FISH MOVEMENT IN MPAS ON CORAL REEFS IN KUBULAU, FIJI

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WILDLIFE CONSERVATION SOCIETY

EBM FIJI ISLANDS

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EXECUTIVE SUMMARY

WCS has been conducting surveys of reef community assemblages inside and outside the marine protected areas (MPAs) within the Kubulau District traditional fishing ground (*qoliqoli*) since an MPA network was established in 2005. The purpose of this study was to collect data of small to medium scale movement of fish in this network of no-take MPAs, which can provide crucial information for the interpretation of demographic fish data from on-going monitoring programme and insight to MPA protection efficiency. The main objectives were:

1. Identify economically and ecologically important key species
2. Determine movement potential of selected key species in the MPA networks through dart tagging fish in the three district MPAs (Namena, Namuri, Nasue)

In total, 548 fish were tagged during three tagging trips from May 2008 to February 2009 in the Kubulau qoliqoli area. The tagged fish were from 12 different families and 56 species. 93% of fish tagged were from only 4 families (Carangidae, Lethrinidae, Lutjanidae and Serranidae). Most fish tagged were primary target fish, which theoretically would increase the likelihood of recapture.

Over the 1.5 years following the initial tagging trip in May 2008, only 3 fish were recaptured (0.6%). Two of these were recaptured in the Namena MPA within less than 30 min after tagging. One grouper, *Plectropomus leopardus,* was recaptured in the Namuri MPA 9 months after being tagged, less than 100 m of the initial tagging location. The fish was in excellent condition and showed no adverse effects from tagging.

Movement studies using dart tagging of fish rely heavily on recapture and reporting of specimens caught by fishermen. They also require a high fishing effort that is evenly distributed spatially and temporally. Part of the reason for low recapture rates may be that most fishing effort in Kubulau is opportunistic, depending on the needs of the communities, and unevenly spread across the qoliqoli the majority of fishers stay inshore away from the fish tagging sites. The very low numbers of recapture would also be influenced by several other factors. One of the most important challenges was the number of fish tagged, which was less than 20% of the targeted number of fish. This was due to a much lower catchability than expected, and logistical as well as financial constraints. The low catchability, in conjunction with a very large study area, resulted in a low density of tagged fish.

Under the conditions found in Fiji and the experience from the present study, we would recommend to focus future studies on smaller areas. This would allow increasing the density of fish tagged in a particular area and also a more targeted information campaign to ensure full awareness of the tagging project and reporting of fish recaptured. In addition, different methods that might be more suitable to gain information on fish movement on coral reefs need to be explored. Existing evidence from acoustic tagging suggest that most fish do not venture very far but if they do, their movement occur at night. Acoustic tagging provides the huge advantage that it is possible to track the fate of individual fish at much higher temporal and spatial resolution.

INTRODUCTION

Increasing numbers of marine protected areas (MPAs) and traditional tabu areas are being established in the South Pacific for conservation and fisheries benefits (Govan et al. 2009). Globally, conservation benefits of no-take MPAs have been well established, with populations of exploited species showing greater abundance, increasing biomass and size within the reserve (Mosquera et al. 2000, Halpern & Warner 2002, Gell & Roberts 2003), as well as recovery of whole ecosystems (Babcock et al. 1999, Shears & Babcock 2002). After recovery, exploited species exhibit a more natural population structure and thus have a substantially higher reproductive output (Palumbi 2004), which may reduce the variability in abundance of the species (Hamer & Jenkins 2004, Hsieh et al. 2006). Moreover, functional ecosystems, as found in marine reserves, have been shown to be more resilient to natural disturbance and human impact (Hughes et al. 2005, Worm et al. 2006).

In addition to their conservation benefits, the potential fisheries benefits of marine reserves have gained increasing attention in the light of increased environmental degradation and over-exploitation of many fisheries worldwide. Increased abundance in target species could lead to density dependent migration out of the reserve ("spillover") (Kramer & Chapman 1999) and enhancement of recruitment through larval cross subsidy to adjacent areas (Nowlis & Roberts 1999, Sale et al. 2005). In contrast to a wealth of theoretical work, direct evidence of fisheries benefits spilling over from marine reserves is still rare (but see Russ & Alcala 1996, Abesamis & Russ 2005).

In order to understand the genesis and extent of conservation and fisheries benefits, there is a clear need to understand the movement patterns of key species. Species with low mobility are predicted to benefit most from marine reserve protection, with mobile species benefiting less (Kramer & Chapman 1999). Consequently, fisheries benefits from adult spillover are less likely to occur for species that are sessile or move very little. Recovery within the reserve and spillover contribution to fished areas of more mobile species is also poorly understood. Knowledge of movement patterns are especially important for exploited species which are generally larger, long lived species and often more mobile. In most cases, adequate information on the movement range and frequency at relevant scales is sparse or entirely lacking and limits the rational planning of marine reserves (Botsford 2005, Sale et al. 2005).

Little is known on fish movement on Fiji coral reefs, particularly regarding their home and movement range, including excursions of fish from protected areas to adjacent exploited areas. While studies in other parts of the world have started to produce empirical evidence of benefits beyond the boundaries (e.g. McClanahan & Mangi 2000, Abesamis & Russ 2005, Harmelin-Vivien et al. 2008), research on this topic is still in its infancy in Fiji. Previous research has focused mainly on the recovery and community composition of fish within the protected areas. Gaining information on actual movement of different fish species within and across the boundaries of protected areas will provide valuable information to interpret the patterns observed in protected stocks and insight into potential beneficial effects beyond the boundaries.

Conventional dart tagging offers a low cost approach to investigate the general nature of fish movement. Tagging studies have provided information on degree of mixing between fish stocks and habitats (Sumpton et al. 2003), as well as stock size and exploitation rates. In addition, well designed tagging studies could allow investigating the spill-over of adult fish tagged inside protected areas through interpretation of spatial and temporal patterns of recaptures.

Most existing information on species' movement comes from conventional, external tag-recapture experiments. However, there are some limitations to this technique. Because tagging only provides a start and end point it results in limited spatial and temporal resolution of mobility. In addition, the quality of the results will be strongly influenced by both the tagging and tag-reporting success. In the absence of any data existing on fish movement from coral reefs in Fiji, this technique can still provide valuable information, particularly if only limited resources and funding are available. Dart tagging has the potential to provide insights into the proportion of the reserve fish stocks that contribute to the adjacent fisheries through cross-boundary movement, as the tag returns will come from the local fishers. The direct involvement of local fishermen (through report of re-captured tagged fish) is likely to increase their support for MPAs if they catch fish from the protected areas. In addition, the involvement of local fishermen together with training and information workshops the awareness of local communities about the importance of MPAs and fish movement can be increased.

WCS has been conducting surveys of reef community assemblages inside and outside the marine protected areas (MPAs) within the Kubulau qoliqoli since the MPA network was established in 2005. Data of small to medium scale movement of fish in this network of no-take MPAs can provide crucial information for the interpretation of demographic fish data from ongoing monitoring programme and insight to MPA protection efficiency. The main objectives were:

1. Identify economically and ecologically important key species

2. Determine movement potential of selected key species in the MPA networks through dart tagging fish in the three district MPAs (Namena, Namuri, Nasue)

METHODS

Study site

The dart tagging was carried out in the Kubulau fishing ground (*qoliqoli*) on Vanua Levu Island (Fiji) between May 2008 and February 2009. The Kubulau qoliqoli contains three district no-take MPAs (Namena, Namuri, Nasue) and a series of 17 traditional tabu areas that are managed by individual villages. The largest reserve is Namena with a total area of 60.6 km^2. This reserve was informally established in 1997 and surrounds the island of Namenalala where an eco-resort is located. The Namuri and Nasue reserve are considerably smaller than the Namena reserve at 4.25 km^2 and 8.14 km^2. These reserves were established in 2006. The total area of Kubulau qoliqoli is 262 km^2 and is comprised of a network of 20 reserves, totalling approximately 80 km^2, or approximately 30% of the qoliqoli (Figure 1).

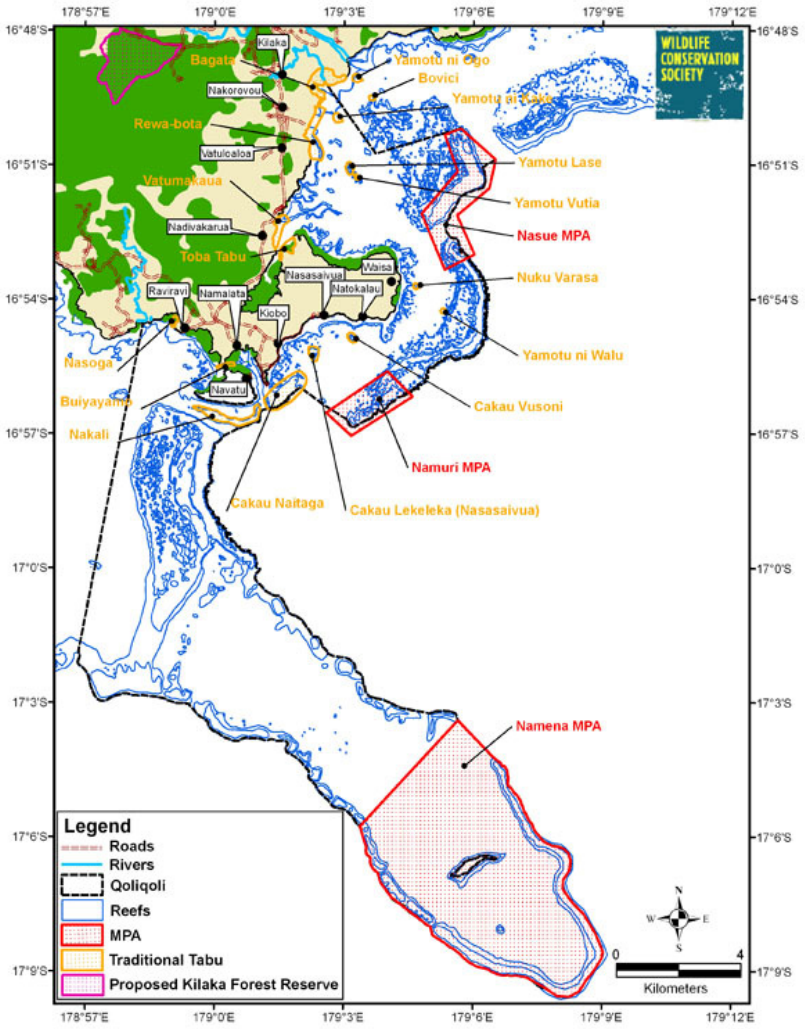

Figure 1 Map of the Kubulau area including the permanent reserves and tabu areas**.**

Fish tagging

All fish were caught with hook and line using barbless hooks. They were wrapped in a wet towel for handling. The fish species and fork length were recorded and fitted with a plastic tipped dart tag (Hallprint PTY Ltd, Australia). The tags were inserted below the dorsal fin and locked behind the spine. The intended tagging method allows quick attachment, minimal handling time and tagging mortality. All individuals captured inside the MPAs were released at the site of capture after ensuring that they were in good condition. Three different colours of tags were used, one for each MPA (Namena: yellow, Namuri: white, Nasue: green). This was chosen to allow local fishermen to identify easily from which MPA any fish they recaptured was originating from.

Site selection

Initial attempts were made to select sites within stratified zones of the MPAs with different distances of the boundary. Low catchability and weather constraints resulted in a more opportunistic site selection with the individual reserves. All sites were characterised by proximity to reef area and depths less than 15 m to minimise damaged swim bladder through pressure differences (Figure 2).

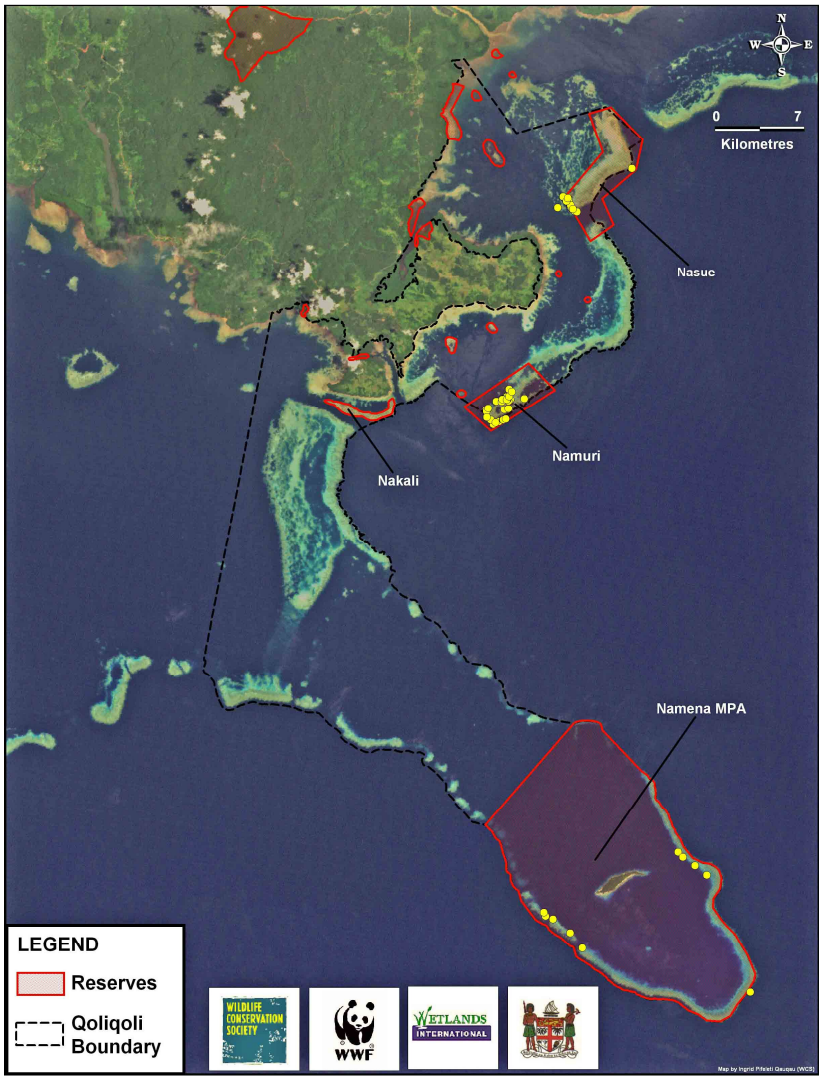

Figure 2 Map of the fish tagging locations in the Kubulau qoliqoli. Each location is marked with a full yellow circle**.**

Community awareness

The tagging project was initially presented to the Kubulau Resource Management Committee (KRMC) in January 2008 for approval. With the consent of the local stakeholders, a community tagging workshop was held in May 2008. The participants of the tagging workshop were informed on the purpose of the project and the tagging process with demonstrations. Each participant received a folder with all contact details, recording sheets (including map for re-capture location) and information on the award offered for a recaptured tag. The reward offered for the reporting of a tagged fish was a T-shirt designed specifically for this project.

During the tagging fieldwork between two and four local community members accompanied the field team. They were actively involved in the selection of tagging sites, capture of the fish and occasionally in the tagging process. Two articles on the nature and status of the tagging program and regular reminders about the reporting and reward were circulated in the community

through the bi-monthly community bulletin (in English & Fijian). In addition, a tagging information brochure was repeatedly distributed in the study area (in English & Fijian; Figure 3).

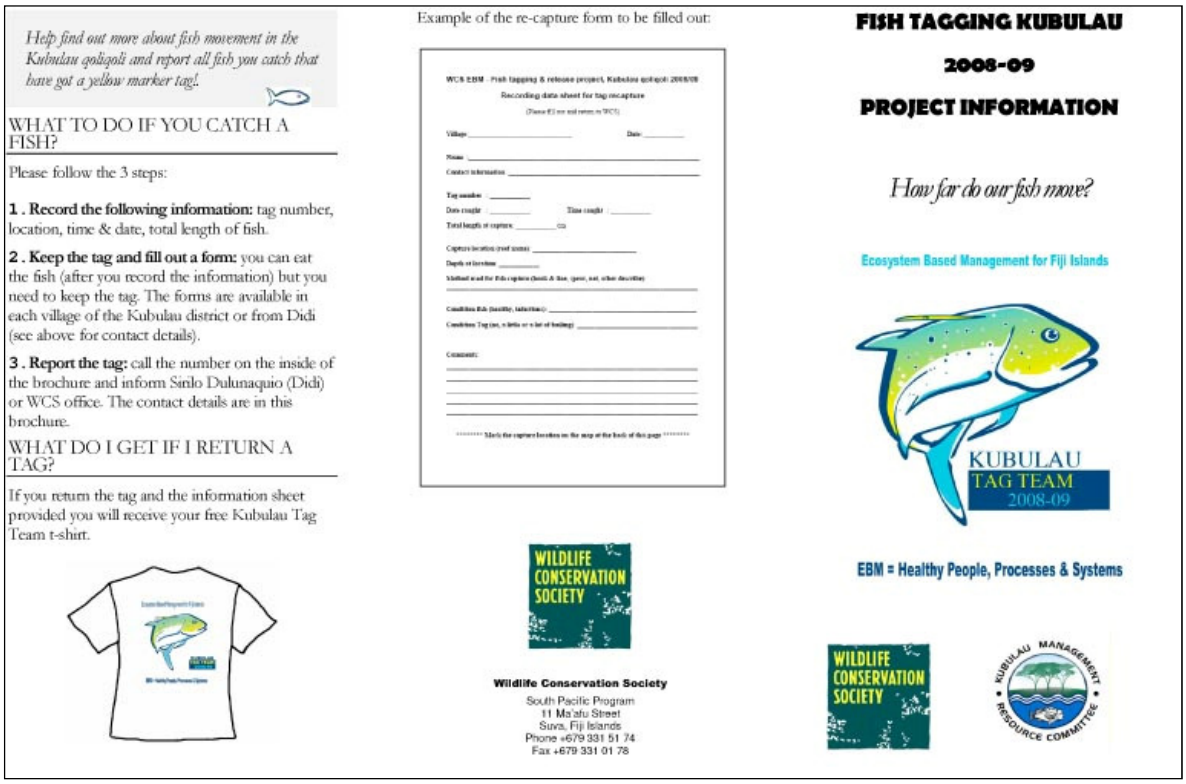

Figure 3 Fish tagging information brochure printed and distributed (in Fijian) to community members and fishers in Kubulau**.**

RESULTS

In total, 548 fish were tagged during three tagging trips from May 2008 to February 2009 in the Kubulau qoliqoli area (Figure 2). From these, 265 fish were tagged in the Namena MPA, 183 in the Namuri MPA and 100 in the Nasue MPA. The tagged fish were from 12 different families (Table 1) and 56 species. 93% of fish tagged were from only 4 families (Carangidae, Lethrinidae, Lutjanidae and Serranidae). Most fish tagged were primary target fish, which theoretically would increase the likelihood of recapture.

Table 1 Total number of fish tagged in each family

Family	Total
Ballistidae	2
Carangidae	85
Holocentridae	3
Labridae	11
Lethrinidae	168
Lutjanidae	111
Mullidae	5
Nemipteridae	1
Rachycenridae	1
Scombridae	12
Serranidae	147
Sphyraenidae	2

The length of fish tagged ranged from 19 – 66 cm FL. With the tag models used in the study, 19 cm FL was established as the minimum length a fish could be tagged without any major influence on its behaviour or health. The majority of the fish tagged from the four dominant families were between 21 – 40 cm FL (Figure 4).

Over the 1.5 years following the initial tagging trip in May 2008, only 3 fish were recaptured (0.6%). Two of these were recaptured in the Namena MPA within less then 30 min after tagging. One grouper, *Plectropomus leopardus,* was recaptured in the Namuri MPA 9 months after being tagged, less than 100 m of the initial tagging location (Figure 5). The fish was in excellent condition and showed no adverse effects from tagging.

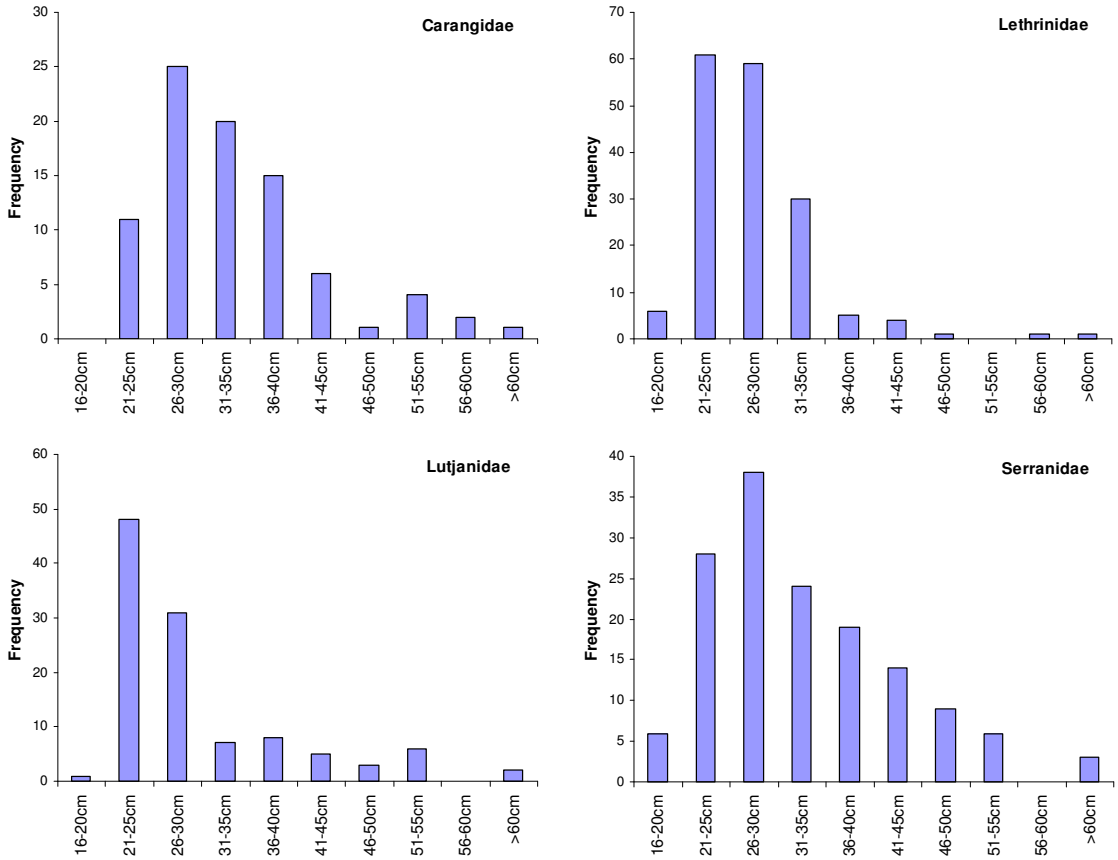

Figure 4 Size frequency tables for the tagged fish of the four dominating families**.**

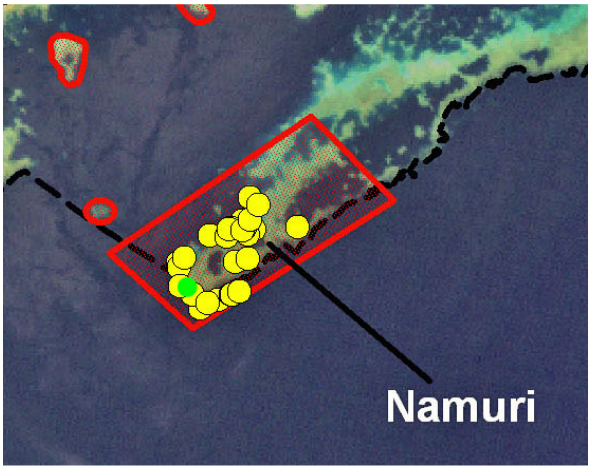

Figure 5 Map of the fish tagging locations in Namuri. Each location is marked with a full yellow circle and the recapture location is marked with a full green circle**.**

DISCUSSION

Movement studies using dart tagging of fish rely heavily on recapture and reporting of specimens caught by fishermen (Bolle et al. 2005). They also require a high fishing effort that is evenly distributed spatially and temporally. In Kubulau qoliqoli, a lot of the fishing effort is opportunistic, depending on the needs of the communities and accessibility of fishing grounds (Cakacaka et al. 2010). Also, nearly all the fish were tagged on the forereef while much of the fishing effort is not necessarily on forereefs (Adams et al. 2010).

Existing data from acoustic tagging fish movement in Fiji suggests that lethrinids might move up to 700 meters (Grober-Dunsmore et al. 2009). These movements occur mostly during the night. The range of movement indicates that it is important for any MPA or traditional tabu area to have a minimum size that well encompasses such movement ranges (i.e. > 1.5 km length). It is therefore likely that in the present study, most fish tagged >700 m away from the MPA boundaries would not have been recaptured outside the MPAs, therefore limiting opportunities for recapture if fishermen were respecting the MPA rules. This is further supported by the single recapture of a grouper being less than 100m away from its initial tagging location 9 months earlier.

The very low numbers of recapture would also be influenced by several other factors. One of the most important challenges was the number of fish tagged, which was less then 20% of the targeted number of fish. This was due to a much lower catchability than expected, and logistical as well as financial constraints. The low catchability, in conjunction with a very large study area, resulted in a low density of tagged fish. The low catchability also prevented a more selective targeting of a low number of specific species.

All three recaptured fish that were caught at the same location or within very close proximity of the original tagging location. Together with the lack of any recaptures outside the MPAs this could be indicative of much lower movement rates than anticipated from other, mainly temperate, tagging work (e.g. Zeller & Russ 1998, Starr et al. 2002). While there is evidence of poaching in all three MPAs (Cakacaka et al. 2010), it would be very unlikely that any fisherman would report a recapture if they would have caught a tagged fish within the no-take area.

CONCLUSIONS AND RECOMMENDATIONS

Under the conditions found in Fiji and the experience from the present study, we would recommend to focus future studies on smaller areas in closer proximity to higher fishing activity. This would increase the density of fish tagged in a particular area and also enable a more targeted information campaign to ensure full awareness of the tagging project and reporting of fish recaptured.

The communities showed great interest in the study and many participated in the information and training workshops: 25 community members that were helping on the boat during tagging process. Thus, the project could potentially be replicated within greater success by tagging fish

within traditional tabu areas which are closer inshore (Figure 1) and surrounded by greater fishing effort (Adams et al. 2010; Cakacaka et al. 2010).

In addition, different methods that might be more suitable to gain information on fish movement on coral reefs need to be explored. Existing evidence from acoustic tagging suggest that most fish do not venture very far, but if they do, their movement occur at night. Acoustic tagging provides the huge advantage that it is possible to track the fate of individual fish at much higher temporal and spatial resolution. This allows the confirmation of low movement range of species. With this method it would also be possible to examine differences in movement patterns with a single species (Egli & Babcock 2004).

The results from the dart tagging study provide valuable information on the presence and catchability of target species in the Kubulau district coral reef areas. This can be used to select a particular area of interest (i.e. continuous and homogenous habitat across boundaries) where there is a high likelihood to capture a particular species of interest.

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