spatial closures of selected offshore sub-tidal reefs. Since such a sacrifice (of giving up an area for closure and protection from exploitation) is not borne by any particular person (or group) there is a possibility that such an initiative may be acceptable. When interviewed fishers were asked about this, the general view was similar to the comments from a fisher from Ravu sondu ulu: *"the sea is much broader out there, there is still more than enough space for everyone to fish, it shouldn't be a hassle to close a few reefs".* The time and effort required to reach offshore sub-tidal reef areas may offer protection for these sites as shown by the *P. leopardus* data from offshore areas (Chapter 4).

6.4 Concluding remarks

In 2000, my research for my MSc thesis on seaweed (Studies on the effect of nutrients, salinity and temperature on growth rate, agar yield and agar quality of the Rhodophyta *Gracilaria maramae* South) inspired me to pursue a career path in phycology, but that changed when I read Foale (1998b) and Aswani (1997a). Thereafter, I developed an interest in CMT systems; particularly their use in fisheries management and this determined my choice of topic for this PhD. How does this study compare with previous studies by Foale and co-workers (Foale and Day 1997; Foale 1998b; Foale 1998a; Foale and Macintyre 2000)? This research found that the CMT system reported for West Nggela (Foale 1998b) occurs throughout the whole of Nggela; there was no local regional variation as for example in Roviana and Vonavona lagoon (New Georgia; Aswani 1999). The focus of this study was on finfish fisheries, while Foale and co-workers (Foale and Day 1997; Foale 1998b; Foale 1998a; Foale and Macintyre 2000) focused on the invertebrate fisheries, the main outcomes (of Foale and co-workers) were similar to this study in that CMT on its own was not a panacea for fisheries management in inshore areas, especially under the burgeoning forces of the market economy (as revealed by

livelihood investigations) and improved technology; overexploitation still occurs in CMT areas in Nggela and exploitation has shifted to offshore sub-tidal reef areas.

Relative to the study of Foale and co-workers (Foale and Day 1997; Foale 1998b; Foale 1998a; Foale and Macintyre 2000), this study has also been able to quantitatively analyse the role of livelihoods in CMT, indicating that livelihood demands in areas with a narrow land-based natural capital (as in the western zone of Nggela) might increase marine resource exploitation rates. Increased exploitation and resource decline are not necessarily a 'death sentence' for marine resources. The realisation that resources are declining may lead to organizational innovations by communities to reinforce the use of CMT for fisheries management (Hviding 1998); current initiatives to establish MPAs (all in west Nggela) and attempts by marine tenure rights owners to seek State support (e.g. more formal governance mechanisms) in enforcing the MPAs are possible reflections of such realisation. Another difference between this study and those of Foale and co workers (Foale and Day 1997; Foale 1998b; Foale 1998a; Foale and Macintyre 2000) is that this research found CMT influence is over only a very narrow strip of the coastal area, while resource exploitation occurs over a much wider marine spatial area. This has important implications for the use of CMT in marine resource management in general, especially for finfish species which are mobile and occur over a much wider geographical area. Fisheries management therefore needs to consider spatial areas on much larger scales than those of CMT. It is unlikely that the provincial government who are mandated by the national government will hurry to undertake management, owing mostly to the lack of capacity to do so. Since fisher folk are stakeholders of the offshore sub-tidal reefs (by virtue of their use of these areas), adaptive co-management initiatives should include them in the management of resources beyond CMT areas.

Foale and Macintyre (2000) argued that complete or partial codification of the CMT system may not be a workable solution to the problem of overfishing in CMT areas in Nggela. The basis for this argument was an analysis of land dispute cases where such disputes were seen as consequences of inter-clan power struggles, which were influenced by political volatility, marriage alliances and fluctuations in lineage size and strength (Foale and Macintyre 2000).

This thesis however holds that partial codification may be the only means to enable the effective use of CMT for fisheries management (Graham 1994b; Aswani 1997b) in Nggela. My examination of the historical changes of the CMT system in Nggela reveals that the social structure and property aspect of the CMT system is still intact although the governance and belief aspects have been lost. While land/marine tenure disputes are commonplace, not all land/marine tenure areas are subject to such disputes. Furthermore, land disputes seem to have occurred throughout the history of the Nggela CMT system. Currently the land dispute resolution mechanisms at the local level are recognised by the State and court system; this means that if rights over a particular area are contested the court system will be able to allot CMT rights over a particular area to a specific social group. Since those rights are underscored by the State it is not unreasonable for the State to enact ordinances to enforce those rights if a particular group intends to establish spatially closed areas for fisheries management. The current existence of local-level MPAs reveals that primary tenure rights holders who exercise decision rights exist. These rights are validated by others in the community by virtue of not exploiting resources within such closed areas. Additional State empowerment through codification (mainly as a coercive force in the enforcement of rules) can facilitate the effective use of CMT for fisheries management (Graham 1994b; Aswani 1997b).

In chapter 1 of the thesis I discussed the reasons for and against the use of CMT for fisheries management, this thesis has contributed to such an understanding in several ways. Framing the entire research on the DPSIR framework to analyse CMT as a policy response for finfish fisheries management it has shown via livelihoods analysis that markets and narrow land-based natural capital are important drivers in the exploitation of finfish fisheries. An investigation of fisher behaviour and target species (as a proxy for pressure) shows that exploitation does not only occur within CMT areas but within areas that do not fall under CMT areas as well. If finfish are to be managed in a holistic manner, the spatial extent of exploitation should be considered; enabling policy frameworks and legislations should be undertaken to enable the participation of fishers (by use of CMT based rules) in the management of finfish resources in areas outside of CMT areas. An investigation of the historical changes the CMT system has undergone (as a

response entity) shows that the social and property aspects of CMT still exists, albeit the governance aspect (enforcement of rules) has been lost.

While this thesis has contributed to some understanding on the use of CMT for finfish fisheries management in Nggela there is however scope for much ongoing enquiry and I conclude with some suggestions. Firstly a comprehensive assessment of reef finfish stock status (S within the DPSIR model) should be conducted in inshore areas and offshore areas and between levels of protection (i.e. MPA versus non-MPA) over time. This could be achieved by long-term recording of catches (beach records) from the areas as well as in-situ assessments. While UVC can be undertaken for in situ assessments of fish stock in inshore areas up to 20m depth, such assessments in offshore fishing areas which can be as deep as 100m will require use of video methods or traps.

Fisher behaviour (D, P and I within the DPSIR model) was understood only from a broad spatial perspective (i.e. that fishers fished both in CMT and open access areas). Study over at least 1 year which considered seasonality, prey choice and patch choice (and any associated social interactions) would have greatly increased understanding of fisher behaviour and fishery exploitation patterns. Coupled with this should be a study on the compliance behaviour of fishers to fisheries management regimes which can be fed into response (R within the DPSIR model).

While an understanding of the nexus between local level governance and the modern governance was generated, an in depth understanding of the role of governance in CMT could have been gained by an in depth study of the power overlaps and contests between the 3 different types of local level leaders (church leaders, traditional leaders and village chiefs) by combining ethnographic and social network analysis methods. Understanding this power overlap and contest is important in dealing with leadership clashes which may arise in resource management.

On a personal reflection of the project; prior to this study my knowledge on the social aspects of fisheries and resource management were poor and patchy as my background was from pure natural sciences (tropical seaweeds to be exact). This study has given me a deeper appreciation of the need for a concerted social and ecological understanding when we seek to address

environmental and resource management problems. The important outcome of this project for me has been the development of a broad set of skills (being able to do multidisciplinary studies that straddles both natural and social sciences, experience in fisheries related field work and the development of statistical skills and use of statistical software like SPSS and R) for future research in inshore marine resource use and management in Solomon Islands.

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APPENDIX 1

HOUSEHOLD AND FISHER SURVEY QUESTIONNAIRE

Survey ID

HOUSEHOLD SURVEY

I.   DEMOGRAPHIC INFORMATION

Household No: _____
Date_____
Village_____

Interviewer_____

1. Where are you initially from?

a. This community	b. This region/island	c. This country	d. Other country

2. How long have you lived in …………..?_____

3. Why did you move to …………?

a. Fishing	b. Other work	c. Family & friends	d. Health/spiritual
e. Other (conflict etc)			

II   HOUSEHOLD ECONOMICS

4. How many people are in your household?

a. Couples/family	b. Adult males	c. Adult females	d. Male children	e. Female children

4(f) Total currently living in the house_____

4(g) Others away at work _____   4(h) Location of work_____

4(i) Others away on education_____   4(j) Location of education_____

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

a. ACTIVITY	b. Interviewee?	c. No of people	d.Frq /Wk	e. Imptnce	f. Notes (Sale value, Lctn etc)	g. Income/ wk	h. Qty/ Wk
Reef Fishing							
Bonito Fishing							
Bechdermer							
Shark-fins							
Trochus							
Aquarium products							
Garden produce							
Copra							
Coconuts							
Food sales							
Cocoa							
Betel nut							
Lime production							
Remittance							
Nuts/seasonal fruits							
Salaried Employment							
Land rent/Royalties							
Trade store							
Bakery							
Carvings							
Tourism							
Ch-Saw/Timber							
Other (Marine)							
Other (Land)							

Code for salability: 1=Very easily sell; 2=Can sell; 3=Seldom sells; 4=Very difficult to sell

5i. Total number of occupations in household = _____   (e.g. 2 teachers = 2 occupations)

5j. Number of different occupations = _____ (e.g. 2 teachers then one type of occupation)

6.   What other work have you done in the last 5 years?

a. Occupation	b. Main job?	c. Why stop?	d. Could you get similar work now?	e.Do you prefer this to current activity?

III. COMMUNITY PARTICIPATION

7a. Are there any community groups/social networks?   Yes /No Describe

7b. Do you belong to any community groups?   Yes /No Describe
_____

7c. How many?_____

7d. What are the priorities/ challenges for these groups_____

8. If there is a decision to be made in your community, are you involved in that decision? How?

a. No	b. Passive	c. Active

IV. PERCEPTIONS ABOUT MARINE RESOURCES

9a. Is there more or less fish in the sea now compared to 5 years ago?

9b. Which areas of the sea have more fish and which areas have less fish

9c. How do you know?

9d. Has the size of fish caught increased, remain the same or decreased?

9e. Has the type of fish caught changed much?

9f. What type of fish do you use to catch five years ago that is not caught anymore?

9g. What type of fish do you catch now?

10a. What can affect the number of fish in the sea?   10b. How?

Factors & Mechanisms that may be mentioned in response to question		Individual logic statements – use arrows to show order of words mentioned.
Fisheries-related	Number of fishers	
	Fishers from outside	
	Over fishing	
	Spear Gun	
	Seine Net	
	Gill Net	
	Other Gear	
	Gleaning	
	Dynamite	
	Poison	
Human	Coral mining	
	tourist activities	
	Land-based pollution	
Environ.	Weather	
	Season	
	Environmental changes	
	Bleaching	
Ecology	Habitat	
	Feeding for fish	
	Reproduction	
	Life history stages	
	Fish moved/hiding/behaviour	
Sociccultur	Political/economic conditions	
	Market demand	
	Social cohesion	
	Supernatural/Superstition	
	Religion /God	
Other	Fish Kills– fish mortality	
	Other	
	Nothing	
	Don't know	

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

Reduce number of fishers	Exclude other fishers	Reduce fishing effort	Closed areas	Enforcement of fishing regulations
Eliminate explosive use	Reduce poison use	Reduce gill net use	Reduce cast net use	Coral mining
Education	Reduce Land-based activities	Stop big fishing companies	Social cohesion	Fish moved/hiding
Supernatural	Nothing	Don't know	Other	

V. MORE SOCIOECONOMIC QUESTIONS

12. Age_____   *13. Sex_____*   *14. Religion _____*

15. Languages _____   *16. Ethnicity _____*

MAIN FOODS

17. Can you tell me how often do you consume the following foods?

a. Food Type	b. Eaten on a Typical day(at least two or more times per week	c. Not eaten on a typical day (less than once per fortnight or longer period	d. From Garden or bought from market
Kumara			
Pana			
Yam			
Cassava			
Rice			
Local cabbage			
Local fruits			
Fin Fish			
Shell fish			
Canned fish			
Chicken			
Pork			
Beef			
Others			

18. HOUSEHOLD EXPENDITURE (Approximations for a fortnight)

a. Items	b. Amount/Fortnight	c. Notes
Clothes		
Consumption (food items)		
Local Marketed goods		
Battery		
Kerosene		
Health Care		
Medicine Cost		
Fuel for Transport		
Ship/boat Fare		
Boat/Canoe Hire		
Religious commitments		
School Fees		
School Contribution		
School Uniform		
School Stationeries		
School Sweets money		
Village commitment		
Alcohol		
Tobacco		
Gambling		
Diving equipment		
Fishing gear		
Agricultural tools		
Carving tools		
Marriages		
Funerals		
Others		

VI. FISHER SURVEY

19. How did you get into fishing?

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

a. Gear	Interviewee uses?	Interviewee's main gear	Number in household using main gear[1]	No. months/ year main gear used[2]	No. of days/week main gear used[3]	Ranking of gears for household income[4]	Gear owned?	b. Description (net length, net gauge, hook length, line size, coils etc.)	c. Areas fished now	d Areas fished 5 years ago
Hand line (reef)										
Hand line (pelagic)										
Bamboo pole & line										
Gillnet (L)										
Gillnet (S)										
Cast net										
Traps										
Lighting for fish (Bulu iga)										
Night spear fishing										
Trolling										
Reef gleaning										
Mangrove gleaning										
Dynamite										
Other										

Key to table for question 20a
[1] – Number of people from the household who use this gear.
[2] – How many months in a year does this house use this gear? (e.g. all year = 12)
[3]- How many days per week is this gear usually used by householders? This is not man-days but total days. (Average total   Man-days/week will be calculated from this, number of householders and Months/yr).
[4]- Rank of importance of the gears for the income of the household

20e Please look at this map of the fishing area. Please tell me the three most important areas (ranked) for each of your gears in each season. [SHOW MAP].

20f Have these areas changed in the last 5 years (record notes on which numbered areas have changed) i.e. Do you fish in different areas NOW than 5 years ago?

21 How important are the following factors on your decision to go fishing now and 5 years ago.

Now				Decision Making Factor	5 Yrs Ago			
1	2	3	4		1	2	3	4
				Weather				
				Season				
				Others Fishing				
				Need for Food				
				Need for Money				
				Loan Repayments				
				Risks/Dangers				
				Enjoyment				
				Distance				
				Cost				
				Gear				
				Fishing ground Productivity				
				Effort				
				Markets-ability to sell				
				Rules & regulations				

1 = Most important; 2 = Major influence; 3=Minor influence; 4=No influence

22. Do you use a boat?

a. Boat type	b. length (metres)	Motor HP?	Owned?		Notes
			Yes	**No**	
			Yes	**No**	

VII. CATCH PER UNIT EFFORT PERCEPTIONS

NOTE FOR INTERVIEWER: remember to write below which gear i.e. main gear the answers are for!

Main gear		How long gear used?		No. of fishing crew	

USE TABLE BELOW FOR ANSWERS TO QUESTION 23a &23b.

23a. With your main gear, how much fish do you catch on a (i) good day, (ii) poor day and (iii) normal day?

23b. How much effort do you put in on a good/poor/normal day (hours, etc)?

	Units	*(i) good day*	*(ii) poor day*	*(iii) normal day*
23a. **Catch** (e.g. kg)				
23b. Daily effort (hours, etc)				

23c. **How much is the catch worth (what is the monetary value) on a normal day?**

24. **On an average day, how many fish are consumed and how many fish are sold?**

 % food_____   % sold/market_____

25i) **What was a normal day's catch and effort with this gear 5 years ago? (Include units for each)**

	Units	*normal day*
25ia. **Catch** (e.g. kg)		
25ib. **Daily effort** (hours, traps etc)		

25ii) What was the value for a normal day?_____

26. Why is your catch different now to 5 years ago?

Less fish	*More fishers*	*Adjust/improve gears*	*Change gear type*
Change daily effort	*Change areas*	*Other*	

*(Left margin, vertical text): **With Interviewee's principlegear***

27. Have you changed the way you fish to try and catch more fish since 5 years ago?
a. How?   **b. Rank success of each change made if more than 1?**

a. Change	b. Rank success/importance

27c. What is the current total effort in the fishing areas you fish in (number of fishers, boats, traps etc)

27d. Is the current effort okay for your catch?

27e. Imagine if the effort is doubled (times two of what it is now), what do you think your average effort and catch will be?

27f. Imagine if it is halved, what do you think your average effort and catch will be?

28. Imagine if nobody else was fishing in those grounds. What do you think your average catch and effort would be?(compare to normal daily catch and effort): *Idea of this question is to get a baseline retrospectively!*

catch:

effort:

VIII. REGULATIONS TO DO WITH FISHING ACTIVITIES

29a. Are you aware of any regulations that influence how, when and where people fish?
Yes/No. If yes complete table below:

Management type	Description	Do people still (go there, use that gear, etc)			
		No	Just a few	Most	All
Are there places where people are not supposed to fish?					
Are there certain gears that people are not supposed to use?	A explosives				
	b. poison				
	c. net				
	d. other				
Are there certain marine organisms that are not allowed to be harvested/fished					
Are there certain sizes that are not allowed to be harvested/caught					
Are there certain seasons when certain areas or organisms are not allowed to be harvested/fished					

29b. Do people agree/support the regulations?

IX. OTHER INFORMATION

30. Is there anything else you would like to tell me about fishing, livelihoods and fish stocks? What are the greatest threats to your livelihood?

31. Can you recommend anyone that i should speak to about fishing related activities?

THANK YOU FOR YOUR HELP AND TIME WITH THIS SURVEY.

APPENDIX 2

FINFISH SPECIES CAUGHT BY NGGELA FISHERS

1.1   Species caught using hand line

Acanthurus nigrofuscus
Aethaloperca rogaa
Alectis ciliaris
Aphareus furca
Aprion virescens
Balistapus undulates
Caesio cuning
Caesio teres
Canthidermis maculatus
Carangoides caeruleopinnatus
Carangoides ferdau
Carangoides malabaricus
Caranx ignobilis
Caranx melampygus
Caranx papuensis
Caranx sexfasciatus
Caranx Spp
Cephalopholis cyanostigma
Cephalopholis miniata
Cephalopholis sexmaculata
Cephalopholis sonnerati
Cephalopholis spiloparaea
Cephalopholis Spp
Cephalopholis urodeta
Cheilinus fasciatus
Cheilinus trilobatus
Decapterus russelli
Elegatis bipinnulata
Epinephelus aerolatus
Epinephelus fasciatus
Epinephelus fuscogutattus
Epinephelus macrospilos
Epinephelus maculatus
Epinephelus morrhua
Epinephelus Spp
Gerres oyena
Grammatorcynas bilineatus
Gymnocranius euanus

Gymnocranius grandoculis
Gymnosarda unicolor
Kyphosus cinerascens
Lethrinus erythracanthus
Lethrinus erythropterus
Lethrinus harak
Lethrinus miniatus
Lethrinus obsoletus
Lethrinus olivaceus
Lethrinus ornatus
Liza vaigiensis
Lutjanus argentimaculatus
Lutjanus bitaeniatus
Lutjanus bohar
Lutjanus fulviflamma
Lutjanus fulvus
Lutjanus gibbus
Lutjanus quinquelineatus
Lutjanus russelli
Lutjanus sebae
Lutjanus semicinctus
Lutjanus Spp
Lutjanus timorensis
Lutjanus vita
Macolor macularis
Melicthys vidua
Myripristis berndti
Myripristis murdjan
Myripristis sp
Parupeneus barberinus
Parupeneus chrysopleuron
Parupeneus heptacanthus
Parupeneus Spp
Pinjalo lewisi
Pinjalo pinjalo
Platybelone argalus
Plectorhinchus chaetodonoides
Plectropomus areolatus
Plectropomus laevis
Plectropomus leopardus
Plectropomus maculatus
Pristipomoide multidens
Sargocentron spiniferum
Scolopsis Spp
Scomberomorus commerson
Seriola dumerili
Seriola rivoliana

Sphyraena barracuda
Sphyraena helleri
Variola albimarginata

1.2 <u>Species caught using gill net</u>

Acanthurus lineatus
Acanthurus xanthopterus
Caranx ignobilis
Cheilinus trilobatus
Chlorurus bleekeri
Crenimugil crenilabis
Ctenochaetus striatus
Ctenochaetus strigosus
Lethrinus harak
Parupeneus barberinus
Scarus chameleon
Scarus dimidiatus
Scarus flavipectoralis
Scarus globiceps
Scarus niger
Scarus Spp
Siganus canaliculatus
Siganus doliatus

1.3 <u>Species caught using spear</u>

Acanthurus auranticavus
Acanthurus lineatus
Acanthurus xanthopterus
Caesio cuning
Macolor macularis
Myripristis vittata
Parupeneus insularis
Parupeneus multifasciatus
Parupeneus Spp
Plectropomus laevis
Plectropomus leopardus
Rastrellinger Spp
Scarus chameleon
Scarus globiceps
Scarus niger
Siganus canaliculatus
Variola louti