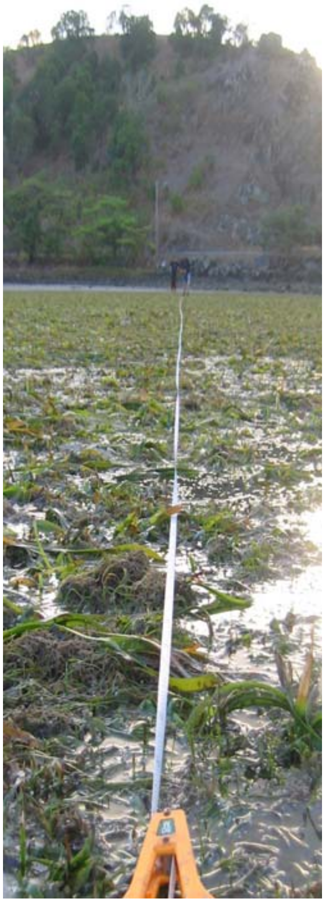
SEAGRASS-WATCH

Seagrass Monitoring Guidelines
for Torres Strait Communities

Meer Island
14-15 September, 2009

Jane Mellors & Len McKenzie
Seagrass-Watch HQ
Department of Employment, Economic Development and Innovation



First Published 2009

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 writing. 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

Mellors, JE & McKenzie, L.J. (2009). Seagrass-Watch: Seagrass Monitoring Guidelines for Torres Strait Communities. Proceedings of a workshop held on Meer Island, Torres Strait September 14-15, 2009 (Seagrass-Watch, Townsville: 58pp)

Produced by Seagrass-Watch HQ (DEEDI)

Enquires with regard to these proceedings should be directed to:
Jane Mellors
Seagrass-Watch Scientist
DEEDI
PO Box1085
Townsville, QLD 4810 Australia

Table of Contents

Seagrass-Watch –The Program

Background

Government agencies often lack the manpower to be able to go and observe all seagrass meadows and report on their health. Seagrass-Watch is a monitoring program that brings a variety of people and organisations together to help conserve seagrass habitats, by training them in easy to use techniques to monitor seagrass meadow health

Monitoring seagrass resources is important for two reasons:

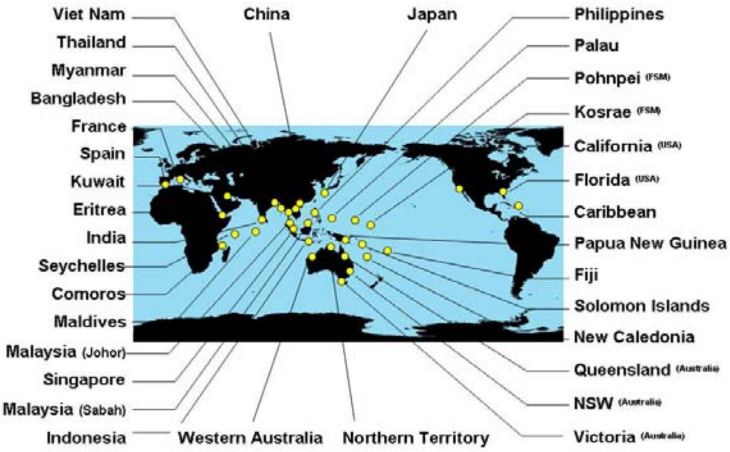
- it is a valuable tool for improving management practices;
- it allows us to know whether resource status and condition is stable, improving or declining.

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 too hard to fix,*
- *Developing a better understanding of coastal issues within the community,*
- *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*
- *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,*
- *Assessing new management practices*

Seagrass-Watch is a global non-destructive, scientific seagrass assessment and monitoring program. Since it's genesis in May 1998 in Australia, Seagrass-Watch has expanded to the Indo and western Pacific, with volunteers in Micronesia, Palau, Japan, Philippines, Malaysia, Indonesia, Papua New Guinea, Solomon Islands and Fiji. Monitoring is now occurring at approximately 271 sites. The participants of Seagrass-Watch are generally volunteers from a wide variety of backgrounds who all share the common interest in marine conservation and sustainability.

Seagrass-Watch 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 sustainability and the information collected is used to assist the management of coastal environments and to prevent significant areas and species being lost. Seagrass-Watch is also a component of the Global Seagrass Monitoring Network.



The program integrates where possible with existing education, government, non-government and scientific programs and aims to

- raise awareness on the condition and trend of nearshore seagrass ecosystems for the benefit of the community
- provide an early warning of major coastal environment changes.

The goals of the Seagrass-Watch program are:

- *To educate the wider community on the importance of seagrass resources*
- *To build the capacity of locals in the use of standardised scientific methodologies*
- *To conduct long-term monitoring of seagrass & coastal habitat condition*
- *To raise awareness of coastal management issues*
- *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.*

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

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

This workshop is being hosted by the TSRA's Land & Sea Management Unit, Seagrass-Watch, and Fisheries Queensland as a key component in the delivery of the consultancy *"Seagrass Habitat Assessment, Monitoring and Mapping Activities in the Torres Strait".*

Workshop Participants will

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

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

Seagrass-Watch HQ
Northern Fisheries Centre
Queensland Primary Industries & Fisheries (DEEDI)
PO Box 5396
Cairns QLD 4870
AUSTRALIA
Telephone (07) 4057 3731
E-mail hq@seagrasswatch.org

or visit

www.seagrasswatch.org

Workshop Presenter

Jane Mellors

- Jane is a Fisheries Biologist with the Queensland Department of Primary Industries & Fisheries. Jane has over 20 years experience in seagrass related research and monitoring. She is the project Leader for the Torres Strait, Education opportunities for indigenous involvement in marine ecosystem monitoring project. Jane is a specialist in tropical seagrass eco-physiology, seagrass taxonomy and geochemistry of marine sediments pertaining to seagrass meadow communities. Jane completed her Doctorate (Dept TESAG, James Cook University) on sediment and nutrient dynamics in coastal intertidal seagrass meadows of north eastern Australia of North Queensland. She is a co-author of *A guide to tropical seagrasses of the Indo-west Pacific*

Current Projects

- Seagrass-Watch
- Queensland Studies Authority: Community Based Learning Enrichment Course Torres Strait
- Seagrass Habitat Assessment, Monitoring and Mapping Activities in the Torres Strait

Agenda

Monday September 14, 2009 - Workshop

Afternoon	13:30- 14:00*(30min)*	Finalise registration
	14:00-14:10*(10mins)*	Acknowledgments, Welcome and Blessing – Jane Mellors, Doug Passi, Don Whap
	14:10 – 14:25 *(15mins)*	Introduction to Workshop and Seagrass-Watch
	14:25 – 14:55 *(30mins)*	Seagrass Biology and Identification
	14:55 – 15:25 *(30mins)*	*Activity 1: Identifying Seagrass*
	15:25 – 15:35 *(10mins)*	How to prepare a seagrass press specimen
	15:35 – 16:00*(25mins)*	*Activity 2: Pressing seagrass & Afternoon Tea*
	16:00 -17:00 *(60mins)*	Seagrass Ecology, Threats and Management

Tuesday September 15, 2009 - Workshop

Morning	8:15 -8:30 *(15mins)*	Seagrass Monitoring
	8:30 – 10:00*(90mins)*	Seagrass-Watch Techniques
	10:00- 10:20*(20mins)*	Safety Briefing and Risk Assessment
	10:30 – 11:00 *(30min)*	*Morning Tea*
	11:00 -11:30 *(30mins)*	*Activity 3 Preparing the kit*
	11:30 – 14:00 *(2.5hrs)*	Seagrass Monitoring – Mud – MR1
	14:00 – 14:45 *(45mins)*	*Lunch*
	14:45 – 15:45 *(15mins)*	Seagrass-Watch data
	15:45 – 16:15 *(30mins)*	Afternoon Tea
	16:15 – 17:00 *(15mins)*	Workshop Wrap-up and Close

Seagrass Biology

Seagrasses

- are flowering plants (= **angiosperms)**
- are unique amongst the angiosperms as they are the only flowering plants to live entirely in the sea.
- were probably called sea grass because many of them look like grasses
- and form meadows that resemble grasslands.
- are not true grasses, but are rather more closely related to the lily family.
- they **are not** related to seaweeds/algae

Morphology (shape and structure of the plant parts)

Parts of a seagrass plant

Seagrass come in many different forms (that do not look like grass at all) and sizes from very small (size of a fingernail) to quite long (~7metre). All seagrasses are **rhizomatous** in habit. This means that they posses **rhizomes,** an underground horizontal stem that produces roots and has shoots that develop into new plants. Like **terrestrial** (land living) plants, a seagrass have leaves stems and roots just like terrestrial plants and can be divided into above ground and below ground parts.

Above ground

Leaves of different types (species) of seagrass can come in a variety of shapes and sizes oan oval (paddle) shape leaf - many of the *Halophila*

- a fern shape – some other *Halophila*
- a long spaghetti like leaf - *Syringodium.*
- and a ribbon shape - *Cymodocea, Thalassia, Thalassodendron, Halodule* and *Zostera.*

Paddle | Fern | Spaghetti | Ribbon

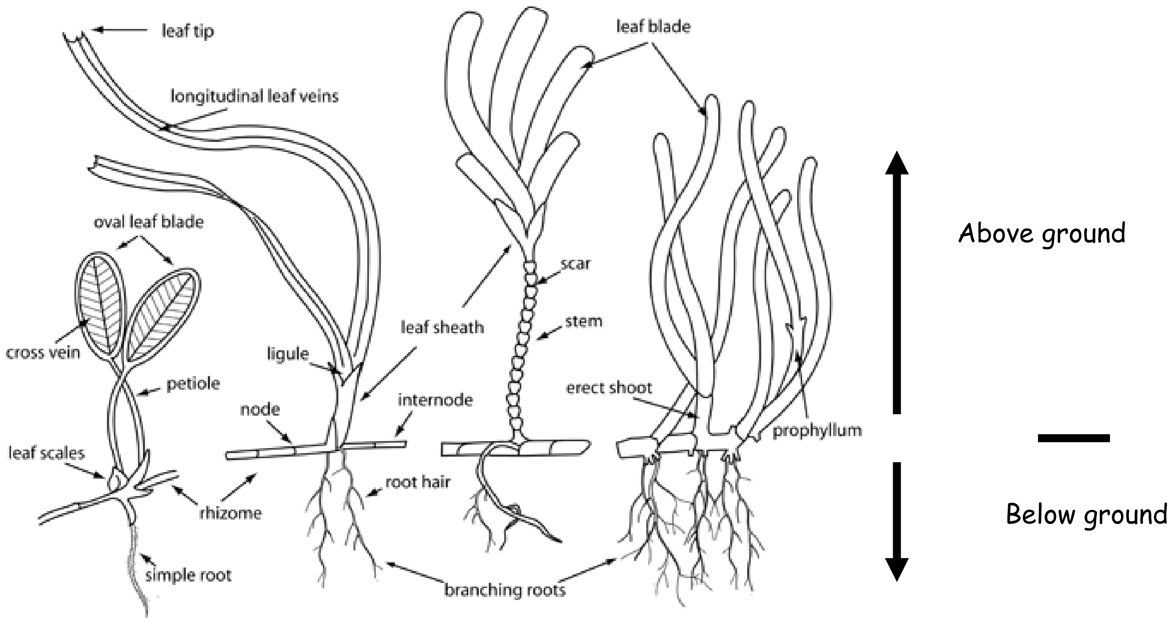
Halophila ovalis, | *Halophila spinulosa* | *Syringodium isoetofolium* | *Cymodocea serrulata*

Some species of *Halophila* have the leaf divided into a **petiole** (stalk) and leaf blade.

The base of a leaf has a **sheath** which protects young leaves. A **ligule** is a short **membranous** (thin, pliable, often translucent tissue) flap on the upper inner side of the leaf that separates the leaf blade from the sheath found in only some seagrass types , such as *Cymodocea, Halodule, Syringodium, Thalassodendron, Zostera).*

Veins - easily seen in the leaves transport water, nutrients and photosynthetic products (carbohydrates, and oxygen) around the plant and is know as the plant's **internal vascular system**. The pattern, direction and placement of veins in the leaf blade are used for identifying different species.

Stems are the upright axis of the plant from which leaves arise. The remnants of leaf attachment on the steam are seen as scars. Vertical stems are only found in some species,



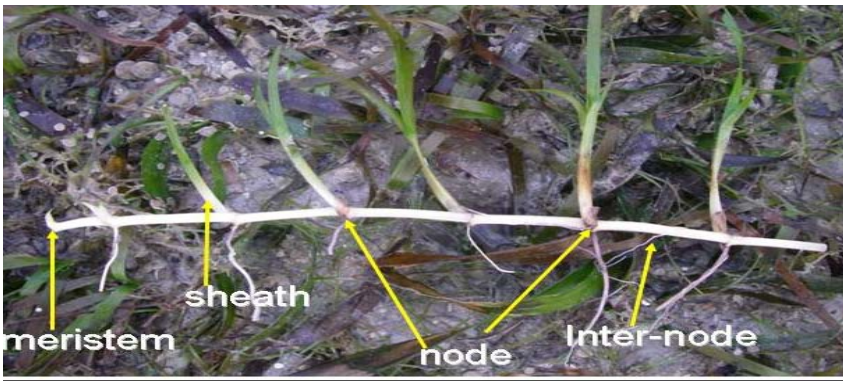
Composite illustration demonstrating morphological features used to identify seagrass types.

Below ground

Rhizomes are the horizontal axis of the seagrass plant. They are usually found buried in the sediment. They are formed in segments, with **leaves** or **vertical stems** arising from the joins of the segments, known as **nodes.** Sections between the nodes are called **internodes**. Rhizomes can be fragile, thick and starchy or feel almost woody and may have scars where the stems originated from.

Roots grow form the node of the rhizome and anchor the plant into the sediment and are important in the uptake of nutrients.

Meristems are the growing tips located at the ends of the rhizomes. They continuously produce new plant tissue and are located at the tips of the rhizomes.



Reproduction

Seagrasses reproduce by increasing rhizomes and producing more stems and leaves (**vegetative/ clonal growth)**. Seagrass can also introduce new plants into the meadow by

reproducing sexually as they have reproductive parts such as flowers and fruits. Most seagrasses have separate male and female plants.

Halophila female flower

Halophila male flower

Enhalus male flowers

Enhalus female flowers

Since they live covered in water for either part or all of their lives, they have mostly adopted means of underwater pollination. 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).

Once the female plant is pollinated it becomes a fruit. The seed within the fruit then germinate into seedlings.

Fruits

Thalassia hemprichii

Enhalus acorides

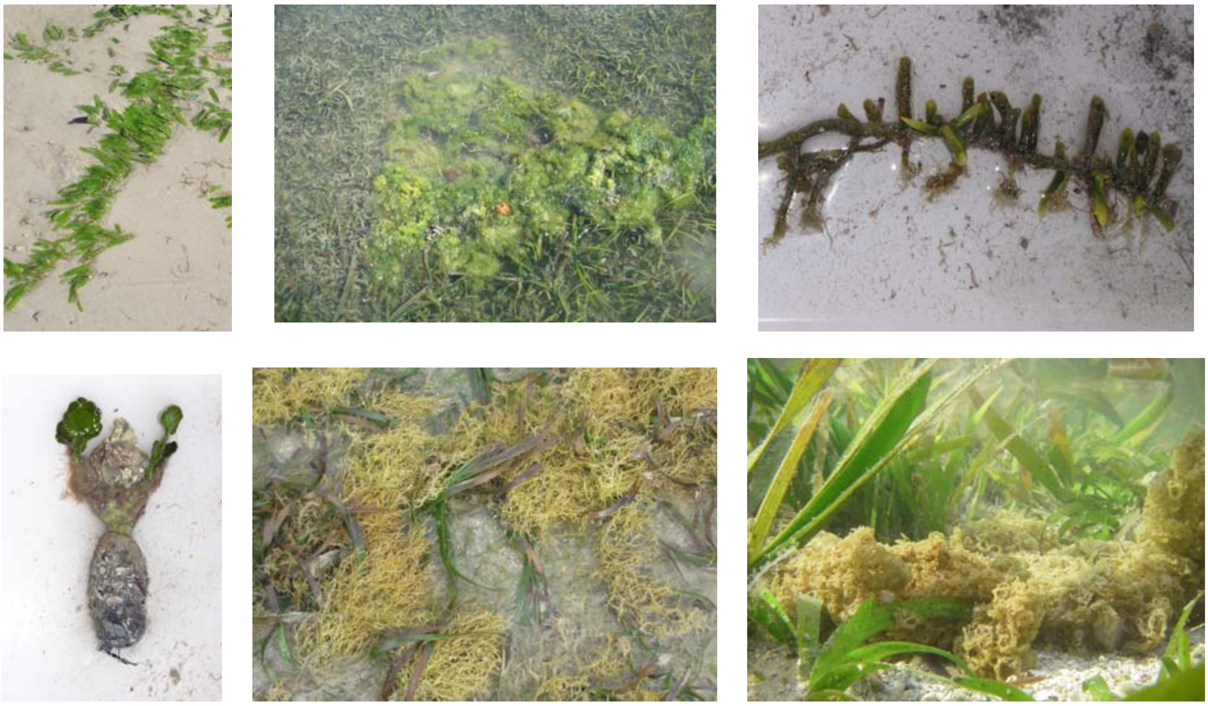
Seeds

Seagrasses are not seaweed. Seaweed is a common name for algae.

Seagrass versus Algae

Algae are plants that also colonised the sea and are often confused with seagrasses, however, they are more primitive than seagrasses. In contrast to seagrasses, algae do not have a true root system (they have holdfasts) and do not have veins that carry nutrients or water around the plant. Algae also use a different method to reproduce. Algae have spores and do not flower or produce fruit, while seagrasses have seeds and fruit

Seagrass	***Marine Algae***
Complex root structure to anchor plant in the sediment, and extract nutrients and minerals	*Simple holdfast to anchor to hard substrate such as rocks or shells*
Photosynthesis restricted to cells in leaves	*Photosynthesis undertaken by all cells*
Transport minerals and nutrients and water is via an internal vascular system	*Uptake of minerals and nutrients from water column via diffusion*
Reproduction via flowers, fruits and seeds	*Reproduction via spores*

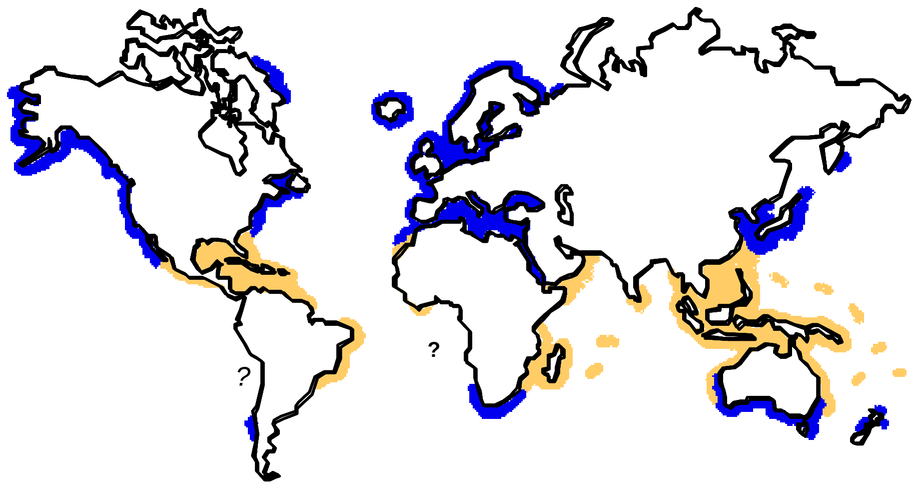


Different types of algae

Distribution

Seagrasses are found in oceans throughout the world. They occur in **tropical** (hot), **temperate** (cool) and the edge of the **artic (**freezing) regions. There is a general acceptance of where certain species are found. Areas less well known include the southeast Pacific reefs and islands, South America, the southern Atlantic, and the west African coast.

Collectively there is more knowledge on the distribution of shallow sub-tidal and intertidal species than seagrasses in water greater than 10 m below MSL. Surveying deep water seagrass is time consuming and expensive. Because of this it is likely that there are areas of deepwater seagrass that we know nothing about.



Global seagrass distribution: tropical and temperate

Seagrass are mainly found :

- in bays, estuaries and coastal waters
- at there extremes from the mid-i**ntertidal** (shallow) region down to depths of 50 or 60 metres (**subtidal**).
- generally though in clear shallow inshore areas between mean sea-level (**MSL**) and 25 metres depth.

The depth range of seagrass is controlled

- at the deep edge by the availability of light for **photosynthesis** (the ability plants have to use the energy of sunlight to convert carbon dioxide and water into sugars and oxygen).
- at the shallow edge - exposure at low tide,
  - wave action and associated **turbidity** (muddy)
  - low **salinity** (containing salt) from fresh water inflow.

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

Seagrass plants form small patches that develop into large continuous meadows. These meadows may consist of one (**monospecific**) or many species (**mulitspecific**). As many as thirteen species have been recorded present within one meadow in the Philippines.

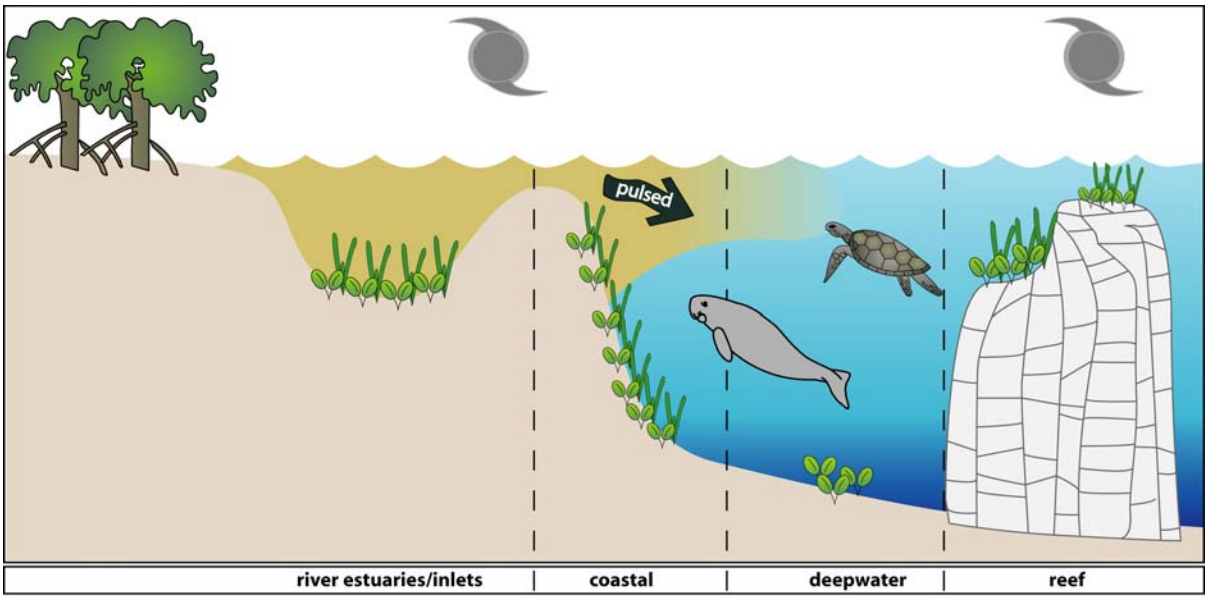
Factors that limit seagrass presence, distribution and abundance in the tropics are generally different to those in temperate or subarctic regions. For example temperature (a stressor) will limit the type (**species**) and amount (**density**) of seagrass present.

Tropical seagrasses tend to be associated with mangroves and coral reef systems. All these systems exert a stabilizing effect on the environment resulting in important physical and biological support for the each other (Amesbury and Francis 1988).

Barrier reefs protect coastlines. The lagoon formed between the reef and the mainland is protected from waves allowing mangrove and seagrass communities to develop. Seagrasses trap sediment washed down from the land by slowing water movement out of creeks and stream. This trapping of sediment benefits coral by reducing the amount of sediment that travels out to the reefs.

Mangroves trap large sediment particles 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

Tropical seagrasses occupy a variety of habitats. Four generalized habitats have been described for seagrasses in north east Australia



Conceptual diagram of the four seagrass habitats for North East Australia
Adapted from Carruthers et al. 2002

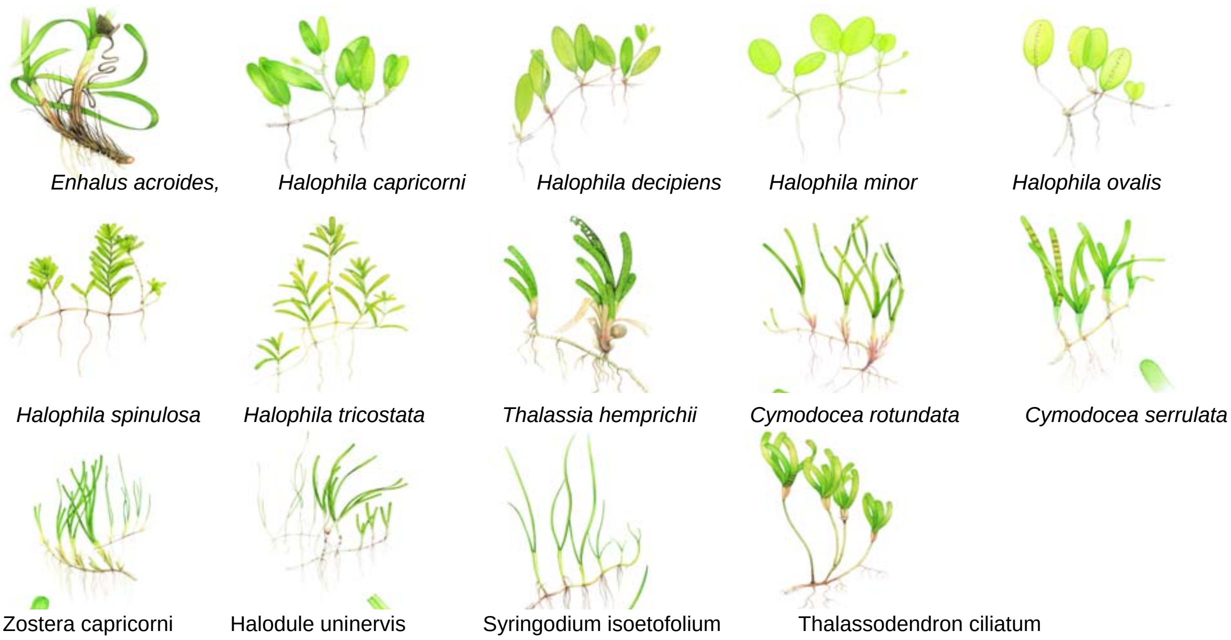
Inshore seagrass communities occur in **river estuaries** and are dominated by species of seagrasses that can tolerate changes in salinity and light availability. **Coastal habitats** can be intertidal or subtidal and are affected by rapid increases in run-off with heavy rain or cyclone events. Increasing the distance from the coast, decreases the impacts from run-off so light is able to penetrate through the clear waters allowing seagrass to grow in deepwater. **Deep water** seagrasses are found in the Torres Strait, within the Great Barrier Reef Lagoon, extending south to the Capricorn Bunker Group. Away from the influences of river plumes coral reefs develop and seagrasses can be associated with them. **Reef** seagrass communities may be intertidal or subtidal.

Taxonomy (identification)

The different seagrass types are not all related to each other (similar taxonomic groupings). Rather the adaptations that they require to survive in the sea have led the seagrass plants to have the same sorts of structures **(morphology)** and cell processes**.** So rather than being a taxonomic grouping the term seagrass represents a ‘biological’ or ‘ecological’ grouping of plants..

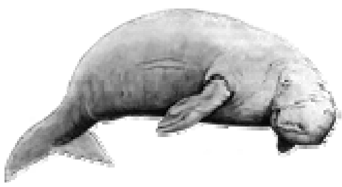
Seagrasses evolved approximately 100 million years ago (MYA) from land plants that returned to the sea on at least three separate occasions within geological time. Each ancestral line has become a separate group and are known botanically as a **family**. Each seagrass family contains several **genera** which are groups of species that are closely related.

There are relatively few species of seagrass globally (**about 60**) and these are grouped into just **13 Genera** and **5 Families**. The highest concentration of species occurs in the Indo-West Pacific region. Around 30 species are found in Australia, with approximately <u>14 species</u> in Queensland waters.



Species found in Queensland waters

Several common names are applied to seagrass species, such as turtle grass, eelgrass and shoal grass. These names are not consistently applied among countries and not commonly used in northern Australia. Seagrasses in the Torres Strait are called ial-damu (KLY) and kolap (MM). These names however do not differentiate between the different species. Islanders tend to note only if the seagrasses has long leaves or short leaves.



Notes:

A guide to the identification of Torres Strait Seagrasses

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

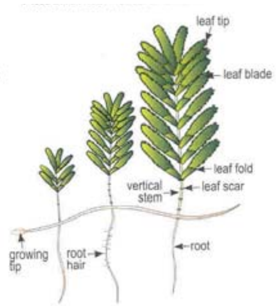
Leaves cylindrical

Syringodium isoetifolium

- Leaf tip pointed
- Leaves contain air cavities
- Inflorescence a "cyme"

Leaves oval to oblong

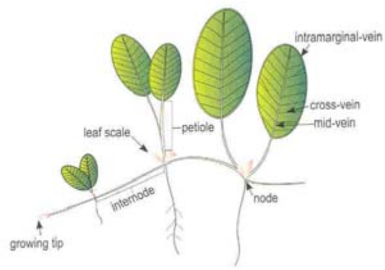
obvious vertical stem with more than 2 leaves



Halophila spinulosa

- leaves arranged opposite in pairs
- leaf margin serrated

leaves with petioles, in pairs



Halophila ovalis

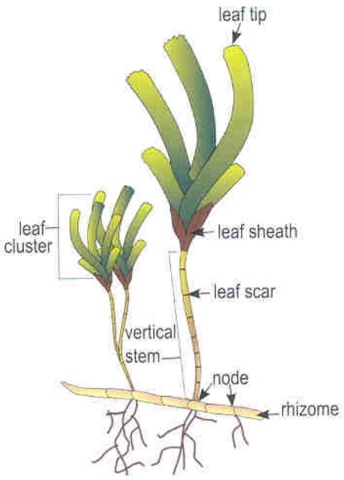
- cross veins more than 10 pairs
- leaf margins smooth
- no leaf hairs
- separate male & female plants

Halophila decipiens

- leaf margins serrated
- fine hairs on both sides of leaf blade
- male & female flowers on same plant

Leaves strap-like

Leaves can arise from vertical stem



Thalassia hemprichii

- Leaf with obvious red flecks, 1-2mm long
- Leaf tip rounded may be slightly serrated
- Leaf often distinctly curved
- Distant scars on rhizome

Cymodocea serrulata

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

Cymodocea rotundata

- Leaf tip rounded with smooth edge
- Leaf sheath not obviously flattened
- Leaf sheath scars continuous around upright stem

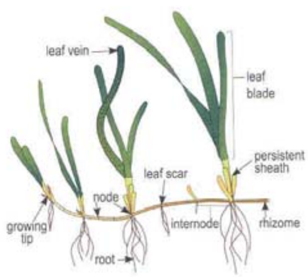
Halodule uninervis

- Leaf tip tri-dentate or pointed, not rounded
- Leaf with 3 distinct parallel- veins, sheaths fibrous
- Rhizome usually white with small black fibres at the nodes

Thalassodendron ciliatum

- distinct upright stem
- clusters of curved leaves (>5 mm wide), margins serrated
- stem and rhizome woody

Leaves always arise directly from rhizome



Enhalus acoroides

- large plant, leaves >30 cm long, >1 cm wide
- inrolled edges of leaves
- long, black bristles protruding from thick rhizome

Zostera capricorni

- leaf with 3-5 parallel-veins
- cross-veins form boxes
- leaf tip smooth and rounded, may be dark point at tip
- rhizome usually brown or yellow in younger parts

Ecology

The study of the relationships between living organisms and their interactions with their natural or developed environment

Seagrass meadows are one of the most productive and dynamic ecosystems globally. Seagrasses provide coastal zones with a number of **ecosystem services.**

Ecosystem Services are the processes by which the environment produces resources that we often take for granted. Seagrasses provide services such as clean water, fishing grounds, wave protection, oxygen production and protection against coastal erosion

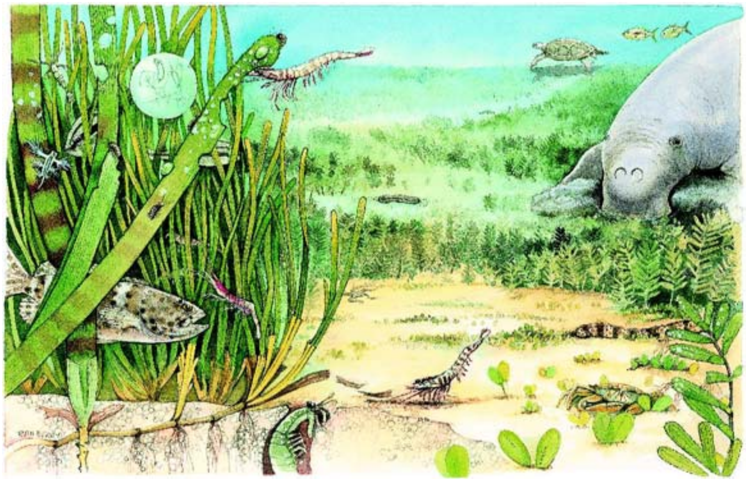
Seagrasses are sometimes labelled 'ecological engineers' because they have the ability to influence their physical, chemical and biological environments. Their leaves slow down water-currents increasing sedimentation, and their seagrass roots and rhizomes stabilize the seabed thereby trapping nutrients within the meadow.

Seagrasses play a number of functional roles: `

- **Nursery and shelter area** for fish and prawns which are valuable to fisheries. Seagrasses meadows when compared with un-vegetated areas, provide up to 27 times more living space . It has been documented that around 40 times more animals occur in seagrass meadows than on bare sand.

- **Major food source** for a number of grazing animals. (**herbivory**)
    - The dugong (Dugong dugon) and the green turtle (Chelonia mydas) mainly feed on seagrass.
    - An adult green turtle eats about two kilograms of seagrass a day
    - An adult dugong eats about 28 to 40 kilograms a day.
    - Dugongs and turtles select seagrass species for food which are high nitrogen, high starch and low fibre.
    - On the east coast for which we have information dugongs eat seagrass in this preference: Halophila ovalis > Halodule uninervis > Zostera capricorni.
    - Other animals that are known to feed on seagrass include, fish, geese, swans, sea urchins and crabs


- **Indirect Food Source**
  - Decomposing seagrasses becomes **detritus** (organic debris) which provides food for animals that live on the bottom of the ocean (benthos eg sea cucumber)
  - The detritus is formed from old seagrass leaves that are broken down by fungi and bacteria
  - The fungi and bacteria are eaten by other microorganisms such as flagellates and plankton.
  - These microorganisms provide food for the juveniles of many species of marine animals such as fish, crabs, prawns and molluscs.



- **Other services that are provided by seagrasses**
  - **buffering** or **filtration** from terrestrial run-off into the marine environment.
  - trapping and binding of sediment by the rhizomes and roots
  - **recycling of nutrients** caught in the bound up sediments
  - **absorption of nutrients;** nitrogen and phosphorus. This leads to improved water quality as excess N&P can create algal blooms.
  - **pumping oxygen** into the water column
  - **storing carbon** within the meadow.

Due to these services that seagrass meadows provide, some people have placed an economic value on meadows dependent on the type and the number of ecosystem services that meadow can provide. Seagrass meadows have been rated the 3rd most valuable ecosystem globally (on a per hectare basis), only preceded by estuaries and wetlands. The average global value of seagrasses for their nutrient cycling services and the raw product they provide has been estimated at 1994 US$ 19,004 ha^{-1} yr^{-1}. These valuations can be quite controversial and difficult to quantify and often do not take into account cultural significance.

Requirements for growth

To survive Seagrasses require:

- light,
- nutrients,
- inorganic carbon,
- suitable substrate
- **hydrodynamic** (properties of water: currents and wave action) regimes,
- tolerable salinity;
- tolerable temperature
- tolerable pH

Light

- is required for all plants as it is needed for **photosynthesis**.(the ability plants have of turning sunlight into food and energy)
- is probably the most important factor in seagrass growth

Seagrasses have high minimum light requirements

- as they live underwater light the amount of light reaching a seagrass plant is reduced as it adsorbed by the water and the plankton and bacteria that live in the water column.
- they need to support the plant structures (rhizomes and roots) that do not photosynthesis.

Light availability can be affected by

- cloud cover,
- daylength,
- clarity (clearness of water).

Water clarity can be modified by

- wind strength,
- depth of water,
- resuspension of sediments
- sediment plumes caused by terrestrial run-off after rain events.

Too much light can also be damaging to seagrasses.

- by causing the cells responsible for photosynthesise to shut down.

This is can be a problem for seagrasses that inhabit intertidal areas.
UV exposure can also have significant impacts on seagrasses as it burns them.

Nutrients

Seagrasses require two key nutrients, nitrogen and phosphorous, for growth.

- Nutrient demand depends on season.
  - during the growing season demand is high,
  - during the senescent season nutrients are stored in the plant.
- Coastal seagrasses are primarily limited by nitrogen.
- they also require inorganic carbon, which they can absorb from the leaf surface.

The availability of nutrients to seagrasses is dependent on

- sediment particle size and the type of sediment (**mineralogy**)
- clay content influences sediment adsorptive capacity
  - the more clays the greater the absorptive capacity.
  - calcium carbonate is another mineral complex. It limits phosphorus to the plants
- reef top seagrass meadows may be phosphorus limited. Reef tops have a lot of calcium carbonate in their sediments.

Sediment

Seagrass presence and abundance can be affected by the sediment.
Important factors of sediment are

- quality,
  - can affect the nutrient content,
  - organic content
  - oxygen levels.
    - Seagrasses are unable to grow in sediments of high organic content, as they tend to be **anoxic** (without oxygen).
- depth
- mobility

Most seagrasses live in sand or mud substrates where their roots and rhizomes anchor the plants to the sea floor.

- *Cymodoceas* prefer deeper sediments
- other species can tolerate a broad range of sediment depths.
- *Halophilas* and *Halodule uninervis* (colonising species) are better suited to mobile sediments than larger species.

Hydrology

- Currents and tides can:
  - affect seagrass meadows from the smallest scale (cellular) to the scale of a meadow
  - influence growth rates
  - survival of seagrass species
  - overall meadow morphology
  - pollination of seagrass flowers
  - movement (dispersal) of broken off plant bits (vegetative material) and seeds to new areas
  - photosynthetic rates of seagrasses
  - the amount of sediment that settles out of he water column (**sedimentation rate).**

Salinity

- as a group seagrasses can live in a range of salt water conditions from fresh water estuarine, marine, or **hypersaline** (very salty).
- for best growth a salinity of 35 parts per thousand is normal
- salinity tolerances differ between species and may be a factor that dictates where different species can survive along estuaries and in the intertidal zone

Temperature

- influences the rate of growth and the health of plants, particularly at the extremes
- as temperatures approach 38°C the efficiency of the plant to photosynthesize is reduced
- temperatures of 38 to 42 °C cause photosynthesis to stop, plant proteins destroyed leading to plant death.

Temperature related impacts resulting in burnt looking seagrass can be caused by

- high water temperatures
- overexposure to warm air

Burnt looking seagrass can also be caused by **desiccation** (lack of water) in intertidal meadows due to long exposure times and drying from wind.

Various combinations of these parameters (light, nutrients, inorganic carbon, suitable substrate, hydrodynamic regimes, tolerable salinity, temperature and pH) will allow seagrasses to either live or not in a certain area. As these parameters can change due to season the presence or absence of seagrasses in some locations may be only temporary.

Seasonality

Seagrass meadows vary seasonally and between years.
This can be seen in changes in

- biomass,
- growth rates,
- flowering
- fruit production

as a as a result of seasonal changes in

- carbon balance,
- light
- temperature.

Temperate seagrasses show a very noticeable seasonal change

- Increasing in spring,
- peak abundance and growth in the summer
- declining in autumn
- maintaining in winter

In temperate and subtropical Australia, seagrasses also follow this pattern of abundance.

In tropical Queensland, seagrass abundance

- peaks late in the dry-season (October - November) or just after the wet season.
- is at a minimum the early dry (south-easterly season (June- August).

Halophila tricostata (found in areas of low light generally deepwater) shows dramatic seasonal changes.

This seagrass is an annual which forms extensive subtidal meadows in the waters of the Great Barrier Reef. It is absent in the autumn and winter months and then re-establishes from its seed bank when sea temperatures rise to 26-28°c.

Seasonal changes in growth for Halophila ovalis

Threats

Seagrass meadows are fragile ecosystems

- losses of seagrasses has been reported from most parts of the world
- around the world about 54% of seagrass meadows have lost part of their distribution
- global losses of seagrass meadows since 1980 is equal to two football fields per hour.

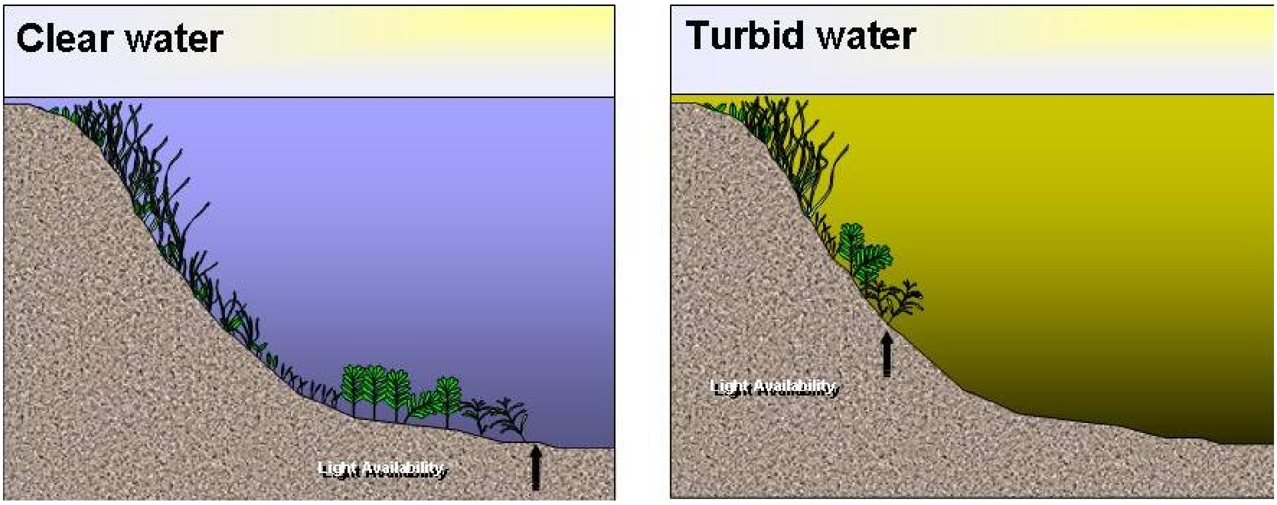
Loss of meadows can be

- natural
  - high energy storms, tropical lows, cyclones
  - wasting disease
- man-made
  - excess nutrients in the system (**eutrophication**)
  - land reclamation
  - changes in land use

Human activities tend to account for the majority of loss or degradation of seagrass habitat. However, the dynamic nature of seagrass meadows in response to natural environmental variation complicates the identification of changes caused by humans.

Light reduction

As good quality and the right amount of light is important to seagrass growth, reduction in light is on of the commonest causes of seagrass decline.



Processes that reduce light available to seagrass include

- pulsed turbidity events during floods,
- enhanced suspended sediment loads
- algal blooms caused by elevated nutrient concentrations.

These processes can be caused by

- poor farming practices ⇨ excess sediments and fertilizers during rain events
- sewage discharge ⇨ elevated nutrients, algal blooms
- storm water runoff ⇨ elevated nutrients, algal blooms
- boating activity ⇨ may also stir up sediment, reducing light levels.

Toxicity

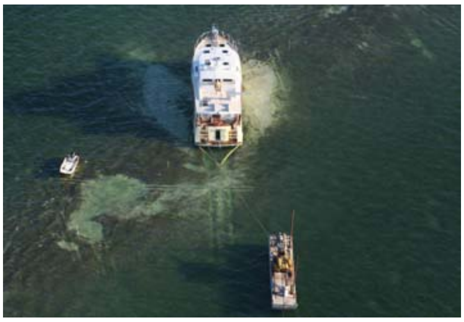
- Oil and trace metal contamination
- these substances **bioaccumulate** (the toxin is added at a rate higher than originally present in the environment) in the seagrass having implications for things that eat seagrass. the trace metals and this has implications for grazers such as dugongs and turtles.
- Herbicides, pesticides
- rubbish and litter with flow on effects to fauna

Physical damage

- removal or burial for
  - coastal development
  - boat marinas,
  - shipping ports.
  - dredging of boat channels

These activities can also change water clarity by making the water muddier.

- rubbish and litter with flow on effects to fauna
- bad boating practices
  - boat anchors and their chains ⇨ dig into seagrass.
  - propellers ⇨ cut into seagrass meadows



- Fishing practices
  - Uncontrolled digging for bait worms
  - Some forms of trawling

Other threats

- introduced marine pests
- Pathogens

Climate Change

The most significant consequence is predicted to be loss of seagrass in the coastal zone, near river mouths and in shallow areas.
Impacts on distribution and reproduction may caused by

- elevated temperatures in shallower habitats,
- reduced light penetration due to more intensive, frequent cyclones with subsequent flooding which will increase the frequency of
  - sediment deposition
  - sediment resuspension

The consequence to this will be a change in species composition in relation to how well a species can withstand disturbance and it ability decolonize. These events are expected to favour the more **ephemeral** (short-lived) species and those with lower minimum light requirements.

Local Eyes Global Wise – or what can be done

Knowledge of regional and global seagrass distributions are still too limited and general for broad scale protection and management. Information gathered from activities such as Seagrass-Watch is needed to minimize future impacts on seagrass habitat worldwide. The information gathered by monitoring and archiving with Seagrass-Watch (one central location) will allow managers, community groups and other interested parties access to detailed information that will to aid them in their planning and development decisions.

To do this we need to

- document seagrass species diversity and distribution at local scales
- identify areas requiring conservation measures before significant changes occur
- determine their ecosystem values
- record spatial and temporal changes in seagrass abundance and species composition and interpret with respect to prevailing environmental conditions.
- measure parameters important to seagrass growth and survival such as
  - light (turbidity, depth),
  - sediment type and chemistry,
  - nutrient levels.

Notes:

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

……

Monitoring

Monitoring is:

- the repeated observation of a system, usually to detect change. I
- an integrated activity to evaluate the condition of the physical, chemical and biological character of the environment.

Environmental monitoring programs should ideally be designed to

- quantify the causes of change;
- examine and assess acceptable ranges of change for the particular site;
- measure levels of impacts.

A good monitoring program should include:

- explicit objectives
- identified responsibilities (eg. Gov agencies, consultants, community groups)
- rationale for using parameters (eg physico/chemico, biological indicators)
- knowledge of spatial and temporal variation – pilot/baseline study
- defined field protocols
- data management procedures, selection of statistical tools
- a system for managing errors - a QA/QC program

Environment monitoring programs provide coastal managers with information and assist them to make decisions with greater confidence.

Monitoring Seagrass

Seagrass meadows are often at the downstream end of catchments, receiving runoff from a range of agricultural, urban and industrial land-uses. They are therefore affected by a range of factors (see Threats – pp 21-23), to which they respond to in a timely manner.

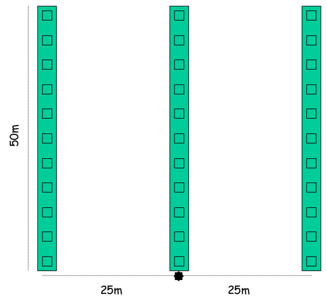
Seagrasses make good **bioindicators** of environmental health because they have

- widespread distribution;
- an important ecological role;
- are **sessile** (don't move around) plants (individuals, populations and communities);
- show measurable and timely responses to impacts
- are integrative of environmental conditions


Seagrass-Watch – the Method

Seagrass-Watch has many different techniques for monitoring seagrass dependent on the meadow type. One of the more widely used methods within the program is **intertidal fixed transect method.**

This method uses 50m by 50m sites established within representative intertidal meadows to monitor seagrass condition. The number and position of sites can be used to investigate natural and anthropogenic impacts.



Establishing your site

The aim of monitoring is to pick up any broad changes in a meadow, not necessarily changes between transects within a meadow.

- Make sure the site is evenly shaped – not a mixture of high sand or mud ridges and troughs.
- Ensure seagrass is the dominant habitat at the site.
- The seagrass community should be representative of that locality.
- The seagrass presence should be similar in coverage across the site.
- The site should be difficult too difficult to access (e.g., weather,tide heights, safety)
- Walk over the 50m by 50m area you would like to establish a site, ensuring that its selection meets these requirements.

When you have found a suitable site, you will need to mark it for future reference. In order to reduce the amount of equipment deployed in the field, only the middle transect will be marked.

To do this you will need

- ❑ *2 star pickets (or stakes)*
- ❑ *A mallet*
- ❑ *3x 50metre fibreglass measuring tapes*
- ❑ *6x 50cm plastic tent pegs*
- ❑ *compass*
- ❑ *GPS (Global Positioning System)*
- ❑ *Clipboard and something to write on*
- ❑ *Pencils & erasers*
- ❑ *Map – anticipated plan for site location*

To mark you site

- Run out your first transect line (tape measure) this will be you middle Transect (Transect 2).
- Knock a picket (marker) in at the 0m mark
- With your compass take a bearing of the direction the transect line is running (remember the transect line must run out from the beach to the sea). Write this bearing down. If you have a GPS create a way point.
- At the 50m mark of your transect knock in your other marker, and if you have a GPS create your second waypoint.

You are now ready to start monitoring!

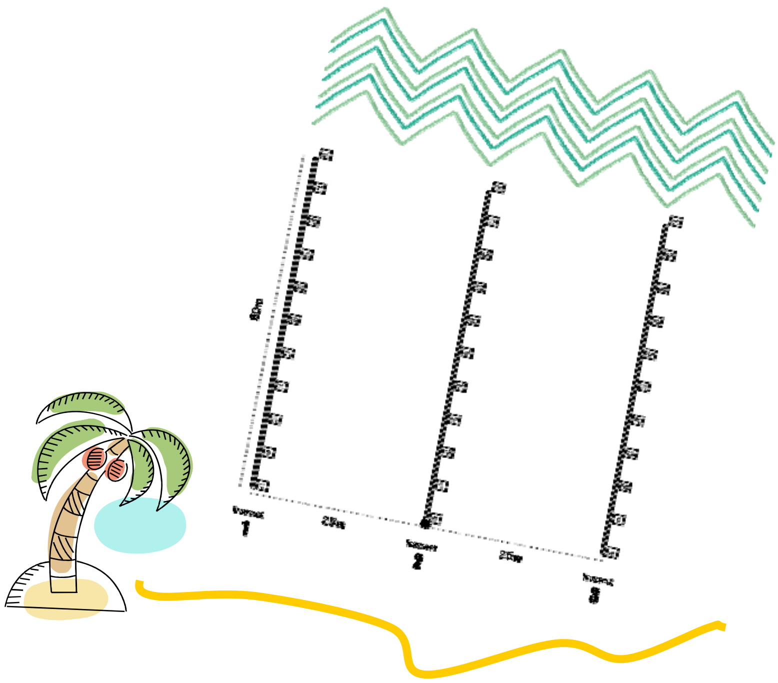
Monitoring your site

You have established your site and set up you middle transect line (Transect 2). Place a quadrat to the right of the tape measure to ensure you do not stand in the space you are going to monitor.

Next:

- Set up your other two transects
- From looking seaward along Transect 2 at the 0m mark turn left to look along the beach, this needs to be at right angles (90^o) to Transect 2. You can do this by subtracting or adding 90^o to the compass bearing you took for Transect 2 depending on the orientation of you site.
- (**Remember: regardless of orientation Transect 1 is always to the left of Transect 2)**
- Now that you have that bearing from your position at Transect 2 run a tape measure 25m along that bearing.
- At 25m stop place another quadrat and peg at that spot.
- Roll in the tape measure to you, place the peg in the end of the tape measure, face seawards and walk out 50m with the tape measure inyour right hand along the same compass bearing that you used to lay out Transect 2. Peg the tape measure down at the end of the 50m.
- To set out Transect 3 repeat what you did for Transect 1 but this time turn to the right from Transect 2.

When taking a compass bearings it is a good idea to and pick a land mark or feature that you can walk towards along the compass bearing..



Remember to place your quadrat to the right of the transect line and you stand to the keep to the left of the transect line

Now that the site is set up we are ready to collect data on the seagrass habitat. All data collected is that which we observe with our quadrats (wire frame).

Seagrass monitoring measures within a quadrat

Quadrats are placed every 5m along the transect line starting at 0m and finishing at 50m, 11 quadrats per transect.

Within each of the quadrats placed for sampling, complete the following

Describe sediment composition

- next, note the type of sediment
- to assess the sediment, dig your fingers into the top centimetre of the substrate and feel the texture. *Remember that you are assessing the surface sediment so don't dig too deep!!*
- Note the grain size in order of dominance (e.g., sand, fine sand, fine sand/mud).
  - **mud** - has a smooth and sticky texture. Grain size is less than 63 µm.
  - **fine sand** - fairly smooth texture with some roughness just detectable. Not sticky in nature. Grain size greater than 63 µm and less than 0.25mm.
  - **sand** - rough grainy texture, particles clearly distinguishable. Grain size greater than 0.25mm and less than 0.5mm.
  - **coarse sand** - coarse texture, particles loose. Grain size greater than 0.5mm and less than 1mm.
  - **gravel** - very coarse texture, with some small stones. Grain size is greater than 1mm.
  - if you find that there are also small dead shells mixed in with the substrate – you can make a note of this in the comments section.

Describe other features and ID/count of macrofauna

- Note any other features within the quadrat which may be of interest (e.g., dugong grazing trails, number of crab/yabby burrows, number of gastropods and worms, ripples in the sand, depth of overlying water, etc).
- The detail of identifications and comments is at the discretion of the observer. Keep in mind collection of information, which may be of a use determining the level of use of the seagrass meadow/habitat, and features that may be an indicator of some impact.

Remember only whole counts.

Estimate seagrass percent cover

- Determine the total cover of seagrass within the quadrat – use the percent cover photo standards as a guide

Estimate seagrass species composition

- identify the species of seagrass within the quadrat , use seagrass species identification sheets provided
- determine the percent contribution of each species within the quadrat
  - the percent compostion for the seagrass species must equal 100%
  - if unsure of a species id then press the specimen and send to Seagrass-Watch HQ for verification

Measure canopy height

- select 3 leaves of the dominant strap leaved species
- extend each leaf to its maximum length/height, without uprooting,
- using the ruler measure from the sediment to the leaf tip in centimetres
  - do not measure heights for *Halophila* the round/oval shaped seagrass..

Estimate macro-algae percent cover

- Algal cover is recorded using the same visual technique used for seagrass cover - use the standard sheets provided.
- Make sure you are estimating the non-epiphytic macro-algae in the quadrat.
  - non-epiphytic algae are those plants that are not attached to the seagrass but they may cover or overlie the seagrass blades.

Estimate epiphyte abundance

- Epiphytes are algae that grow (attached) on seagrass blades.
- This measure is calculated by estimating the percentage of total surface area of leaves within the quadrat covered by epiphyte.
  - To estimate this - look at the individual leaves and see on average how much of the leaf is covered
  - Then look at how many of the leaves in the quadrat are covered

Now do that all again at the next 5m interval

Take photographs of the quadrats for a permanent record

- Photographs are taken at the **5m, 25m** and **45m** quadrats along each transect
- if there is even a small amount of water over the quadrat, to set up without disturbing too much sediment . If sediment is disturbed then wait for it to settle
- First place the photo quadrat labeller beside the quadrat with the correct locality, site number, transect, and quadrat code on it.
- Next, take the photograph from an angle as vertical as possible,
  - which includes
    - the entire quadrat frame
    - the quadrat label.
    - Part of the tape measure
    - Try to avoid having any shadows or patches of reflection off any water in the field of view.
- Record that a photo has been taken on the data sheet for that quadrat.

After all 33 quadrats have been measured you have completed the field component. But wait there is more!!

At completion of Seagrass Monitoring

- Check data sheets are filled in fully.
- Ensure that your name, the date and site/quadrat details are clearly recorded on the datasheet.
- roll up the tape measures
- retrieve the tent pegs leaving the markers in place.
- Before leaving the site, double check that you have left nothing behind.
- **Wash & dry and pack gear away for next field session**

A summary of the field smapling similar to what is provided in the Field Booklets is below, For the full methodology visit www.seagrasswatch.org

Notes:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

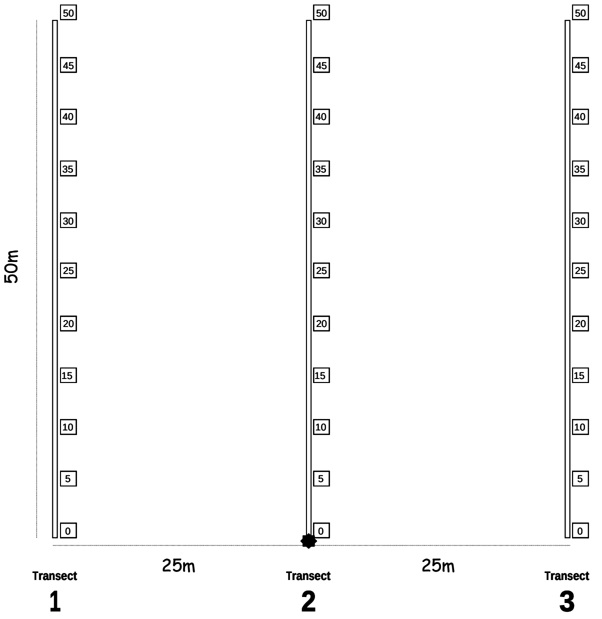
....

....

Seagrass-Watch Protocols

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

Site layout



Quadrat code = site + transect+quadrat

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

Pre-monitoring preparation

Make a Timetable

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

Have a Contact Person

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

Safety

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

Necessary equipment and materials

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

Quarterly sampling

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

Step 1. Take a Photograph of the quadrat

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

Step 2. Describe sediment composition

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

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

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

Step 4. Estimate seagrass percent cover

- Estimate the total % cover of seagrass within the quadrat – use the percent cover photo standards as a guide.

Step 5. Estimate seagrass species composition

- Identify the species of seagrass within the quadrat and determine the percent contribution of each species to the cover. Use seagrass species identification keys provided.

Step 6. Measure canopy height

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

Step 7. Estimate algae percent cover

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

Step 8. Estimate epiphyte percent cover

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

Step 9. Take a voucher seagrass specimen if required

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

At completion of monitoring

Step 1. Check data sheets are filled in fully.

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

Step 2. Remove equipment from site

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

Step 3. Wash & pack gear

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

Step 4. Press any voucher seagrass specimens if collected

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

Step 5. Submit all data

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

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

SEAGRASS-WATCH MONITORING

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

OBSERVER: .... DATE: ..... / ..... / .....

LOCATION: ....

SITE no.: .... TRANSECT no: ....

Start TIME: .... End TIME: ....

START of transect (GPS reading)

Latitude:....°.........'S Longitude:....°.........'E

Quadrat (metres from transect origin)	Sediment (eg, mud/sand/shell)	Comments (eg 10x gastropods, 4x crab holes, dugong feeding trails, herbarium specimen taken)	(✓)	% Seagrass coverage	% Seagrass species composition (must total 100%)							Canopy height (cm)	% Algae cover	% Epi-cover
					HU	HO	CS	TH	CR	EA				
1 (0m)														
2 (5m)			☐											
3 (10m)														
4 (15m)														
5 (20m)														
6 (25m)			☐											
7 (30m)														
8 (35m)														
9 (40m)														
10 (45m)			☐											
11 (50m)														

END of transect (GPS reading)

atitude:....°.........'S Longitude:....°.........'E

Notes:

Seagrasses of Torres Strait

Torres Strait has some of the most extensive seagrass meadows in northern Australia (Coles et al. 2003) They are acknowledged as an invaluable resource for sustaining populations of dugong, turtle, fish, prawns, beche de mer and tropical rock lobster that support their local economies (Marsh et al. 2004; Green 2006). They are an important component of coastal fisheries productivity, as they function as nursery grounds for many commercially important species. They play an important role in maintaining coastal water quality and clarity. The loss of seagrass habitat due to a variety of factors whether manmade or natural would lead to a loss of a food source and nursery areas of species reliant on seagrass meadows. Torres Strait island communities strongly rely on coastal marine habitats for subsistence as well as strong cultural and spiritual links to these environments

Approximately 60 seagrass species are found worldwide, grouped into 13 genera and 5 families (Short and Coles 2001). Torres Strait contains the highest number of seagrass species in the western Pacific, and is included in a diversity “hotspot” for seagrass species which encompasses Sulawesi, Papua New Guinea, Borneo and Malaysia, (Mukai 1993). Of the 14 species that are recorded for Queensland waters, 13 of them are found in the Torres Strait. They are:

- Family **Cymodoceaceae**
  - *Cymodocea rotundata*
  - *Cymodocea serrulata*
  - *Halodule uninervis* (wide- & narrow-leaf)
  - *Syringodium isoetifolium*
  - *Thalassodendron ciliatum*
- Family **Hydrocharitaceae**
  - *Enhalus acoroides*
  - *Halophila decipiens a*
  - *Halophila minor*
  - *Halophila ovalis*.
  - *Halophila spinulosa*
  - *Halophila tricostata*
  - *Thalassia hemprichii*
- Family **Zosteraceae**
  - *Zostera capricorni*

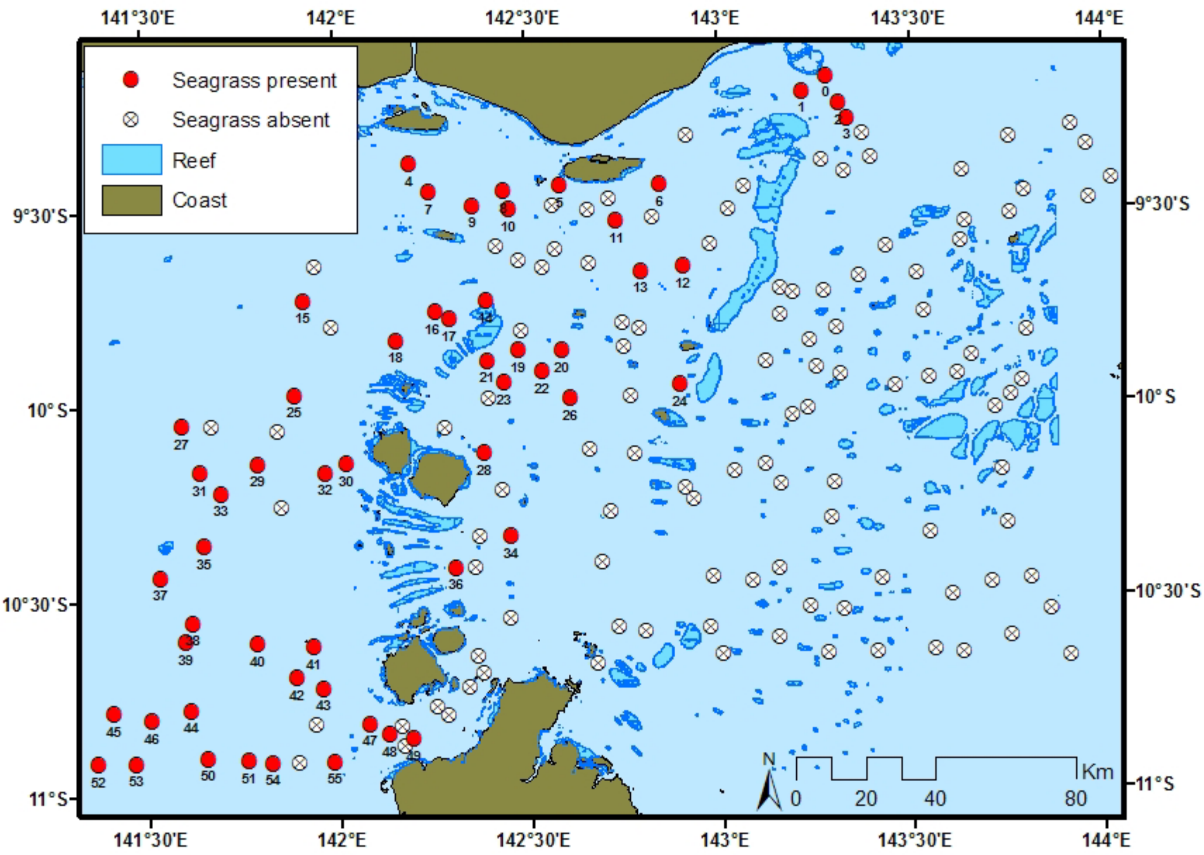
Distribution of Torres Strait seagrasses

Surveys of the open waters of Torres Strait have estimated 13,425 km^2 of seagrass habitat. Seagrass communities occur across the open sea floor, on reef flats and sub-tidally adjacent to continental islands. Seagrass biomass and shoot density is greatest in shallow bays (<7m), foreshore/ intertidal areas landward of the reef crest of fringing reefs of continental islands and on reef tops. *Enhalus acoroides(a species common throughout the Torres Strait)* is generally restricted to shallow subtidal and intertidal regions associated wit the continental islands.

Subtidal meadows displayed a clear east-west partitioning thought to be related to increased turbidity and a change in sediment from coarse sediment in the west to fine sediment in the east. These meadows were populated by sparsely distributed *Halophila* or mixed species (*Halodule, Thalassia* and *Syringodium*) communities. Lush *Halophila ovalis* and *Halophila spinulosa* communities are also found in the deep waters (>25m) of the south-western Torres Strait. Subtidal meadows are common west of the Warrior Reefs and generally absent east of the Warrior Reefs (SOE 2007).

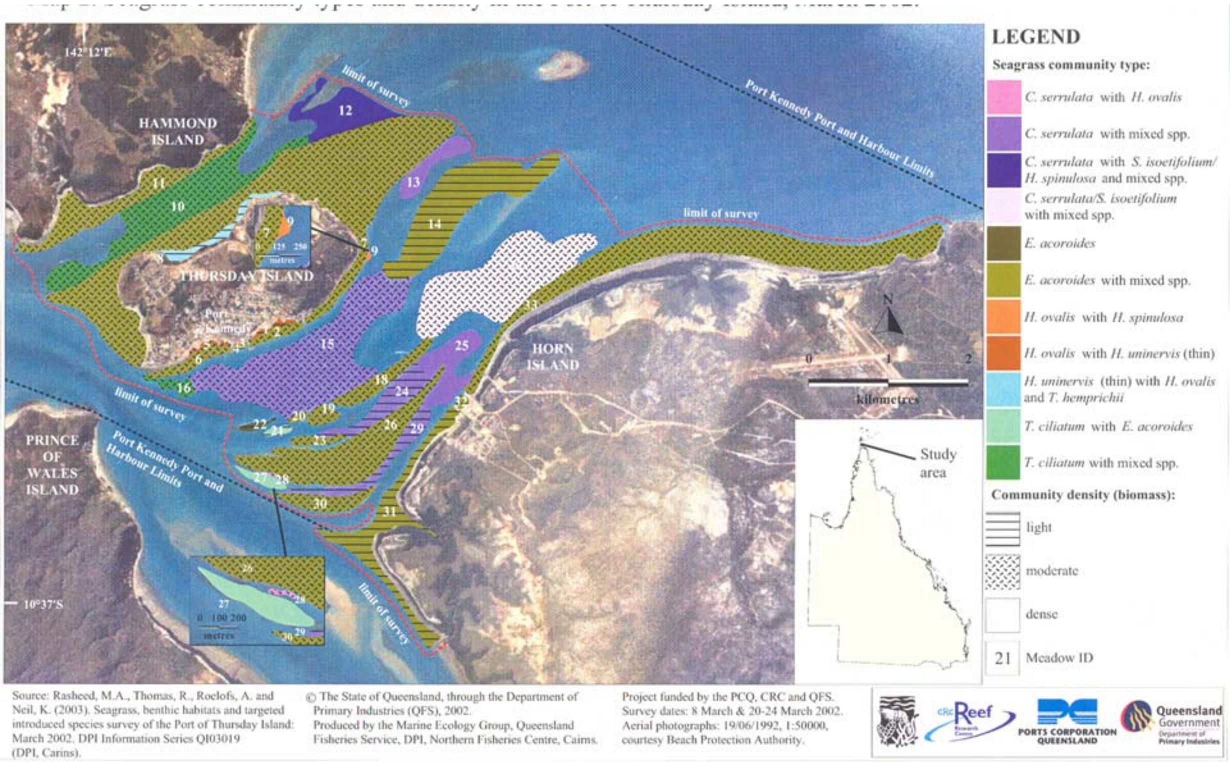
The Warrior Reefs have extensive seagrass-covered reef flats. A number of species co-occur on these flats; most commonly *Halodule uninervis, Thalassodendron ciliatum, Cymodocea rotundata*, and *Thalassia hemprichii*.. These reef platform habitats are also important as nursery grounds for commercial juvenile penaeid prawns (Turnbull and Mellors 1990)

Intertidal seagrass habitat occurred throughout the Torres Strait survey and was mapped over an area of 4179 ± 144 ha (Table 4; Maps 3-12). Of the 19 intertidal island and reef areas surveyed, 14 were found to have a seagrass community present. Despite the fact that seagrasses covered such a large area of the intertidal regions surveyed, it comprised the lowest overall cover in proportion to the other habitat types (Figure 2). Percent cover for the majority of intertidal seagrass meadows was generally very low (0-10%), with the remaining meadows having a low (10-30%) cover of seagrass (Maps 3 & 4). Five species were identified in five distinct community types and fourteen meadows (Figure 3; Table 4; Maps 5-12). Seagrass communities were dominated by *Thalassia hemprichii,* with many meadows having a mix of species present. (Table 4). The meadows identified were typically comprised of aggregated patches and tended to extend to the outer edges of the intertidal regions surveyed. It is important to note that seagrasses may have a much larger extent than reported here, as subtidal areas were not surveyed.



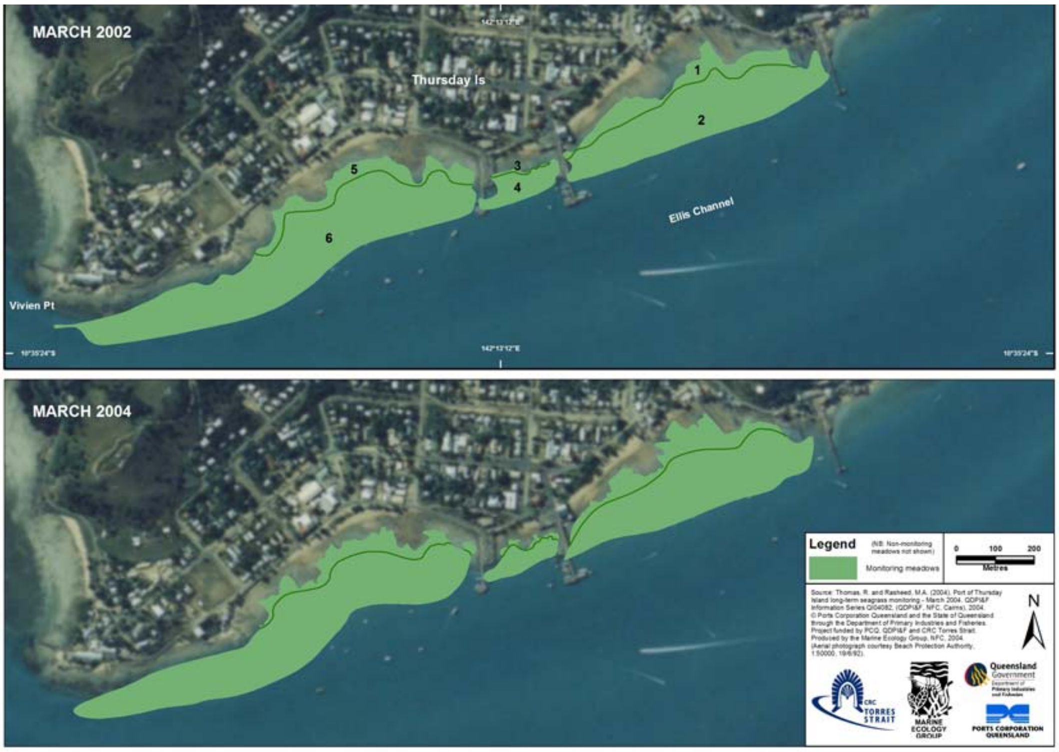
Distribution map of seagrass from areas surveyed

Seagrass meadows have been found to occur in close proximity to the port facilities at Thursday Island. A fine-scale baseline survey of seagrass habitats conducted in March 2002 identified seagrass as the dominant benthic habitat with 11 species, covering over 1500 ha (Rasheed *et al.*, 2003). Extensive intertidal banks of *Enhalus acoroides* are found along the foreshores of Thursday, Horn and Hammond Islands and on the reef platforms around Madge and Holmes reefs. Subtidal meadows dominated by *C. serrulata* or *C. serrulata/S. isoetifolium* occur in Ellis Channel between Thursday and Horn Islands. The channel between Thursday and Hammond Islands is almost entirely occupied by a subtidal *T. ciliatum* dominated meadow (Rasheed *et al.*, 2003).



Seagrass community types and density in the Port of Thursday Island, March 2002

A second survey of a nine representative meadows in the Port was conducted in 2004. This survey found no apparent anthropogenic impacts from port operations or developments had influenced seagrass growth at Thursday Island since March 2002. (Thomas & Rasheed, 2004).Significant increases in seagrass biomass were recorded for four of the nine monitoring meadows since the March 2002 baseline survey..



Thursday Island foreshore meadows in 2002 and 2004

Besides mapping the distribution of seagrass; nutritional profiling of sub tidal seagrasses has been undertaken. This type of mapping may be of use in managing and protecting the ecological, economic and cultural values of the subtidal seagrass meadows and the associated traditional fisheries of the Torres Strait.

Starch and nitrogen within plant tissue are the best indicators of habitat nutritional quality. *H. ovalis* was the most nutritious of the four commonly encountered sub-tidal seagrass species in the Torres Strait, with high nitrogen, starch and digestibility and low fibre levels. Sub-tidal nitrogen and starch distributions in the Torres Strait were concentrated where *H. ovalis* was prevalent, particularly around the south-west and north-central regions. The nutritional superiority of *H. ovalis* coupled with its broad geographic and depth distribution make it an important seagrass species for marine herbivores foraging sub-tidally in the Torres Strait. *H. ovalis* is consistently present in dugong stomach content samples and in the seagrass meadows dugongs target.

S. isoetifolium had considerably less starch content (particularly with increasing depth) and digestibility than *H. ovalis*, it had slightly higher nitrogen content and lower fibre and lignin levels. Given its similar geographic range to *H. ovalis*, *S. isoetifolium* may also constitute an important food resource. *S. isoetifolium* is a larger plant than *H. ovalis*. It also forms denser meadows and has higher total biomass in the Torres Strait than *H. ovalis* (Long and Poiner, 1997). Food seagrasses that occur in concentrated patches will presumably increase the foraging efficiency of a grazing herbivore by reducing search costs and maximising intake rates for grazing effort. *S. isoetifolium* provides less nutritional energy than *H. ovalis* on a plant level, however its morphology, patch characteristics and prevalence (total availability) may enhance its dietary value to a foraging dugong.

Defining, designating and managing areas of seagrass habitat based on their nutritional value and where dugongs are know to forage may assist in the sustainable management of this traditional fishery. Two such sites present themselves based on these factors. The south-western site coincides with the Dugong Sanctuary established in 1985 where hunting is prohibited (Commonwealth of Australia 2003). The second site (north-central) is already recognized as an area of consistently high importance as dugong habitat based on visual surveys in 1987, 1991, 1996 and 2001.

Threats to Torres Strait Seagrasses

Widespread die back of seagrasses has been reported in the past in the central and northern regions of the Torres Strait. More than 1400 square kilometres of seagrass was lost between 1989 and 1993. There is anecdotal evidence of earlier dieback incidents in the 1970's (Long *et al*. 1997). It is possible this is a natural cyclical event but that has not yet been determined.

The seagrasses of this region may be impacted by a number of activities, including: storm run-off during the wet season; migrating sand waves, trampling; boat traffic; small scale infra structure works; shipping and port activities/accidents; anchoring; careening of vessels; introduced marine pests, and climate change.

Despite the remote location of the Torres Strait region, increasing pollution, most notably marine debris, threatens the viability of the wildlife and in turn, the way of life for the local communities. Marine debris poses a threat to local fishery resources, wildlife and habitat, as well as human health and safety. Although the impact of marine debris on wildlife is relatively well known, the impacts on seagrass meadows that support these animals is largely unknown.

Shipping accidents in Torres Strait pose a serious risk to commercial and Indigenous fishing and the habitats that these activities rely on. The Torres Strait region has a high rate of shipping incidents compared to other shipping passages. Queensland Transport has identified the two major shipping lanes of the Torres Strait,The Prince of Wales channel and the Great North East channel, as areas of high risk from shipping accidents with heightened consequences to surrounding habitats.

For example the Torres Strait prawn fishery alone generated in excess of $74 million dollars in 2003 / 2004 (Australian Fisheries Management Authority, 2006). The extensive seagrass habitats located around the Great North East channel provides vital nursery habitats for juvenile prawns associated with the fishery.

There have been at least 19 separate accidents since 1970, seventeen of which were ship groundings on reefs, with the remaining two being discharge accidents while docked at the Port of Thursday Island (Queensland Transport and the Great Barrier Reef Marine Park Authority, 2000). Of these 19 accidents, four caused large quantities of oil and fuel to be spilt into the sea (John Wright, Maritime Safety Queensland, 2006).

Many ecologically, economically and traditionally valuable intertidal marine habitats such as seagrasses, algae, mangroves and coral reefs line are adjacent to these shipping lanes. These habitats are vulnerable to oil and fuel spills, particularly when they occur in intertidal areas.

Other identified impacts that are slightly more insidious and more difficult to counter are natural seagrass die-back, marine pests and global warming. It has been recognized that these factors could impact on local seagrass meadows leading to a loss of a food source and nursery areas of species reliant on seagrass meadows

Despite Islander reliance on these habitats, there exists no mechanism other than anecdotal, in which local communities can report on its condition for use in decision making for the protection of seagrass ecosystems. Monitoring the distribution and abundance of seagrass meadows was recognised as a high priority (TSSAC 2006). The ability to predict the consequences of any disturbance on different seagrass habitats requires ongoing collection of monitoring information that is relevant for making management decisions

Regular detailed monitoring in this region started in March 2004 when Seagrass-Watch was established with the backing of Torres Strait CRC and ongoing support from Tagai College and TSRA Land and Sea Management Unit, (www.seagrasswatch.org).

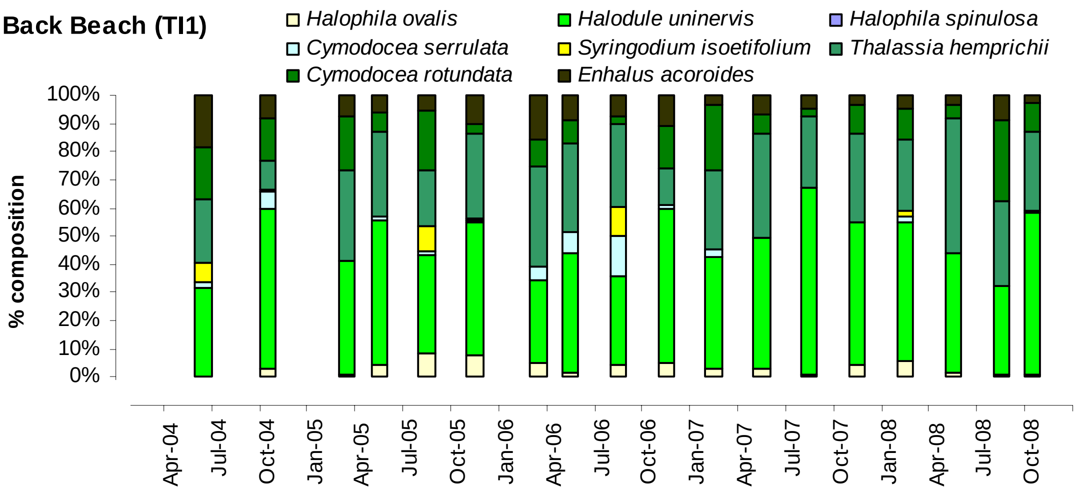
Torres Strait Seagrass-Watch Sites

Back Beach/Battery Point (TI1)

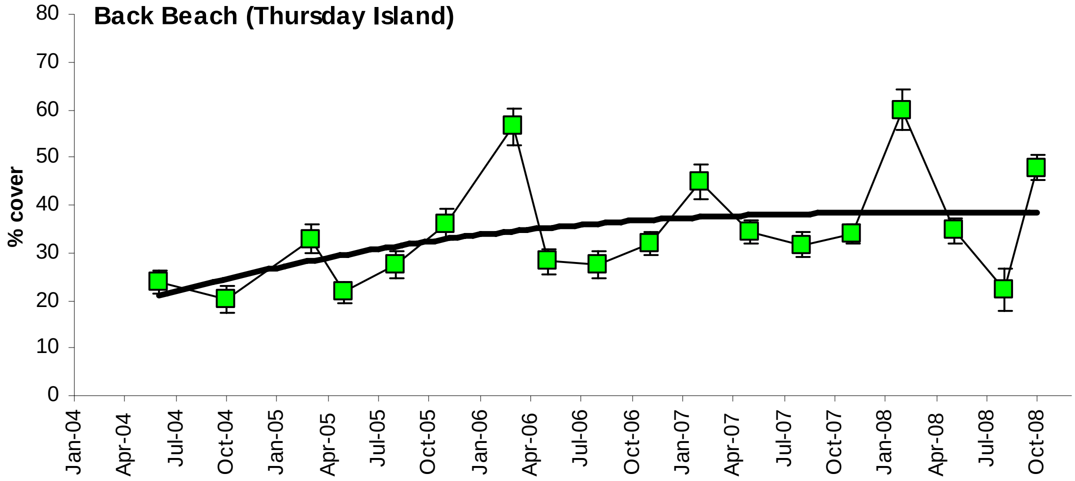
The seagrass meadow at Back Beach (Thursday Island) is an extensive intertidal fringing reef top meadow. On its landward edge it is fringed by mangroves which are used as a roost for a flying fox colony.

Species diversity at Back Beach is high, as 8 species have been identified, including *Enhalus acoroides, Thalassia hemprichii, Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium* and *Halophila spinulosa.* As many as seven species can co-occur in one quadrat

Species composition appears to fluctuate seasonally, driven by changes in *Halodule uninervis* and *Cymodocea rotundata*.



Seagrass abundance appears to have increased gradually since monitoring was established. Seagrass appears to be showing a fairly typical seasonal pattern of abundance (higher in late summer than mid year) and was higher in 2008 than previous years

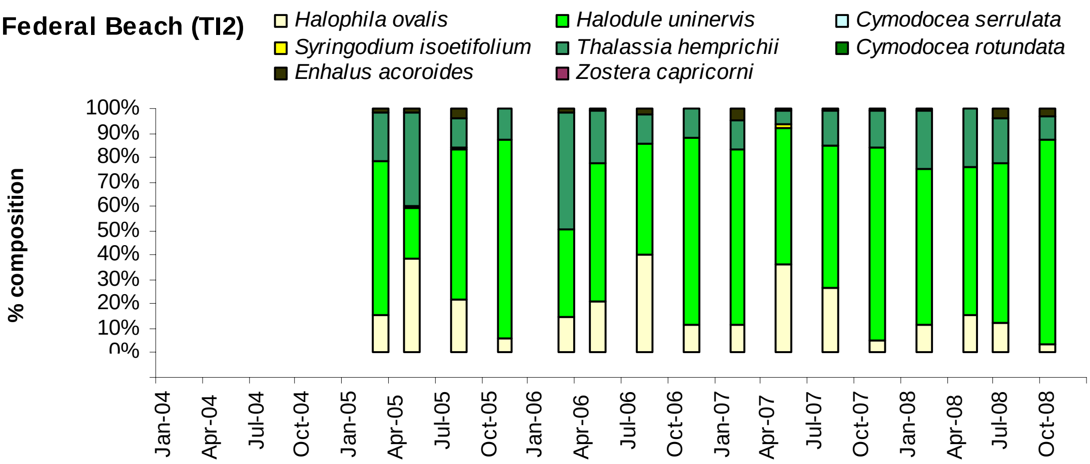


Octopus, crabs and large molluscs flourish at this location demonstrating the notion of seagrass meadows as habitats of great biodiversity. *Enhalus* flowers and fruits are also a common sight at this location.

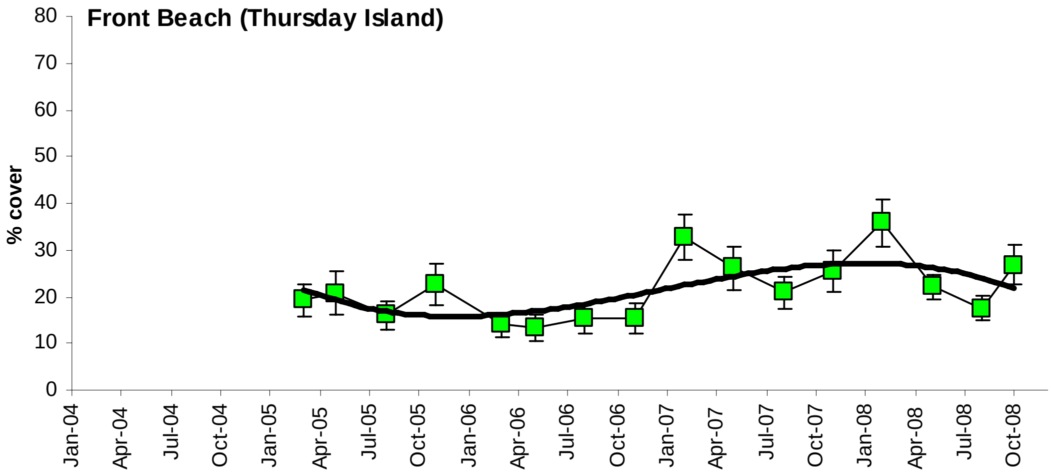
Front/Federal Beach (TI2)

This is a highly disturbed meadow due to its location at the receiving end of many storm water drains on Thursday Island. During the wet season the storm water drains deliver large quantities of freshwater and sediment to this meadow. The meadow overall is quite patchy, though species diversity is moderate. The upper intertidal zone is occupied by *Halodule uninervis* and *Halophila ovalis*. Traversing the meadow seawards, *Enhalus acoroides*, *Thalassia hemprichii* and *Cymodocea serrulata* become more abundant.

Within the Seagrass-Watch site, seagrass cover is sparse, with *Halodule uninervis* being the most abundant species present inshore with *Enhalus* and *Thalassia* occurring in the seaward quadrats. Species composition appears to fluctuate seasonally, driven by changes in *Halodule uninervis* and *Halophila ovalis.*



Seagrass appears to be showing a fairly typical seasonal pattern of abundance (higher in late summer than mid year) and was higher in 2008 than previous years. In general cover is low relative to the other sites being monitored. The frequency of disturbance is relatively high at this site and may explain the persistent low seagrass cover. The site is in the direct path of a large storm water drain and we have observed large amounts of sediment arriving on the site and burying the seagrass. Also, it's proximity to the main harbour results in frequent physical damage from vessel careening, scarring and anchoring. Seagrass abundance appears to have increased gradually since monitoring was established.

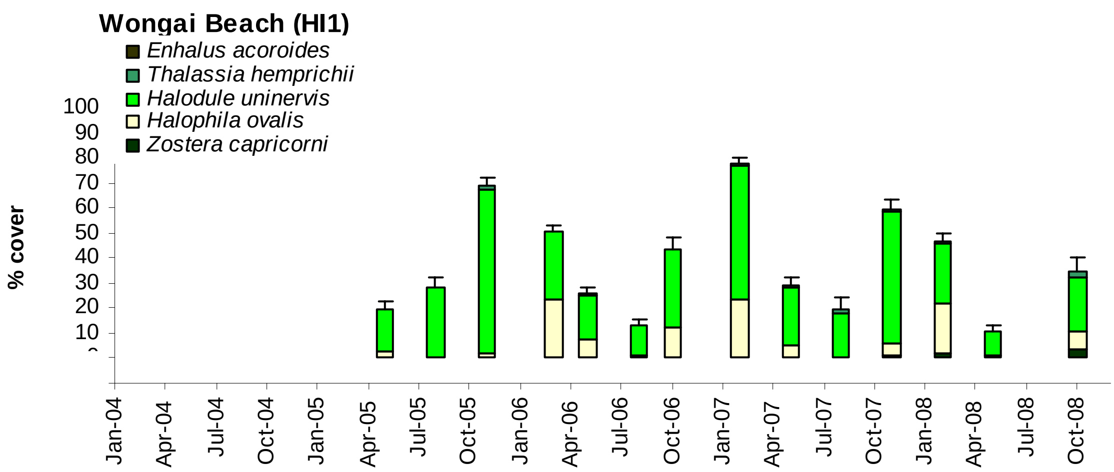


Hermit crabs, and snails are recorded regularly in this meadow with the occasional sighting of sand dollars and heart urchins.

Wongai Beach (HI1)

The meadow at Wongai Beach (Horn Island) is similar to the meadow at Front Beach Thursday Island, in that it has *Halodule uninervis* and *Halophila ovalis* occupying the landward edge of the meadow and *Enhalus acoroides* and *Thalassia hemprichii* seaward. However that is where all similarities end. HI1 has an extremely muddy substrate and in comparison has higher densities of seagrass and seeds. *Zostera capricorni* has also been noted at this site close to transect 3.

Species diversity is lower than Thursday Island sites as only 5 species have been reported: Enhalus acoroides, Thalassia hemprichii, Halodule uninervis, Halophila ovalis and Zostera capricorni. In last 12-18 months, the species composition appears to fluctuate seasonally, due to changes in *Halodule uninervis* and *Halophila ovalis.*



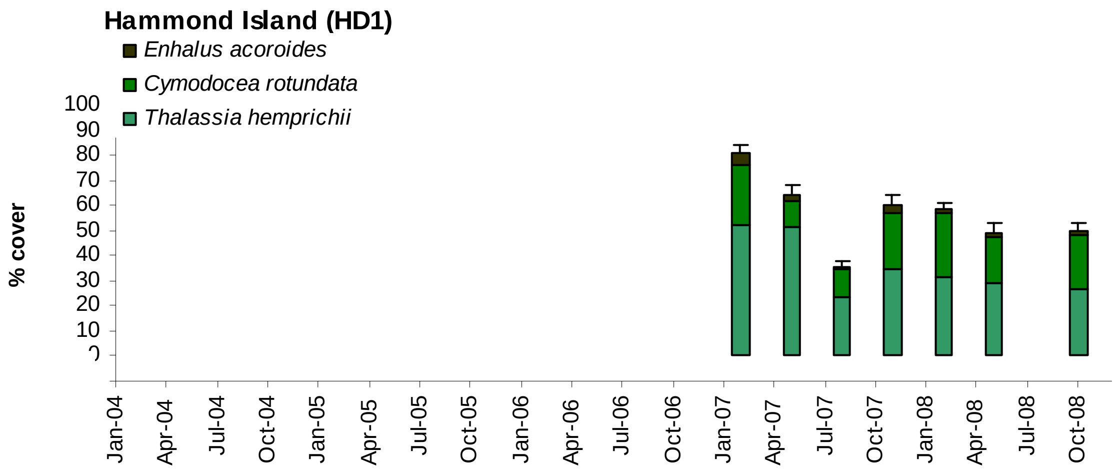
Seagrass abundance appears to have fluctuated greatly since monitoring was established. It does appear to be showing a fairly typical seasonal pattern of abundance (higher in spring/summer than mid year). Abundances were higher in 2007 than previous years or 2008.

The decline in seagrass cover during 2008 can be attributed to the seaward migration of the landward edge of the meadow, possibly a result of impacts from the construction occurring along the foreshore.

During one monitoring trip, large numbers of small sea hares were observed on the site demonstrating the meadow's function as a nursery area.

Corner Beach, Hammond Island HD1

The meadow at Corner Beach is a multispecies meadow. The lower intertidal area of the meadow is dominated by a band of *Halodule uninervis* (narrow leaf). The Seagrass-Watch site is located further out in the multispecific band.



Within the Segrass-Watch site species diversity is low with only three species, *Enhalus acroides, Cymodocea rotundata* and *Thalassia hemprichii* being recorded. In last 12-18 months, the composition species composition appears to have remained stable.

Seagrass abundance appears to have decreased gradually since monitoring was established. The first year of monitoring did show some seasonal signal with minimum abundance occurring in the winter months. This was unable to be supported by a lack of sampling in August 2008 and the fact that the dataset for this site is limited.

.

Macro algae, sponges and mud crabs are commonly found within this reeftop meadow

Torres Strait Seagrass Watch Summation

Monitoring of these sites has established that eight seagrass species inhabit this area. Variation in seagrass cover occurred inter-annually as well as intra-annually. Preliminary evidence from this monitoring data indicates that drivers for seagrass variability were climate related.

Generally seagrass abundance increased during the north-west monsoon (*Kuki)*, possibly a consequence of elevated nutrients, lower tidal exposure times, less wind and higher air temperatures. Most of the annual rainfall (95%) occurs during this time (Mulrennan and Hanssen 1994). Downstream flow from terrestrial habitats occurs with rainfall, bringing nutrients to the near shore environments. Seagrass meadows respond to this by increasing in cover, suggesting that these meadows may be nutrient limited. Decreased wind speeds also lessen turbidity and plants will be able to photosynthesize for longer periods.

Low seagrass abundance coincided with the presence of greater winds and longer periods of exposure at low tides during the south-east trade wind season (*Sager)*. This wind season is characterised by strong persistent winds with speeds up to 37km/hour and rough seas for two thirds of the time. Strong winds lead to an increase in turbidity due to re-suspension of sediments and thereby limiting the light reaching the seagrass canopy. Coupled with desiccation caused by long periods of exposure as low tides occur in the middle to early afternoon during this time of year, these are factors that restrict growth of intertidal seagrasses

This is preliminary evidence that drivers for seagrass variability are related to changes in climate. It is therefore important to maintain this monitoring in light of global warming which is predicting greater changes in climate. Information from Torres Strait is provided to Seagrass-Watch as part of a statewide and global monitoring initiative to ensure a broad comprehensive data stream on seagrass condition and trends. Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources (McKenzie et al. 2006b).

.

Notes:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

Managing seagrass resources

Seagrasses do not exist in nature as a separate ecological component from other marine plants or habitats 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 origin in the protection of wider ecological systems or are designed to protect the overall biodiversity of the marine environment.

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

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

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

Indigenous concepts of management of the sea differ significantly from the introduced European view of the sea as common domain, open to all and managed by governments (Hardin 1968). Unlike contemporary European systems of management, indigenous systems do not include jurisdictional boundaries between land and sea. Torres Strait Islanders have a form of customary ownership of maritime areas that has been operating in place for thousand of years to protect and manage places and species that are of importance to their societies. Many of these systems, have undergone considerable change since Torres Strait became part of Queensland in 1881 and there is a general feeling among modern day islanders that efforts should be made towards cultural revitalisation of those aspects of traditional *Ailan Kastom* that still exist (TSRA 2006).

Marine resource management in Torres Strait should therefore attempt to achieve the following interrelated objectives: *a*) monitor the wellbeing (distribution, health and sustainability) of culturally significant species (dugong, marine turtles, fish, molluscs),and environments (seagrass *etc*.); and *b*) monitor the cultural values associated with these culturally significant species and environments (Smyth et al. 2006).

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 planning applications
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 of any areas that are of special value to the ecosystems that support coastal fisheries and inshore productivity. It is also important that this information is readily available to decision makers in Governments and traditional owners in a form that can be easily understood.

A combination of modern *"western"* science and indigenous knowledge can then be brought together within a co-management framework for the successful management of these resources. (Johannes 2002; Aswani & Weiant 2004; Turnbull 2004; Middlebrook and Williamson 2006; Gaskell 2003, George et al. 2004). 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.

References

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

Carruthers TJB, Dennison WC, Longstaff BJ, Waycott M, Abal EG, McKenzie LJ and Lee Long WJ. (2002). Seagrass habitats of northeast Australia: models of key processes and controls. Bulletin of Marine Science 71(3): 1153-1169.

Coles RG, McKenzie LJ and Campbell SJ. (2003). The seagrasses of eastern Australia. Chapter 11 *In:* World Atlas of Seagrasses. (EP Green and FT Short eds) Prepared by the UNEP World Conservation Monitoring Centre. (University of California Press, Berkeley. USA). Pp 119-133.

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

George, M., Innes, J., Ross, H., 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.

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

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

Long B, Skewes, T, Thomas, M, Isdale, P, Pitcher, R, and Poiner I, (1997). Torres Strait Seagrass Dieback. Final report to TSFSAC 26. CSIRO Division of Marine Research, Cleveland, Brisbane, Australia. 24pp.

Long B.G and Poiner I.R (1997). The Seagrass Communities of Torres Strait, Northern Australia.. Final report to TSFSAC 26. CSIRO Division of Marine Research, Cleveland, Brisbane, Australia. 49pp.

McKenzie et al. (2001b)

McKenzie LJ, Campbell SJ, Roder CA (2001). Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers. (QFS, NFC, Cairns) 94pp.

McKenzie LJ. (1994). Seasonal changes in biomass and shoot characteristics of a *Zostera capricorni* Aschers. dominant meadow in Cairns harbour, northern Queensland. *Australian Journal of Marine and Freshwater Research* **45**: 1337-52.

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

Smyth, D., Fitzpatrick, J., Kwan, D., 2006. Towards the development of cultural indicators for marine resource management in Torres Strait. CRC Torres Strait, Townsville. 61 pp.

Taylor, H., Rasheed, M., McKenna, S., Sankey, T. & Chartrand, K. (2008).Critical Marine Habitats & Marine Debris in the Great North East Channel, Torres Strait – Poruma to Ugar Islands – 2008 Atlas. QDPI&F Information Series Northern Fisheries Centre, Cairns, 47pp.

Thomas, R. and Rasheed, M.A. (2004). Port of Thursday Island long-term seagrass monitoring - March 2004. QDPI&F Information Series QI04082. (Queensland Department of Primary Industries and Fisheries, Northern Fisheries Centre, Cairns), 22 pp.

Torres Strait Regional Authority (TSRA), 2006. Welcome to the TSRA. http://www.tsra.gov.au/

Turnbull, C and Mellors J (1990). Settlement of juvenile Penaeus esculentus (Haswell 1978) on nursery grounds in the Torres Strait. In Torres Strait prawn project: A Review of Research 1986-88, J.E Mellors ed, Queensland Department of Primary Industries QI90018 29 – 38.

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

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

www.seagraswatch.org

www.unep.org

Useful web links

Seagrass-Watch Official Site www.seagrasswatch.org

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

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

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

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

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

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

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

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

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

Puzzlemaker This is a great site where you can create and print customized word search, criss-cross, math puzzles, and more using your own word lists for free. puzzlemaker.discoveryeducation.com

Notes:

Notes:

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

Notes: