Seagrass-Watch

Proceedings of a Workshop for Monitoring Seagrass Habitats in the Fiji Islands

Marine Studies Conference Room, University of the South Pacific,
Laucala Campus, Laucala Bay Road, Suva, Fiji
1-2 March 2010

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Disclaimer

Information contained in this publication is provided as general advice only. For application to specific circumstances, professional advice should be sought.

Seagrass-Watch HQ has taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

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Front cover photos (left to right) Laucala Bay, *Halophila ovalis* ssp. *bullosa* and Levuka Reef by Len McKenzie

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Marine Studies Conference Room, University of the South Pacific, Laucala Campus, Laucala Bay Road, Suva, Fiji

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Overview

Seagrass-Watch is a global scientific, non-destructive, seagrass assessment and monitoring program.

Often governments are unable to protect and conserve seagrass meadows without the assistance of local stakeholders (e.g., local residents, schools, tertiary institutions, non-government organisations). Seagrass-Watch is a monitoring program that brings people together for seagrass conservation. It identifies areas important for seagrass species diversity and conservation. The information collected can be used to assist the management of coastal environments and to prevent significant areas and species being lost.

Monitoring seagrass resources is important for two reasons: it is a valuable tool for improving management practices; and it allows us to know whether resource status and condition is stable, improving or declining. Successful management of coastal environments (*including seagrass resources*) requires regular monitoring of the status and condition of natural resources.

Early detection of change allows coastal management agencies to adjust their management practices and/or take remedial action sooner for more successful results. Monitoring is important in improving our understanding of seagrass resources and to coastal management agencies for:

- *exposing coastal environmental problems before they become intractable,*
- *developing benchmarks against which performance and effectiveness can be measured,*
- *identifying and prioritising future requirements and initiatives,*
- *determining the effectiveness of management practices being applied,*
- *maintaining consistent records so that comparisons can be made over time,*
- *developing within the community a better understanding of coastal issues,*
- *developing a better understanding of cause and effect in land/catchment management practices,*
- *assisting education and training, and helping to develop links between local communities, schools and government agencies, and*
- *assessing new management practices.*

Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. To protect the valuable seagrass meadows along our coasts, everyone must work together.

The goals of the Seagrass-Watch program are:

- *to educate the wider community on the importance of seagrass resources*
- *to raise awareness of coastal management issues*
- *to build the capacity of local stakeholders in the use of standardised scientific methodologies*
- *to conduct long-term monitoring of seagrass & coastal habitat condition*
- *to provide an early warning system of coastal environment changes for management*
- *to support conservation measures which ensure the long-term resilience of seagrass ecosystems.*

This workshop is jointly hosted by BioNET-PACINET, the University of the South Pacific, Coast2Reef ETC and Seagrass-Watch HQ, with local coordination by Dr Posa Skelton. As part of this workshop we will

- *learn seagrass taxonomy*
- *discuss the present knowledge of seagrass ecology,*
- *discuss the threats to seagrasses*
- *learn techniques for monitoring seagrass resources, and*
- *provide examples of how Seagrass-Watch assists with the management of impacts to seagrass resources and provides an understanding of their status and condition.*

The following information is provided as a training guide and a reference for future Seagrass-Watch monitoring activities. For further information, please do not hesitate to contact us at

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Photo: Len McKenzie.

Workshop leaders

Len McKenzie

Len is a Principal Scientist with Fisheries Queensland (a service of the Department of Employment, Economic Development and Innovation) and Seagrass-Watch Program Leader. He is also chief investigator for the Great Barrier Reef Marine & Tropical Scientific Research Facility (MTSRF) task on the condition, trend and risk in coastal seagrass habitats, Task Leader of the Reef Rescue Marine Monitoring Programme – Intertidal Seagrass Monitoring and project leader for a series of projects involving the assessment and sustainable use of coastal fisheries habitats. Len has over 20 years experience as a research scientist on seagrass ecology, assessment and fisheries habitats. This includes experience within Australia and overseas in seagrass research, resource mapping/ assessment and biodiversity. He has provided information on seagrass communities that has been vital in management of seagrass resources of the Great Barrier Reef and also at the state, national and international levels. He has also advised on fisheries and coastal resource-use issues for managers, fishing organisations, conservation and community groups. Len is also the Secretary of the World Seagrass Association.

Current Projects

- Seagrass-Watch
- Status and mapping of seagrass resources in Queensland
- Condition, trend and risk in coastal habitats: Seagrass indicators, distribution and thresholds of potential concern
- Identification of indicators and thresholds of concern for water quality and ecosystem health on a bioregional scale for the Great Barrier Reef
- Assessment of primary and secondary productivity of tropical seagrass ecosystems
- Investigations on the macrofauna associated with seagrass meadows
- Great Barrier Reef Water Quality Protection Plan – Reef Rescue Marine Monitoring Program: seagrass

Rudi Yoshida

Rudi is a Scientific Assistant with Fisheries Queensland (a service of the Department of Employment, Economic Development and Innovation). Rudi has over 12 years experience in seagrass related research and monitoring. He is also a core member of Seagrass-Watch HQ, and ensures data submitted is managed and QA/QC protocols applied. He is also responsible for maintenance of the Seagrass-Watch website.

Current Projects

- Seagrass-Watch
- Great Barrier Reef Water Quality Protection Plan – Reef Rescue Marine Monitoring Program: seagrass

Agenda - Level 1 *(basic)*

Monday 1st March 2010

Morning	0930 - 0940 *(10min)*	Welcome & Introduction
	0940 – 1000 *(20min)*	Seagrass Biology and Identification
	1000 – 1030 *(30min)*	**Classroom activity:** Seagrass Identification
	1030 – 1100 *(30min)*	Seagrass Identification *continued*
	1100 – 1115 *(15min)*	**Classroom activity:** how to prepare a seagrass press specimen
	1115 - 1215 *(60min)*	Seagrass Ecology and Threats
Afternoon	1215 - 1300	*Lunch*
	1300 – 1315 *(15min)*	Seagrass monitoring
	1315 - 1400 *(45min)*	Seagrass-Watch: how to sample
	1400 - 1445 *(45min)*	Seagrass-Watch: how data is used
	1445 – 1500 *(15min)*	*Wrap-up for day*

Tuesday 2nd March 2010

1230 - 1245 *(15min)* — Safety briefing & risk assessment

1245 - 1445 *(2hrs)* — **Field exercise:** Seagrass-Watch monitoring

Where: Nasese (SV2)

How to get there:
- *Meet at car park opposite Corpus Christi Teachers College, Laucala Bay, Suva*
- *be punctual*
- *be well rested, well fed, and well hydrated beforehand. Do not come if you are not feeling well.*

What to bring:
- *hat, sunscreen (Slip! Slop! Slap!)*
- *dive booties or old shoes that can get wet*
- *drink/refreshments and energising snack*
- *wet weather gear: poncho/raincoat*
- *insect repellent*
- *polaroid sunglasses (not essential)*
- *simple medical kit in case of injuries to yourself*
- *change of footwear and clothes*
- *enthusiasm*

You will be walking across a seagrass meadow exposed with the tide, through shallow water.

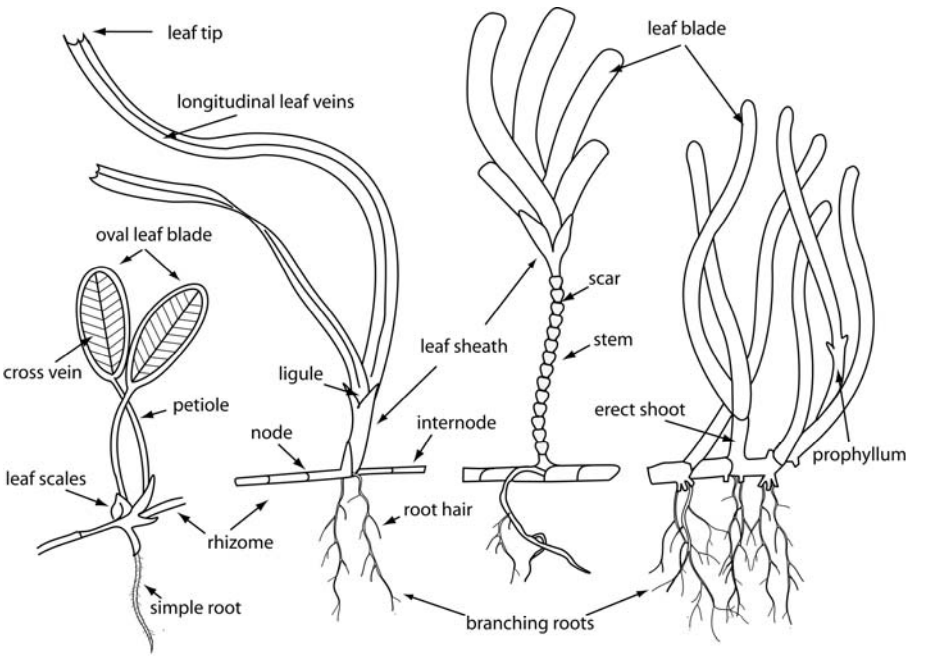
Please remember, seagrass meadows are an important resource. We ask that you use discretion when working/walking on them.

1445 – 1500 — Wrap up *(on foreshore)*
- check gear
- feedback

Low tide: 0.4m at 1344hrs

Background

Seagrasses are unique flowering plants that have evolved to live in sea water. Seagrasses belong to a group of plants known as angiosperms (flowering plants).



Composite illustration demonstrating morphological features used to distinguish main seagrass taxonomic groups.

Various common names are applied to seagrass species, such as turtle grass, eelgrass, tape grass, spoon grass and shoal grass. These names are not consistently applied among countries. Coastal communities would almost certainly recognise the term “turtle grass” as referring to the shallow subtidal and intertidal seagrasses that turtles are associated with.

Like terrestrial (land living) plants, a seagrass can be divided into its **veins** (lignified conducting tissue that transports food, nutrients and water around the plant), stem, roots (buried in the substrate) and reproductive parts such as flowers and fruits. Algae do not have veins in their leaves nor do they possess roots (anchoring to the surface of the substrate by a holdfast) or produce flowers or seeds.

They are called “seagrass” because most have ribbon-like, grassy leaves. There are many different kinds of seagrasses and some do not look like grass at all. Seagrass range from the size of your fingernail to plants with leaves as long as 7 metres. Some of the shapes and sizes of leaves of different species of seagrass include an oval (paddle or clover) shape, a fern shape, a long spaghetti like leaf and a ribbon shape. Species that have a paddle or fern shaped leaf are called *Halophila*. Ones that have a ribbon shaped leaf are the *Cymodocea, Thalassia, Thalassodendron, Halodule* and *Zostera*. Spaghetti-like seagrass is called *Syringodium*. At the base of a leaf is a sheath, which protects young leaves. At the other end of a leaf is the tip, which can be rounded or pointed. A prophyllum is a single leaf arising immediately from the horizontal rhizome instead of from an erect shoot. This feature is unique to the genus *Zostera*.

Seagrass leaves lack stomata (microscopic pores on the under side of leaves) but have thin cuticle to allow gas and nutrient exchange. They

Seagrass are marine flowering plants

Seagrasses have roots, stems and leaves

Seagrass is different to seaweed (algae) as they have internal veins, true roots and produce flowers

Leaves of different seagrass species can be shaped like a flattened ribbon, look like a fern, round like a clover, or even spaghetti shaped also possess large thin-walled aerenchyma. The aerenchyma are commonly referred to as veins as they carry water and nutrients throughout the plant. Aerenchyma is specialized tissue having a regular arrangement of air spaces, called lacunae, that both provides buoyancy to the leaves and facilitate gas exchange throughout the plant. Leaves have a very thin cuticle, which allows gas and some nutrient diffusion into them from the surrounding water. Veins can be across the leaf blade or run parallel to the leaf edge. Also within the leaves are chloroplasts, which use the suns light to convert carbon dioxide and water into oxygen and sugar (photosynthesis). The sugar and oxygen are then available for use by other living organisms.

Seagrass have veins and air channels in their leaves and stems so they can carry water, food and absorb gases

Seagrasses rely on light to convert carbon dioxide and water into oxygen and sugar (photosynthesis)

The roots and horizontal stems (**rhizomes**) of seagrass are often buried in sand or mud. They anchor the plant, store carbohydrates and absorb nutrients. Roots can be simple or branching and all have fine hairs to help absorb nutrients. Rhizomes are formed in segments with leaves or vertical stems rising from the joins, called **nodes** or scars. Sections between the nodes are called internodes. Seagrasses depend upon the growth of rhizomes to increase the area they occupy. This vegetative growth is the most common mode of growth for seagrasses. Although the rhizome mainly runs horizontally, some lateral branches are more or less erect and bear leaves (erect shoots). Sometimes the leaves are on a special type of stalk, called a petiole.

Roots can be simple or branching and all have fine hairs to help absorb nutrients

The Roots and Rhizomes of seagrasses are well endowed with aerenchyma and the lacunae are extensive and continuous with leaf tissues. **Oxygen** transport to the roots creates an oxic environment around the roots, facilitating nutrient uptake.

Seagrass pump oxygen into the sediment via their roots

Seagrasses have flowers and pollination systems that are well adapted for pollination by water. Seagrass form tiny flowers, fruits and seeds. Most seagrasses have separate male and female plants. In most species, flowers are small, white and are borne at the base of the leaf clusters. The stamens (male parts) and pistils (female parts) extend above the petals to facilitate pollen release and pollination respectively.

Seagrass have flowers, fruits and seeds

Most seagrasses reproduce by pollination while submerged and complete their entire life cycle underwater. Pollination in seagrasses is hydrophilic (aided by water), and can occur by: (i) pollen transported above water surface (e.g., *Enhalus*); (ii) pollen transported on water surface (e.g., *Halodule*), or; (iii) pollen transported beneath water surface (e.g., *Thalassia*).

Pollination occurs in the water

Seagrass pollen grains are elongated into a filamentous shape. The filamentous nature of pollen grains facilitates transport within the water medium. *Halophila* and *Thalassia* have spherical pollen grains, but they remain joined together in long chains, giving the same effect as having elongated, filamentous pollen grains.

Pollen from male seagrass flowers is mainly dispersed to female seagrass flowers by tidal currents

Seagrass taxonomy

Seagrasses are monocotyledons that are not true grasses (true grasses belong to the family Poaceae), but are rather more closely related to the lily family.

Seagrasses are not true grasses

Seagrasses evolved approximately 100 million years ago from land plants that returned to the sea in a least three separate lineages or families. Thus, seagrasses are not a taxonomically unified group but a

Seagrasses are more closely related to lilies 'biological' or 'ecological' group. The evolutionary adaptations required for survival in the marine environment have led to convergence (similarity) in morphology.

Seagrass evolved 100 million years ago from land plants that returned to the sea

Worldwide, there are about 12 major divisions, consisting of approximately 60 species of seagrass. The highest concentration of species occurs in the Indo-West Pacific region.

Over 30 species can be found within Australian waters. The most diverse seagrass communities are in the waters of north-eastern Queensland and southern Western Australia.

There are around 60 species of seagrass found in ocean throughout the world

Various common names are applied to seagrass species, such as turtle grass, eelgrass, tape grass, spoon grass and shoal grass. Seagrasses are not seaweeds. Seaweed is the common name for algae.

Seagrass requirements for growth

Seagrasses require light, nutrients, carbon dioxide, substrate for anchoring, tolerable salinity, temperature and pH to survive. The requirements for a seagrass to be able to exist in the marine environment include:

1. adaptation to life in saline (salty) medium
2. growth when completely submerged
3. anchoring system able to withstand the forces of wave action and tidal currents
4. hydrophilous pollination (pollination aided by water).

Seagrasses need plenty of sun and clean water to grow.

Seagrasses are physiologically adapted to life in sea water

The need for physiological adaptations to life in sea water is obvious when one considers that seagrasses evolved from land plants, and most land plants are unable to tolerate even small quantities of salt. In contrast to land plants, some seagrasses can tolerate a salinity range from 4 to 65 parts per thousand (2x seawater concentration). Typically, seagrasses grow best in salinities of 35 parts per thousand. Not all species tolerate all salinities equally well, and salinity tolerance may be a factor promoting different species distributions along salinity gradients, e.g., going up estuaries. Some seagrasses can survive in a range of conditions encompassing fresh water, estuarine, marine, or hypersaline (very salty). A limiting factor for many intertidal seagrasses is osmotic impacts resulting from hypersalinity due to evaporation

Seagrasses can tolerate a range of salinities. Some species are less tolerant than others

Seagrasses being plants need light for photosynthesis. Light availability is the most dominant overriding factor in seagrass growth. Seagrasses have high minimum light requirements (e.g. 10-20% on average, 4.4% minimum and 29% maximum depending on species) of surface irradiance) because: (i) they have a high respiratory demand to support a large non-photosynthetic biomass (e.g. roots, rhizomes); (ii) they lack certain pigments and therefore can utilise only a restricted spectral range; and (iii) they must regularly oxygenate their root zone to compensate for anoxic sediment. However, light in the intertidal can be in excess of requirements and excess light can cause temporary photo damage. UV exposure can also have significant impacts on seagrasses.

Light availability is the most important factor determining seagrass growth

Seagrasses require between 10-20% of surface light to grow

Temperature influences the rate of growth and the health of plants, particularly at the extremes. As water temperatures increase (up to 38ºC) the rate of photorespiration increases reducing the efficiency of photosynthesis at a given CO_2 concentration. The cause of thermal

Water temperature influences the rate of growth and the health of seagrass stress at higher temperatures (38ºC to 42ºC) is the disruption of electron transport activity via inactivation of the oxygen producing enzymes (proteins) of photosystem II. Above these temperatures many proteins are simply destroyed in most plants, resulting in plant death.

Seawater temperatures above 40ºC will stress seagrass. Death occurs at temperatures above 43ºC

Temperature also controls the range of pH and dissolved carbon dioxide (CO_2) concentrations in the water column; factors critical in plant survival in the marine environment.

Seagrasses require inorganic carbon for growth. They uptake inorganic carbon at the leaf surface via two pathways which are species-specific. Some species use bicarbonate (HCO_3^-) as an inorganic carbon source (eg *Halophila ovalis, Cymodocea rotundata, Syringodium isoetifolium* and *Thalassia*), whereas others use enzymes to make CO_2 available as the inorganic carbon source (eg *Enhalus acoroides, Halodule, Cymodocea serrulata*).

Seagrass require inorganic carbon for growth

Seagrass uptake carbon via two different pathways

Seagrasses require two key nutrients, nitrogen and phosphorous, for growth. In the coastal regions, seagrasses appear to be primarily limited by nitrogen and secondarily by phosphorus. The demand for nutrients by seagrasses appears to be seasonally dependent. During the growing season the demand for nutrients is high, however during the senescent season elevated nutrients may become toxic.

Seagrass require two key nutrients, nitrogen and phosphorous, for growth

The availability of nutrients to seagrasses may also be dependent on sediment quality / geochemistry. Bioavailability of nutrients is dependent on particle size and type. For example, clay content influences sediment adsorptive capacity — the more clays the greater the absorptive capacity — and, calcium carbonate binds phosphorus, limiting its bioavailability.

Nutrient availability to seagrass is dependent on the type of sediment they grow in

Sediment quality, depth and mobility are important factors for seagrass composition, growth and persistence. Most seagrasses live in sand or mud substrates where their roots and rhizomes anchor the plants to the see floor. Some seagrasses such as *Cymodocea* spp. prefer deeper sediments while others can tolerate a broad range of sediment depths. Colonising seagrasses such as *Halophila* spp. and *Halodule uninervis* are better suited to mobile sediments than larger species. The biogeochemical characteristics of sediment that can affect the nutrient content/binding capacity, organic content and oxygen levels. Seagrasses are unable to grow in sediments of high organic content.

Most seagrass live in sand or mud sediments

Sediment movement can determine the presence of seagrass species

Currents and hydrodynamic processes affect almost all biological, geological and chemical processes in seagrass ecosystems at scales from the smallest (physiological and molecular) to the largest (meadow wide). The pollination of seagrass flowers depends on currents and without current flows, vegetative material and seeds will not be transported to new areas, and species will not be exchanged between meadows. Factors such as the photosynthetic rate of seagrasses depend on the thickness of the diffusive boundary layer that is determined by current flow, as is the sedimentation rate. Both influence growth rates of seagrass, survival of seagrass species and overall meadow morphology.

Tidal currents are important for pollination and exchange of gases from the water to the plant

Where are seagrasses found?

Seagrasses are found in ocean throughout the world. They occur in tropical (hot), temperate (cool) and the edge of the artic (freezing)

Seagrass are commonly found in estuaries, shallow coastal locations, and on reef-tops.

regions. Seagrass are mainly found in bays, estuaries and coastal waters from the mid-intertidal (shallow) region down to depths of 50 or 60 metres. Most species are found in clear shallow inshore areas between mean sea-level and 25 metres depth.

Seagrass are mainly found in clear shallow inshore areas between mean sea-level and 25 metres depth.

Seagrasses survive in the intertidal zone especially in locations sheltered from wave action or where there is pooling of water at low tide, (e.g., reef platforms and tide pools), which protects seagrass from elevated temperatures and drying.

Seagrasses inhabit all types of ground (substrates), from mud to rock. The most extensive seagrass meadows occur on soft substrates like sand and mud.

The depth range of seagrass is most likely to be controlled at its deepest edge by the availability of light for photosynthesis. Exposure at low tide, wave action and associated turbidity and low salinity from fresh water inflow determines seagrass species survival at the shallow edge.

The depth that seagrass are found underwater depends on the light availability (water clarity)

Seagrass plants form small patches that develop into large continuous meadows. These meadows may consist of one or many species: sometimes up to 12 species present within one location.

Seagrass plants form small patches that develop into large meadows

How are seagrasses important to the marine ecosystem?

Seagrass communities are one of the most productive and dynamic ecosystems globally. Seagrasses may significantly influence the physical, chemical and biological environments in which they grow by acting as 'ecological engineers'. They provide habitats and nursery grounds for many marine animals and act as substrate stabilisers.

Seagrasses are important habitat and feeding grounds for marine organisms.

Seagrass meadows are highly productive. They have been documented to create habitat complexity compared with unvegetated areas, providing up to 27 times more habitable substrate, as well as providing refuge and food for a range of animals. About 40 times more animals occur in seagrass meadows than on bare sand.

About 40 times more animals occur in seagrass meadows than on bare sand.

One of the most important roles of seagrasses is providing a nursery and shelter area for fish and prawns which are valuable to fisheries. Juveniles of some important species which depend on seagrass meadows include fish such as perch, mullet, whiting, tailor, bream, snappers, emperors and sweetlips. Commercial penaeid prawns such as red spot king, brown tiger, grooved tiger and endeavour also live in seagrass meadows as juveniles. Tropical rock lobsters also live in seagrass meadows as juveniles. Shellfish such as some oysters and pearl shell may be more likely to settle and survive where there is seagrass. Juvenile and adult sandcrabs and flathead are just two species which spend most of their lives in seagrass meadows, where there is not only food but also protection from strong tidal currents and predators. Larger predatory animals such as herons, cormorants, sharks, barramundi, salmon, crocodiles, *etc*, are also attracted to the seagrass meadows by the schools of forage fish which seek shelter there.

Seagrasses are important nursery grounds for fish, and they support many human commercial activities.

Seagrass meadows are a major food source for a number of grazing animals and are considered very productive pastures of the sea. The dugong (*Dugong dugon*) and the green turtle (*Chelonia mydas*) mainly feed on seagrass. An adult green turtle eats about two kilograms of seagrass a day while an adult dugong eats about 28 to 40 kilograms a day. Both dugongs and turtles select seagrass species for food which

Dugongs can eat up to 40kg of seagrass per day.

are high nitrogen, high starch and low fibre. For example, the order of seagrass species preference for dugongs is *Halophila ovalis* > *Halodule uninervis* > *Zostera capricorni*. In sub-tropical and temperate areas, water birds such as black swans also eat seagrass.

Dugongs and turtles select seagrass species for food which are high nitrogen, high starch and low fibre

Decomposing seagrasses provide food for benthic (bottom-dwelling) aquatic life. The decaying leaves are broken down by fungi and bacteria which in turn provide food for other micro-organisms such as flagellates and plankton. Micro-organisms provide food for the juveniles of many species of marine animals such as fish, crabs, prawns and molluscs.

Seagrasses also contribute to the productivity of ecosystems via the detrital food pathway

The rhizomes and roots of the grasses bind sediments on the substrate, where nutrients are recycled by micro-organisms back into the marine ecosystem. The leaves of the grasses slow water flow, allowing suspended material to settle on the bottom. This increases the amount of light reaching the seagrass meadow and creates a calm habitat for many species.

Seagrass binds sediments and help prevent erosion

Seagrasses slow water flow and increase water clarity

Seagrasses are nutrient sinks, buffering or filtering nutrient and chemical inputs to the marine environment. Seagrasses uptake nitrogen and phosphorus from coastal run-off that, in overabundance, can lead to algal blooms that can impair water quality.

Seagrass help remove harmful nutrient and sediment pollution from coastal waters

Interactions with mangroves and coral reefs

Tropical seagrasses are important in their interactions with mangroves and coral reefs. All these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities).

Barrier reefs protect coastlines, and the lagoon formed between the reef and the mainland is protected from waves, allowing mangrove and seagrass communities to develop. Seagrasses trap sediment and slow water movement, causing suspended sediment to fall out. This trapping of sediment benefits coral by reducing sediment loads in the water.

Seagrasses, mangroves and coral reef interact, providing physical and biological support for other communities

Mangroves trap sediment from the land, reducing the chance of seagrasses and corals being smothered. Sediment banks accumulated by seagrasses may eventually form substrate that can be colonized by mangroves. All three communities trap and hold nutrients from being dispersed and lost into the surrounding oceanic waters.

Valuation of seagrasses

The valuation of ecosystem services is a very controversial topic in today's literature. Ecosystem Services are the processes by which the environment produces resources that we often take for granted. For seagrasses it is services such as clean water, preventing erosion, and habitat for fisheries.

The economic values of seagrass meadows are very large, although not always easy to quantify. Seagrass meadows are rated the 3rd most valuable ecosystem globally (on a per hectare basis), only preceded by estuaries and wetlands. The average global value of seagrasses for their nutrient cycling services and the raw product they provide has been estimated at 1994 US$ 19,004 ha^{-1} yr^{-1}.

Seagrass meadows are rated the 3rd most valuable ecosystem globally (more valuable than mangroves or coral reefs)

What causes seagrass areas to change?

Tropical seagrass meadows vary seasonally and between years, and the potential for widespread seagrass loss has been well documented.

Factors which affect the distribution of seagrass meadows are sunlight and nutrient levels, water depth, turbidity, salinity, temperature, current and wave action.

Seagrasses respond to natural variations in light availability, nutrient and trace element (iron) availability, grazing pressure, disease, weather patterns, and episodic floods and cyclones. The dynamic nature of seagrass meadows in response to natural environmental variation complicates the identification of changes caused by humans.

Seagrasses can change due to both natural and human impacts

What threatens seagrass?

Seagrass meadows are fragile ecosystems. Approximately 58% of seagrass meadows globally, have lost part of their distribution. According to reports, the documented losses in seagrass meadows globally since 1980 are equivalent to two football fields per hour.

Some losses are natural due to storms and herbivores; however most losses are the result of human activities. Human pollution has contributed most to seagrass declines around the world.

The most widespread and pervasive cause of seagrass decline is a reduction in available light. Processes that reduce light penetration to seagrasses include pulsed turbidity events during floods, enhanced suspended sediment loads and elevated nutrient concentrations. Poor farming practices can result in excess sediments and fertilizers washing down creeks to the sea. Sewage discharge and stormwater runoff from urban development can elevate nutrients in coastal areas. Boating activity may also stir up sediment, reducing light levels. Phytoplankton and fast-growing macroalgae are also better competitors for light than benthic plants and their biomass can shade seagrasses during progressive eutrophication.

People can damage or destroy seagrass by pollution (sewage, oil spills and coastal runoff) and physical destruction (dredging, boat propellers and anchors/moorings).

Oil and trace metal contamination can exert direct toxic effects on some seagrass species. Seagrasses are able to bioaccumulate the trace metals and this can have ramifications for grazers such as dugongs.

People can also physically damage or destroy seagrass. Coastal development for boat marinas, shipping ports and housing generally occurs on the coast in areas which are sheltered and seagrass like to grow. Seagrass meadows are either removed or buried by these activities. Coastal developments can also cause changes in water movement. Dredging boat channels to provide access to these developments not only physically removes plants, but can make the water muddy and dump sediment on seagrass. Litter and rubbish can also wash into the sea if not properly disposed. Rubbish can physically and chemically damage seagrass meadows and the animals that live within them.

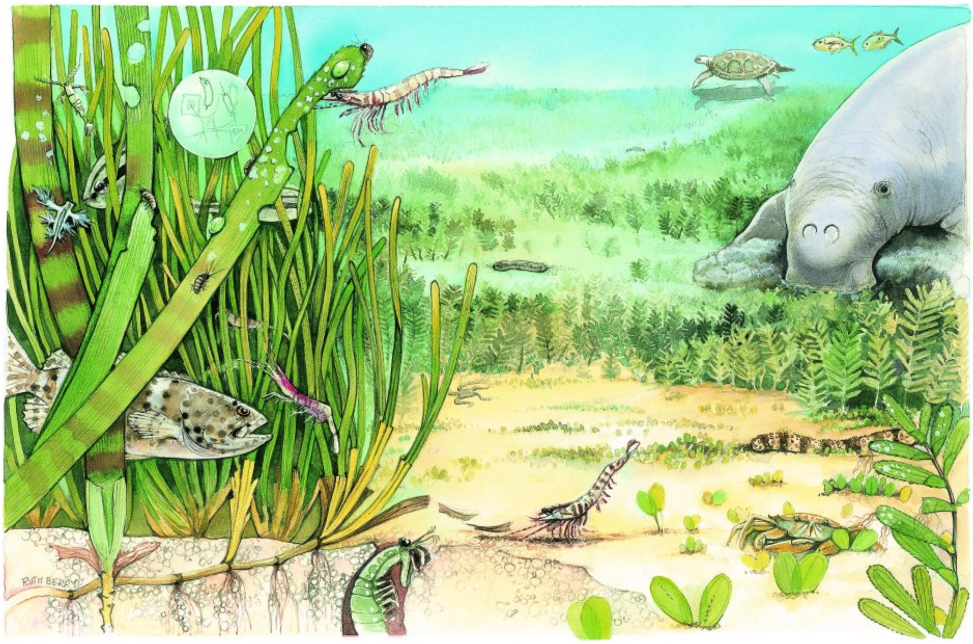
Coastal development can have a major impact on seagrass meadows

Boating and fishing activities can physically impact or destroy seagrasses. Boat anchors and their chains can dig into seagrass. Propellers can cut into seagrass meadows and unstabilise the rhizome mat. Storms can further exacerbate the damage by the physical force of waves and currents ripping up large sections of the rhizome mat. Uncontrolled digging for bait worm can also physically damage seagrasses and some introduced marine pests and pathogens also have the potential to damage seagrass meadows.

One of the other significant impacts to seagrass is climate change. The major vulnerability of seagrass to climate change is loss of seagrass in the coastal zone, particularly near river mouths and in shallow areas. The greatest impact is expected to result from elevated temperatures, particularly in shallower habitats where seagrasses grow (e.g., effecting distribution and reproduction). In addition, reduced light penetration from sediment deposition and resuspension are expected due to more intensive cyclones/hurricanes and elevated flooding frequency and amplitude. This will result in even greater seagrass losses, and changes in species composition are expected to occur particularly in relation to disturbance and recolonisation. Following such events, a shift to more ephemeral species and those with lower minimum light requirements is expected.

Climate change can threaten intertidal seagrass by increased seawater temperature and greater physical disturbance from storms

Please note: citations have been removed for ease of reading. Please see *References & Further Reading* for source/citations on scientific facts.



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Interesting facts:

Over a billion people live within 50 km of a seagrass meadow. Millions of people obtain their protein from animals that live in seagrasses.

The estimated coverage of seagrasses globally is over 177,000 square kilometres.

A hectare of seagrass absorbs 1.2 kilograms of nutrients per year, equivalent to the treated effluent from 200 people.

In northern Australia, whole seagrass meadows are able to completely replace their leaves (turnover) in around 14 days.

A hectare of seagrass sequesters 830 kilograms of carbon per year, equivalent to the CO_2 emissions from an automobile travelling 3,350 km.

One square metre of seagrass can produce up to 10 litres of oxygen per day

In northern Australia, the primary productivity of seagrass meadows is higher than a mangrove forest, a terrestrial forest or grassland.

Seagrasses occupy only 0.1% of the seafloor, yet are responsible for 12% of the organic carbon buried in the ocean, which helps reduce greenhouse gases.

The only endangered marine plant is a species of seagrass (*Halophila johnsonii* in Florida).

There is a single clone of seagrass that is over 6,000 years old (*Posidonia ocea*nica in the Mediterranean Sea). It is possibly the world's oldest plant!

The deepest growing seagrass (*Halophila decipiens*), 86 metres, was reported from Cargados Carajos Shoals in the Indian Ocean northeast of Mauritius.

Seagrass produce the longest pollen grains on the planet.

Some intertidal species of seagrasses can lose up to 50% per cent of their water content and still survive.

Did you know that Australia has the highest number of seagrass species of any continent in the world?

In Alaska, seagrasses remain frozen and in a dormant state over winter and do not start to grow again until the thaw.

The longest known seagrass 7.3 metres in length has been reported from Funakoshi Bay, Japan.

40,000 seeds of *Halodule uninervis* have been found in 1 square metre of mudflat.

In Florida, 80% of the above ground seagrass biomass is consumed by parrot fish.

The anchor and chain from one cruise boat can destroy an area of seagrass the size of a football field!

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Seagrasses of the Fiji Islands

from McKenzie and Yoshida (2007)

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 possibly erroneous. 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 *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) (Skelton & South 2006).

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 they are retained as separate entities, as there is no sufficient evidence from Fijian material to support this merger (Skelton & South 2006).

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 (eg *H. pinifolia, 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* dominate 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 Syringpdium 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 *Syringpdium 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 *Syringpdium 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).

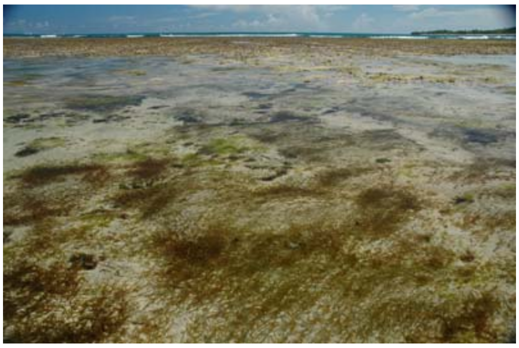
Studies on seagrasses in Fiji are limited. The only detailed studies of biological processes of seagrass meadows have been conducted at Dravuni Island: nutrient dynamics and carbon/nitrogen (Yamamuro *et al.* 1993); growth and production (Aioi and Pollard 1991); irradiance/productivity (Pollard and Aioi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

SEAGRASS-WATCH IN THE FIJI ISLANDS

To provide an early warning of change, long-term monitoring has been established in Fiji as part of the Seagrass-Watch, global seagrass assessment and monitoring program (www.seagrasswatch.org). Establishing a network of monitoring sites in the Fiji Islands provides valuable information on temporal trends in the health status of seagrass meadows in the region and provides a tool for decision-makers in adopting protective measures. It encourages local communities to become involved in seagrass management and protection. Working with both scientists and local stakeholders, this approach is designed to draw attention to the many local anthropogenic impacts on seagrass meadows which degrade coastal ecosystems and decrease their yield of natural resources.

Seagrass-Watch monitoring (clockwise from top left): Nasese (Suva, June 2007); Cawaci (Ovalau, May 2006) and Cawaci (Ovalau, June 2007). Photos: Rudi Yoshida & Len McKenzie

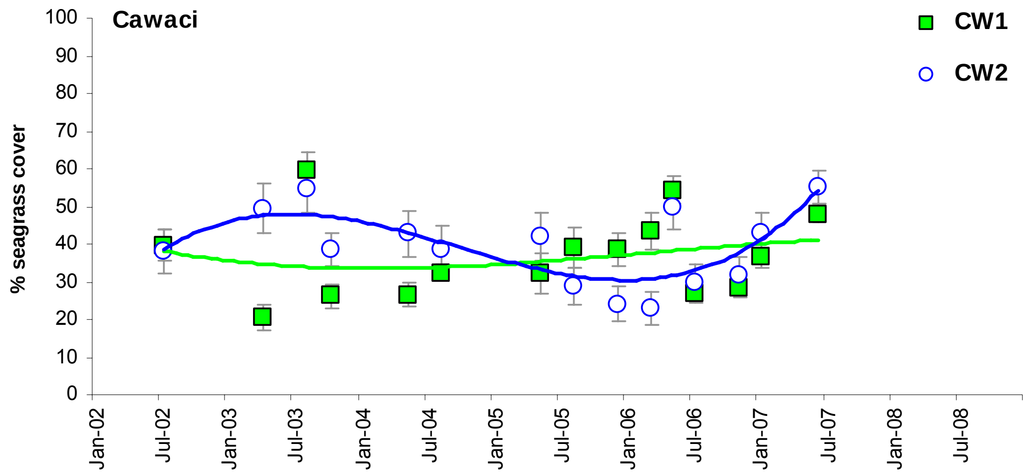
The following is a summary of the current status of Seagrass-Watch monitoring in the Fiji Islands.

Cawaci (Ovalau Island)

Monitoring: ongoing, *ad hoc*
Principal watchers: Masao Yoshida, Nicolette Yoshida, Shaun Ashley, Charlene Ashley & Seagrass-Watch HQ
Occasional and past watchers: Jo Qalo, Kathey Foi, Evan Naqiolevu & Venoma Yoshida
Location: fringing reef flat in front of St John's College
Site code: CW1, CW2
CW1 position: S17.63303 E178.81461 *(heading 50 degrees)*
CW2 position: S17.63462 E178.81570 *(heading 30 degrees)*
Best tides: <0.7m *(port Suva)*
Issues: Sewage effluent, land runoff & limestone extraction
Comments: St. John's College, is located 5 km north of the historic town of Levuka, on the island of Ovalau, which lies off the east coast of Viti Levu.
The fringing reef has large intertidal meadows of *Halodule uninervis, Halodule pinifolia, Syringodium isoetifolium* and *Halophila ovalis* ssp. *bullosa*. In recent years the reef has experienced blooms of green algae (seaweed) and physical disturbance from extraction activities. The fringing reef is popular at low tide with villagers fishing and gleaning.
CW2 is beside a small creek into which untreated effluent from the boys dormitories is discharged. The site is also adjacent to coral extraction activity by the Public Works Department.

Status (Dec09):

- No sampling has been conducted since June 2007
- Sites appear to be showing a typical season pattern of seagrass abundance (higher in late spring-summer than winter). Sites are similar in species composition and abundance.
- CW2 has generally higher abundance and greater canopy height than CW1
- CW1 showed a dramatic increase in abundance in mid 2003, which may have been a consequence of extraction activities on the reef flat which possibly released nutrients into the water column.
- When monitoring began, the abundance of epiphytes was significantly higher at CW2 than CW1, however, now both sites have relatively low epiphyte cover (<10%).

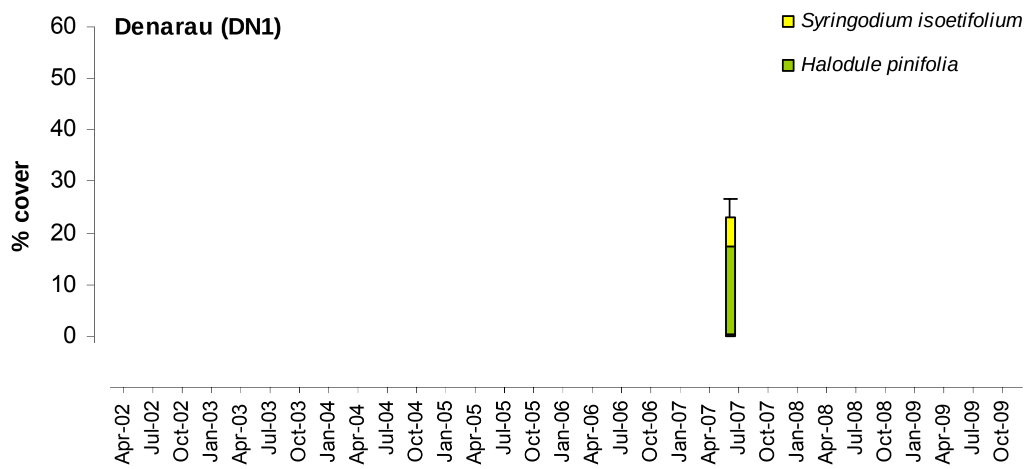


Denarau Island (Western Division, Viti Levu)

Monitoring: ongoing, *ad hoc*
Principal watchers: Seagrass-Watch HQ
Location: On the intertidal flats of Denarau Island, Nadi, in front of Hilton Resort.
Site code: DN1
DN1 position: S17.76588 E177.37818 *(heading 330 degrees)*
Best tides: <0.4m *(port Lautoka)*
Issues: Sewage effluent, development and land runoff
Comments: The site was established on the intertidal flats of Denarau Island, Nadi, in 2007. The island, 684 arces, is located west of Nadi town. Denarau is a reclaimed mangrove island is connected to Viti Levu via a small causeway.

Status (Dec09):

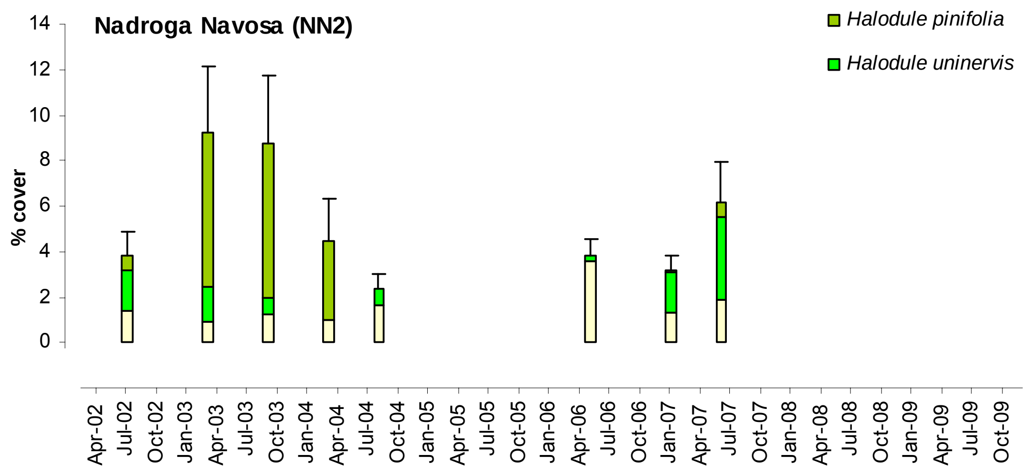
- sites has only been sampled once
- insufficient data to determine seagrass condition
- meadow is comprised of *Halodule pinifolia, Halophila ovalis* and *Syringodium isoetifolium*.



Nadroga Navosa (Viti Levu)

Monitoring: ceased, data archived
Principal watchers: Alfred Ralifo & Seagrass-Watch HQ
Occasional and past watchers: Nadroga Navosa Provincial High School students
Location: On intertidal banks of lagoon separating Cuvu village and Shangri-la Fiji Resort
Site code: NN1, NN2
NN1 position: S18.13762 E177.42204 *(heading 230 degrees)*
NN2 position: S18.13849 E177.42288 *(heading 200 degrees)*
Best tides: <0.6m (*port* Suva)
Issues: Sewage effluent & land runoff
Comments: Nadroga Navosa located on the southern coast of the main island of Viti Levu, 11 Km west of the town of Sigatoka.
There are very large seagrass meadows in Cuvu Bay, but they are threatened by turbid flood waters from the Voua river. Monitoring sites were situated close to a locally managed marine protected area monitored by WWF and the Foundation for the Peoples of the South Pacific.
At low tide, villagers fish and glean the intertidal flats. Children from the adjacent village often catch fish in the shallow pools, which remained in the seagrass meadow at low tide. Evidence that the meadows were still productive even when in a poor condition.
Status (Dec09):

- Monitoring has ceased at this location *(last monitoring was June 2007).*
- Seagrass abundance decreased significantly in 2004 and 2005, possibly a consequence of high turbidity and sedimentation which appeared to be impacting the meadow from nearby streams.
- At cessation of monitoring in 2007, seagrass abundance had increased and was not significantly different from 2003 abundances.
- The site was heavy bioturbated by shrimps (callianassids) and acorn worms over the monitoring period.
- Macro-algal and epiphyte cover remain low (<10%) over the monitoring period.

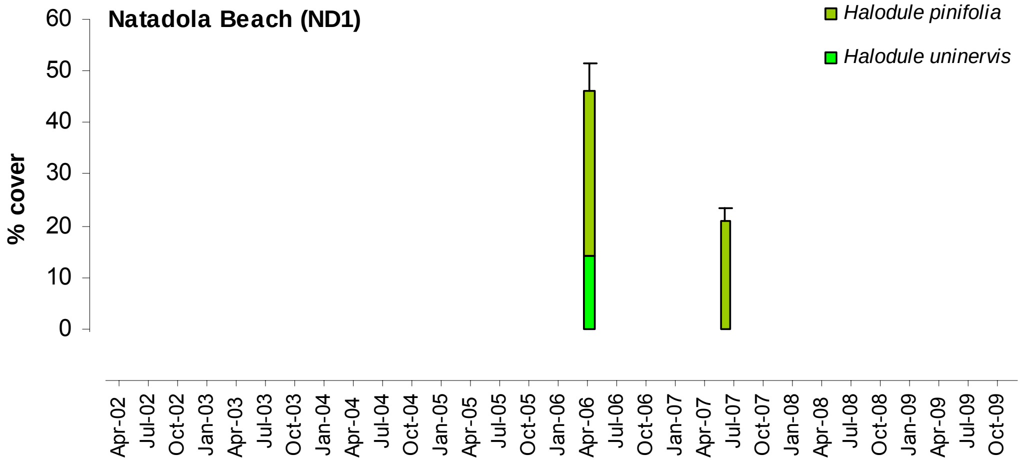


Natadola (Viti Levu)

Monitoring: ongoing, *ad hoc*
Principal watchers: Seagrass-Watch HQ
Location: On intertidal reef flat in front of Natadola beach
Site code: ND1
ND1 position: S18.10733 E177.32007
Best tides: <0.5m (*port* Suva)
Issues: sewage effluent, development and land runoff
Comments: Natadola Beach (about 40 minutes from Nadi) is one of Fiji's best, for the sand, swimming, snorkelling and the sunsets
Status (Dec09):

- no sampling has been conducted since June 2007
- insufficient data to determine seagrass condition

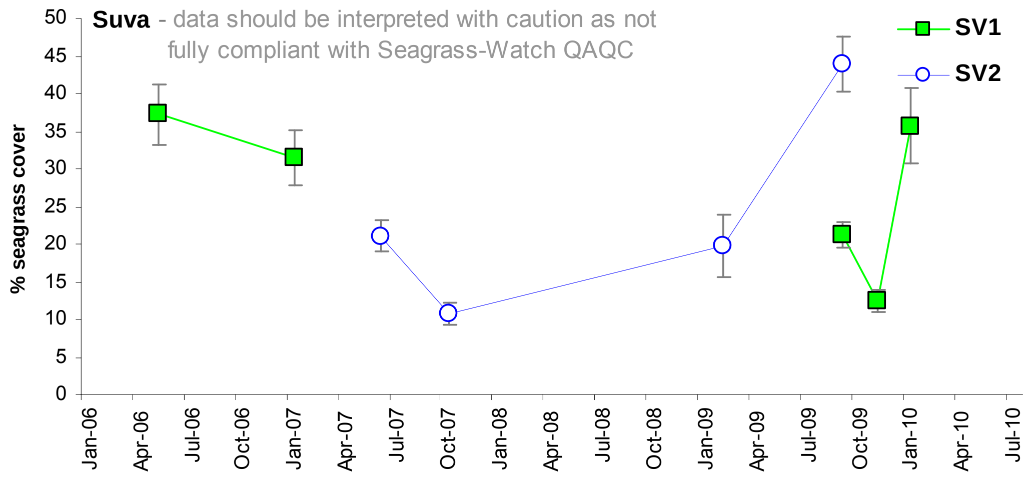
- meadow is comprised of *Halodule uninervis*, *Halodule pinifolia* and *Halophila ovalis* ssp *bullosa*.
- epiphytic algae is very low and indicator of relatively low levels of elevated nutrients



Suva (Viti Levu)

Monitoring: ongoing, *ad hoc*
Principal watchers: Seagrass-Watch HQ, International School Suva
Location: on intertidal banks in front of Nasese Education Precinct and easily accessed by foot.
Site code: SV1, SV2
SV1 position: S18.16257 E178.44326 *(heading 90 degrees)*
SV2 position: S18.16134 E178.44428 *(heading 90 degrees)*
Best tides: <0.6m *(port Suva)*
Issues: sewage effluent, Industry pollution & land runoff
Comments: Suva is located on the south east coat of the main island of Viti Levu and has a population of approx 167,975 (1996 census). A significant part of the city centre, is built on reclaimed mangrove swamp.
Rapid population growth and urbanisation of the city and corridors has put increasing environmental pressure on the region. Environmental degradation is largely due to domestic waste and sewage disposal dumped in mangrove habitat and water ways. Industry in the area discharge their waste directly into rivers and coastal waters, which significantly reduces water quality in the near-shore waters around Suva. Often little or no regard is paid to the importance of mangroves and seagrasses in the marine food chain or the problem of leaching of pollutants during periods of high rainfall.
High concentrations of nutrients (sewage) also cause algal blooms that are destructive to the ecology of the harbour waters. A study undertaken by the University of the South Pacific indicated that the general water quality of Suva harbour gave cause for concern. Pollution is obviously effecting the biology in the area, as fish caught off Suva harbour sometimes have an oily, kerosene flavour, while marine life in the harbour has been degraded. Shellfish found in coastal areas of Suva absorb sewerage waste and the population of Suva has been advised not to eat the local shellfish because of the danger of hepatitis. Nevertheless, Suva harbour and Laucala Bay remain a major source of food for low-income residents *(source www.unescap.org & www.sprep.org.ws)*.
Status (Dec09):

- Seagrass cover is generally between 10 and 45%, and not significantly different in 2009 to 2006.
- A seasonal trend may be present (higher abundance in the earlier months of each year), however due to the paucity it cannot be confirmed.
- Four seagrass species are found at Nasese: *Halodule uninervis, Halodule pinifolia, Halophila ovalis* spp*. bullosa,* and *Syringodium isoetifolium*.
- Sites are dominated by either *Halodule uninervis* or *Halodule pinifolia*. The composition of *Halophila ovalis* spp. *bullosa* fluctuates and may be a seasonal response. *Syringodium isoetifolium* composition fluctuated over the monitoring period.
- Canopy heights are similar at each site.
- Macro-algal abundance is relatively low at both sites and fluctuates greatly. There is insufficient data to identify any trends in epiphyte abundance.


Suva - data should be interpreted with caution as not fully compliant with Seagrass-Watch QAQC
SV1
SV2
% seagrass cover
50
45
40
35
30
25
20
15
10
5
0
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
Apr-07
Jul-07
Oct-07
Jan-08
Apr-08
Jul-08
Oct-08
Jan-09
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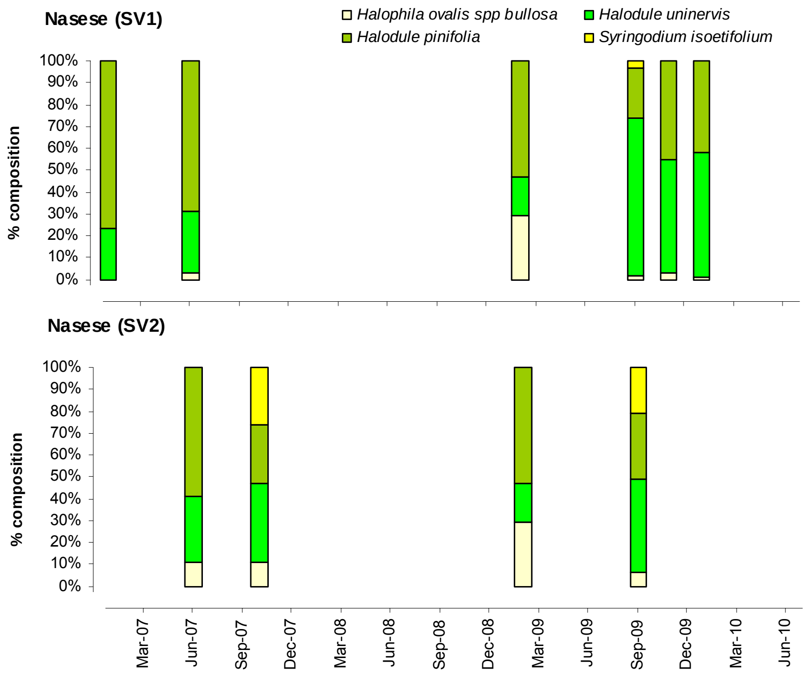
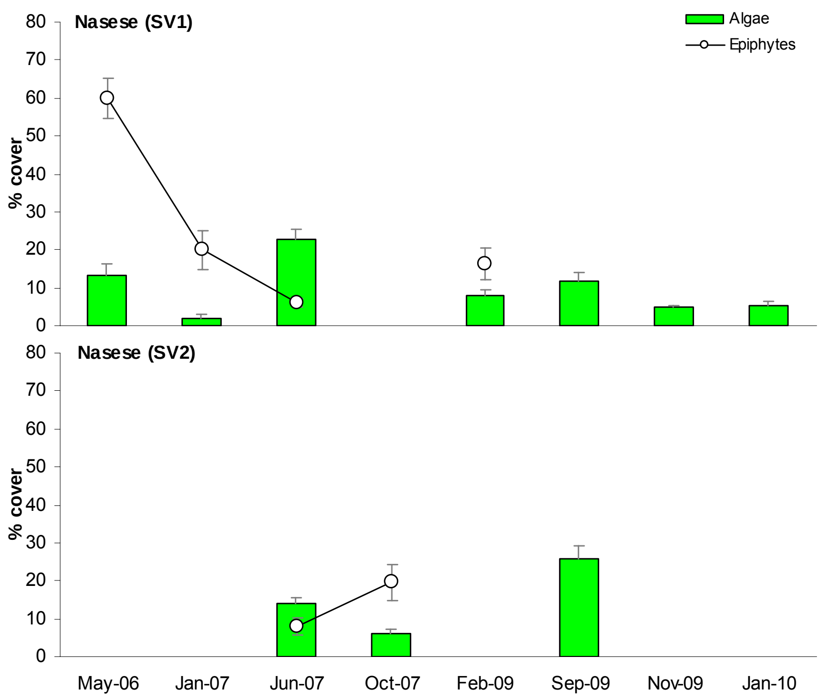
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10

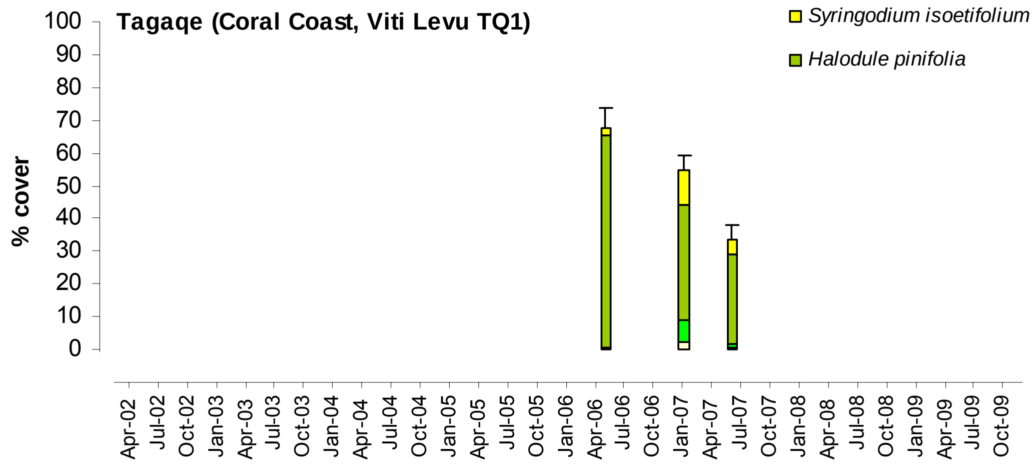

Nasese (SV1)
Halophila ovalis spp bullosa
Halodule uninervis
Halodule pinifolia
Syringodium isoetifolium
% composition
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Nasese (SV2)
% composition
Mar-07
Jun-07
Sep-07
Dec-07
Mar-08
Jun-08
Sep-08
Dec-08
Mar-09
Jun-09
Sep-09
Dec-09
Mar-10
Jun-10


Nasese (SV1)
Algae
Epiphytes
% cover
80
70
60
50
40
30
20
10
0
Nasese (SV2)
% cover
May-06
Jan-07
Jun-07
Oct-07
Feb-09
Sep-09
Nov-09
Jan-10

Tagaqe (Viti Levu)

Monitoring: ongoing, *ad hoc*
Principal watchers: Seagrass-Watch HQ
Location: On intertidal fringing reef in front of Hideaway Resort
Site code: TQ1
TQ1 position: S18.19715 E177.64968 *(heading 172 degrees)*
Best tides: <0.6m *(port Suva)*
Issues: Sewage effluent & land runoff
Comments: Tagaqe is located, on the Coral Coast, approximately 130 kilometers (80 miles) west of the capital of Suva.
In the heart of the Coral Coast is Tagaqe village and the Ridges Resort, who are working together to preserve and regenerate the local coal reefs. Tagaqe village has designated part of the reef in front of Ridges Resort as “tabu” protected. This is a Marine Protected Area (MPA) to provide a safe environment for the coral and marine life to grow and flourish.
To help assess the condition of the reef ecosystem, Seagrass-Watch was granted permission to map the extent of seagrass resources within and adjacent to the tabu area in front of Hideaway Resort, and to establish a monitoring site. In early May 2006, Seagrass-Watch HQ scientists Len McKenzie and Rudi Yoshida mapped 1.6 hectares of predominately *Halodule pinifolia* meadows and established a monitoring site. Just over 20% of the meadows were within the designated tabu area.
Status (Dec09):

- no sampling has been conducted since June 2007
- insufficient data to determine seagrass condition
- Four seagrass species are found in the Seagrass-Watch monitoring site.
- The most noticeable feature of the seagrass condition within the site was the high amount of epiphyte cover on the leaves. High epiphyte can be a natural occurrence, however at some locations it can be an indicator of elevated water column nutrients.



Rotuma

Monitoring: ongoing, annual
Principal watchers: LäjeRotuma
Occasional and past watchers: Rotuma School EcoCamp
Location: reef flat Maka Bay (Motusa)
Site code: RT1
Issues: sewage effluent & land runoff
Comments: Rotuma, a volcanic island of approximately 43 sq. km, is located 465 km north of Fiji.
The LäjeRotuma Initiative established in late 2001, consists of young Rotumans residing in Fiji who wanted to give something back to their community and Rotuma. The name LäjeRotuma literally translates to “coral reefs Rotuma”. Due to the island's isolation and small size, its marine and terrestrial resources are susceptible to over exploitation. The main aim of LäjeRotuma Initiative is to create awareness amongst Rotumans on the island about their natural surroundings, heritage, limited resources and how to protect and use these resources sustainably.

Status (Dec09):

- Seagrass abundance appeared to decline in 2007 but increased back to 2005 and 2006 levels in 2008
- *Syringodium isoetifolium* is the only species of seagrass found in Rotuma.
- Seagrass meadow appears to be generally stable, an indication that the seagrass meadow is relatively healthy.
- There has also been a reduction in the percentage epiphytic algae and macroalgae in the seagrass meadow.
- The mean number of animals found on the seagrass meadow increased slightly from 2004 to 2005 and directly correlates to the increase in the seagrass cover.
- This seagrass meadow provides a lot of shellfish, fish and seaweed to the villages close by.

For more information, visit www.seagrasswatch.org

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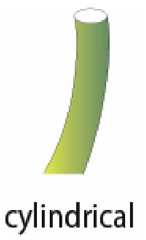
A guide to the identification of seagrasses in the Fiji Islands

Adapted from Waycott, M, McMahon, K, Mellors, J., Calladine, A., and Kleine, D (2004) A guide to tropical seagrasses in the Indo-West Pacific. (James Cook University Townsville) 72pp.

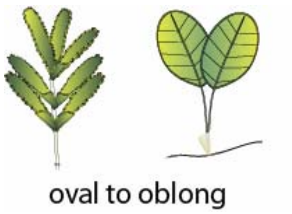
Leaves cylindrical



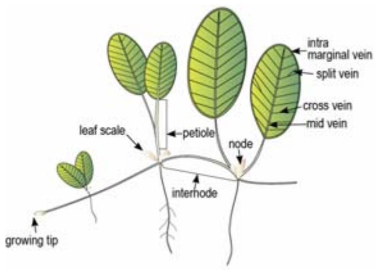
Syringodium isoetifolium

- leaves taper to a point
- leaves contain air cavities
- inflorescence a “cyme”
- leaves 7-30cm long

Leaves oval to oblong



leaves with petioles, in pairs



Halophila ovalis

- 8 or more pairs of cross veins
- leaf margins smooth
- no leaf hairs
- leaf 5-20mm long
- separate male & female plants

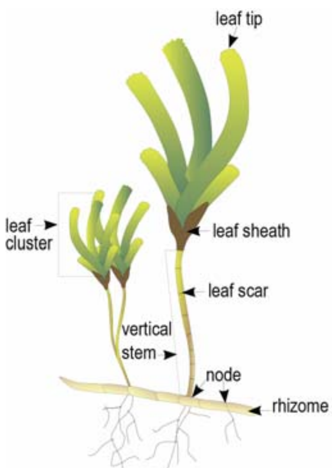
Halophila ovalis ssp *bullosa*

- leaf surface bullate (blister or pucker-like)

Halophila decipiens

- leaf margins serrated
- 6-8 cross vein pairs
- fine hairs on both sides of leaf blade
- leaves are usually longer than wide

Leaves strap-like



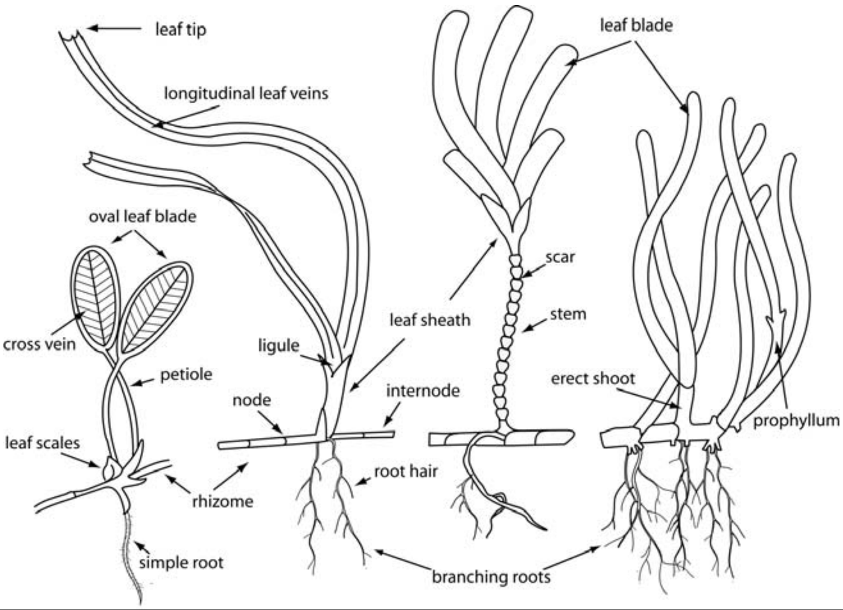
Halodule uninervis

- leaf tip tri-dentate or pointed, not rounded
- leaf with 3 distinct parallel- veins, sheaths fibrous
- narrow leaf blades 0.25-5mm wide
- rhizome usually pale ivory, with small black fibres at the nodes

Halodule pinifolia

- leaf tip rounded
- lateral teeth faintly developed or absent
- leaf with 3 distinct parallel- veins, sheaths fibrous
- rhizome usually white with small black fibres at the nodes

Parts of a seagrass plant



Leaf

Tip

Can be rounded or pointed. Tips are easily damaged or cropped, so young leaves are best to observe.

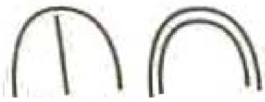

rounded *pointed*

Veins

Used by the plant to transport water, nutrients and photosynthetic products. The pattern, direction and placement of veins in the leaf blade are used for Identification.

- cross-vein: perpendicular to the length of the leaf
- parallel-vein: along the length of the leaf
- mid-vein: prominent central vein
- Intramarginal-vein: around inside edge of leaf


cross *parallel*


mid *intramarginal*

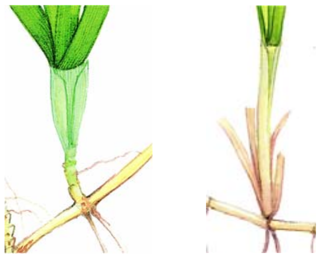
Edges

The edges of the leaf can be either serrated, smooth or inrolled


serrated *smooth* *inrolled*

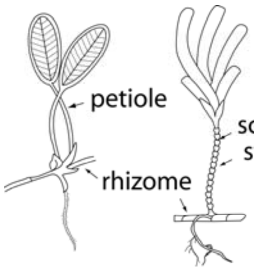
Sheath

A modification of the leaf base that protects the newly developing tissue. The sheath can entirely circle the vertical stem or rhizome (continuous) or not (non-continuous); fully or partly cover the developing leaves and be flattened or rounded. Once the leaf has died, persistent sheaths may remain as fibres or bristles.


clean & flattened fibrous

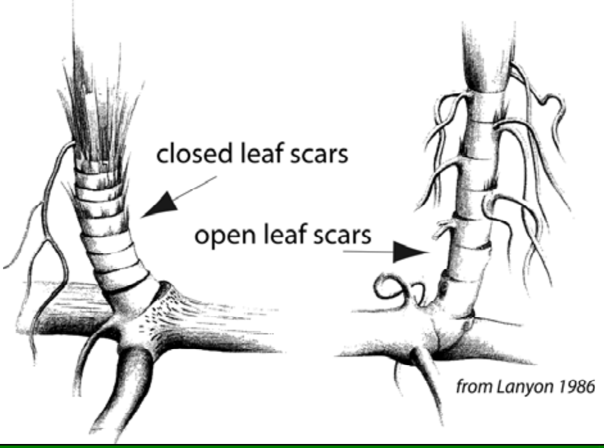
Attachment

The leaf can attach directly to the rhizome, where the base of the leaf clasps the rhizome, or from a vertical stem or stalk (petiole) e.g. *Halophila ovalis*.



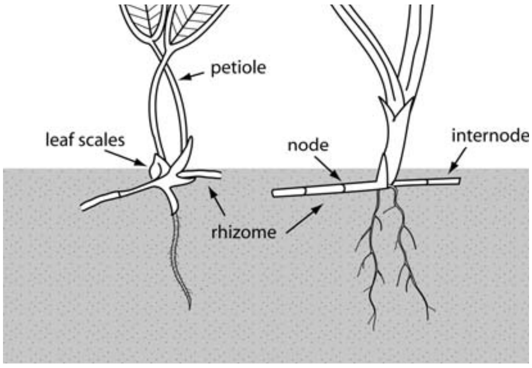
Stem

The vertical stem, found in some species, is the upright axis of the plant from which leaves arise (attach). The remnants of leaf attachment are seen as scars. Scars can be closed (*entirely circle the vertical stem*) or open (*do not entirely circle the vertical stem*).



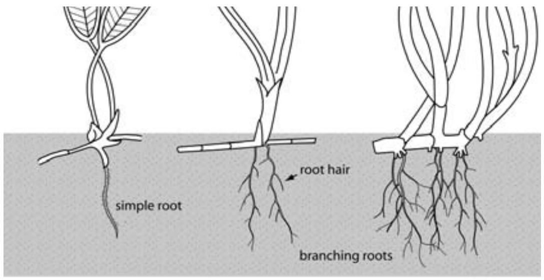
Rhizome

The horizontal axis of the seagrass plant, usually in sediment. It is formed in segments, with leaves or vertical stem arising from the joins of the segments, the nodes. Sections between the nodes are called internodes. Rhizomes can be fragile, thick and starchy or feel almost woody and may have scars where leaves were attached.



Root

Underground tissues that grow from the node, important for nutrient uptake and stabilisation of plants. The size and thickness of roots and presence of root hairs (very fine projections) are used for identification. Some roots are simple or cordlike, others may be branching, depending on seagrass species.



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Monitoring a seagrass meadow

Environment monitoring programs provide coastal managers with information and assist them to make decisions with greater confidence. Seagrasses are often at the downstream end of catchments, receiving runoff from a range of agricultural, urban and industrial land-uses.

Seagrass communities are generally susceptible to changes in water quality and environmental quality that make them a useful indicator of environmental health. Several factors are important for the persistence of healthy seagrass meadows, these include: sediment quality and depth; water quality (temperature, salinity, clarity); current and hydrodynamic processes; and species interactions (e.g., epiphytes and grazers). Seagrass generally respond in a typical manner that allows them to be measured and monitored. In reporting on the health of seagrasses it is important to consider the type of factors that can effect growth and survival. Factors include:

- increased turbidity reduces light penetration through the water, interfering with photosynthesis and limiting the depth range of seagrass;
- increased nutrient loads encourages algal blooms and epiphytic algae to grow to a point where it smothers or shades seagrasses, also reducing photosynthetic capacity;
- increased sedimentation can smother seagrass or interfere with photosynthesis;
- herbicides can kill seagrass and some chemicals (e.g., pesticides) can kill associated macrofauna;
- boating activity (propellers, mooring, anchors) can physically damage seagrass meadows, from shredding leaves to complete removal;
- storms, floods and wave action can rip out patches of seagrasses.

Seagrass-Watch

A simple method for monitoring seagrass resources is used in the Seagrass-Watch program. This method uses 50m by 50m sites established within representative intertidal meadows to monitor seagrass condition. The number and position of sites can be used to investigate natural and anthropogenic impacts.

Seagrass-Watch is one of the largest seagrass monitoring programs in the world. Originally established in Queensland (Australia) as an initiative of Fisheries Queensland, now more than 25 countries globally participate in the program and monitoring is currently occurring at over 270 sites and growing. The success of the program is that information collected can be used in local decision making with regard to habitat management practices and protection.

Seagrass-Watch aims to raise awareness on the condition and trend of nearshore seagrass ecosystems and provide an early warning of major coastal environment changes. Participants in the program range in ages from 18 to 72 and represent a diverse cross-section of the community, including trades people, engineers, Indigenous communities, school teachers, scout leaders, fishers, divers, retirees, university students, biologists and ecologists. Many are involved with local environmental groups and have a keen interest in conservation and environmental issues.

Seagrass-Watch methods were developed to be rigorous, yet relatively simple and easy to use. After 6–9 hours of training, participants can produce reliable data. Training includes both formal and informal approaches. Technical issues concerning quality control of data are important, especially when the collection of data can be by people not previously educated in scientific methodologies. Seagrass-Watch has an accepted Quality Assurance-Quality Control program in place to ensure that the program is producing data of high quality, and that time and resources are not wasted. Quality data reassures the data users (e.g., coastal management agencies) that they can use the data to make informed decisions with confidence.

Early detection of change allows coastal management agencies to adjust their management practices and/or take remedial action sooner for more successful results. The program has provided information about the health of seagrass ecosystems for local management agencies and developed benchmarks where performance and effectiveness can be measured. Ongoing monitoring has detected loss and subsequent recovery of seagrasses in relation to climatic events including flooding. It has also provided an early alert exposing coastal environmental problems before they became intractable and has been used to track the possible consequences of global climate change. The findings from the program have contributed to Ramsar and World Heritage Area assessments, regional and local management plans and reporting on the health of the Great Barrier Reef to determine the effectiveness of management practices applied as part of the Reef Rescue water quality initiative.

Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. To protect the valuable seagrass meadows along our coasts, the community, government and researchers have to work together.

THE GOALS OF THE PROGRAM ARE:

- To educate the wider community on the importance of seagrass resources
- To raise community awareness of coastal management issues
- To develop community participation and ownership
- To build the capacity of local communities in the use of standardised scientific methodologies
- To conduct long-term & broad-scale monitoring of seagrass & coastal habitats, and
- To provide an early warning system of coastal environment changes for management.

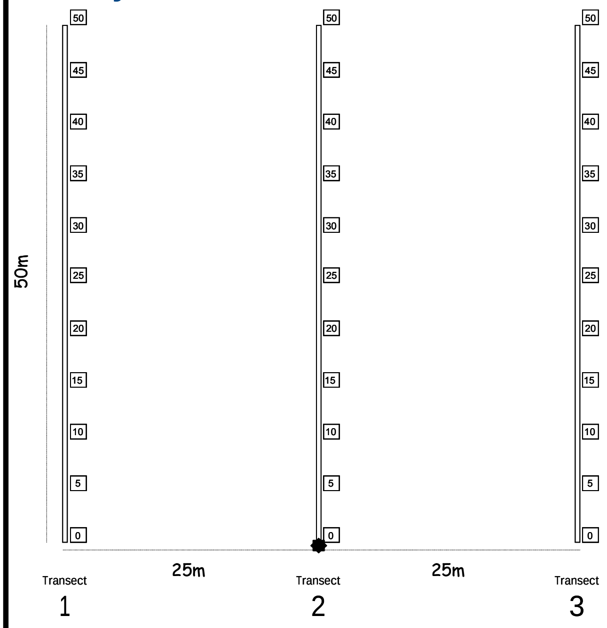
To learn more about the program, visit www.seagrasswatch.org .

Levuka reef, Ovalau, Jan 2007, photo by Len McKenzie

Seagrass-Watch Protocols

Source: *McKenzie, L.J., Campbell, S.J., Vidler, K.E. & Mellors, J.E. (2007) Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources. (Seagrass-Watch HQ, Cairns) 114pp (www.seagrasswatch.org/manuals.html)*

Site layout



Quadrat code = site + transect+quadrat

e.g., PI1225 = Pigeon Is. site 1, transect 2, 25m quadrat

Pre-monitoring preparation

Make a Timetable

Create a timetable of times of departure and arrival back, and what the objective of the day is and what is to be achieved on the day. Give a copy of this to all volunteers involved in advance so they can make their arrangements to get to the site on time. List on this timetable what the volunteers need to bring.

Have a Contact Person

Arrange to have a reliable contact person to raise the alert if you and the team are not back at a specified or reasonable time.

Safety

- Assess the risks before monitoring - check weather, tides, time of day, etc.
- Use your instincts - if you do not feel safe then abandon sampling.
- Do not put yourself or others at risk.
- Wear appropriate clothing and footwear.
- Be sun-smart.
- Adult supervision is required if children are involved
- Be aware of dangerous marine animals.
- Have a first aid kit on site or nearby
- Take a mobile phone or marine radio

Necessary equipment and materials

- ❑ *3x 50metre fibreglass measuring tapes*
- ❑ *6x 50cm plastic tent pegs*
- ❑ *Compass*
- ❑ *1x standard (50cm x 50cm) quadrat*
- ❑ *Magnifying glass*
- ❑ *3x Monitoring datasheets*
- ❑ *Clipboard, pencils & 30 cm ruler*
- ❑ *Camera & film*
- ❑ *Quadrat photo labeller*
- ❑ *Percent cover standard sheet*
- ❑ *Seagrass identification sheets*

Quarterly sampling

Within the 50m by 50m site, lay out the three 50 transects parallel to each other, 25m apart and perpendicular to shore (see site layout). Within each of the quadrats placed for sampling, complete the following steps:

Step 1. Take a Photograph of the quadrat

- Photographs are usually taken at the 5m, 25m and 45m quadrats along each transect, or of quadrats of particular interest. First place the photo quadrat labeller beside the quadrat and tape measure with the correct code on it.
- Take the photograph from an angle as **vertical** as possible, which includes the entire quadrat frame, quadrat label and tape measure. Avoid having any shadows or patches of reflection off any water in the field of view. Check the photo taken box on datasheet for quadrat.

Step 2. Describe sediment composition

- Dig your fingers into the top centimetre of the substrate and feel the texture. Describe the sediment by noting the grain size in order of dominance (e.g., Sand, Fine sand, Fine sand/Mud).

Step 3. Describe other features and ID/count of macrofauna

- Note and count any other features which may be of interest (eg. number of shellfish, sea cucumbers, sea urchins, evidence of turtle feeding) within the comments column.

Step 4. Estimate seagrass percent cover

- Estimate the total % cover of seagrass within the quadrat – use the percent cover photo standards (calibration sheets) as your guide.

Step 5. Estimate seagrass species composition

- Identify the species of seagrass within the quadrat and determine the percent contribution of each species (starting with least abundant). Use seagrass species identification keys provided.

Step 6. Measure canopy height

- Measure canopy height (in centimetres) of the dominant strap-leaf seagrass species, ignoring the tallest 20% of leaves. Measure from the sediment to the leaf tip of at least 3 shoots.

Step 7. Estimate algae percent cover

- Estimate % cover of algae in the quadrat. Algae are seaweeds that may cover or overlie the seagrass blades. Use "Algal percentage cover photo guide". Write within the comments section whether the algae is overlying the seagrass or is rooted within the quadrat.

Step 8. Estimate epiphyte percent cover

- Epiphytes are algae attached to seagrass blades and often give the blade a furry appearance. First estimate how much of the blade surface is covered, and then how many of the blades in the quadrat are covered (e.g., if 20% of the blades are each 50% covered by epiphytes, then quadrat epiphyte cover is 10%).
- Epifauna are sessile animals attached to seagrass blades – please record % cover in the comments or an unused/blank column – do not add to epiphyte cover.

Step 9. Take a voucher seagrass specimen if required

- Seagrass samples should be placed inside a labelled plastic bag with seawater and a waterproof label. Select a representative specimen of the species and ensure that you have all the plant part including the rhizomes and roots. Collect plants with fruits and flowers structures if possible.

At completion of monitoring

Step 1. Check data sheets are filled in fully.

- Ensure that your name, the date and site/quadrat details are clearly recorded on the datasheet. Also record the names of other observers and the start and finish times.

Step 2. Remove equipment from site

- Remove all tent pegs and roll up the tape measures. If the tape measures are covered in sand or mud, roll them back up in water.

Step 3. Wash & pack gear

- Rinse all tapes, pegs and quadrats with freshwater and let them dry.
- Review supplies for next quarterly sampling and request new materials
- Store gear for next quarterly sampling

Step 4. Press any voucher seagrass specimens if collected

- The voucher specimen should be pressed as soon as possible after collection. Do not refrigerate longer than 2 days, press the sample as soon as possible.
- Allow to dry in a dry/warm/dark place for a minimum of two weeks. For best results, replace the newspaper after 2-3 days.

Step 5. Submit all data

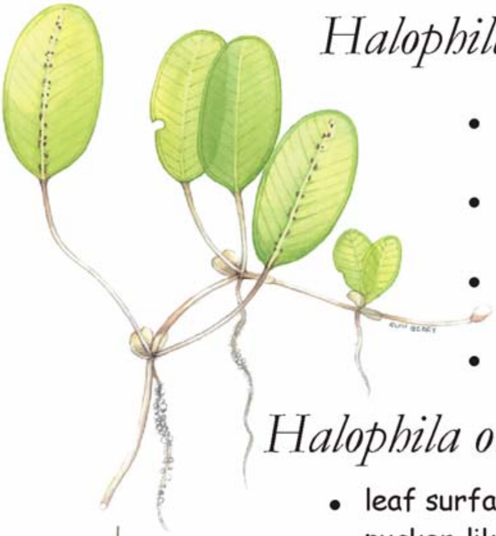
- Data can be entered into the MS-Excel file downloadable from www.seagrasswatch.org. Email completed files to hq@seagrasswatch.org
- Mail original datasheets, photos and herbarium sheets

Seagrass-Watch HQ
Northern Fisheries Centre
PO Box 5396
Cairns QLD 4870 AUSTRALIA

SEAGRASS SPECIES CODES

Ho

Halophila ovalis



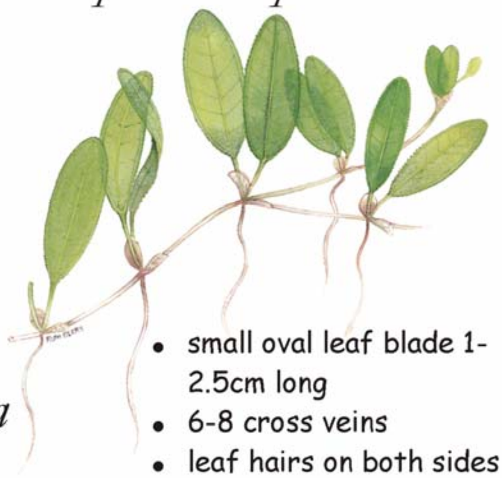
- 8 or more pairs of cross veins
- no hairs on leaf surface
- leaf margins smooth
- leaf 5-20mm long

Halophila ovalis ssp. *bullosa*

- leaf surface bullate (blister or pucker-like)

Hd

Halophila decipiens



- small oval leaf blade 1-2.5cm long
- 6-8 cross veins
- leaf hairs on both sides
- found at subtidal depths

Hu

Halodule uninervis

- trident leaf tip
- 1 central vein
- usually pale rhizome, with clean black leaf scars

Si

Syringodium isoetifolium

- leaf cylindrical in cross section (e.g., spaghetti)
- leaf tip tapers to a point
- leaves 7-30cm long

Hp

Halodule pinifolia

- rounded leaf tip
- 1 central vein
- usually pale rhizome, with clean black leaf scars

SEAGRASS-WATCH MONITORING

ONE OF THESE SHEETS IS TO BE FILLED OUT FOR EACH TRANSECT YOU SURVEY

Seagrass-Watch

OBSERVER: Joe Citizen **DATE:** 19 / 2 / 09.
LOCATION: motupore Is. Bootless Inlet . PNG.
SITE code: BT1 **TRANSECT no.:** 3
START TIME: 1630 **END TIME:** 1705

START of transect (GPS reading)
Latitude: 9° . 31.2642 , S **Longitude:** 147° . 16.9902 , E

Quadrat (metres from transect origin)	Sediment (eg, mud/sand/shell)	Comments (eg 10x gastropods, 4x crab holes, dugong feeding trails, herbarium specimen taken)	(√)	% Seagrass coverage	% Seagrass species composition					Canopy height (cm)	% Algae cover	% Epi-cover
					CR	EA	HO	HU	TH			
1 (0m)	Sand/shell	SP x 3 FO		48	20	5	6	9	8	15,13,12	2	81
2 (5m)	s/sh	WH x 2 GAS x 3	√	53	41	3		3	6	13,11,8	3	86
3 (10m)	mud/sand	HC x 1 worm x 2		31	13	1	1	5	11	6,7,6.5	6	73
4 (15m)	m/s	CH x 3 GAS x 1		24	18	3			3	16,13,14	1	51
5 (20m)	Fine Sand	Crab x 3 SP x 2		29	10	6	2	8	3	12,9,10	3	58
6 (25m)	FS	worm tube x 4 Crab x 1	√	21			100			NA	8	66
7 (30m)	m/s/sh			19	13	4		1	1	9.5,13,12	5	43
8 (35m)	Coarse Sand	water (4cm) SC x 2		41	4	6	5	8	18	10,10,10	0	40
9 (40m)	CS	water (4cm)		23	3	8	2	6	4	15,12,11	1	67
10 (45m)	m	water (6cm)	√	18	8	2		2	6	16,16,15	16	63
11 (50m)	s/m	water (10cm). SC x 3		16	4	4		7	1	9,8,10	18	49

END of transect (GPS reading)
Latitude: 9° . 31.2384 , S **Longitude:** 147° . 16.9794 , E

SP = Sponge.
FO = Foram.
WH = worm Hole
GAS = Gastropod.
HC = Hermit Crab.
CH = Crab Hole.
SC = Sea Cucumber.

Making a herbarium press specimen

Herbaria are repositories of preserved and labelled plant specimens, arranged to allow easy access and archival storage. The specimens are typically in the form of herbarium sheets: pressed and dried plants that have been attached to a sheet of heavy paper together with a data label. A herbarium specimen is simple in form and low-tech in preparation, yet it preserves a wealth of valuable information. If properly stored, a herbarium specimen will last for centuries without much deterioration. Specimens document the variation in form and geographical range of species. Herbaria also document valuable historical collections, such as "type specimens", the original specimens on which a plant's Latin name is based. Many herbarium specimens record the existence of plants in habitats now developed and lost.

COLLECTION

Before collecting any seagrass specimens, ensure you have the appropriate permits.

In the field, collect a handful of representative seagrass shoots, including the leaves, rhizomes and roots. Keep in mind that it is not always possible to get a successful classification if you do not have particular parts such as flowers, fruits, seeds and roots, so try to select shoots which have these features. Ideally, collect plants with growing tips (meristems) as they contain higher concentrations of DNA which could aid genetic identification in the future.

Specimens should be pressed as soon as possible after collection. If it is more than 2 hours before you press the specimen, then you should refrigerate to prevent any decomposition. Do not refrigerate longer than 2 days, press the sample as soon as possible.

PRESSING

Tools

First you will need some clean white cartridge-type paper (photocopy paper will suffice) and herbarium sheets (if available). You will also need forceps, scissors/scalpel, a dish of clean fresh water and a herbarium press. It is not difficult to build a home-made press, keeping in mind that what must be accomplished is to keep the specimens squeezed between layers of paper (newspapers or blotting paper) until they are totally devoid of the original content of water. The upper and lower parts of the press might be made of heavy cardboard or thick plywood or equivalent material. A more advanced kind of press might be built for an optimal drying of your plants. This press can be made with two wooden boards with screws and nuts placed at each corner: turning the nuts the two boards will come closer pushing together the paper with the plants. This kind of press can be built at home or bought in some art tools stores.

Preparation

Wash the seagrass specimen in clean fresh water and carefully remove any debris, epiphytes or sediment particles.

Arrangement

It is very important that the seagrass specimen be arranged so that you can immediately see all the main characters of that particular species; so do not focus only at the aesthetics of the mounted specimen. It is advisable to arrange specimens before being placed in the press as once dried, plant specimens can easily be broken if handled without care. The best manner to place the plants on the mounting sheets is to align them with the right side of the page (or diagonally if space is required) and to have the heaviest parts and specimens at the bottom. Leaves can be folded in larger specimens if a larger press in not available. It is better to leave an empty space at the borders of the mounting sheets; but you can either arrange your specimens (along with the label) in a regular way from page to page, or stagger the specimens at different positions on each sheet, so that each group of sheets will have a more equally distributed pressure.

Labels

Each specimen must have a label on its own sheet, which should include the taxonomic denomination (*at least family, genus and species*) along with information on the date and place of collection. The name of the collector and of the individual who did the determination should also be added. Use permanent and water resistant ink (black or blue) to write your labels; otherwise a pencil can be used (medium lead). Specimen labels should include:

- species name (*if known)*
- location & site code (*if applicable*)
- date collected
- latitude/longitude
- water depth
- % seagrass cover
- sediment type
- other seagrass species present
- name of collector and who identified the specimen
- comments -*such as presence of flowers/fruits or ecological notes*

Place the label on the lower right hand corner of the paper.

Drying

Place another clean sheet of paper over the specimen and place within several sheets of newspaper. As circulating air is very important to get your specimens dried in a short time, the assemblage of specimen/paper should be placed within two sheets of corrugated cardboard and then into a herbarium press. Corrugated cardboard ensures air can penetrate and speed up the drying process. If no corrugated cardboard is available, keep the filled press size small.

Once in the herbarium press, wind down the screws until tight (*do not over tighten*). If you do not have a press, the specimens can be pressed by putting some heavy object on top, i.e. bricks or large books. It is important that the plants are put under sufficient pressure; otherwise more time will be required to achieve a good desiccation, besides they could be damaged by dampness and moulds.

The press should be exposed to a gentle heat source, avoiding excessive heat that will "cook" the specimens. Sometimes it is possible to use the heat from the sun. In this case the presses should be small. If fire is the heat source, keep the press at a safe distance to prevent fire starting on the press.

Changing the paper is a very important step. In the first three or four days a paper change should take place every day, then you can leave more time between changes. If you neglect the change of paper the plants will take more time to loose their water content, besides they could be damaged if the paper stays wet for a few days. When changing the paper you must keep the specimens intact and ensure the label travels with the specimen. The minimum time required for complete dying ranges from two to four days or more. Once a specimen has become dry and stiff, it can be mounted and placed into the herbarium.

Mounting

Once the specimen is completely dry, you will need to mount it to herbarium sheets if available or a new clean white cartridge-type paper.

There are different ways to mount the specimens to the herbarium sheets, such as strapping, gluing, pinning or nothing. We recommend the strapping method using removable adhesive tape (eg Magic Tape). The tape pulls off easily, leaves behind no messy residue, and can be pulled up and moved around. To fix the specimen to the mounting paper, lay small strips of tape across a few sturdy parts of the plant (eg either end of rhizome or a stem) at a minimal number of points. This method will allow a certain degree of movement for further examinations, but the specimen will not fall from the mounting paper

HERBARIA

Once the specimen is mounted it can be stored in a dry place or lodged in Herbaria. If you do not have a Herbaria in your region or state (usually located at a University or Government agency), you can submit specimens to Seagrass-Watch HQ which maintains a Herbaria as part of the Australia Tropical Herbarium.

Alternatively, you can email a scanned image of the pressed specimen. Please ensure that the scanned image is no less then 600 dpi and includes the specimen and label. Scanned images can be sent to hq@seagrasswatch.org and will be lodged in the Seagrass-Watch Virtual Herbarium http://www.seagrasswatch.org/herbarium.html.

The Virtual Herbarium is an electronic gateway to the collections of the Seagrass-Watch HQ herbaria. The goals of the Virtual Herbarium are to make specimen data available electronically for use in biodiversity research projects; to reduce transport of actual specimens for projects where digital representations will suffice for study; and to provide a source of reference information for Seagrass-Watch participants.

Notes:

Understanding sediment

Seagrasses, especially structurally large species, affect coastal and reef water quality by trapping sediments and acting as a buffer between catchment inputs and reef communities. Seagrass meadows have the ability to modify the energy regimes of their environments, and help stabilise sediment by trapping and binding the sediment. However, the trapping ability of seagrass is in reality an equilibrium established between deposition/sedimentation and erosion/resuspension.

Studies have shown that sediment characteristics are important in determining seagrass growth, germination, survival, and distribution. As part of Seagrass-Watch, field descriptions of sediment type collected 0-2 cm below the sediment/water interface are determined by visual and tactile inspection of (wet) samples and constituents (primary descriptors) differentiated according to the Udden – Wentworth grade scale.

Grain size classes used, based on the Udden – Wentworth grade scale of Wentworth (1922).

Mud	Fine-medium Clay	0 – 0.002 mm
	Coarse Clay	0.0021 – 0.004 mm
	Very Fine Silt	0.0041– 0.008 mm
	Fine Silt	0.0081 – 0.016 mm
	Medium Silt	0.0161 – 0.031 mm
	Coarse Silt	0.0311 – 0.063 mm
Sand	Very Fine Sand	0.0631 – 0.125 mm
	Fine Sand	0.1251 – 0.250 mm
	Medium Sand	0.2501 – 0.500 mm
	Coarse Sand	0.5001 – 1.000 mm
	Very Coarse Sand	1.0001 – 2.000 mm
Gravel	Granules	2.0001 – 4.000 mm
	Pebbles and larger	>4.0001 mm

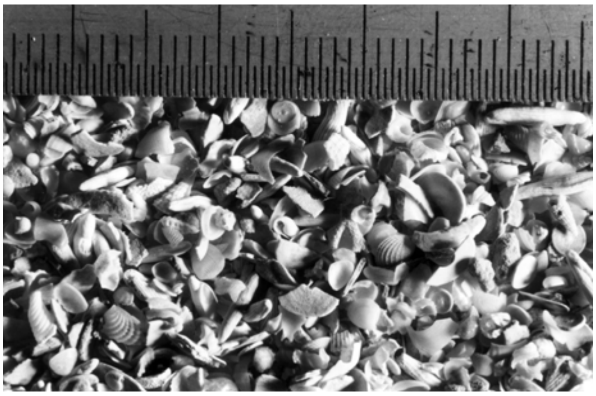
In Seagrass-Watch, the primary descriptors relate to the size of the sediment grains: gravel (>2000µm); coarse sand (>500 µm); sand (>250 µm); fine sand (>63 µm); and mud (<63 µm).

The sediment ***Primary Descriptors*** are written down from left to right in decreasing order of abundance: e.g. Mud/Sand is mud with sand, where mud is determined as the dominant constituent (by volume).

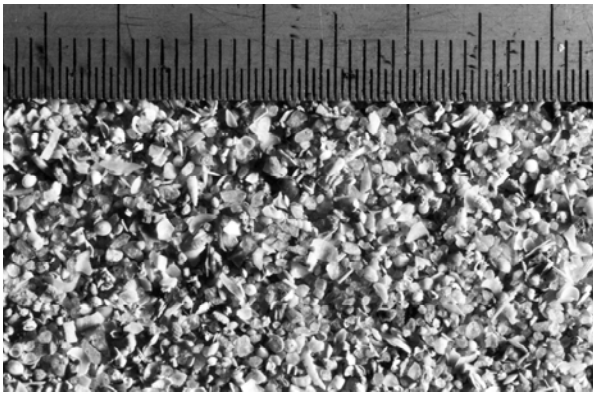
mud *has a smooth and sticky texture.*
fine sand *fairly smooth texture with some roughness just detectable. Not sticky in nature.*
sand *rough grainy texture, particles clearly distinguishable.*
coarse sand *coarse texture, particles loose.*
gravel *very coarse texture, with some small stones.*

Sediment type ***Modifiers*** are also commonly used, however these are recorded in the comments section. Modifiers include: coral, shell grit, forams, diatoms, *etc*.

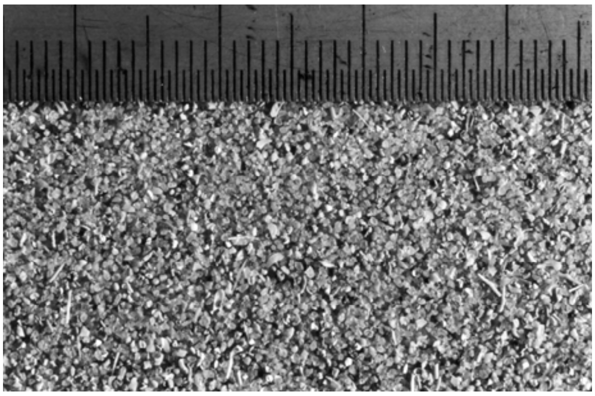
The visual/tactile estimation method used in Seagrass-Watch is a simple yet relatively accurate measure of the sediment grain size which can be used for quantitative assessments (see McKenzie 2007, http://www.seagrasswatch.org/Info_centre/Publications/pdf/371_DPIF_McKenzie.pdf).



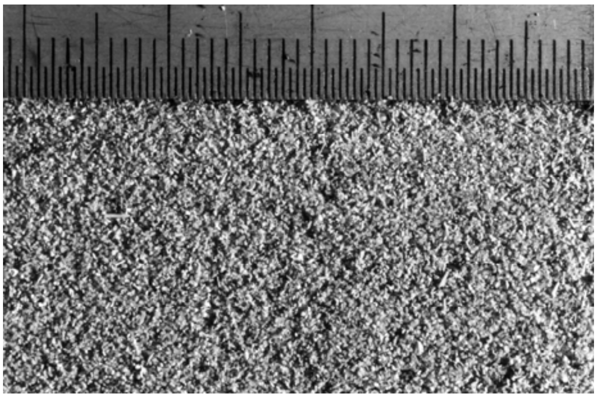
gravel (>2mm)



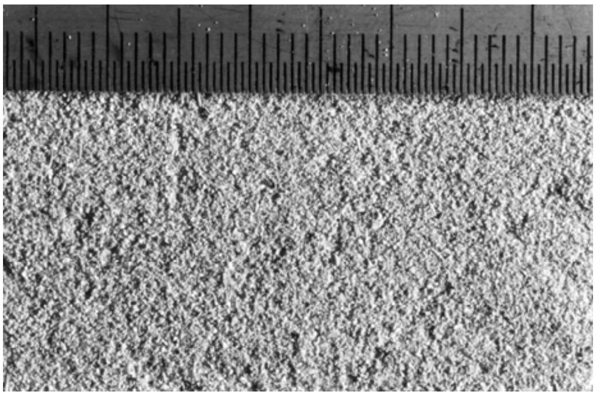
very coarse sand (1 – 2 mm)



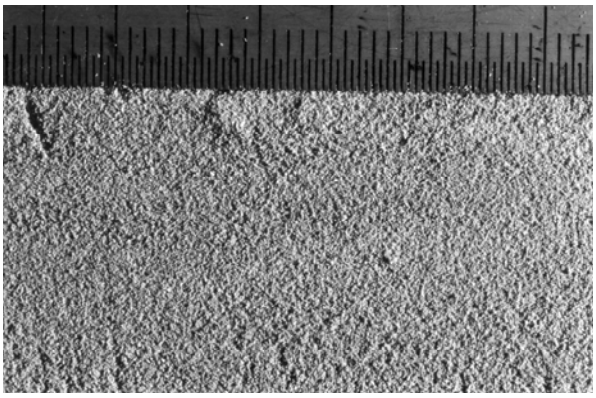
coarse sand (0.5 – 1 mm)



medium sand (0.25 – 0.5 mm)



fine sand (0.125 – 0.25 mm)



very fine sand (0.063 – 0.125mm)

Notes:

Managing seagrass resources

Threats to seagrass habitats

Destruction or loss of seagrasses have been reported from most parts of the world, often from natural causes, e.g., "wasting disease" or high energy storms. However, destruction commonly has resulted from human activities, e.g., as a consequence of eutrophication or land reclamation and changes in land use. Increases in dredge and fill, construction on the shoreline, damage associated with commercial overexploitation of coastal resources, and recreational boating activities along with anthropogenic nutrient and sediment loading have dramatically reduced seagrass distribution in some part of the world Anthropogenic impacts on seagrass meadows continue to destroy or degrade coastal ecosystems and decrease seagrass functions and values, including their contribution to fisheries. It is possible global climate change will have a major impact. Efforts are being made toward rehabilitation of seagrass habitat in some parts of the world: transplantation, improvement of water quality, restrictions on boating activity, fishing and aquaculture, and protection of existing habitat through law and environmental policy.

Management

Seagrasses do not exist in nature as a separate ecological component from other marine plants and are often closely linked to other community types. In the tropics the associations are likely to be complex interactions with mangrove communities and coral reef systems. In temperate waters, algae beds, salt marshes, bivalve reefs, and epiphytic plant communities are closely associated with areas of seagrass. Many management actions to protect seagrasses have their genesis in the protection of wider ecological systems or are designed to protect the overall biodiversity of the marine environment.

Seagrasses are also food for several marine mammal species and turtles, some of which are listed as threatened or vulnerable to extinction in the IUCN Red List (IUCN 2000). Seagrasses are habitat for juvenile fish and crustaceans that in many parts of the world form the basis of economically valuable subsistence and/or commercial fisheries. The need to manage fisheries in a sustainable way has itself become a motivating factor for the protection of seagrasses.

Coastal management decision making is complex, and much of the information on approaches and methods exists only in policy and legal documents that are not readily available. There may also be local or regional Government authorities having control over smaller jurisdictions with other regulations and policies that may apply. Many parts of South East Asia and the Pacific Island nations have complex issues of land ownership and coastal sea rights. These are sometimes overlaid partially by arrangements put in place by colonising powers during and after World War II, leaving the nature and strength of protective arrangements open for debate.

Both Australia and the United States have developed historically as Federations of States with the result that coastal issues can fall under State or Federal legislation depending on the issue or its extent. In contrast, in Europe and much of South East Asia, central Governments are more involved. Intercountry agreements in these areas such as the UNEP Strategic Action Plan for the South China Sea and the Mediterranean Countries Barcelona Convention (http://www.unep.org/) are required to manage marine issues that encompass more than one country.

Approaches to protecting seagrass tend to be location specific or at least nation specific (there is no international legislation directly for seagrasses as such that we know of) and depend to a large extent on the tools available in law and in the cultural approach of the community. There is, however, a global acceptance through international conventions (RAMSAR Convention; the Convention on Migratory Species of Wild Animals; and the Convention on Biodiversity) of the need for a set of standardised data/information on the location and values of seagrasses on which to base arguments for universal and more consistent seagrass protection.

We suggest that there are six precursors to successful management of coastal seagrasses:

1. Important fish habitat is known and mapped

2. Habitat monitoring is occurring

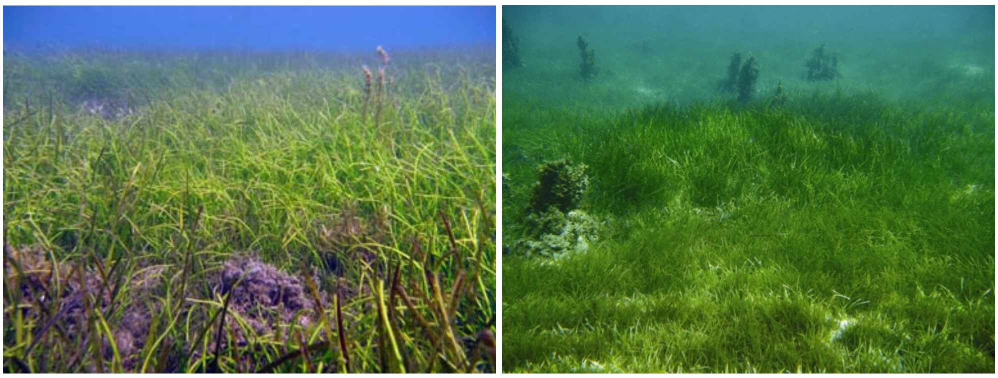
3. Adjacent catchment/watershed impacts and other threats are managed

4. Some level of public goodwill/support is present

5. Legal powers exist hat are robust to challenge

6. There is effective enforcement and punishment if damage occurs

The key element is a knowledge base of the seagrass resource that needs to be protected and how stable/variable that resource is. It is also important to know if possible any areas that are of special value to the ecosystems that support coastal fisheries and inshore productivity. It is important as well that this information is readily available to decision makers in Governments in a form that can be easily understood.



Above left: Syringodium meadow, Cawaci, Ovalau, Jan 2007, photo by Rudi Yoshida
Above right: *Halodule uninervis* patch in *Halodule pinifolia* meadow, Tagaqe, Coral Coast, Viti Levu, Jan 2007, photo by Len McKenzie

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Useful web links

Seagrass-Watch Official Site www.seagrasswatch.org

Seagrass Adventures Interactive website designed by students from Bentley Park College in Cairns (Australia). Website includes games, puzzles and quizzes for students to learn about seagrass and their importance. www.reef.crc.org.au/seagrass/index.html

World Seagrass Association A global network of scientists and coastal managers committed to research, protection and management of the world's seagrasses. wsa.seagrassonline.org

Seagrass Outreach Partnership Excellent website on seagrass of Florida. Provides some background information on seagrasses and has a great section with educational products and Seagrass Activity Kit for schools. www.flseagrass.org

Seagrass forum A global forum for the discussion of all aspects of seagrass biology and the ecology of seagrass ecosystems. Because of their complex nature, discussion on all aspects of seagrass ecosystems is encouraged, including: physiology, trophic ecology, taxonomy, pathology, geology and sedimentology, hydrodynamics, transplanting/restoration and human impacts. wwwscience.murdoch.edu.au/centres/others/seagrass/seagrass_forum.html

Reef Guardians and ReefEd Education site of the Great Barrier Reef Marine Park Authority. Includes a great collection of resources about the animals, plants, habitats and features of the Great Barrier Reef. Also includes an on-line encyclopedia, colour images and videos for educational use, a range of free teaching resources and activities. www.reefed.edu.au

Integration and Application Network (IAN) A website by scientists to inspire, manage and produce timely syntheses and assessments on key environmental issues, with a special emphasis on Chesapeake Bay and its watershed. Includes lots of helpful communication products such as fact sheets, posters and a great image library. ian.umces.edu

Pacific Islands Network for Taxonomy (PACINET) A website about a joint program of the Secretariat for the Pacific Community, the Secretariat of the Pacific Regional Environment Programme and the University of the South Pacific, to build taxonomic capacity in the Pacific Island Countries for sustainable development. Includes background to the program, areas of focus, activities, pest list database and publications. www.spc.int/lrd/PACINET.htm

Reef Base A global database, information system and resource on coral reefs and coastal environments. Also extensive image library and online Geographic Information System (ReefGIS) which allows you to display coral reef and seagrass related data on interactive maps. www.reefbase.org

UNEP - World Conservation Monitoring Centre Explains the relationship between coral reefs, mangroves and seagrasses and contains world distribution maps. www.unep-wcmc.org

for more links, visit **www.seagrasswatch.org/links.htm**

Notes:

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We value your suggestions and any comments you may have to improve the Seagrass-Watch program.

Please complete the following statements in your own words

I found the Seagrass-Watch training to be ....

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What I enjoyed most about the training was..

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It could have been better if ....

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I did not realize that...

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Now I understand that ....

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In my area the types of seagrasses and habitats include..

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When I go back to my area, I will ....

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Other comments..

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Please hand in your form once you have completed it.

Thank you