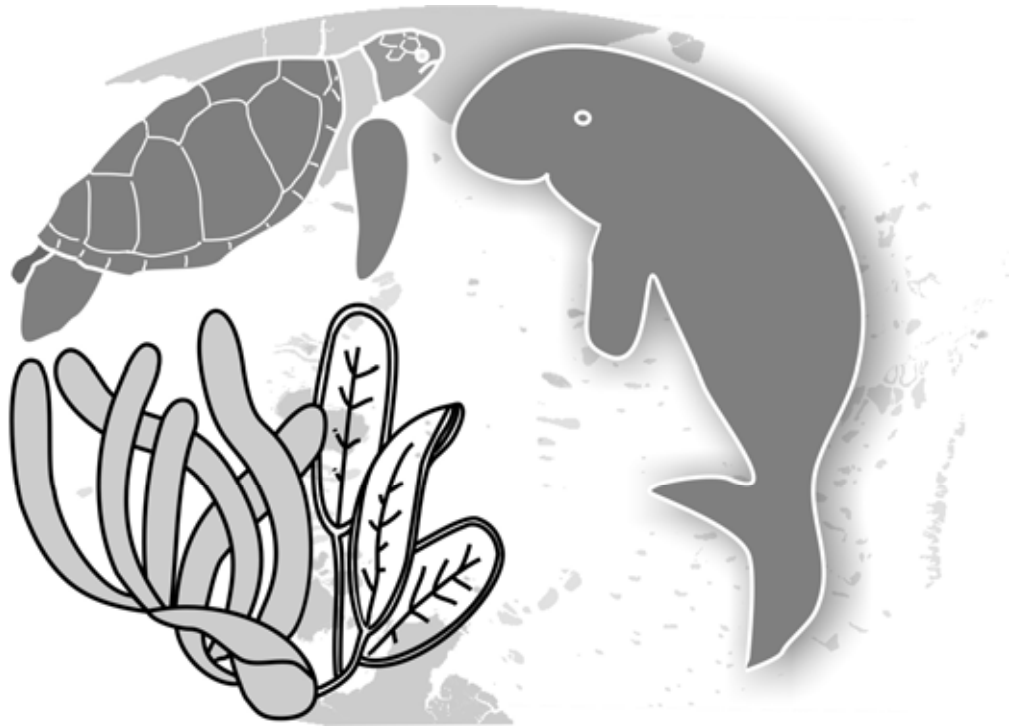


# Seagrass-Watch

Guidelines for Torres Strait Land & Sea Rangers



Port Kennedy Association Hall, Thursday Island

26<sup>th</sup> February 2007

Len McKenzie & Jane Mellors

Department of Primary Industries & Fisheries, Queensland



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# Overview

Seagrass-Watch is a monitoring program that brings interested individuals from community, government, non-government and management agencies together for the sustainability of seagrass habitats. It identifies areas important for seagrass species diversity and management. Information collected is used to assist 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*

It is also important to realise that the reasons for monitoring will also influence the monitoring plan and the methods used. A rapid method for monitoring seagrass resources is used in the Seagrass-Watch program.

The Seagrass-Watch program originated from

- *Community concerns about seagrass loss and habitat integrity*
- *Community interest in science, and*
- *Government objectives in long-term monitoring of critical fisheries habitats.*

The goals of the Seagrass-Watch program are:

- *Partnerships between Government and non-government organisations,*
- *Community participation and ownership of marine resources,*
- *Long-term & broad-scale monitoring of habitat, seasonal patterns, condition and trend data,*
- *An early warning system of coastal environment changes,*
- *Community education on the importance of seagrass resources, and*
- *Community awareness of coastal management issues.*
- *To provide training to build the capacity of local communities to collect information useful for the ongoing management and protection of important marine resources.*
- *Integrate with existing education, government, non-government and scientific programs to raise community awareness and preserve these important marine ecosystems for the benefit of the community.*



This workshop is hosted by the TSRA's Land & Sea Management Unit and Seagrass-Watch, Department of Primary Industries & Fisheries, as a key component of the Torres Strait Marine Debris Project funded under the Natural Heritage Trust. As part of this workshop we will

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

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

**Seagrass-Watch HQ**

Northern Fisheries Centre  
Queensland Department of Primary Industries & Fisheries  
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Cairns QLD 4870  
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Telephone (07) 4035 0131  
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*or visit*

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





# Workshop leaders



## Len McKenzie

Len is a Principal Scientist with the Queensland Department of Primary Industries & Fisheries and Seagrass-Watch Program Leader. He is also chief investigator for the MTSRF task on the condition, trend and risk in coastal seagrass habitats, Task Leader of the RWQPP Marine Monitoring Programme - Seagrass Monitoring and project leader for a series of projects involving the assessment and sustainable use of coastal fisheries habitat. Len has 19 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 Queensland 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.

### **Current Projects**

- Seagrass-Watch community seagrass monitoring
- Status and mapping of seagrass resources in Queensland
- Assessment of primary and secondary productivity of tropical seagrass ecosystems
- Investigations on the macrofauna associated with seagrass meadows
- Water Quality and Ecosystem Monitoring Programs – Reef Water Quality Protection Plan



## Jane Mellors

Jane is a Fisheries Biologist with the Queensland Department of Primary Industries & Fisheries. Jane has over 20 years experience in seagrass related research and monitoring. She is the project Leader for the Torres Strait, Education opportunities for indigenous involvement in marine ecosystem monitoring project. Jane is a specialist in tropical seagrass eco-physiology, seagrass taxonomy, geochemistry of marine sediments and marine invertebrate taxonomy pertaining to seagrass meadow communities. In 2003, Jane completed her Doctorate (Dept TESAG, James Cook University) on sediment and nutrient dynamics in coastal intertidal seagrass meadows of north eastern Australia of North Queensland.

### **Current Projects**

- Seagrass-Watch community seagrass monitoring
- CRC Torres Strait Education opportunities for indigenous involvement in marine ecosystem monitoring
- Co-author of a guide to tropical seagrasses of the Indo-west Pacific
- Investigations on the effects of nutrients on tropical seagrasses
- Water Quality and Ecosystem Monitoring Programs – Reef Water Quality Protection Plan





# Agenda

## Monday 26<sup>th</sup> February 2007

Morning	0845 - 0900	Welcome & Introduction – <i>Pearson &amp; Miya</i>
	0900 – 0930	Seagrass Biology & Identification - <i>Jane Mellors</i>
	0930 – 1015	Laboratory exercise: Seagrass Identification & how to prepare a seagrass press specimen - <i>Len, Jane &amp; Rudi Yoshida</i>
		Morning Tea
	1030 - 1100	Seagrass Ecology and Threats - <i>Len McKenzie</i>
	1100– 1115	Seagrass monitoring - <i>Len McKenzie</i>
	1115 – 1215	Seagrass-Watch - <i>Len McKenzie &amp; Jane Mellors</i>
		Lunch
Afternoon	1300 - 1330	Global Positioning Systems - <i>Len McKenzie</i>
	1330 - 1430	Field exercise: using a GPS - <i>Len &amp; Rudi</i>
		<b>Field exercise:</b>
	1530 - 1540	Safety briefing & risk assessment – <i>Jane Mellors</i>
	1545 - 1730	Seagrass-Watch – <i>Len, Jane &amp; Rudi</i>
		<i>Where: Back Beach, meet at croc sign 3:30pm</i>
		<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</i></li> <li>• <i>polaroid sunglasses (not essential)</i></li> <li>• <i>enthusiasm</i></li> </ul>
		<i>You will be walking across a seagrass meadow exposed with the tide, through shallow water. It may be wet and muddy!</i>
		<i>Please remember, seagrass meadows are an important resource and are protected by law. We ask that you use discretion when working/walking on them.</i>

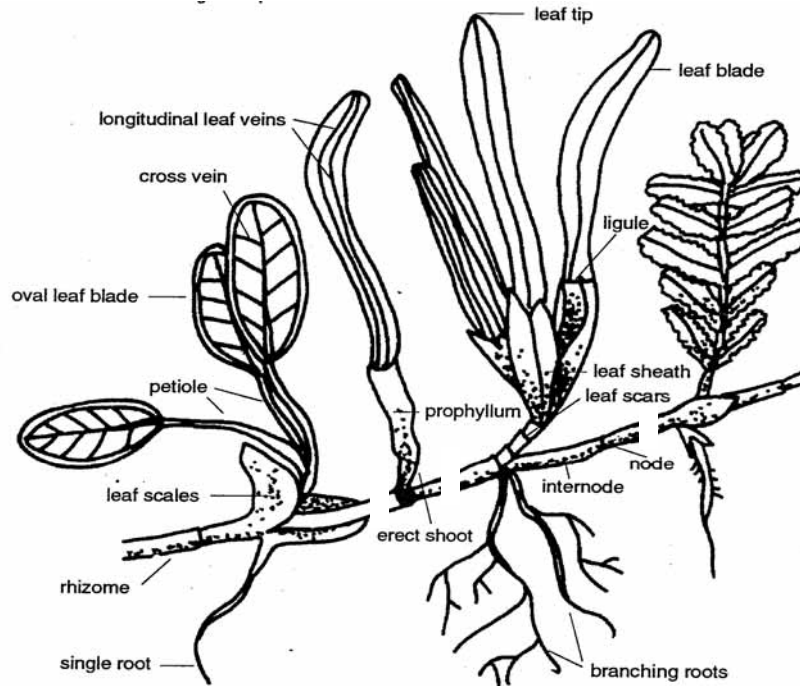
- *Low tide: 0.38m at 17:33*





# Background

Seagrasses are specialised marine flowering plants that have adapted to the nearshore environment of most of the world's continents. Most are entirely marine although some species cannot reproduce unless emergent at low tide. Some seagrasses can survive in a range of conditions encompassing fresh water, estuarine, marine, or hypersaline. There are relatively few species globally (about 60) and these are grouped into just 13 Genera and 5 Families.



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

from Lanyon (1986)

Various common names are applied to seagrass species, such as turtle grass, eelgrass and shoal grass. These names are not consistently applied among countries and in any case are not commonly used in northern Australia. For example, "ial-damu" is the Torres Strait western language name for *Cymodocea* sp and *Zostera capricorni* (Fitzpatrick et al. 2006), however we are not aware of any name for seagrass species used consistently through sea country. Coastal communities would almost certainly recognise the term "dugong grass" as referring to the shallow subtidal and intertidal seagrasses.

There is now a broad understanding of the range of species and seagrass habitats. Areas less well known include the southeast Pacific reefs and islands, South America, the southern Atlantic, the Indian Ocean islands, the west African coast, and Antarctica. Shallow sub-tidal and intertidal species distributions are better recorded than seagrasses in water greater than 10 m below MSL. Surveying deeper water seagrass is time consuming and expensive and it is likely that areas of deepwater seagrass are still to be located.

A number of general parameters are critical to whether seagrass will occur along any stretch of coastline. These include physical parameters that regulate the physiological activity of seagrasses (temperature, salinity, waves, currents, depth, substrate and day length), natural phenomena that limit the photosynthetic activity of the plants (light, nutrients, epiphytes and diseases), and anthropogenic inputs that inhibit the access to available plant resources (nutrient and sediment loading). Various combinations of these parameters will permit, encourage or eliminate seagrass from a specific location.



Tropical seagrasses occupy a variety of coastal habitats. Tropical seagrass meadows typically occur in most shallow, sheltered soft-bottomed marine coastlines and estuaries. These meadows may be monospecific or may consist of multispecies communities, sometimes with up to 12 species present within one location. The stresses and limitations to seagrasses in the tropics are generally different than in temperate or subarctic regions. Temperature related impacts most often result from high water temperatures or overexposure to warm air; osmotic impacts result from hypersalinity due to evaporation; radiation impacts result from high irradiance and UV exposure.

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. Seagrasses survive in the intertidal zone especially in sites sheltered from wave action or where there is entrapment of water at low tide, (e.g., reef platforms and tide pools), protecting the seagrasses from exposure (to heat, drying or freezing) at low tide.

*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 (Amesbury and Francis 1988).*

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

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

The habitat complexity within seagrass meadows enhances the diversity and abundance of animals. Seagrasses on reef flats and near estuaries are also nutrient sinks, buffering or filtering nutrient and chemical inputs to the marine environment. The high primary production rates of seagrasses are closely linked to the high production rates of associated fisheries. These plants support numerous herbivore- and detritivore-based food chains, and are considered as very productive pastures of the sea. The associated economic values of seagrass meadows are very large, although not always easy to quantify.

Tropical seagrass meadows vary seasonally and between years, and the potential for widespread seagrass loss has been well documented (Short and Wyllie-Echeverria 1996). The causes of loss can be natural such as cyclones and floods, or due to human influences such as dredging, agricultural runoff, industrial runoff or oil spills.

Loss of seagrasses has been reported from most parts of the world, sometimes from natural causes, e.g., high energy storms, or "wasting disease". More commonly, loss has resulted from human activities, e.g., as a consequence of eutrophication or land reclamation and changes in land use. Anthropogenic impacts on seagrass meadows are continuing to destroy or degrade these coastal ecosystems and decrease their yield of natural resources.

It is important to document seagrass species diversity and distribution and identify areas requiring conservation measures before significant areas and species are lost. Determining the extent of seagrass areas and the ecosystem values of seagrasses is now possible on a local scale for use by coastal zone managers to aid planning and





development decisions. Knowledge of regional and global seagrass distributions are still too limited and general for broad scale protection and management. Such information is needed to minimize future impacts on seagrass habitat worldwide. With global electronic communication it is now possible to begin the process of assembling both formally published and unpublished notes on the distribution of the world's seagrasses with the eventual aim of providing a global "report card" on the distribution and status of seagrass.

With well-recorded events of seagrass loss from many coastal environments it is important to map and record the distribution of not only the location of existing seagrass but also areas of potential seagrass habitat. Such areas are generally shallow, sheltered coastal waters with suitable bottom type and other environmental conditions for seagrass growth. Potential habitat may include areas where seagrass was known to grow at some time in the past but from which it has recently been eliminated.

Spatial and temporal changes in seagrass abundance and species composition must be measured and interpreted with respect to prevailing environmental conditions. These may need to be measured seasonally, monthly, or weekly, depending on the nature of their variability, and the aims of the study. Physical parameters important to seagrass growth and survival include light (turbidity, depth), sediment type and chemistry, and nutrient levels. Detailed studies of changes in community structure of seagrass communities are essential to understand the role of these communities and the effects of disturbance on their composition, structure and rate of recovery.







# Seagrasses of Torres Strait

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

Torres Strait has been described as the most extensive, ecologically complex shelf in the world, offering a multitude of habitats and niches for the great diversity of Indo-Pacific Marine fauna and flora. In the Torres Strait the seagrass communities are a diverse array of complex assemblages with most combinations of the eleven species found recorded in the field (Long and Poiner 1997).

Surveys of the open waters of Torres Strait have estimated 13,425 km<sup>2</sup> of seagrass habitat with meadows being concentrated in the north-central and southwest regions with very little seagrass to the east of Warrior Reefs (SOE 2007). Seagrass communities occur across the open sea floor, on reef flats and sub-tidally adjacent to continental islands. The Warrior Reefs have extensive seagrass-covered reef flats. A number of species co-occur on these flats; most commonly *Halodule uninervis*, *Thalassodendron ciliatum*, *Cymodocea rotundata*, and *Thalassia hemprichii*. These reef platform habitats are also important as nursery grounds for commercial juvenile penaeid prawns (Turnbull and Mellors 1990). Around the central islands seagrasses tend to be restricted to intertidal areas landward of the reef crest or on reef flats. *Enhalus acoroides* (a species common throughout the Torres Strait) is generally restricted to shallow subtidal and intertidal regions. The large expanses of open water bottom are covered with either sparsely distributed *Halophila* or mixed species (*Halodule*, *Thalassia* and *Syringodium*) communities. Lush *Halophila ovalis* and *Halophila spinulosa* communities are also found in the deep waters (>30m) of the south-western Torres Strait.

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

Based on results of this baseline survey in 2002, the Queensland Department of Primary Industries and Fisheries (QDPI&F) in conjunction with PCQ (Ports Corporation Queensland) established a long-term seagrass monitoring strategy for the port to ensure that the ongoing health of the port's marine environment could be maintained. Nine representative seagrass meadows, located in areas likely to be vulnerable to impacts from port operations and developments, were identified and selected for long-term monitoring. The first survey since the baseline survey was conducted in March 2004 (Thomas & Rasheed, 2004). Results from the March 2004 survey indicated that seagrass communities at the Port of Thursday Island were healthy. Significant



increases in seagrass biomass were recorded for four of the nine monitoring meadows since the March 2002 baseline survey. There were no apparent anthropogenic impacts from port operations or developments that influenced seagrass growth at Thursday Island since March 2002. (Thomas & Rasheed, 2004).

Regular detailed monitoring in this region started in March 2004 when Seagrass-Watch was established on the intertidal meadows associated with Thursday Island and Horn Island. ([www.seagrasswatch.org](http://www.seagrasswatch.org)). The monitored sites are:

### **Back Beach (TI1)**

The seagrass meadow at Back Beach (Thursday Island) is an extensive intertidal fringing reef top meadow. On its landward edge it is fringed by mangroves which are used as a roost for a flying fox colony. Seagrass species diversity at this site is high. As many as seven species can co-occur in one quadrat. Species that regularly occur within this site are *Halodule uninervis*, *Cymodocea serrulata*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Halophila ovalis* and *Enhalus acoroides*. *Syringodium isoetifolium* occasionally turns up in quadrats on the seaward edge of the site. Most recently a single plant of *Halophila spinulosa* appeared in one quadrat. Octopus, crabs and large molluscs flourish at this location ideally demonstrating the notion of seagrass meadows as habitats of great biodiversity. *Enhalus* flowers and fruits are also a common sight at this location.

### **Front Beach (TI2)**

This is a highly disturbed meadow due to its location at the receiving end of many storm water drains on Thursday Island. During the wet season the storm water drains deliver large quantities of freshwater and sediment to this meadow. The meadow overall is quite patchy. The upper intertidal zone is occupied by *Halodule uninervis* and *Halophila ovalis*. Traversing the meadow seawards, *Enhalus acoroides*, *Thalassia hemprichii* and *Cymodocea serrulata* become more abundant. Within the Seagrass-Watch site, seagrass cover is sparse, with *Halodule uninervis* being the most abundant species present inshore with *Enhalus* and *Thalassia* occurring in the seaward quadrats.

### **Wongai Beach (HI1)**

The meadow at Wongai Beach (Horn Island) is similar to the meadow at Front Beach Thursday Island, in that it has *Halodule uninervis* and *Halophila ovalis* occupying the landward edge of the meadow and *Enhalus acoroides* and *Thalassia hemprichii* seaward. However that is where all similarities end. HI1 has an extremely muddy substrate and in comparison has higher densities of seagrass and seeds. *Zostera capricorni* has also been noted at this site close to transect 3. During one monitoring trip, large numbers of small sea hares were observed on the site demonstrating the seagrasses' function as a nursery area.

Widespread die back of seagrasses has been reported in the past in the central and northern regions of the Torres Strait. More than 1400 square kilometres of seagrass was lost between 1989 and 1993. There is anecdotal evidence of earlier dieback incidents in the 1970's (Long *et al.* 1997). It is possible this is a natural cyclical event but that has not yet been determined. The seagrasses of this region may be impacted by a number of activities, including: storm run-off during wet season; migrating sand waves, trampling; boat traffic; small scale infra structure works; shipping and port activities/accidents; anchoring; careening of vessels; introduced marine pests, and climate change.







# A guide to the identification of western Pacific Seagrasses

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

## Leaves cylindrical



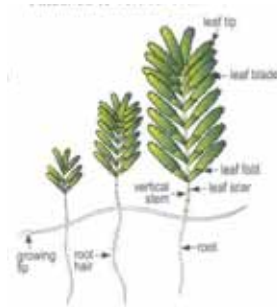
### *Syringodium isoetifolium*

- Leaf tip pointed
- Leaves contain air cavities
- Inflorescence a “cyme”

## Leaves oval to oblong



### obvious vertical stem with more than 2 leaves



### *Halophila spinulosa*

- leaves arranged opposite in pairs
- leaf margin serrated

### *Halophila tricostata*

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

### leaves with petioles, in pairs



### *Halophila ovalis*

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

### *Halophila decipiens*

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

### *Halophila minor*

- Leaf less than 5mm wide
- cross veins up to 10 pairs
- leaf margins smooth
- no leaf hairs
- separate male & female plants

### *Halophila capricorni*

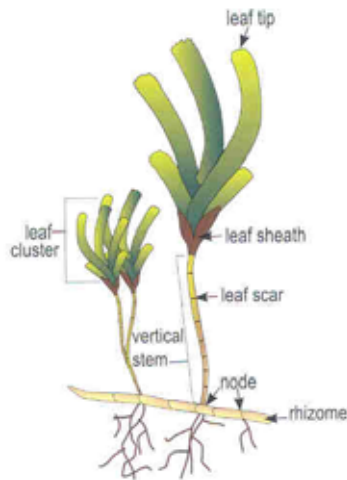
- leaf margins serrated
- fine hairs on one side of leaf blade
- separate male & female plants



## Leaves strap-like



### Leaves can arise from vertical stem



#### *Thalassia hemprichii*

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

#### *Cymodocea serrulata*

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

#### *Cymodocea rotundata*

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

#### *Halodule uninervis*

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

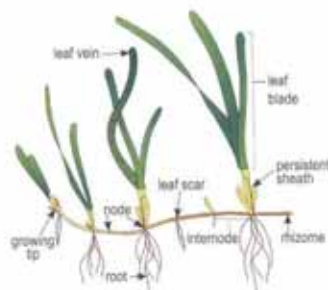
#### *Halodule pinifolia*

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

#### *Thalassodendron ciliatum*

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

### Leaves always arise directly from rhizome



#### *Enhalus acoroides*

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

#### *Zostera capricorni*

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





# 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 shades seagrasses, also reducing photosynthetic capacity;
- increased sedimentation can smother seagrass or interfere with photosynthesis;
- herbicides can kill seagrass and some chemicals (e.g., pesticides) can kill associated macrofauna;
- boating activity (propellers, mooring, anchors) can physically damage seagrass meadows, from shredding leaves to complete removal;
- storms, floods and wave action can rip out patches of seagrasses.

## Seagrass-Watch

A simple method for monitoring seagrass resources is used in the Seagrass-Watch program. This method uses 50m by 50m sites established within representative intertidal meadows to monitor seagrass condition. The number and position of sites can be used to investigate natural and anthropogenic impacts.

Seagrass-Watch is one of the largest seagrass monitoring programs in the world. Since it's genesis in 1998 in Australia, Seagrass-Watch has now expanded internationally to 18 countries. Monitoring is currently occurring at over 165 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 and sustainability. 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 public awareness of these important marine ecosystems 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 sustainability and the



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

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

THE GOALS OF THE PROGRAM ARE:

- To educate the wider community on the importance of seagrass resources
- To raise community awareness of coastal management issues
- To develop community participation and ownership
- To build the capacity of local communities in the use of standardised scientific methodologies
- To conduct long-term & broad-scale monitoring of seagrass & coastal habitats, and
- To provide an early warning system of coastal environment changes for management.

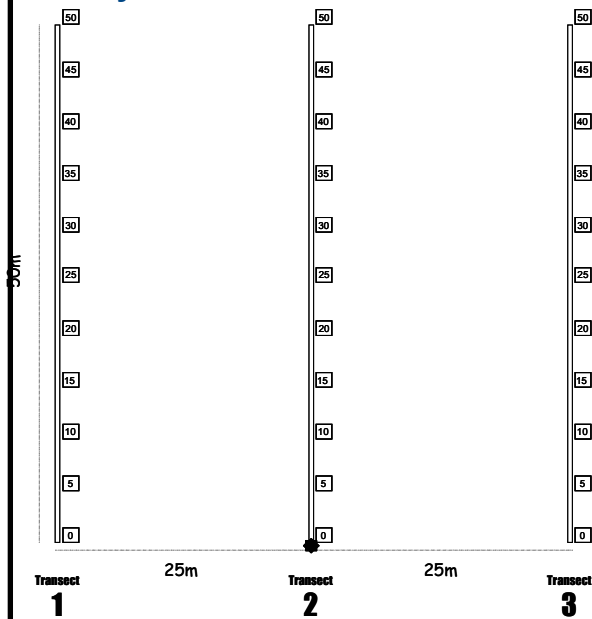




# Seagrass-Watch Monitoring Summary

Source: McKenzie, L.J., Campbell, S.J. & Roder, C.A. (2001) *Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers*. (QFS, NFC, Cairns) 100pp ([www.seagrasswatch.org/manuals.html](http://www.seagrasswatch.org/manuals.html))

## Site layout



**Quadrat code = site + transect+quadrat**

**e.g., T11225 = Thursday Is site 1, transect 2, 25m quadrat**

## Pre-monitoring preparation

### Make a Timetable

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

### Have a Contact Person

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

## Safety

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

## Necessary equipment and materials

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

## Quarterly sampling

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

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

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

### Step 2. Describe sediment composition

- To assess the sediment, 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. Estimate seagrass percent cover**

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

### **Step 4. Estimate seagrass species composition**

- Identify the species of seagrass within the quadrat and determine the percent contribution of each species to the cover (must total 100%). Use seagrass species identification keys provided.

### **Step 5. Measure canopy height**

- Measure canopy height of the seagrass ignoring the tallest 20% of leaves. Measure from the sediment to the leaf tip of at least 5 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”.

### **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%).

### **Step 9. 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).

### **Step 10. 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 number of other observers assisting.

### **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  
Northern Fisheries Centre  
PO Box 5396  
Cairns QLD 4870 AUSTRALIA



# Seagrass mapping

Seagrass-Watch activities initially map the distribution of seagrass meadows at a locality or in a region to better understand the seagrass resources of an area. Mapping is often limited to the accessible intertidal seagrasses, although in some cases subtidal seagrass meadows can be included.

The most important information that is required for management of seagrass resources is their distribution, ie. a map. It would be inappropriate to set up a monitoring program if the most basic information is unavailable - that is, whether seagrass is present or absent.

When planning a mapping task, there are several issues that need to be considered, including:

## *Scale*

Mapping requires different approaches depending on whether survey area is relative to a region (tens of kilometres), locality (tens of metres to kilometres) or to a specific site (metres to tens of metres). Scale includes aspects both of extent and resolution. In both broad and large scale approaches, the intensity of sampling will be low (low resolution), with a statistical sampling design that allows the results to be extrapolated from a few observations to the extent of the study area. For finer scale examinations of seagrass meadows, the sampling intensity required can be high with greater precision (high resolution). Scale also influences what is possible with a limited set of financial and human resources. The financial, technical, and human resources available to conduct the study is also a consideration.

## *Accuracy*

Determining the level of detail required when mapping an area also depends on the level of accuracy required for the final map product. Errors that can occur in the field directly influence the quality of the data. It is important to document these. GPS is a quick method for position fixing during mapping and reduces point errors to <3m in most cases. It is important for the observer to be as close as possible to the GPS aerial receiver to minimise position fix error.

## *Choosing a Survey/Mapping strategy*

The selection of a mapping scale represents a compromise between two components. One is the maximum amount of detail required to capture the necessary information about a resource. The other is the logistical resource available to capture that level of detail over a given area. Generally, an area can be mapped using a grid pattern or a combination of transects and spots. When mapping a region of relatively homogenous coastline between 10 and 100 km long, we recommend that transects should be no further than 500-1000 m apart. For regions between 1 and 10 km, we recommend transects 100-500 m apart and for localities less than 1 km, we recommend 50-100 m apart. This however may change depending on the complexity of the regional coastline, i.e., more complex, then more transects required.

To assist with choosing a mapping strategy, it is a good idea to conduct a reconnaissance survey. An initial visual (reconnaissance) survey of the region/area will give you an idea as to the amount of variation or patchiness there is within the seagrass meadow. This will influence how to space your ground truthing sites.



When mapping, ground truthing observations need to be taken at regular intervals (usually 50 to 100m apart). The location of each observation is referred to a point, and the intervals they are taken at may vary depending on the topography.

When ground truthing a point, there are a variety of techniques that can be used depending on resources available and water depth (free dives, grabs, remote video, etc). First the position of a point must be recorded, preferably using a GPS. Otherwise use a handheld compass to determine the bearing, triangulating to at least 3 permanent landmarks or marker established as reference points. A point can vary in size depending on the extent of the region being mapped. In most cases a point can be defined as an area encompassing a 5m radius. Although only one observation (sample) is necessary at a ground truth point, we recommend replicate samples spread within the point (possible 3 observations) to ensure the point is well represented.

Observations recorded at a point should ideally include some measure of abundance (at least a visual estimate of biomass or % cover) and species composition. Also record the depth of each point (this can be later converted to depth below mean sea level) and other characteristics such as a description of the sediment type (eg. shell grit, rock, gravel, coarse sand, sand, fine sand or mud), or distance from other habitats (reefs or mangroves).

For details on the necessary materials & equipment and the general field procedure for mapping a seagrass meadow, please see Chapter 4 of the Seagrass-Watch manual ([www.seagrasswatch.org/manuals.html](http://www.seagrasswatch.org/manuals.html)).

## Creating the map

The simplest way to map the distribution of seagrasses is to draw the meadows on a paper marine chart from the GPS positions of the ground truth sites. The problem with this type of mapping is that the final map is in a format that does not allow manipulation and transformation. The layout of a paper map is permanent, which makes it difficult for future seagrass mapping studies to be compared, queried and analysed. If resources are available, we recommend that the data be transferred to a digital format and a Geographic Information System (GIS) be used. A detailed description of using and mapping with GIS is beyond the scope of this manual, and we recommend consulting with a scientist experienced in mapping and reading McKenzie *et al.* (2001b).





## Using Global Positioning System (GPS) to map the meadow edge/boundary

The meadow boundary is mapped by recording (or marking) a series of waypoints along the edge of the meadow from which a line representing the meadow boundary can then be drawn.

To map the boundary you should:

- Walk along the meadow edge, stopping to record (mark) waypoints on your GPS approximately every 10 steps or where there is a change in direction of the meadow boundary.
- Alternatively, you can use the “track” feature if the meadow boundary is clear.
- Only record a waypoint when you are sure you are on the edge of the meadow. For meadows where the edge is patchy you may have to do some reconnaissance to make sure you are at the edge of the seagrass meadow before recording a waypoint.
- Keep in mind that others may be using the points that you record on the GPS to draw a line (*“join the dots”*) that represents the meadow boundary, so it is better to have too many points than too few.
- Stand still for approximately 10 seconds on a point before recording (marking) a waypoint. It is good to keep checking the accuracy (in the top right of the screen) to ensure the point is as accurate as possible (generally less than 5m).
- As waypoints are labelled by sequential numbers, ensure you record the label of the first and last waypoint. If you make an error, either delete the waypoint or note the erroneous waypoint.
- At the conclusion of the sampling trip the waypoints you record should be downloaded onto your computer (see later section)

## Using the GARMIN GPS 72

### Turn GPS Receiver On.

Hold down the Red button for 2 seconds. Wait a few seconds and the GPS unit will begin to track available satellites. Make sure to hold the GPS in a vertical position (top to the GPS pointing to the sky) for best reception of satellite signals.





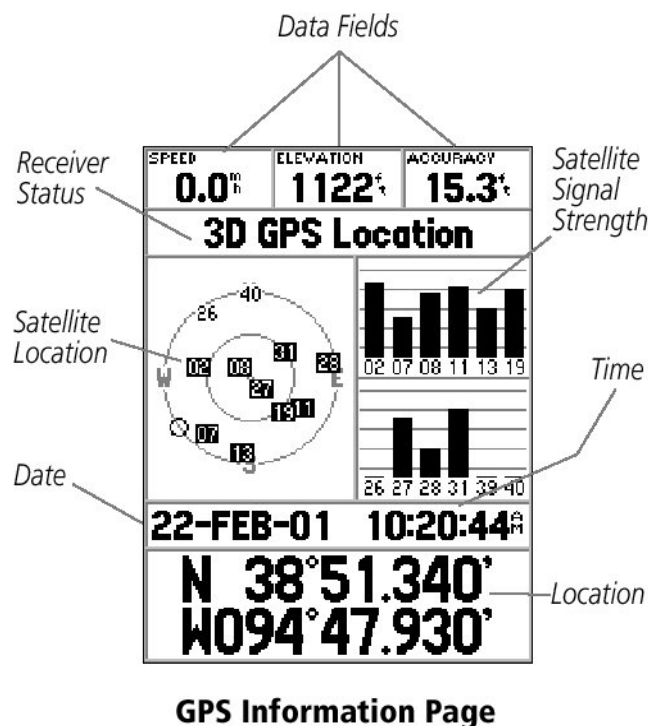


## Using the Interface Keys on the GPS

- **IN & OUT** keys – used on the Map Page to zoom in and out.
- **GOTO/MOB** key – used to begin or stop navigation to a waypoint.
- **PAGE** key – used to cycle through the five main display pages in sequence.
- **POWER** key – used to turn the GPS on or off by holding the button down for 2 seconds.
- **MENU** key – used to display a variety of GPS options which can be altered to suit usage. Press the Menu key twice to access the Main Menu.
- **QUIT** key – used to cycle in reverse to the Page key. Also used to cancel operation in progress.
- **ENTER/MARK** key – used to activate or confirm a selection. To record a Waypoint, press and hold down the ENTER/MARK key.
- **ROCKER** key – used to move up/down and left/right to access and change menu options, and for data entry. The ROCKER key is always used to scroll through the different menu options and the ENTER key is used to activate or confirm the selection.

## Tracking satellites.

Continue to press the PAGE key until the GPS Information Page appear (the Information Page looks like the diagram just below). When the GPS receiver is tracking enough satellites (minimum four), the GPS Information appears.



Receiver is now ready to record Waypoints. It is recommended that there are at least four satellites are present and have a strong signal when marking the waypoints. The more satellites available the better the accuracy.

Before any waypoints are to be collected, you must check that the GPS settings are correct. The settings are in the Main Menu.



## Setting up the correct properties in the Main Menu

- To get to the Main Menu you must press the **Menu** key twice.
- Scroll down to highlight “Setup” and press **Enter**.
  1. You must use the **ROCKER** key and move to the appropriate field and use the **ENTER** key to activate the field.
  2. Then use the **ROCKER** key (to move up/down and left/right) to access the appropriate setting and use the **ENTER** key to confirm selection.
  3. Once changes are made, use the **QUIT** to exit each of the option or menu.
- Scroll across to the “Time” tab and change to the Time settings.

### Time Setup

Time Format : 24 Hour  
Time Zone : Other  
UTC Offset: +10:00

- Scroll across to the “Location” tab and change to the Time settings.

### Units Setup

Elevation : Meters  
Distance and Speed: Metric  
Temperature: Celsius

- Scroll across to the “Location” tab and change to the Time settings.

## Location Setup

Location Format : hddd.ddddd  
MAP DATUM : WGS84

- Scroll across to the “Interface” tab and change to the Time settings.

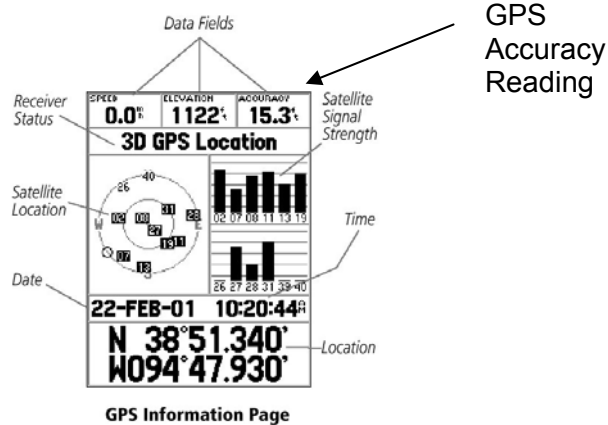
### Interface Setup

Serial Data Format: Garmin

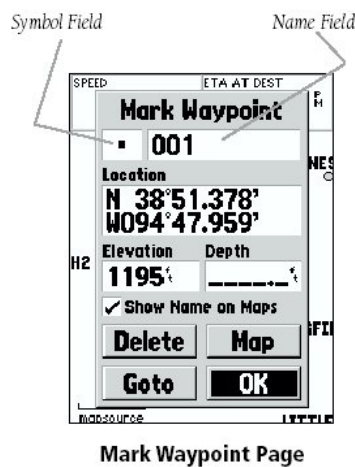
## Mark Location as Waypoints

Mark Waypoints are stored as point locations.

To record Waypoints, it is best to be in the Information Page (continue to press the PAGE button until the Information page appears). Before you record a Waypoint, you must look at the accuracy reading on the GPS Information Page. An acceptable accuracy should be less than 15 metres (<15 m)



**Step 1.** Press and hold the **ENTER** key. The following screen appears:



To save the waypoint without any changes, press **ENTER** on the OK button to save the waypoint.

- Step 2.** You can choose to rename the waypoint number to another name by using the **ROCKER** key to highlight the Name field, then press **ENTER**.
- Step 3.** Use the **ROCKER** key as an Alpha-numeric key selection to type in the new waypoint name. Press the **ENTER** key to accept the name.
- Step 4.** You can choose to delete the waypoint by highlighting 'DELETE?', press **ENTER** and then highlight the 'Yes' prompt and press **ENTER** again to confirm.

## Use the Goto option to get to a location.

- Press the **GOTO** key.
- Highlight the "Waypoint" then press the **ENTER** key.
- Use the **ROCKER** key to highlight the waypoint you want to go to, press the **ENTER** key.
- Press the **PAGE** key until you get to the Map Page to see where you are (use the **IN** or **OUT** key to zoom in or out). Press the **PAGE** key until you get to the Compass Page to see where you need to be heading to get to the waypoint.



## Installing the program MAPSOURCE to download information from your GPS to your computer

### Step 1: Installing MapSource

*Before installing MapSource, all programs should be closed.*

1. Put CD into the CD Drive (Place the CD in with CD labels facing up)
2. If the MapSource setup menu does not appear automatically, Go to **Windows Explorer** (Select Start, Programs, Windows Explorer)
  - Double Click on CD Drive (This could either be D: or E: drive on your computer)
  - Double click on "**Setup.exe**" (To startup the setup program [about 70kb])
    - i. Click **Next** (To say OK to the Welcome Page)
    - ii. Click **Yes** (To accept License Agreement)
    - iii. Click **No** (When ask to check GPS)
    - iv. Click **No** (To confirm not checking the GPS)
    - v. Click **Next** (To select typical install)
    - vi. Click **Finish** (To complete installation)

### Step 2: Installing Updated files for Mapsource

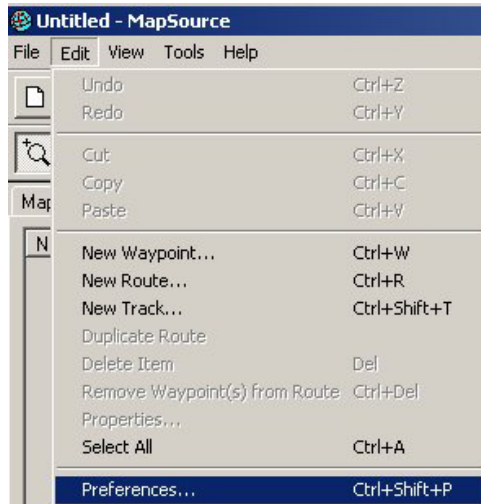
1. While the **CD** is still in the CD drive,
3. Go to **Windows Explorer** (Select Start, Programs, Windows Explorer)
2. Double Click on CD Drive (This could either be D: or E: drive on your computer)
3. Double Click the **Mapsource Upgrade** folder (You will see a MapSource\_680.exe file)
4. Double Click on the file **mapsource\_680.exe** (This will startup the setup program to MapSource)
5. Click **Next** (To choose English language)
6. Click **Next** (To accept MapSource Version 6.8)
7. Click **Yes** (To accept License Agreement)
8. Click **Finish** (To complete installation)
9. Eject CD and take disc out



### Step 3: Setting the correct Properties for MapSource

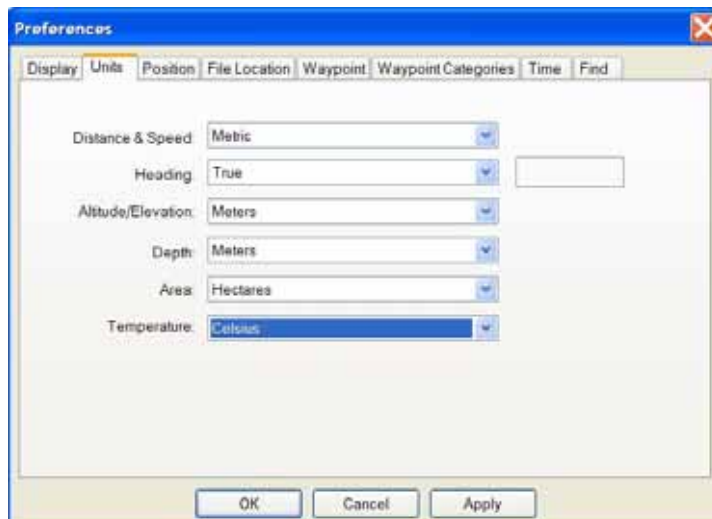
Before using MapSource you must set up some map properties to view the data.

1. Start MapSource (Click the MapSource Icon on the desktop)
2. Go to the **Edit** menu and select **Preferences**



3. The Preferences window will appear.

Go to the **Units** tab

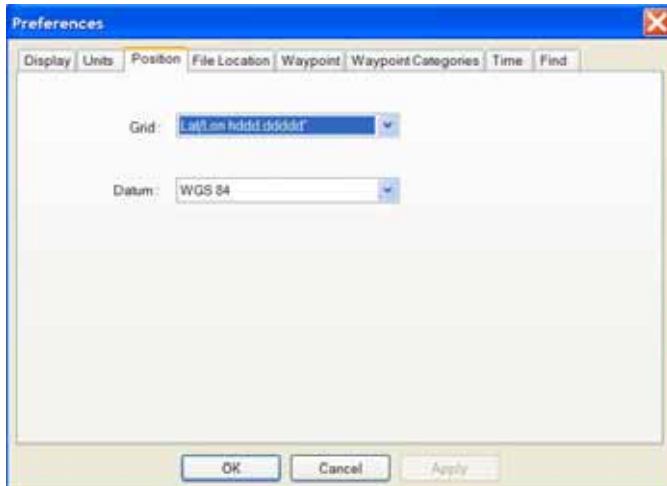


You must set the following properties:

- Distance & Speed      Metric
- Heading                True
- Altitude/Elevation    Meters
- Depth                  Meters
- Area                    Hectares
- Temperature          Celsius



4. Go to the **Position** tab

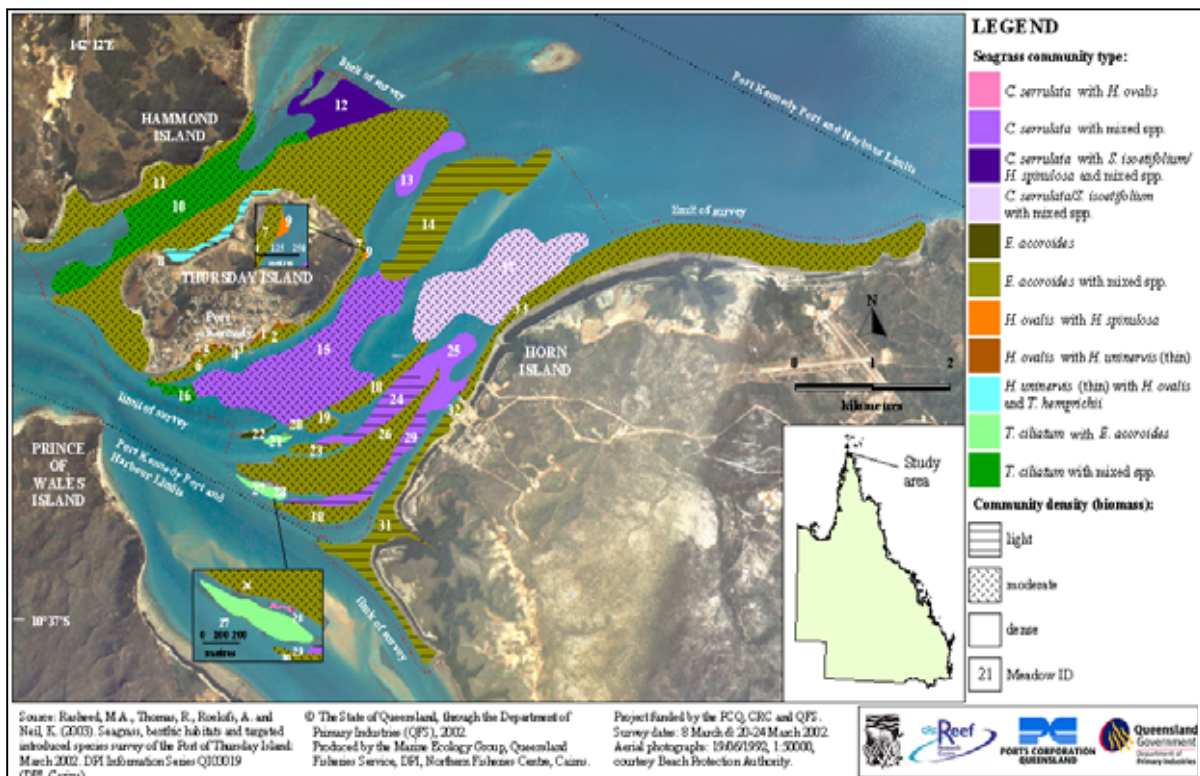


You must set the following properties:

- Grid                                      Lat/Lon hddd.dddd
- Datum                                    WGS 84

5. Click OK to finish.

6. MapSource is now correctly set up for use.

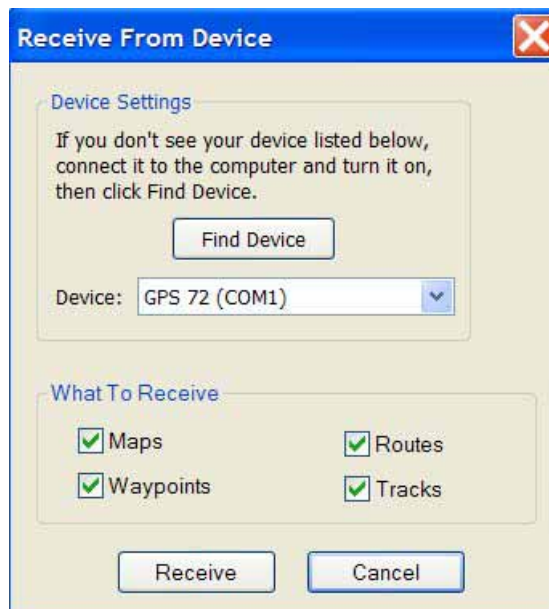




## Downloading information from your GPS using the MapSource program

### Step 1: Downloading GPS data using MapSource (download software)

1. Start MapSource (Double click on the MapSource Icon) or (start, programs, MapSource, MapSource)
2. Plug the Garmin serial cable from your GPS unit to the communications port on your computer.
3. On the GPS unit, make sure that the Garmin interface is set to “**GARMIN**” on the GPS 72. To Check this, go to the “Setup menu”, select “Interface”, select “GARMIN”.
4. In the MapSource program, go to the **Transfer** menu and select “**Receive from Device..**”. The following menu will appear.

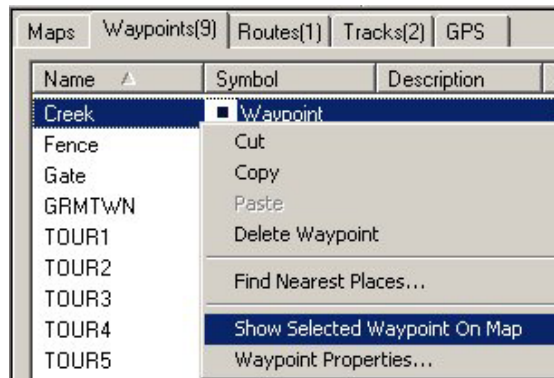


5. Click on the **Receive** button.
6. The GPS data will begin to download to the MapSource software. Click OK after data is successfully opened.

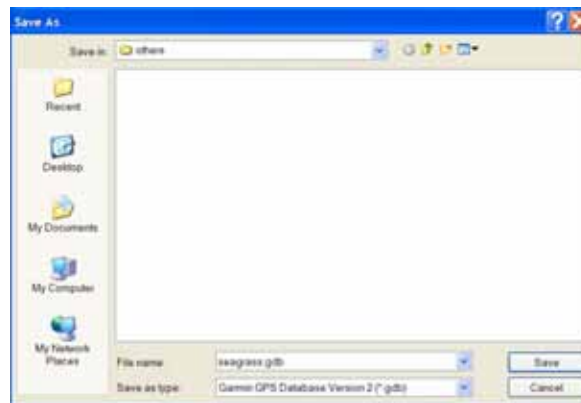


## Saving GPS data in MapSource

1. To Check the GPS data that has just been downloaded, click on the “Waypoints” tab (the full list of all waypoints are listed).
2. To view the waypoints on the MapSource map area, right click on any of the waypoints (a context menu will appear) and select “**Show Selected Waypoint On Map**”. The waypoint will be shown on the map



3. You must always save the GPS data that has been downloaded to MapSource. To save the GPS data in MapSource, Click on “**File**” menu, then select “**Save**”. A “Save As” window will appear. Browse to the directory where you want to save the file in and type in a file name. Click “Save” and the MapSource file is save (this file contains all the GPS data).



The advantages for saving the GPS data are:

- GPS data will not be lost when the data is save in a MapSource file (\*.mps) to your PC.
- The GPS data on the GPS unit can be deleted. The GPS unit will have the maximum memory space available for any further data capture use.
- Once the GPS data is saved as a MapSource file, the data can always be uploaded back onto the GPS unit.





# Managing seagrass resources

## Threats to seagrass habitats

Destruction or loss of seagrasses has been reported from most parts of the world. Man-made impacts on seagrass meadows such as nutrient and sediment overload, land reclamation and changes in land use, continue to destroy or degrade coastal ecosystems and decrease seagrass functions and values. Other impacts include increases in dredging, construction on the shoreline, damage associated with commercial overexploitation of coastal resources, and recreational boating activities. Impacts that may affect the physical condition of seagrass meadows locally include; scarring from vessel landings, intensive trawling, anchoring, moorings, pipelines and shipping accidents (TS NRM Reference Group, 2005). Other identified impacts that are slightly more insidious and more difficult to counter are natural seagrass die-back, marine pests and global warming. It has been recognized that these factors could impact on local seagrass meadows leading to a loss of a food source and nursery areas of species reliant on seagrass meadows.

In other parts of the world efforts are being made towards redressing declines in seagrass habitat through: transplantation of seagrass, 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 or habitats and are often closely linked to other community types. In the tropics the associations are likely to be complex interactions with mangrove communities and coral reef systems. In temperate waters, algae beds, salt marshes, bivalve reefs, and epiphytic plant communities are closely associated with areas of seagrass. Many management actions to protect seagrasses have their origin in the protection of wider ecological systems or are designed to protect the overall biodiversity of the marine environment.

Coastal management decision making is complex, and much of the information on approaches and methods 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. Inter-country agreements in these areas such as the UNEP Strategic Action Plan for the South China Sea and the Mediterranean Countries Barcelona Convention (<http://www.unep.org/>) are required to manage marine issues that encompass more than one country.

Approaches to protecting seagrass tend to be location specific or at least nation specific (there is no international legislation directly for seagrasses as such that we



know of) and depend to a large extent on the tools available in law and in the cultural approach of the community. There is, however, a global acceptance through international conventions (RAMSAR Convention; the Convention on Migratory Species of Wild Animals; and the Convention on Biodiversity) of the need for a set of standardised data/information on the location and values of seagrasses on which to base arguments for universal and more consistent seagrass protection.

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

Marine resource management in Torres Strait should therefore attempt to achieve the following interrelated objectives: a) monitor the wellbeing (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 also important that this information is readily available to decision makers in Governments and traditional owners in a form that can be easily understood.

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





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