Is community-based fisheries management realising multiple objectives? Examining evidence from the literature

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Introduction

Community-based and co-management approaches are key strategies for small-scale fisheries management (Evans et al. 2011; Gutierrez et al. 2011). The expansion of these approaches is particularly apparent in the Pacific, where communities rely heavily on small-scale fisheries (Govan 2009a) and concerns about sustainability are increasing (Bell et al. 2009; Brewer et al. 2009). Many community-based management initiatives are recognised within a regional practitioner's network referred to as the Locally Managed Marine Area (LMMA) network (Parks and Salafsky 2001). There are also likely to be hundreds to thousands of communities implementing management, outside the formal network, which do not appear on any official list (Govan 2009a). For simplicity, we use the term LMMA broadly to encompass local management that: 1) is applied to nearshore marine areas; 2) seeks to meet local management objectives; 3) employs locally negotiated rules that integrate customary or local governance institutions; 4) is adaptable via learning-by-doing approaches; and 5) includes circumstances where resident communities may be collaborating with partners such as non-government organisations, government agencies or research institutes (Govan 2009a). In this regard, the term LMMA is synonymous with community-based marine resource or fisheries management (CBRM and CBFM).

Throughout the Pacific, a diversity of customary institutions exist for controlling the use of fisheries resources, including tenure systems, closures of fishing grounds, and bans on sectors of society consuming or harvesting certain species (Cinner and Aswani 2007; Johannes 1982). Alongside other customary and local governance structures (e.g. chiefly systems), such customary institutions form the foundations of LMMAs (Govan 2009a; Johannes 2002; Ruddle 1998). However, in contemporary, competitive resource-use contexts, customary management institutions alone may be unable to ensure sustainable patterns of resource use without some integration of scientific knowledge, modern management practice or institutional support (Aswani and Ruddle 2013; Foale et al. 2011; Polunin 1984). LMMAs often represent efforts to integrate local and scientific knowledge, customary and contemporary management practices, and, in some situations, to provide legal or other institutional support to customary and local governance.

A recent review (Jupiter et al. 2014) highlighted that LMMAs were not only advocated and established to improve the long-term sustainability of fisheries, but also to achieve other overarching objectives: 1) increasing short-term harvesting efficiency; 2) restoring biodiversity and ecosystems; 3) maintaining or restoring breeding biomass; 4) enhancing livelihoods; 5) reinforcing customs; 6) asserting access rights; and 7) community empowerment. These objectives are often overlapping and, in some cases, can be conflicting. For example, LMMA objectives for enhanced fisheries-supported livelihoods may clash with some objectives for conservation of biodiversity, and LMMAs established to promote short-term increases in catch may not be able to also enhance long-term sustainability of fisheries. Here, we summarise cases from the Pacific that report on these objectives, and then discuss some particular synergies and trade-offs between objectives. By summarising the findings of Jupiter et al. (2014), we then review the effectiveness of management measures or "tools" for progressing fisheries sustainability in particular, as well as the seven other objectives identified.

Increasing the sustainability of fisheries — one of multiple LMMA objectives

LMMAs are commonly established to enhance the long-term sustainability of fisheries-associated livelihoods and food security, and are often initiated in

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response to concerns about resource decline and the sustainability of small-scale fisheries (e.g. Bartlett et al. 2009a; Parks and Salafsky 2001). In some cases, increases in resource abundance have been perceived or quantified over short time-scales and often within small, permanent or periodically harvested closures within LMMAs (e.g. Bartlett et al. 2009b; Cinner et al. 2005; Tawake et al. 2001). Other studies have suggested that human nutrition is improved as a result of such affects (e.g. Aswani and Furusawa 2007; Weiant and Aswani 2006). Yet, there is very limited empirical evidence that short-term or localised (i.e. within small closures) increases might lead to broader and long-term improvements to fisheries-supported livelihoods and food security.

Projections based on population growth rates suggest that coastal fisheries will not meet future needs of many Pacific Island countries, even if coastal fisheries are well managed (Bell et al. 2009). While improving management should help to minimise this deficit, factors operating beyond local levels (e.g. commercial fisheries, government policies) or outside of fisheries systems (e.g. market fluctuations, population growth, natural disasters) also strongly influence fisheries sustainability, and food security and livelihoods more broadly (Schwarz et al. 2011). Yet in the Pacific, where many centralised governments have relatively little capacity to effectively manage dispersed, diverse and dynamic small-scale fisheries, LMMAs will likely remain a key strategy. There are two important areas in which research can focus. First, testing the effectiveness of LMMAs for improving the performance and sustainability of fisheries or, perhaps more realistically in many cases, for achieving "primary management" (i.e. precautionary management designed to prevent the loss of benefits, rather than optimise benefits, Cochrane et al. 2011). Second, improving the understanding of how LMMAs might work in conjunction with centralised management and higher levels of planning to tackle small-scale fisheries concerns. We suggest that a first step in this direction is to develop a better understanding of the multiple objectives for which LMMAs are employed (discussed below), and the potential trade-offs created when managing for multiple objectives simultaneously.

Increase efficiency of harvests for short-term yield

Many communities use LMMAs, most commonly periodically harvested closures or taboo areas, to ensure a ready supply of fish and invertebrates for special occasions (Govan 2009a). Both fishers and scientists have observed that after a period of closure, catch efficiency (particularly of spearfishing) can increase (Cinner et al. 2006; Foale et al. 2011). This can be due to behavioural changes that cause fish to become less wary of fishers (Feary et al. 2011; Januchowski-Hartley et al. 2011). Increased catchability due to these behavioural responses means that a relatively small amount of effort is effective at removing biomass, which benefits fishers in the short term but could increase the likelihood of overharvesting (Feary et al. 2011, Jupiter et al. 2012). Longer-term sustainability is more likely to be effectively coupled with objectives of increased catch efficiency if catch rates are elevated because reproduction and growth have led to increased abundance and size of targeted taxa; this has been observed for some invertebrate fisheries (e.g. Cohen and Alexander 2013; Tawake et al. 2001). Whether short-term improvements in catch efficiency correspond with improved and sustainable yields in the longer term is a pressing question for managers, but will depend on rates of extraction (which, in turn, are affected by resource demand, gear efficiency, and other factors) relative to production (depending on life histories of targeted species, habitat suitability and status, ecological interactions).

Maintain and/or restore biodiversity and ecosystem functions

The conservation of biodiversity and ecosystems is reported as an objective of some LMMAs (e.g. Aswani et al. 2007; Bartlett et al. 2009a; Jupiter and Egli 2011). However, this is not typically a primary objective of communities (Govan and Jupiter 2013), and may emerge due to the influence of ideas about conservation from partner organisations. The LMMA network was founded on the assumption that successful implementation would lead to conservation outcomes, and many LMMA partners are conservation organisations (Cohen et al. 2012). Indeed, there is some evidence that LMMAs can have conservation benefits. Mills and colleagues (2011) demonstrated that national-level coverage of LMMAs in Fiji contributed substantially to the government's target to protect 30% of marine habitats. At local scales, applying tools that are designed to reduce fishing effort or destructive fishing methods may lead to cascading impacts on biodiversity and ecosystem function. For example, local protection from fishing (using reserves) may lead to an increase in prey abundance, which would then lead to increases in top predators (Goetze and Fullwood 2013).

While intact ecosystems and biodiversity support fisheries, there is a distinction between fisheries and conservation objectives (Foale et al. 2013). This distinction is illustrated by the fact that, while no-take marine reserves can perform well for conservation, in some cases (e.g. for species with home ranges that extend beyond reserve boundaries, or where fishing effort becomes intensified in open areas) no-take reserves will be relatively ineffective and inefficient for managing fisheries compared with other measures (Hilborn et al. 2004; Kearney et al. 2012).

Maintain and/or restore biomass and breeding populations

A common community-voiced objective of LMMAs is to restore the abundance and biomass of fish and invertebrate species that are important for fisheries. Supplementing local knowledge with contemporary scientific understanding of reproductive and ecological processes (i.e. through "awareness raising" activities) is a common element of LMMA initiatives (Parks and Salafsky 2001). The goal is to influence management practices so that they increase the likelihood that biomass and breeding populations are maintained, and that long-term sustainability objectives can be met (e.g. Foale et al. 2011). In some cases where community-based management partners have explained ecological processes, communities have readily established area closures (e.g. King and Fa'asili 1998) or spatial and/or seasonal management over breeding and nursery sites (e.g. Almany et al. 2013; Aswani and Hamilton 2004; Hamilton et al. 2011). Abundance and biomass increases are commonly observed within no-take reserves (e.g. Bartlett et al. 2009b; Hamilton et al. 2011). If, after a period of time, increases inside reserves lead to substantial adult spillover and larval export into areas accessible to fishers, then increased catch efficiency or improvements to the long-term sustainability of fisheries may be realised (e.g. Almany et al. 2013; Halpern et al. 2010). However, highly localised protection (i.e. closures of small areas of fishing grounds) will be less likely to lead to improvements in long-term sustainability if fishing effort outside protection zones is too great (e.g. Dumas et al. 2010).

Enhance economy and livelihoods through related activities

Rural Pacific Island communities rely heavily on fisheries for food and income, and in some cases have relatively few alternatives (Bell et al. 2009). Not surprisingly, many communities are attracted to the idea of LMMA establishment in the hope that local economies and livelihoods will be improved — often through means other than fisheries extraction. Livelihood objectives might be pursued through explicit arrangements (or expectations) to: receive payments to cease extraction of resources; develop land-based income generating activities; generate revenue from ecotourism; receive employment associated with management; or participate in alternative income-generating activities introduced by management partners.

For example, the potential for financial gain from tourism development in New Caledonia was a major driver convincing local communities to participate in management (Horowitz 2008). Other examples of economic incentives provided through LMMA-associated ecotourism include fees for diving in Fiji reserves (Weeks and Jupiter 2013), and a paid lease agreement to establish a no-take reserve in Indonesia (Niesten and Gjertsen 2010). In certain cases, tourism has provided additional income to community members through paid employment and boosted sales of fish and handicrafts (Horowitz 2008; Niesten and Gjertsen 2010; Vianna et al. 2012). However, tourism will be unlikely to provide substantive opportunities in remote or environmentally degraded parts of the Pacific. In one such area in Solomon Islands, management partners encouraged community buy-in through alternative livelihood activities (Aswani 2000). In practice, it is often found that the potential for enhanced sustainability of fisheries is not always incentive enough for communities to engage in, or sustain, management.

Maintain or reinforce traditional customs

Customary practices that control resource use (e.g. restricted access through tenure, protection of sacred areas, restrictions on harvesting particular species) are relatively common throughout the Pacific (Hviding 1989; Veitayaki 1997; Zann 1989). Yet, in modern contexts, many of these traditional practices are perceived to be eroding (Bartlett et al. 2010; Foale 2006) and LMMAs are often viewed as a way to strengthen or adapt customary practices (Johannes 2002). For example, in Fiji, a passage considered to be a sacred site was later instated as a closure within an LMMA (J. Cinavilakeba, pers. comm.), and elsewhere in Fiji a lagoon considered to be sacred was reinforced as a permanent no-take area within an LMMA (Veitayaki 2001). Periodically harvested closures or taboo areas (see section below) that have traditional origins are commonly applied and adapted in contemporary community-based management, and may be intended to enhance fisheries performance in both the longer and shorter terms (Cohen and Foale 2013). In other cases, customary marine tenure may be strengthened through LMMA formation to restrict who can access fishing grounds.

Assert access rights

Tenure systems allow communities, clans or families with primary rights to a particular area to limit access and apply rules to the use of resources within the area (Macintyre and Foale 2007), and, thus, they form important foundations for LMMAs (Aswani and Ruddle 2013). Customary marine tenure systems are recognised in the constitution of some countries (e.g. Solomon Islands; Lane 2006); in others, there is legal recognition of traditional fishing rights (e.g. Fiji; Clarke and Jupiter 2010) or legal avenues for communities to establish management rights over coastal areas (e.g. Tonga; Govan 2009a). Tenure arrangements (i.e. the people who hold rights, the nature of those rights, and the areas to which rights are held) are often dynamic and are generally unwritten (Baines 1990). To some extent, arrangements are able to change in response to new

environmental pressures or altered social, economic or ecological conditions (Hviding 1998). Codifying and/or clarifying tenure claims may be an important, but perhaps not overtly stated, objective for establishing LMMAs and formalising management (e.g. Steenbergen 2011). Yet, in some cases, clarifying tenure claims to establish management (or local developments) can work in opposition to objectives of enhanced community cohesiveness, and instead lead to protracted negotiations and disputes (Macintyre and Foale 2007; McDougall 2005). Depending on how rights are assigned and how management is established, benefits and costs may be unequally distributed according to gender, clan or ethnicity, which can undermine management and/or hinder objectives of improving "community" well-being (e.g. Anderson and Mees 1999; Cohen et al. 2013; Vunisea 2008).

Increase community organisation, cohesiveness and empowerment

Many community-based management partners seek to empower communities and strengthen local governance through participatory processes employed for establishing and implementing LMMAs (Govan et al. 2008). These processes often include elements of education, awareness raising and learning for adaptation. Further, processes for establishing LMMAs frequently facilitate community-level consultations for identifying issues, visioning, planning, decision-making and consensus building (Govan et al. 2008; King and Fa'asili 1998). In one case in Solomon Islands, it was reported that as a result of such processes, a communities' LMMA committee was better able to deal with resource-use issues, but also developed into a forum for "addressing other community issues" (Govan 2009b; Leisher et al. 2007). While anecdotal reports of improved governance are relatively common, more critical evaluations of changes in governance capacity are warranted. In a further case, women's participation in decision-making about resources was reportedly enhanced through community-engagement and planning processes (Hilly et al. 2011; Leisher et al. 2007). This is an important outcome because despite women's common and various roles in capturing and marketing fisheries resources (Kronen and Vunisea 2007; Weiant and Aswani 2006), women frequently have limited voice in such decision-making (Vunisea 2008). Partnerships (i.e. those between communities and their management partner) may also bolster local management efforts and raise the profile of local issues. For example, in Solomon Islands a network of LMMA partners provided important pathways for information about resource management to reach communities, and also provided a mechanism for communities and their management efforts to be represented in higher level decision-making arenas (Cohen et al. 2012).

Management measures or "tools" used to progress objectives

Within an LMMA, management falls into six broad categories of fisheries rules and management measures: 1) permanent closures, 2) periodically harvested closures, 3) species-specific restrictions, 4) gear restrictions, 5) access restrictions, and 6) livelihood diversification strategies. Jupiter et al. (2014) used expert opinion alongside appraisal of the literature to rank the effectiveness of each type of management measure for achieving LMMA objectives. Here we refer to findings from mainstream fisheries practice and science, but focus on empirical evidence from the Pacific (reviewed by Jupiter et al. 2014) of the performance of these management measures for achieving LMMA objectives. These measures are not necessarily intended to be employed in isolation (and may achieve complementary objectives if employed in combination), but for simplicity we consider them separately, and highlight some examples where outcomes will be affected by the broader management context as well as differing social and environmental contexts. In addition to the application of these six types of management measures, the *processes* of LMMA formation and adaptation may also contribute to objectives such as "assert access rights" and "increase community organisation and empowerment", but these are not detailed or discussed in depth here (but see Albert et al. 2013; Govan et al. 2008; Jupiter et al. 2014).

Permanent closures

LMMA approaches frequently lead to the formation of small (median 0.1–1.0 km^2) no-take zones, often placed over coral reefs (Govan 2009a). Where these have included spawning aggregation sites, localised increases of some key fisheries species have been observed (Hamilton et al. 2011). However, for species with large home ranges or those with highly dispersing larvae, it is expected that small reserves will be less effective (Ferraris et al. 2005; White and Costello 2011). For example, small closures appeared to be insufficient for restoring breeding biomass and preventing overall population declines (even for relatively immobile invertebrates) in Vanuatu (Dumas et al. 2010). Perceptions of increased marine resources within closed zones are common within fishing communities, even if increases are not apparent from ecological monitoring data or are ecologically unrealistic (World Bank 2000; Yasue et al. 2010). However, there are suggestions that benefits of closures may transcend ecological impact by increasing interest, knowledge and awareness of the benefits of management more broadly (World Bank 2000). In some contexts, no-take areas have facilitated alternative income sources, typically those related to dive tourism (e.g.

Weeks and Jupiter 2013). Permanent no-take areas have also been established within LMMAs to help protect sacred sites or to conserve habitats and species (e.g. Jupiter and Egli 2011). Notably, many no-take zones within LMMAs are closed indefinitely (as opposed to permanently), where communities express the intention to harvest areas at some stage in the future if circumstances change (Govan 2009a). Intentions to someday open areas to harvesting, and the relatively small scale of tenure units are, in certain circumstances, barriers to effective implementation of permanent or larger closures (Foale and Manele 2004; Foale et al. 2011).

Periodically harvested closures

Periodically harvested closures are commonly implemented within LMMAs, and in some cases have been observed to be enthusiastically applied compared with other tools (Cohen et al. 2013; Léopold et al. 2013a), perhaps partly due to their historical origins (Johannes 1982). However, their application is highly variable and typically flexible. As a result, outcomes for enhancing fisheries sustainability, or progress towards biodiversity or ecological conservation and restoration objectives, is highly variable between cases (see review by Cohen and Foale 2013). Short-term elevated catch rates have been observed in periodically harvested closures due to increased abundance of invertebrates, in particular (Cohen and Alexander 2013; Tawake et al. 2001), and increased catchability of fish (Januchowski-Hartley et al. 2011).

In contemporary contexts, periodically harvested closures may play a role in maintaining traditional customs by helping to provide food and income for celebrations (Govan 2009a). One of the attractive features of periodically harvested closures is that loss of access to fishing areas is not permanent and benefits are realised from harvests when areas are opened (Cohen and Foale 2013; Foale 1998; Jupiter et al. 2012). During some opening events it has been observed that fishing effort is elevated and removal of biomass is relatively high, which in turn has led to substantial depletion of local stocks, suggesting that the long-term sustainability of fisheries may be compromised (Cohen et al. 2013; Jupiter et al. 2012). While in other cases, the relatively long periods of closure may result in a net reduction in fishing pressure applied to these areas, which facilitates sustained increases in abundance or biomass (Bartlett et al. 2009b; Cinner et al. 2005). Conservation benefits of periodically harvested closures have rarely been examined, but in one case where fishing was light and infrequent, no substantial benefits of periodically harvested closures were found on species richness, live coral cover and coral diversity (Cinner et al. 2005).

Species-specific restrictions

Application of species-specific size restrictions within LMMAs has met with mixed success. In Vanuatu, Léopold et al. (2013a) found very high levels of compliance with national minimum size limits for trochus but much lower levels of implementation of community-set size limits and other measures within LMMAs. This study suggested that local management and enforcement would need to be improved to promote long-term fisheries sustainability. Spatial or temporal restrictions that ban fishing of particular species during sensitive life history phases (e.g. spawning aggregations) have been shown to effectively maintain or enhance biomass and breeding stocks; for example, in Papua New Guinea, where a ten-fold increase in the density of the camouflage grouper was observed (Hamilton et al. 2011). Locally implemented bans on harvesting particular species have been reported (e.g. Cohen et al. 2013; Johannes 1998), but in many cases the outcomes have not been tested. The use of species-specific quotas is rare in Pacific community-based management (but see Léopold et al. 2013b and Nash et al. 1995 for examples of co-management where government has played a relatively strong role in guiding management), likely due to the high demand for data to appropriately set limits and a lack of capacity to monitor catches.

Gear restrictions

Within LMMAs, restrictions may be promoted to limit the use of destructive methods (e.g. the use of dynamite and fish poisons) or highly efficient gear (e.g. small-mesh nets, or torch lamps and spear-guns for night fishing) (Govan et al. 2008; Johannes 2002). Such measures are expected to improve fisheries sustainability by maintaining habitat structure, ecosystem function and breeding capacity (Fernandes et al. 2012). Assessments of gear restrictions from the Pacific are sparse, although studies from other tropical regions suggest locally implemented gear-based management can be effective for improving fisheries performance (e.g. Hicks and McClanahan 2012). Yet, as with species restrictions, issues with local enforcement and compliance with gear restrictions have been noted in Pacific LMMAs. Léopold et al. (2013a) found that while many communities in Vanuatu initially set gear-based restrictions when they established LMMAs, very few of these restrictions continued to be implemented (similar to findings of Cohen et al. 2013 in Solomon Islands).

Access restrictions

Restricting access is a common input control measure used to manage fisheries (King 2007), and can support the implementation of other concurrent management measures (World Bank 2000). Customary marine tenure provides the

principle mechanism in many Pacific Island countries by which to limit access to inshore fishing grounds (Johannes 2002; Macintyre and Foale 2007). However, implementing access restrictions in isolation to other tools "will not necessarily change the volume harvested, just who harvests it" (Polunin 1984). In this regard, it is also important to note that those who have been excluded may face increased hardship. Further, without concurrent management measures (such as effort restrictions), clarifying access rights may simply shift the distribution of effort and not address the root causes of resource decline. Where demand for local resources is high and use is intense, improving fisheries-supported livelihoods and food security, enhancing fisheries sustainability, or maintaining biomass will likely not be achieved through access restrictions alone.

Livelihood diversification strategies

To reduce fishing effort, or to offset costs associated with management, management partners sometimes promote livelihood diversification strategies alongside LMMA initiatives (O'Garra 2007). Deployment of fish aggregation devices (FADs) is a relatively common strategy that has a long history in the Pacific. In Solomon Islands, fishing at FADs led to increased catch per unit of effort due to enhanced catches of pelagic fish, and fishers perceived that effort on coastal (previously heavily fished) locations had decreased (Prange et al. 2009). However, very few documented examples demonstrate that alternative or supplemental livelihoods, even FADs, have led to more sustainable fisheries practices or improved ecological conditions (Gillett et al. 2008). Further, if hopes for improved income from livelihood diversification strategies are not fulfilled, resource management may stall or fail, and in certain instances conflict may arise due to inequitable distribution of benefits (e.g. Aswani and Weiant 2003; Niesten and Gjertsen 2010). Furthermore, while it is intuitively important to facilitate broader community developments alongside management efforts, there is concern that livelihood projects may create a culture and expectation of payment for participation in management (Foale 2001; Gillett et al. 2008).

Conclusions

LMMAs are widely recognised as a key strategy for managing small-scale fisheries in many Pacific Island contexts. Yet here we highlight that it is important to also recognise the diversity and multiplicity of objectives for which LMMAs may be implemented. The acceptance and proliferation of LMMAs across the Pacific can be attributed, at least in part, to the flexibility with which they can be implemented: the selection and application of management tools can be adapted to different contexts, and adjusted through time to account for social and ecological changes or as new knowledge emerges from experience. Nevertheless, the diversity of social and ecological contexts, and also the resultant form of LMMAs, means that providing best-practice guidance to optimise fisheries through LMMAs is challenging. The multiplicity of objectives for implementing LMMAs (Jupiter et al. 2014) means that trade-offs between objectives may occur, and that "success" can have multiple meanings. As a further complication, community objectives might not be made explicit to management partners, and may only emerge later during implementation. The longevity of any LMMA will ultimately depend on whether communities and other key stakeholders perceive that there is progress toward their objectives, and that the benefits of management outweigh the costs (Lal and Keen 2002).

Our review has also highlighted that, despite reports of hundreds to thousands of active LMMAs in the Pacific, most local management proceeds with little documentation or critical evaluation. As a result, there are relatively few empirical cases that: 1) describe how objectives and management tools are negotiated, 2) report on objectives being pursued, 3) describe the management tools ultimately employed, and 4) test outcomes towards fisheries sustainability or other objectives. Given that LMMAs are an important approach for improving small-scale fisheries management within the Pacific Islands region, improving the understanding of objectives, management measures, and outcomes are important areas for ongoing research and improved reporting.

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