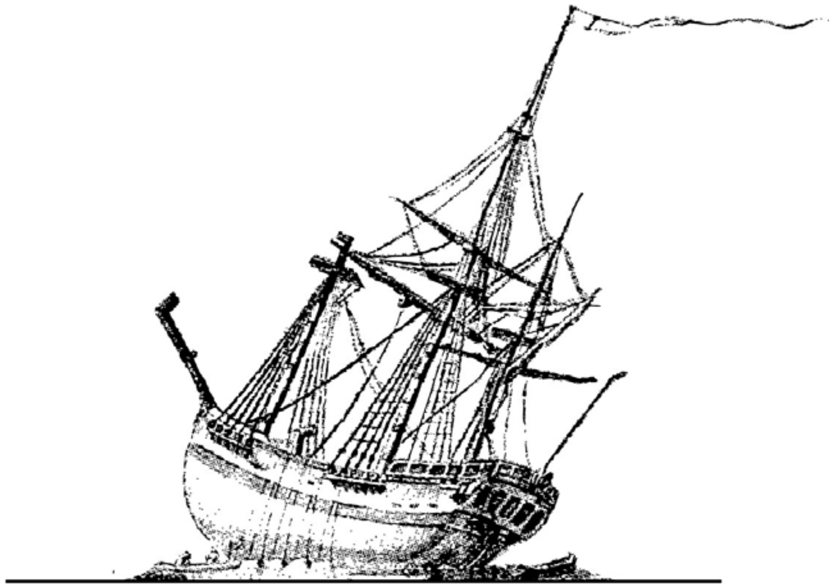
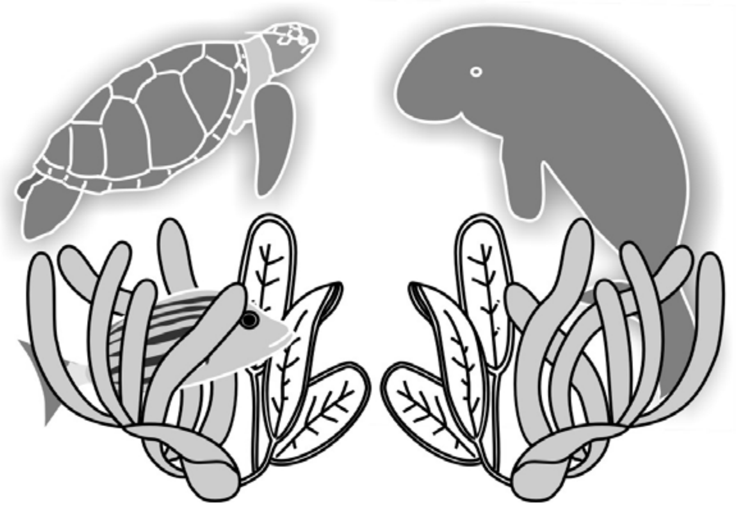
Seagrass-Watch

Proceedings of a Workshop for Monitoring Seagrass Habitats in Cape York Peninsula, Queensland





Northern Fisheries Centre, Cairns, Queensland

9th – 10th March 2009

&

River of Gold Motel Function Room, cnr Hope & Walker Streets
Cooktown, Queensland
26th – 27th March 2009

Len McKenzie & Rudi Yoshida

Seagrass-Watch HQ
Department of Primary Industries & Fisheries, Queensland

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Table of Contents

Overview

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

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

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

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

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

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

The goals of the Seagrass-Watch program are:

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

This workshop is supported by Cape York Marine Advisory Group (CYMAG) and Cape York Sustainable Futures, local coordination by Christina Howley, and sponsored by the Australian Government's Marine & Tropical Sciences Research Facility (Department of the Environment and Water Resources) represented in North Queensland by the Reef & Rainforest Research Centre, the Great Barrier Reef Marine Park Authority (GBRMPA), Seagrass-Watch HQ, and the Queensland Department of Primary Industries & Fisheries. As part of this workshop we will

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

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

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Workshop leader

Len McKenzie

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

Current Projects

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

Rudi Yoshida

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

Current Projects

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

Agenda 1

Monday 9th March 2009 (Northern Fisheries Centre)

Afternoon	1230 - 1240 *(10min)*	Welcome & Introduction
	1240 - 1300 *(20min)*	Seagrass Biology and Identification
	1300 - 1330 *(30min)*	**Classroom activity:** Seagrass Identification
	1330 - 1400 *(30min)*	Seagrass Identification *continued*
	1400 - 1415 *(15min)*	**Classroom activity:** how to prepare a seagrass press specimen
	1415 - 1515 *(60min)*	Seagrass Ecology and Threats
	1515 - 1530	*Break*
	1530 – 1545 *(15min)*	Seagrass monitoring
	1545 – 1630 *(45min)*	Seagrass-Watch: how to sample
	1630 – 1715 *(45min)*	Seagrass-Watch: how data is used
	1715 – 1730 *(15min)*	*Pack up*

Tuesday 10th March 2009 (Yule Point)

Afternoon

1320 – 1330 *(10min)* — Safety briefing & risk assessment

1340 – 1540 *(2hrs)* — **Field exercise:**

Seagrass-Watch monitoring – *Len & Rudi*

Where: Yule Point (YP1)

What to bring:

- *hat, sunscreen (Slip! Slop! Slap!)*
- *dive booties or old shoes that can get wet*
- *drink/refreshments*
- *Polaroid sunglasses (not essential)*
- *enthusiasm*

You will be walking across a seagrass meadow exposed with the tide, through shallow water. It may be wet and muddy!

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

1540 – 1600 — Wrap up *(on foreshore)*

- check gear
- feedback

Low tide: 0.6m 1446hrs

Agenda 2

Thursday 26th March 2009 (River of Gold Motel)

Afternoon	1230 - 1240 *(10min)*	Welcome & Introduction
	1240 - 1300 *(20min)*	Seagrass Biology and Identification
	1300 - 1330 *(30min)*	**Classroom activity:** Seagrass Identification
	1330 - 1400 *(30min)*	Seagrass Identification *continued*
	1400 - 1415 *(15min)*	**Classroom activity:** how to prepare a seagrass press specimen
	1415 - 1515 *(60min)*	Seagrass Ecology and Threats
	1515 - 1530	*Break*
	1530 – 1545 *(15min)*	Seagrass monitoring
	1545 – 1630 *(45min)*	Seagrass-Watch: how to sample
	1630 – 1715 *(45min)*	Seagrass-Watch: how data is used
	1715 – 1730 *(15min)*	*Pack up*

Friday 27th March 2009 (Archer Point)

Afternoon	1400 – 1415 *(15min)*	Safety briefing & risk assessment
	1415 – 1615 *(2hrs)*	**Field exercise:** Seagrass-Watch monitoring *Where*: Archer Point (AP1) *What to bring:* • *hat, sunscreen (Slip! Slop! Slap!)* • *dive booties or old shoes that can get wet* • *drink/refreshments* • *Polaroid sunglasses (not essential)* • *enthusiasm* *You will be walking across a seagrass meadow exposed with the tide, through shallow water. It may be wet and muddy!* *Please remember, seagrass meadows are an important resource and are protected by law. We ask that you use discretion when working/walking on them.*
	1615 – 1630	Wrap up *(on foreshore)* • check gear • feedback

Low tide: 0.5m 1519hrs

Notes:

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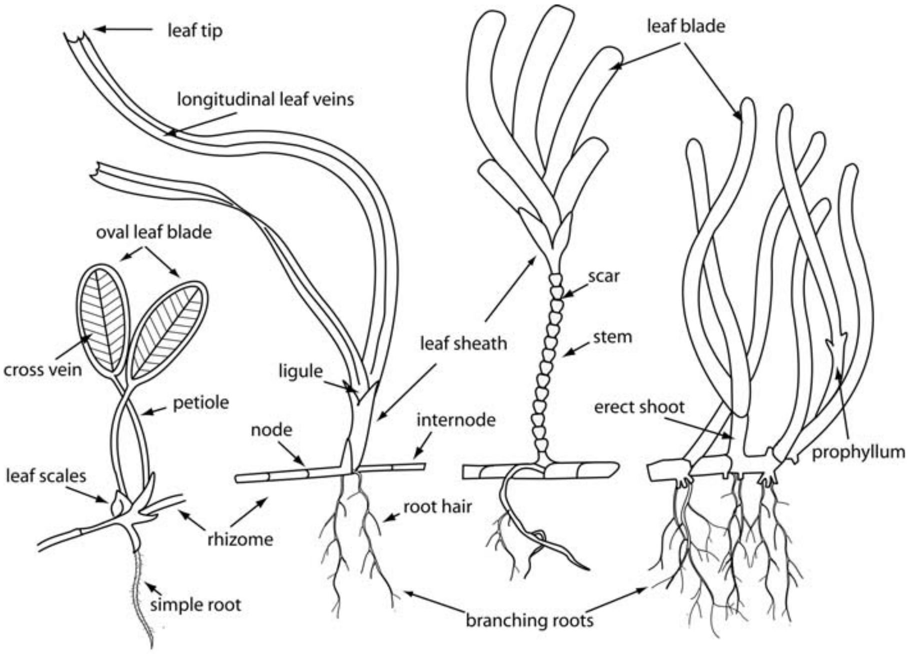
Background

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

Seagrass are marine flowering plants



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

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

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

Seagrasses have roots, stems and leaves

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

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

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

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

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

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

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

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

Seagrass pump oxygen into the sediment via their roots

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

Seagrass have flowers, fruits and seeds

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

Pollination occurs in the water

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

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

Seagrass taxonomy

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

Seagrasses are not true grasses

Seagrasses are more closely related to lilies

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

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

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

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

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

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

Seagrass requirements for growth

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

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

Seagrasses need plenty of sun and clean water to grow.

Seagrasses are physiologically adapted to life in sea water

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

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

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

Light availability is the most important factor determining seagrass growth

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

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

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

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

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

Seagrass require inorganic carbon for growth

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

Seagrass uptake carbon via two different pathways

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

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

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

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

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

Most seagrass live in sand or mud sediments

Sediment movement can determine the presence of seagrass species

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

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

Where are seagrasses found?

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

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

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

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

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

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

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

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

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

Seagrass plants form small patches that develop into large meadows

How are seagrasses important to the marine ecosystem?

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

Seagrasses are important habitat and feeding grounds for marine organisms.

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

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

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

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

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

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

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

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

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

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 binds sediments and help prevent erosion

Seagrasses slow water flow and increase water clarity

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

Seagrass help remove harmful nutrient and sediment pollution from coastal waters

Interactions with mangroves and coral reefs

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

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

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

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

Valuation of seagrasses

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

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

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

What causes seagrass areas to change?

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

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

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

Seagrasses can change due to both natural and human impacts

What threatens seagrass?

Seagrass meadows are fragile ecosystems. Approximately 54% of seagrass meadows globally, have lost part of their distribution. According to reports, the documented losses in seagrass meadows globally since 1980 are equivalent to two football fields per hour.

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

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

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

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

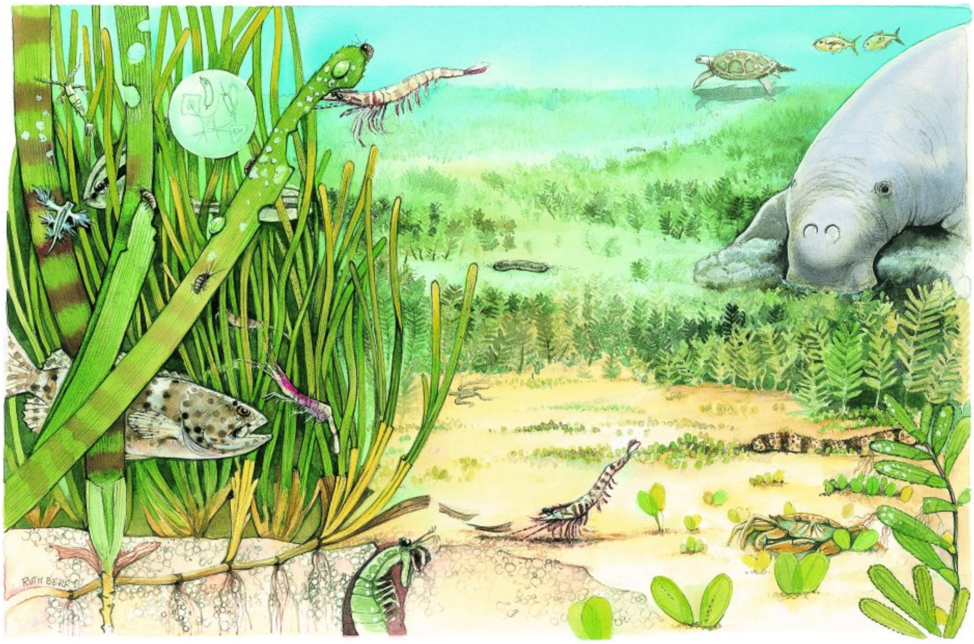
People can also physically damage or destroy seagrass. Coastal development for boat marinas, shipping ports and housing generally occurs on the coast in areas which are sheltered and seagrass like to grow. Seagrass meadows are either removed or buried by these activities. Coastal developments can also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

Coastal development can have a major impact on seagrass meadows

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

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

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



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Interesting facts:

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

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

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

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

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

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

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

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

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

There is a single clone of seagrass that is over 6,000 years old (*Posidonia ocea*nica in the Mediterranean Sea).

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

Seagrass produce the longest pollen grains on the planet.

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

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

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

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

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

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

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

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Seagrass of Cape York Peninsula

Cape York Peninsula (CYP) is the northernmost extremity of Australia, projecting into the Torres Strait between the Gulf of Carpentaria (west) and the Coral Sea (east). From its tip at Cape York it extends southward in Queensland for about 800 km, widening to its base, which spans 650 km from Cairns (east) to the Gilbert River (west). The larger rivers, all emptying into the gulf, are the Wenlock, Archer, Holroyd, Mitchell, Staaten, and Gilbert. Princess Charlotte Bay, in the northeast, is the deepest coastal indentation. The region has a monsoonal climate with distinct wet and dry seasons with mean annual rainfall ranging from 1715 mm (Starke region) to 2159mm (Lockhart River airport). Most rain falls between December and April. Mean daily temperatures in the area range from 19.2 – 32.1ºC. The prevailing winds are from the SE and persist throughout the year (EarthTech, 2005). The peninsula is sparsely populated, although there are Aboriginal reserves on both coasts. The raising of beef cattle is the chief occupation, but the rich bauxite deposits at Weipa are the main resource of the peninsula. Reached in 1606 by Willem Jansz, the peninsula was called Carpentaria Land by Abel Tasman, who charted the west coast in 1644. It was renamed by Captain James Cook in 1770 (Cape York Peninsula 2009).

Cape York Peninsula is considered an area of exceptional conservation value and supports an adventure tourist industry and commercial and non commercial fisheries. The marine coast has social value as sea country to Aboriginal people, and fish turtle and dugong are staple foods (Cape York Peninsula NRM 2005).

Although no area on earth is unaffected by human influence, Cape York Peninsula is located in one of the least impacted regions globally (Halpern *et al.* 2008). Northern Australia is part of the global centre for marine biodiversity. The drivers of anthropogenic change are much less in northern Australia than in the remainder of the Indo-Pacific. Australia as the only developed country in the region has a global responsibility for the conservation of marine biodiversity.

Extensive seagrass meadows are present in the waters surrounding Cape York Peninsula. The Queensland Department of Primary Industries & Fisheries (DPI&F) has mapped and sampled seagrasses along the entire Queensland coast (Coles *et al.* 1985, 1987, 1996, 2000, 2001a, 2001b, 2003, 2004; Lee Long *et al.* 1993). The last broad-scale mapping of the east coast of Cape York occurred in 1984 and the west coast in 1986. More recently, broad scale surveys of intertidal seagrasses in the Gulf of Carpentaria was conducted as part of a larger survey from Kakadu (Northern Territory) to Thursday Island (Torres Strait) (Roelofs *et al.* 2005). There has also been issued focussed fine scale mapping and monitoring is several locations, eg Weipa, Shelburne, Margaret, Bathurst Bay and Cape Flattery. Mapping across the CYCP has a number of limitations, due to the seasonality (extent of seagrass varies with season), depth of survey extent and difficulties of accurate mapping and precise positioning in marine environments (McKenzie *et al.* 2001). Initial mapping results from the CYP were first published in 1985. This data was re entered and validated in 2001 and is available in GIS formats (Coles et al. 2001a, 2001b)

Approximately 1,568 km^2 of seagrass meadows have been mapped in CYP in coastal waters down to 10m bMSL (calculated from composite dataset of all seagrass mapping layers available to DPI&F, December 2008). Seagrass meadows have been found from intertidal regions to depths of 60m near Lizard Islands (Coles *et al.* 2000). These meadows were characterized by high diversity and relatively small total biomass (Lee Long et al. 1993).

The Cape York Peninsula's seagrass communities are amongst the richest in the world and are identified as having conservation significance (EarthTech, 2005). Fifteen seagrass species have been identified in the CYP region: *Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halophila capricorni, Halophila decipiens, Halophila minor, Halophila ovalis, Halophila spinulosa, Halophila tricostata, Cymodocea rotundata, Cymodocea serrulata, Syringodium isoetifolium, Thalassia hemprichii, Thalassodendron ciliatum* and *Zostera muelleri* ssp. *capricorni* (hereafter referred to as *Zostera capricorni)*. Areas notable as species rich include Barrow Point to Murdoch Point (12 species), Flinders Island and Princess Charlotte Bay (9 species), Weymouth Bay, Cape Direction, Murdoch Point - Lookout Point and Bedford Bay - Cape Tribulation (8 species) and Escape River Margaret Bay, Bathurst Bay, Ninian River and Cape Flattery (7 species).

Halodule uninervis and *Halophila ovalis* are the most common species in coastal intertidal areas. *Cymodocea serrulata* and *Syringodium isoetifolium* are found in shallow subtidal areas that are sheltered from the south-east winds in a variety of habitats including estuaries and muddy bays and reef tops (Coles *et al*. 1987, Lee Long *et al*. 1993). Subtidal meadows of *Halophila ovalis* and *Halophila spinulosa* are also quite extensive (Lee Long *et al.* 1993). Species common on coral reef platforms include *Cymodocea rotundata* and *Thalassia hemprichii,* generally around islands and on vegetated cays (Coles *et al.* 2007). *Enhalus acoroides* is generally found as small isolated patches in sheltered embayments (Womersley 1981; Coles *et al.* 2003). Sites that have been revisited since the broadscale surveys in the mid 1980s show that seagrasses generally occurred in similar areas but when surveyed at a finer scale were more extensive (Coles *et al.* 2007). As the majority of information for Cape York Peninsula comes from broadscale surveys, the area of recorded coastal seagrass for the region is likely to be an underestimate.

Most seagrass meadows are within coastal habitats in the CYP region. The majority of these meadows are in the shallow subtidal waters of large bays sheltered from the prevailing trade winds. In the CYP region there is little land-based influence with few major rivers. These seagrass meadows are also highly productive and provide important nursery grounds for fisheries (Coles *et al.* 1985). The meadows are also of important to the large dugong population within the region (Marsh and Lawler 2002). A dominant influence on coastal habitats although small, is terrigenous runoff from seasonal rains, similar to the adjacent estuary habitats (Carruthers *et al.* 2002). Episodic terrigenous runoff events result in pulses of increased turbidity, nutrients and a zone of reduced salinity in nearshore waters. The inter-tidal upper reaches of the meadows are limited by elevated temperatures and desiccation.

Reef-platform habitats are both subtidal and intertidal and support diverse seagrass assemblages. Approximately 3% of all mapped seagrass meadows in the eastern Cape York region are located on fringing-reefs (Coles *et al.* 2007). Meadows are known to be found on mid shelf sand reefs (e.g., Corbett Reef (DPI&F Unpublished Data)) and smaller vegetated cays (e.g., Turtle Island Group), however no detailed mapping has been conducted. On fringing-reefs, physical disturbance from waves and swell and associated sediment movement primarily control seagrass growing in these habitats. Shallow unstable sediment, fluctuating temperature, and variable salinity in intertidal regions characterize these habitats. Sediment movement due to bioturbation and prevalent wave exposure creates an unstable environment where it is difficult for seagrass seedlings to establish or persist.

Seagrasses in deep water (>15m) have been sampled twice, once between 1994 and 1999 (Coles *et al.* 2001; Coles *et al.* In Press) and again between 2003 and 2006 (Pitcher *et al.* 2007). The modelled distribution of seagrass species for both time periods shows spatial discontinuities in deep water seagrass meadows along the north-south axis with a low probability of seagrass being present north of Princess Charlotte Bay and extensive seagrass areas in the south of the region extending out from the coast in the Lizard Island region (De'ath *et al.* 2007; Coles *et al.* In Press). *Halophila ovalis, Halophila spinulosa, Halophila tricostata, Halophila decipiens* and

Halophila capricorni dominated the meadows in both surveys. The deep water comparisons are not true monitoring as they compare modelled distribution rather than actual meadow locations with the potential for unestimated error at small spatial scales. The comparisons for deep water are summarised and discussed in a separate report (De'ath *et al.* 2007).

The distribution of deepwater seagrasses appears to be mainly influenced by water clarity and a combination of propagule dispersal, nutrient supply, and current stress. Deepwater seagrasses are uncommon north of Princess Charlotte Bay which may be result of the East Australian Current diverging at Princess Charlotte Bay and the far northern section may not receive propagules for colonisation from southern meadows (Coles *et al.* In Press). Much of this coast is also silica sand and low in rainfall and stream run-off, and it is possible that limited availability of nutrients restricts seagrass growth (Coles *et al.,* 2000).

Based on the mapped seagrass areas, 49% of coastal seagrass meadows on the eastern Cape York region are protected within declared Fish Habitat Areas (Coles *et al.* 2007). Also on the east coast, approximately 33% of seagrass meadows (excluding deepwater) are covered by the highest levels of protection zones of the GBRWHA (Coles *et al.* 2007).

A more detailed review of seagrass resources in CYP are presented below heading north from Cedar Bay on the east coast to Cape York and then south to Nassau River on the west coast.

CEDAR BAY – COOKTOWN

There are two major rivers within the region: the Endeavour and the Annan River. Both rivers support commercial, recreational and indigenous fisheries. The Endeavour River is the larger of the two river systems and has a catchment area of approximately 992 km^2. The Annan River is located approximately 5 km south of Cooktown and extends inland from Walker Bay. The Annan River catchment area is approximately 850 km^2 (Hortle and Pearson 1990). The Kuku Yalanji bama are the traditional people connected to country between Mowbray River (Port Douglas) and the Annan River.

Broad-scale mapping of the seagrass meadows in the region was conducted between 2-5 February 1985 as the final component of the Cape York to Cairns survey (Coles *et al.* 1985).

In 2004- 2005, coastal seagrass meadows were remapped from Walsh Bay, south of Archer Point, to Lookout Point, north of Cape Flattery, as part of an EnviroFund project (C. Howley Pers. Comm. see http://www.cymag.com.au).

Recently seagrasses on reef platforms in close proximity to river mouths (eg Annan River) and the shipping channel have been examined. Preliminary findings from Egret, Cowlishaw and Dawson reefs indicate that substantial seagrass meadows are present, particularly in areas where siltation is not heavy. For example, seagrass meadows dominated by *Halodule uninervis* and *Halophila ovalis* were reported from the NE side of Egret Reef in 2006 (1 - 8m depth). The sediments were fine silt over sand and the average seagrass percent cover was 1-2 % up to 15% (C. Howley, Pers. Comm.).

Archer Point

Intertidal seagrass meadows are located on a fringing reef platform in a protected section of the bay adjacent to Archer Point. Archer Point is monitored as part of the intertidal seagrass component of the Reef Rescue Marine Monitoring Program. The sites are dominated by *Halodule uninervis* and species composition has remained relatively stable over the past 12 months. The overall meadow distribution however, has increased (www.seagrasswatch.org).

Although seagrass cover has followed a seasonal trend over the last couple of years (higher abundance in late spring/early summer), overall the meadow has generally declined in abundance since monitoring was established in 2003. Fortunately, reproductive effort increased in 2007/2008, indicating the potential for the meadow to recover. Epiphyte and macro-algal cover were generally variable but appear to be declining over time (McKenzie *et al.* 2008).

Nutrient analysis in this coastal fringing reef habitat indicate increasing Nitrogen in the sediments while Phosphate has been declining. Plant tissues indicate a habitat with improving light quality, a relatively small nutrient pool with Phosphate limitation. This is not surprising as the higher calcium carbonate sediments on a reef adsorb the Phosphate making it unavailable to plants for growth. No herbicides were detectable in the sediments at Archer Point in early 2008 (McKenzie *et al.* 2008).

Walker Bay

Walker Bay is a relatively shallow bay protected from the SE swells by the rocky, mangrove covered, Grave Point and adjacent Draper Patch reef. The Annan River discharges into Walker Bay and is undoubtedly a major influence to the coastal environments and water quality. The predominant land use activities in the Annan River catchment are cattle grazing, timber extraction, aquaculture and agriculture. Although these land uses and practises have changed the nature of the Annan River catchment and tributaries, the system supports diverse habitats and provides an important corridor for the movement of a variety of fish species (Sheppard and Helmke 1999). The tidal areas of the catchment support extensive marine plant communities including many species of mangrove, saltcouch and seagrasses.

CYMAG conduct ongoing monitoring in the Annan River and latest findings (June 2008) indicate that river water quality is "good" (Anon 2008).

Walker Bay contains a largest subtidal (2-4m deep) meadow which in February 1985 was dominated by *S. isoetifolium* with *C. serrulata/H. uninervis* (wide) (heavily epiphytised) (seagrass cover 80-100%) (Coles *et al.* 1985; Coles *et al.* 2001b).

In November-December 2004, the meadows were remapped in greater detail (http://www.cymag.com.au). The meadow was more extensive (approximately 3.5 km^2), with more species present (incl *Halophila spinulosa*) but similar in abundance. More recently (2007), it appears these meadows experienced a slight shift in species composition, from being dominated in areas by *Syringodium isoetifolium* to *Cymodocea serrulata*. As *Syringodium* is a species well adapted to disturbed environments (eg sediment movement), the species shift may represent a stabilisation of the seabed (http://www.cymag.com.au).

Quarantine Bay to Endeavour River

Between December 2004 – May 2005, coastal seagrass meadows were remapped in Quarantine bay to the mouth of the Endeavour River (http://www.cymag.com.au). Extensive *Halodule uninervis* and *Halophila ovalis* meadows were mapped inshore and extending offshore. A smaller but dense meadow of *Syringodium isoetifolium* / *Halodule uninervis* was also found offshore.

Cooktown and Endeavour River

Cooktown is situated on the Endeavour River and is a 330 km drive north from Cairns. It has numerous natural, cultural and historical attractions for visitors to explore (http://www.cypda.com.au/cooktown).

CYMAG conduct ongoing water quality monitoring in the Endeavour River and latest findings (June 2008) indicate that river water quality is "good" (Anon 2008). Results indicate elevated metals and hydrocarbons in sediment adjacent to town stormwater drain and boat slipway site with low levels of herbicides (diuron, simazine, and atrazine) in estuary during 2007 - 2008 wet season. Nutrient levels below the sewerage treatment plant do not appear elevated (Anon 2008).

Shallow medium density (30-60% cover) *H. ovalis* meadows were mapped on the southern banks near the mouth of the Endeavour River between Racecourse and Chinaman Creeks in February 1985 (Coles *et al.* 1985; *Coles et al.* 2001b).

Between 9 November 2004 and 5 May 2005, seagrass meadows were mapped in the lower reaches and mouth of Endeavour River as part of the CYMAG mapping project in the region (C. Howley, Pers. Comm. http://www.cymag.com.au). Isolated patches of sparse *Halophila ovalis* were present at the mouth of Chinaman Creek. A large meadow covered much of the northern intertidal bank of the river (Leprosy Creek, west of Point Saunders) with dense (50-75% cover) *Zostera capricorni* on the exposed banks and fringed by *Halophila ovalis* meadow (25-50% cover) along the river edge. At the mouth of the Endeavour River are extensive sandbanks. Adjacent to Sach's Spit was a narrow intertidal meadow of *Zostera capricorni* / *Halodule uninervis* fringed by *Halophila ovalis*. A large intertidal meadow of predominately *Halodule uninervis* with some *H. ovalis* was present on the northern portion of Sach's Spit (http://www.cymag.com.au).


Sach's Spit (Endeavour River) seagrass meadow, 2005
From http://www.cymag.com.au

A major dieback of several meadows located near the mouth of the Endeavour river was reported in July 2007. This included the loss the extensive *H. uninervis* mixed meadow from the sands near Sach's Spit, and a significant loss of density and leaf length at the *Zostera capricorni* meadow near Leprosy Creek (http://www.cymag.com.au). The cause of this dieback is unknown, however the herbicide clopyralid (0.28 mg/kg) was detected in sediments at Leprosy Creek in December 2007 (http://www.cymag.com.au).

COOKTOWN TO CAPE FLATTERY

In this region the coastline includes large bays exposed to SE swells where the seabed is mainly mobile sands. Behind protected headlands the sediment is muddier and more stable. Prevailing wind patterns are typical for this section of the Queensland coast with strong south to south-easterly winds dominating the dry-season months and generally lighter northerly winds prevalent during the wet-season. The only significant coastal meadows are between Cape Bedford and Cape Flattery adjacent to Hopevale.

Broad-scale mapping of the seagrass meadows in the region was conducted on the 2 November 21984 and 2 February 1985 (Coles *et al.* 1985). No seagrass meadows were found between the Endeavour River mouth and Cape Bedford.

In May 2005, seagrass meadows of *Halodule uninervis* and *Halophila ovalis* fringed much of the sandy bay south of Cape Bedford (http://www.cymag.com.au).

Hope Vale

Hope Vale was established as a Lutheran Mission in 1949. The community covers an area of 110,000 hectares and is a Deed of Grant in Trust (DOGIT) land. Today's population is estimated at 856 (www.atsip.qld.gov.au), includes 13 clan groups with approximately 94% of the total population being of Aboriginal or Torres Strait Islander origin from various clans including the Dhuppi, Nukgal, Binthi, Thitharr, Dharrpa, Ngayumbarr-Ngayumbarr, Dingaal, Ngurrumungu, Thaanil, Gamaay, Ngaatha, Burunga . In addition to these clans, the community is made up of the Kuku Yimidhirr speaking peoples, the Yiidhuwarra (traditional owners of Barrow Point, Flinders Island, and the South Annan), the Bagaarrmugu, Muunthiwarra, Juunjuwaara and Muli peoples plus the Gan Gaarr and Bulgoon peoples to the south, the Kings Plain's Thukuun Warra and the Sunset Yulanji peoples in the Maytown area (http://www.cypda.com.au/hopevale).

North west of Cape Bedford is Elim Beach which is renowned for its coloured sands and as the original Cape Bedford Mission by the Lutheran Church in 1886 which later became the HopeVale community.

Seagrass meadows between Cape Bedford and Cape Flattery were first surveyed in November 1984. The seagrass meadows in this region are adjacent and slightly north of Morgan River. The meadows are very low cover (<1%) and patchy *H. decipiens* (sand) or *H. decipiens/H. ovalis* (mud/sand) (Coles *et al.* 1985; Coles *et al.* 2001b).

In July/August 2007 the region was remapped and extensive seagrass (wupan) meadows of *Halodule uninervis* and *Halophila ovalis* were found across much of the shallow/intertidal sand banks at Elim Beach (http://www.cymag.com.au). These meadows were not reported in 1984 as the banks were not accessible due to the low tides. The meadows north of the Morgan River were also mapped in July 2007, however these were shallower than the 1984 surveys and dominated by *Halodule uninervis* and *Halophila ovalis* (http://www.cymag.com.au).

CAPE FLATTERY REGION (CAPE FLATTERY TO LOOKOUT POINT)

Cape Flattery is a port which encloses an area of approximately 150 km^2 of marine habitat and include over 35 km of coastline. The area has two main creeks, Crystal Creek and Blackwater Creek, in a catchment area of approximately 114 km^2 (Ports Corporation Queensland 1995). The regions' climate is tropical and characterised by hot (wet) summers and warm (dry) winters. Prevailing wind patterns are typical for this section of the Queensland coast with strong south to south-easterly winds dominating the dry-season months and generally lighter northerly winds prevalent during the wet-season.

In 2004/05, the Port of Cape Flattery handled 29 ships carrying 1,300,672 tonnes of silica sand (www.pcq.com.au). Silica sand, extracted from the nearby Cape Bedford - Cape Flattery dune-field, is the ports' only export at present. The mine is owned and operated by Cape Flattery Silica Mines Pty Ltd. The silica sand mine is an open cut mine. Mined sand is transported to a processing mill and ultimately to the main export jetty on Cape Flattery via conveyor.

1111 ±200 ha of productive seagrass habitats have been identified between Cape Flattery and Lookout Point (Ayling *et al.* 1997). Eight species of seagrasses, and three types of seagrass meadow have been identified;

- a predominantly *Halodule/Thalassia* meadow in the sandy intertidal area bordered by the shoreline and fringing coral reef.
- a small isolated high biomass *Cymodocea/Thalassia* meadow at the mouth of Crystal Creek in sand/mud sediment.
- a large *Halodule/Halophila* meadow in muddy sediment offshore from the fringing reef in deeper water.

Halophila ovalis was the most widely distributed species followed by *Halodule uninervis* (wide-leaf) and *Halodule uninervis* (narrow-leaf). *Syringodium isoetifolium* was found only in small isolated patches (Ayling *et al.* 1997). No seagrass was found deeper than 7.5 m below Mean Sea Level (MSL). *Cymodocea* spp and *Thalassia hemprichii* were only found in shallow areas (<1.6 m below MSL) (Ayling *et al.* 1997).

Evidence from dugong feeding trails indicates these seagrass meadows are also important feeding habitat for dugong.

STARCKE RIVER REGION (LOOKOUT POINT TO BARROW POINT)

This is an area recognised for its sizeable dugong populations and associated seagrasses. Seagrasses have been reported along almost the entire coast of this region and from inter-reef waters in the vicinity of the Lizard Island group during a deep-water surveys of seagrasses (Coles *et al*. 1985, 1996, 2001b; Lee Long *et al.* 1989).

Coastal seagrass habitats between Lookout Point and Barrow Point were first surveyed in October and November 1984 as part of a study from Cairns to Cape York (Coles *et al.* 1985; Coles *et al.* 2001b; Coles *et al.* 1987). Key seagrass areas along the same coastal region were re-surveyed in the following winter (July 1985). Between 17 - 22 September 1989, seagrass meadows in the area were once again surveyed along the coast and out to 28 m deep as results of dugong aerial surveys suggested the dugong population of the region was large and required an area of seagrass for feeding much larger than that estimated in 1984 (Lee Long *et al.* 1989; Marsh 1989).

In 1989, seagrass formed a near continuous seagrass meadow covering approximately 1,500km^2 extending from the coast between Lookout Point to Murdoch Point to depths of 28m (Lee Long *et al.* 1989). Seagrass cover ranged from dense in shallow water to a patchy and light cover of *Halophila* species in deeper water. Seagrass was also found on every reef platform examined. Deepwater surveys between Cape Weymouth and Cape Tribulation in 1995 confirmed that seagrass meadows were still relatively continuous across the region (Coles *et al.* 1996).

Eleven species of seagrass have been identified in the region. Seagrass cover is generally greatest, reaching 100%, in sheltered, shallow areas of the nearshore. At depths greater than 10 m in the mid-shelf seagrass cover is generally less than 50%.

From the lee (west) side of Lookout Point, a large *H. ovalis* and *H. spinulosa* meadow was reported extending along the sandy shore, becoming a wide, near-shore meadow of *H. spinulosa*, (80-100% cover) as the seabed becomes more muddy. This seagrass meadow continues three to four nautical miles south-east of the Starcke River (Lee Long *et al.* 1989). Between the Starcke River and Murdoch Point seagrass is sparse, however between Murdoch Point and Red Point a dense (>50% cover) *H. spinulosa* meadow extends out to the Cole Islets, possibly a consequence of the improved water clarity (Lee Long *et al.* 1989). Between the Cole Islets and Cape Bowen the seagrass meadows are mostly patchy and composed of *H. ovalis* and *H. uninervis* (10 to 50% cover). Seagrass cover is denser in sheltered shallow waters close to shore. North of Cape Bowen to Barrow Point the meadows are light (<1% cover) and predominately *H. ovalis* and *H. decipiens* on fine mud.

In the deeper waters (10 to 20 m) seagrasses are dominated by *H. ovalis* and *H. spinulosa.* At depths between 15 and 28 m, *H. ovalis* is more common than *H. spinulosa* and bottom cover generally less than 20% (Lee Long *et al.* 1989).

The reef platforms of Jewell, Parke, Martin, Linnett and Ribbon Reef No 10 were examined in December 1994 as part of a survey of 18 reef-tops between Cape Weymouth and Cape Tribulation. Meadows of *Halophila ovalis* (<2% cover) and *Thalassia hemprichii* (<1% cover) were reported from the reef-platforms of Parke and Martin Reefs respectively (DPI&F Unpublished data).

Lizard Island

The Lizard Island group is adjacent to the Starke River region. Price *et al.* (1976) first reported only two species of seagrass (*Cymodocea rotundata* and *Halophila minor*[1]) from the Lizard Island group in their checklist of marine benthic plants. The only other previously reported species for the group was *Thalassia hemprichii* (Nichols and Johns, 1985; Boon, 1986).

In October 1995 McKenzie *et al.* (1997) mapped 292 ±78ha of intertidal and sub-tidal seagrass in the waters surrounding the Lizard Island Group. Seven seagrass species (1 previously undescribed) were identified in the survey area. *Thalassia hemprichii* was the most commonly encountered species, although it was restricted to the shallow reef-tops. *Halophila ovalis* was the second most commonly encountered species and was found in both intertidal and subtidal areas. Other species found in the survey area included *Halodule uninervis, Halophila spinulosa, Syringodium isoetifolium, Cymodocea serrulata* and *Halophila* sp. *H. ovalis* had the widest depth distribution and occurred at both the shallowest (0.4 m below MSL) and the deepest (4.4 m below MSL) sites where seagrass was found. Mean depths of occurrence for individuals species were mostly <15 m below mean sea level (McKenzie *et al.* 1997).

A previously undescribed seagrass species, *Halophila* sp., was found in the survey area near Watson's Bay in depths >10 m below MSL. This species was similar to *Halophila capricorni* although several differences were noted. Significant anchor damage (scars) was observed in the seagrass meadows of Watson's Bay. Shallow-water (<10 m) scars showed evidence of recolonisation/recovery, however deep-water (>10 m) scars appeared recent, as there was little evidence of seagrass recovery.

Turtle Group

In November 1992 Derbyshire *et al.* (1995) conducted a preliminary seagrass survey of reef-top, inshore and deepwater areas between the Turtle Island group and Mid Reef. They reported that seagrass meadows on deepwater and inshore areas were relatively dense, while reef-tops were only sparsely vegetated. Deepwater meadows were predominately *Halophila spinulosa* and *Halophila ovalis*. *Thalassia hemprichii* and *Halophila ovalis* sparsely covered the Mid Reef platform. Nearshore areas were mainly *Cymodocea serrulata* and *Halodule uninervis*.

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

Derbyshire *et al.* (1995) established that seagrass meadows in the Turtle Islands group were habitat for commercial prawn species, although deepwater seagrass, despite its vast area, were not as productive as inshore seagrass meadows for commercial prawns. They found that inshore seagrass meadows had juvenile prawn densities several thousand times greater than those from deep water meadows. Their results found that in respect to juvenile prawn habitats, the value of seagrasses was inshore>reef-top>deepwater. The importance also differed for species of prawn, eg. reef-tops were more important for red spot king prawns, deepwater more important for blue endeavour prawns and inshore more important for tiger prawns (the most valuable and sought after species in the fishery) (Derbyshire *et al.* 1995).

Although the deepwater meadows may not be important juvenile commercial prawn nursery habitat, they are very important feedings areas for the large dugong and turtle populations of the region.

Miscellaneous reef platforms

Most information on reef platforms of this region are either from the September 1989 surveys (Lee Long *et al.* 1989) or December 1994 where reef platforms were examined as an addition to deepwater surveys which were being conducted between Cape Weymouth and Cape Tribulation at the time (DPI&F Unpublished data).

Mid Reef platform has an extensive meadow of *H. ovalis*, with large patches of *T. hemprichii* and *C. rotundata*; Combe Reef platform is covered by light patches of *T. hemprichii, C. rotundata* and *H. ovalis*; Snake Reef has a light cover (<10%) of *T. hemprichii*; the two un-named reefs north of Combe Reef had mostly bare sand and coral rubble platforms but small patches of *H. ovalis* (10% cover) were found on soft, coarse sand on the back reef areas; Martin Reef had very light cover of *T. hemprichii* on sandy patches amongst coral rubble and algae; and Eyrie Reef, has a small area of *H. ovalis* (light cover) in the lee of Eagle Island (Lee Long *et al.* 1989).

No seagrass was found on the reef-platforms of Davies Reef, Tydeman Reef or an un-named reef (GBRMPA # 14-034) in December 1994 (DPI&F Unpublished data). However, dense (40-100% cover) seagrass meadows (including *Thalassia hemprichii*, *Zostera capricorni, Halophila ovalis* and *Cymodocea rotundata*) were reported from the reef flat and back reef of Pipon Reef. Meadows of moderate cover (10-30%) *Halophila spinulosa* and *Halophila ovalis* were also reported in the shallow subtidal areas surrounding the bommies of Pipon Reef (DPI&F Unpublished data).

BARROW POINT TO CAPE MELVILLE

The only seagrass survey conducted in this region was 4th November 1984, when only 22 ground truth sites were examined (Coles *et al.* 1985; Coles *et al.* 2001b).

Extensive seagrass meadows were reported within Ninian Bay, which is protected from the SE trades by Barrow Point. The meadow are reported to be predominately *Halophila ovalis/Halophila decipiens/H. uninervis* (narrow) with *C. serrulata* and *S. isoetifolium* (50-80% cover) on coarse sand (Coles *et al.* 1985; Coles *et al.* 2001b).

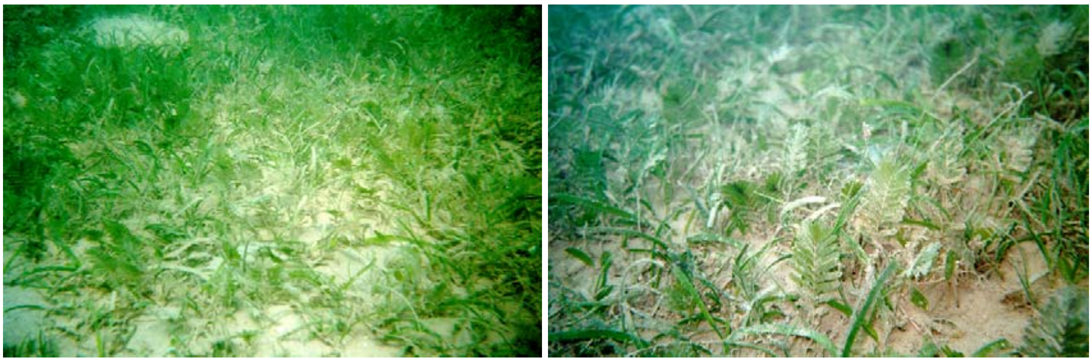
A small but dense (80% cover) meadow dominated by *H. decipiens* with *C. serrulata/H. uninervis* (wide) and *S. isoetifolium* was reportably present on the fringing reef north of North Bay Point (Coles *et al.* 1985; Coles *et al.* 2001b). Immediately seaward was a large extensive meadow of *C. serrulata* (20% cover) which extended north to Hales Island on the rocky rubble bottom protected from the SE trades by the shallow bank off North Bay Point.

BATHURST BAY & PRINCESS CHARLOTTE BAY

Similar to the region from Cape Melville and Lookout Point, this region has been recognised as an area of importance to the dugong populations of the Great Barrier Reef. As such, conservation park zones (dugong sanctuaries) have been in place in both Bathurst and Princess Charlotte Bays since the mid 1980's. This zoning protects animals from extractive activities, especially fishing impacts including incidental capture in commercial gill nets (GBRMP Amendment Regulations 2002 (No. 5) 2002 NO. 209). Other significant impacts on the seagrasses in the region are from the adjacent land. The Normanby and North Kennedy Rivers flow into Princess Charlotte Bay (PCB), but no major catchment in Bathurst Bay.

This region was first surveyed during a broadscale survey between 5-7 November 1984 (Coles *et al.* 1985; Coles *et al.* 2001b). In May and November 1997 a detailed survey was conducted between Cape Rock (Bathurst Bay) and Port Stewart (PCB) to assess seagrass status in the senescent and growing seasons in response to possible changes in commercial gill netting in the region (Short 1999). 34,984 hectares of seagrass was mapped in May and 37,345 hectares in November 1997. Most seagrass was within Bathurst Bay and the eastern and northern (surrounding the Cliff Islands) sections of PCB. From May to November there appeared to be a shift of seagrass away from the western side towards the eastern side of PCB. Approximately 75-80% of seagrass meadow area was subtidal, and this changed little between surveys (Short 1999).

Eleven seagrass species were identified in the region (*Cymodocea serrulata, Cymodocea rotundata, Halodule pinifolia, Halodule uninervis* (thin and wide forms), *Halophila ovalis, Halophila tricostata, Halophila spinulosa, Halophila decipiens, Thalassia hemprichii* and *Syringodium isoetifolium*), however *Cymodocea rotundata* was absent in May 2007. In May the meadows of Bathurst Bay were dominated by either *Halophila decipiens, Cymodocea serrulata, Halophila ovalis, Halodule uninervis* (wide) or *Halophila spinulosa*. In November however there was a shift away from *Halophila decipiens* (Short 1999).



Mixed *Halophila spinulosa, Halodule uninervis* and *Halophila ovalis* meadow, Bathurst Bay May 2007.
Photos: A Roelofs DPI&F

Overall, seagrass distribution was greater in November than May (approximately 2361 ha) and the proportion of meadows with abundance >25% cover was higher (only 4% of the seagrass meadow area had seagrass cover greater than 25% in May compared to 36% in November) (Short 1999).

Nine seagrass species were found around the Flinders Group of islands, the largest number from a single sampling area reported in the CYP (Coles *et al.* 1987). Not reported in the 1997 survey was *Halophila tricostata*, which was reported from the shallow waters (4m) of the Flinders Group of islands during the broadscale survey in 1984 (Coles *et al.* 1987).

Seagrasses were examined at Corbett Reef during a reconnaissance survey in October 1994. Significant seagrass meadows of *Halophila ovalis* and *Thalassia hemprichii* were scattered over the shallow/intertidal sand platform (10-20% cover). Meadows of *Halophila ovalis* occurred along the back edge (<10% cover) and sparse (<1%) meadows of *Thalassia hemprichii* and *Halophila ovalis* were found in the back reef area. In the channels *Halophila spinulosa* and *Halophila ovalis* (10% cover) were also reported (DPI&F Unpublished data). No detailed mapping has been conducted of any reef-tops in this region.

CLAREMONT POINT TO OLIVE RIVER

This is a large region on the east coast of CYP and includes the narrowest section of the Great Barrier Reef where the outer edge is at its closest point to mainland Queensland. The region contains two large bays (Lloyd Bay and Temple Bay). The most significant settlements in this region include Lockhart River and Portland Roads.

Lockhart River was originally a Mission south of Cape Direction, opened in July 1924 by the Church of England under the Torres Strait Anglican Mission. When the Second World War broke out the Europeans left and the Aboriginal people were told to go back to the bush and fend for themselves. In 1947 the mission was re-established on Quintell Beach in Lloyd Bay, with drastic changes inflicted on how the people should live and behave. In particular, tribal groups were forced to combine into a single community. Administration of Lockhart River mission was transferred to the Queensland Government in May 1967. The government then tried to relocate the people to Bamaga. Refusing to go but in 1971, the people were forced to move away from the traditional area of the coast. No consideration was given to traditional owners of the land and this move resulted in much discontent and friction. On the 29 October 1987, pursuant to section 334 of the Land Act 1962, land was assigned to the Council under the Deed of Grant in Trust (DOGIT) (www.apunipima.org.au).

Coastal seagrass meadows in this region have only been mapped during the broadscale Cape York to Cairns survey in November 1984 (Coles *et al.* 1985; Coles *et al.* 2001b). A dense (30-80% cover) and extensive *Halophila spinulosa* with *Halophila ovalis*/*Halodule* spp. meadow and isolated patches *Cymodocea serrulata* were mapped in the shallow waters adjacent to the coast. Smaller and patchy *Halophila* spp./*Halodule uninervis* meadows were scattered along the sandy shallow areas of the coast north to Cape Direction. These meadows were generally low cover (<10%) (Coles *et al.* 1985; Coles *et al.* 2001b).

Seagrass in Lloyd Bay was associated with patch reefs or on the lee side of islands and headlands. The meadows were subtidal (3-10m), low cover (<10%) and generally dominated by *Halophila ovalis/H. decipiens/H. uninervis* with *H. spinulosa* (Coles *et al*. 1985; Coles *et al.* 2001b).

Immediately north of Lloyd Bay is Cape Weymouth and Restoration Island (significant as the first landfall of Captain William Bligh after he and his companions were forced into the long boat during the mutiny of the "Bounty" near Tahiti). A few kilometres further north is Portland Roads which until the 1980's used to have a large timber wharf used by the allies during World War 2 as a jump off point for the New Guinea campaign. The wharf was more recently blown up by the Navy because of its dilapidated condition. Portland Roads is a safe anchorage used by the fishing fleet and the motherships which supply them with fuel, water and stores, and unload their catch which is returned to Cairns for export.

North of Cape Weymouth the meadows in Weymouth Bay are dense isolated patches, found south of the Pascoe River. In 1984 these meadows were either *H. ovalis/H. uninervis* (wide) with *C. serrulata* or *H. uninervis* (wide)/*S. isoetifolium/H. ovalis* with *H. spinulosa* on mud substrates (Coles *et al.* 1985; Coles *et al.* 2001b). den Hartog (1970) reported *Thalassodendron ciliatum* in the vicinity of Weymouth Bay, however it was not reported in 1984.

Large meadow of light seagrass cover (<10%) occurred in the southern regions of Temple Bay. These meadows were subtidal and dominated by *H. spinulosa* with *H. ovalis/Halodule* spp. Isolated patches of *H. ovalis/H. pinifolia* with *H. spinulosa* occur further north (Coles *et al.* 1985; Coles *et al.* 2001b).

Seagrass meadows have also been reported from some of the reef platforms in the region. During a survey in November 1994, seagrass was common on the mid shelf reefs examined. *Thalassia hemprichii* (<5% cover) was present in the lagoon between the isles and on reef flat of Sherrand Reef. On Blanchard Reef, *Thalassia hemprichii* (5% cover) was reported on the sandy reef platform and *Halophila decipiens* (<1%) in 1-10m off back of reef. On the un-named reef south of Ogilvie Reef (GBRMPA #13-077) *Thalassia hemprichii* (<5% cover) was present on the sandy reef platform (DPI&F Unpublished data).

Seagrass was generally absent from outer barrier reefs (including Tijou Reef, Sand Bank No 7, and the unnamed reefs 12-137 and 13-116), with the exception of Sand Bank No 8 where *Thalassia hemprichii* (10% cover) was reported on the back reef and on the reef flat near the cay (DPI&F Unpublished data).

MARGARET BAY REGION (OLIVE RIVER AND DOUBLE [ETATAPUMA] POINT)

The Margaret Bay region has been described as an area of conservation significance and high wilderness value (Schneiders 1999). This area contains two large bays, Margaret Bay and Shelburne Bay, as well as two main rivers, a large creek and a number of other unnamed smaller creeks and tributaries. Margaret Bay is north-west of Cape Grenville and approximately 10 km south-east of Shelburne Bay. Large intertidal flats stretch across both bays. The coastal wetland communities within this region are near pristine, and their associated catchments are virtually untouched by human development. The region has critical cultural significance to the Wuthathi people (Sheppard *et al.* 2002).

Extensive seagrass meadows, which vary from dense (>50% cover) to sparse (<10% cover) occur across Margaret Bay. A large dense seagrass meadow was first identified by Coles *et al.* (1985) at the eastern end of Shelburne Bay during the broadscale survey from Cairns to Cape York in November 1984. Eight species of seagrass were found in these localities (Coles *et al.* 1987).

In August 2001, the fisheries resources of the Margaret Bay region were further investigated as part of the ongoing commitment by DPI&F to extend the network of declared Fish Habitat Areas (FHAs) in Queensland and to investigate the critical habitats adjacent to the inner shipping route (Sheppard *et al.* 2002; Rasheed *et al.* 2005). The survey area extended from Indian Bay (south of Cape Grenville) to Double Point in Shelburne Bay and included the Home Islands, Haggerston Island, Queue Reef, Cockburn Islands and Sunday Island. The fisheries resource assessment of the Margaret Bay region included investigations of marine plants (including seagrass), riparian vegetation and fisheries habitats.

5,623.0 ±843.4 ha of seagrass meadows were mapped in the region in August 2001, which comprised seagrass meadows in Margaret Bay (including Indian Bay) (2441.1 ± 374.2 ha), Shelburne Bay (3069.5 ± 405.9 ha), and the Home Islands (112.4 ± 63.3 ha) sections of the survey. Eight seagrass species were identified: *Cymodocea serrulata, Halodule uninervis, Syringodium isoetifolium, Enhalus acoroides, Halophila decipiens, Halophila ovalis, Halophila spinulosa* and *Thalassia hemprichii* (Sheppard *et al.* 2002; Rasheed *et al.* 2005). Seagrass resources in the Margaret Bay region are important in providing nursery habitats to juveniles of commercially important penaeid prawn species and regarded as highly important dugong habitat.

In August 2001 seagrass was found in all sections of the Margaret Bay region, mostly in the sheltered areas of the bays and on reef flats. Seagrass was identified on intertidal sand banks in Shelburne, Margaret and Indian bays, on intertidal reef flats in the Home Islands, and on sand/mud substrates in subtidal areas of western Shelburne Bay, Indian Bay and Margaret Bay. The most extensive cover of seagrass was in Margaret Bay, where seagrass was found in the majority of the subtidal habitat of the bay (Sheppard *et al.* 2002; Rasheed *et al.* 2005). Seagrass extended from the upper intertidal zone to 11.7m dbMSL in Margaret Bay, and to 9.0m dbMSL in Shelburne Bay. The seagrass species occurring at greatest depth in the Margaret Bay region were *Halophila spinulosa* and *Halophila decipiens*.

The majority of seagrass meadows (84% of total seagrass area) in the Margaret Bay region were low in seagrass cover (<10% cover) (Sheppard *et al.* 2002). Medium coverage seagrass meadows (10–50% cover) were found only in Margaret Bay and in the Home Islands, and no high coverage meadows (>50% cover) were identified (Sheppard *et al.* 2002; Rasheed *et al.* 2005).

The distribution of seagrass meadows in Margaret Bay in 1984 and in 2001 were remarkably similar, suggesting long-term stability in distribution and abundance for these meadows. Most of the differences in total meadow area between 1984 and 2001 may be attributed to different survey methodologies and additional seagrass meadows identified on the intertidal sand flats in Shelburne Bay in August 2001. These meadows were very sparse in above-ground biomass, were dominated by very narrow and small leaved seagrass species (*Halodule uninervis* (narrow leaf form) and *Halophila ovalis*), and were characterised by isolated patches of seagrass interspersed with large areas of unvegetated substrate (Sheppard *et al.* 2002). Also, *Enhalus acoroides* was identified at locations in Margaret Bay, at Cape Grenville and in the Home Islands but was not found in the region in 1984 (Sheppard *et al.* 2002).

DOUBLE POINT TO MOUNT ADOLPHUS ISLAND (CAPE YORK)

The main feature of this region includes the Escape River and Newcastle Bay to the north and the scattered islands and reefs in the very north of the Great Barrier Reef World Heritage Area.

Coastal seagrass meadows in this region have only been mapped during the broadscale Cape York to Cairns survey in November 1984 (Coles *et al.* 1985; Coles *et al.* 2001b). Only a few patchy and isolated meadows were found along the sandy coast. They were generally *Halophila* (including *H. decipiens, H. ovalis, H. spinulosa*) and *Halodule uninervis* dominated. Several moderate but patchy meadows were found in the estuary of the Escape River, however very little seagrass was present in Newcastle Bay. In the Escape River mouth the meadows were mainly *H. ovalis* or *H. spinulosa* with *H. uninervis* (wide)/*C. serrulata* on the sand substrate, and *H. ovalis* with *Thalassia/H. uninervis* (wide) on the mud substrates. There were isolated patches of *Enhalus acoroides* on the mud banks.

Deepwater seagrasses were examined across the region in (Coles *et al.* 2000, In Press; De'ath *et al.* 2007). Deepwater seagrasses are generally sparse north of Princess Charlotte Bay and *H. decipiens* and *H. spinulosa* were reported scattered in the nearshore deepwaters, and in the lee of mid and outer reefs (Coles *et al.* 2000, In Press; De'ath *et al.* 2007).

ALBANY ISLAND TO PUNSAND BAY

Coastal seagrass meadows in this region were first mapped during the broadscale Cape York to Tarrant Point survey in October 1986 (Coles *et al.* 2001a). Intertidal seagrass meadows between Albany Island and Peak Point (Punsand Bay) were also examined in early April 2005 as part of an atlas on the Prince of Wales and Adolphus shipping channels in the Torres Strait (Rasheed *et al.* 2006).

Dense (85-100%) meadows of *S. isoetifloium/ H. uninervis* (wide)/ *C. serrulata/ H. spinulosa* with *H. minor/ H. uninervis* (narrow)/ *H. ovalis* were mapped on the shallow sand/shell substrates between Bishop Point and Evans Point (including Shallow/Muddy Bay) in Oct06 (Coles *et al.* 2001a). Significant intertidal *Zostera* meadows were located in Somerset Bay in Albany Passage and in Shallow Bay west of Ida Island. An Enhalus acoroides meadow dominated the intertidal banks of Stover Bay in Albany Passage (Rasheed *et al.* 2006).

In Punsand Bay a subtidal meadow dominated by *Halophila decipens* with *H. minor* was mapped on the sand substrate in 5-6m at the western edge in October 1986 (Coles *et al.* 2001a). Inshore, a dense (>50% cover) meadow of *Cymodocea serrulata/ Halophila ovalis/Halodule uninervis/Halophila spinulosa* and *Syringodium isoetifolium* was reported in November 1998 (www.seagrasswatch.org/herbarium.html).

NORTH EASTERN GULF OF CARPENTARIA (BAMAGA TO NASSAU RIVER)

The Gulf of Carpentaria is a large, shallow, muddy marine bay shared between the Northern Territory and Queensland. The area has marked seasonality in temperature, rainfall, salinity and wind regimes. The dominant weather feature is a seasonal summer monsoon with associated northerly winds and rain (November through to March) and a very dry winter period with south-east trade winds (April to September). Seasonal temperatures range from 10 º C in winter (Poiner *et al.* 1989) to the high 30's in summer. Tidal ranges vary from 2.4 m at Aurukun to 3.6 m at Crab Island in the north (Qld Transport Official Tide Tables and Boating Safety Guide 2002). Temperature, salinity, wind and rainfall show marked seasonality in this region. From June to September (Winter - Spring) winds are predominantly south-easterly, and from November through to April (Summer - Autumn), winds are generally north-western. It is during these months that the most rain falls associated with the monsoon trough.

The region is sparsely populated with the only major indigenous and non-indigenous populations located at Bamaga, Mapoon, Weipa, Napranum, Aurukun, Pormpuraaw, and Kowanyama (Cape York Regional Advisory Group 1997). The only island in the region is Crab Island in the north (all other islands in the north are within the Torres Strait NRM).

The terrestrial areas of the Northern Gulf region are comprised of extensive areas of woodland (dominated by *Eucalyptus*, some *Acacia*, *Casuarina* and *Melaleuca*), with smaller areas of shrubland and open heath. Major rivers in the Northern Gulf region catchment include the Wenlock R., Jardine R., Archer R., Coen R. and Mitchell. The rivers are typically long and meandering and open on to a flat, dry coastline often with wide tidal wetlands of mangroves and salt-pans. Extensive freshwater wetlands occur along much of the coastline. Large, shallow saline lakes can be found at the Kirke and Love Rivers.

The Northern Gulf coastline is mostly low and open with very few bays. There are three large mangrove lined and protected estuaries at Aurukun, Weipa and Port Musgrave. Coral reefs occur patchily along much of the coastline and there are numerous offshore reefs and shoals. Intertidal sand and mud banks often extend 1-2 km from the coast. Relatively clear water can be found along much of this section of the coastline, especially from Weipa north. The open coastline to the south of Weipa tends to be heavily influenced by wind driven turbidity and wave energy.

The coastline of the eastern gulf is extremely shallow and regularly disturbed by prevailing winds. Sediments throughout the gulf are predominately fine muds, and these are easily resuspended due to the shallow bathymetry resulting in increased turbidity, which restricts seagrass distribution and growth (Coles *et al.* 2004). Twelve species of seagrass have been found in the eastern Gulf of Carpentaria: *Cymodocea rotundata, Cymodocea serrulata, Halodule uninervis* (wide- & narrow-leaf), *Halodule pinifolia, Syringodium isoetifolium, Enhalus acoroides, Halophila decipiens, Halophila minor, Halophila ovalis, Halophila spinulosa, Halophila tricostata* and *Thalassia hemprichii*.

The intertidal seagrasses of the Gulf of Carpentaria were first surveyed by aerial reconnaissance in October 1982 (Crab Island to Karumba) by CSIRO Division of Fisheries (Poiner *et al*. 1987). Following aerial surveys, areas identified as seagrass or unknown were ground truthed using divers. They estimated 18.7 km^2 of seagrass between Crab Island and Tarrant Point. They reported 10 species of seagrass in the eastern Gulf of Carpentaria and seagrass was confined to Crab Island, Port Musgrave, Albatross Bay and Archer Bay.

A more extensive survey of seagrass distribution and abundance in the inlets and bays of the eastern Gulf of Carpentaria ocurred during a broadscale survey between Albany Island and Tarrant Point from 21 October to 7 November, 1986. Approximately 185 km^2 of seagrass was present in 1986 (Coles *et al.* 2001a).

Roelofs *et al.* (2005) mapped approximately 93.26km^2 of intertidal meadows along the mainland coast from 19-20 November 2004 using helicopter. Most meadows across the region were aggregated patches, with relatively few continuous meadows. Fringing reef areas, open sandy beaches and less turbid water was reported found north of Aurukun. Extensive intertidal seagrass meadows were found at Aurukun and Weipa.

The extensive intertidal banks along the Gulf of Carpentaria coast have seagrass meadows that are a mixture of *Halodule* and *Halophila* species. *Syringodium isoetifolium* and *Cymodocea serrulata* are common subtidally and *Halophila ovalis* and *Halophila spinulosa* further offshore (Poiner *et al.* 1989, Coles *et al*. 2001a). Along the exposed eastern coast of the gulf, seagrasses are generally sparse and restricted to the lee side of islands, protected reef flats, estuaries and protected bays (Coles *et al.* 2004). Seagrass species dominating meadows adjacent to the mainland coast are often considered to be pioneering or early colonists (*Halophila* and *Halodule* species). Little is know of the seagrass communities in waters greater than 10m depth. Species which are more common in deeper waters (10 metres and deeper) such as *Halophila decipiens* are however present throughout the gulf.

The 2004 intertidal survey (Roelofs *et al.* 2005) and long - term studies of change in population density and structure which have been carried out associated with port activities in Weipa, Karumba and Kirke River suggest that the distribution of seagrass has remained similar to 1986 but is highly seasonal and declines are associated with flooding during the wet season (Roelofs *et al.* 2001, 2006). These studies suggest considerable interannual variability occurs (Rasheed *et al.* 2001). Seagrass biomass is generally higher in the wet season than in the dry season. This difference in biomass is opposite to changes measured for seagrasses from the tropical east coast of Queensland (McKenzie *et al.* 1998, Mellors *et al.* 1993, McKenzie 1994, Rasheed 1999), but similar to seagrass seasonality measured at Karumba in the southern Gulf of Carpentaria (Rasheed *et al.* 2001).

The following is a detailed review of information about seagrasses in specific regions between Bamaga and the Nassau River.

Bamaga & Jardine River

Seagrass meadows are found scattered along eh coast and on the reef flat of Crab Island. Reef flat communities in this region are dominated by *Thalassia*. Meadows in estuaries and sheltered bays are mostly of the genera *Halodule*, with *Cymodocea* and *Enhalus acoroides* (Coles *et al.* 2001a).

Skardon

Skardon River was declared a port in February 2002 to service the Skardon River kaolin mine. The port facilities are located upstream on the shallow Skardon River. The Skardon River area includes a diverse range of ecologically important marine habitats such as mangroves, saltpans, rock bars, and marine swamps which are likely to support significant fisheries, estuarine crocodiles and green turtles (Roelofs *et al.* 2002, 2004)

Wet season (April 2002) and Dry season (September 2003) baseline marine habitat resources surveys have been conducted in the Port of Skardon River. An isolated *Halodule uninervis* (narrow form) meadow located approximately 2.4 km north of the port facilities on a sand/mud bank was reported during both surveys, however three sparse subtidal *Halophila decipiens* meadows area within 500 metres of the port facility were only reported during the Dry season (Roelofs *et al.* 2002, 2004).

In December 2006, the marine habitat resources were resurveyed as apart on an ongoing (every 3 years) monitoring program for the Port. Seagrass distribution in December 2006 (9.1ha) (Rasheed 2007) was more than double that recorded in September 2003 (4.4ha) (Roelofs *et al.* 2004). Two moderate *Halophila decipiens* and a light *Halodule uninervis* (narrow) meadows were reported adjacent to the eastern bank of the river and a moderate *Halophila decipiens* meadow was reported adjacent to the western bank (south of the barge landing) (Rasheed 2007). This was the first time that *Halodule uninervis* was found in the vicinity of the barge landing area. Previously *H. uninervis* had only been found in a nearby branch of the Skardon River (Roelofs *et al.* 2004)

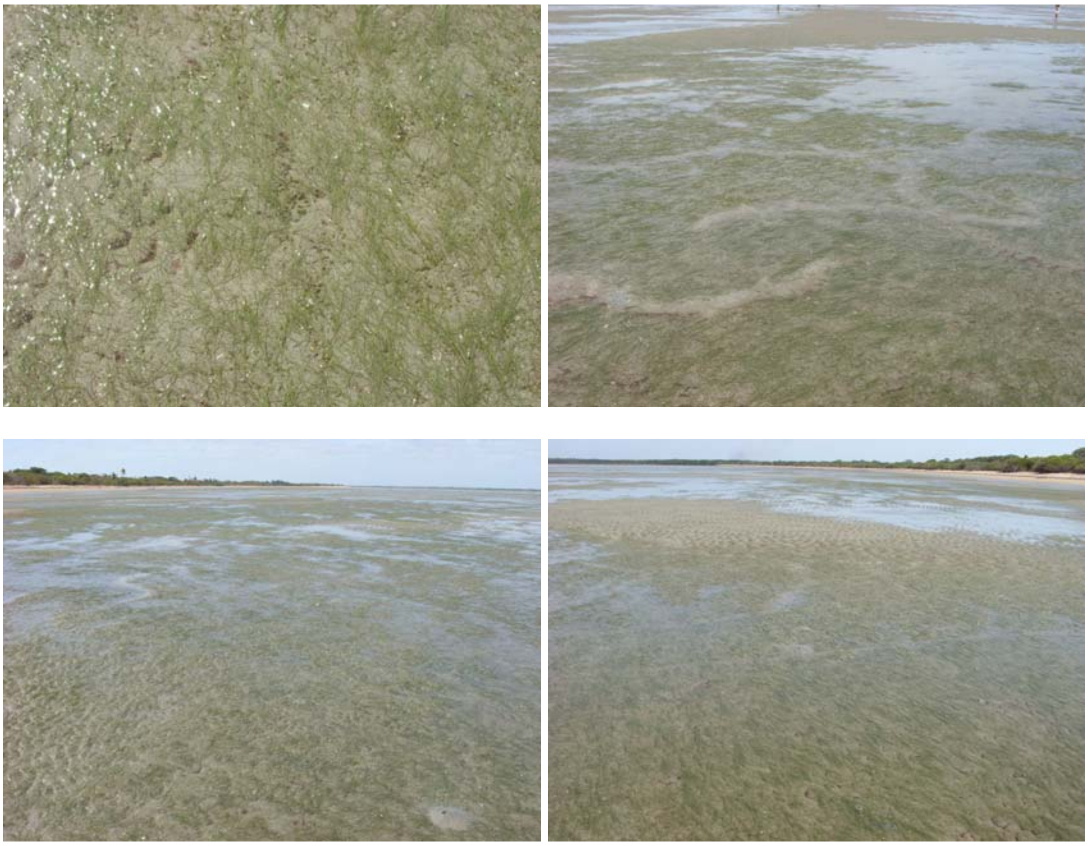
Port Musgrave

Port Musgrave is a shallow, almost enclosed, estuary, forming a bay on the western coast of the Cape York Peninsula. Two major rivers, the Wenlock and the Ducie, to the north and south respectively, discharge into it. The surrounding area is rich in freshwater swamps, while the estuary itself has tidal flats and mangroves. The small Aboriginal community of Mapoon lies on the southern shore of the bay.

Mapoon was declared a Deed of Grant in Trust (DOGIT) in 1998 and is held by a group of nominated trustees. An August 2001 Census stated that 197 persons gave their address of usual residence as Marpuna Community, with about 92 per cent of the total population being of Aboriginal or Torres Strait Islander origin (http://www.cypda.com.au/old_mapoon).

Previous studies have identified significant areas of seagrass on the intertidal banks and subtidal waters at Port Musgrave (Coles *et al.* 2001a). Of particular note, isolated patches of *Halophila tricostata*, a deepwater species and endemic to northern Australia, was found in 3-7m depth off the coast immediately north of Port Musgrave (Coles *et al.* 2001a).

Meadows of *Halodule uninervis/Halodule pinifolia* and *Halophila ovalis* occur on the intertidal banks. *Enhalus acoroides* occurs in the shallow waters on the seaward edge of the banks, and *Halophila decipiens* is found in the deeper waters. The site is frequented by dugongs as lots of grazing trails have been observed (Christina Howley, Pers. Comm).



Mixed *Halodule uninervis* and *Halophila ovalis* meadow, Port Musgrave August 2008.
Photos: Christina Howley

Weipa

Located on the north-west coast of Cape York Peninsula, the Port of Weipa is principally involved in the export of bauxite. In 2004/05, the port handled 374 ships carrying 15,519,910 tonnes of bauxite, 64,701 tonnes of fuel and 22,052 tonnes of general cargo (www.pcq.com.au). The port is located within Albatross Bay, a large shallow bay fed by four rivers (Pine, Mission, Embley, and Hey). The rivers form an extensive estuarine system with a variety of habitats-including mud flats, seagrass beds, and mangroves- that support significant fisheries resources and populations of seabirds, dugongs, turtles and crocodiles.

Seagrass distribution and species composition was originally documented for Weipa during surveys by CSIRO in 1982 and 1989, during a broadscale survey by QDPI&F in 1986 (Coles *et al.* 2001a, 2004), and by WBM (1991) and Fisheries Research Consultants (1994) (Dames & Moore 1995). Collectively, the surveys found up to six seagrass species in meadows located in the Embley, Hey and Mission Rivers and in an area south of Pine River Bay. No seagrasses were mapped in Pine River Bay.

In September 2000, a detailed survey of seagrass meadows in the region mapped 4688 ±418 ha, an area of seagrass larger than in previous surveys of the Port of Weipa; 680 ha in October 1982; 2225 hectares (ha) in October 1986 to 4653 (±422) ha in September 2000 (Poiner *et al.* 1987, Coles *et al.* 2001a, Roelofs *et al.* 2001). One additional seagrass species, *Syringodium isoetifolium,* was found during the September 2000 survey that was not found previous. *Halophila minor* was not found in the 2000 survey, however Waycott *et al.* (2004) consider *H. minor* to be part of the *H. ovalis* complex of closely related entities whose leaves are highly plastic especially in relation to blade size, shape, colour, and texture (Waycott *et al.* 2002).

Since the baseline survey in 2000, DPI&F has conducted annual monitoring as a joint initiative with the Ports Corporation of Queensland (PCQ) to ensure port activities have a minimal impact on the marine environment with special emphasis on sensitive fisheries habitat, particularly seagrass meadows. Due to the large area of the port, long term monitoring focuses on seagrass meadows located near port and shipping infrastructure and activities *(the Intensive Monitoring Area or IMA*). In August / September each year all seagrass meadows within the IMA are mapped. A selection of “core monitoring meadows” representing the range of seagrass meadow communities in the region are assessed for biomass and species composition. At the time of the IMA survey, an aerial reconnaissance of seagrasses in the greater port limits is conducted with re-mapping of the entire port limits occurring every 3 years (i.e. 2002, 2005 and 2008).

The most recent survey results of the September 2008 indicate that total seagrass meadow area (3289 ±52 ha) and landscape cover for the greater port limits has remained at similar levels to the 2005 survey, however significantly lower than the 2001 and 2002 baselines (Chartrand and Rasheed 2009). The most significant change within the greater port limits was a change in species diversity in many for the meadows from mixed-species to mono-specific seagrass in 2008.

Nevertheless, monitoring indicates that seagrass habitat in the Port of Weipa were in a moderate condition (Chartrand and Rasheed 2009). There have been declines in density for a number of meadows compared with the previous eight years of monitoring, particularly for intertidal *Enhalus acoroides* meadows. The observed changes appeared to be partly a response to regional and local climate conditions, however other drivers including anthropogenic factors cannot be discounted. Meadows dominated by *Halodule uninervis* (narrow) had some declines in abundance, however these were generally within the ranges of previous years (Chartrand and Rasheed 2009).

A survey at the southern reaches of Albatross Bay from the northern end of Boyd Bay to Pera Head in September 2007 reported seagrass occurring as a single continuous meadow of dense *Halodule uninervis* (narrow) with *Halophila decipiens* in a coastal strip adjacent to the beach in Boyd Bay (Marine Ecology Consulting 2007).

Kirke/Love

The Kirke and Love Rivers are located south of the Aboriginal Community of Aurukun. Both rivers have large saline lakes and extensive associated seasonal wetlands. Terrain surrounding the rivers is typically flat, allowing saline tidal influence to extend several kilometres upstream, especially in the dry-season.

Seagrasses in the Love and Kirke rivers were first mapped in October 1986 as part of the broadscale seagrass survey of the Gulf of Carpentaria (Coles *et al*. 2001a). They recorded the presence of seagrass in the saline lakes of both rivers and identified two species: *Halodule pinifolia* and *Halophila ovalis*.

In August 1999 the seagrasses of the Kirke and Love Rivers were mapped using a helicopter as part of an investigation by the DPI&F on the suitability of the area as a Fish Habitat Area (Rasheed 2000). No seagrass was found in the Kirke River. Seagrass was confined to six small *Halodule pinifolia* meadows along the edges of shallow intertidal banks in the Love River lake with a total area of 7.614 ± 1.48 hectares (Rasheed 2000; Sheppard *et al.* 2000). Rasheed (2000) however, suggested that the absence of seagrass in August 1999 was due to a prolonged period of freshwater inundation from floods in 1999 and that seagrass are likely to grow in the region when habitat conditions are more optimal for seagrass growth.

A resurvey of the Kirke River region was undertaken during April and September 2001 to examine the presence or absence of seagrass in both wet season and dry season conditions. Seagrass was absent in the Kirke River in April 2001, however two *Halodule pinifolia* meadows with a total area of 22.5 ±1.9 hectares were mapped along the edges of the shallow intertidal banks in the Kirke River lake in September 2001 (Sheppard *et al.* 2000, Appendix 2).

Cape Keerweer to the Nassau River

No seagrass has been recorded in the coastal area between Cape Keerweer and the Nassua River mouth in the south.

THREATS

The CYP region is an area rich in flora and fauna species. It is highly regarded by the Australian and the international community as one of the least impacted regions globally and deserves the highest amount of environmental protection available. The significance of the region to the cultural and natural heritage of Cape York's indigenous communities cannot be understated. The wilderness areas of the region are crucial to their health, well-being and traditional knowledge. Management of this region will need to be mindful of the traditional habitants.

Mining, agriculture, shipping tourism and commercial and recreational fishing are the major economic activities in CYP. All have potential to expand in this region, however, overall threat level to CYP seagrass habitats is currently low. The low level of urban, agricultural and industrial development means threats are localised to port areas where a greater number of potential harmful activities can occur. Threats at these urban and industrial locations include the potential for increased nutrient runoff, port access dredging operations and port infrastructure development along the foreshore. Most threats to seagrass meadows in this region would be largely climate related, eg cyclones. There is potential for sea level rise, thermal damage to seagrasses, and algae blooms smothering meadows if global climate change predictions become real (Coles *et al.* 2007).

Nevertheless, the CYP community perceive the greatest threats to their seagrass meadows to be from the passage of large ships during low tides resuspending sediment plumes in their wakes, sediment erosion associated with dirt roads (and improper road construction), erosion in river catchments, disturbance from trawling and oil or chemical spills (EarthTech, 2005; Howley, 2006). Of potential concern would be unchecked increased levels of extractive mining and the development of pastoral areas for horticulture within the region. These activities can greatly increase the amount of sediment/turbidity and pollutants associated with runoff produced after the monsoon rains. Oil spillage from large vessels possibly represents the single biggest point source pollution threat to the Great Barrier Reef in this region (Haynes *et al.* 2001).

MONITORING & SEAGRASS-WATCH

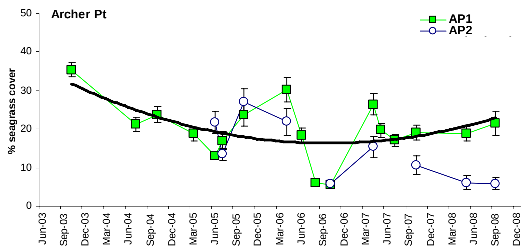
By monitoring the health of seagrass meadows, we can understanding the status and condition (quality) of environmental assets, characterise emerging problems and help evaluate performance/compliance of programs such as Reef Rescue and legislation (eg Fisheries Act 1994).

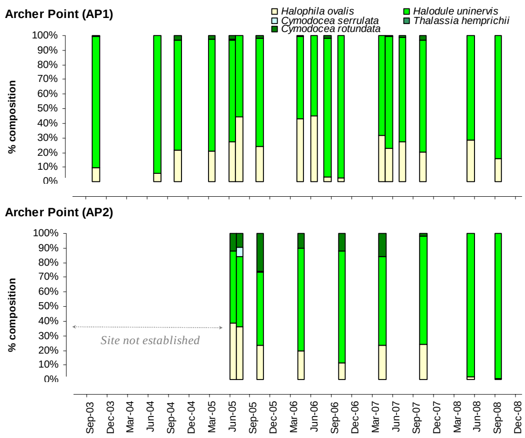
Most seagrass monitoring in the CYP region is concentrated around Ports and shipping activities. At present only three Seagrass-Watch sites are currently monitored in the CYP: one at Naprunum (with the Nanum-Wungthim Land & Sea Centre) and two sites at Archer Point (monitored by CYMAG, Howley Consulting and Cooktown State

High) (see www.seagrasswatch.org). The two sites at Archer Point have the largest data set of continuous data for this region.

Archer Point Status (Dec08):

- Seagrass cover long-term average was between 16% in winter and 19% in late Dry season.
- Seagrass cover significantly improved in 2007 compared to 2006, however it was lower in the late Monsoon 2008 than the previous year.
- Overall, the meadow appears to have generally declined in abundance since monitored was established in 2003.
- Seagrass cover at AP1 has generally followed a seasonal trend with higher abundance in late spring/early summer. However, no seasonal trend is apparent at AP2.
- The sites were dominated by *Halodule uninervis* and *Halophila ovalis*
- Although sites are only 50m apart, AP2 has slightly more *Cymodocea* and *Thalassia* present.
- Species composition remained relatively stable over the past 12 months.





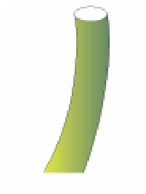
Information from these sites is providing crucial information on seasonal changes in seagrass communities and their environments. An expansion of Seagrass-Watch in CYP is desirable as will provide greater information (improved resolution) and it is a means of actively involving local stakeholders, including indigenous communities, in the collection of natural marine resource information. Recent expressions of interest to establish monitoring at in Elim Beach (HopeVale) and Port Musgrave are encouraging.

For more information, visit www.seagrasswatch.org

A guide to the identification of Cape York 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



cylindrical

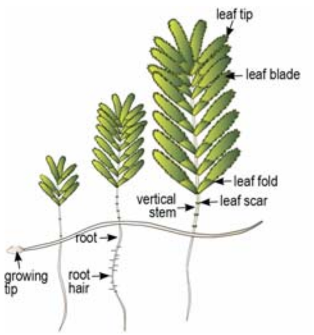
Syringodium isoetifolium

- Narrow spaghetti-like leaves, 1-2mm diameter
- leaf tip pointed
- leaves contain air cavities
- inflorescence a "cyme"

Leaves oval to oblong

oval to oblong

obvious vertical stem with more than 2 leaves



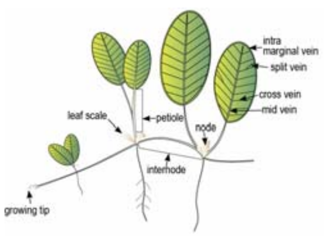
Halophila spinulosa

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

Halophila tricostata

- leaves arranged in clusters of 3, at a node on vertical stem
- leaf margin serrated
- leaf clusters do not lie flat

leaves with petioles, in pairs



Halophila ovalis

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

Halophila decipiens

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

Halophila minor

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

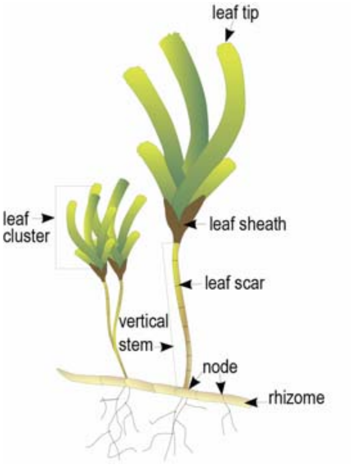
Halophila capricorni

- leaf margins serrated
- fine hairs on one side of leaf blade

Leaves strap-like

straplike

Leaves can arise from vertical stem



Thalassia hemprichii

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

Cymodocea rotundata

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

Cymodocea serrulata

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

Halodule uninervis

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

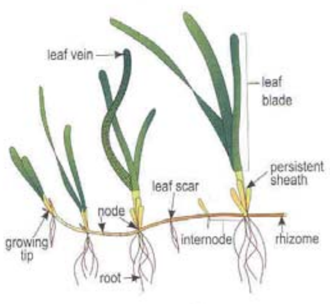
Halodule pinifolia

- leaf tip rounded
- 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



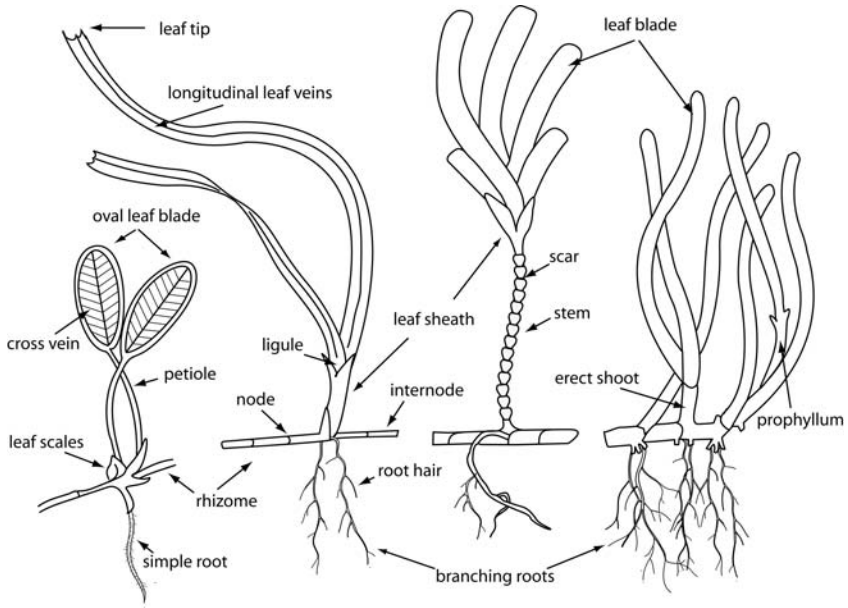
Enhalus acoroides

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

Zostera muelleri ssp. *capricorni*

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

Parts of a seagrass plant



Leaf

Tip

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

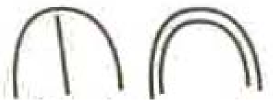
rounded *pointed*

Veins

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

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

cross *parallel*



mid *intramarginal*

Edges

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

serrated *smooth* *inrolled*

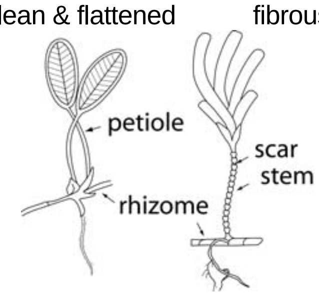
Sheath

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

clean & flattened fibrous

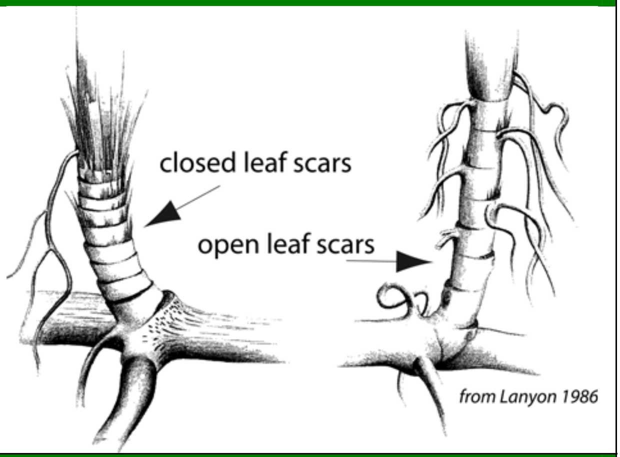
Attachment

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



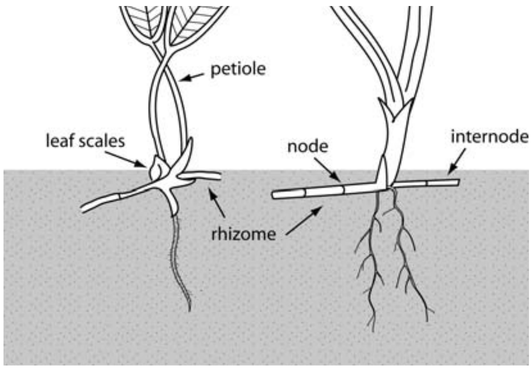
Stem

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



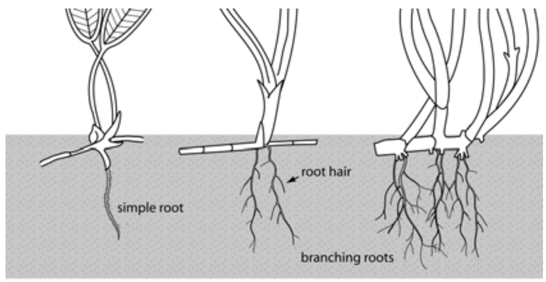
Rhizome

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



Root

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



Notes:

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Monitoring a seagrass meadow

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

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

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

Seagrass-Watch

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

Seagrass-Watch is one of the largest seagrass monitoring programs in the world. Since it's genesis in 1998 in Australia, Seagrass-Watch has now expanded internationally to more than 26 countries. Monitoring is currently occurring at over 250 sites. To learn more about the program, visit www.seagrasswatch.org .

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

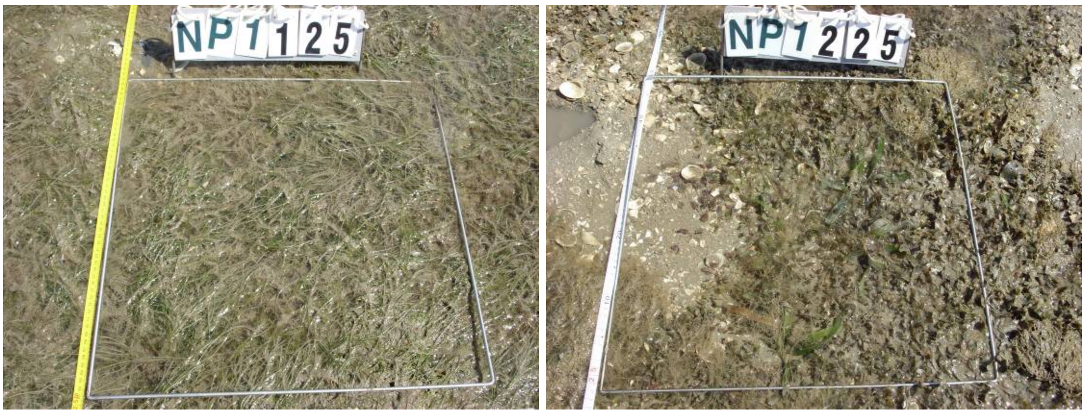
Seagrass-Watch integrates with existing education, government, non-government and scientific programs to raise community awareness to protect this important marine habitat for the benefit of the community. The program has a strong scientific underpinning with an emphasis on consistent data collection,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

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

THE GOALS OF THE PROGRAM ARE:

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

Monitoring NP1 (Napranum) August 2006.
Photo: Christina Howley

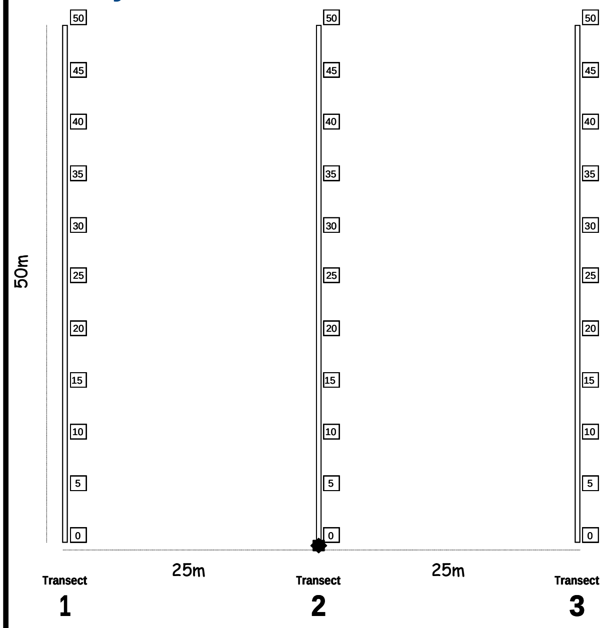


Quadrat photos NP1 (Napranum) April 2008.
Photo: Christina Howley

Seagrass-Watch Protocols

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

Site layout



Quadrat code = site + transect+quadrat

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

Pre-monitoring preparation

Make a Timetable

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

Have a Contact Person

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

Safety

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

Necessary equipment and materials

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

Quarterly sampling

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

Step 1. Take a Photograph of the quadrat

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

Step 2. Describe sediment composition

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

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

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

Step 4. Estimate seagrass percent cover

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

Step 5. Estimate seagrass species composition

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

Step 6. Measure canopy height

- Measure canopy height (in centimetres) of the dominant strap-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%).
- Epifauna are sessile animals attached to seagrass blades – please record % cover in the comments or an unused/blank column – do not add to epiphyte cover.

Step 9. Take a voucher seagrass specimen if required

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

At completion of monitoring

Step 1. Check data sheets are filled in fully.

- Ensure that your name, the date and site/quadrat details are clearly recorded on the datasheet. Also record the names 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

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Managing seagrass resources

Threats to seagrass habitats

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

Management

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

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

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

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

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

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. Indigenous systems 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.

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 (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 hat are robust to challenge
6. There is effective enforcement and punishment if damage occurs

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

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. (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.

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Useful web links

Seagrass-Watch Official Site www.seagrasswatch.org

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

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

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

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

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

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

Notes:

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Notes:

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

Please complete the following statements in your own words

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

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What I enjoyed most about the training was..

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It could have been better if ....

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I did not realize that..

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Now I understand that ....

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

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

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Other comments..

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