Seagrass-Watch

Proceedings of a workshop for monitoring seagrass habitats in Yuwibara Sea Country

Yuwi Aboriginal Corporation Cultural Hub, West Mackay
11-13 August 2026

Len McKenzie & Rudi Yoshida

First Published 2026

Disclaimer

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

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

The correct citation of this document is

McKenzie, LJ & Yoshida, R.L. (2026). Proceedings of a workshop for monitoring seagrass habitats in Yuwibara Sea Country, Queensland. Yuwi Aboriginal Corporation Cultural Hub, West Mackay, 11-13 August 2026. (Seagrass-Watch HQ, Clifton Beach). 52pp.

Produced by Seagrass-Watch HQ

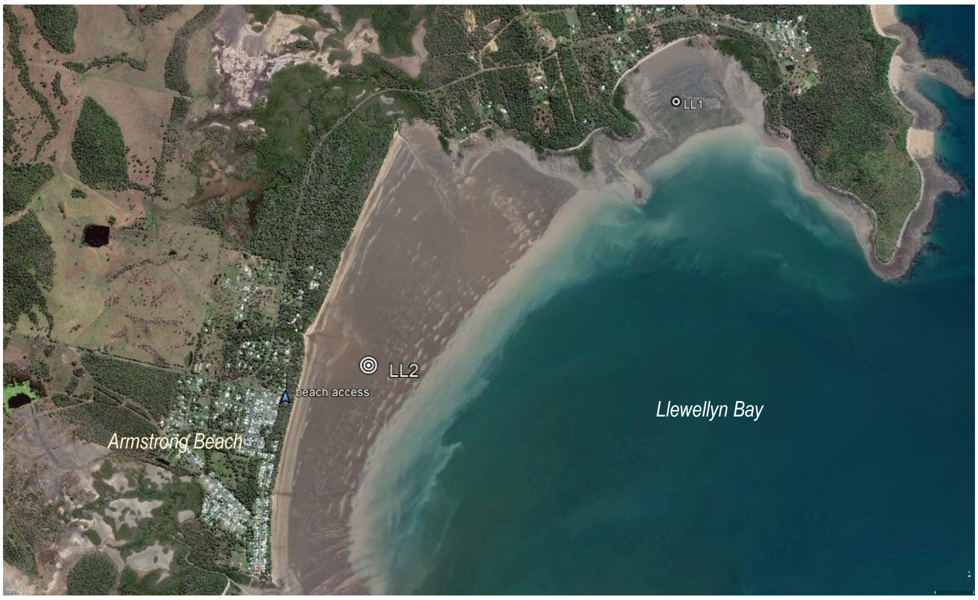
Front cover photos (left to right): aerial drone image of dugong grazing trails within the *Zostera muelleri* dominated meadow on intertidal banks at Seaforth (Apr26); monitoring the *Zostera muelleri* dominated meadow on the intertidal bank at Deception Inlet, Llewellyn Bay; and the submerged intertidal *Zostera muelleri* and *Halodule uninervis* meadow at Armstrong Beach, Llewellyn Bay (Oct25).

Enquires should be directed to:
Seagrass-Watch HQ
Clifton Beach QLD 4879 AUSTRALIA
admin@seagrasswatch.org

Table of Contents

OVERVIEW 5
WORKSHOP TRAINERS 7
AGENDA - LEVEL 1 8
ASSESSMENT REQUIREMENTS 9
BACKGROUND 10
SEAGRASS IN YUWIBARA SEA COUNTRY 18
Dempster Creek to Mackay 19
Mackay to Sarina Inlet 20
Sarina Inlet to Cape Palmerston 21
Seagrass-Watch in Yuwibara Sea Country 22
Great Barrier Reef Marine Monitoring Program 25
PARTS OF A SEAGRASS PLANT 26
A GUIDE TO THE IDENTIFICATION OF SEAGRASSES IN YUWIBARA SEA COUNTRY 28
MONITORING A SEAGRASS MEADOW 30
MAKING A HERBARIUM PRESS SPECIMEN 39
UNDERSTANDING SEDIMENT 42
SEAGRASS CONSERVATION 44
REFERENCES 47
FIELD RISK ASSESSMENT 51
SEAGRASS-WATCH SERVICES 52

Yuwi Aboriginal Corporation Cultural Hub, 316 Nebo Road, West Mackay, QLD, 4740 (next to Col Story Rotary Park).



Armstrong Beach (Llewellyn Bay) field exercise, located 42km south of Yuwi Cultural Hub via Bruce Hwy/A1 and Armstrong Beach Rd (approx 35min drive). Field site (LL2) ~700m from beach access.

This training event is organised with the assistance of Reef Catchments for the *(Sea)Grassroots Community Restoration for Reef Health and Resilience* project, with funding provided by the Australian Government Department of Climate Change, Energy, the Environment and Water as part of the Reef Trust programs grant opportunity.

Seagrass-Watch acknowledges Australia's First Nations People as the first original inhabitants and traditional custodians of this continent, and acknowledge the Traditional Custodians and Owners of the land and sea on which we conduct this workshop. We honour their enduring connection and Cultural Heritage, which includes responsibility for their Sacred Land and Sea Country, Totems, Language, and Songlines. We pay our respects to the peoples, the cultures and the Elders past and present.

Overview

Seagrass-Watch is a global seagrass observing network, where scientists, coastal managers and local stakeholders from across the globe collaborate to assess the status of their seagrass meadows to provide an early warning of coastal ecological decline. The program started in 1998 in Australia, using standardised global monitoring protocols, and has so far expanded to include 429 sites across 33 countries. Anyone can participate in Seagrass-Watch, as it responds to local needs, and includes elements of citizen science. Seagrass-Watch is a monitoring program that brings people together for seagrass conservation.

Seagrass-Watch implements a globally standardised seagrass assessment and monitoring protocol, that has a rigorous quality assurance and quality control procedure to ensure data is of the highest quality and that time and resources are not wasted. The only condition is that on-ground data collection must be overseen by a qualified scientist or trained and competent participant (18 years or over). The program 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 for experienced participants who may plan to participate and/or lead in seagrass monitoring events or conduct seagrass extension activities. Presentations are targeted at participants with a moderate proficiency in English and an education level of year 12 to first year university. As part of the Level 1 workshop we will:

- *study seagrass biology;*
- *learn seagrass taxonomy;*
- *discuss the present knowledge of seagrass ecology, including importance and threats;*
- *gain knowledge of monitoring;*
- *learn about the Seagrass-Watch program and techniques for monitoring seagrass resources; and*
- *become skilled at conducting a Seagrass-Watch field monitoring event.*

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

Seagrass-Watch HQ
PO Box 4
Clifton Beach QLD 4879
AUSTRALIA
E-mail admin@seagrasswatch.org

Photo: Mikael Eriksson

Workshop trainers

Len McKenzie

Len is the Director of Seagrass-Watch and a Principal Researcher with James Cook University. He serves as a seagrass Technical Advisor for the CMS Dugong MoU and is the Project Manager of the Great Barrier Reef 2050 Plan Marine Monitoring Program – Inshore Seagrass Monitoring. He is a full member on the SCOR Working Group 158 for Coordinated Global Research Assessment of Seagrass System (C-GRASS), member of the IUCN Seagrass Specialist Groups and the IUCN Sirenian Specialist Group, an Advisor to the Global Seagrass Mapping Blueprint, and principal investigator for numerous projects focused on the assessment, conservation, and sustainable use of coastal habitats. Len has more than 25 years of experience in seagrass ecology, habitat assessment, fisheries habitats, biodiversity conservation, and resource mapping. His work spans the globe, with extensive experience throughout the Great Barrier Reef, Southeast Asia, and the wider Indo-Pacific region. He has provided scientific information and technical advice that have been instrumental in the management and conservation of seagrass ecosystems worldwide. In addition, he has advised government agencies, fisheries organisations, conservation groups, and community stakeholders on fisheries management and coastal resource-use issues. Len is a qualified Trainer and Assessor (Certificate IV in Training and Assessment – TAE40110) and currently serves as Secretary of the World Seagrass Association.

Current Projects

- Great Barrier Reef Marine Monitoring Program: inshore seagrass
- A blueprint for scalable seagrass ecosystem mapping
- Seagrass Thermal Risk Project & Model Development
- Wuthathi Custodians Strengthening Capacity to Manage Country (*NGaachi*) and Sea (*Karakara*) Integrated Catchment and Foreshore Monitoring Projects
- Scaling Seagrass Restoration on the Great Barrier Reef
- Building local capacity for sustainable livelihoods and community-based conservation of seagrass-linked threatened marine megafauna including dugong and wedgefish in the Bazaruto Seascape, Mozambique
- Expanding Traditional Owner led seagrass monitoring and restoration – Woppaburra TUMRA

Rudi Yoshida

Rudi is the Chief Operations Officer and Data Manager of Seagrass-Watch, and a Researcher with James Cook University. He has more than 20 years of experience in seagrass research, monitoring, and data management. As a core member of Seagrass-Watch HQ, Rudi oversees the management of monitoring data submitted to the program and ensures that rigorous quality assurance and quality control (QA/QC) protocols are consistently applied. He is also responsible for the maintenance and ongoing development of the Seagrass-Watch website and plays a key role in supporting training workshops and capacity-building activities. Through these responsibilities, Rudi contributes significantly to the integrity, accessibility, and long-term value of Seagrass-Watch monitoring data and resources.

Current Projects

- Great Barrier Reef Marine Monitoring Program: inshore seagrass
- Scaling Seagrass Restoration on the Great Barrier Reef
- Building local capacity for sustainable livelihoods and community-based conservation of seagrass-linked threatened marine megafauna including dugong and wedgefish in the Bazaruto Seascape, Mozambique
- Expanding Traditional Owner led seagrass monitoring and restoration – Woppaburra TUMRA

Agenda - Level 1

Tuesday 11 August 2026 (Yuwi Aboriginal Corporation Cultural Hub)

0830 – 0900 *(30min)*	*Sign in (Training will start at 0900am sharp)*
0900 - 0915 *(15min)*	Welcome & Introduction
0915 - 0945 *(30min)*	Seagrass Biology and Taxonomy
0945 - 1030 *(45min)*	Seagrass Identification
1030 - 1100 *(30min)*	*Break*
1100 - 1145 *(45min)*	Seagrass Identification *continued*
1145 - 1230 *(45min)*	Seagrass Biology 2 and Ecology
1230 - 1315 *(45min)*	*Lunch*
1315 - 1445 *(90min)*	Seagrass importance
1445 - 1515 *(30min)*	Seagrass monitoring
1515 - 1530 *(15min)*	Wrap up for day

Wednesday 12 August 2026 (Yuwi Cultural Hub & Armstrong Beach)

0900 - 0930 *(30min)*	recap day 1
0930 - 1045 *(75min)*	Seagrass-Watch: how to sample
1045 - 1115 *(30min)*	*Break*
1115 - 1230 *(75min)*	Seagrass-Watch: how to sample 2
1230 - 1245 *(15min)*	Risk assessment
1245 – 1430 *(1hr 45min)*	*Lunch and relocate to Armstrong Beach*
1430 - 1500 *(30min)*	*Meet at Armstrong Beach/Walk out to site*
1500 - 1700 *(2hrs)*	**Field exercise:** Seagrass-Watch monitoring *Where*: Armstrong Beach (LL2) *(low tide: 1642 0.46, Sunset 1748)* *What to bring:* • *hat, sun protection* • *dive booties or old shoes that can get wet* • *drink/refreshments*
1700 - 1715 *(15min)*	Wrap up for day

Thursday 13 August 2026 (Yuwi Aboriginal Corporation Cultural Hub)

0900 - 0915 *(15min)*	recap day 2
0915 - 1030 *(75min)*	Seagrass threats
1030 - 1045 *(15min)*	*Break*
1045 - 1130 *(45min)*	Seagrass-Watch: QAQC
1130 - 1230 *(60min)*	Seagrass-Watch: how data is used
1230 - 1300 *(30min)*	Discussion and close of Level 1 Training

Assessment requirements

To successfully attain a **Certificate of Achievement**, you will need to demonstrate you have the knowledge, skills, abilities and experience to competently conduct monitoring using Seagrass-Watch protocols.

Successful achievement must to be demonstrated across 9 core units, by completing:

1. *a training workshop (classroom, laboratory and field), and*
2. *three post workshop monitoring events (within 12 months)*

Training workshop (6 units)

Demonstrates you have the knowledge, skills and abilities to conduct monitoring

Classroom (4 units): attendance + achieve 80% of formal assessment (multiple choice, open book)

Laboratory (1 unit): identify 3 local seagrass species correctly and demonstrate how to preserve seagrass samples for a herbarium

Field (1 unit): perform the following to the satisfaction of the trainer:

layout a site and quadrat placement
description of sediment & comments
estimation of seagrass cover
identification of seagrass species
estimation of seagrass species composition
measuring seagrass canopy height
estimation of macro algae cover
estimation of epiphyte cover
taking a quadrat photo
accurately record data

3 post workshop monitoring events (3 units)

Demonstrates you have the experience and competency to conduct monitoring on your own

Must be completed within 12 months: starting no sooner than 1 month after the training workshop. Tentative monitoring events (dates) to be nominated within 1 month of a training workshop. Minimum of 1 site, maximum of 5 sites, per monitoring event assessed. Sites must be sampled within a 2-week period each sampling event. Each monitoring event/period must be separated by at least 1 month, regardless of number of sites monitored. Each participant must assess a minimum of 1 transect per site per sampling event (name must be clearly legible on field datasheet). *A Certified participant can oversee data collection, however, participant being assessed must collect the required data along transect and the name of Certified participant must be clearly legible on datasheet.*

Original datasheets, photos, *etc*, must be submitted to Seagrass-Watch HQ within 2 weeks after each monitoring event. Data submitted must be compliant and must pass QAQC by achieving the following:

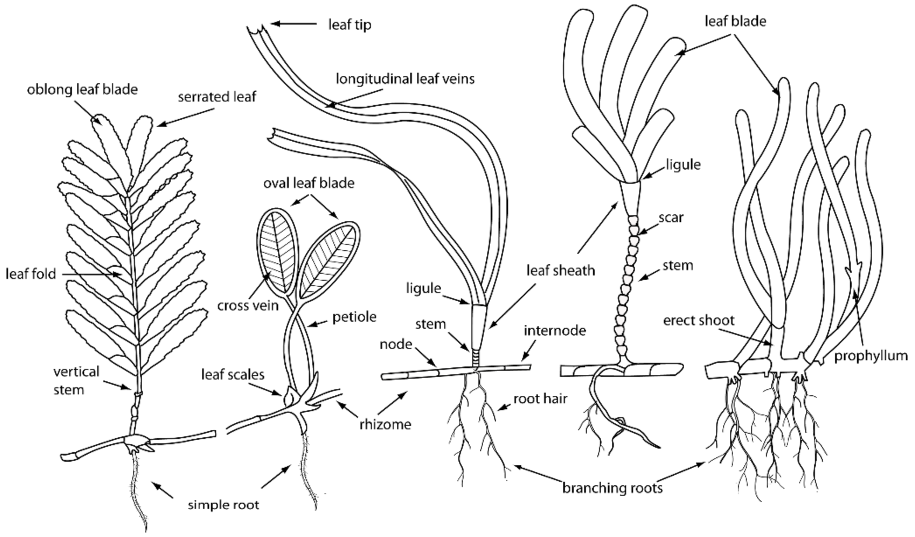
correct description of sediment & comments
seagrass cover estimates within acceptable limits
correct seagrass species identification
correct seagrass species compositions
correct seagrass canopy height measures
macro algae cover estimates within acceptable limits
epiphyte cover estimates within acceptable limits
compliant quadrat photos

Once all QAQC has been completed and the participant has demonstrated they have the skills, ability, experience and competency to conduct monitoring, a certificate will be issued by Seagrass-Watch HQ.

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 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 across countries.

Like terrestrial (land living) plants, a seagrass can be divided into its leaves (which contain veins), rhizome, 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.

Seagrasses have roots, stems and leaves

Seagrass is different to seaweed (algae) as seagrass have an internal vascular system, true roots and produce flowers, fruits and seeds

These marine plants 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), a fern, a long spaghetti like leaf and a ribbon. 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. 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**.

Leaves of different seagrass species can be shaped like a flattened ribbon, look like a fern, round like a clover, or even spaghetti shaped

Seagrass leaves lack stomata (microscopic pores on the underside of leaves) but have thin cuticle to allow gas and nutrient exchange. They also possess large thin-walled aerenchyma (air channels). Aerenchyma are specialised tissue having a regular arrangement of air spaces, called lacunae, that both provide 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. Seagrass leaves also contain **veins** (lignified conducting tissue that transports water, nutrients and photosynthetic products around the plant) (i.e. an internal vascular system). Veins can be across the leaf blade or run parallel to the leaf edge.

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

Also within the leaves are chloroplasts, which use the suns light to convert carbon dioxide and water into oxygen and sugar (photosynthesis).

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

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

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

The roots and rhizomes of seagrasses are well endowed with aerenchyma and the lacunae are extensive and continuous with leaf tissues. Oxygen transport to the roots creates an oxic environment around the roots (in the sediment), facilitating nutrient uptake.

Seagrass pump oxygen into the sediment via their roots

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

Seagrass are angiosperms. Seagrass have flowers, fruits and seeds

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

Pollination occurs in the water

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

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

After fertilization, the ovary of the female flower develops into a fruit. In seagrasses, fruit development and fruit structure are as diversified as their flowering patterns and floral structures. In general, the seeds, ranging in the size from 0.3 to 0.5mm in some *Halophila* species to more than 1–2 cm in *Enhalus*, are furnished with a nutrition reserve and sink rather than float. The number of seeds within a fruit also varies from 1 (e.g. *Halodule uninervis*) up to 25 (e.g. *Halophila ovalis*).

Seagrass taxonomy

Taxonomy can be challenging for seagrasses due to their significantly reduced and variable morphologies. Since the mid-1800s, seagrasses have been classified within the angiosperms. A pivotal taxonomic study on seagrasses was published in 1970 by Cornelis den Hartog, titled "The Sea-Grasses of the World". Since that time, the number and composition of genera has remained largely unchanged. Taxonomy updates, including genera and species names and all the previous names used for each species, can be found at the International Plant Name Index (www.ipni.org) or the

Australian Plant Name Index (biodiversity.org.au). Seagrass-Watch primarily adheres to the classifications established by Cronquist (1981) and den Hartog (1970), while utilizing the family and genus names that are currently recognized by the Angiosperm Phylogeny Group (APG III).

Seagrasses are monocotyledons, which includes flowering plants whose seeds contain only one embryonic leaf, or cotyledon. Seagrasses are not true grasses (true grasses belong to the family Poaceae), but are rather more closely related to other aquatic plants such as duckweeds, pondweeds, peace lilies, the taro plant and world's largest inflorescence titan arum (aka corpse flower), in the order Alismatales. Note: waterlilies, family Nymphaeaceae, are basal angiosperms with the stem anatomy of dicots (an organized ring of vascular tissue) and therefore, not a monocot.

Seagrasses are not true grasses

Seagrasses are closely related to peace lilies and the taro plant

Seagrasses evolved approximately 100 million years ago from land plants that returned to the sea in at least four separate lineages. Thus, seagrasses are not a taxonomically unified group but a 'biological' or 'ecological' group. The evolutionary adaptations required for survival in the marine environment have led to convergence (similarity) in morphology.

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

Worldwide, there are about 12 major divisions, consisting of approximately 60 species (possibly up to 72) of seagrass. The highest concentration of species occurs in the Indo-West Pacific region.

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

Seagrass requirements for growth

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

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

Seagrasses need plenty of sun and clean water to grow.

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 are physiologically adapted to life in sea water

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

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

Light availability is the most important factor determining seagrass growth

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

Temperature influences the rate of growth and the health of plants, particularly at the extremes. As tropical water temperatures increase (above 35°C) the rate of photorespiration increases reducing the efficiency of photosynthesis at a given CO_2 concentration. The cause of thermal 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.

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

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

Seawater temperatures above 35ºC will stress tropical seagrass. Death occurs at temperatures above 42ºC

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

Seagrass require inorganic carbon for growth

Seagrass uptake carbon via two different pathways

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

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

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

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

Sediment quality, depth and mobility are important factors for seagrass composition, growth and persistence. Most seagrasses live in sand or mud substrates where their roots and rhizomes anchor the plants to the sea 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* spp. are better suited to mobile sediments than larger species. The biogeochemical characteristics of sediment that can affect the nutrient content/binding capacity, organic content and oxygen levels. Seagrasses are unable to grow in sediments of high organic content.

Most seagrass live in sand or mud sediments

Sediment movement can determine the presence of seagrass species

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

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

Where are seagrasses found?

Seagrasses are found in oceans throughout the world. They occur in tropical (hot), temperate (cool) and the edge of the arctic (freezing) regions. Seagrass are mainly found in sheltered bays, estuaries and coastal waters from the mid-intertidal (shallow) region down to depths of 50 or 60 metres. Most species are found in clear shallow inshore areas between mean sea-level and 25 metres depth.

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

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.

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

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

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

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

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

Seagrass plants form small patches that develop into large meadows

How are seagrasses important to the marine ecosystem?

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

Seagrasses are important habitat and feeding grounds for marine organisms.

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

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

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

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

Seagrass meadows are a major food source for a number of herbivores 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 (wet weight) of seagrass a day while an adult dugong eats about 28 to 40 kilograms (wet weight) a day. Although dugongs and turtles will feed on any seagrass species within their range, if a range of species is available, they select seagrass species for food which are high nitrogen, high starch and low fibre. For example, the order of seagrass species preference for dugongs is *Halophila ovalis ≥ Halodule uninervis > Zostera muelleri*. In sub-tropical and temperate areas, water birds such as black swans also eat seagrass.

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

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

Decomposing seagrasses provide food for benthic (bottom-dwelling) aquatic life. The decaying leaves are broken down by fungi and bacteria which in turn provide food for other 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.

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

Seagrass leaves in meadows slow/buffer runoff from catchments and the land, allowing suspended sediment, nutrients, and pesticides to settle out before reaching other marine ecosystems, effectively mitigating the environmental impact of runoff. 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.

Seagrass stabilises sediments and helps reduce erosion

Seagrasses buffer sediments and filters nutrients and chemicals, helping reduce the impacts of land based runoff in coastal waters.

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

Seagrass slow water flow and increase water clarity

Seagrasses play a vital role in mitigating climate change by sequestering (capturing and storing) carbon. They, along with other coastal and marine ecosystems like mangrove forests, tidal marshes, and macroalgae beds, contribute to what is known as blue carbon. Seagrasses are highly efficient at absorbing carbon dioxide from seawater during photosynthesis and incorporating the carbon into their biomass. A significant portion of this carbon is then stored in the seagrass meadows' sediments. Because seagrass sediments are saturated with water, maintaining an anaerobic state, and not allowing aerobic microbial carbon oxidation and release, which drives carbon accumulation over time and, therefore, creates long term carbon reservoirs through centuries to millennia. Seagrasses can sequester carbon up to 35 times faster than tropical rainforests. Coastal seagrass meadows are estimated to hold up to 83,000 metric tons of carbon km^{-1}, with the median global soil C_{org} stock estimated to be 24.2 (12.4 – 44.9) Mg C_{org} ha^{-1} in the top 30 cm of soil.

Blue carbon is the carbon captured and stored by coastal and marine ecosystems

The retention of carbon within seagrass meadow sediments contributes significantly to climate change mitigation

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).

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

The value of seagrasses

The value of ecosystem goods and benefits (contributions) is a controversial topic in today's literature. Ecosystem services are the structures and processes by which the environment produces contributions to our quality of life, 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 goods they provide has been estimated at US$ 28,916 ha^{-1} yr^{-1} (in 2007 dollars).

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

In the last decade, seagrass carbon storage capacity (blue carbon) has emerged as a significant factor in valuation. The carbon stored in seagrasses is estimated to be valued at ~USD12,000 ha^{-1}, on par with the annual value of other ecosystem services provided by seagrasses. A study focusing on Caribbean seagrasses estimated their total annual value at USD255 billion, with USD88.3 billion specifically attributed to carbon storage. Although all seagrass species contribute to blue carbon, the capacity for carbon storage varies significantly based on their growth form, biomass, and the specific environmental conditions they inhabit. Carbon storage in seagrass meadows is also strongly location-dependent, even within the same species.

Seagrass ecosystems are increasingly recognised as valuable assets in the growing blue carbon market

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 can change due to both natural and human impacts

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.

What threatens seagrass?

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

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

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

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.

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

One of the other significant impacts to seagrass is climate change. The major vulnerability of seagrass to climate change is loss of seagrass in the coastal zone, particularly near river mouths and in shallow areas. The greatest impact is expected to result from elevated temperatures, particularly in shallower habitats where seagrasses grow. This will influence their distribution and reproduction, while also decreasing photosynthesis and increasing respiration rates. 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.

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

Poor farming practices can result in catchment runoff which can damage seagrass by elevating nutrients, reducing available light and releasing herbicides.

Coastal development can have a major impact on seagrass meadows

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

Notes:

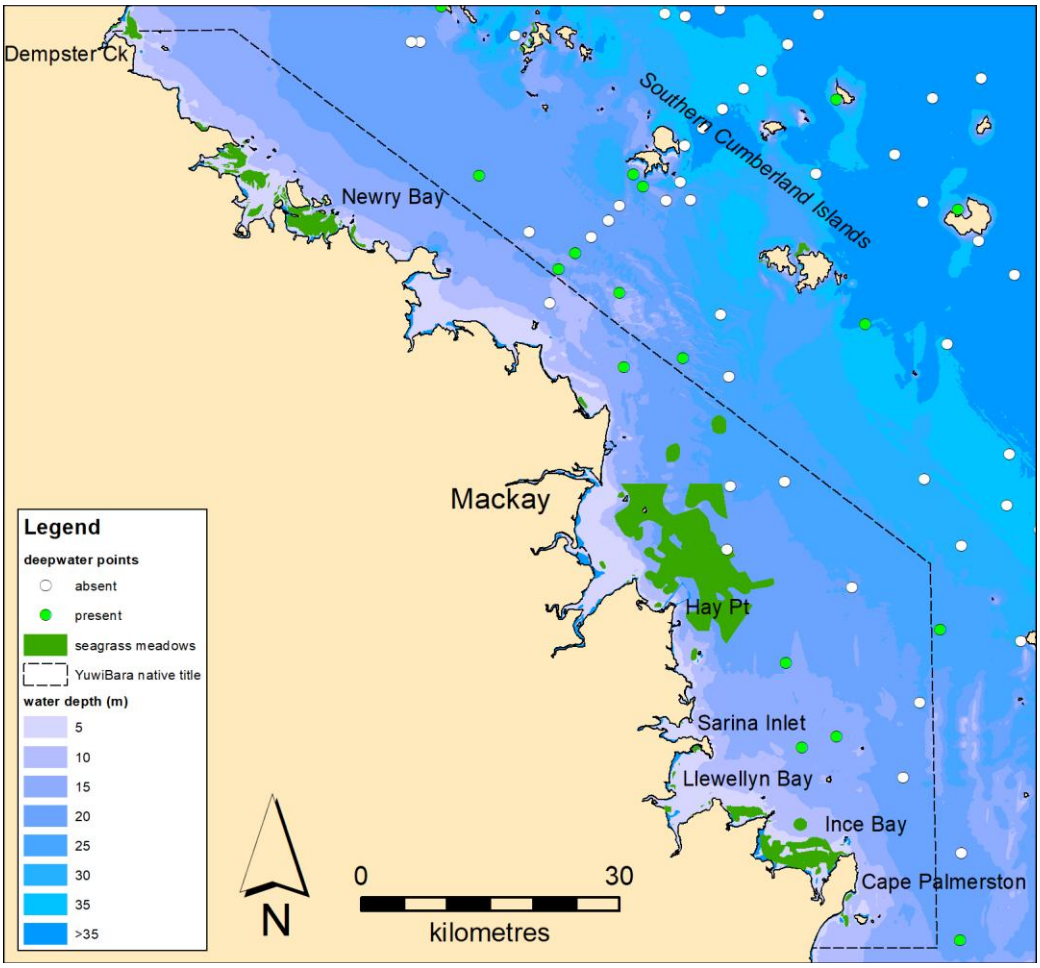
....

....

Seagrass in Yuwibara Sea Country

The Yuwi Aboriginal Corporation RNTBC acts as trustee for the native title rights and interests of the Yuwibara People, whose Sea Country extends from Cape Palmerston in the south to Dempster Creek (near Midgeton) in the north [1]. Located within the Mackay–Whitsunday NRM region on central-east Queensland, the Great Barrier Reef and inshore continental islands provide shelter to the coastline from predominantly south-easterly winds which often accompany a light south-easterly ocean swell. Coastal waters adjacent to the large rivers and mangrove-lined inlets are generally very turbid and shallow, with predominantly muddy sediments dominating the seabed. Tidal range in the south of the region is large, and in some places has the effect of creating extensive tidal banks. Annual rainfall ranges from approximately 500 to 3000 mm, with most precipitation occurring between December and April. The dominant land use in surrounding catchments is livestock grazing, with sugarcane cultivation also widespread.

Seagrasses are a significant component of Yuwibara Sea Country marine ecosystems and their contribution to the total primary carbon production is critical to regionally important dugong and turtle populations [2] and productive fisheries [3]. Coastal meadows are important nursery habitat to juvenile fish and prawns [4], and provide habitat for migratory wading birds. Extensive seagrass meadows occur on intertidal mudflats and sandflats, and in subtidal nearshore and offshore areas in the region. Approximately 192 km^2 of seagrass meadows (temporal composite) have been mapped in Yuwibara Sea Country since 1987.



Distribution of seagrass meadows and location of deepwater points assessed for presence of seagrass within Yuwibara Sea Country.

Ten species of seagrass have been recorded in Yuwibara Sea Country [5-8], including: *Cymodocea rotundata, Cymodocea serrulata, Halophila decipiens, Halophila ovalis, Halophila spinulosa, Halophila tricostata, Halodule pinifolia, Halodule uninervis, Syringodium isoetifolium,* and *Zostera muelleri*. This represents two thirds of the known species found in Queensland waters. The wide range of physical habitats where seagrasses are found undoubtedly contributes to the high species diversity. Habitats include intertidal and subtidal areas of estuary, coastal, and fringing reef habitats and deep-water environments. Based on the mapped seagrass areas, the majority (55%) of seagrass meadows in Yuwibara Sea Country occur in intertidal and shallow subtidal coastal and estuarine habitats (<15 m depth). In contract, approximately 25% of seagrass within Yuwibara Sea Country occurs within port boundaries, with 98% of these meadows located in waters deeper than 15 m.

Seagrass distribution throughout the region appears strongly influenced by shelter, sediment characteristics, water turbidity, and tidal exposure. Seagrass meadows occur predominantly within sheltered embayments along the mainland coast, with the largest and most extensive meadows found in Newry, Llewellyn, and Ince Bays. Most meadows are of low to moderate biomass and are dominated by *Halophila* and *Halodule* species. Extensive intertidal meadows dominated by *Halodule uninervis*, *Halophila ovalis*, or *Zostera muelleri* occur on coastal mudflats and sandflats. Deep-water seagrass meadows are largely restricted to the seabed between the Southern Cumberland Islands and the mainland, where environmental conditions are suitable for their persistence. In contrast, extensive areas devoid of seagrass are likely to reflect strong tidal currents that generate seabed scour and limit seagrass establishment and persistence.

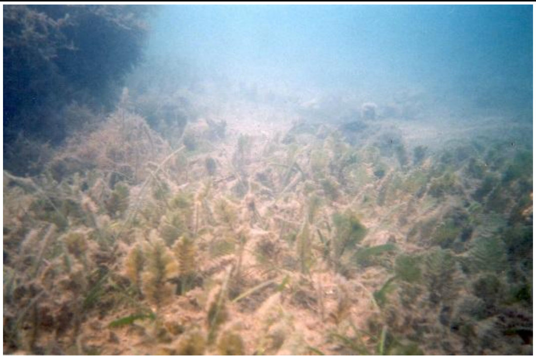
Dempster Creek to Mackay

This part of the region supports diverse and extensive seagrass meadows, which were first mapped during a broad scale survey in 1987. The total cover of seagrass meadows in these areas was estimated at approximately 490 ha, however, this may have been an underestimate of total seagrass area as surveying the large exposed mud and sand banks was not possible due to tidal conditions at the time.

Expansive meadows of *Halodule uninervis/ Halophila ovalis* or *Zostera muelleri* exist on the coastal intertidal flats of the region. Much of the coastline is exposed to south-east winds, with sheltered areas generally few and small. *Halodule* or *Halophila* spp. meadows are found in the lee of islands or bays. Strong tidal currents and associated high water turbidity in this region limit light penetration and therefore the depth to which seagrasses can grow. *H. ovalis, H. decipiens, H. spinulosa* and *H. tricostata* are reported from deeper waters.

The Port Newry region north of Mackay is a Dugong Protected Area (DPA), declared in January 1998. St. Helens Bay and Seaforth are popular areas for recreational boating, camping, and fishing. The area offers sheltered estuarine and reef fishing, easily and safely accessed by small vessel via an all-tide, all-weather public boat ramp. Newry, Rabbit, Acacia, Mausoleum and Rocky islands are all national parks and much of the area including the mangroves is a fauna sanctuary. St. Helens Bay and Sand Bay are Fish Habitat Areas (FHA) (Repulse, 015-041 and Sand Bay, 015-042) while most other land is leasehold or freehold [9]. In 1999, approximately 2,450 ha of seagrass habitat was mapped on mud through to sand substrates and extending to 5.5 m below MSL in St Helens Bay [9]. The meadows were also more abundant and slightly more extensive in October (late dry season) than in May (late wet season) [9].

The main seagrass habitat types identified were large continuous meadows on intertidal banks (dominated by either *Halodule uninervis* (narrow) or *Zostera muelleri*), patchy meadows on intertidal sand banks in St. Helen's Bay (*Halodule uninervis* (narrow) or *Zostera muelleri*), or shallow sub-tidal meadows found in the Seaforth region and eastern parts of St. Helen's Bay (mixed species *Cymodocea serrulata, Halophila spinulosa, Halophila ovalis* and *Halodule uninervis*).



Subtidal mixed *H. spinulosa/H. ovalis/H. uninervis* meadow adjacent to Newry Island reef (left) (Oct99) and *Z. muelleri* meadow at St Helens Bay (right) (Oct18). Photos: Anthony Roelofs (L) and Jacquie Shiels (R).

Minor seagrass habitats in Newry Bay comprised small, isolated meadows of *Halodule uninervis* (wide), *Syringodium isoetifolium* and *Halophila spinulosa* occurring around Rabbit Is, Newry Is and Outer Newry Is, as well as a small mixed *Halodule uninervis*/*Halophila ovalis* meadow north of Dewars Point [9]. *Cymodocea rotundata* was also recorded from a shallow meadow off the south-western corner of Rabbit Island on 27 April 1999 [9]. This record represents the southernmost verified occurrence of the species on the east coast of Australia.

Along the mainland coast south of Sand Bay, two small seagrass meadows were mapped within the Mackay Port limits (Slade Point to Bakers Creek), adjacent to the north-western shores of Flat and Round Top Islands in March 1987 [10]. These meadows were comprised of a single species *Halodule uninervis* (wide), with less than 10% cover at Flat Top and 10-50% cover adjacent to Round Top Island [10]. In a survey of Mackay Port limits in February 2001, three seagrass meadows were mapped [11]. Three seagrass species were present: *H. uninervis* (wide), *Halophila decipiens* and *Halophila ovalis*. A small (2.2 ha) coastal *H. uninervis* (wide)/*H. ovalis* meadow was mapped adjacent to the north-western shore of Round Top Island [11].

Two deep-water (17–22 m) meadows dominated by *Halophila decipiens* were identified approximately 7 km offshore and 12 km east of the marina/harbour, with mapped extents of 272.6 ha and 293.8 ha, respectively [11]. Long-term monitoring of the more shoreward offshore meadow over the past decade documented a substantial increase in meadow extent, reaching approximately 2,300 ha. However, surveys conducted in October–November 2024 recorded a dramatic decline, with the meadow extent decreasing by more than half [12]. Despite this contraction, seagrass biomass increased to its highest level since monitoring commenced in 2017. This increase was driven by a marked shift in species composition, with *Halophila spinulosa* becoming the dominant species and largely replacing *Halophila decipiens* across the meadow [12].

Mackay to Sarina Inlet

South of Mackay, seagrass has been mapped in the areas adjacent to Hay and Dudgeon Points. Seagrass meadows at the Port of Hay Point have been surveyed on fourteen occasions between July 2004 and November 2024 [12].

Several small, low biomass *Halophila ovalis* and *Halodule uninervis* meadows have been recorded in the intertidal and shallow coastal waters adjacent to Dudgeon Point [13, 14]. In 2014 a patch of *Zostera muelleri* was also reported, however, this meadow was lost in 2022 [15, 16]. In 2024, the inshore meadows increased in extent, while biomass remained relatively stable for the sixth consecutive year. A shift in the dominant species was also observed, with *H. ovalis* replacing *H. uninervis* as the dominant species [12]. In 2023, a small *H. decipiens* meadow covering approximately 1.03 ha was mapped in the south-west corner of Half Tide Tug Harbour, however it was absent in 2024 [12].

The offshore area of Hay Point is characterised predominantly by open substrate supporting low-density *Halophila decipiens,* with occasional small amounts of *Halophila spinulosa*. The maximum depth at which offshore seagrass has been recorded for offshore seagrass is 17.8 m below MSL. Offshore seagrasses have been monitored at several key locations between December 2005 and October 2024 [12]. Results of this monitoring has shown that offshore seagrasses at the Port of Hay Point were naturally highly variable, with peak abundance and extent typically occurring in late winter and spring, followed by seasonal declines over summer. Although the offshore *H. decipiens* meadow declined substantially in extent between 2021 and 2024, seagrass abundance in 2024 was the highest recorded to date, reflecting the presence of very dense *H. decipiens* patches in the northern portion of the meadow [12].

Sarina Inlet to Cape Palmerston

Sarina Inlet is a tide-dominated estuary located 35 km south of Mackay. The estuary was poorly assessed in the historic baseline seagrass surveys in March 1987, during which no seagrass was recorded (Coles *et al.* 1987). Subsequent surveys have identified intertidal seagrass meadows at the northern entrance of the estuary, dominated by *Zostera muelleri* with *Halodule uninervis* and *Halophila ovalis*.

Sarina Inlet has moderate sediment-trapping efficiency, naturally high turbidity, well-mixed circulation, and an inherent risk of habitat loss through sedimentation. The estuary receives freshwater inflows from the Plane Creek catchment, which is characterised by extensive land-use modification, limited riparian vegetation, and altered hydrology. Poor water quality has resulted in recurring fish kills within the estuary [17].

Environmental conditions within Sarina Inlet are currently suboptimal for healthy seagrass growth because of unsuitable substrate characteristics and degraded water quality. Water quality remains a major pressure within Sarina Inlet. In particular, concentrations of the herbicide diuron are among the highest recorded in the inshore Great Barrier Reef World Heritage Area (GBRWHA), with elevated levels consistently reported throughout more than a decade of pesticide monitoring [18]

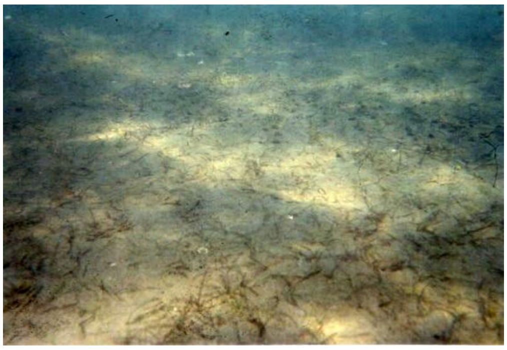
Zostera muelleri / *Halophila ovalis* meadow (left - Oct11) and with dugong grazing trails (right - Sep12), Sarina Inlet. Photos: Len McKenzie.

Immediately south of Sarina Inlet lies Llewellyn Bay. A detailed survey undertaken in 1999 identified 11 small, isolated seagrass meadows within a 1.5 km stretch of coastline in the southern part of the bay, encompassing Deception Inlet, Armstrong Beach, and the mouth of Rocky Dam Creek [19]. These meadows had not been recorded during the earlier baseline surveys in March 1987 [10]. The total mapped seagrass area was approximately 116 ha and changed little between surveys conducted in May and October 1999. Three seagrass species were recorded in May, increasing to four species in October [19]. Small, isolated patches of *Halophila decipiens* and *Halophila spinulosa* were also recorded in deeper water during the October 1999 survey.


Zostera muelleri dominated meadows at Deception Inlet (left) and Armstrong Beach (right) (Oct25). Photos: Len McKenzie.

Seagrass meadows on the intertidal flats of Ince Bay were first mapped in March 1987[10]. Surveys conducted between Allom Point, Glendower Point, Cutlack Island, and Hogans Camp Island mapped a total of 1,471 ha of seagrass [20]. Of this area, 575 ha supported sparse seagrass (<10% cover), while 549 ha had moderate cover (10–50%) [20]. Ince Bay seagrass species included *Halophila ovalis, Halodule pinifolia* and *Halophila spinulosa*.

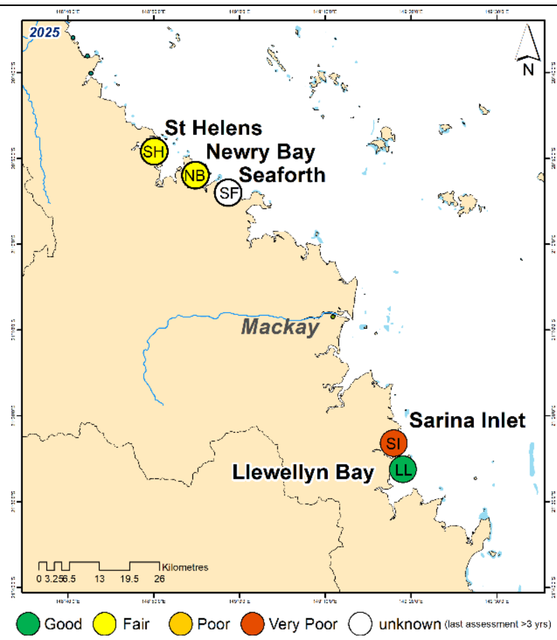
A subsequent survey of Ince Bay conducted during June–July 1997 documented an approximately 50% decline in seagrass extent relative to previous surveys [21]. However, extensive meadows were again recorded on the inter-tidal banks of Ince Bay in 1999, with four species present in May 1999 and five in October 1999 [19]. Total seagrass extent increased from 1203.6 ±133.8 ha in May to 1572.75 ±187.1 ha in October. The larger meadows were dominated by *Halodule uninervis* (narrow-leaf morphotype) and *Zostera muelleri*. An isolated *Halophila spinulosa* meadow expanded markedly between surveys, increasing from 4.3 ha in May to 58.1 ha in October. Smaller mixed meadows of *Halophila ovalis* and narrow-leaf *H. uninervis*, together with meadows of wide-leaf *Halodule uninervis*, were also recorded on intertidal banks, within channels, and in shallow subtidal areas in the eastern part of Ince Bay, north of the mouth of Cape Creek.




Intertidal *Halodule uninervis* meadow (left, Oct99) and dugong grazing trails (right, Apr99) in Ince Bay. Photos: Anthony Roelofs (L) and Chantal Roder (R).

SEAGRASS-WATCH IN YUWIBARA SEA COUNTRY

To provide an early warning of change, long-term monitoring has been established at five locations as part of the Seagrass-Watch, global seagrass assessment and monitoring program (www.seagrasswatch.org). Establishing a network of monitoring sites in Yuwibara Sea Country 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.

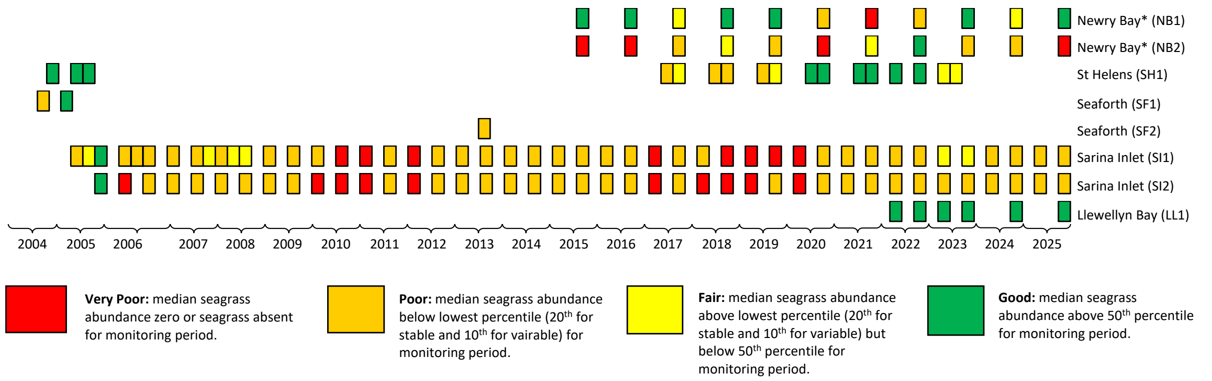


Status of seagrass at monitoring locations in Yuwibara Sea Country:

St Helen's Beach (SH) (ongoing, ad hoc)	https://www.seagrasswatch.org/mackaywhitsunday/#SH
Newry Bay (NB) (ongoing, annual)	https://www.seagrasswatch.org/mackaywhitsunday/#NB
Seaforth (SF) (suspended)	https://www.seagrasswatch.org/mackaywhitsunday/#SF
Sarina Inlet (SI) (ongoing, biannual)	https://www.seagrasswatch.org/mackaywhitsunday/#SI
Llewellyn Bay (LL) (ongoing, annual)	https://www.seagrasswatch.org/mackaywhitsunday/#LL

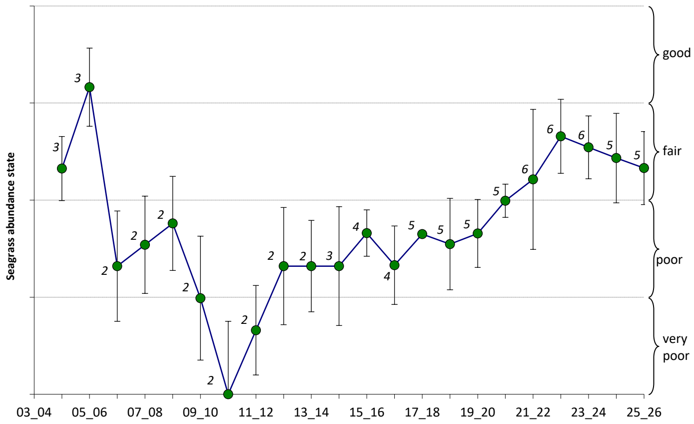
Yuwibara Sea Country seagrass abundance report card –2025

- From 2005 to 2011, seagrass abundance declined across the region following multiple consecutive years of above-average rainfall, reaching its lowest levels in early 2011.
- After 2011, seagrass abundance recovered across all habitat types until early 2017, when a slight decline occurred following the severe impacts of Tropical Cyclone Debbie on regional seagrass meadows.
- From 2018 onwards, seagrass abundance resumed an overall recovery trajectory, continuing to improve until 2024. Since 2024, however, abundance has shown an overall declining trend.
- Seagrass state was determined for each monitoring event at each site using the seagrass guideline values. Median percent cover for each monitoring event was compared with the long-term percentile thresholds, and a state score was assigned accordingly.



*NB: Guidelines for LL and NB are provisional. * subtidal*

- Overall indications are that seagrass abundances in the Yuwibara Sea Country in late-2025 were in a **fair state**.



Long-term trend in seagrass abundance condition score (±SE) for Yuwibara Sea Country since monitoring was established. Site scores are average for each monitoring period (June to May), and overall score is all sites pooled for each period. Numbers presented in plot are the number of individual sites contributing to the overall score.

For more information, visit http://www.seagrasswatch.org/

Great Barrier Reef Marine Monitoring Program

Data from the five Seagrass-Watch long-term monitoring locations is integrated within MMP reporting. The MMP forms an integral part of the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (Paddock to Reef program), which is used to evaluate the efficiency and effectiveness of water quality management plans implemented across GBR catchments to reduce the impact of land-based run-off on water quality, coral and seagrass ecosystems[22]. The overarching objective of the inshore seagrass monitoring program is to quantify the extent, frequency and intensity of acute and chronic impacts on the condition and trend of seagrass meadows and their subsequent recovery.

Current indications from the MMP are that inshore water quality in the Mackay-Whitsunday region has remained 'moderate' for the eighth consecutive year [23]. The long-term Water Quality Index showed that inshore water quality was deteriorating in 2024–25, which was related to two consecutive years (2023–25) of above-median river discharge [23]. This interrupts the gradual improvement in the region observed since Tropical Cyclone Debbie in March 2017.

Inshore seagrass meadows across the Great Barrier Reef deteriorated in overall condition in 2024–25, with the Seagrass Index declining from 'moderate' to 'poor' [24]. The Seagrass Index for the Mackay-Whitsunday region in 2024–25 was 'moderate'. Seagrass condition in the Mackay–Whitsunday NRM region has fluctuated between 'poor' and 'moderate' since 2011–12 due to a range of environmental pressures at both regional and local scales. The seagrass abundance score decreased to 'poor', driven by declines in reef intertidal and subtidal habitats. The overall resilience score for the region remained 'moderate', however, the absence of reproductive structures and seedbank indicates there is limited recovery potential for seagrass at reef intertidal and subtidal sites [24].

Read the latest reports:

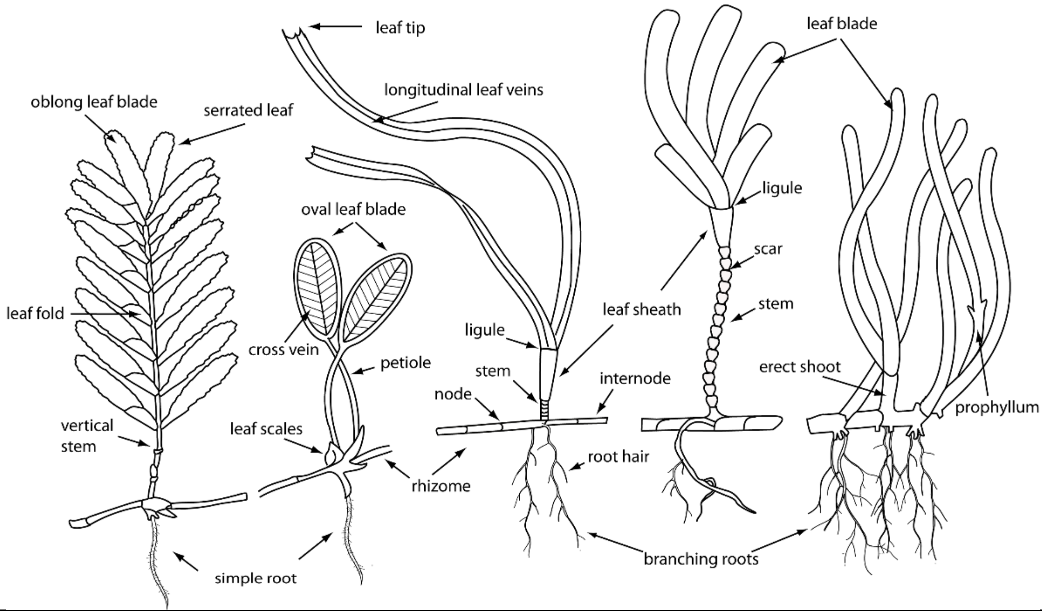
2024-25 Synthesis Report https://shorturl.at/7Q0un (provides summary results of the 2024-25 monitoring year findings and long-term trends with reference to 20 years of data)

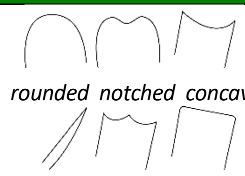
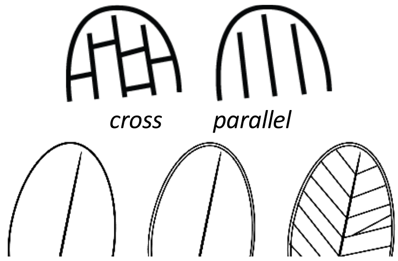
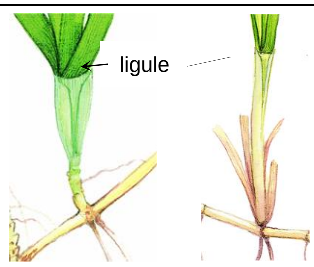
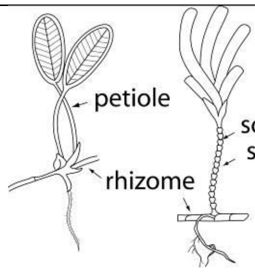
2024-25 Summary Booklet https://shorturl.at/dCErz (provides a snapshot of the results)

2024-25 MMP technical reports https://shorturl.at/Ged3N

View results on the Reef Authority's interactive dashboard

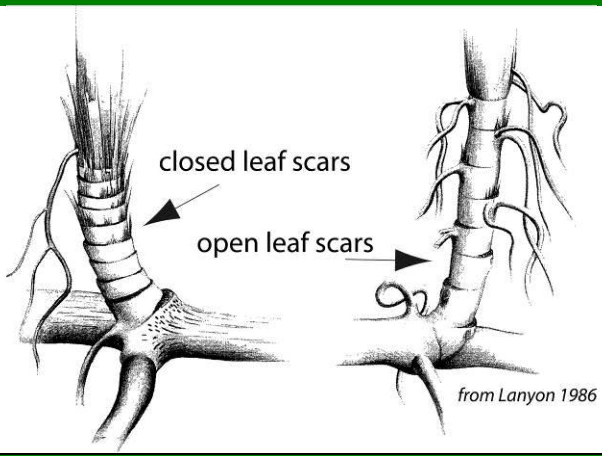
Parts of a seagrass plant



Leaf		
Tip	End of leaf with a variety of shapes and some may be dentate (having toothed-like projections). For identification use young leaves, as old leaves are easily damaged or cropped.	 *rounded notched concave* *pointed dentate flat*
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 length of leaf • parallel-vein: along the length of the leaf • mid-vein: prominent central vein • intramarginal-vein: around inside edge • split-vein: cross-veins that fork	 *cross parallel* *mid intramarginal cross + split*
Edges	The edges of the leaf can be either serrated, smooth or inrolled	 *serrated smooth inrolled*
Ligule	Membranous structure found at the junction of the blade and sheath. Clasps leaf sheaths, aiding protection of enclosed younger plant parts.	 clean & flattened fibrous
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.	
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*.	

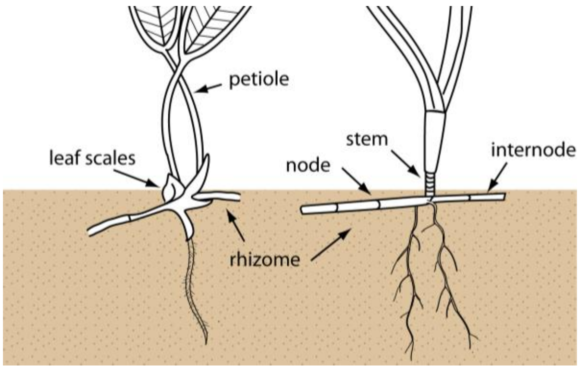
Stem

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*).



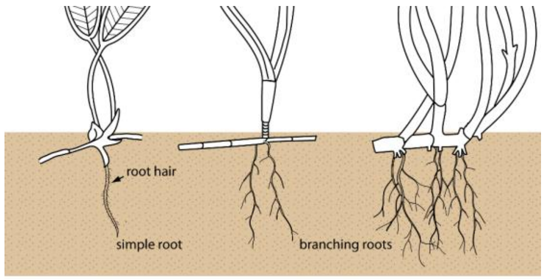
Rhizome

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:

....

....

....

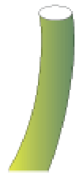
....

....

A guide to the identification of seagrasses in Yuwibara Sea Country

Adapted from [25]

Leaves cylindrical



cylindrical

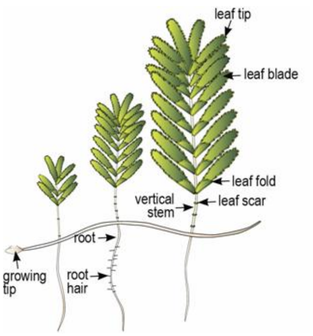
Syringodium isoetifolium

- leaves noodle/spaghetti like and taper to a point
- leaves contain air cavities
- leaves 7-30cm long

Leaves oval to oblong

oval to oblong

obvious vertical stem with more than 2 leaves



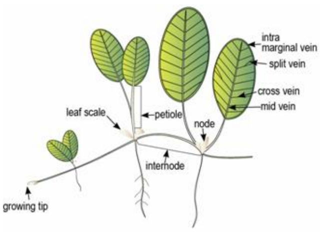
Halophila spinulosa

- leaves arranged opposite in pairs
- leaf margin serrated
- 10-20 pairs of leaves per shoot
- leaf 15-20mm long and 3-5mm wide

Halophila tricostata

- leaves arranged in clusters of 3, at a node on vertical stem
- leaf margin sparsely serrated
- leaf clusters do not lie flat
- 5-12 leaf clusters per shoot
- leaf 12-20mm long and 2-4mm wide

leaves with petioles, in pairs



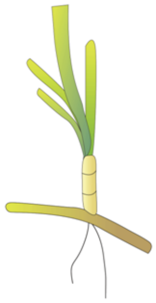
Halophila decipiens

- leaf margins finely serrated
- fine hairs on both sides of leaf blade
- leaf apex rounded to slightly pointed
- leaf 10–25mm long and 3–10mm wide
- 6-8 cross vein pairs

Halophila ovalis

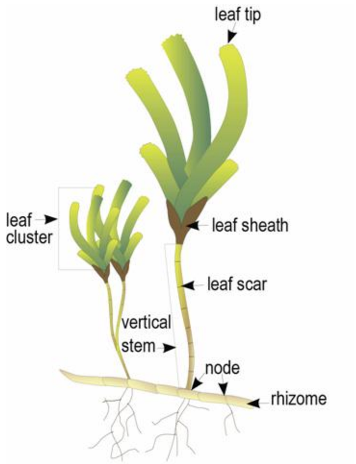
- cross veins 8 or more pairs
- leaf 5-40mm long and 5-20mm wide
- leaf margins smooth
- no leaf hairs

Leaves strap-like



straplike

Leaves can arise from vertical stem



Cymodocea rotundata

- leaf tip rounded or slightly notched, with smooth edge
- leaf 2-4mm wide with 9-15 parallel veins
- leaf scars continuous around stem
- old sheaths forming a fibrous mass at the base of each shoot

Cymodocea serrulata

- leaf tip rounded with serrated edge
- leaf 4-9mm wide with 13-17 parallel veins
- leaf sheath broadly flat and triangular, not fibrous
- leaf scars not continuous around upright stem

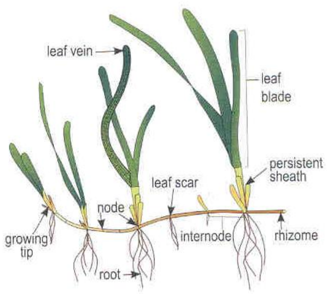
Halodule uninervis

- leaf tip tri-dentate, not rounded
- leaf blades 0.5-5mm wide
- leaf with 3 distinct parallel veins, sheaths fibrous
- rhizome usually white with small black fibres at the nodes

Halodule pinifolia

- leaf tip rounded
- narrow leaf blades 0.25-1.2mm wide
- leaf with 3 distinct parallel veins, sheaths fibrous
- rhizome usually white with small black fibres at the nodes

Leaves always arise directly from rhizome



Zostera muelleri

- leaf with 3-5 parallel-veins
- cross-veins form a mesh across leaf blade
- leaf tip smooth and rounded/truncate
- midrib widens at apex, may have dark point
- rhizome usually brown or yellowish in younger parts
- rhizome with 2 groups of roots at each node
- prophyllum present, i.e. single leaf originating from rhizome instead of from vertical, leaf bearing shoot.

Monitoring a seagrass meadow

Monitoring is the repeated observation of a system, usually to detect change. It is an integrated activity to evaluate the condition of the physical, chemical and biological character of the environment. Environment monitoring programs provide coastal managers with information and assist them to make decisions with greater confidence.

Environmental monitoring programs are ideally designed to: quantify the causes of change; examine and assess acceptable ranges of change for the particular site; and to measure levels of impacts.

Common drivers (reasons) for monitoring include: community interest; government policies such as Coastal Strategies and Plans, Oceans Policy, State of the Environment Reporting (SoE), Water Quality guidelines or Best Practice Guidelines; and Government Legislation (e.g., Fish Habitat Protection).

Users of the monitoring program information/results are diverse, including for example: the general public, environmental regulators - legislators, resource managers and scientists.

There are a number of issues to consider when implementing a monitoring program, including: ensure the protocols used have explicit objectives; clearly identified responsibilities of the partners (e.g. Gov agencies, consultants, First Nations and community groups); a clear and defensible rationale for using the parameters that are measures (e.g. physico/chemico, biological indicators); to have a baseline (first) assessment / measure against which subsequent changes can be measured/compared; knowledge of spatial and temporal variation prior to designing the program (i.e. pilot study); clearly defined field protocols; data management procedures, ensure the level of change and accuracy of the detection is appropriate (as will vary according to the methodology); selection of statistical tools; and a mechanism to reduce and manage errors (i.e. QA/QC program).

Appropriate Quality Assurance and Quality Control (QA/QC) procedures are an integral component of all aspects of sample collection and analysis in monitoring programs. QA is proactive, focusing on preventing defects through process improvements, while QC is reactive, focusing on identifying defects in the final product. This includes participation in relevant inter-laboratory studies, proficiency testing, and the use of standard reference materials. Monitoring programs often include the following guidelines for implementation by data collectors and reporters:

- appropriate methods must be in place to ensure consistency in field procedures to produce robust, repeatable and comparable results including consideration of sampling locations, replication and frequency;
- all methods used must be fit for purpose and suited to a range of conditions;
- appropriate accreditation of participating laboratories or provision of standard laboratory protocols to demonstrate that appropriate laboratory QA/QC procedures are in place for sample handling and analysis;
- participation in inter-laboratory performance testing trials and regular exchange of replicate samples between laboratories;
- rigorous procedures to ensure 'chain of custody' and tracking of samples;
- appropriate standards and procedures for data management and storage; and
- a process to ensure data collectors are aware of any errors and provide an opportunity to clarify or correct data.

Monitoring seagrass

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. Seagrass make good **bioindicators** of environmental health because they are:

- widely distributed,
- sessile plants which show measurable and timely responses to external stressors/impacts (rather than relocating to a less stressful environment) and,
- integrative of environmental conditions.

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 affect 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 method for monitoring seagrass resources is used in the Seagrass-Watch: Global Seagrass Observing Network. This method uses globally standardised measurements taken from sites established within representative 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 its genesis in March 1998 in Australia, Seagrass-Watch has expanded internationally to more than 26 countries. Currently 445 sites have been established across 26 countries, with active monitoring at 298 sites (85 sites suspended and 62 archived). 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 scientists and volunteers from a wide variety of backgrounds who all share the common interest in marine conservation. Most participants are associated with universities & research institutions, government (local & state), non-government organisations or established local stakeholder groups.

Seagrass-Watch integrates with existing scientific programs to protect this important marine ecosystem for the benefit of the global 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 methods were developed to be rigorous, yet relatively simple and easy to use. Each of the parameters used have been carefully chosen with a clear and defensible rationale. The protocols used have explicit objectives and the sampling strategy is prepared using baseline and knowledge of spatial and temporal variation. This ensures data is of the highest quality and that time and resources are not wasted. The only condition is that on ground data collection must be overseen by a qualified scientist or trained and competent participant (18 years or over). After comprehensive training, participants can produce reliable data. Training includes both formal and informal approaches. Formal training is conducted by Seagrass-Watch HQ for participants 18 years of age and over, and includes lectures and on-site assessments with a tiered level of certification for competency. Formally trained participants are certified to supervise on-site monitoring and demonstrate (i.e. informally train) monitoring methods. At least a professional scientist or a formally trained volunteer must be present at each monitoring event. Evidence of competency is securely filed at Seagrass-Watch HQ.

QUALITY ASSURANCE-QUALITY CONTROL

Seagrass-Watch has an accepted Quality Assurance-Quality Control program in place to ensure that the program is producing data of high quality, and that time and resources are not wasted. Seagrass-Watch HQ has systems in place to manage the way Seagrass-Watch data is collected, organised, documented, evaluated and secured. The Seagrass-Watch program collects and collates all data in a standard format. By using simple and easy methods, Seagrass Watch ensures completeness (the comparison between the amounts of valid or useable data originally planned to collect, versus how much was collected). Standard seagrass cover **calibration sheets** are used to ensure precision (the degree of agreement among repeated measurements of the same characteristic at the same place and the same time) and consistency between observers and across sites at monitoring times to ensure percentage covers are close to a true or standardised value.

Other QAQC procedures include the selection of intertidal seagrass sites which are **permanently marked** with either plastic star pickets or an accurate (±3m) GPS waypoint. Labels identifying the sites and contact details for the program are attached to these pickets. This ensures that the same site is monitored each event and that data can be compared between periods of time.

Ongoing standardisation of observers is achieved by on-site refreshers of standard percentage covers by all observers prior to monitoring and through *ad hoc* comparisons of data returned from duplicate surveys (e.g. either a site or a transect will be repeated by Seagrass-Watch HQ scientists – preferably the next day and unknown to local observers). Any discrepancy in these duplicates is used to identify and subsequently mitigate bias. For the most part, uncertainties in percentage cover or species identification are mitigated in the field via direct communication (as at least one experienced/certified observer is always present), or the collection of voucher specimens (to be checked under microscope and pressed in herbarium) and the use of a digital camera to record images (protocol requires all quadrats are photographed) for later identification and discussion.

Seagrass-Watch HQ has implemented a quality assurance management system to ensure that data collected is organised and stored and able to be used easily. All data (datasheets and photographs) received are entered onto a relational database on a secure server. Receipt of all original data hardcopies is documented and filed within the Seagrass-Watch File Management System, a formally organised and secure system, and housed at James Cook University. Seagrass-Watch HQ operates as custodian of data collected from other participants and provides an evaluation and analysis of the data for reporting purposes. Access to the IT system and databases is restricted to only authorised personnel. Provision of data to a third party is only on consent of the data owner/principal.

Seagrass-Watch HQ checks all data for completeness, consistency and accuracy. All data submitted to Seagrass-Watch HQ it is first checked for compliancy:

- *legible original datasheets,*
- *good quality quadrat photographs (high resolution),*
- *voucher specimens (if required) and*
- *completed MS Excel spreadsheet.*

Validation is provided by checking observations against photographic records to ensure consistency of observers and by identification of voucher specimens submitted. In accordance with QA/QC protocols, Seagrass-Watch HQ advises observers via an official Data Notification of any errors encountered/identified and provides an opportunity for correction/clarification (this may include additional training).

Once Seagrass-Watch HQ has completed all checks, a field in the Master database identifies data as either passed, quarantined, non-compliant or not-passed. Non-compliant data is used for large-scale summary reporting only if the data quality is deemed acceptable, i.e. if it was collected by a scientist or formally trained participant, then the scans/copies of datasheets are sufficient (*only if originals are not available*), and/or that the quadrat images were acceptable to complete QAQC, *etc*. If data quality is unacceptable, the data is either not entered into the Master database or remains quarantined/not-passed (excluded from analysis & reporting). If predominantly non-compliant data is used for detailed analysis and reporting at a site or location/region, it is marked on the outputs with a notice of non-compliancy (e.g., site graphs). If officially requested data is non-compliant, a note in the metadata advises of non-compliancy and includes a caveat to "use with caution". Any data considered unsuitable (e.g. nil response to data notification within thirty days) is quarantined or removed from the database.

Seagrass-Watch employs a proactive approach to monitoring, involving ongoing training for observers and the continued development of new methods and refinement of existing methods, including location/habitat specific calibration sheets, operation & validation of autonomous temperature and light loggers, *etc*. Quality data reassures the data users (e.g., coastal management agencies) that they can use the data to make informed decisions with confidence.

Data Property And Ownership

All raw data collected throughout the Seagrass-Watch program is the property of the individual/group/institution (*Principal*) who collected it, and Seagrass-Watch Ltd is custodian. When a Principal (*data collector*) submits data to Seagrass-Watch HQ, they do so under the proviso that Seagrass-Watch HQ can conduct a data quality assessment as part of the Seagrass-Watch program's QAQC protocols and that the validated data is available for condition and trend reporting at location, regional, state, national and global scales (e.g., State of the Environment). Copies of raw data are provided to third parties only when permission from the Principal is provided.

Ownership of data within the Seagrass-Watch program is determined by mutual agreement based on who is collecting the raw data, whether the data undergoes a quality assessment as part of Seagrass-Watch QAQC protocols and the funding sources that support the monitoring:

- **Raw Data** ownership (intellectual property rights) lies with the Principal (*data collector*). Seagrass-Watch Ltd is custodian of the Raw Data.
- **Validated Data** ownership (intellectual property rights) is shared between the Principal and Seagrass-Watch Ltd.

All data interpretation is conducted by Seagrass-Watch HQ. This ensures that the interpretation of data is consistent, unbiased and of scientific merit. Seagrass-Watch HQ also encourages peer review of published results.

Apart from the regional & state-wide report cards, the data has also been used for:

- understanding and responding to impacts from catchment runoff [26, 27], coastal developments (e.g., marina constructions) and dredging proposals.
- Understanding natural levels of change [28-30] and supporting marine habitat conservation (e.g., GSS Ramsar Wetland, Cooloola World Heritage area, and Great Sandy Marine Park).

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.*

Notes:

....

....

....

....

....

....

....

....

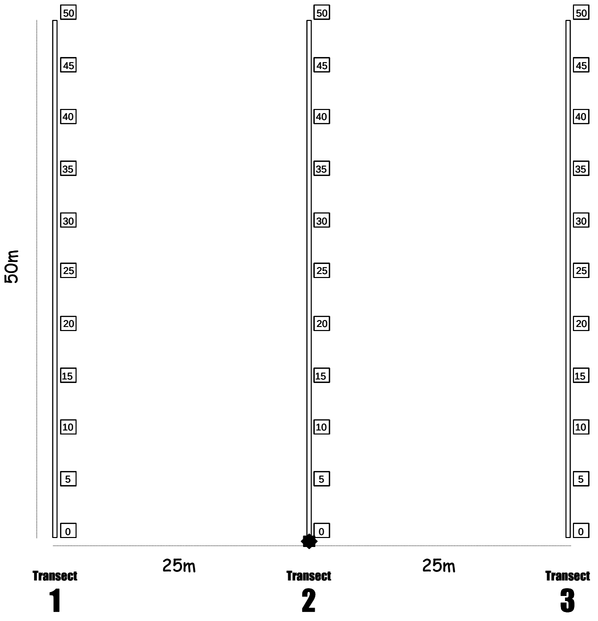
....

....

Permanent Transect Monitoring Protocols

Source: McKenzie et al. 2003[31] (www.seagrasswatch.org/manuals/)

Site layout



Quadrat code = site + transect+quadrat

e.g., GH11225 = Chek Jawa. 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 participants involved in advance so they can make their arrangements to get to the site on time. List on this timetable what participants 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.
- 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*
- ❑ *3x monitoring datasheets*
- ❑ *clipboard, pencils & 30 cm ruler*
- ❑ *camera*
- ❑ *quadrat photo labeller*
- ❑ *percent cover standard sheets*
- ❑ *seagrass identification sheet*

Each sampling event

Within the site, lay out the three 50 metre transects parallel to each other, 25 m 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 (photoquadrats)

- Photographs are taken of **every quadrat** along each transect. Use a quadrat free of strings and place the photo quadrat labeller beside the quadrat and tape measure, with the correct site code displayed.
- Take the photograph from an angle as **vertical** as possible, which includes the entire quadrat frame, quadrat labeller and tape measure. Fill the field of view as best as possible and avoid having any shadows or patches of reflection off any water. Tick the photo taken box on datasheet for the 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 (whole numbers only - never use < or > symbols) any features which may be of interest (e.g. gastropods, hermit crabs, dugong excavating, turtle cropping, crab burrows, worm holes) within the comments column.
- Note features such as ripples across the sediment surface (indicates the level of sediment movement from wave action)
- If covers half or more of the quadrat, measure the depth in centimetres.

Step 4. Estimate seagrass percent cover

- Looking down on the quadrat from above, estimate the total percentage of the seabed (substrate) within the quadrat covered by seagrass leaves. Estimate the footprint/shadow provided by the seagrass shoots.
- Always use the percent cover photo standards (calibration sheets) as your guide, estimating cover as accurate as possible, e.g. 27%, 61%. Remember, the lower the cover, the more accurate the measures.
- If cover is below 3%, you can count the seagrass shoots and calculate percent cover using the rule of approx 1 shoot = 0.1%. Please note: this will be greater for shoots of larger sized species.

Step 5. Estimate seagrass species composition

- Identify the species of seagrass within the quadrat and determine the percent contribution of each species (always start with least abundant species, total composition must equal 100%).
- Use seagrass species identification keys provided and use more than one feature to identify each species.

Step 6. Measure seagrass canopy height

- Measure canopy height (in centimetres) of the dominant strap-leaf species, ignoring the tallest 20%.
- Measure from the sediment to the leaf tip of 3 shoots, entering all 3 measures onto datasheet.

Step 7. Estimate algae percent cover

- Looking down on the quadrat from above, estimate the total percentage of the seabed (substrate) within the quadrat covered by macroalgae (independent of seagrass cover)
- Macroalgae is **not attached** to seagrass leaves and may be attached to rocks, shells or may be drifting.

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 an average seagrass leaf surface is covered, and then how many of the leaves/shoots in the quadrat are covered. For example, if 20% of the leaves are 50% covered by epiphytes, then quadrat epiphyte cover is 10%. Use the epiphyte matrix to assist you.
- Do not include epifauna with epiphytes. Epifauna are sessile animals attached to seagrass blades – record % cover of epifauna in the comments or an unused/blank column – do not add to epiphyte cover.

Step 9. Take a voucher seagrass specimen (if required and have a permit)

- Select a representative specimen of the species and ensure that you have all the plant parts, including the rhizomes and roots. Collect plants with fruits and flowers structures if possible. Place seagrass specimen in a labelled plastic bag with a little seawater and a waterproof label.

Step 10. Move to next quadrat

- Repeat steps 1 to 8 for the remaining 32 quadrats

Step 11. Monitoring seed banks (an indicator of meadow resilience)

- Using the seed corer, sample sediment to a depth of 10cm every 10m along five transects, 12.5m apart.
- Release core contents into a sieve, wash away the sediment and count the number of seeds retained.

At completion of monitoring

Step 1. Before leaving the site

- Check data sheets are filled in fully.
- Remove equipment from site (e.g. non-permanent pegs)

Step 2. Wash & pack gear

- Rinse all tapes, pegs and quadrats with freshwater and let them dry. Do this after every day of monitoring.
- Review supplies for next sampling and purchase new materials if needed.
- Store gear in a safe and dry place for next sampling event.

Step 3. Press any voucher seagrass specimens if collected

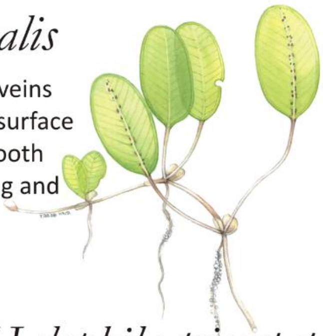
- Voucher specimens should be pressed as soon as possible after collection. Do not refrigerate >2 days.

Step 4. Submit all data

SEAGRASS SPECIES CODES

Ho
Halophila ovalis

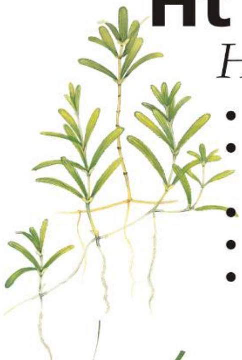
- 8 or more cross veins
- no hairs on leaf surface
- leaf margins smooth
- leaf 5-40mm long and 5-20mm wide



Hd
Halophila decipiens

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

Ht
Halophila tricostata



- fern like
- leaves arranged in clusters of 3, at a node on vertical stem
- leaf clusters do not lie flat
- 5-12 leaf clusters per shoot
- found at subtidal depths

Hs
Halophila spinulosa

- fern like
- leaves arranged in opposite pairs
- erect shoot to 15cm long
- mainly found subtidally

Hu
Halodule uninervis

- tridentate leaf tip
- 1 clear central vein
- rhizome usually white with small black fibres at the nodes

Hp
Halodule pinifolia

- rounded leaf tip
- 3 distinct parallel veins, 1 clear central vein
- rhizome pale, with small black fibres at the nodes

Cr
Cymodocea rotundata

- leaf tip rounded, slightly notched, with smooth edge
- narrow leaf blade (2-4mm wide)
- leaves 7-15 cm long
- 9-15 longitudinal veins
- well developed leaf sheath

Cs
Cymodocea serrulata

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

Si
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

Zc
Zostera muelleri

- leaf with 3-5 parallel-veins
- cross-veins form boxes
- leaf tip smooth and rounded, may be dark point at tip
- leaf grows directly from rhizome ie no stem
- prophyllum present
- rhizome usually brown or yellow in younger parts, with 2 groups of roots at each node

Illustrations not to scale

SEAGRASS-WATCH MONITORING

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

OBSERVER: Beverly Citizen DATE: 17 / 2 / 21

LOCATION: Burrum Heads

SITE code: BH1 TRANSECT no.: 2

START TIME: 1304 END TIME: 1340

START of transect (GPS reading)

Latitude: .... ° .... ' ...... Longitude: .... ° .... ' ......

Quadrat (metres from transect origin)	Sediment (eg, mud/sand/shell)	Comments (eg 10x gastropods, 4x crab holes, dugong feeding trails, herbarium specimen taken)	📷 (√)	% Seagrass coverage	% Seagrass species composition					Canopy height (cm)	% Algae cover	% Epi-cover
					Ho	Hu	ZC		Water			
1 (0m)	Sand	SC x 3 HC x 1 DFT x 1	√	40	30	70			0	5,4,7	5	33
2 (5m)	FS/S	GAS x 2 Ray pit x 2	√	33	50	50			0	6,6,6	10	18
3 (10m)	CS	HC x 3	√	0					0	–	0	–
4 (15m)	m/S	CH x 10	√	0					1 cm	–	17	–
5 (20m)	m/S	Turtle cropping GAS x 3	√	18	5	90	5		1 cm	7,5,6	12	57
6 (25m)	m/S/sh	SC x 3 mw x 2	√	36		90	10		1 cm	8,6,6	2	95
7 (30m)	Fine Sand	CH x 9 Gw x 1	√	48	100				3 cm	–	0	10
8 (35m)	CS/S	Nothing	√	0.7		100			2.5 cm	6,5,5	0	36
9 (40m)	FS	HC x 2	√	23	96	4			1 cm	5.5,5,6	5	38
10 (45m)	S/m	Gw x 2	√	41	3		97		1 cm	8,8,7	3	90
11 (50m)	mud	CH x 2 SC x 1	√	16	3	7	90		0	7,7,8	38	95

END of transect (GPS reading)

Latitude: .... ° .... ' ...... Longitude: .... ° .... ' ......

FS = Fine Sand
CS = Coarse Sand
m = mud
S = Sand
sh = shell

SC = Sea Cucumber
HC = Hermit Crab
GAS = Gastropod
CH = Crab Hole
mw = mud whelk
Gw = Green worm

DFT = Dugong feeding trail

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. Herbarium specimens are 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. For example, in Queensland, all marine plants, including seagrass, are protected under the Fisheries Act 1994.

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 (apical meristems) as they contain higher concentrations of DNA which could aid genetic identification in the future.

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

Pressing

Tools

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

Preparation

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

Arrangement

It is very important that the seagrass specimen be arranged so that you can immediately see all the main characters of that particular species; so do not focus only at the aesthetics of the mounted specimen. It is advisable to arrange specimens before being placed in the press as once dried, plant specimens can easily be broken if handled without care. The best manner to place the plants on the mounting sheets is to align them with the right side of the page (or diagonally if space is required) and to have the heaviest parts and specimens at the bottom.

Leaves can be folded in larger specimens if a larger press in not available. It is better to leave an empty space at the borders of the mounting sheets; but you can either arrange your specimens (along with the label) in a regular way from page to page, or stagger the specimens at different positions on each sheet, so that each group of sheets will have a more equally distributed pressure.

Labels

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

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

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

Drying

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

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

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

Changing the paper is a very important step. In the first three or four days a paper change should take place every day, then you can leave more time between changes. If you neglect the change of paper the plants will take more time to 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 dying ranges from two to four days or more. Once a specimen has become dry and stiff, it can be mounted and placed into the herbarium.

Mounting

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

There are different ways to mount the specimens to the herbarium sheets, such as strapping, gluing, or pinning. We recommend the strapping method using removable adhesive tape (e.g. 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 (e.g. 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 nearby (usually located at a University or Government agency), you can submit specimens to Seagrass-Watch HQ which maintains a Herbaria.

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/.

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

Notes:

....

....

....

....

....

....

....

....

Understanding sediment

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

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

Grain size classes used, based on the Udden – Wentworth grade scale [32].

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

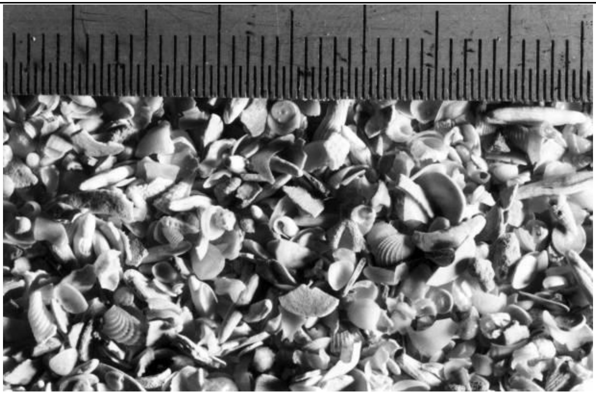
In Seagrass-Watch, the primary descriptors relate to the size of the sediment grains: gravel (>2000µm); coarse sand (>500 µm); sand (>250 µm); fine sand (>63 µm); and mud (<63 µm).

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

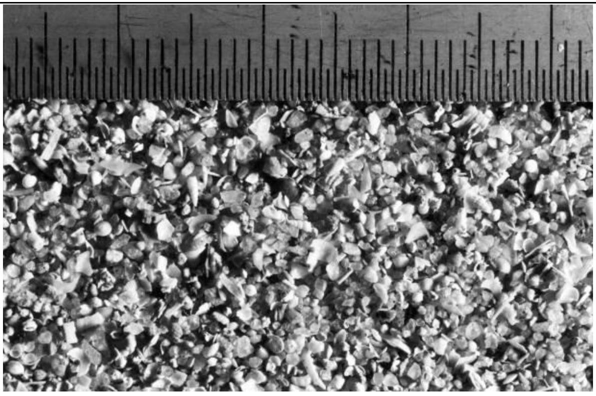
mud *has a smooth and sticky texture.*
fine sand *fairly smooth texture with some roughness just detectable. Not sticky in nature.*
sand *rough grainy texture, particles clearly distinguishable.*
coarse sand *coarse texture, particles loose.*
gravel *very coarse texture, with some small stones.*

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

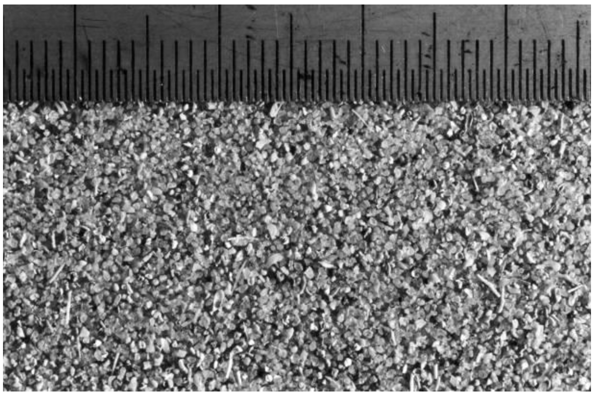
The visual/tactile estimation method used in Seagrass-Watch is a simple yet relatively accurate measure of the sediment grain size which can be used for quantitative assessments [33], https://bit.ly/3pjTowW.



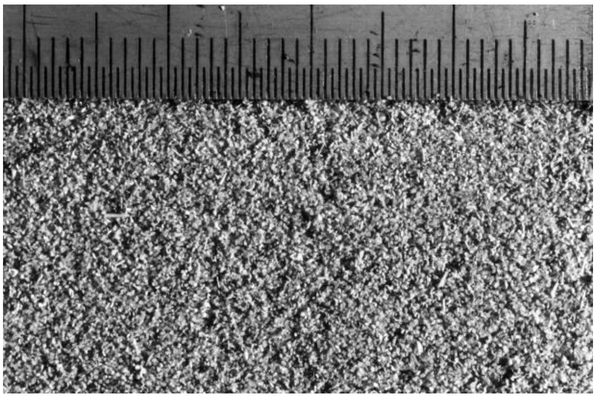
gravel (>2mm)



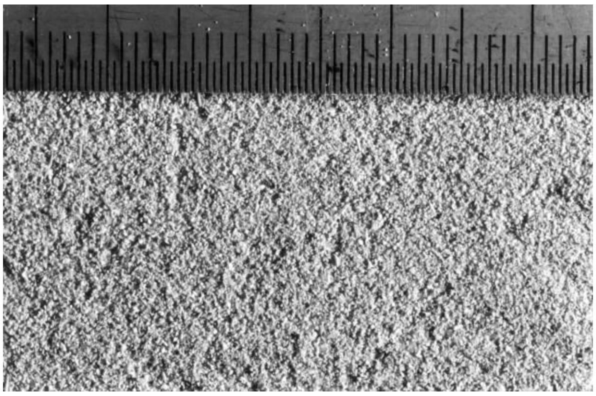
very coarse sand (1 – 2 mm)



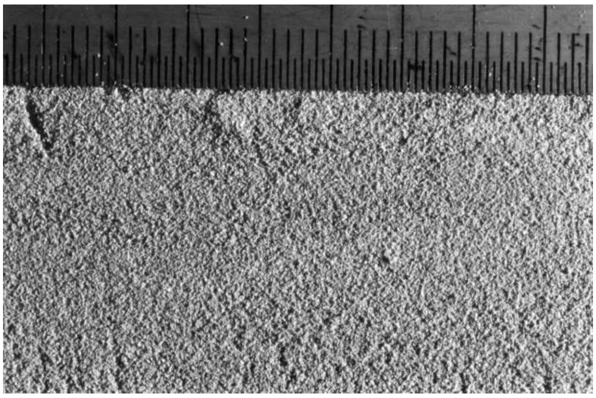
coarse sand (0.5 – 1 mm)



medium sand (0.25 – 0.5 mm)



fine sand (0.125 – 0.25 mm)



very fine sand (0.063 – 0.125mm)

Notes:

Seagrass conservation

Threats to seagrass habitats

Destruction or loss of seagrasses have been reported from most parts of the world, often from natural causes, e.g., high energy storms. However, destruction commonly has resulted from human activities, e.g., as a consequence of eutrophication or land clamation 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 serve as a vital food source for several marine mammals and turtles. Notably, species like the dugong (*Dugong dugon*) are classified as vulnerable to extinction on 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.

Methods of direct protection range from legislative instruments and associated legal sanctions through to education [34]. These can be separated into three approaches: a proscriptive legal approach; a non-proscriptive 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. It is these three approaches that Seagrass-Watch supports for the protection/conservation of seagrass.

Reactive (on-ground)

Reactive processes generally occur in response to a perceived operational threat such as a coastal development proposal [34]. Reactive processes can include port contingency planning, risk management plans and environmental impact assessments.

Prescriptive (informing, advising or directing)

Prescriptive management of seagrass issues focuses on relevant laws, regulations, and legal principles which can range from local laws to a Presidential Decree, or Executive Order. Regulations can directly safeguard seagrasses or can protect them indirectly by protecting habitat types (all aquatic vegetation) or by influencing a process, e.g., prevention of pollution [34].

In some locations, protection is often strongest at the village or community level. This may be by Government supported agreements or through local management marine area level. For example, sea country management protects seagrass through a combination of traditional knowledge, scientific monitoring, and collaborative management practices. This includes mapping and monitoring seagrass health, implementing water quality improvements, and engaging in restoration efforts. In these cases, successful enforcement is dependent on community support for the measure.

Non-prescriptive (planning & education)

Non-prescriptive methods of protecting seagrasses are usually part of planning processes and may have a strong extension/education focus [34]. Providing information is important as it enables individuals to voluntarily act in ways that reduce impacts to seagrasses. Non-prescriptive methods range from simple explanatory guides to complex industry codes of practice.

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.

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.

Indigenous concepts of management of the sea differ significantly from the introduced Western view of the sea as common domain, open to all and managed by governments [35]. Unlike contemporary European systems of management, indigenous systems do not include jurisdictional boundaries between land and sea. Indigenous systems have a form of customary ownership of maritime areas that has been operating in place for thousands of years to protect and manage places and species that are of importance to their societies.

Marine resource management these days should, therefore, attempt to achieve the following interrelated objectives: a) monitor the wellbeing (e.g. distribution, health and sustainability) of culturally significant species and environments (e.g. dugong, marine turtles, fish, molluscs, seagrass *etc.*); and b) monitor the cultural values associated with these culturally significant species and environments [36].

To realize objective a) we believe the following also needs to be accomplished if the successful management of coastal seagrasses is to be achieved.

1. Important fish habitat is known and mapped,
2. Habitat monitoring is occurring,
3. Adjacent catchment/watershed impacts and other threats are managed,
4. Some level of public goodwill/support is present,
5. Legal powers exist that are robust to challenge,
6. There is effective enforcement and punishment if damage occurs.

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

Consequently a combination of modern “western” science and indigenous knowledge should be brought together within a co-management framework for the successful management of these resources [37-42]. This can only occur if the resource owners actively involve themselves in the management of their resources. Western science also needs to recognise that resource owners have practical and spiritual connections with the resources found within their environment. Once this is recognized then this approach will have the added benefit of empowering communities who own the knowledge to be the primary managers and leaders in decisions about their land and sea country.

Notes:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

References

1. Federal Court of Australia. 2020, Mooney on behalf of the Yuwibara People v State of Queensland (QUD12/2019, 25 February 2020). https://shorturl.at/cN5Z6.

2. Marsh, H., and I. Lawler, 2001, Dugong distribution and abundance in the southern Great Barrier Reef Marine Park and Hervey Bay: Results of an aerial survey in October- December 1999. Report to Great Barrier Reef Marine Park Authority. GBRMPA, Townsville.

3. Coles, R., L.J. McKenzie, and S. Campbell, 2003, The seagrasses of Eastern Australia. In: E.P. Green and F.T. Short (Eds.), The World Atlas of Seagrasses: present status and future conservation. University of California Press, Los Angeles, USA, pp. 119-133.

4. Coles, R., L. McKenzie, M.A. Rasheed, J. Mellors, H. Taylor, K. Dew, S. McKenna, T. Sankey, A. Carter, and A. Grech. 2007, Status and trends of seagrass habitats in the Great Barrier Reef World Heritage Area. *Unpublished report to the Marine and Tropical Sciences Research Facility*, 122.

5. Council of Heads of Australian Herbaria. (2025). Australia's Virtual Herbarium Retrieved 19 March 2025, from http://avh.chah.org.au/

6. Seagrass-Watch HQ. (2025). Seagrass-Watch Virtual Herbarium Retrieved 19 March 2025, from http://www.seagrasswatch.org/herbarium.html

7. Unsworth, R.K.F., B.L.H. Jones, A. Rogers, L.C. Cullen-Unsworth, and R.J. Lilley. (2024). SeagrassSpotter. Available from https://seagrassspotter.org Retrieved 24 September, 2024

8. Carter, A.B., S.A. McKenna, M.A. Rasheed, C. Collier, L. McKenzie, R. Pitcher, and R. Coles. 2021, Synthesizing 35 years of seagrass spatial data from the Great Barrier Reef World Heritage Area, Queensland, Australia. *Limnology and Oceanography Letters, 6*(4), 216-226. doi: https://doi.org/10.1002/lol2.10193

9. Roelofs, A., and C. Roder, 2002, Seagrass and marine resources of the Newry region and Sand Bay dugong protection areas. In: R. Coles, et al. (Eds.), Seagrasses and marine resources in the dugong protection areas of Upstart Bay, Newry Region, Sand Bay, Llewellyn Bay, Ince Bay and the Clairview Region, April/May 1999 and October 1999. Great Barrier Reef Marine Park Authority, Townsville, pp. 55-88.

10. Coles, R.G., J.E. Mellors, J.M. Bibby, and B. Squire, 1987, Seagrass beds and juvenile prawn nursery grounds between Bowen and Water Park Point. QDPI, Brisbane, Australia.

11. Rasheed, M., C. Roder, and R. Thomas, 2001, Port of Mackay Seagrass, Macro-Algae and Macro-Invertebrate Communities. February 2001. CRC Reef Research Centre, Technical Report No. 43. CRC Reef Research Centre, Townsville.

12. York, P., C. van de Wetering, S.A. McKenna, and M. Rasheed. 2025, Annual Seagrass Monitoring in the Mackay-Hay Point Region – 2024. TropWATER Publication 25/42. 42pp.

13. Thomas, R., and M. Rasheed, 2011, Port of Hay Point Seagrass, Algae and Benthic Macro-invertebrate Survey - October 2010. DEEDI, Cairns.

14. York, P., and M. Rasheed. 2021, Annual Seagrass Monitoring in the Mackay-Hay Point Region – 2020. TropWATER Publication 21/20. 42.

15. McKenna, S., and M. Rasheed, 2015, Port of Hay Point & Keswick Island Seagrass & Benthic Habitat: baseline survey – 2014.Centre for Tropical Water & Aquatic Ecosystem Research Publication. JCU Cairns.

16. York, P., C. van de Wetering, C. Reason, and M. Rasheed. 2023, Annual Seagrass Monitoring in the Mackay-Hay Point Region – 2022. TropWATER Publication 23/32. 40.

17. GBRMPA, 2013, Plane basin assessment: Mackay Whitsunday, natural resource management region. . Great Barrier Reef Marine Park Authority, Townsville.

18. Taucare, G., A. Bignert, S. Kaserzon, P. Thai, R.M. Mann, C. Gallen, and J. Mueller. 2022, Detecting long temporal trends of photosystem II herbicides (PSII) in the Great Barrier Reef lagoon. *Marine Pollution Bulletin, 177*, 113490. doi: https://doi.org/10.1016/j.marpolbul.2022.113490

19. Roder, C., and A. Roelofs, 2002, Seagrass and marine resources of the Llewellyn Bay and Ince Bay dugong protection areas. In: R. Coles, et al. (Eds.), Seagrasses and marine resources in the dugong protection areas of Upstart Bay, Newry Region, Sand Bay, Llewellyn Bay, Ince Bay and the Clairview Region, April/May 1999 and October 1999. Great Barrier Reef Marine Park Authority, Townsville, pp. 89-120.

20. Lee Long, W.J., J.E. Mellors, and R.G. Coles. 1993, Seagrasses between Cape York and Hervey Bay, Queensland, Australia. *Australian Journal of Marine and Freshwater Research, 44*, 19-32.

21. FRC Coastal Resource & Environmental. 1997, Ince Bay Inshore Seagrass Survey. Prepared for The Queensland Commercial Fishermen's Organisation. (frc Ref: 97.07.04), 10.

22. Australian Government and Queensland Government, 2018, Reef 2050 Water Quality Improvement Plan: 2017 - 2022. State of Queensland, Brisbane.

23. Gruber, R., J. Waterhouse, C. Petus, C. Howley, K. Thompson, S. Lewis, C. James, M. Logan, U. Bove, B. Brady, L. Bray, S. Choukroun, K. Connellan, J. Davidson, E. Dick, J. Massuger, J. Mellors, B. Molinari, D. Moran, M. O'Callaghan, C. O'Dea, L. Polglase, C. Carswell, S. Xia, P. Prasad, M. Gallen, T. Reeks, J. Clokey, K. Marano, and S. Kaserzon, 2026, Great Barrier Reef Marine Monitoring Program: Annual Report for Inshore Water Quality Monitoring 2024–25. Report for the Great Barrier Reef Marine Park Authority. Great Barrier Reef Marine Park Authority, Townsville.

24. McKenzie, L.J., C.J. Collier, L.A. Langlois, H. Brien, N. Wilson, and R.L. Yoshida. 2026, Marine Monitoring Program: Annual Report for Inshore Seagrass Monitoring 2024–25. Report for the Great Barrier Reef Marine Park Authority. 191.

25. Waycott, M., K.M. McMahon, J.E. Mellors, A. Calladine, and D. Kleine, 2004, A guide to tropical seagrasses of the Indo-West Pacific. James Cook University, Townsville.

26. Campbell, S.J., and L.J. McKenzie. 2004, Flood related loss and recovery of intertidal seagrass meadows in southern Queensland, Australia. *Estuarine, Coastal and Shelf Science, 60*(3), 477-490.

27. Petus, C., M. Devlin, A. Thompson, L. McKenzie, E. Teixeira da Silva, C. Collier, D. Tracey, and K. Martin. 2016, Estimating the Exposure of Coral Reefs and Seagrass Meadows to Land-Sourced Contaminants in River Flood Plumes of the Great Barrier Reef: Validating a Simple Satellite Risk Framework with Environmental Data. *Remote Sensing, 8*(3), 210.

28. McKenzie, L.J., S.M. Yaakub, R. Tan, J. Seymour, and R.L. Yoshida. 2016, Seagrass habitats in Singapore: Environmental drivers and key processes. *Raffles Bulletin of Zoology, Supplement 34*, 60-77.

29. Yaakub, S.M., L.J. McKenzie, P.L.A. Erftemeijer, T. Bouma, and P.A. Todd. 2014, Courage under fire: Seagrass persistence adjacent to a highly urbanised city–state. *Marine Pollution Bulletin, 83*(2), 417-424. doi: http://dx.doi.org/10.1016/j.marpolbul.2014.01.012

30. Macreadie, P.I., P.H. York, and C.D.H. Sherman. 2014, Resilience of *Zostera muelleri* seagrass to small-scale disturbances: the relative importance of asexual versus sexual recovery. *Ecology and Evolution, 4*(4), 450-461. doi: 10.1002/ece3.933

31. McKenzie, L.J., S.J. Campbell, and C.A. Roder, 2003, Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources. QFS, NFC, Cairns.

32. Wentworth, C.K. 1922, A scale of grade and class terms for clastic sediments. *Journal of Geology, 30*, 377-392.

33. McKenzie, L.J., 2007, Relationships between seagrass communities and sediment properties along the Queensland coast. Progress report to the Marine and Tropical Sciences Research Facility. Reef and Rainforest Research Centre Ltd, Cairns

34. Coles, R.G., and M.D. Fortes, 2001, Protecting seagrass—approaches and methods. In: F.T. Short and R.G. Coles (Eds.), Global seagrass research methods. Elsevier, Amsterdam, pp. 445–463.

35. Hardin, G. 1968, The tragedy of the commons. *Science, New Series, 162* (3859), 1243-1248.

36. Smyth, D., J. Fitzpatrick, and D. Kwan, 2006, Towards the development of cultural indicators for marine resource management in Torres Strait. CRC Torres Strait, Townsville.

37. Johannes, R.E. 2002, The renaissance of community-based marine resource management in Oceania. *Annu. Rev. Ecol. Syst, 33*, 317-340.

38. Aswani, S., and P. Weiant. 2004, Scientific evaluation in women's participatory management: monitoring marine invertebrate refugia in the Solomon Islands. *Human Organisation, 63*(3), 301-319.

39. Turnbull, J. 2004, Explaining complexities of environmental management in developing countries: lessons from the Fiji Islands. *The Geographical Journal, 170* (1), 64-77.

40. Middlebrook, R., and J.E. Williamson. 2006, Social attitudes towards marine resource management in two Fijian villages. *Ecological Management & Restoration, 7*(2), 144-147.

41. Gaskell, J. 2003, Engaging science education within diverse cultures. *Curriculum Inquiry, 33*, 235-249.

42. George, M., J. Innes, and H. Ross, 2004, Managing sea country together: key issues for developing co-operative management for the Great Barrier Reef World Heritage Area. CRC Reef Research Centre Technical Report No 50. CRC Reef Research Centre Ltd, Townsville.

Useful web links

Seagrass-Watch Official Site www.seagrasswatch.org

SeagrassSpotter A conservation and education tool that could lead to new discoveries about one of the ocean's most under-appreciated habitats – seagrass. With SeagrassSpotter, ocean enthusiasts around the world can become citizen scientists who contribute to marine conservation with just a few taps of their phone. https://seagrassspotter.org/

Project Seagrass A marine conservation charity dedicated to ensuring that seagrass meadows are protected globally, for the biodiversity and people that depend on them. https://www.projectseagrass.org/

Dugong & Seagrass Research Toolkit Helps you refine your research questions and provide you with a list of recommended techniques and tools to answer them. Designed for use by marine natural resource managers and decision-makers and for dugong and seagrass researchers, the Toolkit will show you which techniques are the most effective and efficient for your team capacity, budget and timeline. http://www.conservation.tools/

World Seagrass Association A global network of scientists and coastal managers committed to research, protection and management of the world's seagrasses. https://worldseagrass.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. lists.murdoch.edu.au/mailman/listinfo/seagrass_forum

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. https://ian.umces.edu/

Notes:

....

....

....

....

....

....

....

....

....

....

Risk Assessment

Let someone else know where and for how long you will be sampling
Assess the risks before monitoring
Use your instincts - if you do not feel safe then abandon sampling.
Do not put yourself or others at risk.
Adult supervision is required if children are involved

Hazard	Risk	Control
Sun	Sunburn	• wear hat with good cover • use sunscreen (preferably 40+). • wear appropriate clothing (long sleeved shirt).
	Eye strain	• sunglasses (preferably polarised lenses)
	Dehydration	• take a water bottle/drink (water) • take regular breaks to drink water
	Exposure	• wear proper clothing and footwear depending on the weather
Beware of holes, oysters, broken glass, etc.	Cuts & twisted ankles	• use common sense when walking to and from a site • don't stray from designated clear walking tracks on way to site • walk at own pace • watch where you step • wear proper footwear e.g., diving booties or old shoes with tough sole and good grip. • have a first aid kit on site or nearby and re-acquaint yourself with the treatment of marine stings (e.g., jellyfish, stonefish)
Be aware of dangerous marine animals. (e.g. *snakes, stonefish, cone shells, sting-ray, crocodiles, mosquitoes etc*)	Marine stings	• be on the lookout and avoid contact with any dangerous animal • wear proper footwear depending e.g., diving booties or old shoes with tough sole and good grip.
	Bites	• have a first aid kit on site or nearby and re-acquaint yourself with the treatment of marine stings (e.g., jellyfish, stonefish) • wear appropriate clothing (long sleeved shirt) and/or apply Insect repellent which is available
	Attacks	• conduct sampling when site is fully exposed • if crocodiles occur in your area, check with local Parks & Wildlife before conducting sampling (preferably the day prior) • if sampling at night, each participant to have adequate personal light (torch) • have a dedicated observer to check for crocodiles • if walking, do not venture into water of poor clarity deeper than ankles
Deep mud	Stranded/stuck	• communication device (i.e. mobile phone working in area or marine radio)
	Exhaustion	• do not over exert yourself - move at your own pace
	Bacterial infection	• wash hands and feet carefully upon return
Tide & Weather	Stranded/stuck	• check weather, tides, time of day, etc. and avoid extreme weather conditions • ensure appropriate time is available to conduct sampling • ensure suitable tides • communication device (i.e. mobile phone working in area or marine radio)
Other beach/water users	Verbal or physical abuse	• do not approach if other users acting suspiciously • be courteous to other users • act professionally so as not to arouse suspicion • ensure monitoring sign clearly displayed • if you feel uncomfortable or in any way unsafe, abandon sampling and leave the area.
	Risks to Third Parties/General Public:	• ensure that all monitoring equipment is stored safely or gathered together on site when not in use
Equipment (eg, *clip-boards, tapes, pegs etc*)	Scratches	• handle equipment with care and use it appropriately according to the task.
Postural Compromise (eg, *lifting and carrying equipment; bending and reaching while monitoring*)	Sore back	• use correct techniques (bending the knees). • work at your own pace. • ensure equipment is evenly distributed among the buckets.
Seed coring (*digging, sieving sediment*)	Scratches	• look where placing hands. • use equipment appropriately
General Health	special needs (heart condition, diabetes, etc)	• ensure fitness via verbal enquiry • ensure you have notified the co-ordinator of pre-medical conditions. • if you are uncertain of a particular task, please do not attempt to do it.

SEAGRASS-WATCH SERVICES

Research, Educate, Collaborate

01 Mapping

Seagrass-Watch can assist you in effectively planning, mapping and producing detailed seagrass maps of your area of interest.

02 Monitoring

More than 25 countries participate in the Global Seagrass Observing Network. Seagrass monitoring is currently occurring over 445 sentinel sites and growing. Our Team can help you develop long-term monitoring strategies effectively.

03 Research

Seagrass-Watch has a strong scientific underpinning with an emphasis on consistent data collection, recording and reporting. Our team offers critical seagrass ecology research services, including monitoring, mapping and publishing.

04 Training

Our training builds the capacity and upskills participants to collect information critical for management and protection of important marine resources. This includes subtidal monitoring, transect-based monitoring and drone use.

The program encourages collaboration and partnerships between communities, scientists and environmental managers.

Global Seagrass Observing Network

MORE INFORMATION:
seagrasswatch.org
admin@seagraswatch.org