© Lill Haugen 2009

Fiji Marine Ecological Gap Assessment: Interim Progress Report

Stacy Jupiter[1], Morena Mills[2], James Comley[3], Aisake Batibasaga[4], Aaron Jenkins[5]

[1] Wildlife Conservation Society South Pacific Program, Suva, Fiji
[2] ARC Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, Australia
[3] Institute for Applied Sciences, University of the South Pacific, Suva, Fiji
[4] Fiji Department of Fisheries, Suva, Fiji
[5]Wetlands International-Oceania, Suva, Fiji

Foreword

In 2001, the Fiji Government ratified the Convention on Biological Diversity. Through ratification, Fiji committed to completing protected area system gap analyses at national and regional levels to develop and/or enhance representative networks of protected areas encompassing terrestrial, marine and freshwater habitats that fulfil the requirements for protecting Fiji's biodiversity.

In 2005 at the Barbados Plan of Action in Mauritius, the Fiji Government made a bold declaration that "at least 30% of Fiji's inshore and offshore marine areas will be effectively managed and financed within a comprehensive, ecologically representative network of marine protected areas by the year 2020". Fiji was the first Pacific nation to set national area targets for its marine habitats and thus affirmed its leadership role in marine conservation in the region.

In 2008, the Fiji national Protected Area Committee was formally established as a technical advisory arm to the National Environment Council with the mandate to carry out the Ecological Gap Analysis under Fiji's Programme of Work on Protected Areas (PoWPA), with seed funding from the Global Environment Facility. Overall work is led by the National Trust of Fiji, who host Fiji's focal point on PoWPA activities. Active work on the marine component of the ecological gap analysis is led by the Wildlife Conservation Society, in collaboration with researchers and staff at James Cook University (Townsville, Australia), the University of the South Pacific (USP), Wetland International-Oceania (WIO) and the Fiji Department of Fisheries.

This summary report provides a brief synthesis of the outcomes of two workshops to advance Fiji's marine ecological gap analysis under PoWPA. A workshop was held in June 2009 to identify marine biological targets for Fiji, with important contributions from government (Fiji Department of Fisheries), NGOs (WCS, WWF, WIO, IUCN, Fiji Locally Managed Marine Area Network, Whale and Dolphin Conservation Society, BirdLife International), research and academia (USP, Pacific Islands Applied Geoscience Commission), and private sector (Beqa Adventure Divers). A follow-up workshop was held in March 2010 to assess the contribution of marine management strategies across Fiji to achieving these biodiversity targets.

The following text describes the process undertaken to date towards Fiji's marine ecological gap analysis, principally of the inshore areas within traditional fisheries management (*qoliqoli*) boundaries. The document is designed for stakeholders to review and refine both the process and the draft effectiveness weightings of different marine management strategies for biodiversity protection. The Protected Area Committee notes that the gap assessment is an ongoing, iterative process and welcomes feedback to improve Fiji's ability to conserve its unique biodiversity. In particular, specific focus needs to be placed on representation of offshore marine areas within the national network.

Table of Contents

Foreword 2
Table of Contents 3
Introduction 4
Step 1. Identify Focal Marine Biodiversity 5
Data Gaps 7
Marine Habitat Targets 7
Step 2. Map occurrence of marine biodiversity targets 9
Step 3. Map occurrence and status of marine protected areas 10
Step 4. Identify gaps 12
Differential Biological Effectiveness 12
Assessing Effectiveness Weightings 13
Step 5. Prioritise gaps to be filled 14
Sharks 14
Sea Turtles 15
Cetaceans 15
Endemic marine and estuarine fish 15
Coral Reefs 15
Mangroves 16
Seabirds 17
Step 6. Agree on a strategy 18
Conclusions 19
Acknowledgements 19
References 20
Appendix 1. Questionnaire to Support Development of Marine Conservation Targets for the Fiji Islands 22
Appendix 2. Draft differential effectiveness weightings for marine management strategies in Fiji 23

Introduction

The *Programme of Work on Protected Areas* (PoWPA) was drafted at the 7th Conference of Parties of the Convention on Biological Diversity (CBD), held in Kuala Lumpur, Malaysia in February 2004. The ultimate aim of PoWPA is for countries to develop ecologically representative networks of protected areas, covering terrestrial, freshwater and marine habitats, that provide protection to all national biodiversity, particularly threatened and endemic species (Dudley and Parish 2006).

The CBD encourages signatories to carry out a gap analysis to determine whether current systems of protected areas are inadequate to protect all important national biodiversity. The basic concept of a gap analysis involves comparing the current distribution of biodiversity with the distribution of established protected areas, typically within a geographic information system (GIS), to determine which species and ecosystems are under- or over-represented (Dudley and Parish 2006).

A full scale gap analysis should address three main questions across all terrestrial, freshwater and marine habitats in order to identify gaps in representation, ecological functionality and management within national jurisdiction (Dudley and Parish 2006):

(1) How much is currently protected? (*representation gaps*),
(2) Are the systems currently under protection ecologically healthy? (*ecological gaps*), and
(3) Are the current protected areas managed effectively? (*management gaps*)

This document summarises the work today on Fiji's **marine ecological gap analysis**, with particular focus on the first two questions dealing with representation and ecological effectiveness of the current network. The question relating to management effectiveness will require further investigation at a later time.

The document reports on the progress to date against the six main steps of a standard ecological gap analysis (Figure 1; Dudley and Parish 2006). Once completed, results from the marine ecological gap analysis will be integrated with work on Fiji's terrestrial and freshwater ecological gap analyses to provide recommendations for expansion of the national protected area network.

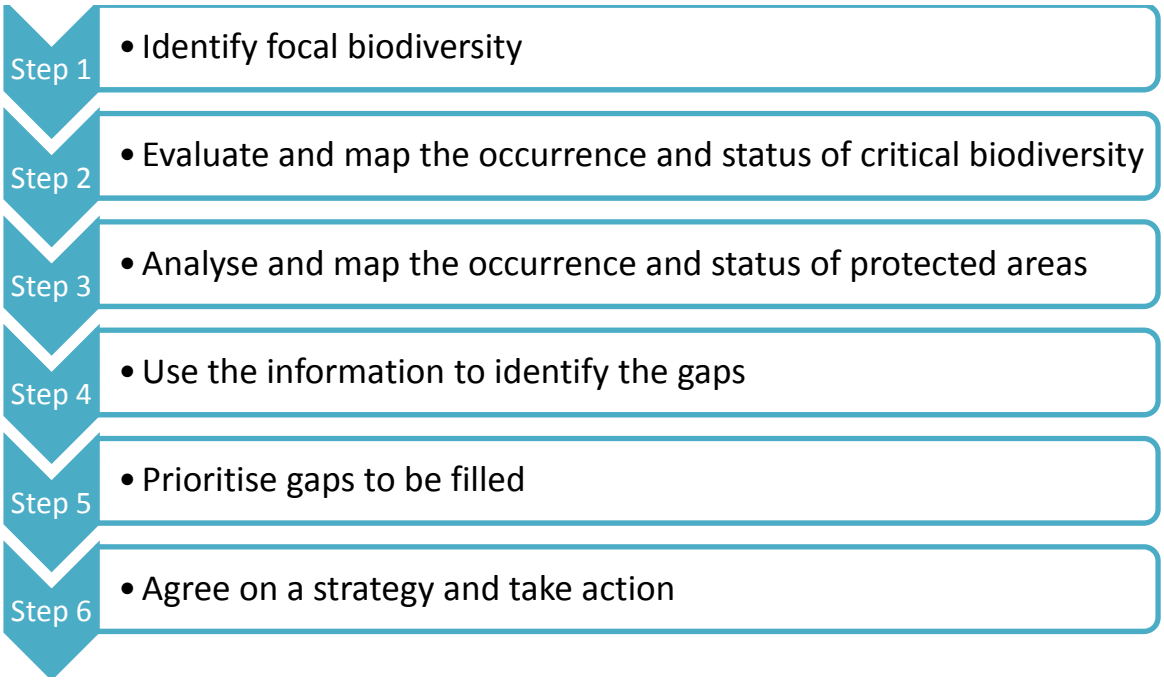

Figure 1. Flow diagram of main conceptual steps of an ecological gap analysis. Based on Dudley and Parish (2006).

Step 1. Identify Focal Marine Biodiversity

The Fiji National Biodiversity Strategy and Action Plan (2007) recognises that Fiji has an "extensive and high diversity of marine habitats" with high value for subsistence and commercial fisheries, but the overall distribution of marine organisms is not well known. Recent rapid declines in marine resources (e.g. Teh et al. 2009) have created a sense of urgency for increased management to protect remaining stocks and species. At the time that the Fiji national Protected Area Committee was established in late 2008, the Fiji government had not yet set quantitative, time-bound national targets for marine biodiversity protection beyond the commitment to protect 30% of inshore and offshore waters by 2020.

Fiji's coral reefs support over 342 stony coral species (Lovell and McLardy 2008), which build the habitat foundation for many of Fiji's 2304 fish species from 200 families (Seeto and Baldwin 2010) and lower invertebrates. Marine gastropod diversity has been documented through collection of ~760 species (by K. Gilchrist), held by the Smithsonian Museum (DoE 2007). There are eight species of mangroves and one hybrid species found in Fiji (Watling 1985), which support a diversity of bird, fish and invertebrates. Six species of marine turtles are recorded from Fiji's waters (green, hawksbill, loggerhead, flatback, Ridleys and leatherbacks), with two species that nest on Fiji's beaches (green turtle *Chelonia mydas*, and hawksbill turtle, *Eretmochelys imbricata*, DoE 2007). Seventeen species of cetaceans have been sighted in Fiji, with confirmed records of the: minke whale, Bryde's whale, humpback whale, short-finned pilot whale, false killer whale, pantropical spotted dolphin, spinner dolphin, bottlenose dolphin, and sperm whale (C. Miller, personal communication).

In May 2009, a questionnaire was distributed to marine experts within Fiji to begin the process of identifying focal marine biodiversity targets. The targets are for use in both the PoWPA process and for threat assessment to identify key management strategies that should be prioritized under the NBSAP Implementation Plan 2010-2014. The questions engaged respondents to identify species with priority for conservation due to their ecological roles, cultural significance, uniqueness (e.g. endemics) and rarity (e.g. threat status on IUCN red-list) and across which marine habitats were these species likely to be found (Appendix 1). Based on the responses of 10 individuals/organisations, a preliminary list of the following habitats as surrogates for species of high conservation value was developed for discussion at a workshop in June 2009:

- **Beaches and small islets:** turtle and seabird nesting
- **Coastal littoral forests:** breeding habitat for turtles, seabirds and land crabs
- **Estuaries:** with particular attention to passages between river and sea and shark breeding grounds
- **Mangroves:** importance for fish nurseries, bird and invertebrate habitat, with special emphasis on protection for mangrove islands
- **Seagrass:** fish nursery habitat, turtle grazing grounds
- **Lagoons:** soft/mud bottomed-dwelling invertebrates
- **Sand cays:** breeding ground for turtles
- **Coral reefs:** with particular focus on reefs with high three dimensional complexity, high geomorphological diversity, and isolated reefs
- **Reef channels:** which attract spawning aggregations and pelagic species
- **Deep passages:** corridors for migrations of cetaceans, sharks and other pelagic species
- **Seamounts:** upwelling areas support unique and high biodiversity

During the workshop, marine experts were invited to give presentations on state of the knowledge of species and species groups identified as having high conservation value for Fiji (Table 1).

Table 1. Presentations on key species and habitats at Protected Area Committee workshop on marine targets in June 2009. (Presentations can be made available upon request to infofiji@wcs.org)

Species Group	Presenting Organisation
Sharks	Department of Fisheries; Beqa Adventure Divers
Sea Turtles	WWF
Seabirds	BirdLife International
Cetaceans	WDCS/USP
Marine/estuarine fish	WIO, WCS
Spawning Aggregations	Department of Fisheries
Seamounts and Deep Reefs	SOPAC
Coral reefs	Marine Ecology Consulting
Mangroves	WCS
Marine algae/Seagrass	Information provided from P. Skelton and A. N'Yeurt

Data Gaps

The presentations made by marine experts and key stakeholders at the June 2009 workshop to define marine targets for Fiji highlighted many large gaps in biodiversity data availability. In particular, there are no comprehensive national spatial databases for distributions of seagrass, macroalgae, coastal littoral forests and permanent sandy cays and beaches. Exposed and submerged coral reefs have been digitized by the Fiji Department of Lands from aerial photographs taken in 1994 and 1996 and Fiji topographic map sheets, however there are notable gaps in reef areas that is evident when comparisons are made with satellite images on Google Earth(R). Intertidal areas were extracted from hydrology data by the Fiji Department of Lands. Similarly, mangrove area has been digitized by the Fiji Department of Forestry from 2001 Landsat ETM+ data (Jenkins et al. 2010), but only for the main islands of Fiji. While coastal littoral forests, sandy cays and beaches, shallow seagrass beds, mangrove gaps and exposed coral reef gaps could potentially be digitized from existing government aerial photograph holdings or Google Earth(R), the process is time consuming and requires large staffing resource. Fiji still awaits the release of the Millenium Coral Reef data (Andrefouet et al. 2008), which would close some of the above gaps.

With regard to offshore areas outside traditional fisheries management zone (*qoliqoli*) boundaries and within Fiji's exclusive economic zone (EEZ), the Secretariat of the Pacific Communities (SPC) and the Pacific Geoscience Commission (SOPAC) have access to spatial locations of many seamounts which could be made available for planning and management purposes (R. Smith, personal communication), and deep channels and trenches could be easily visually mapped from existing and available imagery. General bathymetric chart of the oceans data at 1 km resolution can be used to derive information on pooled other benthic substrates (e.g. soft bottomed lagoons), which can be evaluated at a range of depths.

Specific data on habitat requirements for culturally important and threatened marine species (e.g. turtles, humphead wrasse, cetaceans) are still lacking. The Protected Area Committee has submitted an Expression of Interest for funding through the German Lifeweb initiative (http://www.cbd.int/lifeweb/project.shtml?id=9df31f3e-c861-4292-8ba7-9645be69819f) in order to conduct biodiversity surveys to fill some of these gaps.

Marine Habitat Targets

Following presentations on the status of species and habitats at the June 2009 workshop, participants were asked to deliberate on a preliminary list of key habitat surrogates which would encompass distributions of important marine species and species groups and to nominate percentage targets for each habitat required to adequately protect the identified focal species. The list was refined at subsequent Protected Area Committee meetings and informal workshops, with a draft working list presented in Figure 2.

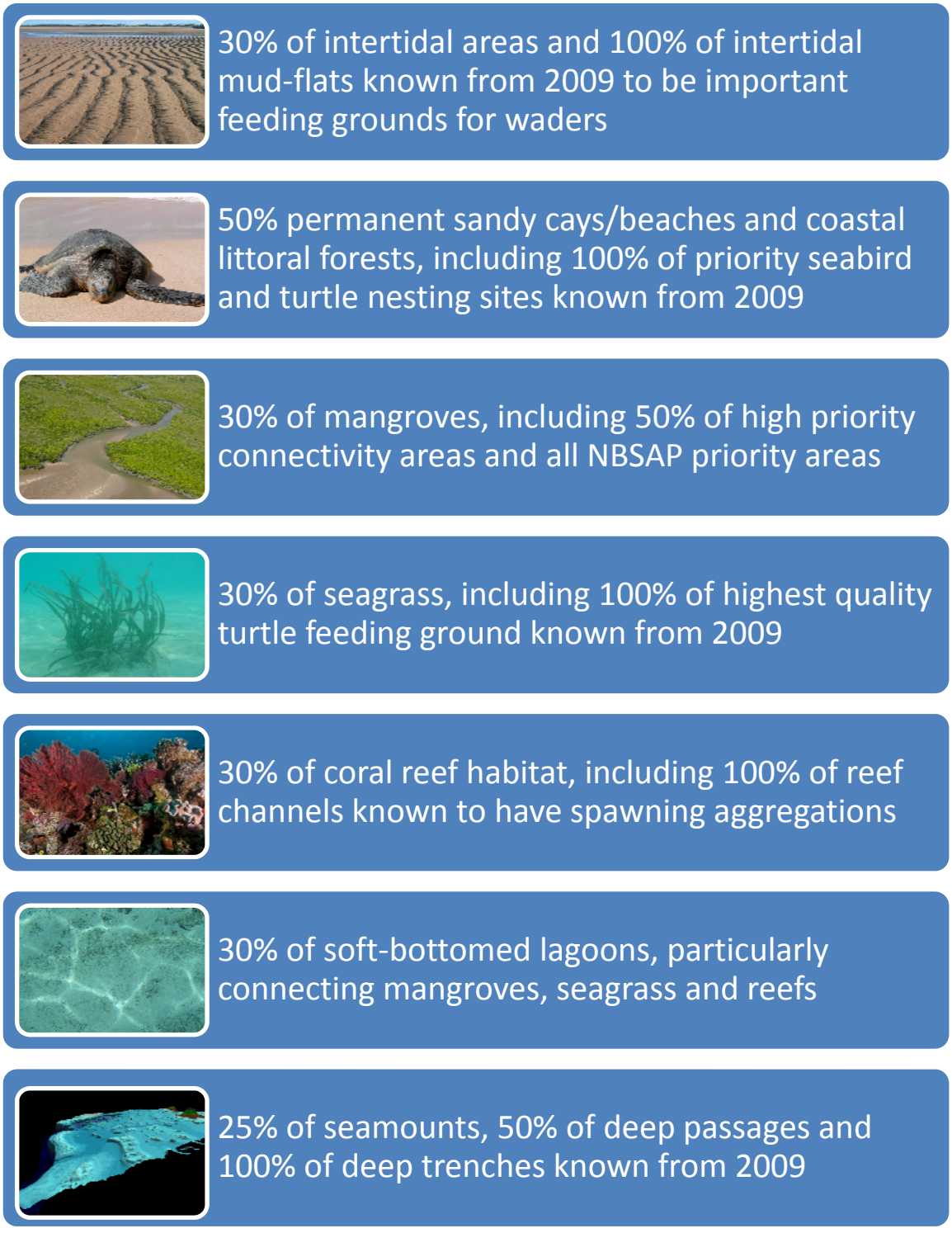

Figure 2. Surrogate habitat targets for marine biodiversity conservation in Fiji.

Step 2. Map occurrence of marine biodiversity targets

For management and planning purposes, habitat maps are often used as spatially continuous surrogates of diversity (Margules and Pressey 2000; Klein et al. 2008). In recognition that the marine gap analysis is an iterative process, current work has proceeded using data on marine habitat surrogates which can be represented on a national scale. These data include: reefs (fringing reefs and other reefs, based on the merged Department of Lands exposed and submerged shapefiles), mangroves, intertidal areas and other benthic substrate at a variety of depths (Figure 3).

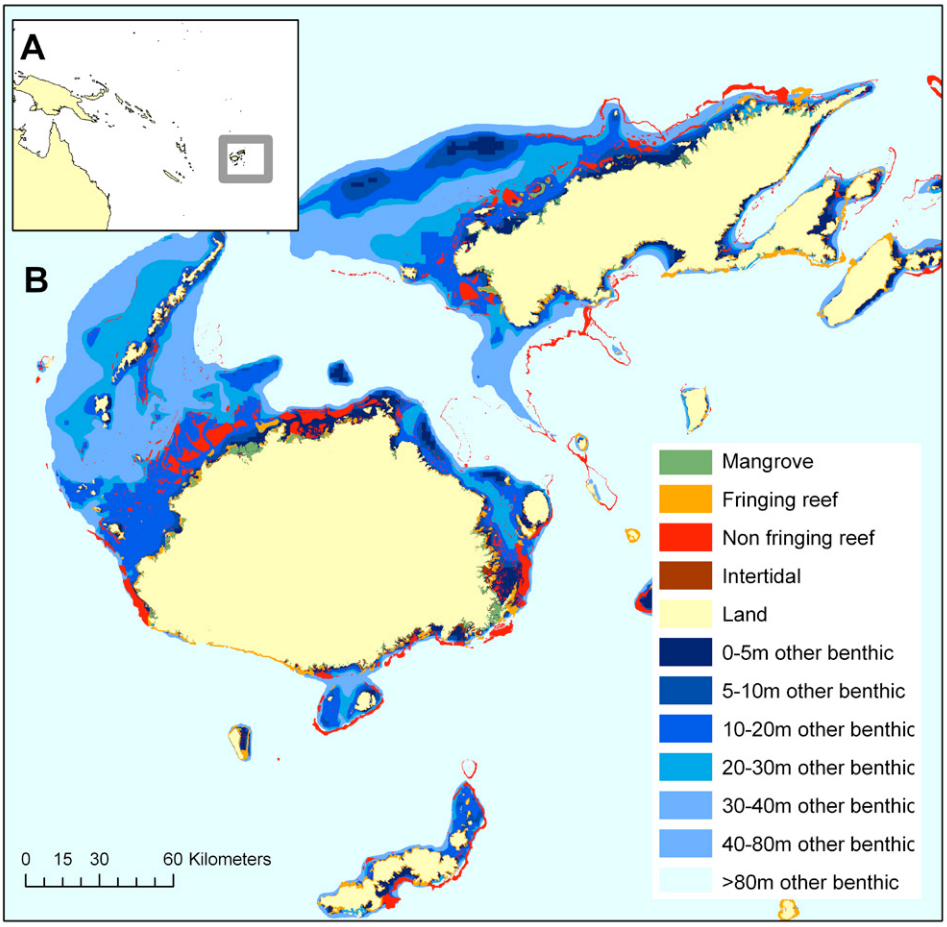

Figure 3. (a) Location of Fiji in the south-west Pacific. (b) Spatial distribution of habitat targets across the main Fiji islands.

When data on distribution of other important habitat surrogates become available, the gap analysis process can be repeated to ensure representation of all habitat types across Fiji's marine protected area network.

Step 3. Map occurrence and status of marine protected areas

The definition of a protected area adopted by IUCN is:

" A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley 2008)

Many countries have used the IUCN categories for protected areas (Table 2) to assess the status of current protected areas to achieving national biodiversity targets, and the CBD recommends that networks should include a variety of the different types of protected areas (Dudley and Parish 2006). However, marine conservation initiatives throughout the Pacific do not always neatly fit into any one of the six IUCN categories.

Table 2. IUCN categories of protected areas.

Category	Definition
Ia	Protected area managed mainly for science or wilderness protection
Ib	Protected area managed mainly for wilderness protection
II	Protected area managed mainly for ecosystem protection and recreation
III	Protected area managed mainly for conservation of specific natural features
IV	Protected area managed mainly for conservation through management intervention
V	Protected area managed mainly for landscape/seascape conservation or recreation
VI	Protected area managed mainly for the sustainable use of natural resources

In Fiji and across Melanesia, the large majority of marine protection and conservation is through indigenous community conserved areas (ICCAs; Govan et al. 2009a). Marine conservation is facilitated by traditional environmental stewardship by indigenous people through customary management units such as the *vanua* (Fiji) or *puava* (Marovo, Solomon Islands), which often occur from ridge to reef (Govan et al. 2009a). Within these areas, customary management measures have included: seasonal closures, size limits, temporary closures, catch limits and species bans (Johannes 1978; Veitayaki 1997). The principle goal of most ICCA initiatives has been food security (Govan et al. 2009a).

Marine ICCAs in Fiji, known as Locally Managed Marine Areas (LMMAs), have grown rapidly in number from one site in 1997 to approximately 150 LMMAs in 2009 (Govan et al. 2009b). An LMMA can be defined in Fiji as a spatially demarcated coastal and/or marine area, actively managed under a management plan that includes at least one of the following: closures, size limits, catch limits, gear bans/restrictions, seasonal bans or licensing controls. While the area of an LMMA does not necessarily always encompass the entire qoliqoli area, in practice any qoliqoli for which there is a management plan covering a portion or all of its waters has been mapped as an LMMA (J. Comley, personal communication; Figure 4). Most, though not all,

LMMAs in Fiji include the presence of one or more marine closures (*tabu*), which may be permanently closed, periodically harvested or harvested on a rotational basis. There are currently spatial records for 216 of such tabu areas (Figure 4). While more tabu areas are known to exist, in some cases communities have been reluctant to release the exact spatial location of their boundaries (J. Veitayaki, personal communication).

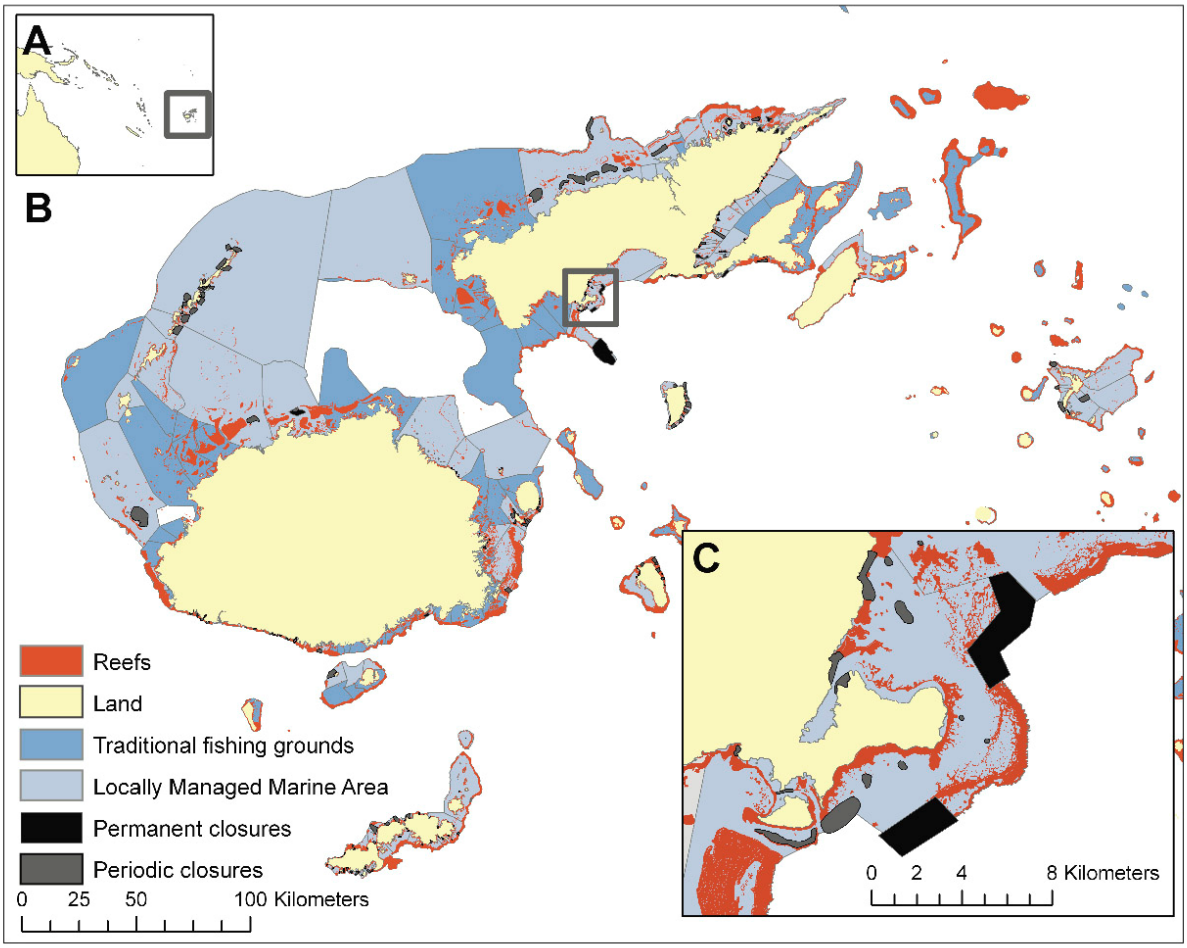

Figure 4. (a) Location of Fiji in the south-west Pacific. (b) Map of marine managed areas showing permanent closures (black), periodically harvest closures (dark grey) and LMMAs (light grey) within qoliqoli boundaries. (c) Close-up of managed areas within the Kubulau region of Bua Province.

Step 4. Identify gaps

A preliminary gap analysis was conducted evaluating the coverage of the five target habitats (fringing reef, non-fringing reef, mangrove, intertidal other benthic) within: (a) closures [no-take areas (NTAs) and tabu areas] within LMMAs; and (b) LMMAs (in this case considered the entirety of the qoliqoli; Table 3).

Table 3. Results of preliminary gap assessment evaluating percentage coverage of target habitats in (a) NTAs and tabus; and (b) LMMAs.

	Fringing reef	Non-fringing reef	Man-grove	Intertidal	Other benthic to 5 m	Other benthic >5-10 m	Other benthic >10-20 m	Other benthic >20-30 m
(a) NTA and tabu (%)	5.6	3.9	4.3	1.1	2.2	5.0	1.3	0.8
(b) LMMA (%)	45.3	39.1	40.9	42.9	59.1	60.1	52.4	52.2

If the area of habitats covered within LMMAs are considered as ecologically effective for biodiversity protection, then Fiji has already exceeded the 30% protected target for each habitat class by considerable margins. However, this approach assumes that marine organisms are 100% effectively protected within qoliqoli areas where high levels of commercial and artisanal resource extraction may legally and illegally occurring (Teh et al. 2009).

If only the area of habitats covered within NTAs and tabu areas are considered as ecologically effective for biodiversity protection, then Fiji has a long way to go to achieve the 30% targets. However, if it is assumed that the broader LMMAs offer some, but not 100% effective, ecological contribution towards biodiversity conservation, Fiji's contribution towards meeting marine biodiversity targets is more likely to fall somewhere in between the 0-6% range calculated from NTAs/tabu areas and the 39-60% range calculated from LMMA area.

Differential Biological Effectiveness

A topic that is only being recently considered by managers is that not all habitats are equally effective with regard to biodiversity conservation, and spatial configuration of habitats may result in differential ecological effectiveness (Edwards et al. 2010). For example, Edwards et al. (2010) present data from the Caribbean indicating that commercially important fish have different relative biomass than ecologically important fish across various reef habitats and that these values can be affected by both protection status and proximity to mangrove habitat.

Similarly, not all management strategies are equally effective for biodiversity protection. Permanent no-take protected areas have been widely used as a fisheries management tool to allow recovery of exploited populations of marine species (Lester et al. 2009), and have had

strong effects at maintaining live coral cover across the Indo-Pacific (Selig and Bruno 2010). In certain studies, while there is some evidence that periodic closures with infrequent, controlled harvests can promote short-term recovery of targeted fish abundance and biomass (Cinner et al. 2005a; Cinner et al. 2005b; Bartlett et al. 2009), during uncontrolled harvests resources can be removed with "alarming efficiency" (Foale and Manele 2004; WCS, unpublished data), thus rapidly eliminating the accrued benefits of protection (Russ and Alcala 2003). Closures that are harvested on a rotational basis may have similar shortcomings: for example, a measured increase of fish biomass over 1-2 years in areas in Hawaii under closure was removed by following rotational opening (Williams et al. 2006).

Assessing Effectiveness Weightings

A workshop was held in March 2010 to make a first attempt at assessing the differential contribution of various marine management strategies to marine biodiversity protection across Fiji. Participants from FLMMA/IAS, WCS, WIO, IUCN and Fiji Department of Fisheries gathered to: (1) review marine biodiversity targets; (2) identify focal species and species groups within each habitat target; (3) identify marine management strategies currently in place across Fiji; and (4) assign weightings for ecological effectiveness of each management strategy across species groups within each target habitat (Figure 5). Participants did not yet make any attempt to assess the differential contribution of habitat connectivity to ecological effectiveness.

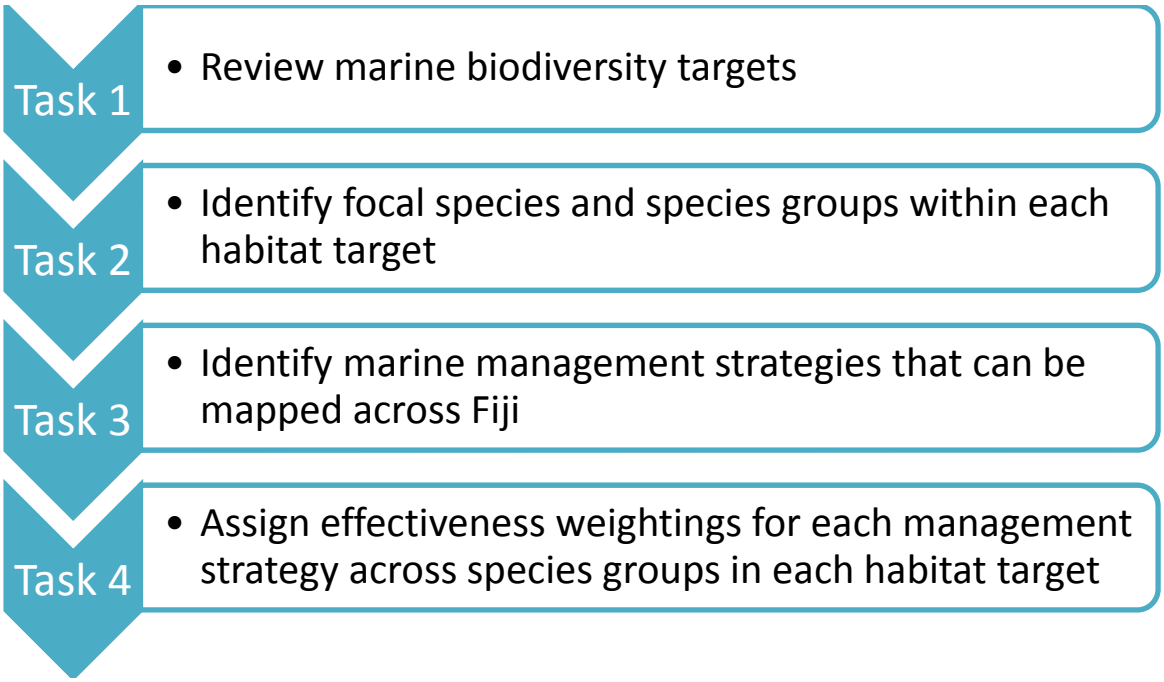

Figure 5. Flow diagram of main steps followed to derive ecological effectiveness weightings for a refined marine ecological gap analysis.

The list of marine management strategies identified by workshop participants that are currently in place across Fiji included: permanent no-take closures; periodic closures with controlled harvest (e.g. with stipulations in management plan that closures can be opened for a short, fixed duration); periodic closures with uncontrolled harvests (e.g. tabu areas known to have

been intensively harvested for a much greater duration than stipulated in the management plan); rotational closures; areas with gear restrictions; areas with seasonal/species bans; sacred sites; areas with size limits; areas with catch limits; and areas with licensing controls. Because sacred sites are not mapped and are generally kept secret, they were not included in any further assessment. As size limits apply throughout the entire country, they were also excluded from further assessment. Participants lumped all of the remaining management strategies apart from closures together into an LMMA category because it is currently too resource intensive to spatially assess which of the other management strategies are operating in individual LMMAs, and because in many cases more than one of those strategies are operating. Although the participants acknowledged that the exact benefits to marine biodiversity within a broader LMMA are unknown, it is anticipated that species are more protected within an LMMA than in a completely unmanaged area.

Focal species groups were discussed and are presented for review along with draft ecological effectiveness weightings across each target habitat (fringing reef, non-fringing reef, mangrove, intertidal, other benthic <30 m) in Appendix 2. The effectiveness weightings assumed 100% compliance with management rules at each managed area, however it was recognized that this is far from the case in most marine protected areas across Fiji and further analysis is required to assess management gaps. Because complete marine biodiversity data does not exist across the entire range of species groups within each habitat and management strategy, the weightings represent hypotheses based on known ecological processes and general rule of thumb (e.g. (Carr et al. 2010). These hypotheses could potentially be tested with well-designed, intensive marine biodiversity surveys.

Step 5. Prioritise gaps to be filled

Both prior to and since the initiation of PoWPA work in Fiji, a variety of assessments have been carried out to identify priority locations for marine biodiversity protection across the Fiji Islands. These processes have included: consultations for the Fiji NBSAP (DoE 2007); the Fiji Islands Marine Ecoregion Planning workshop (WWF 2004); an assessment of important bird areas in Fiji (BirdLife International 2006); a review of reef areas that have recovered well from coral bleaching in 2000 and 2002 (Lovell and Sykes 2008); an assessment of important connectivity areas in Fiji (Jenkins et al. 2010); and the marine targets workshop in June 2009. Priority localities for protection of different species and habitats are described below.

Sharks

Presentations at the June 2009 marine targets workshop highlighted areas for shark protection at existing shark sanctuaries (e.g. Shark Reef, Lake Reef) in Beqa Lagoon, as well as pupping grounds in Nadi Bay. A shark management plan was under development by the Fiji Department of Fisheries in 2009 which will specific specific national management regulations to improve shark protection in Fiji waters.

Sea Turtles

The following localities were all named at the June 2009 marine targets workshop to be important regions for sea turtle nesting, feeding and migration: Yadua Taba Island; Namena (Kubulau corridor); Yasawa island group; and Kadavu. In 2009, the Fiji Department of Fisheries extended the moratorium on harvesting turtles for another 10 years. The Fiji National Turtle Recovery Plan aims that by 2026, sea turtle populations in Fiji have measurably recovered to levels allowing for sustainable harvest and traditional use.

Cetaceans

The passages around Levuka to Vatu-i-Ra and Bligh Waters (particularly near the Kubulau corridor) were both cited as important cetacean migration routes during the June 2009 marine targets workshop. Funds have been requested through the LifeWeb initiative to provide more information on: (1) occupancy rates of short-finned pilot whales near Makogai and Leleuvia islands; (2) monitoring endangered sub-population of humpback whales; and (3) mapping of key habitats for spinner dolphin resting areas, feeding areas for beaked and sperm whales, migratory pathways of humpback whales, and foraging areas of short-finned pilot whales.

Endemic marine and estuarine fish

Records of endemic fish collections have been compiled (A. Jenkins, unpublished data) and have been mapped into priority locations for protection (Figure 6). Participants at the June 2009 workshop emphasized that 100% localities where marine and estuarine fish endemics are known to occur should be included in the national marine protected area network, through ICCAs or other types of more top-down management. Important areas for endemic fish include: Tongan trench; Lau group, including Moala Island; Vatu-i-Ra/Bligh waters passage; Nadaku Bay; mangrove islands, especially around the Great Sea Reef; Koro Island; Tomberua passage; Malolo Island (Mamanucas); mangroves around Lauri; and Naviti Island (Yasawas).

Coral Reefs

The consensus among stakeholders present at the June 2009 and March 2010 workshops was that representation of marine protected areas across coral reefs needs to include more barrier reefs, with special priority for more pristine and remote areas. Ongoing monitoring has indicated that several reef areas across Fiji have recovered rapidly from severe bleaching events in 2000 and 2002 and should be protected due to their high resilience (Lovell and Sykes 2008). These areas include Namena, Vatu-i-Ra, Yasawa group, Kadavu and Taveuni.

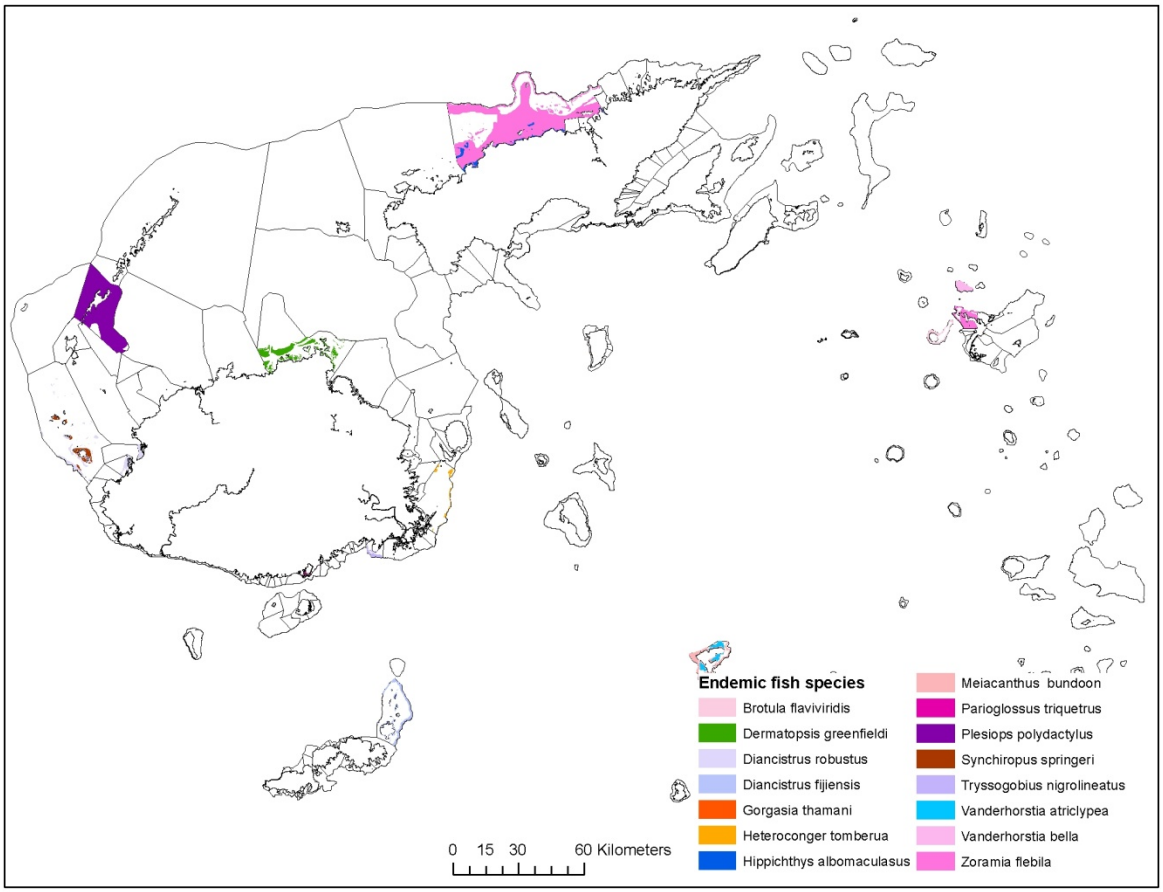

Figure 6. Known locations of endemic fish collections across Fiji.

Mangroves

Mangroves of the Ba, Rewa and Labasa deltas have been prioritised for protection and management under both the Fiji NBSAP (2007) and the Mangrove Management Plan for Fiji (Watling 1985). Proposed mangrove zonation plans have been described for the above-mentioned deltas, as well as for mangroves within the Suva-Navua corridor and the Nadi Bay locale (Watling 1985). In addition, regions with estuaries that have strong ecological connectivity between terrestrial, freshwater and marine areas were prioritised for protection and management by Jenkins et al. (2010; Figure 7).

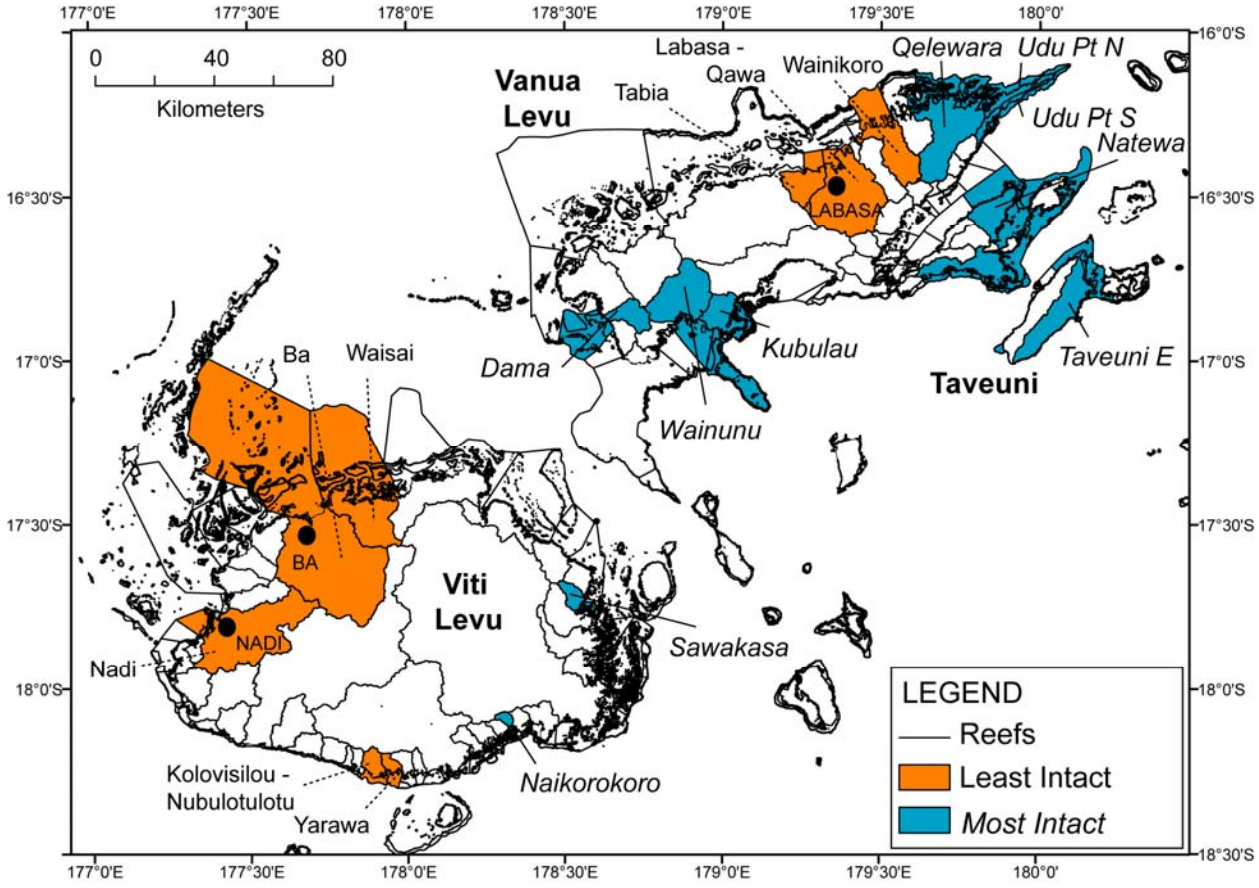

Figure 7. Priority connectivity areas for Fiji. Blue areas are regions with the greatest intact connectivity and should be prioritised for preservation. Orange areas are regions with the lowest connectivity and should be prioritised for restoration (Jenkins et al. 2010).

Seabirds

BirdLife International published a list of important bird areas (IBAs) for Fiji in 2006 (BirdLife International 2006), which included the following sites: Suva point and Saweni flats (for waders); Gau (for Fiji petrel, Tahiti petrel and Collared petrel); Vatu-i-Ra Island (for black noddies); Rotuman offshore islets of Ha'atana, Hofliua and Hatawa (seabird colonies); Taveuni (for Tahiti petrel); Kadavu (for Collared petrel, Polynesian storm petrel); Ovalau, Vanuabalavu (historic nesting sites for Collared petrel); Vatu-i-Lami, Mavualau, Namenalala, Cikobia, Nukubasaga, Nukusimanu, Vetaua, Yabu, Sovu, Wailagilala Atoll, Naiabo, Vanuamasi, Reid Reef, Lateviti, Kibobo Island, Nuku Cikobia, Vekai Island, Nukusoge, Yasaga Levu Island, White Rock, Kadomo Island, Monoriki Island, Nanuyaira Island, and Vanuivadra Island (seabird colonies). Additional sites are currently being considered as candidate marine IBAs (Figure 8).

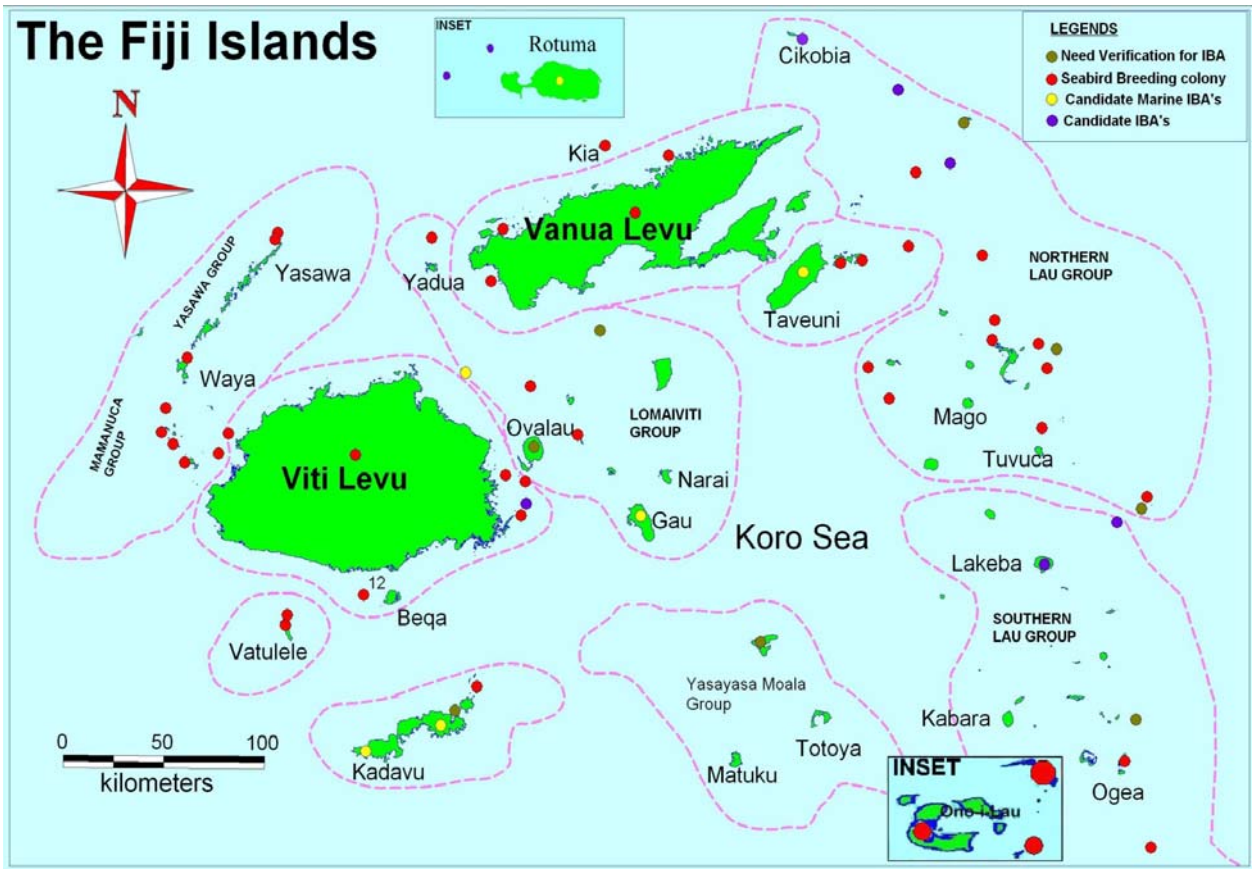

Figure 8. Existing and candidate IBAs and marine IBAs for Fiji (BirdLife International 2009)

Step 6. Agree on a strategy

Although the Fiji Protected Area Committee is still in the process of completing the terrestrial, freshwater and marine ecological gap analyses, discussions have begun in earnest about strategies to integrate the results and establish new protected areas in Fiji. There is broad recognition that an ecosystem approach is necessary, under which the protected areas are integrated into broader management systems to ensure effective conservation of Fiji's biodiversity (Dudley and Parish 2006; Clarke and Jupiter 2010). Additionally there is strong consensus that protected areas can help Fiji's population adapt to climate change in a win-win approach (Dudley et al. 2010).

Given legally recognized customary tenure of terrestrial resources and strong recognition of customary marine resource use rights in Fiji, establishment of any new protected areas will require broad stakeholder consultation to ensure that: (1) community needs are being met alongside national biodiversity targets; (2) the relationship of community management processes is understood within national legal frameworks; and (3) mechanisms exist for equitable distribution of any derived benefits (e.g. ecological services, ecotourism income; (Dudley and Parish 2006; Clarke and Jupiter 2010).

With the success of the Fiji Locally Managed Marine Area network in Fiji, there is strong belief that the current network could be scaled-up to add more area under protection (using the five management strategies described in Step 4) under the existing management framework. Ongoing work in collaboration with James Cook University is assessing the feasibility of meeting national biodiversity targets within a realistic time frame by adding existing sites based on current size distributions of tabu areas and frequency with which they have been added to the FLMMA network since 1997.

Once this work is complete, maps will be distributed to each of the 14 provincial offices which quantify the habitat gaps that need to be filled in order to meet the national area targets. These maps will be overlaid with important priority areas for protection to meet the requirements of specific focal species (e.g. seabirds, endemic fish) and ecological processes (e.g. connectivity areas). Provincial managers, together with provincial Yaubula Management Support Teams which have been established to help grow and manage the FLMMA network, can then consult with communities to identify which communities are willing and capable of protecting more of their traditional fisheries management areas both to provide direct resource benefits and to improve provincial level, and therefore national-scale, biodiversity protection.

Conclusions

Given that a majority of marine conservation initiatives in Melanesia and Polynesia are community managed (Govan et al. 2009a), there is a strong need to recognize their contribution towards biodiversity conservation, even if biodiversity protection is not their primary goal and if certain management strategies only provide partial protection. The inclusion of community conserved areas combined with ecological effectiveness scores into Fiji's national marine gap analyses is an important step towards achieving this recognition and demonstrates the strong commitment of Fiji towards using its human capital as stewards of biodiversity.

Acknowledgements

This work has been funded through a grant from the Global Environmental Facility (GEF) to the National Trust of Fiji to support Fiji's progress under PoWPA, as well as funding to WCS through the MacArthur Foundation. The following individuals have made invaluable contributions to various workshops and stakeholder planning meetings to date: W. Aalbersberg (IAS/USP and FLMMA), A. Bolabola (WWF), A. Cakacaka (WCS), S. Cranwell (BirdLife International), A. Jenkins (WIO), N. Kuridrani (Fiji Department of Fisheries), M. Laveti (WWF), E. Lovell (USP), S. Meo (IAS/USP and FLMMA), C. Miller (WDCS/USP), Y. Nand (Fiji Department of Fisheries), S. Navuku (WWF), K. Passfield (IUCN), R. Pressey (ARC Centre of Excellence for Coral Reef Studies), E. Rupeni (IUCN), S. Sharma (Fiji Department of Fisheries), L. Sivo (CI), P. Skelton (USP), R. Smith (SOPAC), P. Solomona (WWF), H. Sykes (Marine Ecology Consulting), K. Tabunakawai (WWF), S. Tawaka (Fiji Department of Environment), R. Thaman (USP), E. Tokaduadua (Fiji Department of Environment), and N. Yakub (WCS).

References

Andrefouet S, Muller-Karger FE, Robinson J, Kranenburg CJ, Torres-Pulliza D, Spraggins SA, Murch B (2008) Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. 10th International Coral Reef Symposium:1732-1745

Bartlett CY, Manua C, Cinner JE, Sutton S, Jimmy R, South R, Nilsson J, Raina J (2009) Comparison of outcomes of permanently closed and periodically harvested coral reef reserves. Conservation Biology 23:1475-1484

BirdLife International (2006) Important bird areas in Fiji: Conserving Fiji's natural heritage. International Pacific Partnership Secretariat, Suva, Fiji

Carr MH, Saarman E, Caldwell MR (2010) The role of "rules of thumb" in science-based environmental policy: California's Marine Life Protection Act as a case study. Stanford Journal of Law, Science & Policy URL <http://www.stanford.edu/group/sjlsp/cgi-bin/users_images/pdfs/61_Carr%20Final.pdf>

Cinner JE, Marnane MJ, McClanahan TR (2005a) Conservation and community benefits from traditional coral reef management at Ahus Island, Papua New Guinea. Conservation Biology 19:1714-1723

Cinner JE, Marnane MJ, McClanahan TR, Almany GR (2005b) Periodic closures as adaptive coral reef managment in the Indo-Pacific. Ecology and Society 11:31. URL <http://www.ecologyandsociety.org/vol11/iss31/art31>

Clarke P, Jupiter SD (2010) Principles and practice of ecosystem based management: A guide for conservation practitioners in the tropical Western Pacific. Wildlife Conservation Society, Suva, Fiji

Clarke P, Jupiter SD (2010) Law, custom and community-based natural resource management in Kubulau District, Republic of Fiji Islands. Environmental Conservation. In press

DoE (2007) Fiji National Biodiversity Strategy and Action Plan. Fiji Department of Environment, Suva, Fiji

Dudley N (2008) Guidelines for applying protected area management categories. IUCN, Gland, Switzerland, x + 86 pp

Dudley N, Parish J (2006) Closing the gap. Creating ecologically representative protected area systems: A Guide to conducting the gap assessments of protected area systems for the Convention on Biological Diversity. Technical Series no. 24. Secretariat of the Convention on Biological Diversity, Montreal, Canada, 108 pp

Dudley N, Stolton S, Belokurov A, Krueger L, Lopoukhine N, MacKinnon K, Sandwith T, Sekhran N (2010) Natural Solutions: Protected areas helping people cope with climate change. IUCN-WCPA, TNC, UNDP, WCS, The World Bank and WWF, Gland, Switzerland, 130 pp

Edwards HJ, Elliott IA, Pressey RL, Mumby PJ (2010) Incorporating ontogenetic dispersal, ecological processes and conservation zoning into reserve design. Biological Conservation 143:457-470

Foale S, Manele B (2004) Social and political barriers to the use of Marine Protected Areas for conservation and fishery management in Melanesia. Asia Pacific Viewpoint 45:373-386

Govan H, Tawake A, Tabunakawai K, Jenkins A, Lasgorceix A, Techera E, Tafea H, Kinch J, Feehely J, Ifopo P, Hills R, Alefaio S, Meo S, Troniak S, Malimali S, George S, Tauaefa T, Obed T (2009a) Community conserved areas: a review of status & needs in Melanesia and Polynesia. ICCA regional review for CENESTA / TILCEPA / TGER / IUCN / GEF-SGP, 66 pp

Govan H, Tawake A, Tabunakawai K, Jenkins A, Lasgorceix A, Schwarz A-M, Aalbersberg B, Manele B, Vieux C, Notere D, Afzal D, Techera E, Rasalato ET, Sykes H, Walton H, Tafea H, Korovulavula I, Comley J, Kinch J, Feehely J, Petit J, Heaps L, Anderson P, Cohen P, Ifopo P, Vave R, Hills R, Tawakelevu S, Alefaio S, Meo S, Troniak S, Malimali S, Kukuian S, George S, Tauaefa T, Obed T

(2009b) Status and potential of locally-managed marine areas in the South Pacific: meeting nature conservation and sustainable livelihood targets through wide-spread implementation of LMMAs. SPREP/WWF/WorldFish-Reefbase/CRISP, Suva, Fiji, 95 pp + 95 pp annexes

Jenkins AP, Jupiter SD, Qauqau I, Atherton J (2010) The importance of ecosystem-based management for conserving migratory pathways on tropical high islands: A case study from Fiji. Aquatic Conservation: Marine and Freshwater Ecosystems 20:224-238

Johannes RE (1978) Traditional marine conservation methods in Oceania and their demise. Annual Review of Ecology and Systematics 9:349-364

Klein CJ, C. S, Scholz AJ, Possingham HP (2008) Effectiveness of marine reserve networks in representing biodiversity and minimizing impact to fishermen: a comparison of two approaches used in California. Conservation Letters 1:44-51

Lester SE, Halpern BS, Grorud-Colvert K, Lubchenco J, Ruttenberg BI, Gaines SD, Airame S, Warner RR (2009) Biological effects within no-take marine reserves: a global synthesis. Marine Ecology Progress Series 384:33-46

Lovell E, Sykes H (2008) Rapid recovery from bleaching events - Fiji Global Coral Reef Monitoring Network assessment of hard coral cover from 1999-2007. 11th International Coral Reef Symposium

Lovell ER, McLardy C (2008) Annoted checklist of the CITES-listed corals of Fiji with reference to Vanuatu, Tonga, Samoa and American Samoa.JNCC report No. 415, Suva, Fiji, 82 pp

Margules CR, Pressey RL (2000) Systematic conservation planning. Nature 405:243-253

Russ GR, Alcala AC (2003) Marine reserves: rates and patterns of recovery and decline of predatory fish, 1983-2000. Ecological Applications 13:1553-1565

Seeto J, Baldwin WJ (2010) A checklist of the fishes of Fiji and a bibliography of Fijian fish. Division of Marine Studies Technical Report No. 2010/01. The University of the South Pacific, Suva, Fiji, 102 pp

Selig ER, Bruno JF (2010) A global analysis of the effectiveness of marine protected areas in preventing coral loss. PLoS ONE 5:e9278

Teh LCL, Teh LSL, Starkhouse B, Sumaila UR (2009) An overview of socio-economic and ecological perspectives of Fiji's inshore reef fisheries. Marine Policy 33:807-817

Veitayaki J (1997) Traditional marine resource management practices used in the Pacific Islands: an agenda for change. Ocean & Coastal Management 37:123-136

Watling D (1985) Mangrove Management Plan for Fiji, Phase 1. Government Printer, Suva, Fiji

Williams ID, Walsh WJ, Miyasaka A, Friedlander AM (2006) Effects of rotational closure on coral reef fishes in Waikiki-Diamond Head Fishery Management Area, Oahu, Hawaii. Marine Ecology Progress Series 310:139-149

WWF (2004) Setting priorities for marine conservation in the Fiji Islands Marine Ecoregion. WWF South Pacific Programme, Suva, Fiji, 79 pp

Appendix 1. Questionnaire to Support Development of Marine Conservation Targets for the Fiji Islands

Background: Fiji has received funding through the Convention on Biological Diversity through the United Nations to initiate a Programme of Work on Protected Areas. The initial seed funding was granted to conduct an ecological gap assessment and to review legislative and institutional barriers to implementing a national network of protected areas in Fiji. The Protected Area Committee (PAC), as a technical advisor to the National Environment Council, has initiated the process of gathering information from relevant stakeholders to help set Fiji's conservation targets at a national scale for terrestrial, freshwater and marine systems. This questionnaire applies specifically to development of marine conservation targets for Fiji.

Objective: To collate information from stakeholders in Fiji and international experts to identify which biodiversity features and habitats have the highest conservation value at a national level.

Q1. What marine species, or suites of marine species, have the highest conservation value for Fiji? Please indicate whether the species are important because they are: (a) critically threatened (e.g. IUCN red-listed); (b) endemic; (c) culturally significant; or (d) provide critical ecosystem functions.

Q2. In what marine habitats (or across what range of habitats) are the above species most likely to be found? Please list the habitat criteria for each species named and identify any particular sites of national significance for those species.

Q3. In an ideal scenario, what proportion of each of the habitats listed above should be protected/preserved across Fiji to ensure survival of species identified with high biodiversity, ecological or cultural conservation value?

Q4. Which marine habitat features are likely to support the highest biodiversity in Fiji?

Q5. Are there any particular geographic areas in Fiji that support unusually high marine biodiversity or unique species assemblages? Please justify any responses.

Appendix 2. Draft differential effectiveness weightings for marine management strategies in Fiji

Habitat	LMMA	Rotational	Uncontrolled Periodic Harvest	Controlled Periodic Harvest	Permanent
Fringing Reef					
Corals	0.4	0.25	0.5	0.8	1
Target invertebrates	0.2	0.25	0.1§	0.7	1
Non-target invertebrates	0.45	0.50	0.6¥	0.9	1
Target fish	0.2	0.25	0.15ǂ	0.8ǂ	1
Non-target fish	0.45	0.45	0.5¥	0.9	1
Coralline algae	0.4	0.25	0.5	0.8	1

§ The effectiveness for protection of targeted invertebrates in uncontrolled periodically harvested areas was weighted very low because most commercially important invertebrates do not exhibit quick behavioural responses to rapid resource extraction. The consensus was that target invertebrates would be more protected within the broader LMMA than in a *tabu* area that experienced uncontrolled periodic harvests.

ǂ The effectiveness for protection of targeted fish in both controlled and uncontrolled periodically harvested areas was weighted slightly higher than for target invertebrates because many targeted fish are highly mobile and can exhibit strong behavioural responses to fishing (Gotanda et al. 2009).

¥ The effectiveness for protection of non-target fish and invertebrates on fringing reefs in uncontrolled periodically harvested areas was weighted lower than on other reefs because trampling during uncontrolled harvests on fringing reefs may destroy habitat for these species groups.

Habitat	LMMA	Rotational	Uncontrolled Periodic Harvest	Controlled Periodic Harvest	Permanent
Non-fringing Reef					
Corals	0.4	0.25	0.55	0.8	1
Target invertebrates	0.2	0.25	0.1§	0.7	1
Non-target invertebrates	0.45	0.5	0.8	0.9	1
Target fish	0.2	0.25	0.15ǂ	0.8 ǂ	1
Non-target fish	0.45	0.45	0.6¥	0.9	1
Coralline algae	0.4	0.25	0.55	0.8	1

§ The effectiveness for protection of targeted invertebrates in uncontrolled periodically harvested areas was weighted very low because most commercially important invertebrates do not exhibit quick behavioural responses to rapid resource extraction. The consensus was that target invertebrates would be more protected within the broader LMMA than in a *tabu* area that experienced uncontrolled periodic harvests.

ǂ The effectiveness for protection of targeted fish in both controlled and uncontrolled periodically harvested areas was weighted slightly higher than for target invertebrates because many targeted fish are highly mobile and can exhibit strong behavioural responses to fishing (Gotanda et al. 2009).

¥ The effectiveness for protection of non-target fish and invertebrates on other reefs in uncontrolled periodically harvested areas was weighted higher than on fringing reefs because less trampling behavioural during uncontrolled harvests is likely to occur since the reefs are less accessible.

Habitat	LMMA	Rotational	Uncontrolled Periodic Harvest	Controlled Periodic Harvest	Permanent
Mangrove					
Target invertebrates	0.2	0.4	0.15°	0.8	1
Non-target invertebrates	0.5	0.6	0.85	0.95	1
Target fish	0.15	0.35	0.1β	0.5β	1
Non-target fish	0.3	0.55	0.3β	0.6β	1
Mangrove	0.25	0.85	0.85	0.95	1
Seabirds	0.20	0.85	0.85∞	0.95∞	1
Bats	0.25	0.85	0.85∞	0.95∞	1

° The effectiveness for protection of targeted invertebrates in uncontrolled periodically harvested mangrove tabus is higher than for reefs because it is more difficult to manoeuvre in mangrove habitats therefore people would be less likely to find all target invertebrates, particularly those that hide in mud.

β The effectiveness for protection of target fish in mangrove areas is moderate for controlled periodically harvested areas and very low for uncontrolled periodically harvested areas because these fish are easy to remove with gill nets. Because the nets are non-selective, they also have strong effects on non-target fish. If bans on gill nets were employed, the effectiveness weightings would be higher. Because the nets are non-selective, they also have strong effects on non-target fish.

∞ Seabirds are not as likely to be affected by removal of invertebrates and fish from small periodically harvested areas because they have large foraging areas. Seabirds and bats are generally not targeted in mangrove habitats, so the effectiveness for their protection should be equivalent to the effectiveness for mangroves themselves, which serve as important roosting (seabirds and bats) and foraging (seabirds) habitat.

Habitat	*LMMA*	*Rotational*	*Uncontrolled Periodic Harvest*	*Controlled Periodic Harvest*	*Permanent*
Intertidal					
Target invertebrates	0.2	0.25	0.1§	0.7	1
Non-target invertebrates	0.45	0.5	0.8	0.9	1
Target fish	0.20	0.25	0.15	0.8	1
Non-target fish	0.45	0.5	0.8	0.9	1
Seabirds	0.25	0.3	0.2∞	0.95∞	1

Habitat	*LMMA*	*Rotational*	*Uncontrolled Periodic Harvest*	*Controlled Periodic Harvest*	*Permanent*
Other benthic substrate <30 m					
Target invertebrates	0.12	0.35	0.3£	0.7£	1
Non-target invertebrates	0.45	0.6	0.8	0.9	1
Target fish	0.2	0.5	0.5 ǂ	0.8 ǂ	1
Non-target fish	0.45	0.6	0.8	0.9	1

§ The effectiveness for protection of targeted invertebrates in uncontrolled periodically harvested areas was weighted very low because most commercially important invertebrates do not exhibit quick behavioural responses to rapid resource extraction. The consensus was that target invertebrates would be more protected within the broader LMMA than in a *tabu* area that experienced uncontrolled periodic harvests.

∞ Seabirds are not as likely to be affected by controlled removal of invertebrates and fish from small periodically harvested areas because they have large foraging areas, but they would be more affected if almost all of their prey were removed during uncontrolled harvests.

£ Target invertebrates are less likely to be harvested in the other benthic substrate of a controlled or uncontrolled periodically harvested area as most people would be extracting resources from right around the reef.

ǂ The effectiveness for protection of targeted fish in both controlled and uncontrolled periodically harvested areas was weighted slightly higher than for target invertebrates because many targeted fish are highly mobile and can exhibit strong behavioural responses to hunting.