



# Seagrass-Watch

Proceedings of a Workshop for Monitoring  
Seagrass Habitats in the  
Great Sandy Marine Park, Queensland.

Coast Guard Sandy Straits QF21, Boonaroo  
2nd – 3rd April 2011

Len McKenzie & Rudi Yoshida

First Published 2011

©Seagrass-Watch HQ, 2011

Copyright protects this publication.

Reproduction of this publication for educational or other non-commercial purposes is authorised without prior written permission from the copyright holder provided the source is fully acknowledged.

Reproduction of this publication for resale or other commercial purposes is prohibited without prior written permission of the copyright holder.

#### *Disclaimer*

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

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

The correct citation of this document is

*McKenzie, LJ & Yoshida, R.L. (2011). Seagrass-Watch: Proceedings of a Workshop for Monitoring Seagrass Habitats in the Great Sandy Marine Park, Queensland. Coast Guard Sandy Straits QF21, Boonooroo, 2nd – 3rd April 2011. (Seagrass-Watch HQ, Cairns). 66pp.*

Produced by Seagrass-Watch HQ

Front cover photos (left to right): Inskip Point (Pelican Bay), Burrum Heads, Hanne & Robyn, by Len McKenzie.

Enquires should be directed to:

Len McKenzie  
Seagrass-Watch Program Leader  
Northern Fisheries Centre,  
PO Box 5396  
Cairns, QLD 4870 Australia



# Table of Contents

<b>OVERVIEW .....</b>	<b>5</b>
<b>WORKSHOP LEADERS .....</b>	<b>7</b>
<b>AGENDA - LEVEL 1 (BASIC) .....</b>	<b>8</b>
SATURDAY 2 <sup>ND</sup> APRIL 2011 (COAST GUARD SANDY STRAITS QF21) .....	8
SUNDAY 3 <sup>RD</sup> APRIL 2011 (BN1).....	8
<b>BACKGROUND.....</b>	<b>9</b>
<b>INTERESTING FACTS:.....</b>	<b>19</b>
<b>SEAGRASS IN HERVEY BAY AND THE GREAT SANDY STRAIT .....</b>	<b>21</b>
<i>HERVEY BAY</i> .....	21
<i>GREAT SANDY STRAIT</i> .....	23
SEAGRASS-WATCH.....	24
<i>BROWN'S GUTTER</i> .....	26
<i>BOONOOROO</i> .....	27
<i>KAURI CREEK</i> .....	28
<i>POONA</i> .....	29
<i>REEF ISLANDS</i> .....	31
<i>TIN CAN INLET</i> .....	31
<i>TOOTOOWAH CREEK</i> .....	33
<i>TINNANBAR</i> .....	34
<i>WANGGOOLBA &amp; BENNETT'S CREEK</i> .....	35
<b>WETLANDS AUSTRALIA 2011 ARTICLE .....</b>	<b>37</b>
<b>A GUIDE TO THE IDENTIFICATION OF GREAT SANDY REGION SEAGRASSES .....</b>	<b>39</b>
<b>PARTS OF A SEAGRASS PLANT.....</b>	<b>41</b>
<b>MONITORING A SEAGRASS MEADOW .....</b>	<b>43</b>
SEAGRASS-WATCH.....	43
<b>HOW TO USE A COMPASS.....</b>	<b>49</b>
<b>MAKING A HERBARIUM PRESS SPECIMEN.....</b>	<b>52</b>
<i>COLLECTION</i> .....	52
<i>PRESSING</i> .....	52
<i>HERBARIA</i> .....	54
<b>UNDERSTANDING SEDIMENT .....</b>	<b>55</b>
<b>DATA ENTRY.....</b>	<b>57</b>
<b>MANAGING SEAGRASS RESOURCES .....</b>	<b>59</b>
THREATS TO SEAGRASS HABITATS.....	59
MANAGEMENT .....	59
<b>REFERENCES .....</b>	<b>61</b>



Coast Guard Sandy Straits QF21  
Rescue Services - Boonooroo, QLD  
Eckert Rd, Boonooroo QLD 4650, Australia  
*Telephone: (07) 4129 8141*

# Overview

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

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

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

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

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

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

The goals of the Seagrass-Watch program are:

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

This workshop is jointly hosted by Cooloola Coastcare Association, with local coordination by Maree Prior and supported by Seagrass-Watch HQ. As part of the Level 1 workshop we will:

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

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

**Seagrass-Watch HQ**

Northern Fisheries Centre

PO Box 5396

Cairns QLD 4870

AUSTRALIA

Telephone +61 7 4057 3731

E-mail [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)

*or visit*

**[www.seagrasswatch.org](http://www.seagrasswatch.org)**



Photo: Jurgen Freund.

# Workshop leaders



## Len McKenzie

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

### **Current Projects**

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



## Rudi Yoshida

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

### **Current Projects**

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



# Agenda - Level 1 (*basic*)

## Saturday 2<sup>nd</sup> April 2011 (Coast Guard Sandy Straits QF21)

<b>Morning</b>	0900 - 0915 (15min)	Welcome & Introduction
	0915 - 0935 (20min)	Seagrass Biology and Identification
	0940 - 1020 (40min)	<b>Classroom activity:</b> Seagrass Identification
	1020 - 1050 (30min)	Seagrass Identification <i>continued</i>
	1050 - 1100 (10min)	<i>Break</i>
	1100 - 1120 (20min)	<b>Classroom activity:</b> how to prepare a seagrass press specimen
	1120 - 1205 (45min)	Seagrass Biology 2 and Ecology
<b>Afternoon</b>	1205 - 1240	<i>Lunch</i>
	1240 - 1310 (30min)	Seagrass importance
	1310 - 1410 (60min)	Seagrass threats
		<b>Classroom activity:</b> Seagrass threats
	1410 - 1420 (10min)	<i>Break</i>
	1420 - 1435 (15min)	Structure/framework of NRM in the Burnett-Mary, OHS & insurance, & obligatory CfoC reporting/budgeting requirements ( <i>Maree Prior</i> )
	1435 - 1450 (15min)	Seagrass monitoring
	1450 - 1540 (50min)	Seagrass-Watch: how to sample
	1540 - 1630 (50min)	Seagrass-Watch: how data is used
	1630 - 1700 (30min)	<i>Wrap-up for day</i>

## Sunday 3<sup>rd</sup> April 2011 (BN1)

	1330 - 1345 (15min)	Safety briefing & risk assessment
	1345 - 1545 (2hrs)	<b>Field exercise:</b> Seagrass-Watch monitoring
		<i>Where:</i> Boonooro (BN1)
		<ul style="list-style-type: none"> <li>• <i>meet at Schrimshaw Place, Boonooroo</i></li> <li>• <i>be punctual</i></li> <li>• <i>be well rested</i></li> </ul>
		<i>What to bring:</i>
		<ul style="list-style-type: none"> <li>• <i>hat, sunscreen (Slip! Slop! Slap!)</i></li> <li>• <i>dive booties or old shoes that can get wet</i></li> <li>• <i>drink/refreshments and energising snack</i></li> <li>• <i>wet weather gear: poncho/raincoat</i></li> <li>• <i>insect repellent</i></li> <li>• <i>polaroid sunglasses (not essential)</i></li> <li>• <i>simple medical kit in case of injuries to yourself</i></li> <li>• <i>change of footwear and clothes</i></li> <li>• <i>enthusiasm</i></li> </ul>
		<i>You will be walking across a seagrass meadow exposed with the tide, through shallow water.</i>
	1545 - 1615	Wrap up ( <i>on foreshore</i> )
		<ul style="list-style-type: none"> <li>• check gear</li> <li>• feedback</li> </ul>

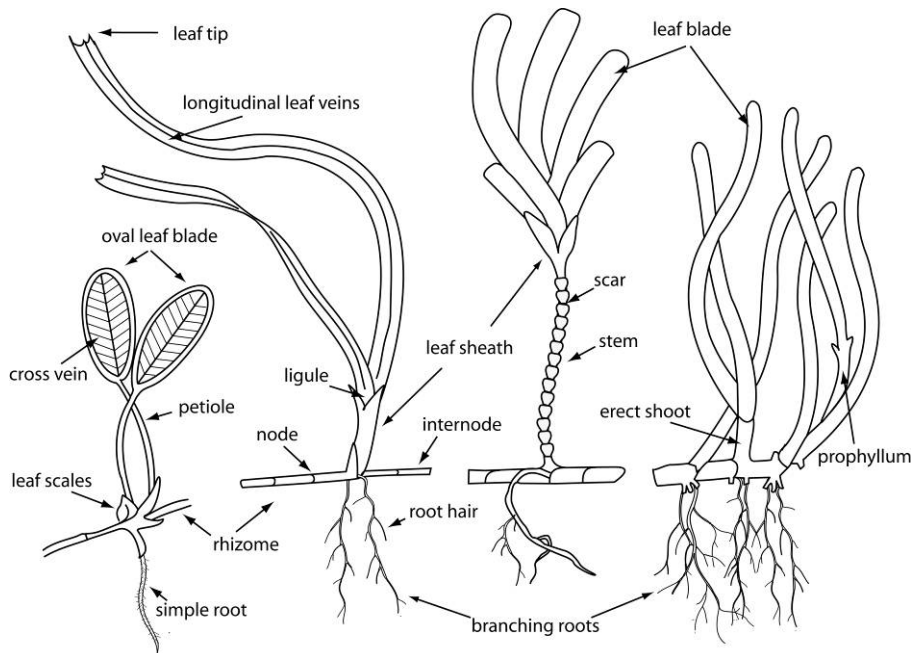
*Low tide: 0.8m at 1521pm*



# Background

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

Seagrass are marine flowering plants



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

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

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

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

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

Seagrasses have roots, stems and leaves

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

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



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

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

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

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

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

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

### Seagrass taxonomy

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

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

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

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

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

Seagrass pump oxygen into the sediment via their roots

Seagrass have flowers, fruits and seeds

Pollination occurs in the water

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

Seagrasses are not true grasses

Seagrasses are more closely related to lilies



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

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

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

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

### Seagrass requirements for growth

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

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

The need for physiological adaptations to life in sea water is obvious when one considers that seagrasses evolved from land plants, and most land plants are unable to tolerate even small quantities of salt. In contrast to land plants, some seagrasses can tolerate a salinity range from 4 to 65 parts per thousand (2x seawater concentration).

Typically, seagrasses grow best in salinities of 35 parts per thousand. Not all species tolerate all salinities equally well, and salinity tolerance may be a factor promoting different species distributions along salinity gradients, e.g., going up estuaries. Some seagrasses can survive in a range of conditions encompassing fresh water, estuarine, marine, or hypersaline (very salty). A limiting factor for many intertidal seagrasses is osmotic impacts resulting from hypersalinity due to evaporation

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

Temperature influences the rate of growth and the health of plants, particularly at the extremes. As water temperatures increase (up to 38°C) the rate of photorespiration increases reducing the efficiency of photosynthesis at a given CO<sub>2</sub> concentration. The cause of thermal

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

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

Seagrasses need plenty of sun and clean water to grow.

Seagrasses are physiologically adapted to life in sea water

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

Light availability is the most important factor determining seagrass growth

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

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



stress at higher temperatures (38°C to 42°C) is the disruption of electron transport activity via inactivation of the oxygen producing enzymes (proteins) of photosystem II. Above these temperatures many proteins are simply destroyed in most plants, resulting in plant death.

Temperature also controls the range of pH and dissolved carbon dioxide (CO<sub>2</sub>) concentrations in the water column; factors critical in plant survival in the marine environment.

Seagrasses require inorganic carbon for growth. They uptake inorganic carbon at the leaf surface via two pathways which are species-specific. Some species use bicarbonate (HCO<sub>3</sub><sup>-</sup>) as an inorganic carbon source (eg *Halophila ovalis*, *Cymodocea rotundata*, *Syringodium isoetifolium* and *Thalassia*), whereas others use enzymes to make CO<sub>2</sub> available as the inorganic carbon source (eg *Enhalus acoroides*, *Halodule*, *Cymodocea serrulata*).

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

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

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

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

### Where are seagrasses found?

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

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

Seagrass require inorganic carbon for growth

Seagrass uptake carbon via two different pathways

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

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

Most seagrass live in sand or mud sediments

Sediment movement can determine the presence of seagrass species

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

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



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

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

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

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

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

### **How are seagrasses important to the marine ecosystem?**

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

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

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

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

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

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

Seagrass plants form small patches that develop into large meadows

Seagrasses are important habitat and feeding grounds for marine organisms.

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

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

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



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

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

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

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

### Interactions with mangroves and coral reefs

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

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

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

### Valuation of seagrasses

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

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

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

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

Seagrass binds sediments and help prevent erosion

Seagrasses slow water flow and increase water clarity

Seagrass help remove harmful nutrient and sediment pollution from coastal waters

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

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



### What causes seagrass areas to change?

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

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

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

### What threatens seagrass?

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

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

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

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

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

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

Seagrasses can change due to both natural and human impacts

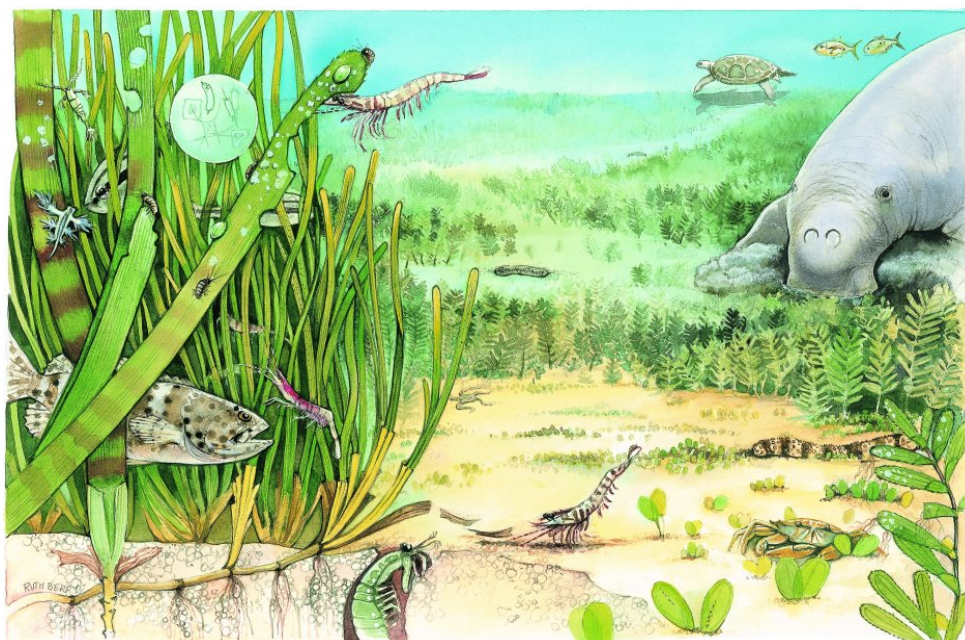
People can damage or destroy seagrass by pollution (sewage, oil spills and coastal runoff) and physical destruction (dredging, boat propellers and anchors/moorings).

Coastal development can have a major impact on seagrass meadows

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

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

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



**Notes:**

.....

.....

.....

.....

.....

.....

.....



**Notes:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

**Notes:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

## 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 during the growing season.

A hectare of seagrass sequesters 830 kilograms of carbon per year, equivalent to the CO<sub>2</sub> emissions from an automobile travelling 3,350 km.

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

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

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

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

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

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

Seagrass produce the longest pollen grains on the planet.

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

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

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

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

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

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

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

# Notes:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



# Seagrass in Hervey Bay and the Great Sandy Strait

Updated from McKenzie & Yoshida (2008)

Seagrass meadows in Hervey Bay and the Great Sandy Strait are one of the largest single areas of seagrass resources on the eastern Australian seaboard. Seagrasses are a major component of the Hervey Bay and Great Sandy Strait marine ecosystems and their contribution to the total primary carbon production is the basis for such regionally important dugong and turtle populations and productive fisheries.

## Hervey Bay

Seagrasses in Hervey Bay were first mapped during a broad-scale survey between Water Park Point and Hervey Bay in October and November 1988 (Lee Long *et al.* 1992). Seagrass distribution was estimated to be a least 1026.34 km<sup>2</sup> (Lee Long *et al.* 1993) and mainly in large, dense meadows in the southern and western parts of the bay, extending from intertidal areas to 25 m depths in the centre of the bay.

Approximately 1000 km<sup>2</sup> of seagrass was lost in Hervey Bay after two major floods and a cyclone within a 3 week period in 1992 (Preen *et al.* 1995). The deeper water seagrasses died, apparently as a result of light deprivation caused by a persistent plume of turbid water that resulted from the floods and the resuspension of sediments caused by the cyclonic seas. The heavy seas uprooted shallow water and intertidal seagrasses.

Recovery of sub-tidal seagrasses (at depths >5m) began within two years of the initial loss (Preen *et al.* 1995), but recovery of inter-tidal seagrasses was much slower and only appeared evident after 4-5 years (J. Comans, HBDSMP, Pers Comm). The seagrasses appeared to be fully recovered in December 1998 (McKenzie 2000).

In December 1998 a detailed dive and remote camera survey of Hervey Bay and the Great Sandy Strait estimated 2,307 ±279 km<sup>2</sup> of seagrass existed in Hervey Bay (McKenzie 2000). Seagrass meadows extended from the intertidal and shallow subtidal waters to a depth of 32 m. The dominant (43%) deep water (>10 m) meadows in the southern section of Hervey Bay were large continuous meadows of medium-high biomass *Halophila spinulosa* with *Halophila ovalis* (high cover of drift algae).

The south eastern section of the bay consisted of generally bare substrate with isolated patches of *Halophila spinulosa*/*H. ovalis*/*H. decipiens*. In the south western section of the bay however, the subtidal seagrass meadows were generally patchy, medium to high biomass, *H. spinulosa* with *H. ovalis*/*H. decipiens* on sand down to 15 m. The shallow subtidal Dayman Bank, extending from near Urangan out to near the fairway buoy, was covered with low biomass *H. spinulosa*/*H. decipiens*.

Seagrass meadows were also present on the intertidal sand banks between Burrum Heads and Eli Creek (Point Vernon). These meadows were generally low biomass *Zostera capricorni*, or *Halodule uninervis*, with *H. ovalis*. A narrow intertidal band of sparse (1-10% cover) *Z. capricorni* with *H. ovalis* was also present on the sand banks adjacent to the Esplanade from Pialba to Torquay.

In mid February 1999, the Mary River once again flooded into Hervey Bay. The flood was the fifth highest in the last 50 years, and ninth highest since reliable recordings were first made in 1870. The flood was only 0.75 m less than the February 1992 floods which, when combined with the effects of tropical cyclone “Fran”, caused devastating

losses of seagrass resources within Hervey Bay. The 1999 flood produced a large freshwater plume of suspended sediments which extended 35 km north-west into Hervey Bay. Substantially reduced light conditions were logged by light meters at 4 sites coinciding with the fairway buoys and lead markers. Light conditions in the main plume were significantly reduced for 19 days before returning to pre-flood levels (Ben Longstaff, UQ, Pers. Comm.).

The Mary River flood of February 1999 had the greatest adverse effect on the intertidal and shallow subtidal seagrasses in Hervey Bay that were in the path of the flood plume (McKenzie *et al.* 2000). Shallow sub-tidal (2–10 m depth below MSL) seagrass resources of Hervey Bay (adjacent to the City of Hervey Bay) declined dramatically in abundance (from  $23.24 \pm 5.05$  grams DW  $m^{-2}$  above-ground abundance in December 1998) and distribution after the flood. By November 1999 the seagrass had completely disappeared. Deepwater seagrass resources in Hervey Bay within the path of the flood plume also declined significantly in abundance six months after the impact and remained significantly lower than outside the impact area after nine months (McKenzie *et al.* 2000).

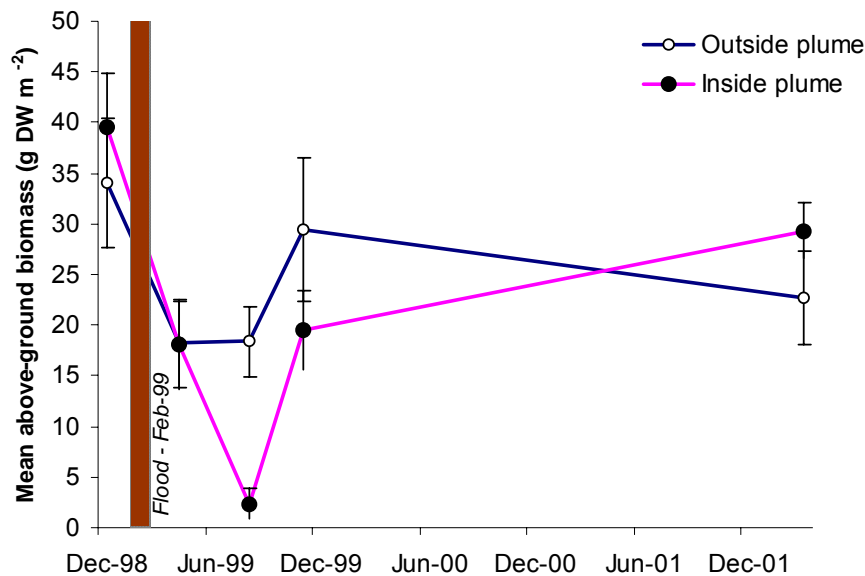


Figure 1. Plot of above-ground seagrass biomass (g DW  $m^{-2}$ , all species pooled) from survey sites inside (Impact) and outside (Reference) the area impacted by the Mary River flood plume following flooding in Hervey Bay and the Great Sandy Strait in February 1999. Error bars represent 95% confidence limits.

In February 2002, the sites examined in the deep water meadows of Hervey Bay were generally patchy, with light to moderate abundance of *H. spinulosa* with *H. ovalis*/*H. decipiens* on sand (McKenzie and Campbell 2003). The meadow mapped in December 1998 on the shallow subtidal Dayman Bank, extending from near Urangan out to near the fairway buoy, showed little recovery in the northern tip with light *H. spinulosa*/*H. decipiens* (<5% cover). More recent studies have suggested that these shallow subtidal meadows, often dominated by *H. ovalis*, are more vulnerable to light deprivation than intertidal populations dominated by *Z. capricorni* (Bité *et al.* 2007).

Mean above-ground seagrass biomass at deepwater sites within the flood plume (Impacted sites) and for sites outside the flood plume (Reference sites) were pooled respectively for analysis. Impact and Reference sites did not appear to differ significantly in abundance in February 2002, and the all sites appear to have recovered to near or above pre-flood levels (McKenzie and Campbell 2003).

Long term monitoring at Seagrass-Watch sites within Booral wetlands by local volunteers, found that initial re-colonisation of seagrass occurred in November 2000,

21 months post-flood. Full recovery of meadows to pre-flood cover values (~20-40%) occurred August 2002, 30 months post-flood. Monitoring sites also exhibited seasonal trends in abundances with highest cover in November and lowest seagrass cover post-summer from April to June. This typical seasonal response coupled with a trend of increasing seagrass cover indicates a post-flood recovery.

Recovery was also apparent in the deeper water seagrass communities of Hervey Bay, however in February 2002, deepwater seagrass abundances at monitoring sites within the impacted area had recovered to near pre-flood levels. The areas of seagrass that showed little recovery were the shallow sub-tidal seagrasses (2-4 m) along Dayman Bank. Only a few isolated patches of seagrass had recovered off the northern tip of the bank in February 2002. Further reading - Campbell and McKenzie 2004.

### **Great Sandy Strait.**

Seagrass meadows provide a major marine habitat in the Great Sandy Strait. The meadows form part of significant Ramsar wetlands sites, are within the proposed Great Sandy Marine Park (Northern Section), and provide critical nursery habitat for regional prawn and finfish fisheries.

Seagrass distribution was first mapped in the Great Sandy Strait in July/December 1973 (Dredge *et al.* 1977). Seagrass was found south of the co-tidal line, which occurs at Moonboom Islands (25°20' S) and within Tin Can Inlet. No seagrass was found north of Moonboom Islands, including Urangan. Aerial photographs and ground truthing at 25 locations, were used to map an area of seagrass covering >4,800 hectares (~5,232 hectares digitised from Fig 2 in Dredge *et al.* 1977). There were six species of seagrass within the study area, although the total extent of the subtidal *Halophila spinulosa* meadows could not be estimated.

Lennon & Luck (1990) estimated that the Great Sandy Strait had approximately 12,300 hectares of seagrass covering extensive intertidal and subtidal areas. This estimate is based on remote sensing analysis and may have overestimated the intertidal (confused with algae) and underestimated the subtidal (high turbidity) seagrass habitat.

In October-November 1992 an aerial photographic survey of the Strait was conducted and significant decreases were reported in Tin Can Inlet (Fisheries Research Consultants 1993). Increases in seagrass distribution however, were reported in the northern section of the Strait, between River Heads and Urangan, and Blackfellow's Point and Moon Point. Seagrass community changes were also reported, especially in the dense monospecific *Cymodocea serrulata* meadow off Kauri Creek, which changed to sparse *C. serrulata* subtidally and *Z. capricorni* intertidally.

In 1994, a broad scale survey of the Great Sandy Strait seagrass meadows was conducted (mainly by air) which reported an increase in distribution of meadows south of Urangan to River Heads compared with 1992 (Fisheries Research Consultants 1994a). In June 1994, long-term monitoring transects were established throughout the Great Sandy Strait. Resurveys were conducted in March 1995, November 1996, February 1998, September 1998 and February 1999. Large decreases in seagrass distribution were recorded in 1996 and recovery to February 1999 remained low (Conacher *et al.* 1999).

In December 1998 a detailed dive survey of the Great Sandy Strait was conducted which estimated  $5,554 \pm 1,446$  ha of seagrass habitat (McKenzie 2000). Seven species of seagrass were present in the Great Sandy Strait (*Zostera capricorni*, *Halodule uninervis*, *Halophila ovalis*, *Halophila decipiens*, *Halophila spinulosa*, *Cymodocea serrulata* and *Syringodium isoetifolium*). Most of the meadows throughout

the Great Sandy Strait were intertidal on large mud- and sand-banks, and were predominantly in the northern and central sections.

Subtidal meadows contributed to only 5% (256 ±105 ha) of the total seagrass distribution of the Great Sandy Strait. Subtidal meadows were mostly in the northern and southern sections of the Strait in narrow bands along the edge of intertidal banks, or extending across the large subtidal banks. Subtidal meadows were dominated by *Halophila* species (*H. spinulosa*, *H. decipiens*, *H. ovalis*) or *Z. capricorni*. Algae were often mixed within the subtidal meadows with cover ranging between 5 and 40%.

Flooding of the Mary River and other tributaries in the Sandy Strait in February 1999 caused the complete loss of seagrass meadows in the northern Great Sandy Strait and loss of some other regions in the central and southern Sandy Strait region (McKenzie *et al.* 2000).

In February 2002 the total area of seagrass throughout the Great Sandy Strait had recovered to 7007 ±1945 hectares (Figure 2) (McKenzie and Campbell 2003; Campbell and McKenzie 2004). This was greater than the pre-flood survey conducted in December 1998.

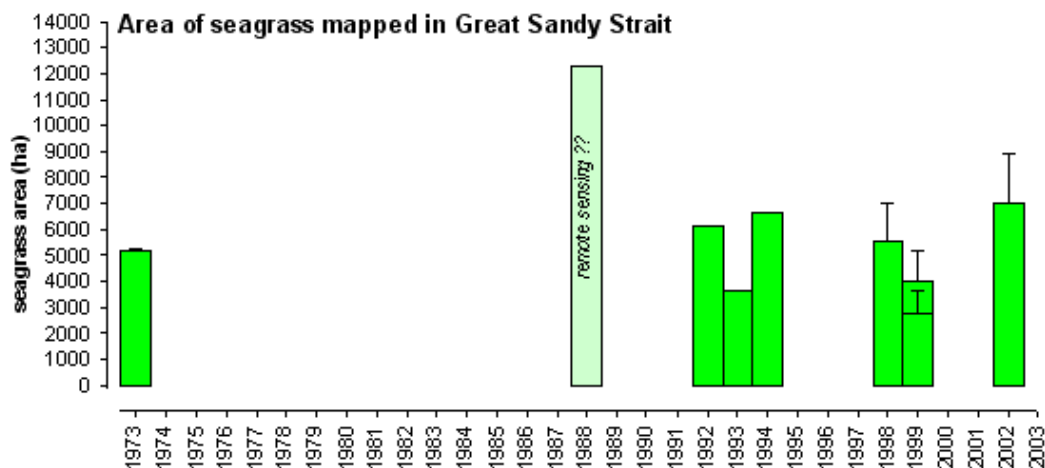


Figure 2. Mean area ±R (estimate of reliability) for seagrass mapped in the Great Sandy Strait pre- and post-flood.

In February 2002, approximately 92% of the area of seagrass meadows in the Great Sandy Strait was dominated by *Zostera capricorni*. The remainder was dominated by other species including *Halophila spinulosa*, *Halophila ovalis*, *Halophila decipiens*, *Halodule uninervis* and *Syringodium isoetifolium*. In February 2002, 14 seagrass meadow/community types were identified according to the order of species dominance, and meadow boundaries were mapped for each community type (McKenzie and Campbell 2003). Most meadows appeared to be of similar pre-flood abundances with biomasses appeared approximately the same or marginally lower.

## Seagrass-Watch

The inaugural Seagrass-Watch training workshop was conducted at Urangan in 1998, and the inaugural Seagrass-Watch monitoring site was established at Boonooroo, Great Sandy Strait. To date, 23 sites have been established at 9 locations in the Great Sandy Strait. Sampling frequency at some sites has been reduced from four to three times per year in March/April, July/August and October/November due to access during suitable low spring tides.



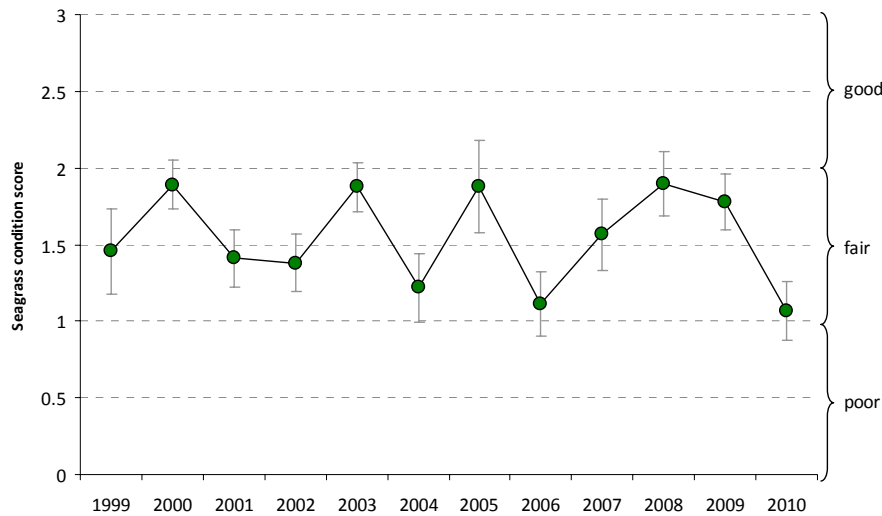
### Regional report card - December 2010

- Seagrass meadows throughout the Great Sandy Strait support significant fisheries, turtle and dugong populations
- Seagrass meadows in the Great Sandy Strait region were classified as **fair** in abundance in 2010.
- Seagrass abundance in the Great Sandy Strait has fluctuated since 1999 (fair to good), but there is no apparent long-term trend.
- Species composition has remained stable across the sites.
- Algal abundance is generally low, but seasonally increases in the middle of each year at most sites. Episodic algal blooms occurred in mid 2002.
- Epiphyte blooms regularly occur at most sites in the mid-latter part of the year, with a dramatic decline in the summer months. Epiphyte abundance has continued to increase (not significantly) at some sites on the western shores of the Great Sandy Strait.
- Sediment grain size has remained relatively stable of the monitoring period, with only a few sites becoming either more muddy or more sandy.
- Seagrass-Watch data provides understanding of seasonal trends and effects of climatic patterns on seagrass meadows
- Management controls depend on public and government support.

Sampling events were first grouped into seasons (Mar-May, Jun-Aug, Sep-Nov, Dec-Feb), and then using the seagrass abundance guidelines (McKenzie 2009), seagrass state was determined for each monitoring event at each site, relative to the previous sampling event, and allocated as poor (median abundance below 20<sup>th</sup> or 10<sup>th</sup> percentile), fair (median abundance below 50<sup>th</sup> and above 20<sup>th</sup> percentile) or good (median abundance above 50<sup>th</sup> percentile) state.



To examine the long-term trend in regional seagrass condition, seagrass state was pooled across sites within years. Seagrass abundance in the Great Sandy Strait has fluctuated since 1999 (fair to good), but there is no apparent overall trend.



The following is a brief summary of the seagrass status at each location:

### Brown's Gutter

Monitoring: ongoing, annual

Principal watchers: Gordon Cottle, Robyn Bailey, Pat Cottle and Paul Bailey

Occasional and past watchers: Gary Nielsen, Steve Winderlich, John Lindberg, John Roberts, Anne O'Dae, Matthew Hamilton, Hanna Larson & Seagrass-Watch HQ

Location: shallow anchorage on the south western shores of Fraser Island

Site codes: BG1 BG2 BG3

BG1 position: S25.74305 E153.00058 (heading 50 degrees)

BG2 position: S25.75004 E153.00311 (heading 70 degrees)

BG3 position: S25.76155 E153.00830 (heading 70 degrees)

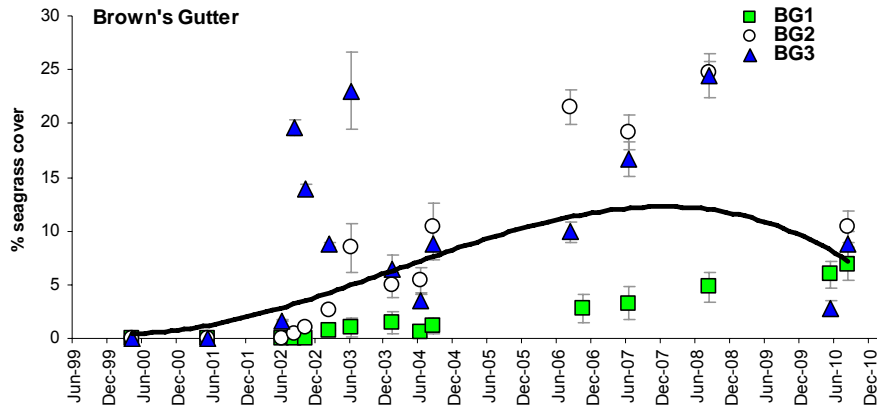
Best tides: <0.6m

Issues: stormwater & land runoff, boat traffic

Comments: dugong and turtle feeding grounds

Status (Dec10):

- seagrass abundance at Brown's Gutter is currently in a **poor state**
- BG1 has progressively increased in abundance since 2000, however seagrass abundance at BG2 & BG3 has fluctuated over the last 9 years, and currently at low levels.
- seagrass abundance appears seasonal within years, with lower levels from Jun-Aug and highest levels from Nov-Jan.
- episodic algal bloom occurred in mid 2002, however the algal abundances subsequently declined early in the new year. Epiphyte blooms regularly occur at most sites in the middle of the year.
- sediment grain size has changed little over the monitoring period.
- species composition has remained stable - dominated by *Zostera*.
- polychaete worms and gastropods (including mud whelks) common.



## Boonooroo

**Monitoring:** ongoing, triannual

**Principal watchers:** Gordon Cottle, Robyn Bailey, Pat Cottle, Paul Bailey & Seagrass-Watch HQ

**Occasional and past watchers:** John Roberts, Anne O'Dae, Steve Winderlich, Hana Larsson, Wayne Mathews, Peter Lusk, Bill Alston, Maryborough West School, Trischelle Lowry, Faye Ferguson & Mary Starkey

**Location:** on the western shores of the Great Sandy Strait, adjacent to Boonooroo township, between Big Tuan Creek and Maroom. BN2 is located close to Big Tuan Creek and BN3 is located approximately 1.6km north, with BN1 midway between BN2 and BN3. BN2 is considered the "impacted" site and BN3 the "control"/"reference" site

**Site codes:** BN1 BN2 BN3

**BN1 position:** S25.66866 E152.90736 (heading 100 degrees)

**BN2 position:** S25.68208 E152.89377 (heading 230 degrees)

**BN3 position:** S25.64812 E152.90670 (heading 280 degrees)

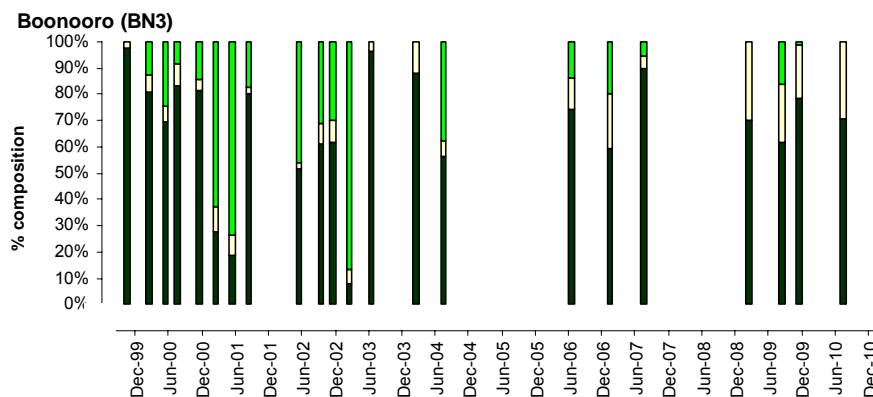
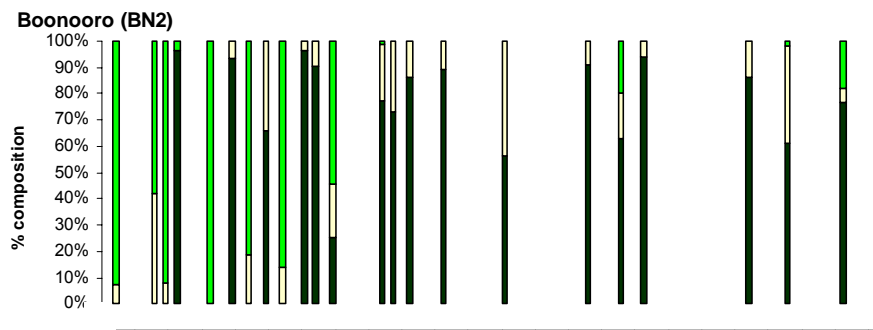
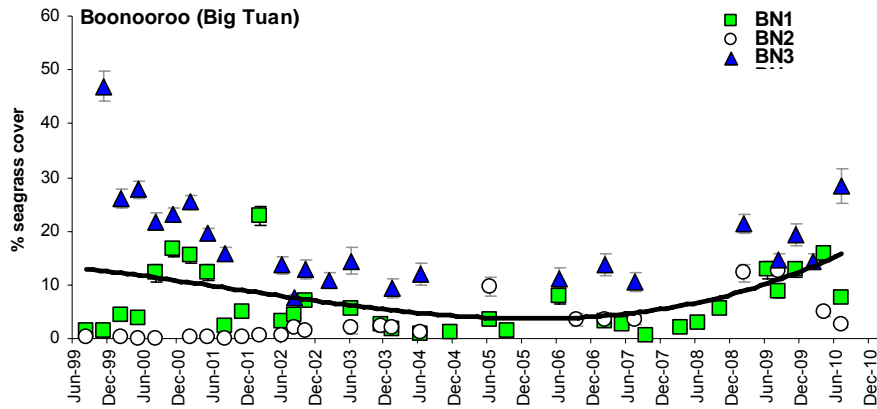
**Best tides:** <0.8m

**Issues:** Small unsewered village, boat traffic & land use

**Comments:** significant nursery grounds for juvenile prawns and fish. Dugong and turtle feeding grounds.

**Status (Dec10):**

- seagrass abundance at Boonooroo is currently in a **poor state**
- seagrass abundance at both "impacted" (BN1 & BN2) and "control" (BN3) sites declined from 1999 to 2005, however since 2005 seagrass abundance has continued to increase at BN3. Abundances similarly increased at BN1 & BN2 until 2010 when they declined.
- algae abundance appears seasonal as it generally increases in the middle of each year.
- epiphyte abundance, although highly variable, has continued to increase (not statistically significantly) over the monitoring period, possibly indicating elevated nutrients.
- sediment grain size has remained stable of the monitoring period.
- dugong feeding trails found year round, with the most intensive grazing occurred from May to November, coinciding with the nutritional demands of calving from September to December. During this period seasonal forces support high seagrass growth ensuring that losses from grazing are outweighed by tissue production.
- turtle feeding (cropping) was evident year round.
- polychaete worms and gastropods (including mud whelks) were common. The diversity and abundance of gastropods appears to be dependent on seagrass abundance, most likely due to associated detrital and prey food sources.
- species composition has varied over the monitoring period, particularly at BN1 where *Zostera capricorni* was becoming more dominant until recently when the meadow reverted back to *Halodule uninervis*. *Halodule uninervis* and *Halophila ovalis* are colonising species and may indicate levels of physical disturbance (eg wave action and sediment movement).



## Kauri Creek

Monitoring: ongoing, *ad hoc*

Principal watchers: Lyn McPherson, Carole Gillies, Norma Sanderson, Gordon Cottle, Robyn Bailey,

Occasional and past watchers: Steve Winderlich, Gary Nielsen, Wayne Mathews Pat Cottle, Paul Bailey & Anne O'Dae

Location: on intertidal bank (Ballast Bank) on the southern side of the mouth to Kauri Creek

Site code: KC1

KC1 position: S25.79597 E152.98675 (*heading 130 degrees*)

Best tides: <0.8m

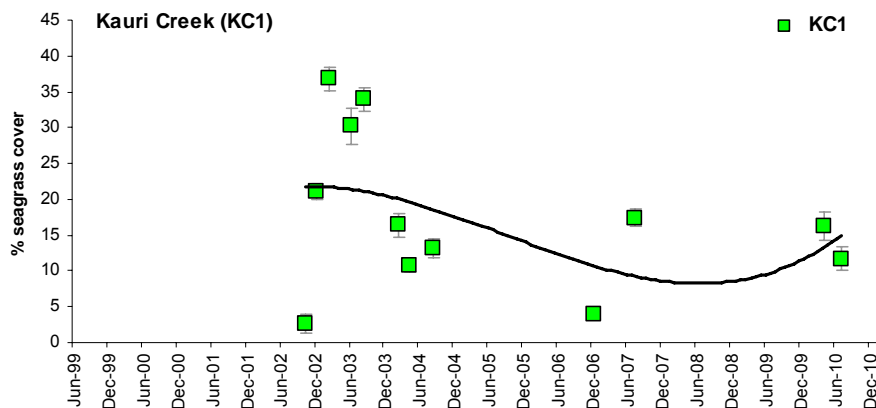


Issues: defence land runoff

Comments: dugong and turtle feeding grounds

Status (Dec10):

- seagrass abundance at Kauri Creek is currently in a **poor state**
- seagrass abundance has fluctuated since monitoring was established, and abundances in 2010 were not significantly different from 2007.
- canopy height is showing a close correlation with seagrass abundance.
- epiphyte abundance appears highly variable.
- sediment grain size and seagrass species composition appear stable.
- polychaete worms and gastropods were common.



## Poona

Monitoring: ongoing, triannual

Principal watchers: Gordon Cottle, Robyn Bailey & Hanne Larson

Occasional and past watchers: Gary Neilsen, Di-anne Duffield, Maryborough Special School, Mary Dixon, Sarah De Ghen, Trischelle Lowry, Wayne Mathews, Desley Nielsen, Anne O'Dae, Steve Winderlich & Seagrass-Watch HQ

Location: Intertidal banks adjacent to township

Site codes: PN1 PN2 PN3

PN1 position: S25.70853 E152.92433 (heading 30 degrees)

PN2 position: S25.71847 E152.91953 (heading 117 degrees)

PN3 position: S25.72980 E152.92285 (heading 15 degrees)

Best tides: <0.8m

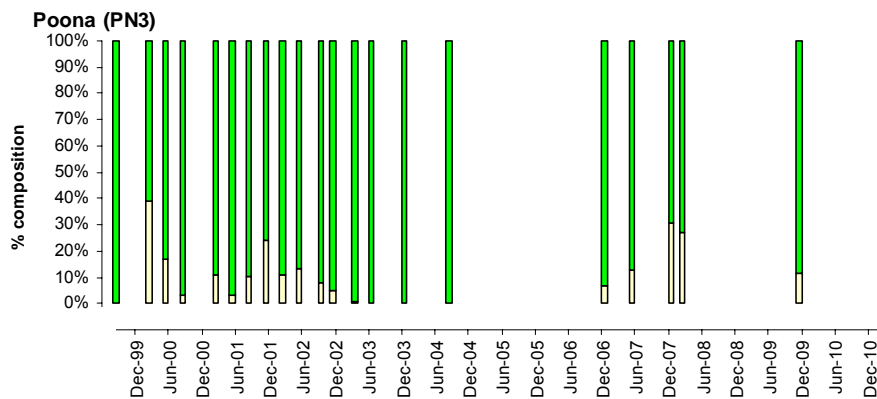
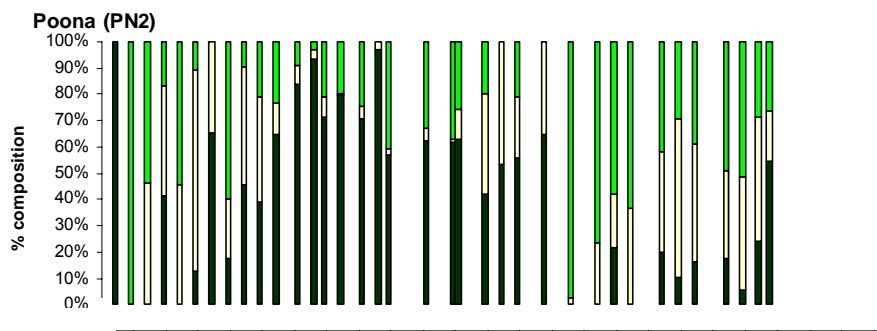
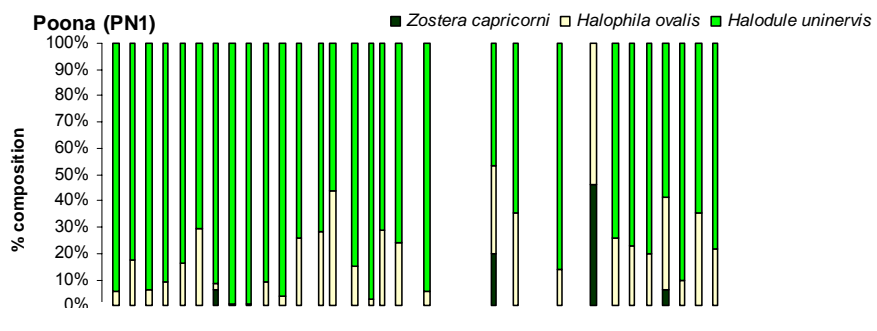
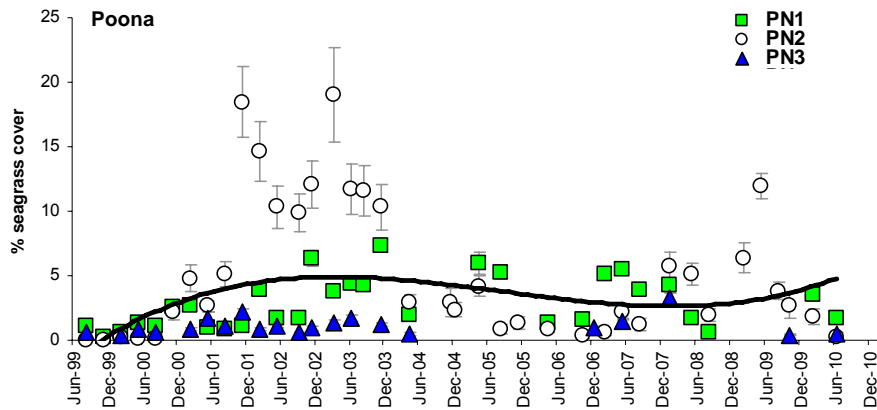
Issues: small unsewered village increasing development, access channel dredging, boat traffic, stormwater, land runoff

Comments: significant fish habitat. Dugong and turtle feeding grounds

Status (Dec10):

- seagrass abundance at Poona is currently in a **poor state**
- seagrass abundance has fluctuated greatly since monitoring was established in 1999.
- seagrass composition appears relatively stable at PN1 and PN3.
- PN2 has changed the most of all sites at Poona, both in abundance and species composition. The site appears to be generally dominated by *Zostera capricorni*, however the composition of the colonising species *Halodule uninervis* and *Halophila ovalis* has fluctuated over the years and has become more dominant in 2008, suggesting a high level of localised physical disturbance.
- sediment grain size has remained relatively stable at PN1 and PN2, however PN3 appears to have become muddier (this corresponds with the abundance of *Zostera* which is better adapted to muddier sediments).
- dugong feeding trails were found year round, with the most intensive grazing occurred from May to November, coinciding with the nutritional demands of calving from September to December. During this period seasonal forces support high seagrass growth ensuring that losses from grazing are outweighed by tissue production. Turtle feeding was evident year round.

- polychaete worms and gastropods were common. The diversity and abundance of gastropods appears to be dependent on seagrass abundance, most likely due to associated detrital and prey food sources.
- seagrass meadows at Poona were predominantly composed of fine mud and fine sand with a high organic component. Meadows near Poona Creek (PN2) had low seagrass cover, contained muddy sediments with a low sand component. At meadows distant from freshwater inputs (PN3) sand rippling indicates the influence of tidal movement and/or a low exposure to catchment influences.



## Reef Islands

**Monitoring:** ongoing, biannual

**Principal watchers:** Gordon Cottle, Robyn Bailey, Hanne Larson, Paul Bailey & Seagrass-Watch HQ

**Occasional and past watchers:** Steve Winderlich, John Roberts, Anne O'Dae, Gary Nielsen, Michael Ford, Sarah De Ghen, Bill Alston, Jerry Comans & Sue Olsson

**Location:** central Great Sandy Strait

**Site codes:** RI1 RI2 RI3

**RI1 position:** S25.65463 E152.95354 (*heading 240 degrees*)

**RI2 position:** S25.65899 E152.94900 (*heading 40 degrees*)

**RI3 position:** S25.67718 E152.95652 (*heading 90 degrees*)

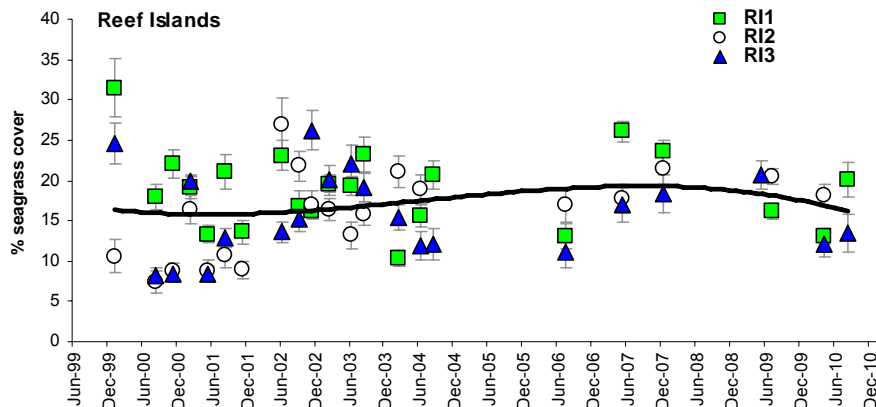
**Best tides:** <0.6m

**Issues:** Boat traffic, oyster leases, land runoff

**Comments:** significant nursery grounds for juvenile prawns and fish. Dugong and turtle feeding grounds

**Status (Dec10):**

- seagrass abundance at the Reef Islands is currently in a **fair state**
- seagrass abundance fluctuates (either doubling or halving) at times, but the long-term trend is stable.
- algal abundance is generally low with the exception being a significant algal bloom at RI1 in late 2003.
- epiphyte abundance appears seasonal with increases in the later part of the year, with a dramatic decline in the summer months.
- sediment grain size and species composition relatively stable over monitoring period.
- dugong feeding trails were found year round, with the most intensive grazing occurred from May to November, coinciding with the nutritional demands of calving from September to December. During this period seasonal forces support high seagrass growth ensuring that losses from grazing are outweighed by tissue production. Turtle feeding was evident year round.
- polychaete worms and gastropods were common. The diversity and abundance of gastropods appears to be dependent on seagrass abundance, most likely due to associated detrital and prey food sources. Filter feeding bivalves and oysters were found at Reef Island sites.



## Tin Can Inlet

**Monitoring:** ongoing, quarterly

**Principal watchers:** Gordon Cottle, Robyn Bailey, Hanne Larson & Pat Cottle

**Occasional and past watchers:** Seagrass-Watch HQ, Wayne Mathews, Dennis Osborn, Marc Dargosch, Dean Richardson, Di-anne Duffield & Sarah De Ghen

**Location:** Southern Great Sandy Strait, including Pelican Bay and on intertidal flats in front of Tin Can Bay township

**Site codes:** TB1, PB1, PB2

**PB1 position:** S25.81285 E153.04767 (*heading 145 degrees*)

**Best tides:** <1.0m

**PB2 position:** S25.82231 E153.06244 (*heading 50 degrees*)

Best tides: <0.6m

TB1 position: S25.90615 E153.01533 (*heading 115 degrees*)

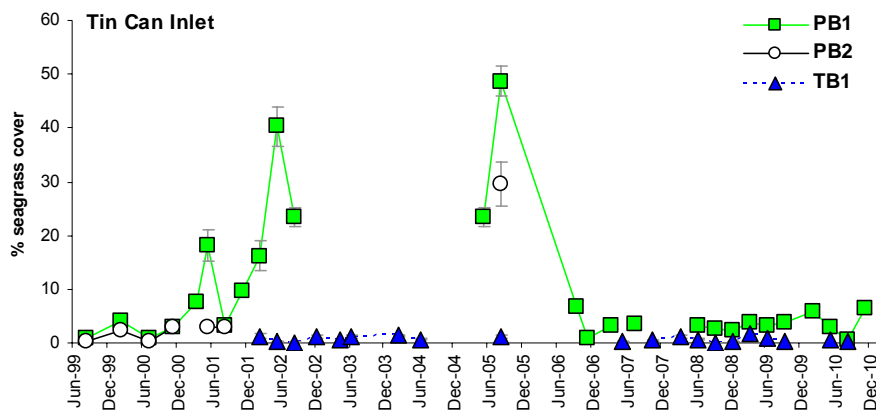
Best tides: <0.6m

Issues: Tourism (periodic camping) & urban development, vehicles, stormwater, sewerage & restoration of old wharf

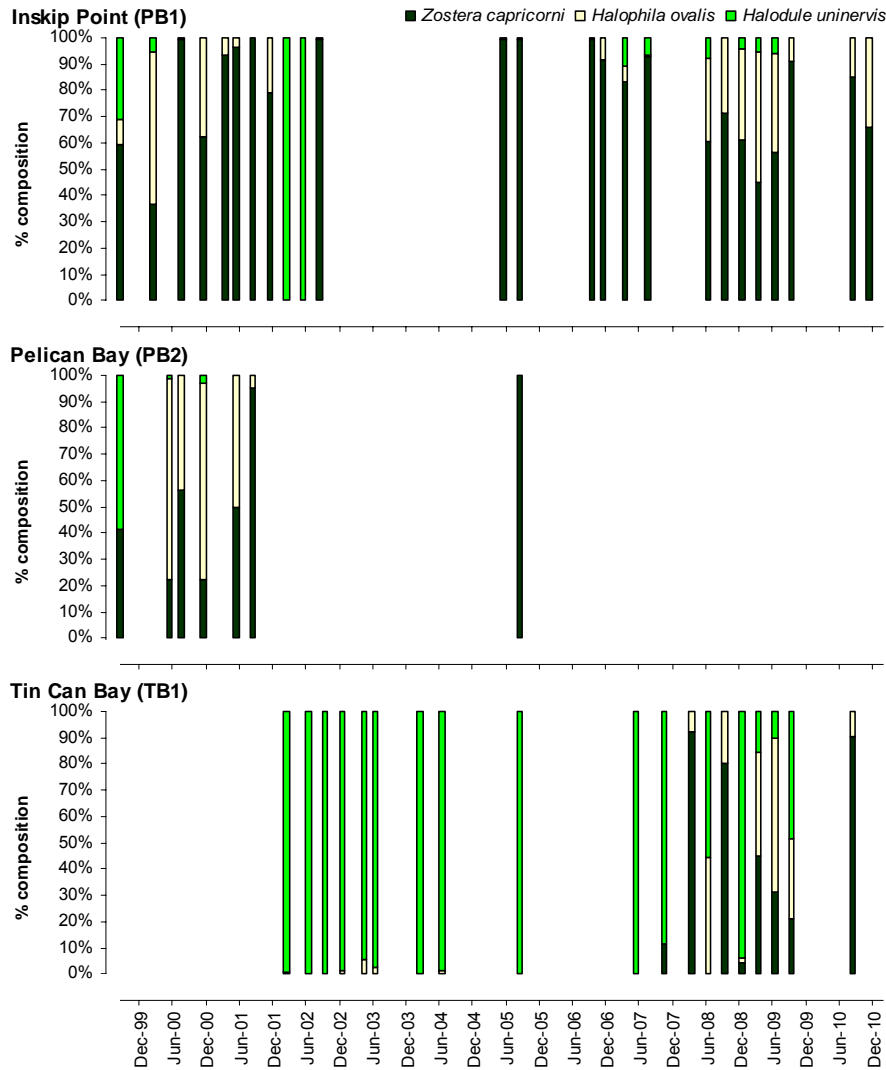
Comments: Dugong and turtle feeding grounds, popular fishing (recreational & commercial)

Status (Dec10):

- seagrass abundance at Boonooroo is currently in a **fair** state
- seagrass abundance has remained low (generally less than 1%) at the site adjacent to the Tin Can Bay township (TB1). The sparse meadows are dominated by the colonising seagrass species *Halodule uninervis* (narrow leaf morphology) and *Halophila ovalis*. The intertidal banks are dynamic (sand movement and physical disturbance from sting rays etc) and predominately sand with shell/gravel. Results suggest that due to the dynamic nature of the intertidal banks and the persistence of colonising species, the banks are adverse to establishment of dense seagrass meadows and little change would be expected in the near future.
- seagrass abundance at PB1 (Inskip Point) has fluctuated greatly over the monitoring period, however it has since decreased in 2008 to 1999-2000 abundances (ie post 1999 flood).
- the site at Bullock Point (PB2) in Pelican Bay was last monitored in August 2005.
- algal abundance appears to increase seasonally in the winter months and epiphyte abundance is highly variable. No persistent long-term trends are apparent, suggesting elevated nutrients are not a significant issue at present.
- seagrass composition at TB1 appears stable, although sediment grain size is variable.
- polychaete worms and gastropods (including mud whelks) were common. The diversity and abundance of gastropods appears to be dependent on seagrass abundance, most likely due to associated detrital and prey food sources.
- seagrass meadows at Pelican Bay were predominantly composed of fine mud and fine sand with a high organic component.







### Tootoowah Creek

Monitoring: suspended

Principal watchers: Gordon Cottle, Robyn Bailey, Hanne Larson, Paul Bailey & Seagrass-Watch HQ

Occasional and past watchers: Wendy Jones, Gary Nielsen, Steve Winderlich, Jerry Comans & Seagrass-Watch HQ

Location: Shallow anchorage on the western shores of Fraser Island.

Site codes: TC1 TC2

TC1 position: S25.69122 E152.98925 (heading 70 degrees)

TC2 position: S25.69295 E152.98495 (heading 270 degrees)

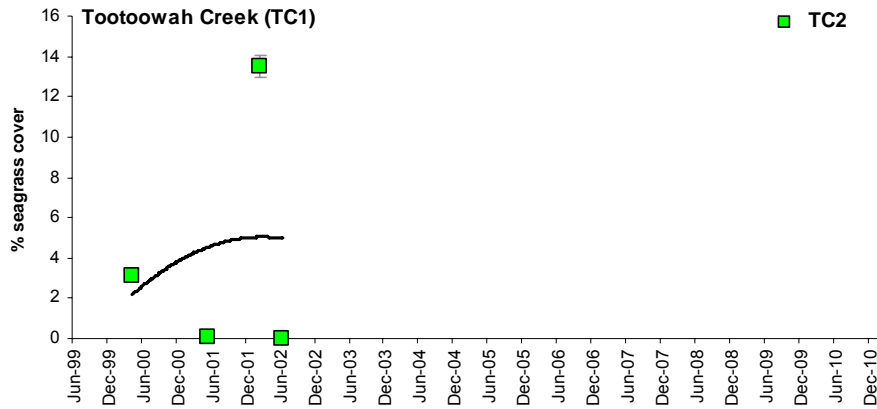
Best tides: <0.7m

Issues: boat traffic, land runoff

Comments: Dugong and turtle feeding grounds

Status (Dec10):

- Sites have not been examined since June 2002, when nearly the entire loss of seagrass at the location was reported.
- Insufficient data to describe long-term trends.
- Current condition unknown



## Tinnanbar

**Monitoring:** ongoing, triannual

**Principal watchers:** Gordon Cottle, Robyn Bailey, Hanne Larson & Pat Cottle

**Occasional and past watchers:** Gary Nielsen, Peter Lusk, Wayne Mathews, Hans Van Roey, Sarah De Ghen, Steve Nicol, D. Eckert, Megan Dale, Nigel Woodward, Rex Coleman, Steve Winderlich & Seagrass-Watch HQ

**Location:** southern Great Sandy Strait on the intertidal banks in front of the Tinnanbar township & caravan park.

**Site codes:** TN1 TN2 TN3

**TN1 position:** S25.75617 E152.95235 (*heading degrees*)

**TN2 position:** S25.75827 E152.96378 (*heading 15 degrees*)

**TN3 position:** S25.75807 E152.96788 (*heading 55 degrees*)

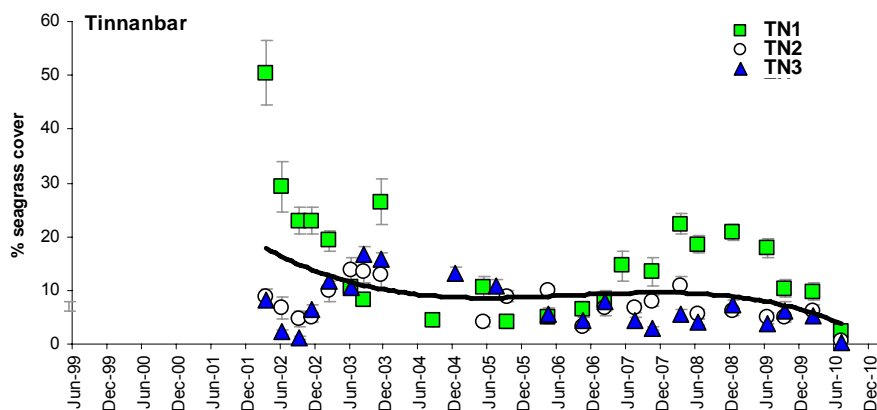
**Best tides:** <0.8m

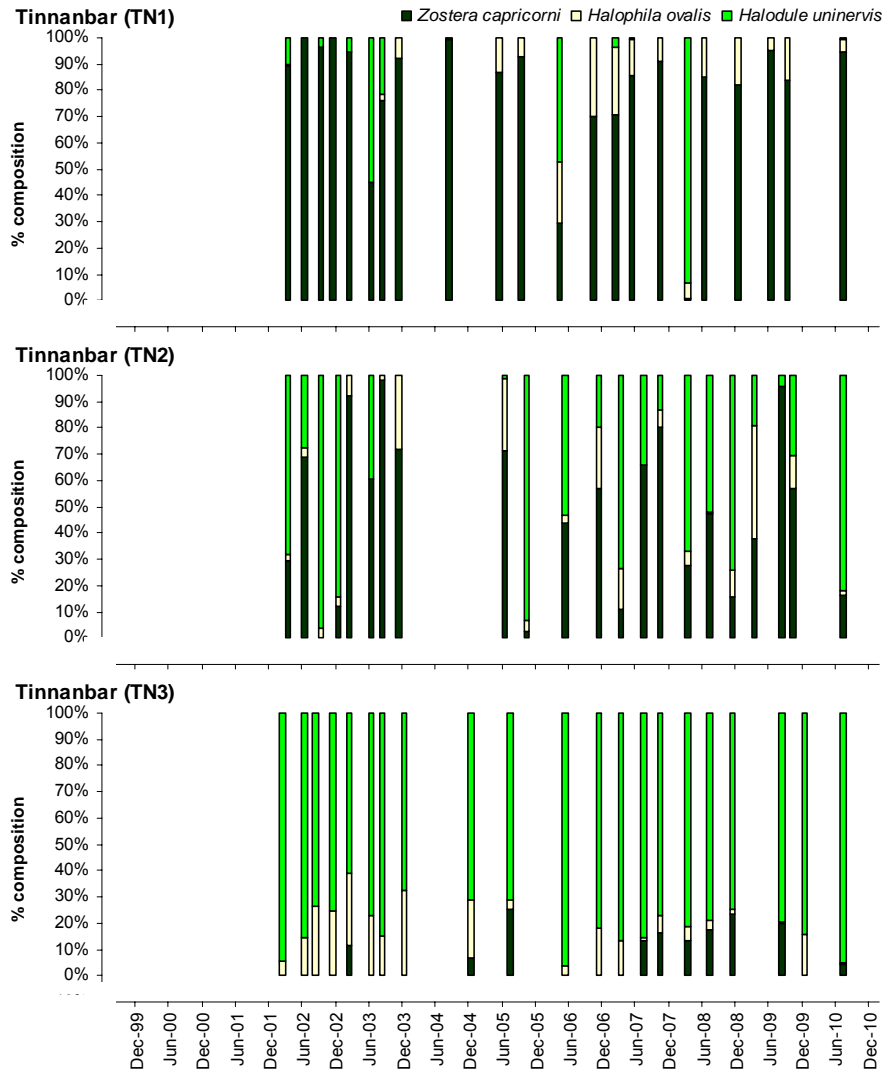
**Issues:** high urban development, boat traffic, stormwater, land runoff

**Comments:** Dugong and turtle feeding grounds. Popular fishing (recreational & commercial)

**Status (Dec10):**

- seagrass abundance at Tinnanbar is currently in a **poor state**
- seagrass abundance decreased between 2004 and 2006, and although TN1 increased between 2008 and early 2009, all sites have decreased since mid 2009.
- algae cover is generally low and epiphyte cover is high and variable.
- sediment grain size and species composition relatively stable over monitoring period.
- polychaete worms and gastropods were common.





### Wanggoolba & Bennett's Creek

Monitoring: suspended

Principal watchers: Michael Ford & Seagrass-Watch HQ

Occasional and past watchers: Anne O'Dae, Bill Alston, John Lindberg, Peter Lusk

Location: On the western shores of Fraser Island in the northern Great Sandy Strait. Wanggoolba Creek is one of the main access points (ferry) to the World Heritage listed Fraser Island

Site codes: WC1 WC2

WC1 position: S25.41610 E153.00559 (heading 120 degrees)

WC2 position: S25.44732 E152.98397 (heading 105 degrees)

Best tides: <0.8m

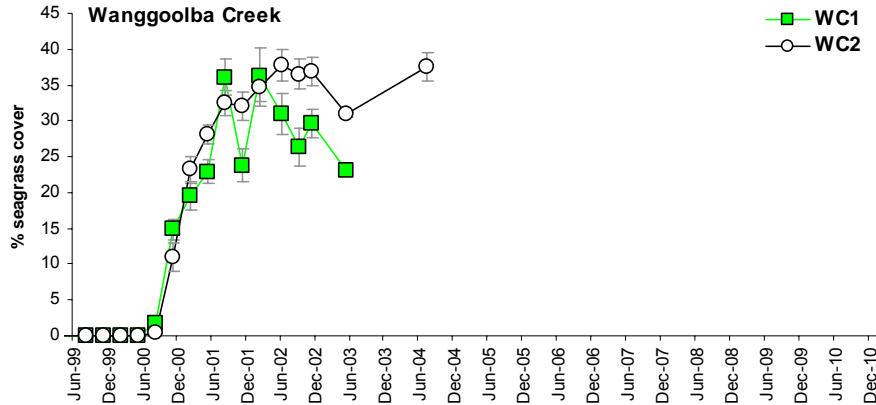
Issues: access dredging & spoil disposal, boat traffic

Comments: Dugong and turtle feeding grounds. Wanggoolba Creek is a declared Fish Habitat Areas (FHA) to enhance existing and future fishing activities and to protect the habitat upon which fish and other aquatic fauna depend.

Status (Dec10):

- sites have not been monitored since July 2004
- seagrass abundance recovered significantly after it was lost in February 1999, the result of a major flood.
- canopy height continued to increase at the site in close correlation with seagrass abundance.
- algae cover is relatively insignificant at these sites.
- irregular epiphyte blooms occur at both sites from time to time.
- sediment grain size appears to be less muddy, with more sand present.
- seagrass species composition relatively stable over monitoring period.

- dugong feeding was absent until late 2001, coinciding with seagrass recovery. Feeding trails are regularly observed across the meadows.
- the high abundance of gastropods at Wanggoolba Creek may be due to high amounts of mud and organic detrital matter in the sediments. Polychaete worms and mud whelks (a type of gastropod) were abundant at Wanggoolba Creek. Both animals are detrital feeders and competition for available detrital matter may explain the dominance of one over the other. The occurrence of polychaete worms at sites low in seagrass abundance suggests that they are likely to survive on low amounts of food relative to the larger gastropods. They are possible indicators of low seagrass abundance.



For more information, visit [www.seagrasswatch.org](http://www.seagrasswatch.org)

### Notes:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

# WORKING TOGETHER TO MONITOR SEAGRASS IN QUEENSLAND'S RAMSAR SITES

Len McKenzie and Rob Coles, Fisheries Queensland, Queensland Department of Employment, Economic Development and Innovation

Shallow water and intertidal seagrass meadows are a key ecological characteristic of four of Queensland's five Ramsar wetland sites. These marine and estuarine dominated Ramsar sites are Bowling Green Bay, Shoalwater and Corio Bays, Great Sandy Strait and Moreton Bay. During low tide, the intertidal meadows provide globally significant feeding areas for shorebirds. During high tide they provide the primary food source for dugong, endangered green turtles, fish and numerous other animals.

There are approximately 58 000 hectares of seagrass meadow within the boundaries of Ramsar wetlands in Queensland. This is approximately 13 per cent of the seagrass meadows along the east coast of Queensland.

The pressures on these habitats are increasing due to our activities on the land and on our coasts. Fisheries Queensland is working closely with community groups and other government agencies to report on the condition of our seagrass meadows and the general health of our nationally and internationally important wetlands. We now have good information on the status of seagrass in our Ramsar sites.

## Great Sandy Strait

The Great Sandy Strait Ramsar site is an estuary in southern Queensland. This was the location of the inaugural Seagrass-Watch monitoring site (August 1999). Seagrass-Watch is a participatory program which involves community groups and agencies in monitoring changes to coastal seagrass meadows in Queensland, as well as nationally and globally, providing an early warning of coastal ecological decline.

The 23 Seagrass-Watch long-term monitoring sites in the Great Sandy Strait have been monitored by the Great Sandy Strait Flora and Fauna Watch community group for the last eight years, with assistance of Burnett Mary Regional Group and the Cooloola CoastCare Association. The monitoring sites have been strategically located to gather information on marine resources in areas critical for fisheries, dugong and turtle. The monitoring provides information for strategic marine park planning, and assessments of impacts both on local and regional scales. Currently the status of seagrass in the Great Sandy Strait is rated as fair.

## Shoalwater and Corio Bays

The Shoalwater and Corio Bays Ramsar site on the central Queensland coast includes many wetland types including fringing coral reefs, rocky shores, beaches and sandbars, mangrove forests, melaleuca woodland, freshwater lagoons or swamps, intertidal mudflats as well as shallow open water with seagrass meadows.

The land surrounding Shoalwater Bay is owned by the Australian Defence Force and since the mid 1960s has been used as a military training exercise area with only limited access to the public. The bay has one of the highest tidal ranges in Queensland, up to seven metres, and contains extensive intertidal mud banks which support shallow seagrass meadows. Approximately 16 700 hectares of seagrass are within the Ramsar area. These meadows support a wide diversity of fish species and are visited by many threatened species of turtles (green, loggerhead, hawksbill and flatback) and are home to the threatened dugongs.

The seagrasses within Shoalwater Bay are monitored to assess water quality and habitat resilience as part of the Great Barrier Reef marine monitoring program, a component of *Reef Rescue*, an initiative under *Caring for our Country*. These assessments confirm that seagrass meadows in Shoalwater Bay are in a good condition.



Great Sandy Strait Flora and Fauna Watch volunteers (from left: Pat Cottle, Hanne Larson and Robyn Bailey) monitor the intertidal seagrass meadows at Tinnanbar, Great Sandy Strait. Photo: Len McKenzie



## Bowling Green Bay

The most northern Ramsar site in Queensland is Bowling Green Bay, just to the south of the regional Queensland city of Townsville. Bowling Green Bay contains examples of the richest coastal habitats typical of north-east Australia's coastal dry tropics.

Dugong and turtle feed in these meadows with extensive areas of feeding trails and groups of dugong observed during recent surveys by Fisheries Queensland. The seagrass meadows are close inshore and combine with the mangrove forests and wetlands to form a highly productive nursery habitat for commercial and recreational fish and prawn species.

Unfortunately recent monitoring in nearby areas has shown intertidal seagrasses to be in a poor state; although most meadows have a high resilience to impacts and a capacity for relatively fast recovery. Whether this situation also applies to the seagrasses of Bowling Green Bay is unknown, as currently there is no monitoring within the site.

While there are no direct threats to the marine environment, the hydrological connectivity of various aquifers, interactions with surface waters, and how irrigation activity in the adjacent catchments affects regional groundwater hydrology needs further assessment. Increases in pesticides and nutrients, as well as fine sediment from agricultural tail-waters may pose a long-term threat to seagrass meadows.

## Moreton Bay

Located in one of Australia's fastest growing regions is the Moreton Bay Ramsar site in southern Queensland. The site covers more than 110 000 hectares and includes the offshore sand islands, intertidal mudflats and seagrass meadows, marshes, sandflats and mangroves. This variety of wetlands enhances the Bay's biological diversity with an overlap of wildlife species normally considered tropical or temperate. Approximately 33 500 hectares of seagrass meadows are within the Ramsar site.

The threats to seagrass in this site are many as the population of Brisbane has more than doubled in the last 20 years, resulting in a rapid growth in housing and coastal development. Keeping the bay clean and the productive seagrasses healthy will depend on effective management. Approximately 50 Seagrass-Watch sites are monitored throughout the area, providing information on the condition of the seagrass habitats. Community volunteers, conservation organisations and government agencies have been working together to monitor seagrass since 2001. Current seagrass condition is rated as good, with no sustained losses in the last 10 years.

## The future

In the next 10 to 20 years it is expected that changes in climate, for example increasing temperature, sea-level rise and tropical storm frequency, will increase stress to coastal habitats. This will add to impacts on seagrass meadows that support fisheries productivity. The best defence against unnecessary habitat loss will be to use high quality, long-term information in decision making regarding coastal development and management. Monitoring change in seagrass performance and understanding the factors underpinning trends in change, resilience and recovery processes will be critical to understanding the changes occurring in Ramsar wetlands.



*Dugong grazing trails (zigzagging marks in foreground) are evidence of the importance of Bowling Green Bay seagrass meadows to local dugong populations. Photo: Rob Coles*

# A guide to the identification of Great Sandy region 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*

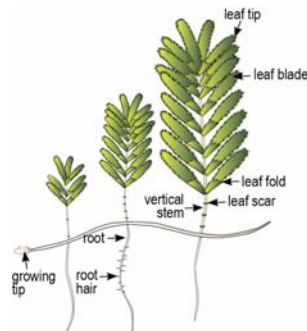
- leaves taper to a point
- leaves contain air cavities
- inflorescence a "cyme"
- leaves 7-30cm long

## Leaves oval to oblong



oval to oblong

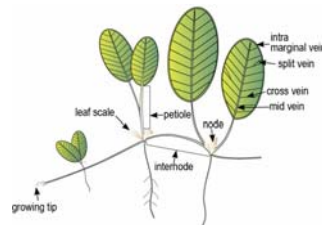
### obvious vertical stem with more than 2 leaves



### *Halophila spinulosa*

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

### leaves with petioles, in pairs



### *Halophila ovalis*

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

### *Halophila decipiens*

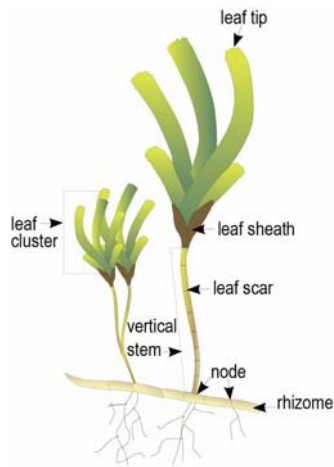
- leaf margins serrated
- 6-8 cross vein pairs
- fine hairs on both sides of leaf blade
- leaves are usually longer than wide

## Leaves strap-like

### Leaves can arise from vertical stem



straplike



#### *Cymodocea serrulata*

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

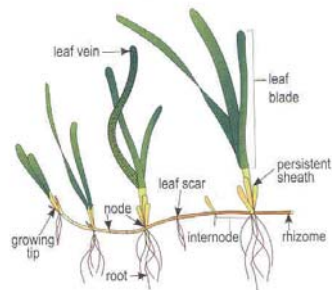
#### *Halodule pinifolia*

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

#### *Halodule uninervis*

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

### Leaves always arise directly from rhizome

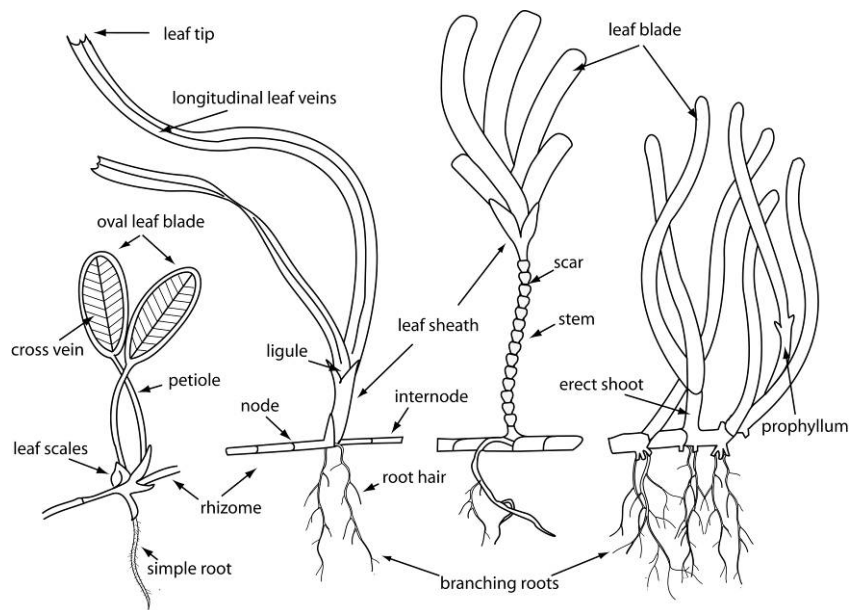



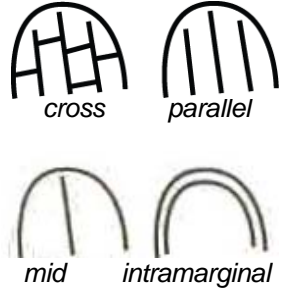


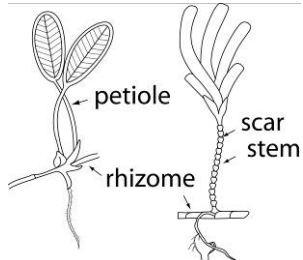
#### *Zostera muelleri* subsp. *capricorni*

- leaf with 3-5 parallel-veins
- cross-veins form boxes
- leaf tip smooth and rounded, may be dark point at tip
- rhizome usually brown or yellow in younger parts
- prophyllum present, i.e. a single leaf originating from the rhizome instead of from the vertical, leaf bearing shoot.



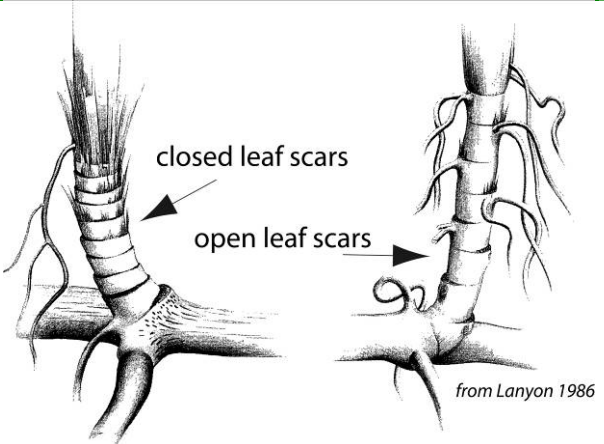
# Parts of a seagrass plant



Leaf		
Tip	Can be rounded or pointed. Tips are easily damaged or cropped, so young leaves are best to observe.	 <p style="text-align: center;"><i>rounded</i>      <i>pointed</i></p>
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. <ul style="list-style-type: none"> <li>• cross-vein: perpendicular to the length of the leaf</li> <li>• parallel-vein: along the length of the leaf</li> <li>• mid-vein: prominent central vein</li> <li>• Intramarginal-vein: around inside edge of leaf</li> </ul>	 <p style="text-align: center;"><i>cross</i>      <i>parallel</i></p> <p style="text-align: center;"><i>mid</i>      <i>intramarginal</i></p>
Edges	The edges of the leaf can be either serrated, smooth or inrolled	 <p style="text-align: center;"><i>serrated</i>    <i>smooth</i>    <i>inrolled</i></p>
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.	 <p style="text-align: center;"><i>clean &amp; flattened</i>      <i>fibrous</i></p>
Attachment	The leaf can attach directly to the rhizome, where the base of the leaf clasps the rhizome, or from a vertical stem or stalk (petiole) e.g. <i>Halophila ovalis</i> .	 <p style="text-align: center;"><i>petiole</i>      <i>scar</i>      <i>stem</i></p> <p style="text-align: center;"><i>rhizome</i></p>

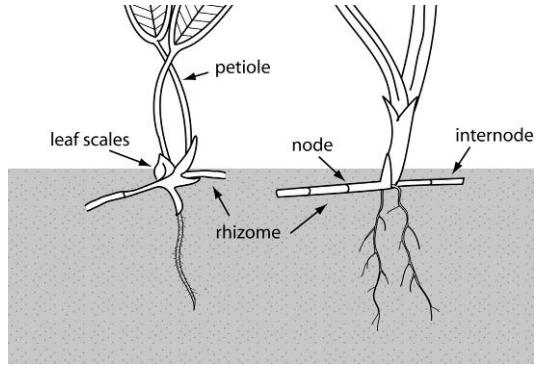
**Stem**

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*).



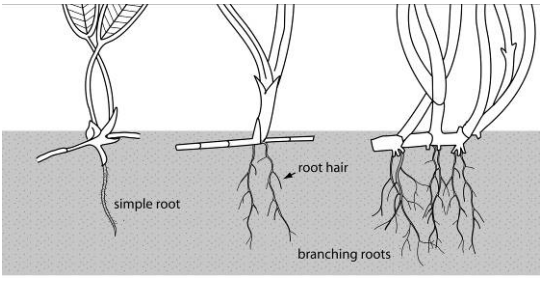
**Rhizome**

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:**

.....

.....

.....

.....

.....

.....

# 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, limited impact, 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 its genesis in 1998 in Australia, Seagrass-Watch has now expanded internationally to more than 26 countries. Monitoring is currently occurring at over 300 sites. To learn more about the program, visit [www.seagrasswatch.org](http://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.*



Above left: Steve, Mike, Robyn, Helen, Paul and Carla, Poona – February 2009. Photo: Gordon Cottle.

Above right: Hanne and Pat, Tin Can Bay – December 2008. Photo: Len McKenzie.



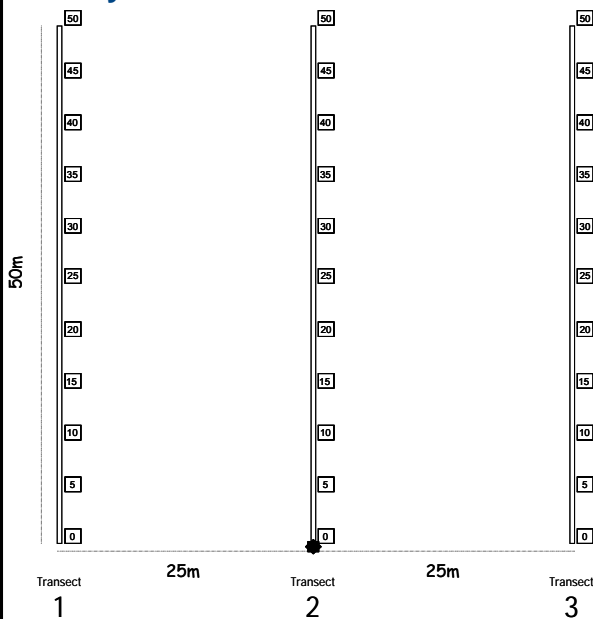
Above left: Gordon and Rudi, Tinnanbar – March 2007. Photo: Len McKenzie.

Above right: Lyn and Carole, Inskip Point – February 2010. Photo: Neil Gillies.

# 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](http://www.seagrasswatch.org/manuals.html))

## Site layout



Quadrat code = site + transect+quadrat

e.g., PN1225 = Poona site 1, transect 2, 25m quadrat

## Pre-monitoring preparation

### Make a Timetable

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

### Have a Contact Person

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

## Safety

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

## Necessary equipment and materials

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

## Quarterly sampling

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

### Step 1. Take a Photograph of the quadrat

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

### Step 2. Describe sediment composition

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

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

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

#### **Step 4. Estimate seagrass percent cover**

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

#### **Step 5. Estimate seagrass species composition**

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

#### **Step 6. Measure canopy height**

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

#### **Step 7. Estimate algae percent cover**

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

#### **Step 8. Estimate epiphyte percent cover**

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

#### **Step 9. Take a voucher seagrass specimen if required**

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

### **At completion of monitoring**

#### **Step 1. Check data sheets are filled in fully.**

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

#### **Step 2. Remove equipment from site**

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

#### **Step 3. Wash & pack gear**

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

#### **Step 4. Press any voucher seagrass specimens if collected**

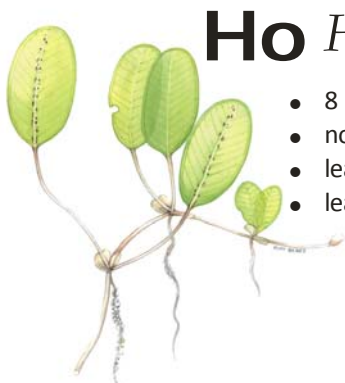
- The voucher specimen should be pressed as soon as possible after collection. Do not refrigerate longer than 2 days, press the sample as soon as possible.
- Allow to dry in a dry/warm/dark place for a minimum of two weeks. For best results, replace the newspaper after 2-3 days.

#### **Step 5. Submit all data**

- Data can be entered into the MS-Excel file downloadable from [www.seagrasswatch.org](http://www.seagrasswatch.org). Email completed files to [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)
- Mail original datasheets, photos and herbarium sheets

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

## SEAGRASS SPECIES CODES



**Ho** *Halophila ovalis*

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



**Hd** *Halophila decipiens*

- small oval leaf, slightly pointed
- 6-8 cross veins
- leaf hairs on both sides
- leaf 10-25mm long
- found at subtidal depths



**Hs** *Halophila spinulosa*

- fern like
- leaves arranged in opposite pairs
- erect shoot to 15cm long
- found at subtidal depths

**Cs** *Cymodocea serrulata*

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



**Hu** *Halodule uninervis*

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



**Hp** *Halodule pinifolia*

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



**Si** *Syringodium isoetifolium*

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

**Zc** *Zostera muelleri* subsp. *capricorni*



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

Illustrations copyright Seagrass-Watch HQ



# SEAGRASS-WATCH MONITORING



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

START of transect (GPS reading)

Latitude:  $25^{\circ} 11.2878$ , S Longitude:  $152^{\circ} 37.5372$ , E

OBSERVER: Bev Citizen DATE: 17 / 2 / 09

LOCATION: Burnum Heads

SITE code: BH1 TRANSECT no.: 2

START TIME: 1304 END TIME: 1340

Quadrat (metres from transect origin)	Sediment (eg. mud/sand/shell)	Comments (eg 10x gastropods, 4x crab holes, dugong feeding trails, herbarium specimen taken)	Seagrass coverage (%)	% Seagrass species composition				Canopy height (cm)	% Algae cover	% Epi- cover
				HO	HU	ZC	water			
1 (0m)	Sand	SC x 3 HC x 1	40	30	70		0	514.7	5	33
2 (5m)	S	GAB x 3	33	50	50		0	1017.8	10	18
3 (10m)	mud/sand	worm x 1	18	70	20	10	0	618.5	0	48
4 (15m)	m s	DFT x 1	0				0	0	17	0
5 (20m)	m s shell	HC x 3	36	5	90	5	1cm	917.5	12	57
6 (25m)	m s sh	Turtle cropping	48	100			1cm	NA.	2	96
7 (30m)	Fine Sand		0				1.5cm	0	23	0
8 (35m)	FS	SC x 2 CH x 3	0.7		100		2cm	717.7	18	31
9 (40m)	s m		23	96	4		2cm	214.6	6	17
10 (45m)	m	Mudworek x 2 HC x 1	41	2	95	3	2cm	551.6	3	21
11 (50m)	m s		16	3	7	90	2cm	716.7	38	6

END of transect (GPS reading)

Latitude:  $25^{\circ} 11.2656$ , S Longitude:  $152^{\circ} 37.5546$ , E

SC = Sea Cucumbers

GAB = Gastropod

DFT = Dugong feeding trail

HC = Hermit Crab

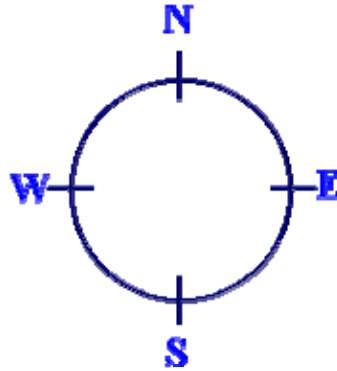
CH = Crab Hole



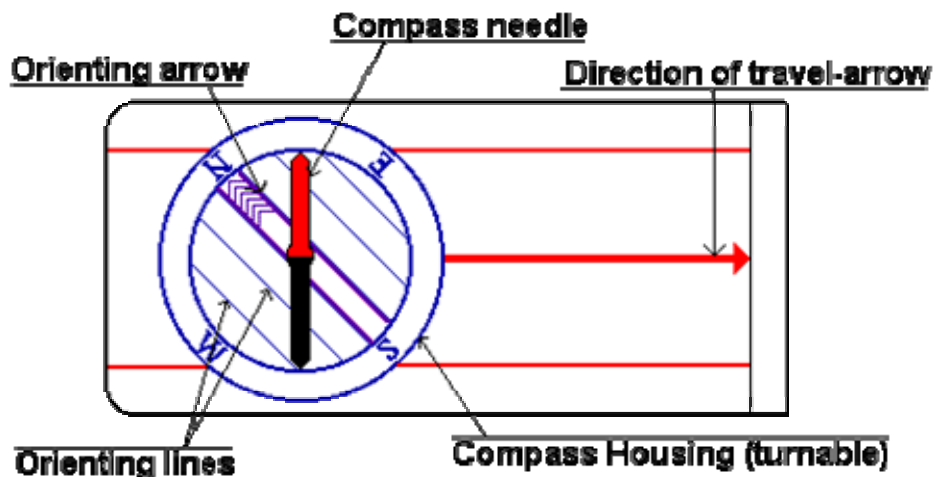
# How to use a compass

Modified from Kjetil Kjernsmo (<http://www.learn-orienteeing.org/old/lesson1.html>)

The most important thing you first need to learn before using a compass are the directions **North**, **South**, **East** and **West**. Look at the figure below and learn how they are. **North** is the most important. *Remember the sun rises in the east and sets in the west.*



A type of compass often used in Seagrass-Watch is an orienteering compass. It has a large rectangular base-plate (often of clear rigid plastic), on which is a large red travel arrow. Attached to the base-plate is a turnable dial.

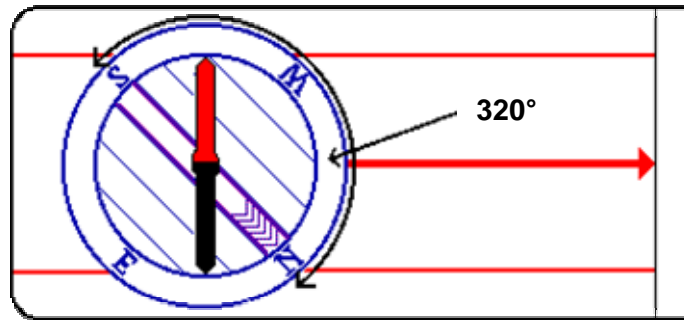


The turnable dial on the compass is called the *Compass housing*. On the edge of the compass housing is a scale from 0 to 360. These are the degrees or the *azimuth*. Also on the housing are the letters N, S, W and E for North, South, West and East.

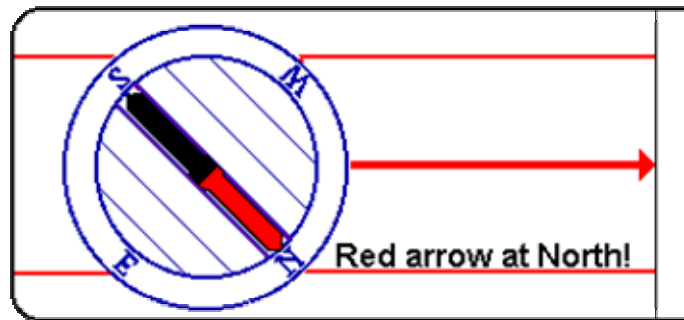
Within the compass housing is a red and black arrow, called the *compass needle* (on some compasses it might be red and white). **The red part of the needle always points towards the earth's magnetic north pole.**

To find a direction using the compass, you first turn the compass housing until the direction you desire comes exactly in line with the travel arrow, then holding the compass flat, you then turn the whole compass until the compass needle is aligned within the orienting arrow and the red end of the needle points to **N** (north).

For example, if you have arrived at your site and want to lay out transect 2 at bearing (compass heading) of 320 degrees, you first turn the compass housing so that 320 on the housing comes exactly in line with where the large *direction of travel*-arrow meets the housing.



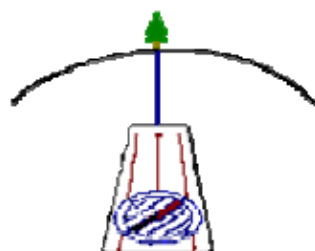
Hold the compass flat in your hand so that the compass needle can turn freely. Then turn yourself, your hand, the entire compass (*make sure the compass housing doesn't turn*), until the compass needle is aligned with the orienting arrow lines inside the compass housing.



It is *extremely* important that the red (**N**orth) part of the compass needle points to **N**orth in the compass housing. If the red points to the **S**outh, you would walk off in the exact opposite direction of what you want!

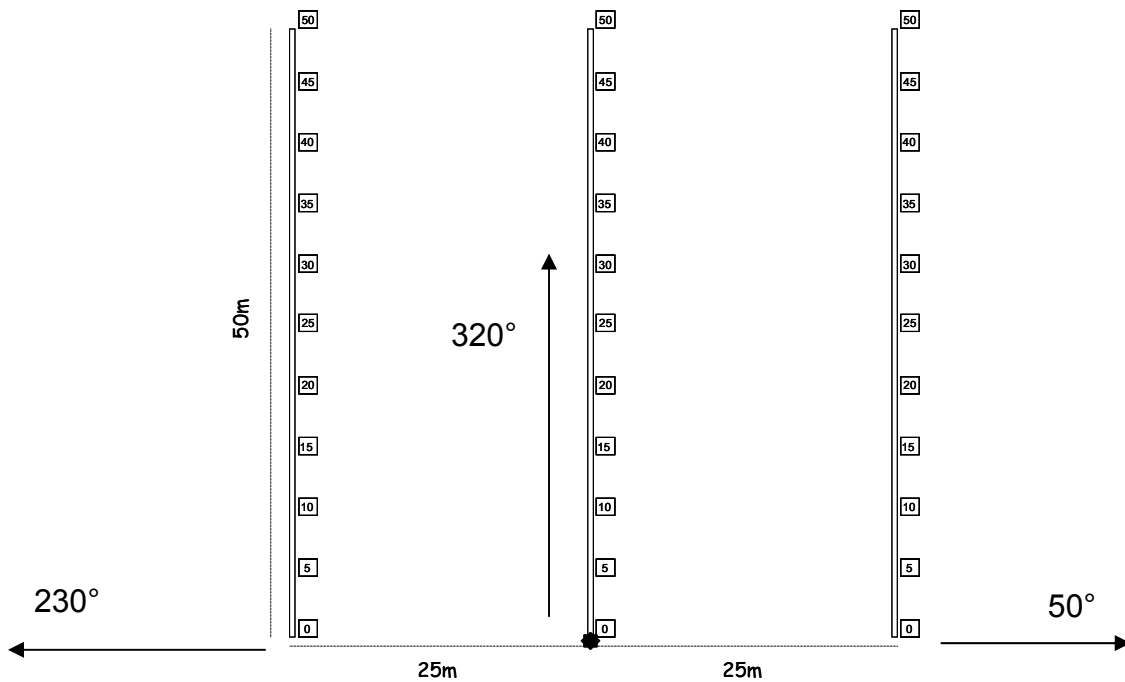
A problem can occur if there is a local magnetic attraction. For example, if you are carrying something of iron, it might disturb the arrow. Even a staple in your book might be a problem. Make sure there is nothing of the sort around. There is a possibility for magnetic attractions in the soil as well, "magnetic deviation", but they are rarely seen.

If the needle is directly aligned, you should now be facing 320 degrees. When you are sure you've got it right, fix your eye on some special feature on the horizon (e.g., a rock or coral) with the travel arrow and now head for it. If you are directing someone, keep them informed and line them up with hand signals when they reach the 50m mark.



When standing at the start of transect 2 and you want to find the start of transect 1, you need to change your compass bearing by subtracting 90 from the transect bearing (e.g., in the previous example,  $320-90= 230$ ). Measure 25m from the start of transect 2, heading 230 degrees, and put in the peg. This is the start of transect 1. Lay out transect 1 using the same procedure as you just completed for transect 2 (heading 320).

To locate the start of transect 3, you need to change your compass bearing by adding 90 from the transect bearing (e.g., in the previous example,  $320+90 = 410$ , but as only 360 in a compass your bearing will be 50). Measure 25m from the start of transect 2, heading 50 degrees, and put in the peg. This is the start of transect 3. Lay out transect 3 using the same procedure as you just completed for both transects 1 and 2 (heading 320).



# Making a herbarium press specimen

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

## **COLLECTION**

Before collecting any seagrass specimens, ensure you have the appropriate permits. Contact Seagrass-Watch HQ ([hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)) if you are unsure.

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

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

## **PRESSING**

### **Tools**

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

### **Preparation**

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

### **Arrangement**

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

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

## Labels

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

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

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

## Drying

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

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



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

Changing the paper is a very important step. In the first three or four days a paper change should take place every day, then you can leave more time between changes. If you neglect the change of paper the plants will take more time to lose their water content, besides they could be damaged if the paper stays wet for a few days. When



changing the paper you must keep the specimens intact and ensure the label travels with the specimen. The minimum time required for complete drying ranges from two to four days or more. Once a specimen has become dry and stiff, it can be mounted and placed into the herbarium.

## Mounting

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

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

## HERBARIA

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

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

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

# Understanding sediment

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

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

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

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

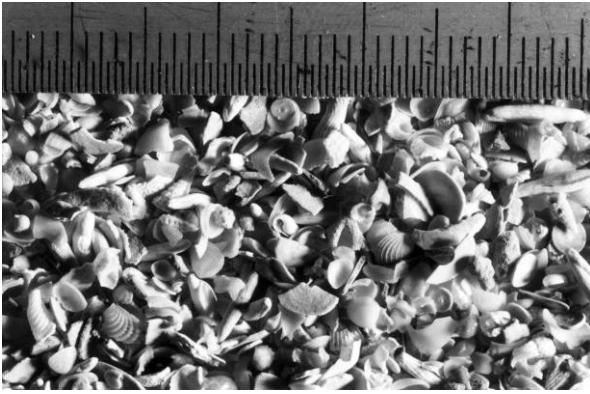
In Seagrass-Watch, the primary descriptors relate to the size of the sediment grains: gravel (>2000µm); coarse sand (>500 µm); sand (>250 µm); fine sand (>63 µm); and mud (<63 µm).

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

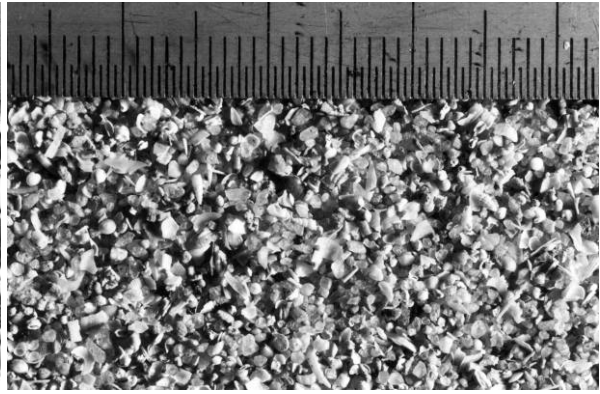
- mud** *has a smooth and sticky texture.*
- fine sand** *fairly smooth texture with some roughness just detectable. Not sticky in nature.*
- sand** *rough grainy texture, particles clearly distinguishable.*
- coarse sand** *coarse texture, particles loose.*
- gravel** *very coarse texture, with some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

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

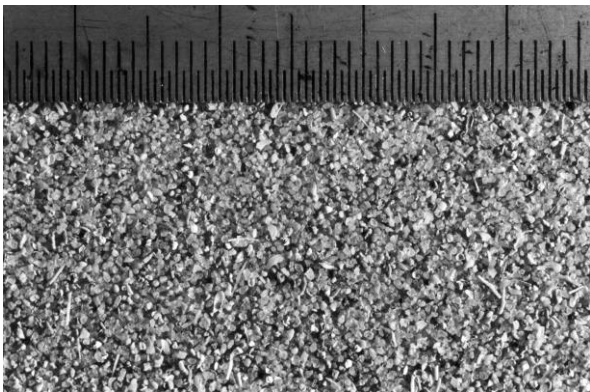
The visual/tactile estimation method used in Seagrass-Watch is a simple yet relatively accurate measure of the sediment grain size which can be used for quantitative assessments (see McKenzie 2007, [http://www.seagrasswatch.org/Info\\_centre/Publications/pdf/371\\_DPIF\\_McKenzie.pdf](http://www.seagrasswatch.org/Info_centre/Publications/pdf/371_DPIF_McKenzie.pd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



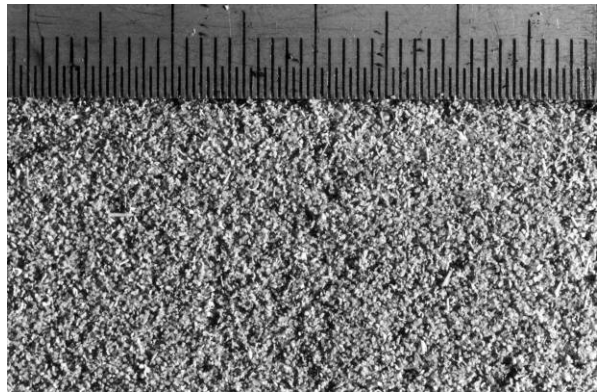
gravel (>2mm)



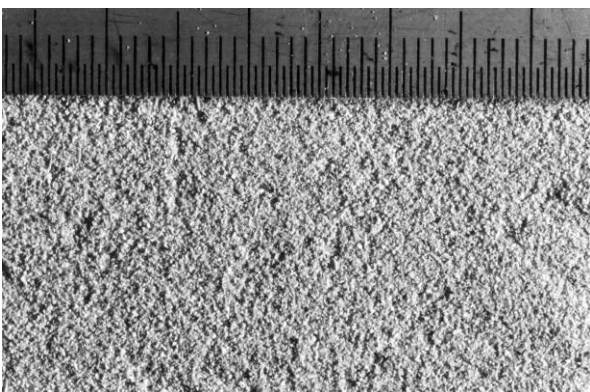
very coarse sand (1 - 2 mm)



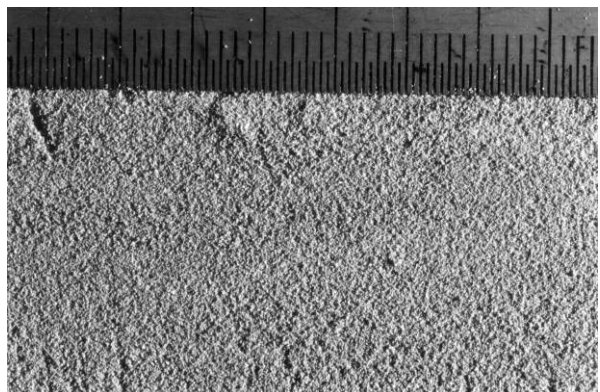
coarse sand (0.5 - 1 mm)



medium sand (0.25 - 0.5 mm)



fine sand (0.125 - 0.25 mm)



very fine sand (0.063 - 0.125mm)

**Notes:**

.....

.....

.....

.....

.....



# Data entry

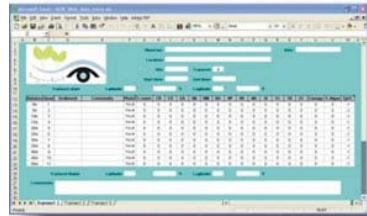
All data collected in the Seagrass-Watch program is the property of the group (principal) who collected it, and Seagrass-Watch HQ is custodian. When a group submits data to HQ, it does so under the proviso that the data can be used by Seagrass-Watch HQ for condition and trend reporting at location, regional, state, national and global scales (eg, State of the Environment). Copies of raw data are provided to third parties only when permission from the principal is provided.

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

Once you have monitored your Seagrass-Watch site, you can now enter the data collected into a downloadable Microsoft Excel spreadsheet and submit via email.

To enter the data, first go to the website

[http://www.seagrasswatch.org/data\\_entry.html](http://www.seagrasswatch.org/data_entry.html) and click on the datasheet image



- Save the spreadsheet file to your computer before you begin data entry. We suggest changing the file name to the site code and the sampling date, eg if the site was Town Beach, and it was sampled on 10 September 2010 then the filename would be "RO1\_10Sep10.xls"
- The spreadsheets are a similar layout to the standard datasheets. Each transect has its own worksheet. To select the appropriate worksheet, click on the tab at the bottom
- To enter data, select each cell with your mouse. You can jump between cells by using the TAB button on your keyboard.
- First enter the name of the observers and the sampling date.
- Enter the location and site code. For the above example, the location is "Town Beach" and the site code is "RO1".
- Enter the time you started sampling the transect and the time you finished. Times are entered at 24 hr with the hour separated from the minutes by a colon. For example, if the time was half past one in the afternoon, the time entered would be "13:30".
- If you had a GPS (Global Positioning System) at the monitoring site, the latitude and longitude of the transect start



- Enter the data for each quadrat

*Sediment:* enter by the dominant grain size first, separating sediment categories by a forward slash. For example, if the quadrat was predominantly mud with some sand, then the data would be entered as "Mud/Sand". *Please do not use abbreviations "M/S" when entering into the spreadsheet.*

*Comments:* Enter information (including counts) of any features which may be of interest. For example, "sea cucumbers (x2), sea urchin (x1), evidence of turtle cropping"

*Photograph:* type in "True" if you took a photo of the quadrat

*% cover:* enter the total percent cover of seagrass within the quadrat

*% cover by species:* enter the percentage cover that each species contributes to the total cover

*Photograph:* type in "True" if you took a photo of the quadrat

*% cover:* enter the total percent cover of seagrass within the quadrat. *There is no need to write %.*

*% cover by species:* enter the percentage cover that each species contributes to the total cover

*Canopy:* enter the three canopy heights of the dominant strap leaf species (*the average will calculate automatically*)

*% Algae:* enter the percent cover of macro-algae in the quadrat. Macro-algae are seaweeds that are not attached to seagrass leaves and may even overlie the seagrass shoots. The combined seagrass and algae cover may be greater than 100%.

*Epi %:* Enter the percentage cover of epiphytes on the total seagrass leaves.

- Enter the latitude and longitude of the transect finish
- Enter any general comments about the transect or site
- **Repeat steps 5 to 10 for the remaining transects**
- Ensure your file is securely saved

Submit a copy of the excel file via internet to Seagrass-Watch HQ  
[hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)

Mail original datasheets, photos and herbarium sheets to  
**Seagrass-Watch HQ**  
 PO Box 5396  
 Cairns Qld 4870  
 AUSTRALIA



# 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 clamation and changes in land use. Increases in dredging and landfill, construction on the shoreline, commercial overexploitation of coastal resources, and recreational boating activities along with anthropogenic nutrient and sediment loading has dramatically reduced seagrass distribution in some parts of the world. Anthropogenic impacts on seagrass meadows continue to destroy or degrade coastal ecosystems and decrease the function and value of seagrass meadows including their contribution to fisheries. It is possible global climate change will have a major impact. Efforts are being made toward rehabilitation of seagrass habitat in some parts of the world: transplantation, improvement of water quality, restrictions on boating activity, fishing and aquaculture, and protection of existing habitat through law and environmental policy.

## Management

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

Seagrasses 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](http://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 that are robust to challenge
6. There is effective enforcement and punishment if damage occurs

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

Consequently a combination of modern “western” science and indigenous knowledge should be brought together within a co-management framework for the successful management of these resources. (Johannes 2002; Aswani & Weiant 2004; Turnbull 2004; Middlebrook and Williamson 2006; Gaskell 2003, George et al. 2004). This can only occur if the resource owners actively involve themselves in the management of their resources. Western science also needs to recognise that resource owners have practical and spiritual connections with the resources found within their environment. Once this is recognized then this approach will have the added benefit of empowering communities who own the knowledge to be the primary managers and leaders in decisions about their land and sea country.

# References

- Aswani, S., Weiant, P. (2004). Scientific evaluation in women's participatory management: monitoring marine invertebrate refugia in the Solomon Islands. *Human Organisation* **63** (3), 301-319.
- Bité, J.S., Campbell, S.J., McKenzie, L.J. and Coles, R.G. (2007). Chlorophyll fluorescence measures of seagrasses *Halophila ovalis* and *Zostera capricorni* reveal differences in response to experimental shading. *Marine Biology* **152**: 405–414.
- Campbell, S.J. and McKenzie, L.J. (2004). Flood related loss and recovery of intertidal seagrass meadows in southern Queensland, Australia. *Estuarine, Coastal and Shelf Science* **60**: 477-490.
- Coles RG, McKenzie LJ and Campbell SJ. (2003). The seagrasses of eastern Australia. Chapter 11 In: World Atlas of Seagrasses. (EP Green and FT Short eds) Prepared by the UNEP World Conservation Monitoring Centre. (University of California Press, Berkeley. USA). Pp 119-133.
- Conacher, C., Thorogood, J. and Boggon, T. (1999). Resurvey of long-term seagrass monitoring sites in the Great Sandy Strait and Tin Can Inlet: February 1999. Unpublished report to the Cooloola Fishermen's Festival Association Inc., Hervey Bay Seafood Festival Associated Inc. and the Heritage Trust. 26 pp.
- Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neil RV, Paruelo J, Raskin RG, Sutton P and van der Belt M. (1997). The Value of the world's ecosystem services and natural capital. *Nature* **387**(15): 253-260.
- Dredge, M., Kirkman H., and Potter, M. (1977). A Short term Biological Survey. Tin Can Inlet/Great Sandy Strait. Division of Fisheries and Oceanography (CSIRO, Sydney). 29pp
- Fisheries Research Consultants (1993). Aerial photographic survey of seagrasses: the Great Sandy Strait and Tin Can Inlet. Report prepared for the Queensland Department of Environment and Heritage.
- Fisheries Research Consultants (1994). A re-survey of the seagrasses of the Great Sandy Strait and Tin Can Estuary, November 1993. Report prepared for the Queensland Department of Environment and Heritage. 34.pp.
- Gaskell, J. (2003). Engaging science education within diverse cultures. *Curriculum Inquiry*. **33**: 235-249.
- George, M., Innes, J., Ross, H. (2004). Managing sea country together: key issues for developing co-operative management for the Great Barrier Reef World Heritage Area. CRC Reef Research Centre Technical Report No 50, CRC Reef Research Centre Ltd, Townsville.
- Green EP. and Short FT (Eds) (2003). World Atlas of Seagrasses. Prepared by the UNEP World Conservation Monitoring Centre. (University of California Press, Berkeley. USA). 298pp.
- Hardin, G. (1968). The tragedy of the commons. *Science, New Series* **162** (3859), 1243-1248.
- Johannes, R.E. (2002). The renaissance of community-based marine resource management in Oceania. *Annu. Rev. Ecol. Syst.* **33**: 317-340.
- Lee Long WJ, Coles RG, Miller KJ, Vidler KP and Derbyshire KJ (1992). Seagrass beds and juvenile prawn and fish nursery grounds: Water Park Point to Hervey Bay, Queensland. *QDPI Information Series* QI92011. 39pp.
- Lee Long WJ, Mellors JE and Coles RG (1993). Seagrasses between Cape York and Hervey Bay, Queensland, Australia. *Australian Journal of Marine and Freshwater Research* **44**: 19-32.



- Lennon, P. and Luck, P. (1990). Seagrass mapping using landsat TM data: a case study in southern Queensland. *Asian Pacific Remote Sensing Journal* **2**:2
- Marsh, H. and Lawler, I. (2001) Dugong distribution and abundance in the southern Great Barrier Reef Marine Park and Hervey Bay: Results of an aerial survey in October- December 1999. Report to Great Barrier Reef Marine Park Authority.
- McKenzie, L.J. (2000). Seagrass communities of Hervey Bay and the Great Sandy Strait - December 1998. Queensland Department of Primary Industries GIS.
- McKenzie, L.J. (2009) Observing change in seagrass habitats of the GBR– Seagrass-Watch monitoring: Deriving seagrass abundance indicators for regional habitat guidelines. Attachment 1. In McKenzie, L.J. and Waycott, M. Marine and Tropical Sciences Research Facility Milestone and Progress Report #3, 2008-2009 (ARP 3) Project 1.1.3 Report 3, 11th June 200. pp.7-15.
- McKenzie, L.J. and Campbell, S.J. (2003). Seagrass resources of the Booral Wetlands and the Great Sandy Strait: February/March 2002. QDPI Information Series QI03016 (DPI, Cairns) 28 pp
- McKenzie, L.J., Roder, C.A., Roelofs, A.J. and Lee Long W.J. (2000). Post-flood monitoring of seagrasses in Hervey Bay and the Great Sandy Strait, 1999. *QDPI Information Series* No. QI00059, (QDPI, Brisbane) 46 pp.
- 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
- Middlebrook, R., Williamson, J.E. (2006). Social attitudes towards marine resource management in two Fijian villages. *Ecological Management & Restoration* **7** (2): 144-147.
- Preen A.R., Lee Long W.J. and Coles R.G. (1995). Flood and cyclone related loss, and partial recovery, of more than 1000 km<sup>2</sup> of seagrasses in Hervey Bay, Queensland, Australia. *Aquatic Botany* **52**:3-17.
- Smyth, D., Fitzpatrick, J., Kwan, D. (2006). Towards the development of cultural indicators for marine resource management in Torres Strait. CRC Torres Strait, Townsville. 61 pp.
- Turnbull, J. (2004). Explaining complexities of environmental management in developing countries: lessons from the Fiji Islands. *The Geographical Journal* **170** (1), 64–77.
- Waycott, M, McMahan, K, Mellors, J., Calladine, A., and Kleine, D (2004) A guide to tropical seagrasses in the Indo-West Pacific. (James Cook University Townsville) 72pp.

### **Further reading:**

- Sheppard, J.K., Lawler, I.R. and Marsh, H. (2007). Seagrass as pasture for seacows: Landscape-level dugong habitat evaluation. *Estuarine, Coastal and Shelf Science* **71**: 117-132.
- Carruthers TJB, Dennison WC, Longstaff BJ, Waycott M, Abal EG, McKenzie LJ and Lee Long WJ. (2002). Seagrass habitats of northeast Australia: models of key processes and controls. *Bulletin of Marine Science* **71**(3): 1153-1169.
- Coles, R. G., McKenzie, L. J., Rasheed, M. A., Mellors, J. E., Taylor, H., Dew, K. McKenna, S., Sankey, T. L., Carter A. B. and Grech A. (2007). Status and Trends of seagrass in the Great Barrier Reef World Heritage Area: Results of monitoring in MTSRF project 1.1.3 Marine and Tropical Sciences Research Facility, Cairns (108 pp).
- den Hartog C. (1970). The seagrasses of the world. (North-Holland Publishing, Amsterdam). 293pp.



- Green EP and Short FT (Eds) (2003). *World Atlas of Seagrasses*. Prepared by the UNEP World Conservation Monitoring Centre. Uni California Press, Berkeley. USA. 298 pp.
- Hemminga M and Duarte CM. (2000). *Seagrass ecology*. United Kingdom: Cambridge University Press.
- Kirkman H (1997). *Seagrasses of Australia*. Australia: State of the Environment .Technical Paper Series (Estuaries and the Sea), Department of the Environment, Canberra.
- Lanyon JM, Limpus CJ and Marsh H. (1989). Dugongs and turtles: grazers in the seagrass system. In: *Biology of Seagrasses: A treatise on the biology of seagrasses with special reference to the Australian region*. (AWD Larkum, AJ McComb and SA Shepherd eds). (Elsevier: Amsterdam, New York). pp 610-34.
- Larkum AWD, Orth RJ and Duarte CM (2006). *Seagrasses: biology, ecology and conservation*. Springer, The Netherlands. 691 pp.
- Lee Long, W. J., Coles, R. G. & McKenzie, L. J. (2000) Issues for seagrass conservation management in Queensland. *Pacific Conservation Biology* 5, 321-328.
- McKenzie LJ, Lee Long WJ, Coles RG and Roder CA. (2000). Seagrass-Watch: Community based monitoring of seagrass resources. *Biol. Mar. Medit.* 7(2): 393-396.
- McMahon, K., Bengston-Nash, S., Mueller, J., Eaglesham, G. and Duke, N. (2003). Relationship between seagrass health and herbicide concentration in Hervey Bay and the Great Sandy Strait. Report to EPA, Queensland Parks and Wildlife, Maryborough. March 2003 (UQ, Brisbane).
- McRoy CP and Helfferich C. (1977). *Seagrass Ecosystems*. Marcel Dekker, New York.
- Orth RJ, Carruthers TJB, Dennison WC, Duarte CM, Fourqurean JW, Heck Jr KL, Hughes AR, Kendrick GA, Kenworthy WJ, Olyarnik S, Short FT, Waycott M and Williams SL. (2006). A Global Crisis for Seagrass Ecosystems. *BioScience* 56 (12): 987-996.
- Phillips, R.C, E.G Menez. (1988). *Seagrasses*. Smithsonian Institution Press, Washington, D.C. 104 pp.
- Poiner, I.R., Walker, D.I., and Coles, R.G. (1989). Regional Studies - Seagrass of Tropical Australia. In: *Biology of Seagrasses*. A.W.D. Larkum, A-J. McComb and S.A.Shepherd (Eds). Elsevier, Amsterdam, New York; 841 pp.
- Short FT and Coles RG. (Eds.) (2001). *Global Seagrass Research Methods*. Elsevier Science B.V., Amsterdam. 473 pp.
- Waycott M, Collier C, McMahon K, Ralph P, McKenzie L, Udy J and Grech A (2007) Vulnerability of seagrasses in the Great Barrier Reef to climate change. In *Climate Change and the Great Barrier Reef*, eds. Johnson JE and Marshall PA. Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Australia. Part II, Chapter 8, pp 193-235.



---

## Useful web links

**Seagrass-Watch** Official Site [www.seagrasswatch.org](http://www.seagrasswatch.org)

**Western Australian Seagrass Webpage** Focuses on Western Australian research and provides some general information and links to international seagrass sites. [www.science.murdoch.edu.au/centres/others/seagrass/](http://www.science.murdoch.edu.au/centres/others/seagrass/)

**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](http://www.reef.crc.org.au/seagrass/index.html)

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

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

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

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

**UNEP - World Conservation Monitoring Centre** Explains the relationship between coral reefs, mangroves and seagrasses and contains world distribution maps. [www.unep-wcmc.org](http://www.unep-wcmc.org)

for more links, visit [www.seagrasswatch.org/links.htm](http://www.seagrasswatch.org/links.htm)



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

**Please complete the following statements in your own words**

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

.....  
.....

*What I enjoyed most about the training was.....*

.....  
.....

*It could have been better if.....*

.....  
.....

*I did not realize that.....*

.....  
.....

*Now I understand that.....*

.....  
.....

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

.....  
.....  
.....



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

.....

.....

.....

Other comments.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

*Please hand in your form once you have completed it.*



**Thank you**