A Preliminary Assessment of Mud Crab Stocks in Mangrove Forests in Bua Province, Fiji

WCS

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Introduction

Coastal communities in Fiji rely heavily on inshore fish and invertebrate fisheries for food and livelihoods. Known to be fairly ubiquitous and abundant in estuarine and mangrove forests, mud crabs (*Scylla serrata)* known locally as *qari,* are a popular food and valuable income source for local communities. The fishery is largely dominated by women who collect mud crabs largely by hand collection or using small hand nets during the low tide from mangrove forests adjacent to their villages (Mangubhai et al. in prep.).

While there are a few population studies on mud crabs (*Scylla* spp.) associated with mangrove systems throughout Indo-West Pacific (Lebata et al. 2007), there is limited information on the actual movement patterns, habitat and density of different species. Given they are a highly aggressive species with cannibalistic tendencies they disperse over a variety inshore habitats during their life cycle (Hill 1982). Ovigerous females swim substantial distances offshore from a few to many tens of kilometres where the eggs hatch and larvae enter the plankton (Perrine 1978, Hyland et al. 1984).

The mud crab fishery in Fiji is understudied, with very little information on population status, distribution patterns, abundance, threats, and their economic value. There is a growing concern for the increase in undersized crabs being sold in local markets, suggesting declines in local stocks likely from over harvesting. *In situ* surveys of mud crab stocks have not been conducted in Fiji to date. To address this gap, the Wildlife Conservation Society (WCS) undertook a preliminary assessment of select mangrove forests in Bua Province to estimate the density and biomass of mud crab stocks using a small quadrat depletion technique. The information gathered through this method can be used to estimate crab density by extrapolating the relationship between harvest area and crab removal, over a fixed period of time.

Mangrove forests where women fish at low tide for mud crabs in Bua Province.

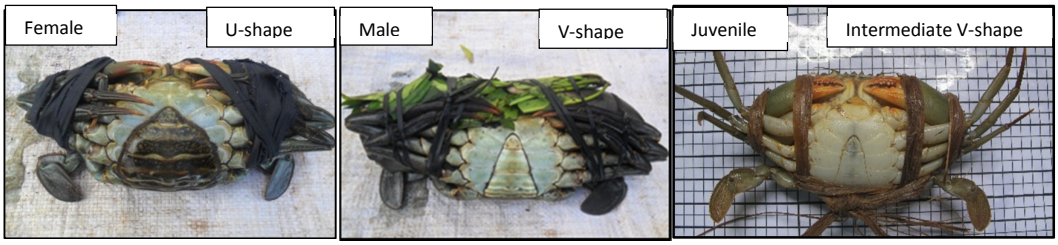
Methods

WCS researchers partnered very experienced local mud crab fishers to conduct ecological surveys to assess the population of mud crabs in mangrove systems of Bua Province from 23-30 July, 2016. Sites were identified by local mud crab fishers based on the following criteria: (i) fishing pressure, measured as the number of fishers using the area; (ii) density of mangroves and accessibly to sites; and (iii) mud crab habitats where harvesting occurs. These habitats include mangrove forests usually near high tide mark, and intertidal habitat between the high and low tide mark. However, we only sampled mangrove forests for this study.

A total of at 8 sites were surveyed across three districts (Dama, Navakasiga, Lekutu) in Bua Province over 9 days (Table 1). The vegetation was described by a visual qualitative assessment of the density and the dominant species of mangrove at each site. To limit potential biases resulting from vegetation use, quadrat were set by the same people across different districts (Dumas et al. 2012). The aim was to collect as many of the crabs within individual quadrats to deplete the resource to the greatest extent possible. This is a modification of the depletion technique used by Hay et al. (2005), with the main difference being our technique is conducted over a fixed timeframe and does not require multiple days. We did this to avoid the chance that new crabs migrate into the quadrat area.

An average of 8 quadrats (range = 8-12 quadrats) were sampled per site. Distance between consecutive and parallel quadrats was 5 m. Quadrats were placed where vegetation cover was homogeneous. Coordinates for each quadrat was marked at the beginning of using a Garmin GPSMAP78 device, and boundaries for each quadrat was closed using tapes to avoid fishers collecting crabs outside the boundary. The size of each quadrat was 400 m^2 and the minimum area surveyed per site was 3200 m^2. For each quadrat, crabs were collected and immediately tied using string or mangrove vines. Each quadrat had 2-4 fishers were assigned to it, and the time taken to deplete each quadrat was recorded (Table 1). Variation in number of fishers harvesting each quadrat did not affect our results as crabs were removed from the quadrat, hence there was no double counting.

Once all the quadrats were completed, all crab were sexed, measured to the nearest cm for both total length and carapace width (CW) using a wooden/steel ruler, and weighed to the nearest gram using an electronic scale. Note that crabs were weighed while tied with string or vines. The weight of crab was then calculated by subtracting the weight of string or vines. Crabs were sexed and classified as adult or juvenile based on the shape and size of abdominal flap. Abdominal flaps of crabs are usually V-shape, U-shape or intermediate V-shape (see photos below). Male crabs usually tend to have a shape V abdominal shape, females tend to have a U-shape abdominal and juveniles fall in the category of poorly developed intermediate V-shape abdominal (Islam et al. 2010).



Spatial data were entered into a geographical information system (GIS) to mark survey sites on mangrove maps. Using latest available mangrove layer and GPS coordinates recorded in the field, total area of mangrove system per district was calculated in ArcGIS. For each quadrat, mud crab density per quadrat was calculated by dividing the number of crabs caught per quadrat by the size of the quadrat. Sex-ratio per female over was calculated by dividing the total number of females over total number of males per quadrat. Biomass was calculated by totalling the weight of crabs (kg) per quadrat divided by the total area of quadrat (m^2). A non-parametric Kruskal-Wallis test was used to further investigate the influence of site and districts on recorded density patterns of mud crabs in Bua province. Statistical analysis was done in R Version 3.3.1: Statistical Computing Software (R Development Core Team 2016).

Table 1. Characteristics of sampling sites of mud crab (*S. serrata*) in Bua Province. All quadrats covered an area of 400 m^2.

Date	District	Villages	Site	# quadrats	# fishers / site	Total area surveyed (m^2)	Dominant mangroves	#crabs
22/07/16	Dama	Dama, Nasau, Tavolomo	D2	5	6	2400	*Rhizophora*	0
23/07/16	Dama	Dama, Nasau, Tavolomo	D3	12	10	4000	*Bruguiera*	6
25/07/16	Navakasiga	Nasau	N1	8	12	4800	*Rhizophora*	6
26/07/16	Navakasiga	Nasau	N2	8	11	4400	*Rhizophora*	0
27/07/16	Navakasiga	Nasau	N3	8	12	4800	*Mixed forest*	3
29/07/16	Lekutu	Tavea	T1	8	8	3200	*Rhizophora*	0
29/07/16	Lekutu	Tavea	T2	8	8	3200	*Rhizophora*	0
30/07/16	Lekutu	Tavea	T3	11	8	3200	*Rhizophora*	3



People setting up quadrats in a Bruguiera forest (left) and fisher women tying up crab in a Rhizophora forest (right). *©Margaret Fox/WCS (left) and Yashika Nand/WCS (right)*

Results

Mangrove systems in Bua province were classified into three types – *Rhizophora*, *Bruguiera* and mixed mangrove forests. Mixed mangrove forest was defined as areas that had of *Rhizophora* (dominating the seaward edges) and *Bruguiera* species. Local fishers mainly harvest mud crabs in *Rhizophora* dominated forests because they are generally characterised by soft muddy sediments which is a favourable habitat for mud crabs (M. Fox, pers. comm.). While *Rhizophora* mangrove forests can also be found in areas with sandy hard sediments, these areas are mostly by fishers for harvesting other invertebrates such as gastropods.

A total mangrove area of 30,800 m^2 was surveyed in the districts of Dama (7,200 m^2), Navakasiga (14,000 m^2) and Lekutu (9,600 m^2). A total of 18 mud crabs was recorded. Prevalence was low with crabs only present in a third of the quadrats surveyed. The highest densities of crabs were recorded in Dama District (12.5 ± 1.2 crabs/ha) while lowest densities were recorded in Lekutu District (2.3 ± 3.9 crabs/ha) (Table 2). Within Bua province, the largest mangrove area surveyed was in Navakasiga District which also had the highest number of crab fishers. There was no significant difference in mud crab density between sites ($p = 0.24$) when pooled, but there was significant difference between districts ($p = 0.02$).

The average mud crab carapace width was 13 cm (± 3.4). There was some variation in size of crabs between males and females and between districts, with females slightly larger across all districts (Table 3). Interestingly, despite being closer to markets Navakasiga District recorded bigger size crabs than other districts, though there were variations in crab sizes at each site.

An analysis of sex-ratios showed an overall dominance of male mud crabs at the sites surveyed. The districts of Dama and Navakasiga recorded a higher ratio of male crabs during the survey, while Lekutu recorded a high ratio of females. None of the female crabs were gravid (i.e. with eggs) at the time of survey. Life stage ratios showed an overall dominance of adults compared to juveniles in mangrove systems (Table 2). Very few juveniles were recorded in general during the study.

Mud crab buried in soft sediments (left) and sandy sediments in *Rhizophora* mangrove forests.
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Table 2. Density, biomass, sex ratio (female to male) and life stage ratios (adult to juvenile) of mud crabs (*S. serrata*) in mangrove forests in Bua Province. Standard deviations are provided in parentheses.

District	Average density (m^2)	Average density (ha)	Average biomass (kg/m^2)	Sex ratio	Life stage ratio
Navakasiga	0.0093 (±0.0009)	9.4 (±9.4)	442.0 (±263)	0.8	3.5
Dama	0.0013 (±0.0012)	12.5 (±1.2)	351.2 (±28.8)	0.5	1.7
Lekutu	0.0007 (±0.0004)	2.3 (±3.9)	187.8 (±158.7)	2.0	2.0

Table 3. Average carapace width (cm) and weight (kg) of mud crabs (*S. serrata*) recorded in Bua Province. Standard deviations are provided in parentheses.

District	Carapace width			Weight		
	Male	Female	Overall	Male	Female	Overall
Navakasiga	14.2 (± 3.3)	15.3 (± 5.0)	14.7 (± 3.9)	0.59 (± 0.44)	0.38 (± 0.57)	0.61 (± 0.47)
Dama	10.9 (± 2.6)	12 (± 0.9)	11.3 (± 2.1)	0.28 (± 0.16)	0.31 (± 0.04)	0.29 (± 0.13)
Lekutu	9.7	13 (± 2.1)	11.9 (± 2.4)	0.19 (±)	0.28 (± 0.22)	0.31 (± 0.19)

Discussion

The status and health of mud crab stocks is poorly documented and understood in Fiji and the wider Pacific (Dumas et al. 2012). Without this information the Ministry of Fisheries and communities cannot assess if there are adequate management measures in place to protect the fishery and ensure harvesting remains at sustainable levels. Ecological assessments are also hampered by poor knowledge on habitat preferences and movement patterns of mud crabs throughout their life history, and the lack of a standardised methodology for doing stock assessments (see Hay and Calogeras 1999).

This study is the first to get preliminary data on of the population density and biomass of mud crabs in mangrove forests in Bua Province. The results suggest that adult crabs dominate mangrove forests while juvenile crabs may be using other habitats. With so few studies available from the Pacific it is difficult to assess whether the densities in Bua (2.3-9.4 crabs/ha) are typical for the habitat. In contrast, a study from New Caledonia recorded 19.3 crabs/ha (Dumas et al. 2012), which is 2-8 times higher than densities in Bua Province. It is not known if differences in densities between Fiji and New Caledonia are a result of different methods being used or due to an uneven or scattered distribution of crabs within a mangroves system (Bonine et al. 2007). The New Caledonia study conducted surveys on burrows with and without crabs using a larger quadrat size (3300 m^2) and calculated density by estimating the ratio of burrows with crabs and without crabs within quadrats (Dumas et al. 2012).

Given the size of mud crabs recorded and discussions with local fishers with a long history with the mangrove forests surveys, it is unlikely that the densities recorded in Bua Province are indicative of highly overexploited populations. This study does not enable us to conclude whether the low densities recorded reflect the choice of method that was used (i.e. depletion technique), size of quadrats, areas covered, or the patchy distribution of natural populations. There were also significant challenges in laying transect lines to mark quadrats in *Rhizophora* forests, especially since the tides limited the amount of time available for sampling. Given it took an average of 45 minutes to set up the quadrats for *Rhizophora* forest, the depletion technique may be better suited to *Bruguiera* or mixed mangrove forests where there are more spaces between the trees.

Moving forward, a more useful way to assess trends in the population may be through catch per unit effort logbooks, which are currently being trialled by local fishers in Bua Province in partnership with WCS.

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