SEAGRASSES OF THE FIJI ISLANDS: REVIEW OF CURRENT KNOWLEDGE

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INTRODUCTION

Seagrass meadows (veivutia) are found intertidal and in the shallow subtidal waters of protected and soft shores throughout Fiji. They play an important role in maintaining coastal water quality and are vital in supporting coastal marine communities and maintaining diverse flora and fauna.

Seagrasses have high biological productivity, are efficient recyclers of nutrients and support a large biomass of consumers, especially those of fisheries importance. It has been suggested that 400 square metres of seagrass (10 metres long and 40 metres wide) can support 2000 tonnes of fish a year. Fiji's coastal fisheries productivity depends greatly on seagrass habitats. For example, juvenile Emperors (kawago - *Lethrinus nebulosus*; sabutu, cabutu - *L. atkinsoni*; kabatia, kabatiko - *L. harak*) live in the shallow, inshore areas such as seagrass and mangrove before they move to deeper water as adults (Richards *et al.* 1994). The ark shell (kaikoso, qeqe - *Anadara cornea*) although patchily distributed, are common in seagrass meadows of Laucala Bay (Butler 1983). It has been suggested that kaikoso recruits into sand/seagrass areas, though it can live in mud where the sediment is dynamic (due to floods and other causes) when older (Butler 1983).

Seagrass is also a nursery habitat for the witch prawn (uranicakau - *P. canaliculatus*). Post-larvae settle into seagrass meadows on the intertidal mudflats in June and November of each year, after adults spawn in the deep channels of Laucala Bay (Choy 1982). The post-

larvae grow in the nursery grounds for approximately 5 months, until as juveniles they move offshore into the adult stocks, eventually mating and spawning in October-November (Choy 1982). Seagrass are also important habitats for moci (mangrove prawns/shrimps – *Palaemon* sp.) and octopus (kuita, sulua - *Octopus* sp.) (Lewis 1985; Richards *et al.* 1994). Seagrass is also one of the food items of rock lobsters (e.g., uraukula, uraudina, urautamata - *Panulirus* spp) (Lewis 1985).

Fiji's extensive pastures of seagrass are also a significant resource for green turtles in the central south Pacific region. Green turtles spend most of their adult life foraging in Fijian waters, occupying home ranges averaging 27 km^2, taking only brief migrations (up to 1066km) to French Polynesia, American Samoa, Tonga and Cook Islands to nest (Craig *et al.* 2004). The seagrass foraging areas in Fiji may well be providing foraging habitat for over half of the adult greens in the central South Pacific. This is possibly a consequence of lower availability of turtle food east of Fiji where most islands are small, steep and have limited areas suitable for seagrass. The need to protect such foraging areas is becoming widely recognized as a critical part of sea turtle conservation.

Five seagrass species and one subspecies are reported from the Fiji Islands: *Halodule pinifolia, Halodule uninervis, Halophila ovalis, Halophila ovalis* ssp. *bullosa, Halophila decipiens* and *Syringodium isoetifolium* (Spalding *et al.* 2003; Skelton and South 2006). Records of *Thalassia hemprichii, Cymodocea serrulata, Halophila minor*, and *Halophila ovata* credited to Fiji are either erroneous or remain to be verified. All the species within Fiji waters have an Indo-Pacific distribution, except *H. ovalis* ssp. *bullosa* which is endemic to Fiji, Tonga, and Samoa (McMillan and Bridges 1982).

Halodule pinifolia is generally found in the high intertidal to upper subtidal areas of sheltered bay, reef platforms and in high energy locations. *H. pinifolia* often forms homogenous patches or occasionally intermixes with other seagrass species including the closely related *H. uninervis*. They are easily distinguishable in the field by their much narrower blade size compared with that of *H. uninervis* (1 mm versus 4 mm). Waycott *et al.* (2004) suggested that *H. pinifolia* and *H. uninervis* are conspecific, recognising that the plasticity of blade size is attributed to local conditions. Nevertheless, in Fiji we retain them as separate entities, as there is no sufficient evidence from Fijian material to support this merger. Future studies, both ecological and molecular, would help to clarify this.

Halodule uninervis is found from intertidal to 30m in sheltered or exposed coral reefs, in creeks and mangroves. *H. uninervis* often forms dense meadows at some sites, or is patchy and intermixed with other seagrass species (viz. *H. uninervis, S. isoetifolium,* or *Halophila* spp.).

Halophila ovalis is the most eurythermic of all seagrasses in Fiji and extends from the intertidal to 10-12m deep. First reported in Fiji in 1874 from Viti Levu, there are both bullate (blister or pucker-like) and smooth leaf forms (den Hartog 1970). The bullate form is recognized as a subspecies *H. ovalis* ssp. *bullosa* because it appears sufficiently distinct (McMillan and Bridges 1982). However the synonymy adopted here follows Waycott *et al.* (2004) who consider *H. ovalis* to be a complex of closely related entities whose leaves are highly plastic especially in relation to blade size, shape, colour, and texture (Waycott *et al.* 2002). The bullate forms have only been reported from Samoa, Tonga and the Fiji islands.

H. ovalis forms dense meadows in some locations, but is frequently encountered in small patches. It tolerates a wide variety of substrata from fine muddy sand to coarse sand, mixed sandy-rubble or large boulders with sandy patches.

Halophila decipiens is a recent addition to the seagrass inventory in Fiji. It is no surprise that it occurs in Fiji, as the species is pan tropical and has been reported in New Caledonia and Tahiti from the mid-late 1800's (den Hartog 1970). Globally, *H. decipiens* is a sciophilous species which occurs from the water surface to a depth of 85m (Cargados Carajos Shoals, Mascarene Islands in the Indian Ocean). In the Fiji Islands it occurs from 10–25 m depth and has only been found growing in the fine muddy/sandy substratum along the reef channels of the Great Sea Reef (Skelton and South 2006). The plants form sparse patches and grow to 40 mm tall. *H. decipiens* is distinguished from *H. ovalis* and its subspecies *bullosa* by the presence of marginal serrations and hairs on either side of the leaf blade.

Syringodium isoetifolium is usually found in the shallow subtidal areas (1–6 m depth), with some meadows are occasionally exposed during extreme low tide on reef flats. Earliest records are from 1926 in Suva Bay (den Harotg 1970). *Syringodium* is known to be more tolerant of oxidized substrata than other seagrass species and it has been reported that *Syringodium* will take over as a pioneer after a disturbance (den Hartog, 1977). *S. isoetifolium* also has the ability to utilise a very high proportion of the available dissolved inorganic carbon compared to other seagrass species. Such an environment provides *S. isoetifolium* with a competitive advantage, especially when combined with disturbances that remove existing seagrass species.

A number of general parameters are critical to whether seagrass will occur along any stretch of coastline. These include physical parameters that regulate the physiological activity of seagrasses (temperature, salinity, waves, currents, depth, substrate and day length), natural phenomena that limit the photosynthetic activity of the plants (light, nutrients, epiphytes and diseases), and anthropogenic inputs that inhibit the access to available plant resources (nutrient and sediment loading). Various combinations of these parameters will permit, encourage or eliminate seagrass from a specific location. In Fiji, seagrasses are distributed throughout the Islands and local conditions may often determine which seagrass species are present.

VITI LEVU

Along northern Viti Levu, *H. uninervis*, *H. pinifolia*, *H. ovalis* and *S. isoetifolium* are present on intertidal mudflats and fringing reefs (e.g., Navolau village, Raki Raki) (Pers. Obs.). However, most information for Viti Levu is concentrated along the southern shores.

Coral coast

The Coral Coast stretches along an 80 km length of coast on the southern side of Viti Levu. It is the longest chain of fringing reefs in Fiji. The Coral Coast embraces Natadola Beach in the west, to Pacific Harbour further to the east. Seagrass meadows cover the nearshore areas of the fringing reef, where these is sufficient sediment depth and stability.

Seagrass meadows have been surveyed on the shallow mudflat on the north west of Likuri Island (Robinson Crusoe Resort), just off the start of the Coral Coast. The surveys identified *Syringodium isoetifolium* meadows which had the highest algal cover (probably *Dictyota* sp) of all the habitats examined around the island (Sykes 2003). The shallow mudflats have been extensively over-fished over a long period by village subsistence fishers, and small scale commercial fishers from the main island. It is also heavily affected by silt run-off from the nearby river. Coral health is poor. The survey was part of a project to develop a standard Environmental Impact Assessment technique that would be suitable for use at small resorts throughout the Fiji islands.

A few kilometres south, small patches of *H. uninervis* and *H. pinifolia* can be found on the fringing reefs of Natadola. The seagrass has very little epiphyte cover and the environment excellent water clarity. Although relatively pristine, the meadows are threatened by adjacent coastal development.

In the nearby Cuvu Bay, there are large seagrass meadows, but they are also threatened by turbid flood waters from the Voua river. Meadows are dominated by *Halophila ovalis* ssp. *bullosa*, *Halodule uninervis* with some *Halodule pinifolia. H. uninervis* is much denser in the channels or intertidal pools. Two Seagrass-Watch sites (NN1, NN2) are located on intertidal banks separating Cuvu village and Shangri-la Fijian Resort. The sites are monitored by Alfred Ralifo, Nadroga Navosa Provincial High School students and Seagrass-Watch HQ. Mounded topography formed by callianassid shrimp is ubiquitous on the sandy carbonate intertidal banks. At low tide, villagers fish and glean the intertidal flats.

Seagrasses are also found on the inshore area from the Naidiri River to Nakorola Point at Malomalo. The Malomalo seagrass meadows are dominated by *Halodule uninervis* (Solomona *et al.* 2002). Their interlacing rhizome / root mat providing stability to the sand and rubble zone prevalent in this area. They also function as a nursery for organisms, although crab holes and the synaptid *S. maculata*, were the only form of species presence recorded in these meadows.

In the heart of the Coral Coast is Tagaqe where a Seagrass-Watch site (TQ1) is established in the 1.6 hectare *Halodule pinifolia* dominated meadow. The site in on the intertidal reef-flat in front of Hideaway Resort, and is monitored by Seagrass-Watch HQ. The site is also immediately adjacent to a “tabu” area declared by Tagaqe village. Just over 20% of the seagrass meadow is within the designated tabu area. Four seagrass species are found in the meadow: *Halodule uninervis, Halodule pinifolia, Halophila ovalis* ssp. *bullosa* and *Syringodium isoetifolium*. The most noticeable feature of the meadow condition is the high amount of epiphyte cover on the leaves, possibly a consequence of elevated water column nutrients.

Suva

Nukubocu is part of a barrier reef system which encloses Laucala Bay and Suva harbour, in the Suva Peninsula. Seagrasses are widespread in the back reef regions, and dense *Syringodium isoetifolium* meadows fringe the channels between the reefs. Until recently, coral sand was also dredged from the back reef region of Nukubocu reef by a local industry as raw material in the cement making process. *Halodule uninervis, Halodule*

pinifolia and *Halophila ovalis* ssp *bullosa* are also found on the reef flat and back reef, often in a mosaic of patchy meadows

Seagrass meadows also cover much on the intertidal reef platform surrounding Suva Point and surrounding the shores of Laucala Bay. Seagrass-Watch has one site (SV1) established on the intertidal banks at Nasese. The meadow is comprised of *Halodule uninervis, Halodule pinifolia* and *Halophila ovalis* ssp *bullosa*. Of concern, are the high amounts of epiphytic algae covering the leaves and macroalgae, which formed a thick mat over the grass.

Tailevu (Bau landing to Natovi)

The area north east of Suva has patch reef and fringing reef complexes, quite unique in the south Pacific. Shallow subtidal areas of *Halodule uninervis, Halophila ovalis,* and *Syringodium isoetifolium* are reported to be found in the area, although no detailed survey has been conducted (Nair *et al.* 2006).

LOMAIVITI GROUP

Seagrass meadows are scattered throughout the Lomaiviti Group, where they are recognised as significant areas for green turtle foraging.

Ovalau

Significant seagrass meadows are present on the intertidal fringing reefs and within the lagoons surrounding Ovalau. Dense meadows of *Syringodium isoetifolium* are located inside the barrier reef on either side of the entrance to Levuka Harbour. A narrow band of *Halophila ovalis* separates the dense *Syringodium isoetifolium* meadows from the back reef, and isolated patches of *Halodule uninervis* are scattered throughout.

Sparse *Halodule pinifolia* and *Halophila ovalis* ssp. *bullosa* meadows are scattered across the intertidal fringing reefs between Nacobo and Cawaci (incl. Levuka seafront and Vagadaci Bay). Meadows are denser and more diverse adjacent to mangrove areas. Large intertidal meadows of *Halodule uninervis, Halodule pinifolia, Syringodium isoetifolium* and *Halophila ovalis* ssp. *bullosa* are found on the fringing reef has opposite St John's College at Cawaci. Two Seagrass-Watch sites (CW1, CW2) are located in front of St John's College, monitored by Masao Yoshida, Shaun Ashley, Charlene Ashley and Seagrass-Watch HQ. In recent years the reef has experienced blooms of green algae and physical disturbance from PWD extraction activities. The fringing reef is popular at low tide with villagers fishing and gleaning.

Gau Island

Seagrass meadows have been reported on the fringing reef platforms of Gau, adjacent to Lovu and Vadravadr villages. The shoreline of Tikina Sawaieke presents a series of extensive seagrass meadows located near mangroves and mudflats. Two seagrass species (*Halodule uninervis* and *Halodule ovalis*) are found in meadows where Halodule uninervis is the dominate species closer to shore, with higher cover, decreasing seaward where Halodule ovalis become more dominant (Fiu 2005). Overall, seagrass meadows in Tikina

Sawaieke are relatively healthy in terms of the extensive growth to at least 0.5 km from shore. Villagers have noticed the regrowth of the seagrass in their local shore area as a healthy indication of the marine environment; however these areas are being impacted from boating activity.

Kadavu

Significant *Syringodium isoetifolium* meadows have been reported and studied in the lagoon at Dravuni. *Halodule uninervis*, *Halodule pinifolia* and *Halophila ovalis* ssp *bullosa* are also present in varying amounts. Seagrass meadows are also reported from the south eastern coasts of Kadavu Island (e.g., adjacent to Matava Resort), although no species are described. As the islands are protected by the Great Astrolabe Reef, the longest barrier reef in Fiji, it is possible that extensive subtidal meadows may exist.

VANUA LEVU

Until recently little was known about the northern shores of the second largest island in Fiji, Vanua Levu, in particular Cakaulevu (literally the 'Big Reef') or the Great Sea Reef. Running parallel to the coastline of the provinces of Macuata and Bua, the Great Sea Reef area (including barrier reef with inshore mangrove islands and fringing reefs) was identified as a globally significant area by a variety of stakeholders at the FIME vision workshop in December 2003 (Heaps 2005; Nair *et al.* 2006). In December 2004, a biological survey expedition of the area further identified significant seagrass meadows (*Halodule uninervis, Halodule pinifolia, Halophila ovalis, Halophila ovalis* ssp *bullosa* and *Syringodium isoetifolium*) surrounding the coral/mangrove islets of Vatuka. During this expedition, the first collection of *Halophila decipiens* was recorded for Fiji (Skelton and South 2006).

To the north east, there have been anecdotal reports of *Halodule uninervis* and *Halophila ovalis* on fringing reefs in the Nabuna area and on the mudflats and slopes within Natewa Bay (Nair *et al.* 2006).

On the southern shores of Vanua Levu, seagrasses appear to be restricted to bays which provide some protection from the prevailing weather. Significant areas of seagrass (*Halodule uninervis, Halodule pinifolia, Halophila ovalis* ssp *bullosa* and *Syringodium isoetifolium*) have been reported in the past in Wainsunu Bay and on the scattered reefs of Savusavu Bay, although these appear to have declined in recent years (Nair *et al.* 2006).

LAU GROUP

Sparse to moderately abundant Halodule uninervis and Halophila ovalis meadows are common on reef platforms within the group. On Kabara, seagrass meadows are located on both leeward and windward sides (Fiu 2004). The meadows are composed of *Halophila ovalis* and *Halodule uninervis* and abundance is high. Seagrass meadows on the leeward (protected) side of the island (e.g., adjacent to Naikeleaga) are higher in abundance with more macroalgae, than compared to the windward meadows (e.g., adjacent to Udu). Invertebrates (including urchins, sea hares and clams) and turtles however, were higher in windward meadows than leeward.

Fulaga in southern Lau has an interesting outlay of limestone islets which creates marine caves, fringing and atoll reefs and lagoons which host seagrass meadows with *Halodule* species dominant (Nair *et al.* 2006).

YASAWA GROUP

In the Yasawa Group, seagrass has been reported from the fringing reefs and the lee slopes of islands (Nair *et al.* 2006). Unidentified seagrass has been described in patches on white, coarse, coronous sand adjacent to Malakati Village, Nacula Island (Parkinson 1982). *Halophila* spp. have also been reported from the subtidal slopes in protected bays of the island group (V. Vuki Pers. Comm.). Unfortunately detailed information is not readily available, although it can possibly be gleaned from consultancy reports and environmental impacts assessments associated with proposed developments in the region.

MAMANUCA GROUP

The Mamanuca Islands in western Fiji have been the focus of tourism development in Fiji for many years and the industry is very much aware of the value of conserving the reef habitats and fostering sustainable development.

During a survey to characterise the major benthic marine habitats of five reef complexes in the Mamanuca Islands, baseline transects were examined at Mana Island, Navini Island, the Namotu and Malolo Island groups (Harborne *et al.* 2001). From a preliminary habitat map produced using 'Landsat 7' satellite imagery, coupled with ground truthing characterisation, the area occupied by each of the habitats within the project area (1826 km^2) was calculated. Only one of the seven major benthic classes included seagrass and it was estimated to cover 6.46 km^2. As the habitat discrimination was no more detailed than "sand with sparse algae and seagrass", the species of seagrass present were not identified, but possibly include *H. pninfolia* and *H. ovalis*, similar to nearby Castaway Island.

During baseline surveys to characterise the marine habitats adjacent to Castaway Island, Solandt *et al.* (2002) identified sparse *Halophila ovalis* and *Halodule pinifolia* meadows from 4 transects on the fringing reefs and in the shallow subtidal waters.

No other information is available on seagrasses of the Mamanuca Islands, however large meadows of *Syringodium isoetifolium*, *Halophila ovalis* and *Halodule pinifolia* are known to fringe the adjacent Viti Levu coast surrounding Denarau Island (e.g., Sofitel and Sheraton Resorts) (Pers. Obs.).

L: *Syringodium isoetifolium* meadow, C: *Halodule pinifolia* meadow, R: *Halophila ovalis* ssp. *bullosa* meadow
Photos: Denarau, Viti Levu, Jan 2007, by Len McKenzie

ROTUMA

Only one seagrass species has been reported from Rotuma: *Syringodium isoetifolium*. In late 2004 and 2005, Laje Rotuma conducted seagrass monitoring in the *Syringodium isoetifolium* in Motusa Bay (Alfred Ralifo, Pers. Comm.). The results showed a percentage seagrass cover increased by 6% from 2004 to 2005, indicating that the seagrass was relatively healthy. There was also a reduction in the percentage epiphytic and macro-algae. The mean number of animals found on the seagrass meadow also increased slightly from 2004 to 2005. Seagrass has also been reported in Maka Bay (Nair *et al.* 2006).

Studies on seagrasses in Fiji are limited. The only detailed studies of biological processes of seagrass meadows have been conducted at Dravuni Island: nutrient dynamics and carbon/nitrogen (Yamamuro *et al.* 1993); growth and production (Aioi and Pollard 1991); irradiance/productivity (Pollard and Aioi 1991); litter production and decomposition (Pollard and Kogure 1993).

The total area of seagrasses world-wide is estimate to be at least 177,000 sq km (Spalding *et al.* 2003). The total area of seagrass meadows in the Fiji Islands however is unknown, as no broad scale mapping exercise has been conducted (Coles *et al.* 2003). This is because mapping in tropical systems is generally from field observations as remotely sensed data (satellite and aerial imagery) is often ineffective for detecting tropical seagrasses of low biomass and/or in turbid water (McKenzie *et al.* 2001). New technologies may assist and there are several projects currently underway attempting to at map Fiji's seagrass resources, mainly at the local level.

IMPACTS

Seagrasses in Fiji are threatened by a number of impacts, including tourism, improper methods of disposal of solid waste, sewage pollution, depletion of fisheries, coral harvesting, coastal erosion, storm surge and flooding, siltation of rivers and coastal areas as a result of soil erosion inland agriculture and forestry and sand mining. Long-term ecological studies of seagrass meadows on Suva Reef revealed that losses occurred in some years because of major disturbances such as tsunami, cyclones and flood (Vuki 1994). Analysis of spatial pattern of seagrass meadows from airborne images showed clearly that there were oscillations in abundance on Suva Reef; seagrass meadows extended towards the lagoon in some years and regressed in others. Regressions in seagrass meadows on Suva back reef areas were attributed to high turbidity and siltation cause by foreshore reclamations (Vuki 1994). Coastal modifications mostly occur near major urban areas and coastal towns. At least 110 hectares have been reclaimed in Suva since 1881 (Vuki *et al* 2000)

All of these issues and associated threats pose a challenge for conserving healthy seagrass meadows in the Fiji Islands.


Above left: *Halodule uninervis & Halophila ovalis* ssp. *bullosa*, Nadroga Navosa, Viti Levu, Jan 2007, photo by Len McKenzie
Above right: *Halodule pinifolia* meadow, Natadola, Viti Levu, April 2006, photo by Len McKenzie
Below: *Halophila ovalis* ssp. *bullosa*, Korotogo, Viti Levu, April 2006, photo by Len McKenzie

For more information, visit www.seagrasswatch.org

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