



Adaptive Comanagement of a Marine Protected Area Network in Fiji

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Abstract: Adaptive management of natural resources is an iterative process of decision making whereby management strategies are progressively changed or adjusted in response to new information. Despite an increasing focus on the need for adaptive conservation strategies, there remain few applied examples. We describe the 9-year process of adaptive comanagement of a marine protected area network in Kubulau District, Fiji. In 2011, a review of protected area boundaries and management rules was motivated by the need to enhance management effectiveness and the desire to improve resilience to climate change. Through a series of consultations, with the Wildlife Conservation Society providing scientific input to community decision making, the network of marine protected areas was reconfigured so as to maximize resilience and compliance. Factors identified as contributing to this outcome include well-defined resource-access rights; community respect for a flexible system of customary governance; long-term commitment and presence of comanagement partners; supportive policy environment for comanagement; synthesis of traditional management approaches with systematic monitoring; and district-wide coordination, which provided a broader spatial context for adaptive-management decision making.

Keywords: adaptive management, community-based conservation, conservation planning, coral reefs, customary management, Fiji, marine protected areas, resilience

Co-Manejo Adaptativo de una Red de Áreas Marinas Protegidas en Fiyi

Resumen: El manejo adaptativo de los recursos naturales es un proceso interactivo de toma de decisiones donde las estrategias de manejo son cambiadas progresivamente o ajustadas en respuesta a información nueva. A pesar del incremento en el interés por la necesidad de estrategias de conservación adaptativa, todavía hay pocos ejemplos de su aplicación. Describimos el proceso de 9 años de co-manejo adaptativo de una red de áreas marinas protegidas en el Distrito Kubulau, Fiyi. En 2011, la necesidad de mejorar la efectividad del manejo y el deseo de mejorar la resistencia al cambio climático motivó a realizar una revisión de los límites del área protegida y las reglas de manejo. A través de una serie de consultas, con la Sociedad de Conservación de Vida Silvestre proporcionando entradas a la toma de decisiones comunitarias, la red de áreas marinas protegidas se reconfiguró para maximizar la resistencia y la conformidad. Los factores que se identificaron como contribuyentes para este resultado incluyen: derechos de acceso a recursos bien definidos, respeto comunitario hacia un sistema flexible de gobernanza común, compromiso a largo plazo y presencia de compañeros de co-manejo, una política ambiental que apoye el co-manejo, una síntesis de los acercamientos de manejo tradicional con monitoreo sistemático y una coordinación a lo largo del distrito, que proporcionó un contexto espacial más amplio para la toma de decisiones en el manejo adaptativo.

Palabras Clave: áreas marinas protegidas, arrecifes de coral, conservación basada en la comunidad, Fiyi, manejo adaptativo, manejo común, planificación de la conservación, resistencia

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Introduction

Adaptive management of natural resources (Holling 1978; Walters 1986) recognizes the need for conservation strategies to be flexible to changing social, economic, and environmental contexts (Cinner et al. 2012) and responsive to new information on biological diversity, costs, threats, and how to include these in planning. It acknowledges the need to act now rather than wait for complete information, with the expectation that management objectives and strategies will change over time as new challenges arise (Ban et al. 2011). Yet conservation planning and network design have rarely been as dynamic or iterative as intended (Game et al. 2010), and despite an increasing focus in the literature on the need for adaptive conservation strategies (e.g., Grantham et al. 2010; McCook et al. 2010; Ban et al. 2011), there remain few examples of adaptive management in practice (Holness & Biggs 2011; Roux & Foxcroft 2011).

Adaptive management is an iterative process of decision making whereby management strategies are changed or adjusted as new information becomes available (Walters & Hilborn 1978). Effective adaptive management requires clearly defined objectives (Ban et al. 2011), systematic monitoring and evaluation of progress toward objectives (Douvere & Ehler 2011), and management structures that are sufficiently flexible to adapt and change in response to this information (Gunderson 1999; Cinner et al. 2012). The process can be conceptualized as a cycle of planning, implementation, monitoring, and evaluation (Plummer 2009). Minor fine-tuning (e.g., adjustments to individual protected area boundaries or management rules) may occur at any time, whereas major revisions (e.g., new planning phases) are typically motivated by the acquisition of new data or results of assessments of the overall effectiveness of the process (Pressey et al. 2013).

Much has been written about the potential adaptive capacity of customary natural resource management systems (e.g., Berkes et al. 2000; Johannes 2002; Cinner et al. 2006). In contrast to the centralized management institutions of developed countries, which are typically slow to respond to new information (Armitage et al. 2009; McCook et al. 2010), management rules that are implemented locally and enforced under customary law can be adapted quickly to changing circumstances (Johannes 2002; Cinner et al. 2012). Customary governance systems retain a central role in natural resource management in many Pacific island societies (e.g., Cinner et al. 2006; Cinner & McClanahan 2006; Clarke & Jupiter 2010), and recognition of this role has been integral to the widespread implementation of locally managed marine areas (LMMAs) throughout this region (Govan et al. 2009).

Although likely to have evolved primarily as social or cultural tools (Foale et al. 2011), contemporary mo-

tivations for LMMA designation are more diverse, including the desire to maintain or improve livelihoods and food security, conservation of biological diversity, and to guard against effects of climate change (Govan et al. 2009; Bartlett et al. 2010). An LMMA frequently exists as a synthesis of local custom and scientific knowledge, incorporating a diverse range of management strategies, including permanent and temporary closures, size limits of harvested species, bans on harvest of particular species, and gear restrictions (Govan et al. 2009). In Fiji, approximately 400 villages have established LMMAs with support from the Fiji Locally Managed Marine Areas network (FLMMA), a national network of government and nongovernment organizations (NGOs) that help communities implement marine resource management. The role of these organizations range from purely advisory to active instructive roles (Pomeroy & Rivera-Guieb 2006; Govan et al. 2009).

Since 2005, the Wildlife Conservation Society (WCS) has worked closely with communities in Kubulau District, Fiji, to develop a network of locally implemented and managed marine protected areas (MPAs) (Jupiter & Egli 2011). This collaborative effort combines customary, periodically harvested closures (*tabu* areas) with permanent no-take areas, and represents one of the first attempts to design and implement an ecologically functional MPA network in Oceania. Placement of MPAs was informed by ecological surveys, design criteria, and extensive consultations with resource rights owners (Jupiter & Egli 2011). Here, we describe the process of community-based adaptive comanagement (Govan 1999; Olsson et al. 2004; Armitage et al. 2009) undertaken by WCS and the communities in Kubulau to revise the MPA network design in response to a review of existing management effectiveness and new information on coral reef resilience to climate change.

Methods

Study Region

Kubulau District is in Bua Province on Fiji's second largest island, Vanua Levu (Fig. 1). Bua is one of the least developed provinces in Fiji, and Kubulau's 10 villages are highly dependent on natural resources for income and subsistence (Wildlife Conservation Society 2009). Kubulau's 260-km² traditional fisheries management area (*qoliqoli*) extends to the outer edge of the coral reefs and supports relatively high levels of reef-fish biomass (Jupiter & Egli 2011). Traditional fishing rights of customary landowners within these boundaries are recognized under the Fiji Fisheries Act (Clarke & Jupiter 2010).

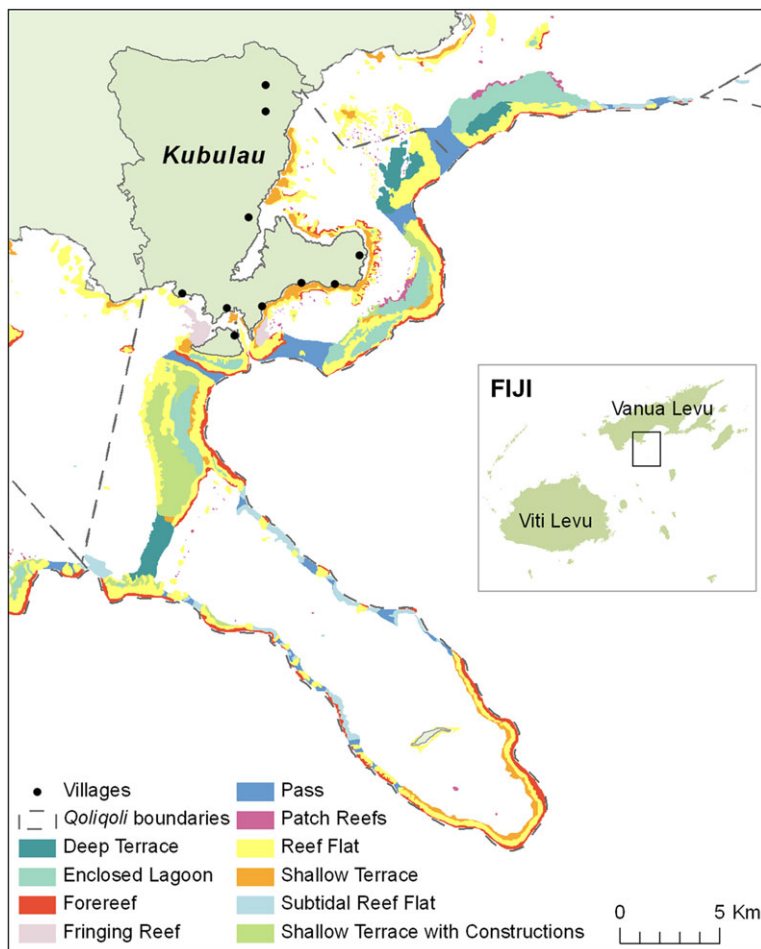


Figure 1. Kubulau District and traditional fisheries management area (qoliqoli) (inset, location of Kubulau on Vanua Levu, Fiji). Reef classes are from the Millennium Coral Reef Mapping Project (Andrefouet et al. 2006).

History of Community Engagement

In 2003, Kubulau communities asked WCS for assistance in managing their natural resources (Supporting Information). At this time, the Namena MPA had been informally designated, but no formal management was in place. From 2004 to 2005, the concept of an MPA network was introduced during a series of meetings between WCS and communities. A management approach as described in Margoluis and Salafsky (1998) and refined for Fiji by Govan (1999) was agreed on, whereby WCS would provide scientific input to management undertaken through a committee of village representatives. In 2005, WCS conducted biological assessments of fish and invertebrate abundance and coral cover and undertook resource-use mapping surveys with residents of all 10 villages to inform a proposed MPA network design that aimed to maximize fisheries benefits while spreading costs as equitably as possible among communities (Clarke & Jupiter 2010; Jupiter & Egli 2011).

Community meetings were held to develop a draft management plan for the Kubulau qoliqoli with the primary objective of ensuring food security for communities. In October 2005, the Kubulau Resource Management Com-

mittee (KRMC) of representatives from each village was formed. The KRMC reviewed the draft management plan and refined the boundaries of an MPA network that consisted of 3 district-wide permanent no-take areas and 17 village-managed tabu areas. The concept of adaptive management was discussed and a management-effectiveness monitoring framework was developed. Subsequently, WCS conducted biological monitoring of 2 tabu areas and the 3 no-take areas between 2007 and 2009, to assess changes to fish stocks, and repeated household surveys in 2005 and 2009 to gauge changes in community perceptions of resource status (see Egli et al. [2010] and Jupiter & Egli [2011] for full methods and results). The WCS also conducted targeted surveys of households in 4 villages in 2009 to assess level of local compliance with management rules and support for management decisions (see Clarke & Jupiter [2010] and Jupiter et al. [2010] for methods and results). In 2009, the network was embedded in a broader management framework through the development of a ridge-to-reef ecosystem-based management (EBM) plan (Wildlife Conservation Society 2009) that included management actions for the adjacent catchments and marine areas outside the network.

Current Phase of Adaptive Management

In 2011, 2 factors motivated a revision of the Kubulau EBM plan: the need to improve management effectiveness of existing MPAs and the desire to improve resilience to climate change. Results of biological monitoring indicated management effectiveness varied among MPAs due to MPA size, productivity, level of compliance with management rules, and duration and level of protection (i.e., frequency of permitted harvests within tabu areas) (Jupiter & Egli 2011). Resource-use mapping indicated fishing occurred within select parts of the district no-take areas and 7 tabu areas. This noncompliance was primarily attributed to poor awareness of MPA boundaries, although some deliberate poaching was openly acknowledged (Clarke & Jupiter 2010; Jupiter & Egli 2011). Key actions derived from these findings were to improve compliance with management rules by clarifying and simplifying MPA boundaries; increase the size of the smallest (approximately 0.04 km²) tabu areas, which did not effectively protect species with larger home ranges (Jupiter & Egli 2011); and consider whether rules dictating the frequency and intensity of permitted harvest are compatible with management objectives.

Climate change was recognized by community members as a threat to coral reefs at the time the Kubulau EBM plan was developed (Wildlife Conservation Society 2009); however, when the MPA network was designed, no data were available to explicitly incorporate reef resilience. Guidelines and tools for identifying reef resilience and designing resilient MPA networks have since emerged (e.g., Green et al. 2009; McLeod et al. 2009; Obura & Grimsditch 2009). These science-based principles for resilient MPA network design emphasize the need to spread risk by protecting multiple examples of habitat types; include critical areas most likely to survive disturbance events; and incorporate biological connectivity to ensure protected areas act as mutually replenishing networks that can facilitate recovery after disturbance. Table 1 provides a summary of how principles for MPA network design were considered in Kubulau.

A gap analysis of representation of coral reef classes (Fig. 1) (Andrefouet et al. 2006) within the existing Kubulau network indicated that although some reef types were well represented, others were largely absent. To identify critical areas for reef resilience, new underwater visual census surveys were undertaken at 53 sites throughout the qoliqoli in 2010. Data were collected on reef fish species abundance and size, benthic community composition, coral population structure and recruitment, and physical site characteristics likely to reduce temperature stress, such as shading and flushing (Obura & Grimsditch 2009). These data were analyzed to produce a single resilience score for each site (weighted sum of ecological and physical indices of likely resistance to, or recovery potential from, climate-related disturbance) (method details in Supporting Information).

Conservation-planning software (Marxan) (Ball & Possingham 2000) was used to produce maps of priority areas for management not included in the current network. To improve habitat representation, a target to include 30% of the area of 10 coral reef classes was adopted. Socio-economic costs were considered uniform because community decision makers would identify social, cultural, and economic priorities more effectively than could be achieved through modeling of these factors. Resilience scores were applied as an inverse cost so that reefs with higher predicted resilience (critical areas) were preferentially selected to be included in MPA networks (Supporting Information). Existing MPAs were retained in the design, and the boundary-length modifier (variable used to control how much emphasis is placed on spatially cohesive networks) was adjusted to avoid creating unfeasibly large or small MPAs.

In July 2011, a 3-day adaptive-management workshop in Kubulau was attended by KRMC members, village representatives, the high chief, and other government stakeholders (approximately 60 participants). The workshop objectives were to develop community awareness of effects of climate change on local resources (Grantham et al. 2011); present survey results and key messages from biological monitoring (detailed in Jupiter & Egli 2011); discuss issues of noncompliance and sources of conflict over current management measures (Jupiter et al. 2010); and discuss options for adaptive management of the MPA network to improve management effectiveness and increase reef resilience to climate change. Large-format maps of coral reefs and conservation priority areas (Marxan selection frequency output, a measure of how many times each planning unit is selected across multiple runs) provided a focal point for these discussions.

Following the workshop, changes to MPA boundaries and management rules proposed by participants were digitized and compiled into 3 options: keep existing MPA boundaries; alter boundaries to those proposed by workshop participants; and alter boundaries as recommended by WCS (e.g., extending protection to deep-water areas between protected patch reefs to minimize edge effects [McLeod et al. 2009]). The WCS also recommended the establishment of a fourth district no-take area on reefs predicted to have high resilience. These maps were used to inform final stakeholder consultations to determine new boundaries to be endorsed by the *Bose Vanua* (district council of chiefs).

Results

Five new tabu areas were established, 3 villages substantially increased the size of their existing tabu areas, and 500-m buffers were added to the 3 district no-take areas (Fig. 2). The enlarged MPA network included 3 district no-take areas and 21 village tabu areas. An additional 35

Table 1. Application of guidelines for resilient marine protected area (MPA) network design to the adaptive-management process in Kubulau, Fiji.

<i>Resilience principle^a</i>	<i>Strategy^b</i>	<i>Outcomes^c</i>
Size bigger is better—MPAs large enough to protect full range of marine habitat types and ecological processes	increase the size of small <i>tabu</i> areas, which may be smaller than the home range of targeted fish species	size of 2 smallest <i>tabu</i> areas increased substantially (Nuku Varasa: 0.04–0.5 km ² ; Yamotu ni Walu: 0.04–1.28 km ²)
Shape simple shapes that minimize edge effects while maximizing interior protected area	have MPA boundaries follow the reef edge, especially where confusion over boundaries has led to reduced management effectiveness	boundaries of Namuri and Nasue MPAs adjusted to conform to recognizable reef features
Risk spreading protect at least 20–30% of each habitat type overall, with replicates spread out to reduce the chances sites will all be affected by the same disturbance event	establish target 30% of each coral reef class within the <i>qoliqoli</i> (Marxan outputs provide priority maps for achieving this goal)	increase in number of reef classes achieving 30% target in Kubulau <i>qoliqoli</i> from 4 to 7 out of 10; 8 reef classes replicated at least 3 times in the network
Critical areas protect critical areas most likely to survive climate change	identify sites with high natural resilience to bleaching events; prioritize for inclusion in MPA network	at least one critical area for reef resilience added to the network; recommendation for new district no-take areas on highly resilient offshore reefs not taken up
Connectivity space MPAs a maximum 15–20 km apart to allow for replenishment via larval dispersal	ensure no-take areas and <i>tabu</i> areas in the Kubulau <i>qoliqoli</i> meet this recommendation	no-take areas and <i>tabu</i> areas in the Kubulau <i>qoliqoli</i> already met this recommendation
Maintain ecosystem function maintain robust populations of key functional groups, particularly herbivorous fishes	communicate importance of herbivores to reef resilience through workshop presentations	fish rulers distributed to communities with recommended size limits for parrotfishes
Ecosystem-based management embed MPAs in broader management frameworks that address other threats external to their boundaries	strengthen existing ecosystem-based management framework through adaptive management, revising management rules where necessary	ridge-to-reef ecosystem-based management plan reviewed through community workshops, updated and endorsed by <i>Bose Vanua</i>

^aAdapted from McLeod et al. (2009).

^b*Qoliqoli* is the Fijian term for a traditional fisheries management area. A *tabu* area is a locally managed fisheries closure.

^c*Bose Vanua* is the district-level council of chiefs.

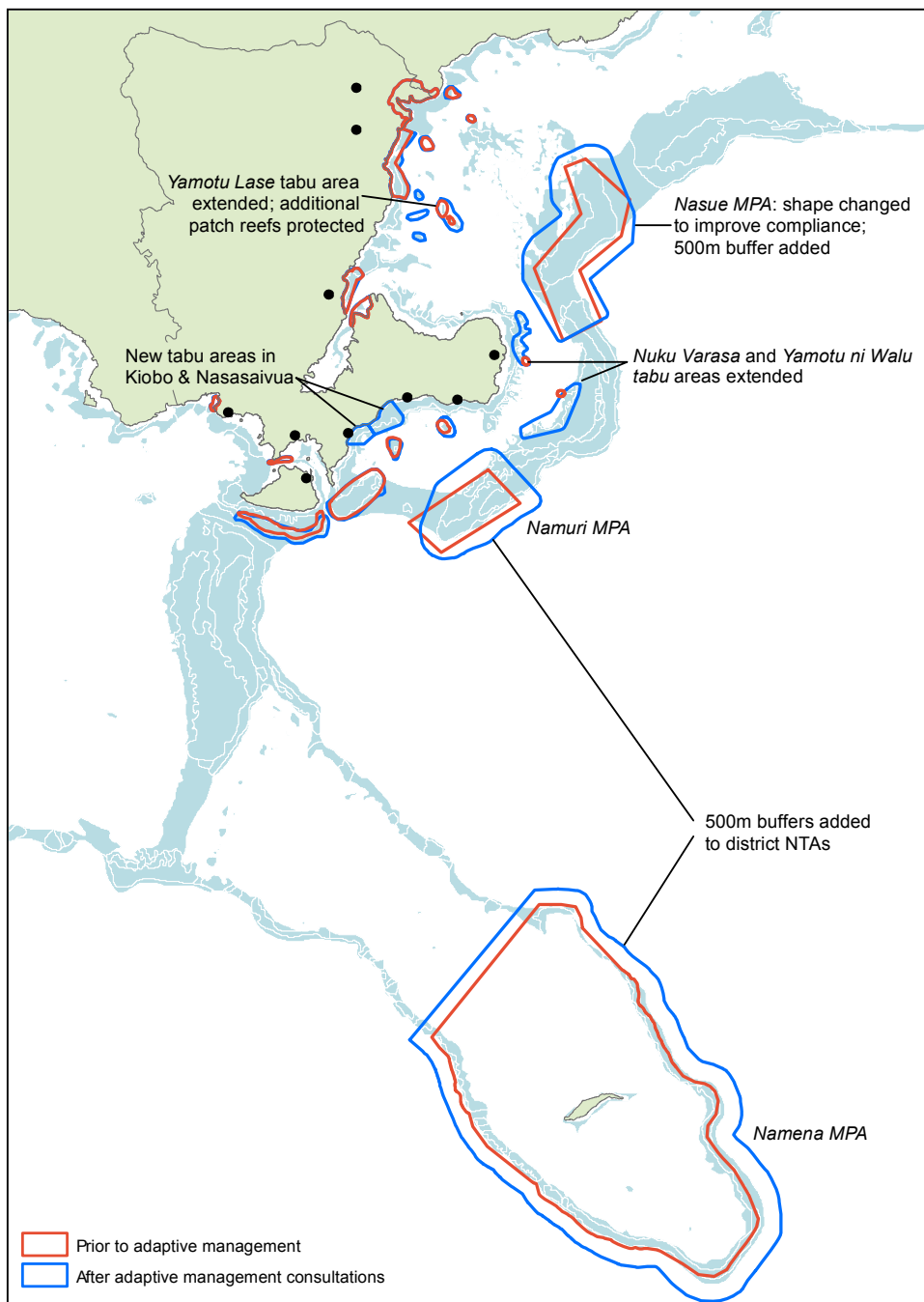


Figure 2. Boundaries of the Kubulau marine protected area (MPA) network prior to (red) and after (blue) consultations to adaptively manage the network to improve management effectiveness and resilience to climate change.

km² was placed under management, increasing the total area of the MPA network to 120 km², which is equivalent to 44% of the Kubulau qoliqoli. The revised MPA network design was endorsed by the Bose Vanua in March 2012 and was incorporated into the updated EBM plan.

Recommendations to clarify and simplify MPA boundaries were acted on, particularly in the case of the district no-take areas. A 500-m buffer to facilitate enforcement was added and boundaries of the Namuri and Nasue MPAs were adjusted to fit recognizable reef features, making it easier for fishers to comply with management rules

(Fig. 2). The size of the 2 smallest tabu areas was increased substantially (Nuku Varasa: 0.04–0.5 km²; Yamotu ni Walu: 0.04–1.28 km²). No changes were made to the management rules dictating permitted harvests within tabu areas.

With respect to improving resilience to climate change, the revised network design increased representation of all reef classes; 7 of 10 types exceeded the 30% representation target (Fig. 3). The largest increase in protection was for patch reefs, which increased from 8% to 70%. The sites with highest resilience potential

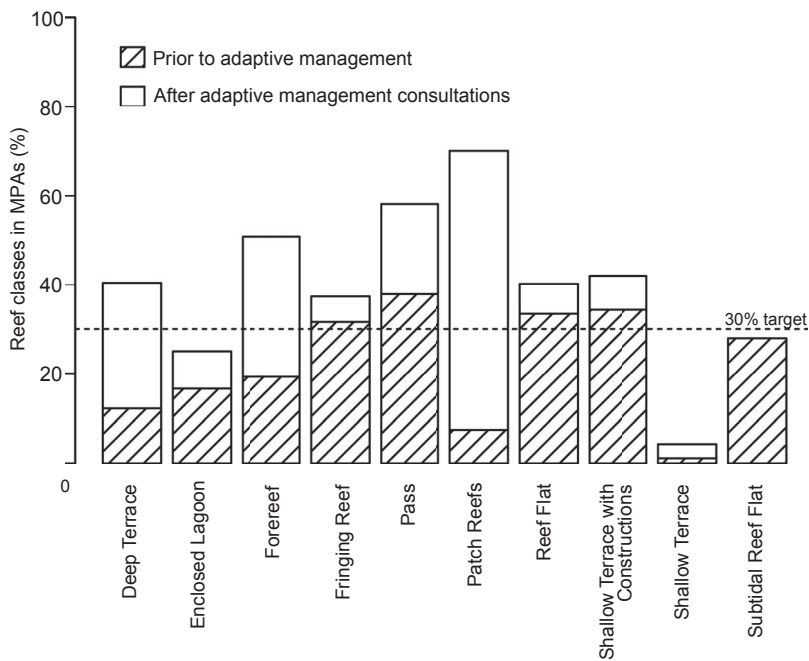


Figure 3. Percentage of coral reef classes in the Kubulau traditional fisheries management area (qoliqoli) included in the network of marine protected areas (MPAs) before and after consultations to reconfigure boundaries to improve reef resilience

were those already included in the existing network. One critical area for reef resilience was added to the network, although the recommendation for new district no-take areas on highly resilient offshore reefs was not adopted. Outcomes corresponding to principles for resilient MPA network design are summarized in Table 1.

Discussion

The Pacific Islands have a long history of local-scale adaptive management through the implementation of temporary fisheries closures (Hviding 1998; Johannes 2002; Cohen & Foale 2013), within which management rules are changed in response to ecological or social baselines, such as the abundance of, or demand for, natural resources (Berkes et al. 2000; Cinner et al. 2006). For example, a tabu might be established when resources are perceived to be scarce or lifted when abundant resources are required for a feast or funeral (Foale et al. 2011). Our case study from Kubulau demonstrates that customary management strategies can also be adaptive across broader spatial scales and in a contemporary context, adjusting in response to feedback from systematic monitoring and new scientific information.

Without a large disturbance event, it is impossible to measure whether the resilience of Kubulau's coral reefs has increased as a result of adaptive management. Reefs with the most resilience potential in the qoliqoli were those already protected within the Namena MPA, likely the result of a naturally productive reef system combined with long-term, effective management (Jupiter & Egli 2011). We can conclude, however, that the design of

the network has improved in 2 important criteria for resilience: representation of reef types and inclusion of critical areas (McLeod et al. 2009). These improvements were achieved largely through small concessions, for example, increases to the size of existing small tabu areas, rather than through larger actions, such as the addition of a new district no-take area. That communities did not act on recommendations aimed at improving reef resilience could be due to the high proportion of the qoliqoli already under management; difficulties in communicating in the Fijian language and context the nature and importance of climate change (see Grantham et al. 2011); or community prioritization of food security and livelihood objectives (Govan et al. 2009).

Communities responded positively to the feedback of monitoring results, which confirmed their perceptions of how MPAs were performing (Egli et al. 2010). In an effort to facilitate improved compliance, the boundaries of the Nasue and Namuri no-take areas were simplified to correspond with recognizable reef features; however, whether compliance will improve and be sustained as a result cannot be immediately known. Following discussions about the home range requirements of many food fishes, the smallest tabu areas were made substantially larger. The WCS also discussed whether existing rules dictating the frequency and intensity of permitted harvest events were compatible with community objectives for management (ensuring food security) because frequent harvests are likely to prevent sufficient buildup of fish biomass required to benefit the wider qoliqoli through spillover (Abesamis & Russ 2005; Cohen & Foale 2013). However, no changes were made to these rules. It is possible that communities see the role of the district no-take areas as fulfilling long-term food security objectives

and the village tabu areas as providing for cultural objectives (ensuring abundant resources at times of social importance).

In common with other community-driven planning processes (e.g., Green et al. 2009; Game et al. 2010), we found large-format habitat and prioritization maps a powerful tool for engaging communities and focusing group discussions. Production of the spatial prioritization maps required extensive data collection, analyses, and technical expertise from WCS staff. Nevertheless, despite perceptions that the technical complexities inherent in conservation-planning software present a barrier to their use in community-based management (The Nature Conservancy et al. 2008; Didier et al. 2009), we found that workshop participants easily understood the Marxan outputs.

By not using an economic cost in our Marxan analyses, we risked producing output maps that indicated conservation priorities in areas of high opportunity cost to stakeholders, which could have undermined their support for the planning process. Fortunately, this was not the case. Communities were clearly influenced toward protecting high-priority areas, but they combined these recommendations with their own social, cultural, and economic priorities, rather than accepting them without question. Through this participatory process, the communities gained ownership of the plan, which may result in greater local compliance (Clarke & Jupiter 2010).

Several authors have attempted to identify fundamental attributes of effective adaptive comanagement (e.g., Olsson et al. 2004; Armitage et al. 2009; Plummer 2009). In Table 2, we interpret our case study within the context of Armitage et al.'s (2009) 10 key conditions for success, which they propose must be met to some extent to achieve successful outcomes. Many of these are typical of Pacific customary management systems (small-scale resource-use context, social entities with shared interests, clear resource use and access rights, flexible management measures), which highlights their suitability for adaptive comanagement approaches. Other conditions may be less common. For example, the willingness of Kubulau communities to combine traditional management approaches (periodically harvested tabu areas) with permanent no-take areas and to allow customary management to be informed by Western science is rare, although it reflects a growing practice of integrating local ecological knowledge into ecosystem management through comanagement arrangements (Gadgil et al. 2003).

Some conditions (long-term commitment, capacity building) were created by WCS and partner organizations, whereas others were intrinsic to the ecological (well-defined resources) and political (supportive policy environment) systems. More specifically, the coral-reef-associated fisheries in Kubulau are relatively spatially

bound within one qoliqoli under the authority of a single chief; thus, the potential for resource-use conflicts is low. Meanwhile, the Fiji government acknowledges FLMM as the main body responsible for inshore fisheries management. This establishes a strong policy-enabling environment for comanagement arrangements between FLMM partners and coastal communities (Table 2).

The fostering of a multilevel governance structure (through the district-level KRMC who seek endorsement from the Bose Vanua), along with input from partner NGOs, facilitated and expedited social learning about the system being managed (Armitage et al. 2009). The Kubulau network acts as an opportunistic experimental design, consisting of closures of different sizes and with different permitted harvest frequencies. The comparative ecological (and social) effectiveness of these different management measures allowed community decision makers to identify the attributes of successful MPAs in the network and to adjust the design of others accordingly. Adaptive management undertaken by individual villages would lack this perspective and thus would likely proceed more slowly. Similar approaches to scaling up natural resource management initiatives through the development of social networks have been successfully applied elsewhere (Horigue et al. 2012).

Included in the first iteration of the Kubulau EBM plan was a provision for review and amendment as necessary every 5 years (Wildlife Conservation Society 2009). This first major revision was expedited to take advantage of new reef-resilience data and improved technical capacity within WCS and in response to donor deadlines. The willingness of Kubulau communities to make early concessions in terms of increasing the area under management was likely due to positive attitudes toward existing protected areas, perceptions that the MPA network had benefited local fisheries (Egli et al. 2010; Jupiter et al. 2010), and financial rewards from a scholarship program funded by dive tags sold to tourists. We suggest that a review of the district plan after 5 years, with more frequent fine-tuning revisions in response to monitoring feedback, will be most effective. Although district-level planning provides necessary spatial context for management decisions (Mills et al. 2010), it also requires significant financial resources and coordination effort and, if undertaken too frequently, could lead to process fatigue. Sufficient time must be allowed between planning iterations to allow ecosystem-scale effects of management actions to be detected; ecological responses can take years to develop (Russ & Alcala 2004), and these typically precede livelihood benefits.

The Kubulau EBM plan and adaptive comanagement framework provides a template for engagement with communities in the districts adjacent to Kubulau. These districts have recently established resource management committees following the KRMC model and have developed and endorsed their own MPA networks and

Table 2. Factors affecting successful adaptive comanagement in Kubulau on the basis of conditions for success outlined by Armitage et al. (2009).

<i>Condition for success</i>	<i>Explanation and manifestation in Kubulau</i>
Well-defined resource system	The coral-reef-associated fisheries within the Kubulau <i>qoliqoli</i> ^a are relatively immobile resource stocks, which are likely to generate fewer institutional management challenges and resource-user conflicts.
Small-scale resource-use contexts	The Kubulau MPA ^b network is designed to manage small-scale subsistence and artisanal fisheries, minimizing the number of competing stakeholder interests, institutional complexities, and layers of organization.
Clear and identifiable set of social entities with shared interests	Kubulau's villages maintain a traditional governance structure, with strong cultural connections to place. Horizontal linkages between communities were facilitated by ancestral connections and shared resource-use interests.
Reasonably clear property rights to resources of concern	Kubulau has clearly defined and legally recognized <i>qoliqoli</i> boundaries, which demarcate traditional fishing-rights access. Traditional leaders assume responsibility for managing this area, and high respect of customary law translates into compliance with management rules (Aswani 2005; Clarke & Jupiter 2010).
Access to adaptable portfolio of management measures	Kubulau communities use a diversity of management strategies within their <i>qoliqoli</i> , including permanent no-take areas, periodically harvested areas, size limits, and species bans (Wildlife Conservation Society 2009). Customary governance ensures flexibility to rapidly modify management rules in response to environmental or social change with minimal bureaucracy (Hviding 1998).
Commitment to support a long-term institution-building process	The long-term presence of WCS in Kubulau (Supporting Information) has led to more effective bottom-up planning processes (Olsson et al. 2004), both as a result of ongoing management support provided to the KRMC ^b and WCS learning to engage with communities more effectively.
Provision of training, capacity building, and resources for local-, regional-, and national-level stakeholders	Throughout the adaptive-management cycle, WCS and partner NGOs have provided training and capacity building at the local level (Supporting Information). Concurrently, WCS has engaged with stakeholders at the regional and national level (e.g., through the Fiji Protected Area Committee) to ensure continued multilevel support for comanagement (Jupiter & Egli 2011). Cross-level linkages have been fostered through the presence of government representatives (e.g., fisheries divisional representatives) at community meetings, and KRMC representatives at regional planning workshops.
Key leaders or individuals prepared to champion the process	Outspoken support from traditional leaders, in particular the high chiefs Tui Nadi and Tui Kubulau, provided legitimacy for the management plan from the outset (Berkes et al. 2000; Cinner et al. 2006). Advocacy by local champions, such as the chairman of the KRMC, has sustained local support for management.
Openness of participants to share and draw upon a plurality of knowledge systems and sources	Kubulau communities have been open to the synthesis of traditional knowledge and management (in the form of periodically harvested <i>tabu</i> ^a areas) with scientific information and Western conservation practices (in the form of permanent no-take areas, which are rarely implemented in Fiji). This plurality of information sources and management strategies was undoubtedly key to achieving successful outcomes.
National and regional policy environment explicitly supportive of collaborative management efforts	The Fiji government acknowledges FLMMA's ^b role in facilitating inshore fisheries management, providing explicit support for collaborative processes and multistakeholder engagement across policy sectors.

^a*Qoliqoli* is the Fijian term for a traditional fisheries management area; a *tabu* area is a locally managed fisheries closure.

^bMarine protected area; Kubulau Resource Management Committee; Fiji Locally Managed Marine Areas network.

EBM plans. Such institutional arrangements can develop quickly with initial high levels of community motivation and support from conservation partners, but they must be maintained through repeated interaction among stakeholders if they are to be effective (Armitage et al. 2009). Fostering multilevel linkages (e.g., by facilitating community resource management committee meetings and NGO-led workshops) requires significant investment, particularly in remote areas with poor infrastructure. To facilitate broader scaling up of management throughout communities in Fiji and across the region, we recognize the need for cost-effective means to transfer lessons learned from Kubulau to other sites. Although transaction costs associated with comanagement appear high in the short term, they can pay off in the long term through

fisheries and livelihoods benefits if they result in more effective resource management decisions (Armitage et al. 2009).

Acknowledgments

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Supporting Information

A timeline of community-engagement activities undertaken in Kubulau by WCS and partner NGOs (Appendix S1), methods for identifying critical areas for reef resilience (Appendix S2), and details of the adaptive-management workshop focus groups (Appendix S3) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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