



Seagrass-Watch

**Proceedings of a Workshop for Monitoring
Seagrass Habitats in Indonesia**

The Nature Conservancy, Coral Triangle Center,
Sanur, Bali, Indonesia
9th May 2009

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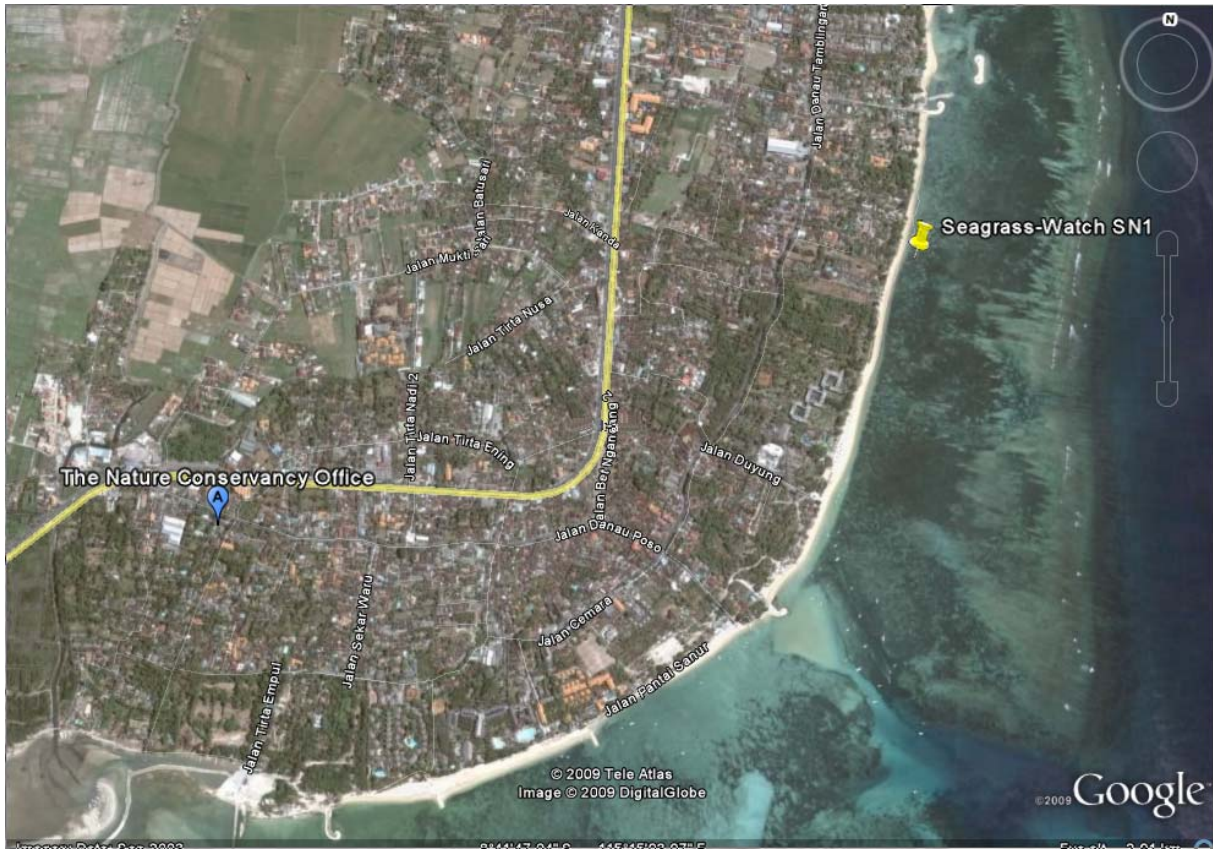
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The Nature Conservancy, Coral Triangle Center,
Jl. Pangembak 2, Sanur, Bali

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 supported by the Wildlife Conservation Society (Indonesia, Marine), local coordination by Stuart Campbell (WCS Marine Program Co-ordinator), and Seagrass-Watch HQ. 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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Workshop leaders



Len McKenzie

Len is a Principal Scientist with Queensland Primary Industries & Fisheries (Department of Employment, Economic Development and Innovation) and Seagrass-Watch Program Leader. He is also chief investigator for the Marine & Tropical Scientific Research Facility (MTRSF) 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 habitat. 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 Queensland Primary Industries & Fisheries (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)

Saturday 9th May 2009 (The Nature Conservancy, Sanur)

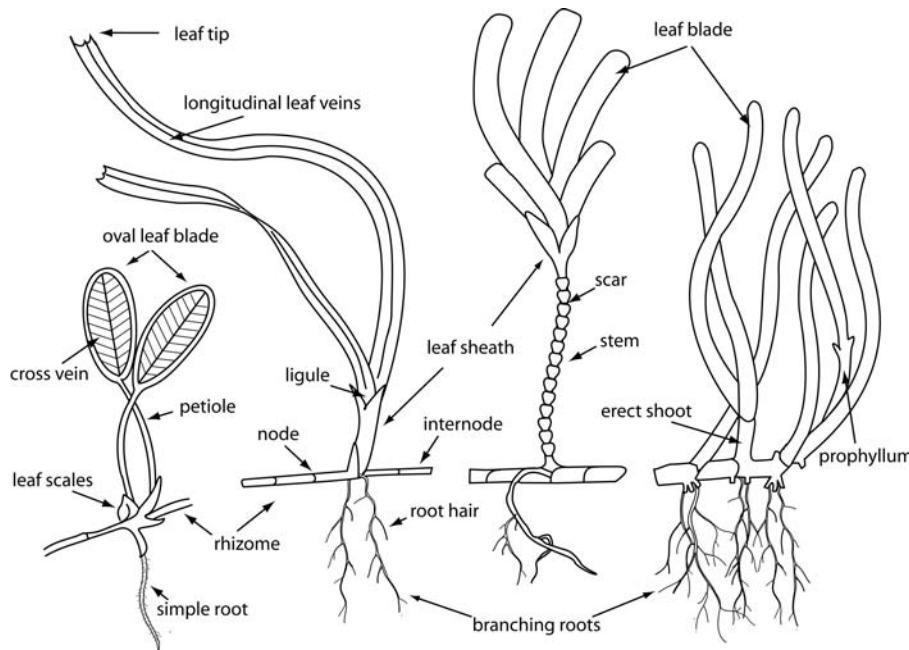
Morning	0830 - 0840 (10min)	Welcome & Introduction
	0840 - 0900 (20min)	Seagrass Biology and Identification
	0900 - 0930 (30min)	Classroom activity: Seagrass Identification
	0930 - 0945 (15min)	Seagrass Identification <i>continued</i>
	0945 - 1000 (15min)	Classroom activity: how to prepare a seagrass press specimen
	1000 - 1045 (45min)	Seagrass Ecology and Threats
	1045 - 1100	<i>Break</i>
	1100 - 1120 (20min)	Seagrass monitoring
	1120 - 1200 (40min)	Seagrass-Watch: how to sample
	Afternoon	1200 - 1300 (60min)
1300 - 1315 (15min)		<i>Wrap-up presentations</i>
1315 - 1430		<i>Lunch</i>
1430 - 1445 (15min)		Safety briefing & risk assessment
1445 - 1700 (2hrs)		Field exercise: Seagrass-Watch monitoring <i>Where:</i> Jalan Pantai Sanur (SN1) <i>How to get there:</i> <ul style="list-style-type: none"> • <i>Meet on the beach at the end of the lane past Parigata Hotel (Parigata Resort N Spa), Jalan Danau Tamblingan No. 87,</i> • <i>be punctual</i> • <i>be well rested, well fed, and well hydrated beforehand. Do not come if you are not feeling well.</i>
		<i>What to bring:</i> <ul style="list-style-type: none"> • <i>hat, sunscreen (Slip! Slop! Slap!)</i> • <i>dive booties or old shoes that can get wet</i> • <i>mask and snorkel (if available)</i> • <i>drink/refreshments and energising snack</i> • <i>wet weather gear: poncho/raincoat</i> • <i>insect repellent</i> • <i>polaroid sunglasses (not essential)</i> • <i>simple medical kit in case of injuries to yourself</i> • <i>change of footwear and clothes</i> • <i>enthusiasm</i>
		<i>You will be walking across a seagrass meadow exposed with the tide, through shallow water.</i> <i>Please remember, seagrass meadows are an important resource. We ask that you use discretion when working/walking on them.</i>
	1700 - 1730	Wrap up (<i>on foreshore</i>) <ul style="list-style-type: none"> • check gear • feedback

Low tide: 0.2m at 1600hrs

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).

Seagrass are marine 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

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 sun's 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.

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 joints, 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.

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.

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.

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*).

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.

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

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)

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

Seagrass pump oxygen into the sediment via their roots

Seagrass have flowers, fruits and seeds

Pollination occurs in the water

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

Seagrasses are not true grasses

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.

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.

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).

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 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.

Temperature influences the rate of growth and the health of plants, particularly at the extremes. As water temperatures increase (up to 38°C) the rate of photorespiration increases reducing the efficiency of photosynthesis at a given CO₂ concentration. The cause of thermal

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

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

Seagrasses need plenty of sun and clean water to grow.

Seagrasses are physiologically adapted to life in sea water

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

Light availability is the most important factor determining seagrass growth

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

Water temperature influences the rate of growth and the health of seagrass

stress at higher temperatures (38°C to 42°C) 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.

Temperature also controls the range of pH and dissolved carbon dioxide (CO₂) 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 (HCO₃⁻) as an inorganic carbon source (eg *Halophila ovalis*, *Cymodocea rotundata*, *Syringodium isoetifolium* and *Thalassia*), whereas others use enzymes to make CO₂ available as the inorganic carbon source (eg *Enhalus acoroides*, *Halodule*, *Cymodocea serrulata*).

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.

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.

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.

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.

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)

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

Seagrass require inorganic carbon for growth

Seagrass uptake carbon via two different pathways

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

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

Most seagrass live in sand or mud sediments

Sediment movement can determine the presence of seagrass species

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

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.

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.

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.

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.

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.

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.

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

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

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

Seagrass plants form small patches that develop into large meadows

Seagrasses are important habitat and feeding grounds for marine organisms.

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

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

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.

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 microorganisms such as flagellates and plankton. Microorganisms provide food for the juveniles of many species of marine animals such as fish, crabs, prawns and molluscs.

The rhizomes and roots of the grasses bind sediments on the substrate, where nutrients are recycled by microorganisms 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.

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.

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.

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.

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

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

Seagrass binds sediments and help prevent erosion

Seagrasses slow water flow and increase water clarity

Seagrass help remove harmful nutrient and sediment pollution from coastal waters

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

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 54% 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

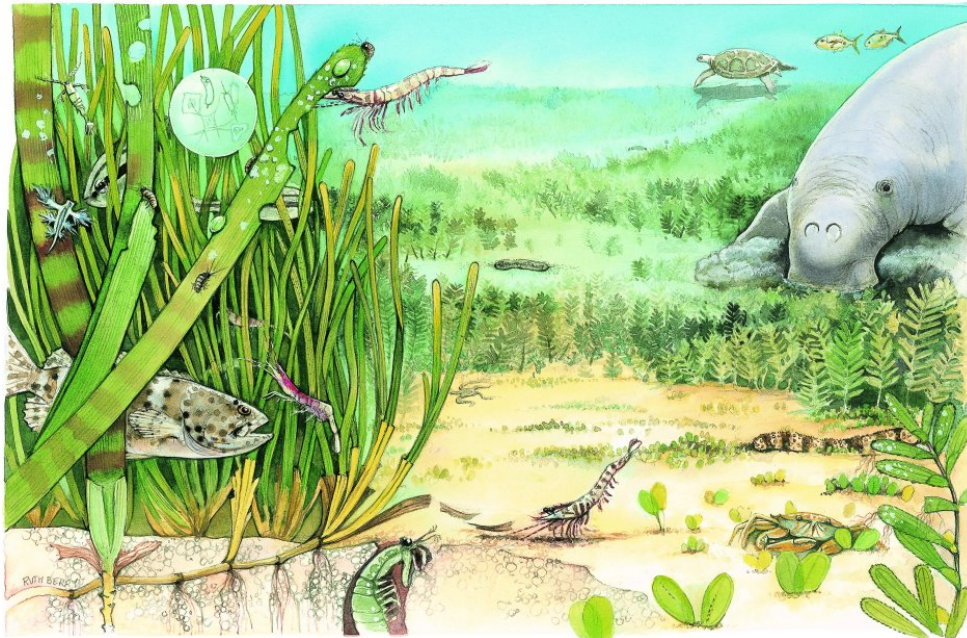
Boating and fishing activities can physically impact or destroy seagrasses. Boat anchors and their chains can dig into seagrass. Propellers can cut into seagrass meadows and destabilise the rhizome mat. Storms can further exacerbate the damage by the physical force of waves and currents ripping up large 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 CO₂ 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 oceanica* in the Mediterranean Sea).

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 Indonesia

Seagrass meadows form a significant coastal habitat throughout the Indonesian Archipelago, extending from intertidal to subtidal, along mangrove coastlines, estuaries, and shallow embayments, as well as coral-reef platforms, inter-reef seabeds and island locations. Seagrass meadows in Indonesia play a vital role in supporting coastal marine communities and in maintaining diverse flora and fauna. They are an important component of coastal fisheries productivity (Unsworth 2007) and they play an important role in maintaining coastal water quality and clarity. The seagrasses of Indonesia are also important food for marine green turtles and dugongs (Kiswara 1994).



Fishing over seagrass meadows at Sanur (Bali) (left) and Ontoloe island (Flores) (right).

Photos: Len McKenzie & Stuart Campbell

Indonesian seagrasses often form extensive mixed or monospecific meadows. Mixed seagrass communities composed of 8-9 species are common in many coastal areas in Indonesia. Along coastlines dominated by mangrove forests, seagrass communities often provide a functional link and a buffer between the seaward coral reefs and the inshore mangroves.

Seagrasses are integral components of Indonesian reefs (i.e., fringing, barrier, patch and atoll), where they occupy a variety of habitats. They are most often found in shallow-water back-reef environments (eg reef flats, moats) and lagoons where they achieve their highest abundances. However, in some locations they dominate the reef crest of barrier reefs and atolls.

It is generally acknowledged that eight genera and 13 species of seagrass inhabit Indonesian coastal waters (Humoto and Moosa 2005). These include: *Cymodocea serrulata*, *Cymodocea rotundata*, *Enhalus acoroides*, *Syringodium isoetifolium*, *Halodule pinifolia*, *Halodule uninervis*, *Halophila spinulosa*, *Halophila decipiens*, *Halophila ovalis*, *Thalassia hemprichii*, *Halophila minor*¹, *Thalassodendron ciliatum* and *Ruppia maritima*. The *R. maritima* records are based on specimens at Herbarium Bogoriense collected from Ancol-Jakarta Bay and Pasir Putih-East Java, but have never been reported since (the development of Jakarta has destroyed the mangrove forest in Ancol). A 14th species *Halophila beccarii*, although similarly known from a specimen at the Herbarium Bogoriense, was thought to exist in Indonesian waters, but there is no information on where it was collected and it has not been found in the field (Kuriandewa *et al.* 2003). No endemic species have been found (Nienhuis 1993).

Seagrass diversity in Indonesia is similar to adjacent countries (eg Philippines=13 species, Papua New Guinea=13 and northern Australia=15 (McKenzie 2007;

¹ *Halophila minor* was originally reported as *H. ovata*, however taxonomists now regard *H. ovata* in the Indo-western Pacific as only present in the South China Sea and Micronesia (Kuo 2000).

McKenzie 2006; McKenzie and Yoshida 2009)) even though habitat diversity is among the highest in the world (Tomasik *et al.* 1997; Kuriandewa *et al.* 2003).

The distribution of seagrass throughout the Indonesian Archipelago is not completely known with vast areas including the Papua coast unsurveyed (McKenzie *et al.* 2007b). At least 30,000 km² are known to occur throughout the Indonesian archipelago (Nienhuis 1993). Short *et al.* (2001) identified nine factors that influence the distribution of seagrasses. These include: light, water depth, tide and water movement, salinity, temperature, human impacts, climate change, availability of viable reproductive material (eg seeds and fragments) and competition from other plants. In the tropics, key seagrass habitats occur on shallow fringing reef platforms and sheltered shallow bays where distribution is also driven by the physical micro-topography of the location. Although studies on the geographical distribution of seagrasses throughout the Indonesian Archipelago are scarce, the location of species is undoubtedly a consequence of all or some of these factors.

It has also been suggested that species diversity in Indonesia may be partly a consequence of the oceanic currents that effectively form geographic barriers to seagrass dispersal. High-velocity currents (e.g., >5.0 m.sec⁻¹; e.g., Sape Strait) flowing between the islands through numerous narrow straits (usually in a north-to south direction) may explain some longitudinal differences in species composition of shallow-water benthic communities, especially along the Great Sunda Arc (Tomasik *et al.* 1997).

Seagrasses in the Indonesian archipelago occur either as monospecific or mixed communities. In monospecific seagrass meadows any one of the 13 known species can dominate the community, which may be a small patch (i.e., <1 m²) on an intertidal reef flat or a dense and extensive subtidal meadow (i.e., > 100 m²). *Thalassia hemprichii*, *Enhalus acoroides*, *Halophila ovalis*, *Halodule uninervis*, *Cymodocea serrulata* and *Thalassodendron ciliatum* usually grow in monospecific meadows and muddy substrates on the seaward edges of mangroves often have meadows of high biomass (Kuriandewa *et al.* 2003). Mixed species meadows are typically dominated by pioneering species such as *Halophila ovalis*, *Cymodocea rotundata* and *Halodule pinifolia*. These meadows occur in the lower intertidal and shallow subtidal zones in sandy, stable and low relief sediments (Kuriandewa *et al.* 2003).

Among the 13 species, besides *R. maritima*, *T. ciliatum* has a distribution limited to only in the south eastern part of Indonesia, and *H. spinulosa* and *H. decipiens* have been recorded in only a few locations (Tomasik *et al.* 1997; Kuriandewa *et al.* 2003).

While seagrasses predominately grow on soft substrata, *Thalassodendron ciliatum* is often found attached to hard rock and coral limestone at the seaward margin of reefs (i.e., fringing reefs to atolls). With its strong woody rhizomes and roots, it is able to root in a variety of sediment types, including coral rubble. Along the fringing reef of the Nusa Dua and Sanur coast (south Bali) the inner walls of the well-developed grooves of the reef crest, which run almost perpendicular to the incoming swell, are heavily overgrown by *T. ciliatum*. It appears that in all high energy environments, *T. ciliatum* has shorter branched stems than in sheltered lagoonal environments (i.e., calm, turbid), where it occurs in mixed communities (Tomasik *et al.* 1997).



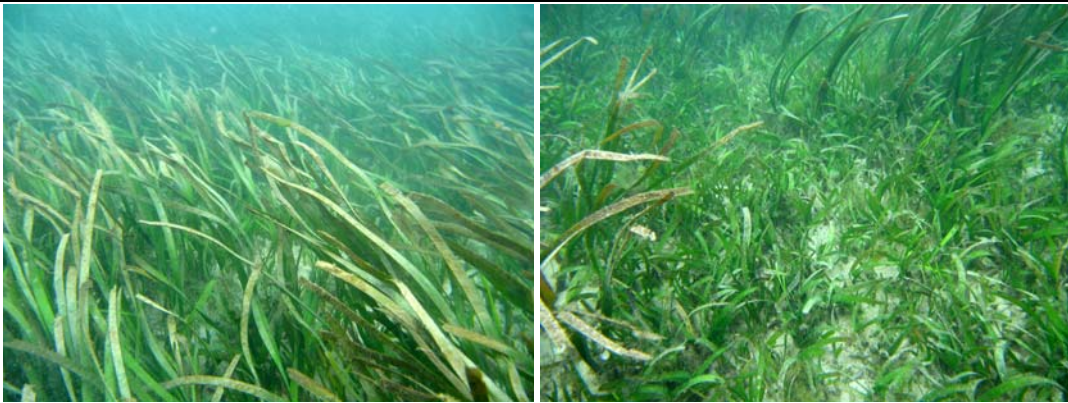
Thalassodendron ciliatum on reef-crest, Sanur (Bali) May 2005.
Photos: Len McKenzie

The two other species with relatively limited distribution are *Halophila spinulosa* and *H. decipiens*. *H. spinulosa* and *H. decipiens* often form monospecific meadows in subtidal environments. *H. spinulosa* has been recorded from Riau, the Sunda Suait, the east Java Sea, Lombok and Papua, while *H. decipiens* has been recorded from locations in Jakarta Bay to the Flores Sea (Kuriandewa 2008). The location of collection sites suggests that they may be widely distributed, however as these species are adapted for less accessible deep water (>10m) or lower light environments, they are often overlooked during surveys.

The other species of genus *Halophila* found in the Indonesian archipelago, *H. ovalis* and *H. minor*, are in contrast widely distributed. *H. ovalis* has a wide vertical range and occurs from the intertidal zone down to depths greater than 20m (Erftemeijer and Stapel, 1999). It is a pioneering species often found growing on recently disturbed sediments (Kuriandewa *et al.* 2003). In the high eulittoral, it is often associated with the smaller, more delicate, *H. minor*, which is frequently buried under the sediment and difficult to observe.

The most abundant seagrass species in Indonesia are *Thalassia hemprichii* and *Enhalus acoroides* (Neinhuis *et al.* 1989, Kiswara 1996). Monospecific meadows of *Thalassia hemprichii* are the most widespread throughout Indonesia and occur over a variety of habitats and substrate types and large vertical range from the intertidal down to the lower subtidal zone (Brouns 1985). It is frequently the most abundant species of high energy intertidal reef flats with sandy to coarse rubble substrates. *T. hemprichii* often forms monospecific meadows at the seaward margin of intertidal reef flats where it is subjected to waves and high velocity tidal currents. In these environments the blades are short, but the root/rhizome network is extensive providing a strong anchorage that stabilises and consolidates otherwise loose sediments

In many sheltered and muddy environments in the Indonesian Archipelago, monospecific stands of *Enhalus acoroides* occur (Kiswara *et al.* 2005). *E. acoroides* is the structurally largest seagrass species and is widespread throughout the archipelago. It has been found in a number of environments, ranging from intertidal reef flats to mud-banks adjacent to mangrove forests (Kuriandewa *et al.* 2003). Leaf size of *E. acoroides* is significantly larger in coastal than offshore meadows (Verheij and Erftemeijer 1993), biomass and shoot densities are higher and epiphyte cover lower, factors attributed to the less severe environments fluctuations of offshore meadows (Kuriandewa *et al.* 2003).



Enhalus acoroides (left) and *Cymodocea rotundata*/*E. acoroides* in lagoon, Sanur (Bali) March 2007.
Photos: Rudi Yoshida

Two species of *Cymodocea* (*C. rotundata* and *C. serrulata*) occur in the Indonesian Archipelago. *C. rotundata* appears more common than *C. serrulata*, and often forms extensive monospecific meadows in the lower eulittoral. It is highly tolerant to sub-aerial exposure, and is one of the most common seagrasses associated with the intertidal reef flats of fringing reefs, barrier reefs and atolls. *C. rotundata* is found in a number of reef habitats, but it is most abundant in shallow-water lagoons of wide fringing reefs. For example, it is one of the dominant seagrasses in the shallow lagoon of the extensive Sanur Reef along the southeast coast of Bali. It colonizes a variety of sediments ranging from coarse sands as well as rubble areas where it stabilizes and consolidates the substrate.

Cymodocea serrulata is found mainly in subtidal environments to a depth of ~5m. It is able to grow on a variety of substrates, ranging from silty mud to coarse coral rubble. In relatively sheltered environments with substrates consisting of medium-grained coral sands it was found to form extensive and dense monospecific meadows. In lagoonal mixed seagrass communities, *C. serrulata* may be the dominant species. *C. rotundata* and *C. serrulata* have higher below ground biomass when growing in established mixed meadows than in monospecific pioneering meadows (Nienhuis *et al.* 1989).

Both species of *Halodule* are found in Indonesia. *H. uninervis* and *H. pinifolia* have similar distributions and both are widespread throughout the archipelago. Waycott *et al.* (2004) suggested that *H. uninervis* and *H. pinifolia* are conspecific, recognising that the plasticity of blade size is attributed to local conditions. Nevertheless, in Indonesia we retain them as separate entities, as there is no sufficient evidence from Indonesian material to support this merger. Future studies, both ecological and molecular, would help to clarify this. *H. uninervis* tends to be locally more abundant, but extensive monospecific meadows of *H. pinifolia* are not uncommon, and occur mainly on muddy or fine-grained calcareous sands (Kiswara and Tomascik 1994). *H. uninervis* density also depends on the phenotype (wide and narrow leaves) (Kiswara 1994). *H. uninervis* has a wider depth range (lower eulittoral to 8-10 m) than *H. pinifolia*, which is usually found in a narrow zone between the middle eulittoral to subtidal (1-2 m).

H. uninervis was observed to form monospecific meadows on exposed inner reef flats as well as on steep sediment slopes consisting of silty to coarse-grained sand (Kuriandewa *et al.* 2003). *H. uninervis* is generally considered as a typical pioneering species able to rapidly colonize newly available substrates. *H. uninervis* has higher below ground biomass when growing in established mixed meadows than in monospecific pioneering meadows (Nienhuis *et al.* 1989). *H. uninervis* is also a preferred food for dugong (de longh *et al.* 1995; Kiswara 1994)

Syringodium isoetifolium has a wide distribution throughout the archipelago. It is basically a subtidal species, being very sensitive to exposure and desiccation (Bjork

et al. 1999; Bridges and McMillan 1986). The sensitivity to desiccation is most likely related to its leaf morphology. Most seagrasses are tolerant of desiccation for relatively long periods, because their broad leaves overlap one another, thus creating areas where water is trapped and high relative humidity is maintained. The cylindrical leaves of *S. isoetifolium* do not offer this type of protection, and therefore *S. isoetifolium* is seldom found above the low spring tide mark.

THREATS

The degradation of seagrass meadows in Indonesia has been poorly documented but appear to be relatively generic across the archipelago with coastal development, local land clearing and resulting sediment run off, elevated turbidity from vessel movement, coral excavation for building material, inappropriate fishing methods and nutrient from sewage likely to be the major problems at a local scale. The loss of 116ha of seagrass meadows in the western section of Banten Bay was a consequence of coastal development and reclamation (Kiswara 1994; Kuriandewa *et al.* 2003).

Climate change is likely to be the major variable in the medium to long term. Climate change is predicted to raise sea level and seawater temperatures, and increase carbon dioxide concentrations in seawater. Rising sea levels could increase the distribution of seagrass because more inland areas will be covered by seawater. However, the sediment erosion that is likely to be associated with sea level rise could destabilise the marine environment and cause seagrass losses. Increasing concentrations of carbon dioxide in seawater could increase the area of seagrass because seagrasses will have more carbon available for growth and could increase photosynthetic rates. Increased seawater temperatures might raise the photosynthetic rate of seagrasses. However, in some places, seagrasses are close to their thermal limit and rising temperatures could cause “burning” and tissue death.

SEAGRASS-WATCH IN INDONESIA

To provide an early warning of change, long-term monitoring and community engagement programs have been established across Indonesia as part of the Seagrass-Watch, global seagrass assessment and monitoring program (www.seagrasswatch.org; McKenzie *et al.* 2000). Establishing a network of monitoring sites in Indonesia 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: L-R, Sanur (Bali) May 2005 and Seraya Kecil (Komodo) July 2002.

Photos: Len McKenzie

The following is a summary of the current status of Seagrass-Watch monitoring in the Indonesia archipelago.

Bali

The reef flat at Sanur in southern Bali is covered by extensive intertidal and subtidal *Enhalus acoroides* dominated seagrass meadows. Meadows extend from nearshore to reef crest. Large meadows of *Thalassodendron ciliatum* cover the reef crest on the edge of the surf zone and adjacent to channels.

Monitoring: ongoing, *ad hoc*

Principal watchers: TNC Indonesia, Indonesian Seagrass Association and Seagrass-Watch HQ

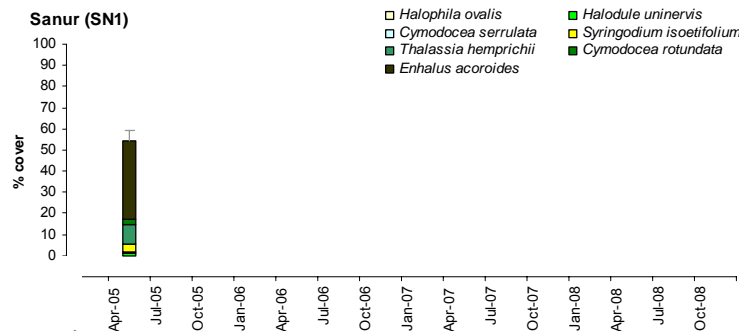
Location: fringing reef flat at Sanur.

Site code: SN1

Issues: coastal development, vessel movement, stormwater and urban runoff

Status (Dec08):

- monitoring has not been conducted since site was established in May 2005
- meadow is dominated by *Enhalus* with *Thalassia* and *Syringodium* making up most of the understory.



Komodo

Komodo National Park is located in the centre of the Indonesian archipelago, between the islands of Sumbawa and Flores. Komodo National Park lies in the Wallacea Region of Indonesia, identified by WWF and Conservation International as a global conservation priority area.

There are approximately 4,000 human inhabitants living within the park spread out over four settlements (Komodo, Rinca, Kerora, and Papagaran). All villages existed prior to 1980 before the area was declared a national park.

Monitoring: suspended

Principal watchers: PKA Balai Taman Nasional Komodo and The Nature Conservancy, local villagers, WWF

Location: on the island Seraya Kecil, just outside the Komodo National Park boundary, in front of a local tourist accommodation facility. Other sites were established on the island of Papagaran, inside the park boundaries and monitored with the assistance of the local village community.

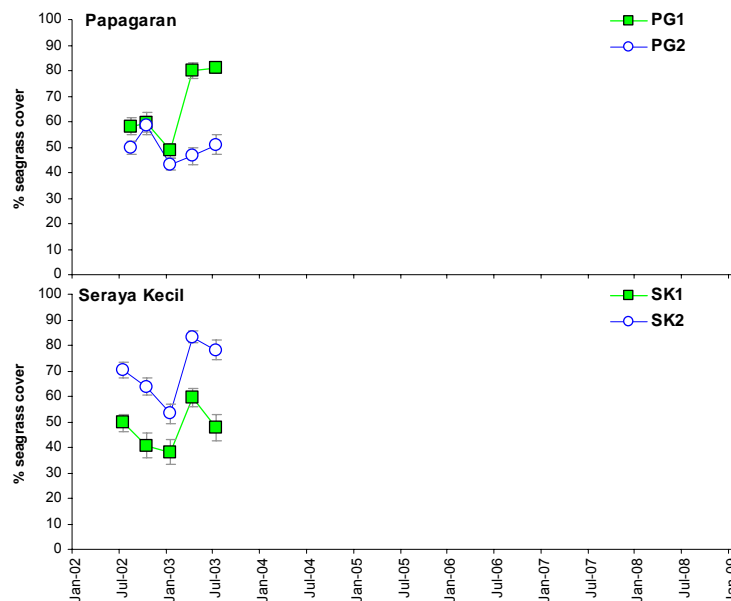
Site code: PG1, PG2, SK1, SK2

Issues: raw sewage from adjacent village, blast fishing

Status (Dec08):

- No monitoring has been conducted since July 2003
- Both sites at Seraya Kecil appear to exhibit typical season patterns in seagrass abundance.
- Seraya Kecil sites were dominated by *Enhalus acoroides* and *Thalassia hemprichii* with varying amounts of *Halophila ovalis*, *Syringodium*, *Halodule* and *Cymodocea* species.
- Both sites at papagaran appeared to show a possible seasonal increase in April, with July 2003 abundances returning to 2002 levels.

- Sites at Papagaran were dominated by *Enhalus* with some *Thalassia*.
- PG2 is adjacent to the coastal village and PG1 is approximately 500m south away from the village. The lower seagrass abundance at PG2 compared to PG1, may be the result of impacts from boat movements (anchoring & propeller scarring) and higher levels of nutrients (from village sewage effluent).



Riung (Flores)

Riung village, on the coast north of Bajawa, is adjacent to the Seventeen Island National Reserve. The National Park, Pulau Tujuhbelas (Seventeen Islands), in fact has more than 20 islands, but, in a gesture of patriotism, the number was declared to 17, to conform to Indonesia's Independence Day, August 17. The biggest island is Pulau Ontoloe. The coastline is fringed by extensive intertidal and subtidal seagrass meadows connecting mangrove and coral reef ecosystems. The Department of Fisheries and WWF had previously mapped the extent and condition of coral habitats and mapped seagrass meadows in the region. Seagrass-Watch sites were established using information from these surveys. Both sites are accessed by boat. The seagrass meadows support extensive subsistence fisheries that harvest of sea urchins, sea cucumbers, small fish and shellfish for local markets.

Monitoring: suspended

Principal watchers: Marthen Leuna, Modesta Meme, Ainas Perikanan, Kilautan, Woltman Tuga (Dept. of Fisheries), Purwanto (TNC), Mr Abdurahman (MTS Nangamese), Seagrass-Watch HQ.

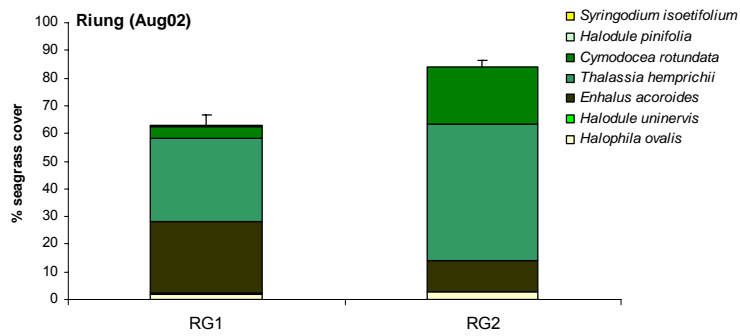
Location: Ontoloe Island & Bakau Island on the central north coast near Riung

Site code: RG1, RG2

Issues: Sewage from adjacent village, boat traffic, overfishing.

Status (Feb05):

- No monitoring since sites were established in August 2002
- Monitoring sites were significantly different in seagrass abundance and species composition.
- Bakau Island (RG1) was dominated by *Enhalus acoroides* and *Thalassia hemprichii*, while Ontoloe Island (RG2) was dominated by *Thalassia hemprichii* and *Cymodocea rotundata*.
- Current condition is unknown.



Karimunjawa

Karimunjawa is one of six Marine National Parks in Indonesia and is located off the northern part of the central Java coast. The marine park contains vast areas of seagrass meadows growing on sandy islands cays and in sheltered muddy habitats adjacent to mangrove forests.

Seagrass meadows in Karimunjawa are fished using traps, spears and lines for a range of fish species commonly eaten by local inhabitants. Reef fish on the other hand, are commonly sold to the mainland as they fetch considerably higher prices. Seagrass areas are also increasingly being used for the placement of seaweed farms, an alternative livelihood being promoted to reduce the pressure on wild fisheries.

As part of an ongoing initiative by the Wildlife Conservation Society to train National Parks rangers in marine survey techniques and develop a new management regime for the park, a number of rangers were trained in Seagrass-Watch techniques in September 2003.

Monitoring: ongoing, *ad hoc*

Principal watchers: Indonesia National Parks

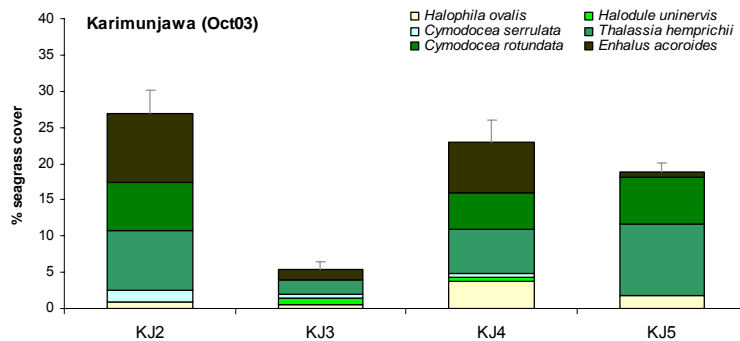
Occasional and past watchers: Wildlife Conservation Society (WCS)

Location: Menjangan Kecil, Karimunjawa, Menjangan Besar, Kemujan Island

Site code: KJ1, KJ2, KJ3, KJ4, KJ5

Status (Dec08):

- Each of the monitoring sites differ significantly in seagrass abundance and species composition.
- In September 2004 the Park Rangers conducted surveys at 6 sites of seagrass significance identified by local inhabitants and the Marine Park Authority.
- In November 2004 staff from the Wildlife Conservation Society assisted the Park Rangers to conduct park wide surveys in a bid to identify further sites for Seagrass-Watch monitoring.
- Current status is unknown as results from previous surveys are still pending.



Manado

Blongko is a small village (115 km southwest of Manado) with a population of 1,250, located on the northwest shore of Minahasa. Its approximately 6.5 kilometers of coastline is healthy and productive, bordered by relatively thick and vigorous mangrove. Most of the population lives along the water, and the majority are fishers, although almost all residents both fish and farm. The fishery, both offshore and on the coral reef, plays a significant role in the livelihood of the community. Most fish captured is used for home consumption or sold by the fishers wives in the local community.

Blongko Marine Sanctuary established in 1998, covers 12 ha along the coast, and contains a mangrove forest, seagrass and part of a coral reef. Blast fishing still occurs in the vicinity, by using soda bottles stuffed with explosive potassium nitrate-detonate underwater, killing or stunning reef fish so that they are easy to net. Dugong have also been reported in the region. At full moon dugongs come over from a nearby bay to feed on seagrass meadows, which are only accessible for them during spring tide.

A second site was established at the village of Terremel, about 150 kilometres north east of Manado. This intertidal site is part of a locally managed marine protected area established by the community, with assistance from Coastal Marine Resources Program and students from the Sam Ratulangi University. The CMRP program is US Aid funded and has been working with the university to establish small locally managed marine protected areas with villages where all harvesting is prohibited.

Monitoring: suspended

Principal watchers: Billy Wagey (Sam Ratulangi University), students & Coastal Marine Resources Program (CMRP)

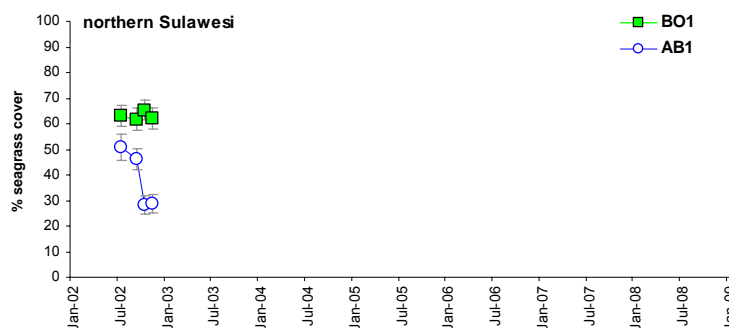
Location: Blongko and Airbanua (Terremel), northern Sulawesi

Site code: AB1 (Airbanua, Terremel), BO1 (Blongko)

Issues: Raw sewage from adjacent village, blast fishing

Status (Dec08):

- Monitoring has not been conducted since November 2002.
- Current status of seagrass resources unknown.
- Abundances at Airbanua appeared to be declining, but this may have been a seasonal trend.
- The Blongko site consists of a mix of species including *Cymodocea rotundata*, *Thalassia hemprichii* and *Enhalus acoroides*.
- At Airbanua (Terremel), the seagrass species included *Enhalus acoroides* and *Thalassia hemprichii*.
- The success of establishing an ongoing monitoring program at all sites is dependent on the resources and commitment of CMRP, university staff and students and residents the local villages.



For more information, visit www.seagrasswatch.org



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A guide to the identification of seagrasses in Indonesia

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



cylindrical

Syringodium isoetifolium

- narrow spaghetti-like leaves, 1-2mm diameter
- leaf tip pointed
- leaves contain air cavities
- inflorescence a “cyme”

Ruppia maritima

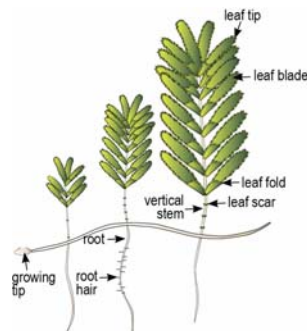
- leaves fine and thread-like
- pointed tip on leaves, sometimes serrated
- inflorescence on a long stalk, sometimes spiralled

Leaves oval to oblong



oval to oblong

obvious vertical stem with more than 2 leaves



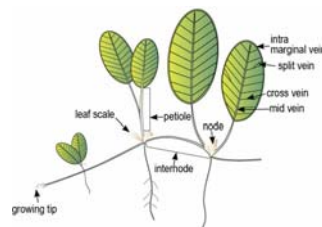
Halophila spinulosa

- leaves arranged opposite in pairs
- leaf margin serrated
- shoots can be up to 15cm long
- 10-20 pairs of leaves per shoot
- leaf 15-20mm long and 3-5mm wide

Halophila beccarii

- leaves arranged in clusters of 5-10, at a node on vertical stem
- leaf clusters do not lie flat
- leaf margin finely serrated

leaves with petioles, in pairs



Halophila ovalis

- cross veins more than 8 pairs
- leaf margins smooth
- no leaf hairs
- leaf 5-20mm long

Halophila decipiens

- leaf margins serrated
- fine hairs on both sides of leaf blade
- leaves are usually longer than wide

Halophila minor

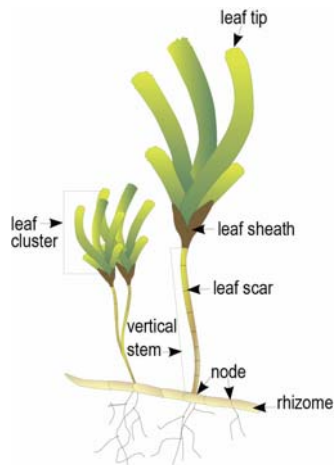
- leaf less than 5mm wide
- cross veins up to 8 pairs
- leaf margins smooth
- no leaf hairs

Leaves strap-like

Leaves can arise from vertical stem



straplike



Cymodocea rotundata

- leaf tip rounded with smooth edge
- leaf sheath not obviously flattened, fibrous
- leaf sheath scars continuous around upright stem

Cymodocea serrulata

- leaf tip rounded with serrated edge
- leaf sheath broadly flat and triangular, not fibrous
- leaf sheath scars not continuous around upright stem

Halodule pinifolia

- leaf tip rounded
- leaf with 3 distinct parallel-veins, sheaths fibrous
- rhizome usually white with small black fibres at the nodes

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

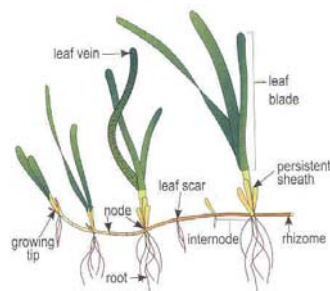
Thalassia hemprichii

- ribbon-like, curved leaves 10-40cm long
- short red/black bars of tannin cells, 1-2mm long, in leaf blade
- leaf tip rounded may be slightly serrated
- 10-17 longitudinal leaf veins
- thick rhizome (up to 5mm) with conspicuous scars

Thalassodendron ciliatum

- distinct upright stem
- clusters of curved leaves (>5 mm wide), margins serrated
- stem and rhizome woody
- seedling germinates while attached to female plant

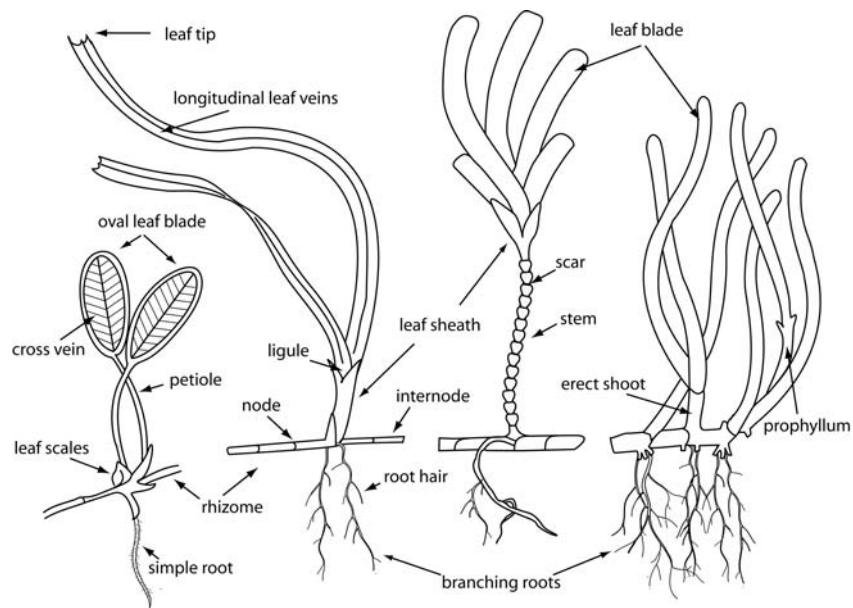
Leaves always arise directly from rhizome



Enhalus acoroides

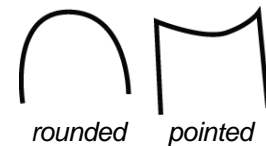
- large plant, leaves >30 cm long, >1 cm wide
- in-rolled edges of leaves
- long, black bristles protruding from thick rhizome
- cord-like roots

Parts of a seagrass plant

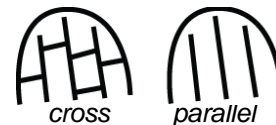


Leaf

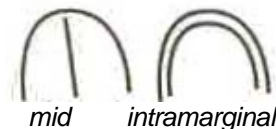
Tip Can be rounded or pointed. Tips are easily damaged or cropped, so young leaves are best to observe.



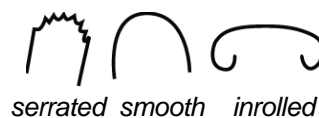
Veins Used by the plant to transport water, nutrients and photosynthetic products. The pattern, direction and placement of veins in the leaf blade are used for Identification.



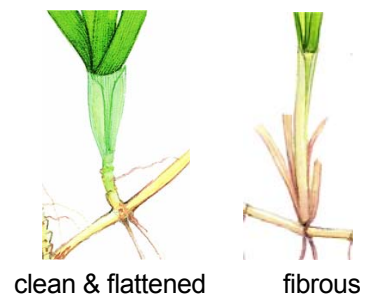
- cross-vein: perpendicular to the length of the leaf
- parallel-vein: along the length of the leaf
- mid-vein: prominent central vein
- Intramarginal-vein: around inside edge of leaf



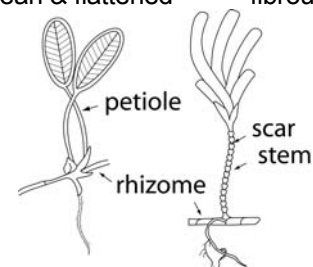
Edges The edges of the leaf can be either serrated, smooth or inrolled



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.

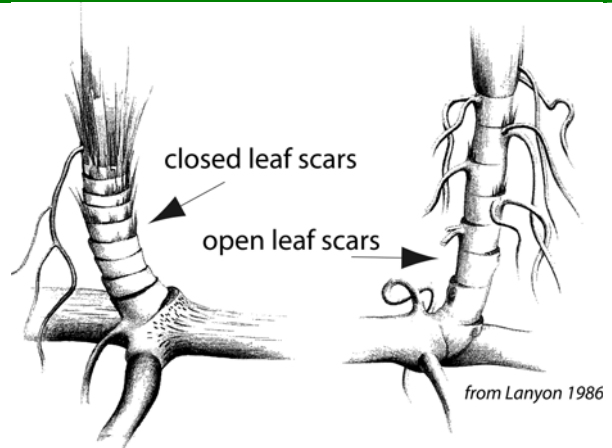


Attachment The leaf can attach directly to the rhizome, where the base of the leaf clasps the rhizome, or from a vertical stem or stalk (petiole) e.g. *Halophila ovalis*.



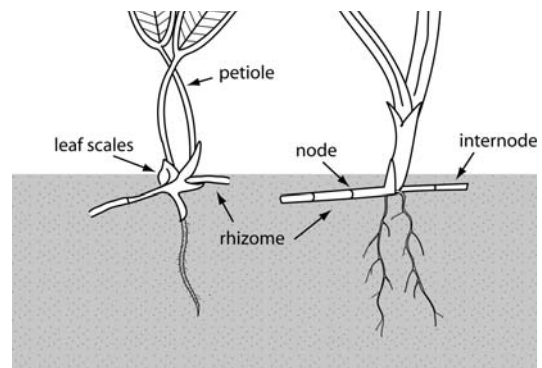
Stem

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*).



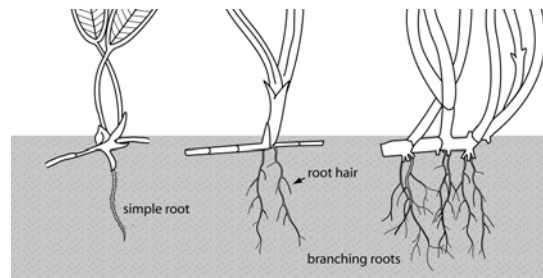
Rhizome

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.



Notes:

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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 shade seagrasses, thereby reducing photosynthetic capacity;
- increased sedimentation can smother seagrass or interferes 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 standardised measurements taken from 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. Since it's genesis in 1998 in Australia, Seagrass-Watch has now expanded internationally to more than 26 countries. Monitoring is currently occurring at over 250 sites. To learn more about the program, visit www.seagrasswatch.org .

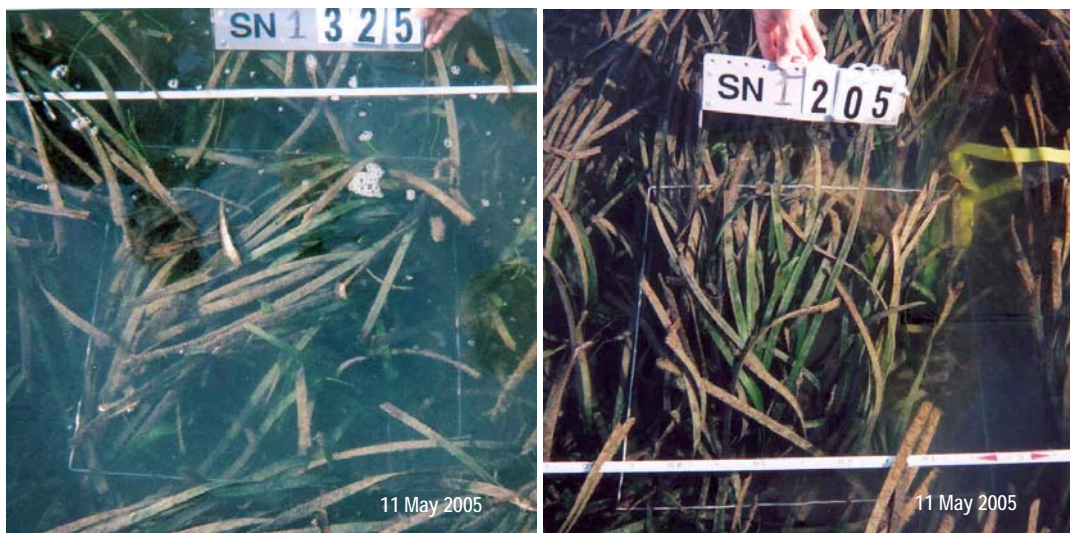
Seagrass-Watch aims to raise awareness on the condition and trend of nearshore seagrass ecosystems and provide an early warning of major coastal environment changes. Participants of Seagrass-Watch are generally volunteers from a wide variety of backgrounds who all share the common interest in marine conservation. Most participants are associated with established local community groups, schools, universities & research institutions, government (local & state) or non-government organisations.

Seagrass-Watch integrates with existing education, government, non-government and scientific programs to raise community awareness to protect this important marine habitat for the benefit of the community. The program has a strong scientific underpinning with an emphasis on consistent data collection, recording and reporting. Seagrass-Watch identifies areas important for seagrass species diversity and conservation and the information collected is used to assist the management of coastal environments and to prevent significant areas and species being lost.

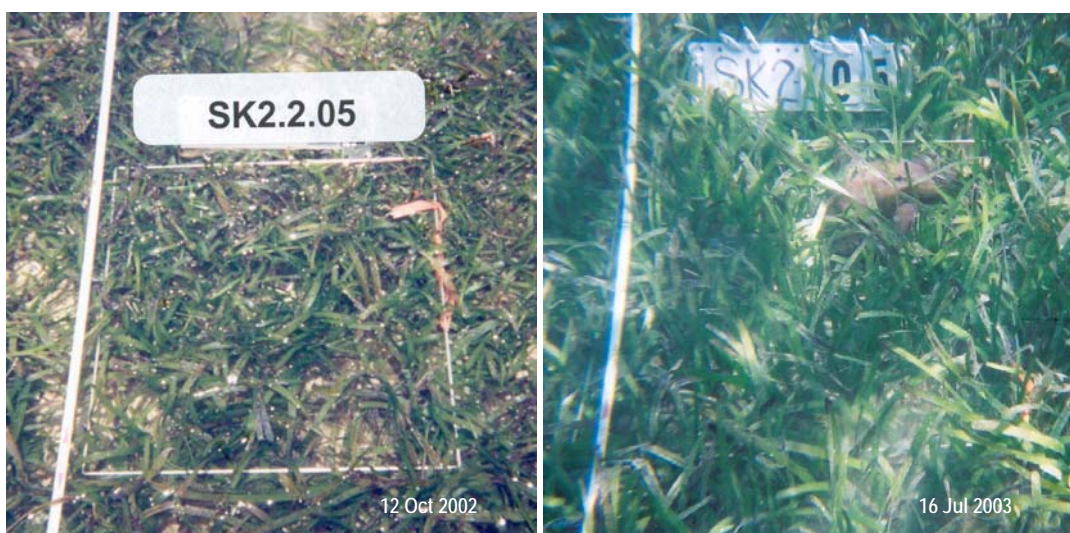
Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assessing human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their value as a natural resource. Responsive management based 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 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.*



Quadrat photos from Sanur, SN1, May 2005

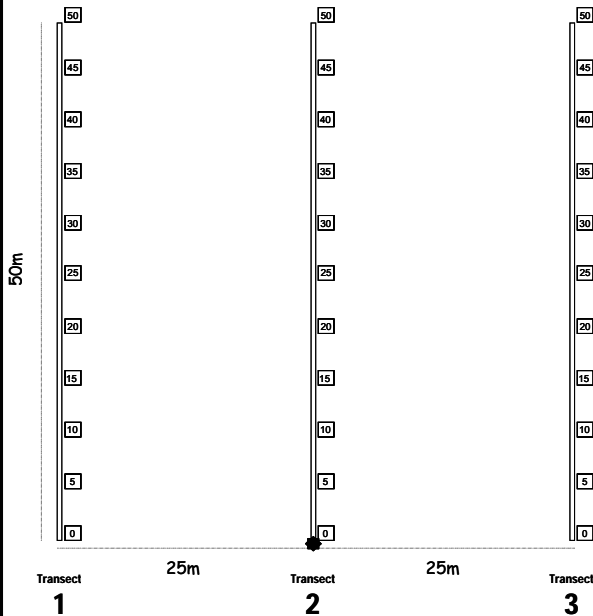


Quadrat photos from Seraya Kecil, Komodo, SK2.

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., P11225 = 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

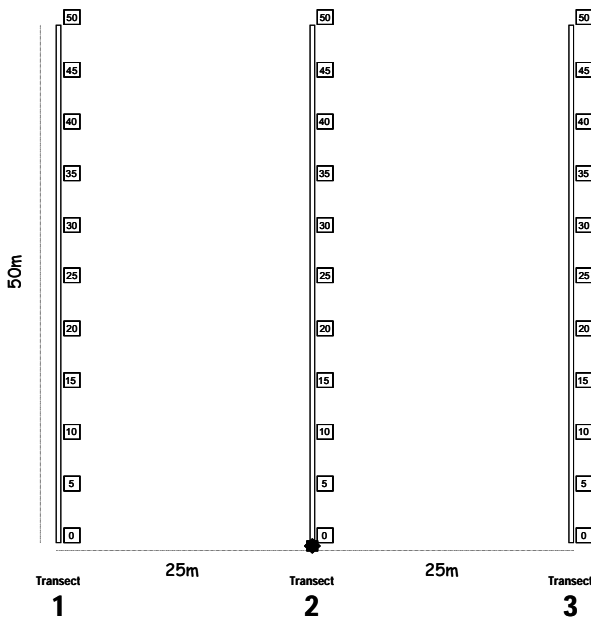
- Data can be entered into the MS-Excel file downloadable from www.seagrasswatch.org. Email completed files to hq@seagrasswatch.org
- Mail original datasheets, photos and herbarium sheets

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Northern Fisheries Centre
PO Box 5396
Cairns QLD 4870 AUSTRALIA

Seagrass-Watch Indonesia

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. MH1225 = Minahasa site 1, transect 2, 25m quadrat

Tingkat Kesulitan: Mudah **Peralatan:** Dasar
Lamanya: 1-2 Jam **Frekuensi:** Kali/tahun

Definisi

Mengamati suatu perubahan/distribusi pada komunitas lamun lewat partisipasi masyarakat local secara aktif.

Tujuan

1. Untuk mengukur perubahan-perubahan pada rumput laut dalam hal:
 - Distribusi via posisi rumput laut pada kuadrat
 - Komposisi jenis (*species*) koleksi sepanjang kuadrat sample
 - Kelimpahan untuk mengukur prosentasi tutupan pada kuadrat.
2. Untuk mengembangkan suatu kelompok komunitas seagrass monitoring lewat pengenalan manual standart. Untuk dikembangkan sebagai pilot studi.

Kuadrat

Suatu alat (ukuran 50x50 cm) besi segi empat yang digunakan untuk mengawasi distribusi organisme rumput laut pada suatu daerah yang diteliti.

Alat yang digunakan

- 3 x 50 meter pita pengukur
- 6 x 50 cm patok tenda plastik
- kompas
- lembaran/kertas data monitoring
- standart
- Klipboard, pensil dan mistar 30cm
- Lembaran/kertas identifikasi rumput laut
- Label foto kuadrat
- Lembaran/Kertas % luas tutupan
- Kamera

Casa Pengamatan

Sampling Kuadrat

Dengan 50x50m 'site' (lokasi), letakkan 3 transek (masing-masing 50 m) parallel satu dengan lainnya, 25m jauhnya dan tegak lurus dari pantai. (lihat contoh gambar); dimana tiap kuadrat yang ditempatkan sebagai sampling harus mengikut langkah-langkah dibawah ini:

1. **Setelah lokasi disiapkan dan transek telah terpasangi/tersusun; segera diambil foto dokumentasi dengan prosedur; Foto dokumentasi diambil pada 5m, 25m, 45m kuadrat pada tiap transek; atau pada kuadrat-kuadrat tertentu yang dipilih khusus.**

- Sebelum foto diambil, pertama-tama letakkan foto kuadrat yang ditandai (diberi label) disampling kuadrat menurut kode penomoran yang telah ditentukan .
- Ambil foto dokumentasi dengan sudut severtikal mungkin, sudah termasuk didalamnya keseluruhan rangka/frame kuadrat dan label kuadrat. Diusahakan agar menghindari bayangan atau daerah refleksi/pantulan air di area pandang.

2. Cek kotak foto yang diambil pada lembaran data kuadrat.

3. Gambarkan komposisi sedimennya;

Untuk memperoleh hasil tersebut, benamkan jari-jari anda pada dasar perairan/substrat tersebut dan raba teksturnya (susunannya). Jelaskan keadaan sedimen tersebut sesuai urutan dominannya; misalnya: pasir, pasir halus/berlumpur.

4. Estimasi/taksir prosentasi luas tutupan.

Taksiran prosentasi luas tutupan rumput laut pada kuadrat menggunakan "foto lembaran persentase luas tutupan standar" sebagai penuntun.

5. Identifikasi jenis-jenis rumput laut pada kuadrat lewat penentuan persentase kontribusi tiap spesies/jenis. Gunakan kunci indentifikasi yang tersedia.

6. Pengukuran tinggi kanopi.

Ukur tinggi kanopi rumput laut dengan mengabaikan 20% dari daun-duan tertinggi. Pengukuran dilakukan dari dasar hingga ujung-ujung daun.

7. Perkiraan prosentasi tutupan alga.

Perkiraan prosentasi tutupan alga dalam kuadrat. Alga bisa saja menutupi daun-daun dari rumput laut. Gunakan pertunjuk presentasi tutupan alga.

8. Catat dan hitung semua organisme lain.

Catat dan hitung organisme lain yang mungkin penting (Contoh, jumlah dari moluska, teripang, bulu babi, bebas dari aktifitas makan dari penyu) yang ada dalam kuadran.

9. Ambil contoh dari rumput laut bila diperlukan.

Contoh rumput laut harus ditempatkan dalam kantong plastik yang berisi air dan telah diberi label/kode lokasi. Pilih contoh rumput laut yang dapat mewakili setiap spesies dan pastikan bahwa semua bagian rumput laut terambil, termasuk rizoma akar. (Bila mungkin kumpulkan lamun beserta dengan buah daunnya).

Setelah pemantauan selesai lakukan prosedur bawah ini:

Langkah:

- 1. Cek lembaran data bila sudah terisi dengan benar. Pastikan semua kolom sudah terisi dengan benar.**
- 2. Kumpulkan kembali semua peralatan dari lokasi pengamatan.**
- 3. Semua peralatan dibersihkan.**
- 4. Akhir transek (baca GPS)**

www.seagrasswatch.org



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Enhalus acoroides



- very long ribbon-like leaves with inrolled leaf margins
- thick rhizome with long black bristles and cord-like roots
- leaves 30-150 cm long

Halophila ovalis



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

Thalassia hemprichii



- ribbon-like, curved leaves 10-40cm long
- leaf tip rounded, slightly serrated
- short black tannin cells, 1-2mm long, in leaf blade
- thick rhizome with scars between shoots

Halodule uninervis



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

Halodule pinifolia



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

Cymodocea rotundata

- rounded leaf tip
- narrow leaf blade (2-4mm wide)
- leaves 7-15 cm long
- 9-15 longitudinal veins
- well developed leaf sheath



Cymodocea serrulata

- serrated leaf tip
- wide leaf blade (5-9mm wide)
- leaves 6-15cm long
- 13-17 longitudinal veins



Syringodium isoetifolium



- narrow spaghetti-like leaves
- cylindrical in cross section, 1-2mm diameter
- leaves contain air cavities
- leaf tip tapers to a point
- leaves 7-30cm long

Halophila minor



- less than 8 pairs of cross veins
- small oval leaf blade less than 5mm wide
- leaf margins smooth
- no leaf hairs

SEAGRASS-WATCH MONITORING



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

START of transect (GPS reading)

Latitude: $9^{\circ} 31.2642.3$ Longitude: $147^{\circ} 16.9902.5$

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

Quadrat (metres from transect origin)	Sediment (eg. mud/sand/shell)	Comments (eg. 1lx 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: $9^{\circ} 31.2384.5$ Longitude: $147^{\circ} 16.9794.5$

SP = Sponge. HC = Hermit Crab.
 FO = Foram. CH = Crab Hole.
 WH = Worm Hole
 GAS = Gastropod. 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 if required.

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 is 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 lose 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 drying 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 (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 than 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.



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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).

	Fine-medium Clay	0 – 0.002 mm
	Coarse Clay	0.0021 – 0.004 mm
Mud	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
	Very Fine Sand	0.0631 – 0.125 mm
	Fine Sand	0.1251 – 0.250 mm
Sand	Medium Sand	0.2501 – 0.500 mm
	Coarse Sand	0.5001 – 1.000 mm
	Very Coarse Sand	1.0001 – 2.000 mm
	Granules	2.0001 – 4.000 mm
Gravel	Pebbles and larger	>4.0001 mm

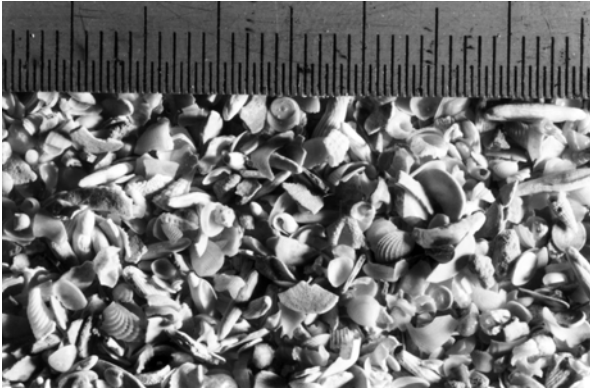
In Seagrass-Watch, the primary descriptors relate to the size of the sediment grains: gravel (>2000µm); coarse sand (>500 µm); sand (>250 µm); fine sand (>63 µm); and mud (<63 µm).

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).

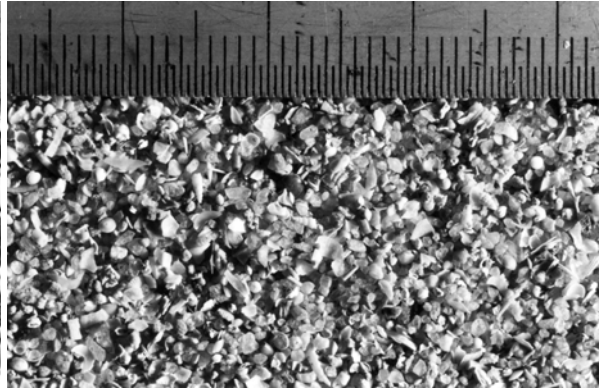
- mud** *has a smooth and sticky texture.*
- fine sand** *fairly smooth texture with some roughness just detectable. Not sticky in nature.*
- sand** *rough grainy texture, particles clearly distinguishable.*
- coarse sand** *coarse texture, particles loose.*
- gravel** *very coarse texture, with some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

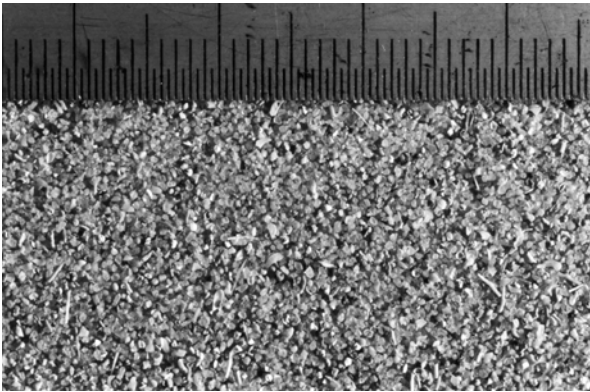
The visual/tactile estimation method used in Seagrass-Watch is a simple yet relatively accurate measure of the sediment grain size which can be used for quantitative assessments (see McKenzie 2007, http://www.seagrasswatch.org/Info_centre/Publications/pdf/371_DPIF_McKenzie.pdf).



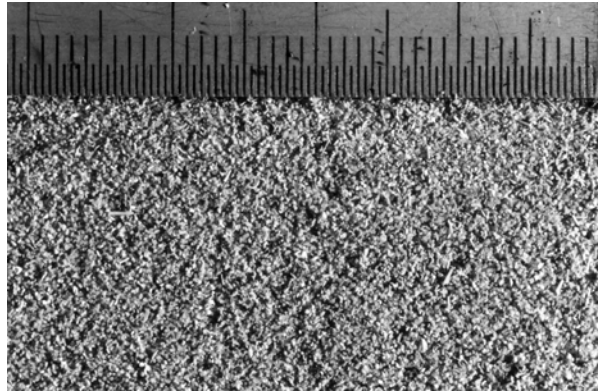
gravel (>2mm)



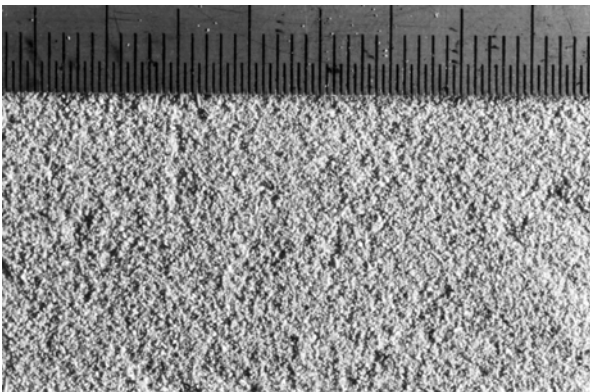
very coarse sand (1 – 2 mm)



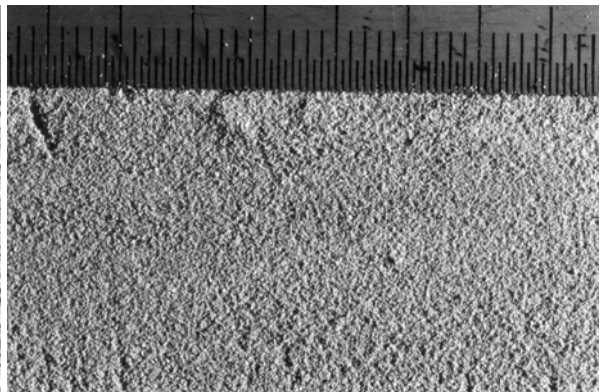
coarse sand (0.5 – 1 mm)



medium sand (0.25 – 0.5 mm)



fine sand (0.125 – 0.25 mm)



very fine sand (0.063 – 0.125mm)

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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 dredging and landfill, construction on the shoreline, commercial overexploitation of coastal resources, and recreational boating activities along with anthropogenic nutrient and sediment loading has dramatically reduced seagrass distribution in some parts of the world. Anthropogenic impacts on seagrass meadows continue to destroy or degrade coastal ecosystems and decrease the function and value of seagrass meadows 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 (such as the dugong *Dugong dugon* and green turtle *Chelonia mydas*) are listed as threatened or vulnerable to extinction in the IUCN Red List (www.iucnredlist.org). 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 are not aware of any legislation currently in Indonesia that specifically stipulates that the function of seagrass ecosystems should be maintained (Hasyilm *et al.* 2003; Soemodihardjo *et al.* 2003). There is existing legislations in Indonesia relevant to the management of seagrass ecosystems, directly or indirectly, which are considered sufficient for current use, but there is an urgent need to attain common understanding regarding the vision and mission in its implementation in the field (Hasyilm *et al.* 2003). Law enforcement is still weak and ineffective; hence pollution and degradation of seagrass ecosystem keep on occurring (Hasyilm *et al.* 2003).

The Indonesian Seagrass Committee in 2002 (Hasyilm *et al.* 2003; Soemodihardjo *et al.* 2003) assessed many of the problems of legal aspects relevant to seagrass management in Indonesia, and made a number of recommendations, these include:

- It is necessary to assign an institution to be endowed with a specific authority to coordinate the campaign against pollution/ degradation of the sea
- That many legal acts (incl. Fisheries, Management of Living Environment, and acts concerning natural, resources and their ecosystems) should be revised
- That terrestrial spatial planning be integrated with that of coastal and sea on the basis of ecosystem entities - Provincial and District/Municipality Governments should assign specific areas as new conservation areas in accordance with the land use plan
- That the division of authority between Provincial and District/ Municipality Governments in administrative aspects be socialised so that the management of ecosystems are assessed holistically and in integrated manner, and free of administrative constraint.
- That forest cutting which may cause direct impact on coastal and marine ecosystems (incl. river banks, greenbelts of dams, lakes, rivers and coast lines) should be prohibited.

To implement such recommendations may require several approaches. Coles and Fortes (2001) separated these into three approaches: a **prescriptive** legal approach; a **non-prescriptive** broad based approach ranging from planning processes to education; and a **reactive** approach designed to respond to a specific issue such as a development proposal. These may overlap and be used simultaneously in many cases.

Prescriptive management of seagrass issues can range from local laws to a Presidential Decree. In South East Asian countries such as Indonesia and in the Pacific Island Nations, protection is often strongest at the village or district level by Government supported agreements or through local management level (Coles and Fortes 2001). At a village level, successful enforcement is very dependent on community support.

While there is no international legislation that specifically protects seagrass, there are international conventions that recognise the importance of wetlands and coastal areas, such as the Ramsar Convention on Wetlands. In some cases, seagrass meadows have been inadvertently protected because they are located within protected areas, such as Komodo National Park, Karimunjawa National Park and Wakatobi Marine

National Park. It is hoped that the localities recognised as of global significance, which also include seagrasses will also provide future protection of some degree.

Prescriptive management can include establishment of marine protected areas (MPAs). MPAs are defined as any area of sea especially dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources and managed through legal and other effective means (IUCN 1994). An MPA may be a “no-take” area like a terrestrial national park or it may comprise a multiple-use area, zoned in such a way to minimise conflicts and allow extractive activities to occur in specific areas. Establishing even a small MPA is a complex process and includes a need assessment and the involvement of all stakeholders and Government agencies in defining a border and existing uses. The Government of Indonesia has declared 24 marine protected areas throughout the country. There are plans to expand this to 85 reserves covering 30 million hectares.

An alternate and complementary non-prescriptive approach is a locally-managed marine area (LMMA). A locally-managed marine area is an area of nearshore waters (incl. include coral reefs, seagrass meadows, mudflats, mangrove and other areas) that is actively being managed by local communities or land-owning groups, or is being collaboratively managed by local communities together with local government and/or other partners based in the immediate vicinity. For example, Yayasan Rumsram, a non-government conservation organization in Biak and Padaido, is pioneering the use of LMMAs in Indonesia through traditional marine resource management and customary sasizen (prohibition) practices.

Non-prescriptive methods of protecting seagrasses generally have a strong extension and/or education focus. Providing information is important as it encourages and enables individuals to voluntarily act in ways that reduce impacts to seagrasses. Actions in response to such information could range from being more aware of the down-stream effect of poor agricultural practices to lobbying politicians for stronger sanctions against decisions that lead to seagrass loss. Non-prescriptive methods range from simple explanatory guides to complex industry codes of practice developed in negotiation with the industry in question (Coles and Fortes 2001).

Reactive processes generally occur in response to a perceived operational threat such as a coastal development proposal. Reactive processes can also include risk management plans that identify areas of seagrass to be protected in the event of an impact (e.g., oil spill or ship grounding). Reactive processes are generally identified in environmental impact statements (EIS), which also propose strategies (e.g., redesign, response, or by reducing future risk) to minimise the effect of a development or structure on the coastal environment including seagrasses. The combination of project redesign in response to EIS information and reactive environment management systems can provide enormous improvements to coastal seagrass protection.



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Useful web links

Seagrass-Watch Official Site www.seagrasswatch.org

id_seagrass A Yahoo Group for scientists, coastal resource managers, etc, to share ideas and knowledge on protecting and managing seagrasses in Indonesia. Established after a seagrass workshop in Sanur, Bali, Indonesia, 9-12 May 2005. Moderated by Yayu La Nafie, Dept. of Marine Science, Faculty of Marine Science and Fisheries Hasanuddin University, Indonesia. id_seagrass@yahoo.com

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. www.science.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

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

Western Australian Seagrass Webpage Mainly focused on Western Australian research, but provides some general information and links to international seagrass sites. www.science.murdoch.edu.au/centres/others/seagrass/

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

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