Can Management Actions Within the Fiji Locally Managed Marine Area Network Serve to Meet Fiji's National Goal to Protect 30% of Inshore Marine Areas by 2020?

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WILDLIFE CONSERVATION SOCIETY

ARC Centre of Excellence Coral Reef Studies

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Executive Summary

In 2005 at the Barbados Plan of Action in Mauritius, the Fiji Government made a commitment to effectively manage and finance at least 30% of Fiji's inshore marine areas by 2020. Given that much of the planning for inshore marine management is undertaken by partners of the Fiji Locally Managed Marine Area (FLMMA) network, this study was undertaken to evaluate whether the expansion through the FLMMA network could achieve national conservation objectives by 2020. The work was completed as part of a prioritized action for quarter 3 of 2011 under Fiji's National Biodiversity Strategy and Action Plan (NBSAP) Implementation Plan 2010-2014 thematic section for Inshore Fisheries.

We developed a model simulating opportunistic expansion of the FLMMA network to 2020 under business as usual conditions using data collected from key informant interviews to identify factors driving establishment of fisheries closures in Fiji, data on the existing distribution of closures, FLMMA documents and maximum entropy modelling. We additionally compared this model to results obtained through systematic conservation planning techniques, which by definition are designed to optimize the cost-effectiveness of the management actions. We found that under the opportunistic scenario, where conditions were designed to reflect an optimistic continuation of the current conditions, the FLMMA network will achieve a good portion of the national objectives, but will fall considerably short of the 2020 objectives. The systematic planning scenario achieved a much higher proportion of objectives, which suggests that systematic assessments could be useful to coordinate the FLMMA approach to help guide development of the marine protected area network in Fiji.

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- Although the FLMMA network is designed to help communities achieve local marine management objectives, it is also contributing a significant amount towards achieving the Fiji Government commitment to protect 30% of inshore areas by 2020. Thus, FLMMA should continue its good work and expand as resources permit.
- However, under business as usual, if Fiji Government solely relies on the FLMMA network, it will not achieve its 2020 objectives. Therefore, Fiji should identify approaches to incorporate a regional perspective into local conservation decisions and coordinate individual LMMAs to fill existing habitat representation gaps.

Nai Kau Ni Tukutuku

Na bose a vakayacori mai Mauritius ena 2005 e ya mai vakatututaka kina na matanitu e Viti mena qarava ka vakailavotaka e rauta ni 30% nai qolioqoli ni bera na 2020. E dina ga ni ra vakaitavi ena kena qaravi nai tuvatuva ni qoliqoli nai soqosoqo ka vakarurugi ena Fiji Locally Managed Marine Area network (FLMMA), e ya mai vakayacori na vakadidike oqo me dikevi kina na kena rawa ni sotava na veiqaravi ni FLMMA na vakatutu oqo ni bera na 2020. E mai vakacavari na cakacaka oqo enai ka tolu ni wasese ni yabaki 2011 ena veiqaravi ni National Biodiversity Strategy and Action Plan (NBSAP) Implementation Plan 2010-2014 me baleta nai qoliqoli e Viti.

Keitou a bulia e dua nai vakaraitaki ni kena vakalevutaki se vakatetei na veiqaravi ni FLMMA me yacova na 2020. Ena gauna saraga oqo sa vakasokumuni kina eso nai tukutuku mai vei ira na veiliutaki ena veikoro me laurai kina na veika e vakavuna tiko na kena tauyavutaki na vakatabui ni dua nai qoliqoli e Viti. Keitou a vakatauvatana na veika oqo kei na macala ni vakadidike ka rawa mai na “systematic conservation planning techniques” kina dua nai walewale ni tataqomaki mena vakalailaitaka nai sau vakailavo ni kena cakacakataki nai tuvatuva ni veiqaravi oqo. E laurai ni sa daumaka tiko na veiqaravi ni FLMMA ena gauna oqo, ka sotava e levu sara na gagadre e vinakata na matanitu, ia na ririko ga e koto ni na sega ni sotavi na vakatutu ni 2020. Nai tuvatuva ni veiqaravi oqo e sotava sara vakalevu na veivakatutu eso ka nanumi kina, ni, kevaka erau na okati vata nai tuvatuva ni veqaravi oqo kei na walewale ni veiqaravi ni FLMMA ena vukea na torocake ni vanua vakatabui se maroroi e Viti.

TUKUTUKU MO KAUTA LESU

- E dina ga ni a yavutaki na FLMMA me vukei ira na veikoro ena kena rawati nai naki ni kena qaravi vakavinaka nai qoliqoli, e sa veivuke tale tikoga ena nona rawata na matanitu na vakatutu ni kena taqomaki e 30% ni nodai qoliqoli ni bera na 2020. Sa dodonu me na tomana tikoga na FLMMA na cakacaka vinaka oqo ka me vakalevutaki yani kevaka e levu tiko nai lavo, liganiveiqaravi kei na gauna mena vakayacori kina na cakacaka oqo.
- Ia kevaka e vakararavi tikoga na matanitu kina veiqaravi ni FLMMA, ena sega ni rawata rawa na vakatutu ni kena taqomaki na 30% ni qoliqoli ni bera na 2020. Sa dodonu kina vua na matanitu me okati ira na veisoqosoqo tale eso me vaka na otela kei na so tale nai tuvatuva ni veiqaravi me vukea na kena vakalevutaka na veiqaravi ka veiganiti ki nai tuvatuva ni veikoro ka vakakina na kena rawati nai tuvatuva ni matanitu.

Introduction

The Fiji Locally Managed Marine Area (FLMMA) network is a group of resource management and conservation practitioners who focus on lessons learned about the benefits and shortcomings of marine management actions in Fiji. The FLMMA network works to achieve local objectives, integrates local knowledge and customs, and involves local resource users in developing strategies and actions to sustainably manage fisheries resources and biodiversity for the future (FLMMA 2010). These management strategies and actions may consist of permanent closures, rotational closures, gear restrictions, seasonal/species bans, sacred sites, catch size limits, and licensing controls (Jupiter et al. 2010). When any of these management actions are applied within one of Fiji's 410 traditional fisheries management areas (*qoliqoli*), the entire area within the qoliqoli is considered a locally managed marine area (LMMA). Currently, over 10,000 km^2 of inshore marine waters are included within a network of LMMAs in Fiji, which has expanded rapidly from 1 in 1997 to over 150 by 2009 (Govan et al. 2009).

The establishment of LMMAs has mostly taken advantage of opportunities where communities are interested in engaging in marine management and have been planned based on local values and costs. There are clear advantages to this opportunistic approach because the communities are engaged from the outset and have interest and ownership over the management process (Clarke and Jupiter 2010). Theoretically, LMMAs can coalesce into ecologically and socially functional networks of marine protected areas (MPAs) that achieve national, as well as local conservation objectives. However, from a top-down perspective, areas that contribute little to national conservation objectives may not represent the optimal allocation of resources (Pressey and Tully 1994).

The Fiji Government made a commitment at the Barbados Plan of Action in Mauritius in 2005 to effectively manage and finance at least 30% of Fiji's inshore marine areas (Jupiter et al. 2010). Between 2009 and 2010, the Fiji National Protected Area Committee, in collaboration with researchers at the ARC Centre of Excellence for Coral Reef Studies at James Cook University (Australia), conducted a gap analysis to determine how much of Fiji's inshore marine area was then effectively protected by the current management strategies in the LMMA network. They used an innovative approach that considered the relative effectiveness of each management strategy for different species groups across the main habitats for which national data were available, including fringing reefs, non-fringing reefs, mangroves, intertidal mudflats, and other benthic areas (Figures 1 and 2) (Jupiter et al. 2010; Mills et al. in press). The results indicated that Fiji will require approximately an additional 10-20% effective coverage across fringing reefs, non fringing reefs, mangroves and intertidal habitats to successfully achieve the 30% objective by 2020.

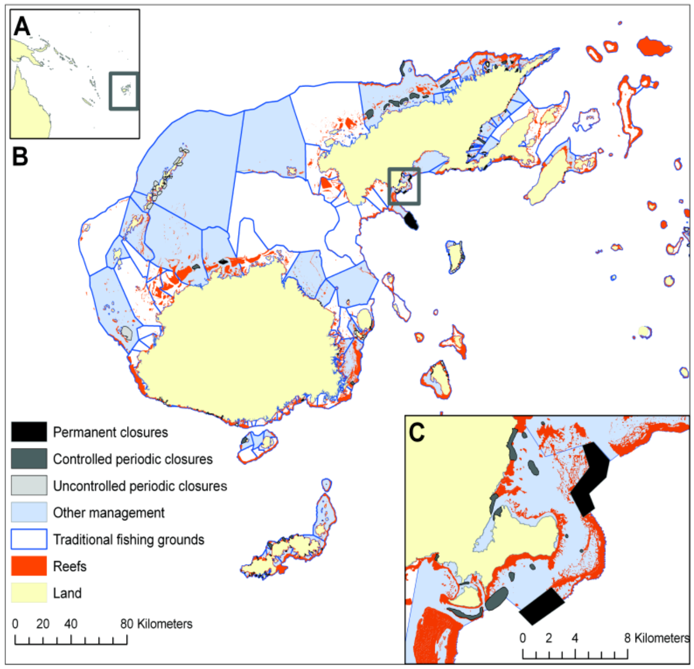

Figure 1. Management actions established by communities with the Fiji Locally Managed Marine Area network. (Reprinted from Mills et al. 2011)

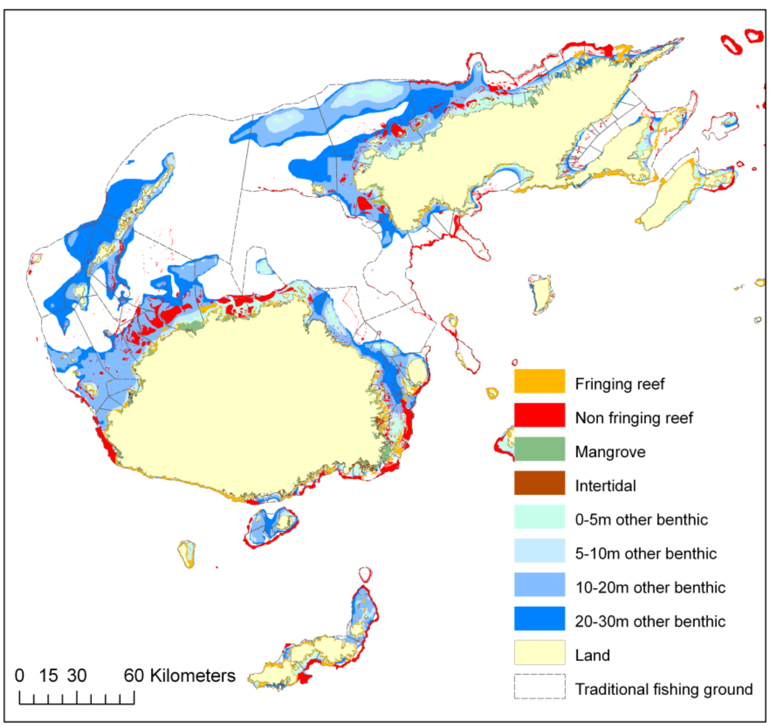

Figure 2. Map of habitats for which national data were available to complete a preliminary gap analysis for Fiji. (Reprinted from Jupiter et al. 2010)

Consequently, this study was undertaken to evaluate whether the expansion through the FLMMA network could achieve national conservation objectives by 2020 given current trends in the establishment of new LMMAs in Fiji. We report on a model simulating expansion of the FLMMA network to 2020 using data collected from key informant interviews to identify factors that influence opportunities for and constraints on implementing closures in Fiji. We additionally compare this model to results obtained through systematic conservation planning techniques. Systematic conservation planning is an approach to designing networks of conservation areas to achieve specific objectives, such as protecting a defined amount of biodiversity features, while minimizing costs to stakeholders characterized (Margules and Pressey 2000). Intuitively, this more systematic approach should allocate conservation actions most efficiently to achieve objectives. We compared the opportunistic approach currently employed by FLMMA with a systematic approach to choosing sites for closures and determined whether either approach would achieve national conservation objectives by 2020.

Planning Region and Data

The study region covered Fiji's inshore marine waters, extending across ~30,000 km^2 from the high water mark to the outer barrier reef, within the 410 legally-demarcated qoliqoli. We used all available national-scale data on the spatial distribution of the following marine ecosystems: fringing reefs, non-fringing reefs, mangroves, intertidal mudflats and other benthic substrata. The latter included soft-bottomed lagoons and seagrass, and was divided into four depth classes (0-5 m, 5-10 m, 10-20 m, 20-30 m; Mills et al. in press). The habitat-specific conservation objectives were set by participants of the marine working group of the National Protected Area committee during a workshop in 2010, based on the government's 30% goal. The objectives were 10% representation of other benthic substrata in all depth classes and 30% for other habitats. At the same workshop in 2010, participants scored the ecological effectiveness of the different management actions for major species groups found in each habitat. A score of 1 represented the maximum level of protection from fishing and associated damage (e.g. one would expect local fish populations to return to non-exploited levels if the population has not fallen below critical thresholds) and 0 represented no benefit from management. No-take closures, all given a value of 1, were assumed to be fully ecologically effective although it was recognized that they might in fact have varying management effectiveness (e.g. compliance with rules, enforcement capacity). Additional details on definition of objectives, methods used for scoring and the effectiveness weightings for all species groups across all target habitats can be found in Mills et al (in press).

As progress toward Fiji's 2020 commitment has mostly been through opportunistic implementation of community-based LMMAs, we considered management actions currently undertaken within the FLMMA network, for which data are available nationwide. LMMAs can have multiple, simultaneously operating forms of management. Among these are permanent closures where resource extraction is prohibited permanently. Conditional closures are divided into two categories: those with controlled harvesting (harvesting allowed once per year or less as dictated by a management plan or community decision) and those with uncontrolled harvesting. Areas outside closures under "other management" have a suite of management forms including bans on fishing gear, species bans and seasonal prohibitions. After one or more closures are implemented within a qoliqoli, other management is applied across the remainder of that qoliqoli (Figure 3) (Mills et al. 2011).

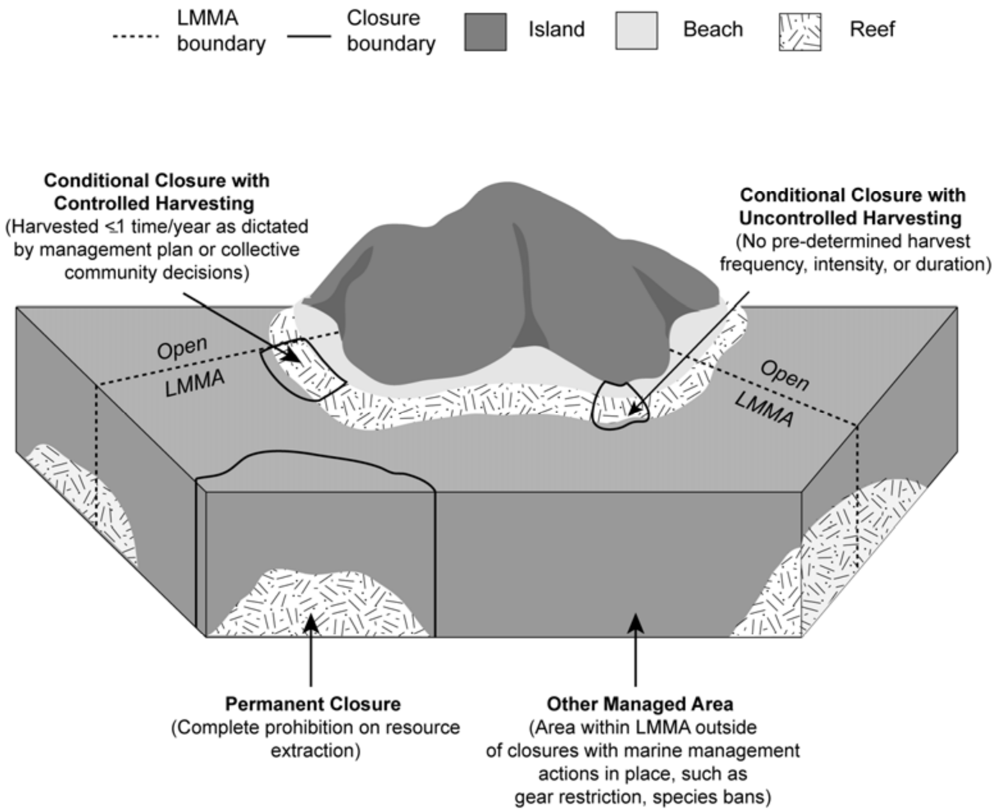

Figure 3. Schematic diagram of types of community-based management actions that may be implemented within a locally managed marine area (LMMA). (Reprinted from Mills et al. 2011)

Determining Suitability of Locations for New Fisheries Closures

Our models required us to determine the suitability of each planning unit to be selected as a fisheries closure. To understand drivers of the presence and location of closures, we identified 24 potential key informants were identified using snowball sampling (Bernard 1994). All had a minimum of 2 years of experience in establishing LMMAs and were members of partner organizations within the FLMMA network. All were contacted and 11 replied and were available for interviews (Table 1). We conducted semi-structured interviews with these informants to identify factors that influence where communities establish closures. In addition, we also identified spatial predictors of existing closures (Table 2).

Table 1. Background information on key informants interviewed to assess drivers of the presence and location of fisheries closures.

Interviewee	Organization	Fijian or Expatriate staff	# years working with LMMAs	# LMMAs helped establish
1	Wetlands International	Expatriate	5-10	>10
2	Wildlife Conservation Society	Fijian	5-10	<5
3	Institute of Applied Sciences - University of South Pacific	Fijian	2-5	5-10
4	Institute of Applied Sciences - University of South Pacific	Expatriate	>10	<5
5	Institute of Applied Sciences - University of South Pacific	Fijian	>10	>10
6	Institute of Applied Sciences - University of South Pacific	Fijian	>10	>10
7	Wildlife Conservation Society	Fijian	>10	>10
8	Institute of Applied Sciences - University of South Pacific	Fijian	2-5	<5
9	Institute of Applied Sciences - University of South Pacific	Fijian	2-5	<5
10	Institute of Applied Sciences - University of South Pacific	Fijian	2-5	<5
11	Institute of Applied Sciences - University of South Pacific	Fijian	>10	>10

From the interviews, we identified important factors that influence where communities establish fisheries closure for which we had national-scale data, which included: distance from another closure; proportion of qoliqoli <3 km from the coast within closures; distance from nearest road; distance from nearest village; presence of a Yaubula Management Support Team (YMST); and habitat type (see Table 2 for rationale). We used this information within modeling software (Maxent, Phillips et al. 2006) to develop maps of suitability for all closures combined, produced with grid cells at 1 ha resolution. For additional information, please see Mills et al (in review).

We used Maxent because it is robust to the limitations of presence-only data that indicate where features of interest have been observed but not where they have been looked for and not observed (Phillips et al. 2006). We interpreted data on the distribution of closures as presence-only because we did not know which areas outside existing closures might have been considered by villagers for closures but found to be unsuitable.

To develop the Maxent model, we divided the fishing grounds into grid squares of 1 ha, allowing relatively precise estimates of distance for some of our predictors. We developed four suitability maps, one for each type of closure (permanent, controlled and uncontrolled) and one for all closures combined. To train the model, we associated the centroid of each grid square within existing closures (n = 2153) with the six predictors. Background points, selected from outside closures but only in fishing grounds with closures, informed the model about variations in values of the six predictors within the Fijian seascape (Elith et al. 2011). A random selection of background points across all fishing grounds would have identified fishing grounds engaged with the Fiji LMMA network themselves as an important influence on suitability for closures. This would have incorrectly obscured the signal from our six predictors in fishing grounds where communities have not begun to collaborate with the Fiji LMMA network. We tested model performance using the area under the receiver operator curve (AUC), where 1 indicates that the model reflects the current distribution of closures perfectly and 0.5 indicates a model no better than random at predicting the distribution of closures (Phillips et al. 2006).

Developing Opportunistic Scenarios for Expansion of FLMMA Network

To examine whether national objectives could be met by 2020 through the opportunistic expansion of community-based MPAs, we simulated the possible future expansion of closures in Fiji in a way that reflected past decisions. Rules established for the simulation were based on the approach by the FLMMA Network and on Maxent modelling of suitability for closures. The simulation steps (detailed in Figure 4) were repeated iteratively within each yearly time step until an average of 90 km^2 were placed in closures, reflecting the average annual area closed when the expansion of locally managed marine areas was peaking (between 2002-2004). This rate gave the most optimistic picture of achievement of conservation objectives by opportunistic expansion. We ran the simulation 100 times to produce 100 different configurations of opportunistically established closures. Each simulation extended over 10 yearly time steps from 2011 to 2020.

In designing the simulation, we made a series of assumptions. First, we assumed that once a qoliqoli had 30% or more of its area in fisheries closures, the FLMMA network would not approach additional villages with resource use rights in that qoliqoli for further expansion of closures. This was based on the FLMMA's stated commitment to help the government achieve its objective of 30% representation of inshore waters under protection (Jupiter et al. 2010), while aiming to distribute costs and benefits of conservation equitably among villages. We therefore restricted our simulation to eligible qoliqoli, defined as those with less than 30% closed, and split these qoliqoli into two groups. The first group was *Empty*, meaning that there were currently no closures within that qoliqoli. The second group was *Locally Managed Marine Area* (*LMMA*), meaning that the qoliqoli was an existing LMMA and already contained some closures. In our simulation, *LMMA* qoliqoli were only engaged once more over the 10 year period, with closures added before they were removed from the list of eligible qoliqoli. *Empty* qoliqoli followed the same engagement rule: if after their first engagement they had less than 30% closed, they were engaged at most once more in our simulation. Second, we assumed that *Empty* and eligible *LMMA* qoliqoli would be engaged by the FLMMA network equally often.

Table 2. Factors that influence where Fijian communities in the FLMMA network establish fisheries closures, as determined by key informant interviews.

Factors	Spatial Data Used in Model	Rationale provided by key informants and literature
Benefits of being associated with an international conservation NGO	N/A	Community members are attracted to conservation projects by direct benefits (e.g. employment opportunities) or indirect benefits (e.g. help with leveraging funds from other organizations) (Foale 2001)
Establishment of closures by adjacent villages	Distance from nearest other closure within any qoliqoli	After a village joins the FLMMA network, local managers present work at provincial meetings (LMMA 2003), initiating interest from other villages in the same province.
Perception of resource decline	N/A on national scale	Local managers will undertake management actions when they see their natural resources as threatened or in decline (Johannes 2002)
Need for access to qoliqoli	Proportion of qoliqoli <3 km from the coast within closures	Community members are unlikely to change their preferred fishing areas and abide with new resource regulations if they do not have suitable alternative fishing areas (Abernathy et al. 2007). Because few community members have access to motorboats, most people are restricted to fishing and collecting resources within ~3 km of their villages (Adams et al. 2011)
Accessibility and visibility from village (equating to ability to enforce and monitor resource regulations)	a. Distance from nearest road	The spatial mobility of fishers is limited by transport and fuel costs. Qoliqoli closer to roads are more accessible by fishers who live away from the coast.
	b. Distance from nearest village	Enforcement of regulations is highly reliant on vigilance by community members. Managed areas must be visible from villages (Aswani and Hamilton 2004)
	c. Presence of a YSMT	One of the responsibilities of the YMST is to integrate rules from LMMAs into provincial legislation. When regulations are so integrated, they can be legally enforced (Tawake 2007)
Habitat health, productivity and type	Habitat type (Information on habitat health and productivity were not available at a national scale)	Local managers generally choose to protect either (1) the most productive and healthy habitats to get the maximum benefit from their management actions; or (2) degraded habitats to promote recovery.
Preferences of the chief and/or villages	N/A	Chiefs and community members have strong authority to determine locations

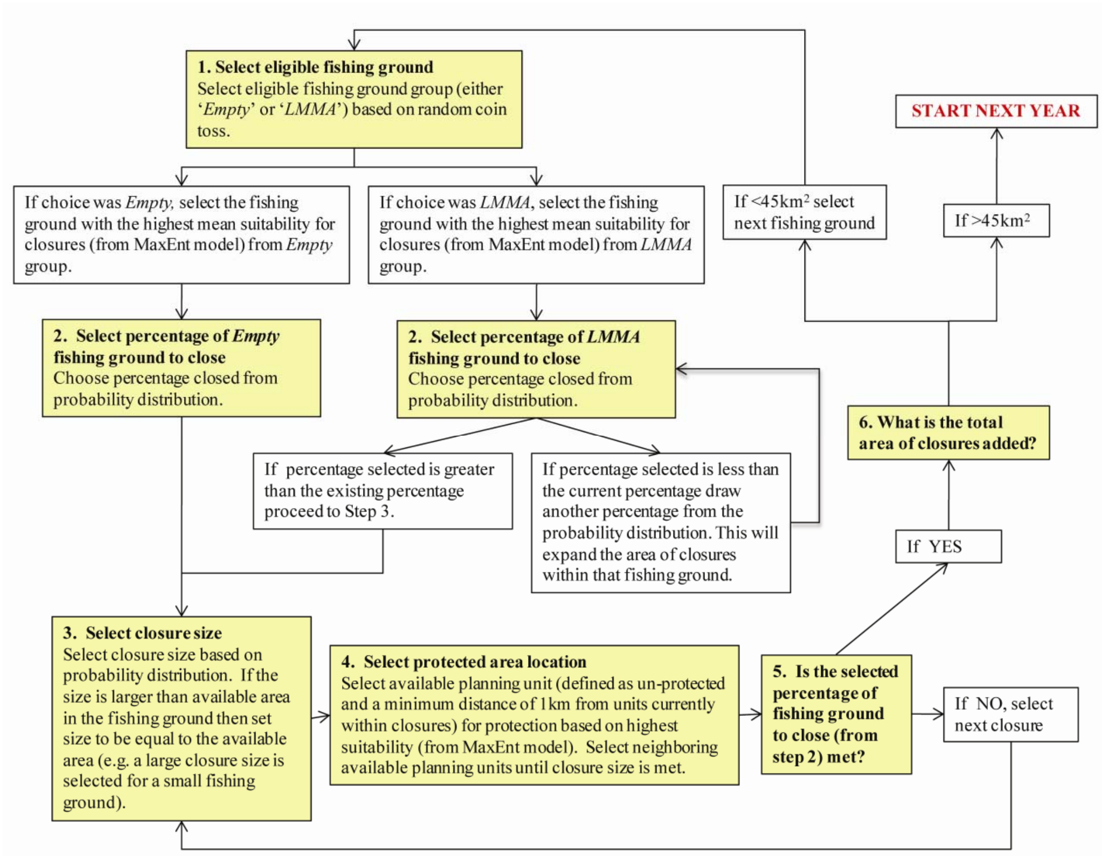

Figure 4. Flow diagram simulating the current process taken to identify sites for new LMMAs. Yellow boxes represent steps. White boxes represent alternative routes within those steps. The steps were applied multiple times within each year until an annual average area of 90 km^2 was placed in closures. For additional information see Mills et al. (in review).

We needed to relate the results of the Maxent models, applied at 1 ha resolution, to planning units that were the building blocks of the simulations. We assigned each of the 0.5 km^2 planning units the average suitability value of its 1 ha cells based on the Maxent model of suitability for establishment of a new closure. At the start of the simulation, we coded planning units as protected if they were already closures and planning units as available for establishment of closures if they were open and at least 1 km away from other closures. During the simulation, if a planning unit was selected by the model to be designated a closure, we assigned it to one of the three types of closures (permanent, controlled or uncontrolled) based on the unit's distance from the nearest road and type of nearest existing closure (Figure 5). We selected distance to nearest road because it was the most important Maxent predictor of the locations of the three types of closures within individual qoliqoli. To inform the simulation about how much area to close within each qoliqoli and the size of each new closure, we used data on existing closures to develop frequency distributions of percentage of qoliqoli closed and size of closures. The size of new closures added to the network during the simulation therefore reflected these probabilities: for example, if 50% of existing closures are smaller than 1 km^2, then 50% of the time the model would select new closures of sizes below 1 km^2. Similarly, the final distribution of percentage of qoliqoli closed resulting from the simulation would reflect the current distribution of qoliqoli closed for all current LMMA sites. . After closures had been allocated to qoliqoli, all other planning units within qoliqoli that had closures were classified as “other management”, reflecting practices by the FLMMA network (Mills et al. 2011).

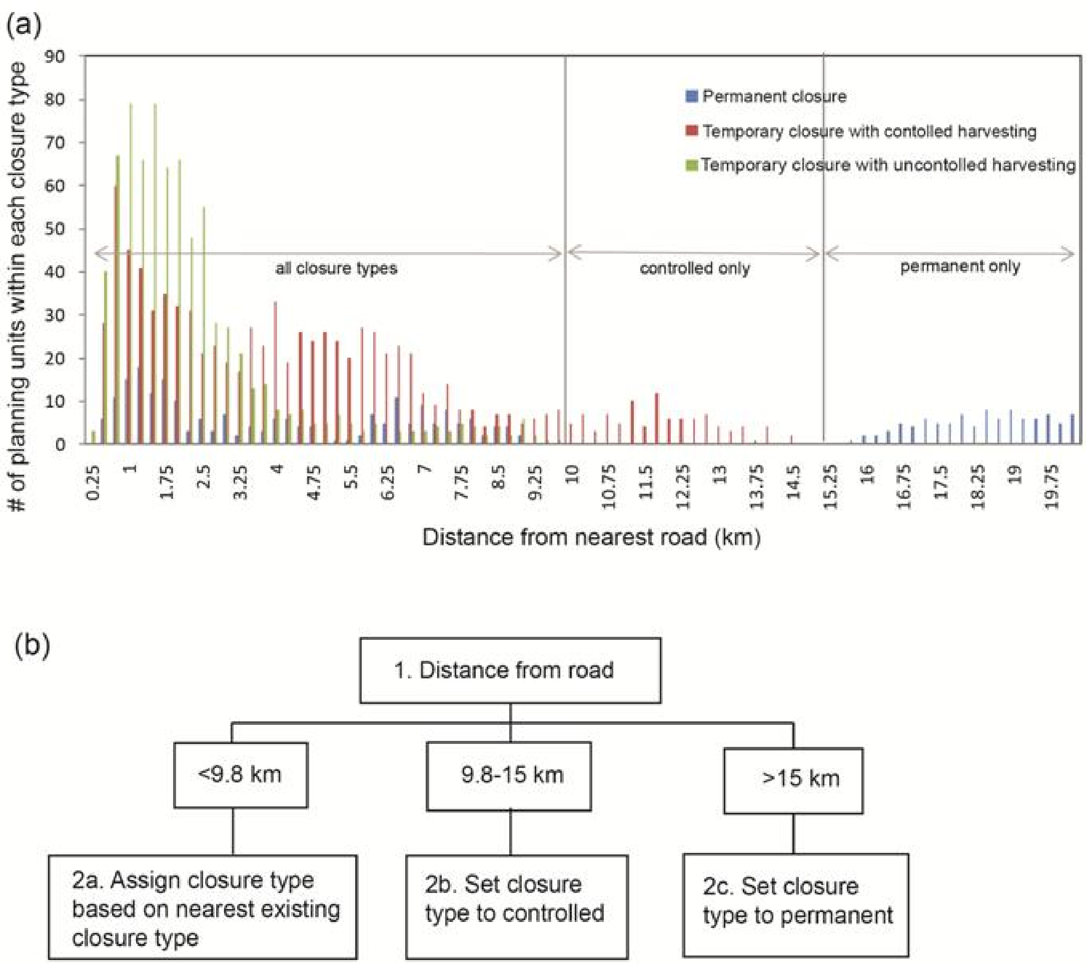

Figure 5. TOP: Observed distances of three closure types from the nearest road for all existing closures in the FLMMA network. BOTTOM: Rules for assigning closure types in the opportunistic simulation. Assignment rules proceeded in two steps: (1) assign permanent and conditional controlled closures based on distance from nearest road and, if the distance from nearest road is less than 9.8 km, then (2) assign the closure to the type of the nearest existing closure.

Developing Systematic Scenarios for Expansion of FLMMA Network

We used the decision support software Marxan with Zones (Watts et al. 2009) to systematically identify closure configurations that achieved national biodiversity objectives, which were set to 30% objectives for all habitats because the 10% objective has already been achieved for other benthic areas under the existing FLMMA network. Marxan with Zones allocates planning units to different forms of management (in this case, permanent no-take or controlled harvest areas) to optimize the amount of habitat area protected to achieve conservation objectives with the least amount of cost. In this instance, the measure of cost was the planning unit suitability calculated by Maxent. Each “run” of the software produces a single zoning plan that achieved our objective. Given that this objective could be achieved with many different designs, we ran Marxan 100 times to generate different solutions.

We began the selection process with existing closures locked into their current configuration. Planning units outside existing closures could be assigned to one of three zones: permanent, controlled or no management. Uncontrolled closures were not considered because accrued benefits can be rapidly reversed during intensive harvests (Foale and Manele 2004). We made objectives proportional across qoliqoli so, for example, 30% of the mangroves within each qoliqoli selected as an LMMA had to be represented. We adjusted the weightings of the costs of the forms of management so that selected permanent and controlled closures were in the same ratio (1:4) as existing ones. We ran the analyses to maximize achievement of national objectives, within the constraint of adding an average of 90 km^2 of closures per year, the same as in the opportunistic scenario. Selected closures were attributed to individual years between 2011 and 2020, assuming that closures with highest suitability would be added first. As with the opportunistic scenario, after closures had been allocated to qoliqoli, all other planning units within qoliqoli that had closures were classified as “other management”.

Comparing the Opportunistic and Systematic Scenarios

To calculate the achievement of future conservation efforts against the national objectives, we used these effectiveness weightings in both the opportunistic and systematic scenarios. For each action, we chose the most common minimum effectiveness to focal species groups across habitats as the most conservative measure of the effectiveness of the overall system. After the different forms of management were allocated to qoliqoli in the opportunistic and systematic scenarios, we averaged the percentage achievement of each habitat’s objective across the 100 simulations (opportunistic) or 100 repeat runs (systematic) for each annual time step over the 10 years. We also averaged yearly achievement of objectives across the 100 replicates and across all ecosystems to give a single parameter for comparing opportunistic and systematic scenarios over time.

Results

The simulations showed that neither the opportunistic nor systematic scenario achieved all national conservation objectives by 2020, although the systematic approach came closer to achieving this objective (Figure 6). In the opportunistic scenario, fringing and non-fringing reefs, mangroves and intertidal ecosystems missed their objective of 30% effective protection by at least 12-17%, while the 10% effective protection objectives for habitats of other benthic substrata were exceeded (Figure 6a,c). In the systematic scenario, non-fringing reefs and mangroves missed their objectives by 2-5%, but all other objectives were met (Figure 6b,d). The overall achievement of objectives by the opportunistic and systematic scenarios, averaged across 100 selection processes and across all ecosystems, was similar for the first four years (Figure 6e). After 2013, achievement of objectives by the systematic scenario rose much more quickly.

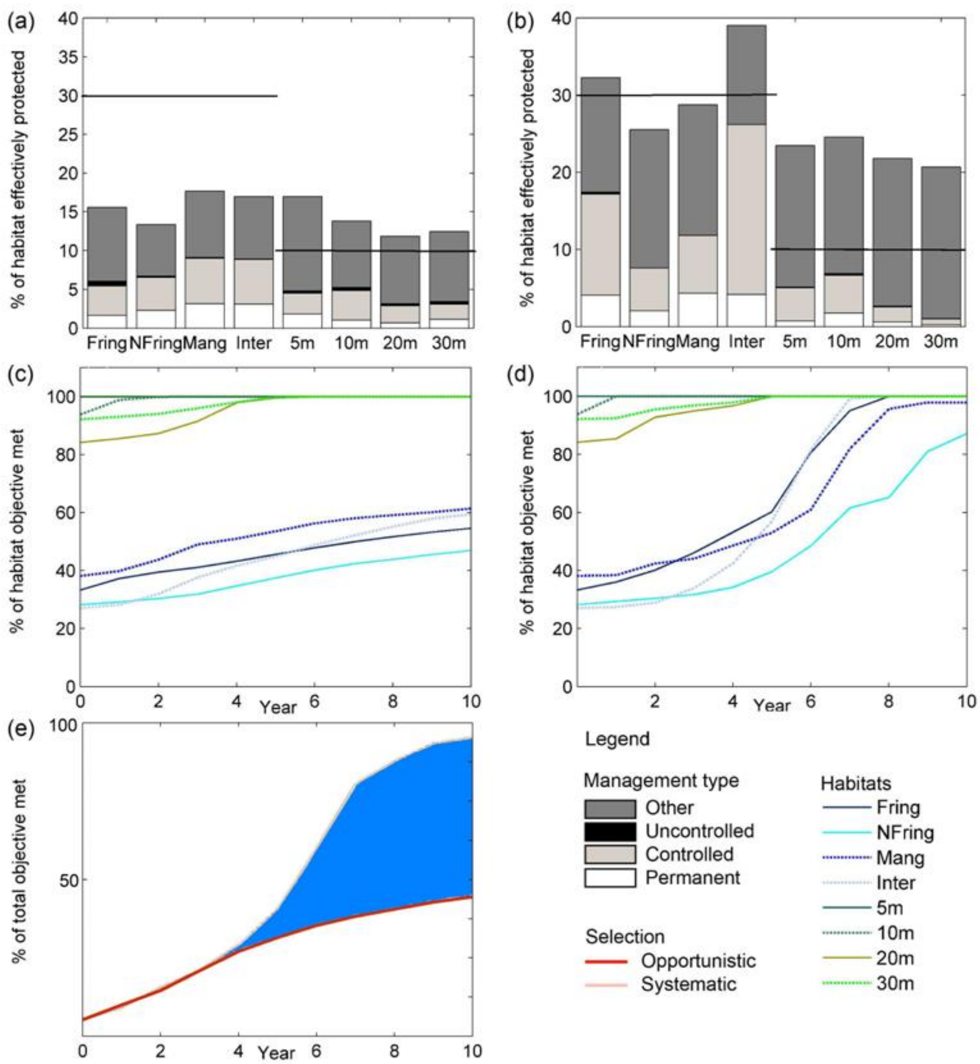

Figure 6. Achievement of national 2020 objectives by the opportunistic and systematic scenarios. (a) Percent representation of each habitat by 2020 in the simulated FLMMA network under the opportunistic scenario. Horizontal lines indicate national objectives. (b) Percent representation of each habitat by 2020 of all MPAs in the modeled systematic scenario. Horizontal lines indicate national objectives. (c) For the opportunistic scenario, the per-year increase in representation of each habitat over the ten years to 2020, averaged across 100 simulations. (d) For the systematic scenario, the per-year increase in representation of each habitat over the ten years to 2020, averaged across 100 runs. (e) Achievement of national overall objective over the ten years to 2020 in the opportunistic and systematic scenarios, averaged across 100 selection processes and across all habitats.

Discussion and Management Implications

Given limited government resources in Fiji for coastal management (Lane 2008), much of the planning for inshore marine management is undertaken by partners of the FLMMA network. There are thus both high hopes and high stakes for the community-based management measures established under FLMMA to serve the dual purposed of achieving local and national objectives. The main outcome of this work was that under our opportunistic scenario, where conditions were designed to reflect an optimistic continuation of the business as usual conditions by which new sites are added to the FLMMA network, the network will achieve a good portion of the national objectives, but will fall considerably short of the 2020 objectives. Furthermore, given the current weak status of the global economy, it may not be realistic to assume that donor investment to the FLMMA network and FLMMA partners will be at the same level when expansion peaked in 2002-2004. Therefore, these simulations may under-represent what can actually be achieved should funding be reduced over the next 10 years.

Although a systematic approach came closer to achieving the national 2020 objectives, we do not recommend abandoning the FLMMA approach in favour of systematic conservation planning. However, systematic assessments can be useful in Fiji to help scale up where FLMMA partners and government could additionally allocate resources to fill important gaps to achieve national objectives. This is already being done in several parts of Fiji such as Kubulau and Kadavu. As an example, a community may want to establish a small, periodically harvested marine closure with the local aim of increasing fisheries resources so that they are available for an annual feast. Systematic assessments may help identify mangrove and mudflat areas that will help achieve local fisheries objectives and that are of high importance for meeting national representation objectives for mangrove and mudflat protection. With the guidance of systematic assessments, FLMMA partners and other government organizations may be able to provide incentives to the community to expand the boundaries of its tabu so that it will contribute to both local and national objectives. Such incentives could include both financial and/or non-monetary benefits (e.g. payment of school fees, national public recognition), which may be a necessary step as we recognize that local communities are unlikely to be willing to take on the cost burden of contributing to national objectives for free.

While our models offer important lessons in terms of additional benefits that can be gained from coordinating local management, we recognize that there are many limitations to this study. For example, the likelihood of implementing management rests on additional factors not considered here. Policies, markets, characteristics and spatial distribution of resource users, cultural values, and governance will additionally influence where management regulations can be applied and whether individuals and communities will support those regulations (Aswani 2005; Berkes 2007; Govan et al. 2009). Furthermore, we recognize that this study did not consider contributions to national objectives from marine protected areas managed by the private sector, which include MPAs established by hotels and owners of private islands, as we did not have spatial data on their distribution. Therefore, a revised gap analysis with this data could show that Fiji is further towards meeting national objectives than previously anticipated.

Acknowledgements

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