

# Seagrass-Watch

## Guidelines for Community Groups & Volunteers in the Whitsunday Region



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# OVERVIEW



**SEAGRASS-WATCH** is a program being developed by the Seagrass Ecology Group at the Queensland Department of Primary Industries, Northern Fisheries Centre, Cairns. The program is being developed with the assistance of Department of Environment and Heritage, community groups and volunteers.

The ultimate aim of the **SEAGRASS-WATCH** program is to collect and assess information for coastal management on changes in seagrass meadow characteristics (eg., area, position & depth of habitat, seagrass species and composition, estimates of biomass, presence of dugong feeding trails, notes on other fauna and possible impacts). The community will be primarily involved in collecting data that is urgently needed to update existing information and maps of seagrasses around Queensland.

Interested community volunteers and/or groups will be trained to conduct seagrass monitoring techniques similar to those used by fisheries staff when assessing seagrass habitats in Queensland. Sampling techniques including visual estimation of the percent coverage of seagrass, species composition and seagrass species identification.

Initially **SEAGRASS-WATCH** activities will focus on mapping of the seagrass meadows in their region. After the data from the mapping activities has been validated and analysed, GIS (Geographic Information System) maps will be prepared for the region. Using these maps, a community consultation meeting with the **SEAGRASS WATCH** volunteers will be held to discuss which sites will be monitored. A monitoring strategy will be formulated for the region and the **SEAGRASS WATCH** volunteers will be involved in short and long term monitoring activities of these seagrass meadows. The program is initially targeting inshore, intertidal seagrasses, however in some cases other seagrass meadows will be included. These **SEAGRASS-WATCH** monitoring programs will establish a reliable early warning system on the status of our seagrass resources, and a broad measure of changes in these resources.

The following information is provided as a training guide and a reference for future community based **SEAGRASS- WATCH** mapping and monitoring activities. Please do not hesitate to contact the DPI Northern Fisheries Centre in Cairns for further information:

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Queensland Department of Primary Industries  
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# GENERAL INTRODUCTION TO SEAGRASSES

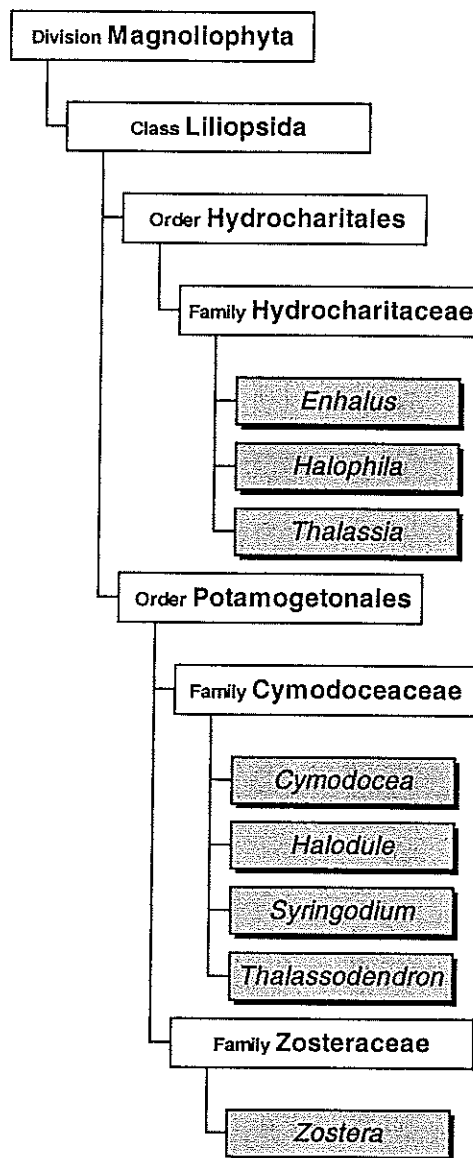
Seagrasses are angiosperms (flowering plants) more related to terrestrial lilies and gingers than to true grasses. They grow in sediment on the sea floor with erect, elongate leaves and a buried root-like structure (rhizomes). There are only 58 described species of seagrasses worldwide, within 12 genera, 4 families and 2 orders. There are several genera of seagrasses in Queensland, *Cymodocea*, *Enhalus*, *Halodule*, *Halophila*, *Syringodium*, *Thalassia*, *Zostera* and *Thalassodendron*. The small number of species however, does not reflect the importance of seagrass ecosystems which provide a sheltered, nutrient-rich habitat for a diverse flora and fauna.

Seagrasses are unique amongst flowering plants, in that all but one genus, can live entirely immersed in seawater. *Enhalus* plants are the exception as they must come to the surface to reproduce, all others can flower and be pollinated under water. Adaptation to a marine environment imposes major constraints on morphology and structure. The restriction of seagrasses to seawater has obviously influenced their geographic distribution and speciation.

Seagrass meadows occur in most shallow, sheltered soft-bottomed marine coastlines and estuaries of the world. These meadows may be monospecific or may consist of multispecies communities, sometimes with up to 12 species present.

Seagrass meadows physically help to reduce wave and current energy, help to filter suspended sediments from the water, and contribute to stabilising bottom sediments. 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 also very large, although not always easy to quantify.

Seagrass/algae beds 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



*Taxonomic classification of Queensland's seagrasses.*

<sup>1994</sup>US\$ 19,004 ha<sup>-1</sup> yr<sup>-1</sup> (Costanza *et al.* 1997). This value would be significantly greater if the habitat/refugia and food production services of seagrasses were included. In seagrasses meadows of western Cairns Harbour for example, the estimated landed value of the three major commercial penaeid prawns (*Penaeus esculentus*, *P. semisulcatus* and *Metapenaeus endeavouri*) was <sup>1992</sup>AUS\$3,687 ha<sup>-1</sup> yr<sup>-1</sup> (Watson, R.A., Coles, R.G., and Lee Long, W.J. (1993). Simulation estimates of annual yield and landed value for commercial penaeid prawns from a tropical seagrass habitat, northern Queensland, Australia. *Australian Journal of Marine and Freshwater Research*. 44(1), 211-220.)

Tropical seagrass meadows vary seasonally and between years. The potential for widespread seagrass loss has been well documented. 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, eg high energy storms, or "wasting disease". More commonly, loss has resulted from human activities, eg. as a consequence of eutrophication or land reclamation and changes in land use. Anthropogenic impacts on seagrass meadows are continuing to destroy or degrade coastal ecosystems and decrease their yield of natural resources.

It is important to document seagrass species diversity and distribution, to be able to identify areas requiring conservation measures. Responsive management based on adequate information should prevent any further significant areas and species being lost.

In order to determine the importance of seagrass ecosystems and to detect changes that occur through perturbations (man-made and natural), it is necessary to first map the distribution and density of existing seagrass meadows. These maps must be monitored to determine natural variability in the extent of seagrasses (e.g. seasonal dieback) before estimates of loss or gain due to perturbation can be made. Coastal management agencies need to know what levels of change are likely to be ecologically or economically important, and sampling designs for baseline and monitoring surveys need to be sufficient to measure changes that are statistically significant.

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 tropical seagrass communities are essential to understand the role of these communities and the effects of disturbance on their composition, structure and rate of recovery. Seagrass meadows should be mapped as a first step towards understanding these communities.



## **SEAGRASS ECOLOGY GROUP, NORTHERN FISHERIES CENTRE, CAIRNS**

*The Seagrass Ecology Group, based at the Northern Fisheries Centre, Cairns, is internationally recognised and industry-funded. The team are deeply committed to the QDPI vision of a Fishing Industry Sector based on sustainable use of resources. They undertake pure and applied research and provide management advice directly related to the priority fisheries areas of maintaining marine fish habitats, improving fisheries productivity, coastal and regional environment planning for sustainable resource use, and the development of recreational fisheries.*

The Group's ten staff focus on seagrass management and research. In May 1997, the Seagrass Ecology Group were presented with a DPI Client Services Awards. Projects include mapping of seagrass and juvenile prawn nursery grounds for the fishing industry (managed by the Queensland Fisheries Management Authority), dugong management, Marine Park zoning plans (GBRMPA), and monitoring fisheries productivity and marine plants. Seagrass habitat maps produced by this work have:

- enabled the prawn trawling industry to phase out trawling on these sensitive habitats, to enable the protection of juvenile prawn nursery grounds and recruitment activity to the fishery;
- provided fisheries and marine park managers with new knowledge on the status of our seagrass resources and likely trends in these habitats; and
- highlighted the necessity for sustainable land-use practices in catchments to ensure maintenance of these valuable coastal fisheries habitats;
- been invaluable towards the understanding of resource sharing between dugong and humans in areas such as Shoalwater and Hervey Bay.

Group members regularly speak at national and international conferences and committees on biodiversity, restoration, and monitoring of coastal habitat. In 1995 the group was requested to develop the Australian Standard for monitoring change in seagrasses. This resulted in the development of an innovative and internationally accepted method of visual assessment of seagrass habitats. These methods provide a national protocol for seagrass habitat mapping and monitoring that will lead to nation-wide awareness of the resource status and management priorities for sustainable seagrass habitats.

As an example of the groups acceptance as an international authority on coastal marine science in the Asia-Pacific region, group members were invited as the regional experts to Hawaii in 1994 to present papers to an international committee on biodiversity. These papers were on the taxonomy and systematics of Pacific seagrasses and on the effects of development and conservation of the coastal zone. Maintaining biodiversity is the basis for protecting the complex marine ecosystems that support our fisheries. While there is much information for temperate systems only a few agencies worldwide research tropical systems. The Group is recognised as one of those lead agencies that can represent fisheries issues and the complex issues of habitat productivity. By contributing to the international understanding of tropical Pacific systems and their sustainability the Group are assisting DPI's vision of primary industries confidently competing in a world market.



The Seagrass Ecology Group, as a participant in the CRC for Reef Research brings Government and Industry together in a forum which helps meet DPI's mission of ensuring marine primary industries are managed in a sustainable way. The program involves research on determining the status of seagrass resources within the Great Barrier Reef and monitoring seagrass productivity and response to terrestrial influence as well as research on recovery after loss of seagrass. Key issues in this research are the long-term viability and competitiveness of the Great Barrier Reef region tourist industry and fishing industries in the world market. With CRC Reef Research support, the group has developed and evaluated new sampling and research methodologies to conduct a Great Barrier Reef wide survey of deep water seagrass, in order to overcome the enormous logistic problems of surveying vast areas of water deeper than 30 metres. The project will help determine much of the zoning for fishing in deep-water inter-reef areas of the Great Barrier Reef lagoon. In doing so it will ensure the long-term sustainability of the coastal ecosystem, the marine habitat, and the commercial and recreational fisheries that depend on the viability of the inter-reef ecosystems.

Since its inception in 1985 the Seagrass Ecology Group has maintained it's reputation as the leading advisers on seagrass management in North-Eastern Queensland. Almost all research is externally funded and is to a contract timetable. Since 1989 the group has received funding from:- the Ports Corporation of Queensland; The CRC for Reef Research; the Australian Fisheries Management Authority; the Fishing Industry Research and Development Corporation; the Trinity Inlet Management Plan Technical Committee; Connell Wagner Engineering; Department of Economic Trade and Development; The Program on Environment East-West Centre; The Department of Primary Industries and Energy; the Department of Environment and the Great Barrier Reef Marine Park Authority. Continued funding from external agencies has been achieved by keeping a high level of client and funding body support by ensuring timely publication of reports; excellent quality control; and continuing public awareness activities to maintain the public and commercial acceptance along with goodwill.

The Seagrass Ecology Group fosters a spirit of team research, and gets the best out of staff by including them in the whole process - from project planning; to analysis; to write up. The group has been involved in increasing community awareness by providing information to schools, attending public events (eg. boatshows) and other public awareness programs. The group also provides information for Integrated Catchment Programs and through the Seagrass-Watch program is advising and training community and government agencies to establish a statewide network of seagrass habitat monitoring programs.

***Researchers in the Seagrass Ecology Group at Northern Fisheries Centre are:***

Dr Robert Coles (Snr Principal Scientist, Group Leader)  
Mr Warren Lee Long (Biologist, Project Leader)  
Mr Len McKenzie (Snr Research Scientist, CRC Program)  
Ms Jane Mellors (PhD Student)  
Mr Anthony Roelofs (Biologist)  
Ms Chantal Roder (Biologist)  
Mr Michael Rasheed (PhD Student)  
Mr Paul Daniel (Technician)  
Ms Wendy Baker (Scientific Assistant)  
Ms Karen Vidler (Seagrass Watch Coordinator)

# WHITSUNDAY SEAGRASSES

Seagrass meadows in the Whitsundays region play a vital role in supporting coastal marine communities and in maintaining diverse flora and fauna. They are an important component of coastal fisheries productivity, which includes being nursery grounds for many commercially important species. They play an important role in maintaining coastal water quality and clarity. They are also used by dugong and are important to this endangered species. The loss of seagrass habitat due to anthropogenic effects would further reduce the viability of dugong surviving in the long term in the Whitsundays Region.

The importance of seagrass in the Whitsundays to commercial and recreational fisheries production, and threatened species such as dugong and turtle populations is widely recognised. The value of seagrass areas in the Whitsunday region is recognised with the Port Newry area being declared a Dugong Protection Area. The loss of seagrass habitat due to anthropogenic effects would further reduce the viability of dugong surviving in the long term in this part of the Great Barrier Reef region.

There are extensive and diverse seagrass meadows in the Whitsundays Region. However most of the larger and more dense seagrass meadows are locations where tourism use is increasing, and/or are adjacent to urban or agricultural expansion. Cid Harbour is the largest dense seagrass meadow in the Whitsundays and is also one of the most popular anchorages. Vessel use in Cid Harbour has been increasing in parallel with tourism in the Whitsunday Area, and there are often about 50 vessels anchored overnight in Cid Harbour.

Seagrasses are damaged at these sites by vessel anchors and anchor-chain sweeps, by vessel hulls scraping across seagrass in shallow water, and by disturbing and eroding sediments from vessel propulsion. At low levels of vessel use, recovery through regrowth will compensate for impacts. However above a threshold level of vessel impacts seagrass meadows will not survive chronic impacts and continue to deteriorate. Impacts from human-associated vessel effluent can result in sub-lethal effects such as increased epiphyte load, decreased productivity, and/or loss of associated fauna, or lead to broad scale reduction in seagrass cover.

The need to better understand the status of seagrasses in the Whitsunday area has been identified as a key issue by:

- Whitsundays Plan of Management
- The Draft Conservation Plan for Dugong in Queensland
- The Great Barrier Reef Ministerial Council Dugong Review Group
- Environment Australia - Coastal Monitoring Program, Seagrass Project

# WHITSUNDAYS SEAGRASS- WATCH

## BACKGROUND

In July 1997, an application to fund a project titled "*Community Seagrass-watch and Protection Program - Whitsunday Region*" was submitted to the Natural Heritage Trust, Coast & Clean Sea, Monitoring Program. Funding for this application was granted in July 1998. The application supports local community groups to attend a workshop of community seagrass monitoring methods in October 1998. This training exercise provides instruction in the methods required for scientifically rigorous assessment. Participants trained with these methods are invited to assist with the baseline survey of Whitsunday seagrasses, scheduled for January 1999.

The training program is envisaged to create a focus for community interest, build community awareness, and train community groups in how to assess/map intertidal seagrass meadows in the Whitsunday region. After training, volunteers and community groups would be involved in collecting data from the region to give some indication of the overall extent of the seagrass meadows, and to identify any areas which may need particular attention/focus in the main project. The main project will be undertaken primarily by the Seagrass Ecology Group from the Northern Fisheries Centre, Department of Primary Industries with close coordination through the Whitsunday regional office of the Department of Environment, the local council and other concerned groups.

A scientifically based ongoing monitoring program is proposed. This will be implemented after the extent of the Whitsunday region seagrasses have been mapped. The monitoring program will be designed to detect changes and provide an early warning of possible threats to the seagrass of the Whitsunday region. The program will be established at specific sites identified using the results of the remapping surveys. How to monitor, the sampling design, and the parameters to be measured will depend on the specifics of each individual location and will be decided in collaboration with the community and research scientists (this will include peer review). The purpose of monitoring is to provide an early warning of change to alert management agencies and formulate response activities.

The complexity of the monitoring activities will increase as the program progresses, as will the capability of the community members involved. The program will monitor changes in several of the following seagrass parameters considered appropriate by the community: area; biomass/shoot density; species mix and/or diversity; root/leaf ratio; shape for location; productivity; epiphyte load; faunal composition and depth range. Finally, research projects will be developed (QDPI acting in advisory role) to address specific questions relating to impacts on and health of the seagrass resources. It is envisaged that much of this could be done by collaborating with universities/colleges and supplementing operating costs.

Outcomes and Outputs from the project would include:

- A GIS (Geographic Information System) of the Whitsundays including up-to-date results of subtidal and intertidal seagrasses.
- Assessment of present status of seagrass meadow area and cover, relative to a decade ago.
- Map information and data available to improve planning
- Recommendations for management and further research
- Management actions undertaken
- Management actions evaluated for success
- Trained local volunteers - experience in seagrass monitoring
- Local education of the values and importance of an important marine habitat
- Accurate scientific data and results addressing questions specific to understanding seagrass issues in the Whitsunday area.

# SEAGRASS-WATCH TRAINING

## **DAY 1. FIELD TRAINING**

*Saturday 3<sup>rd</sup> October*



### **Where:**

At the Marine Parks/ National Parks office, Cnr. Mandalay Road and Shute Harbour Road, Airlie Beach.

### **When:**

11am start (finishing at around 4pm)

BBQ lunch provided

### **What to bring:**

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

*We welcome your children, but please keep them under close supervision.*

### **What to expect:**

In the morning, there will be a briefing for the day's activity, a short seminar, and an open discussion about Seagrass-Watch. Techniques currently used by the Seagrass Ecology Group (NFC) to survey seagrass meadows will be explained. During the afternoon, you will be practising these techniques and conducting an actual survey of an intertidal seagrass meadow, with assistance from DPI staff.

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

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



## **DAY 2. LABORATORY TRAINING**

*Sunday 4<sup>th</sup> October*

### **Where:**

At the Marine Parks/ National Parks Office, Cnr. Mandalay Road and Shute Harbour Road, Airlie Beach.

### **When:**

QDPI staff members will be at the Parks Office between 1:00pm - 4:00pm. The actual lab session will only take you approximately 2 hours.

### **What to bring:**

- You will be in a laboratory and suitable dress is needed (covered shoes, no thongs please).
- enthusiasm

### **What to expect:**

During the laboratory training you will have the opportunity to learn more about:

- seagrass taxonomy
- how to prepare a seagrass press specimen
- how the data collected from a seagrass survey is put into a GIS (Geographic Information System), interpreted, and used for management.

### **DPI staff:**

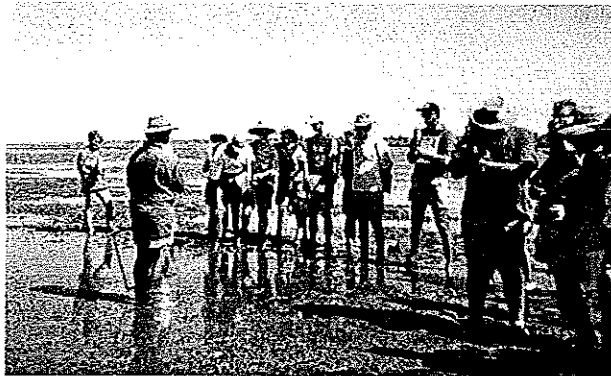
Len McKenzie (*Senior Research Scientist*)  
Chantal Roder (*Fisheries Biologist*)  
Karen Vidler (*Seagrass-Watch Coordinator*)



# FIELD TRAINING

*Please sign the attendance sheet with you name and address.*

*A short talk will be given prior to the field exercise*



The aim of this exercise is for you to:

- become familiar with seagrass habitats;
- learn how to undertake seagrass mapping;
- learn and practise how to estimate the percent coverage of seagrass using a visual assessment method.

## ***SITE SELECTION***

- ↳ Initially topographic maps, secondary data and local knowledge, will help us to identify the general location of seagrass meadows.
- ↳ Aerial photographs will help identify the location and extent of these seagrass meadows. Review these photographs and decide on an area to survey.
- ↳ A preliminary (general) visual assessment of the area is required to validate existing general information, it allows us to obtain an overview of the variation and extent of the seagrass meadow. This assists us in deciding where to conduct the transects and the frequency of the quadrat sampling.



## FIELD EQUIPMENT

- ☐ Quadrat (50 centimetre x 50 centimetre).
- ☐ Clipboard with pre-printed data sheets on (A4 size) underwater paper. The sheets are attached to the map and kept as a permanent record.
- ☐ Pencils.
- ☐ Waterproof labels. Pre-printed labels help ensure that all the required data are recorded for each sample.
- ☐ Plastic bags
- ☐ Compass / portable GPS



## GENERAL PROCEDURE

- ✦ Select 5 reference quadrats (*we will help*). The quadrats should represent the range of seagrass coverage (from the highest to the least), which is likely to be encountered during sampling.
- ✦ Decide on a percent coverage for each of the reference quadrats. You need to consider the area of bare ground between plants, plant height, and the leaf shape and type. Discuss your percent cover estimate with the instructors and other volunteers.
- ✦ Percent coverage estimates for the reference quadrats must be agreed upon by all observers.
- ✦ Select the position for the start of the survey after a visual reconnaissance of the area (*we will help*)
- ✦ Record the position of the first site along the transect on the map provided. The origin (inshore end) of the transect is the most useful reference.
- ✦ A GPS (Global Positioning System) is very useful if one is available, or you can use a hand-held compass to determine the bearings, with reference to at least 2 permanent landmarks or markers established as reference points.
- ✦ The length of the transect will depend on the size of the seagrass meadow. The transect should extend to the outer limits of the meadow.
- ✦ The transects should be spaced/ separated from each other by a reasonable distance (somewhere between 100 to 500 metres). This may depend on variation within the seagrass meadow.
- ✦ Starting at the transect origin, haphazardly toss 3 quadrats within an area of an approximately 5 metre radius.
- ✦ For each quadrat, first estimate the percent coverage of seagrass as per the 5 reference quadrats. Then determine the percentage of each seagrass species present. Record all data legibly onto the data sheets provided.

*Note: photograph these quadrats for future reference.*

- ✦ Record the sediment code and write any comments if any (eg. *lots of algae, dugong feeding trail 10m from site, anchor/propeller scar*).
- ✦ Proceed along the transect recording the percent of seagrass coverage in 3 quadrats at each site. Sites should be taken at regular intervals (usually 20 metres) along the transect, this is so that gradients in community structure are covered.

*In a large uniform (homogeneous) seagrass meadow that extends out from the shore for more than 100 metres, the sample interval may be every 15 to 20 metres. In mixed (heterogeneous) or highly variable meadows, intervals may be less than 5 metres.*


- ✦ Collect a voucher specimen of each seagrass species you encounter (only 1 or 2 shoots which have the leaves, rhizomes and roots intact). Label each specimen clearly and bag.
- ✦ When you have completed the transect, check with the DPI staff. Discuss with the staff and other volunteers how you found the field work, was it difficult??
- ✦ If time permits, try a transect of your own.
- ✦ Take the seagrass samples back to the laboratory for analysis tomorrow.

*Remember, tomorrow is the laboratory exercise. This is where you will learn how your data will be used to aid management. See you there!!!*



# SEAGRASS WATCH FIELD DATA SHEET

Example



Observer: Joe Bliggs Date: 03 / 08 / 98  
 Location: West Pioneer Bay Film Roll #: 1

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Site #: W.LA.03.08.98.1 Lat: 29 ° 14.339 ' S Long: 152 ° 49.133 ' E

Quadrat	Seagrass cover (✓)					% Species composition (nearest 10%)					Photo #
	nil	<1%	1-10%	10-50%	50-100%	Zostera capricornis	Halophila ovalis	Cymodocea serrulata	Halophila decipiens	Halophila spinulosa	
1	✓										
2		✓				10	90				
3			✓			50	50				

mud ☐ gravel ☐ Water depth: .....m Seagrass voucher spec. # .....  
 sandy-mud ☒ rock ☐ Comments.....  
 sand ☐

---

Site #: W.LA.03.08.98.1 Lat: 29 ° 12.321 ' S Long: 152 ° 41.963 ' E

Quadrat	Seagrass cover (✓)					% Species composition (nearest 10%)					Photo #
	nil	<1%	1-10%	10-50%	50-100%	Zostera capricornis	Halophila ovalis	Cymodocea serrulata	Halophila decipiens	Halophila spinulosa	
1	✓										
2											

## Determining the site number

The Site # can be determined easily by dividing it into four parts, these are:

- (1) region;
- (2) initials of observer;
- (3) date;
- (4) site number for that date.

For example the Site# for the first record above is W.LA.03.08.98.1

W	the region - Whitsunday
LA	the observer - Ms Lily Acoroides
03.08.98	the date of the survey
1	this is the first site for that day.

# LABORATORY TRAINING

*The laboratory exercise follows on from the field exercise.*

*Please sign the attendance sheet with you name and address if you have not already done so.*



In the lab you will have the opportunity to learn how to identify seagrass species using a taxonomic key, how to prepare a seagrass press specimen for lodging in a herbarium collection, and how the data you collected can be analysed, interpreted, and used for coastal management.

## 1. SEAGRASS TAXONOMY AND PREPARING A HERBARIUM PRESS:

- ✦ Wash your voucher seagrass specimen collected from yesterday and carefully remove any debris or epiphytes.
- ✦ Identify the specimen to species level if possible, using the keys provided. Most of the gross morphological characters used can be seen with the naked eye. A hand lens or dissecting microscope can be useful for some of the more minute features.
- ✦ Layout the specimen on a clean sheet of white paper, spreading leaves and roots to make each part of the specimen distinct.
- ✦ Place specimen label with site information (including: location, lat/long, depth, %cover, substrate, other species present, collector, comments) on lower right hand corner of paper.
- ✦ Place another clean sheet of paper over the specimen, and place within several sheets of newspaper.
- ✦ Place the assemblage of specimen/paper within two sheets of cardboard and then place into the **Seagrass Herbarium Press**, winding down the screws until tight (*do not over-tighten*).

☞ Allow to dry in a dry/warm/dark place for a minimum of two weeks.

☞ For best results, it is advisable to replace the newspaper after 2-3 days.

#### SEAGRASS HERBARIUM LABEL

A sample from Hervey Bay

**Seagrass Watch** Herbarium # 20003

Species *Posidonia oceanica*

Location Hervey Bay 28.3.98

Lat/Long 28.8953 152.28246

Depth — Cover — %

Substrate sand

Other Spp. —

Preserved as press

Collector(s) Karen Kirk

Comments found on beach

## 2. DEMONSTRATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) AND MAPPING.

Often the most enjoyable part of seagrass research is the field based data collection. Unfortunately, this is only a small part of the process, the data collected needs to be entered onto a computerised database, crosschecked, and analysed. Once the data has been analysed and checked again, the information is then ready to be interpreted and used for coastal management. The GIS is an important mapping tool used for coastal management assessment, monitoring and planning activities. Information from the Seagrass Watch program will be used to allow more accurate seagrass distribution maps to be generated.

*Please do not hesitate to ask a DPI staff member for assistance or information.*



# KEY FOR STERILE MATERIAL OF QUEENSLAND SEAGRASSES

1. Leaves petiolate or compound, or strap-shaped without a ligule (i.e. a tongue-like structure at the junction of leaf blade and sheath) (Hydrocharitaceae) 2  
 Leaves linear to strap-shaped and ligulate, neither petiolate nor compound 4
2. Leaves strap-shaped, neither compound nor petiolate 3  
 Leaves compound or petiolate *Halophila*  
 A. Plants with erect lateral shoots bearing a number of leaves B  
 Plants without erect, lateral shoots, but one pair of petiolate leaves at each rhizome node C  
 B. 10-20 pairs of distichous leaflets on an erect lateral shoot, blade with dense serrated margin *H. spinulosa*  
 3 leaves per erect lateral shoot node; blade with sparse serrated margin *H. tricostata*  
 C. Leaf blade longer than petiole; blade margin finely serrated, blade surface usually hairy *H. decipiens*  
 Leaf blade normally shorter than petiole; blade margin entire, blade surface naked D  
 D. Leaf blade oval to oblong, less than 5mm wide, cross veins up to ten pairs *H. minor*  
 Leaf blade oval to elliptical, more than 5mm wide, cross veins more than 10 pairs *H. ovalis*
3. Rhizome more than 1cm in diameter, without scales, but covered with long black bristles (fibre strands); roots cord-like *Enhalus acoroides*  
 Rhizome less than 0.5mm in diameter, covered with scales, but no fibrous bristles; root normal *Thalassia hemprichii*
4. Leaf blade more or less terete *Syringodium isoetifolium* 5  
 Leaf blade linear, flat, not terete
5. Plants with elongated erect stem bearing terminal clustered leaves; rhizome stiff, woody; root stiff *Thalassodendron ciliatum*  
 Plants with a short or no erect stem, bearing linear leaves; rhizome herbaceous; root fleshy 6
6. Rhizome bearing short erect stems; leaf sheath finally falling and leaving a clean scar, blade apex usually serrated or dentated; roots arising not in groups 7  
 Rhizome without erect stems; leaf sheath persistent, remaining as fibrous strands covering rhizomes;  
 blade apex truncate, neither serrated nor dentated; roots arising in 2 distinct groups of 4-8 at each node *Zostera capricornii*
7. Leaf blade with 3 veins *Halodule* 8  
 Leaf blade with more than 7 veins *Cymodocea* 9
8. Leaf apex tridentate, with median tooth blunt and well developed lateral teeth *H. uninervis*  
 Leaf apex more or less rounded, lateral teeth weak *H. pinifolia*
9. Leaf scars closed; blade apex rounded with no or weakly serrated *C. rotundata*  
 Leaf scars open; blade apex blunt with strongly to moderately serrated *C. serrulata*

(Prepared by J Kuo, UWA, Apr. 94)

# A GUIDE FOR MAPPING SEAGRASSES

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.

The **SEAGRASS-WATCH** program is essentially is about community member's going to an area, establishing the edges/boundaries of their local seagrass meadows and recording information on species present, % cover, species composition, sediment type, and depth (*if subtidal*).

## SEAGRASS-WATCH EQUIPMENT CHECKLIST.

- ☐ Quadrat (50 centimetre x 50 centimetre).  
At least one quadrat but take three if available.
- ☐ Clipboard with pre-printed data sheets and pencils.
- ☐ Waterproof labels (pre-printed labels ensure that all essential data are recorded for each sample).
- ☐ Seagrass collection permit
- ☐ Plastic bags - for seagrass samples
- ☐ Map/ aerial photograph of the area
- ☐ Compass or portable GPS unit
- ☐ Weatherproof camera (optional)

Check the tides to help you plan when is the easiest time to do the mapping. *Eg. spring low is best for intertidal meadows and neaps for subtidal.*

Permits are a legal requirement and can be obtained from your nearest DPI office

## STEP ONE. PRELIMINARY ASSESSMENT OF AN AREA

It is useful to use a topographic map as a base

- An initial visual survey of the area will allow you to map the general area of the seagrass bed, and at the same time it will give you an idea as to the amount of variation there is within the seagrass meadow. This will influence how to space your transects and quadrat.

- Maps and aerial photographs will help give more accurate information regarding the location and general extent of seagrass meadows to be mapped.

## STEP TWO. MAPPING THE SEAGRASS MEADOW.

1. On your map, select a starting point to begin sampling and go to that site. Sites can either be:
  - a) within transects across the meadow, **or**
  - b) haphazardly scattered over the entire meadow.

*Transects do not have to be accurately measured using a tape. You can estimate distances between sites depending on the size of the meadow. eg. in a small meadow you can have sites 20m or 50m apart, but in a large meadow sites may be 100m or 500m apart.*

2. Record the position of the site using a map with GPS or compass. *If using a hand-held compass to determine the site location, use at least 2 permanent landmarks or markers as reference points. Record the compass bearings and mark the reference markers on the map.* Roughly mark the site on the map and assign it a site code.
3. At the site, haphazardly toss three quadrats within an area of an approximate 5 metre radius around you.
4. Record the general site information and the data for each of the three quadrats.

#### ***SITE INFORMATION***

*(this is the minimum information required for mapping):*

For the general site:

1. Record the observer, location, and date.
2. Record the sediment type and write any comments if any (eg. lots of algae).
3. Record the water depth if the site is subtidal.

For each quadrat:

1. Calculate the overall percentage seagrass cover.
2. Identify the seagrass species present within the quadrat.
3. Calculate the percent composition of these species within each quadrat.

5. Photographing every quadrat would be expensive, so instead we recommend that you photograph a quadrat from every 10th site (ie. 10% of the sites will have a quadrat that has been photographed) **or** if the meadow changes **or** if there is something *unusual*. It is best to photograph a quadrat from two angles:
  - 1) from directly above and
  - 2) from 45-60 degrees (navel height?)

*Make sure the photo details are noted on the data sheet so the photo can be matched with the quadrat details.*

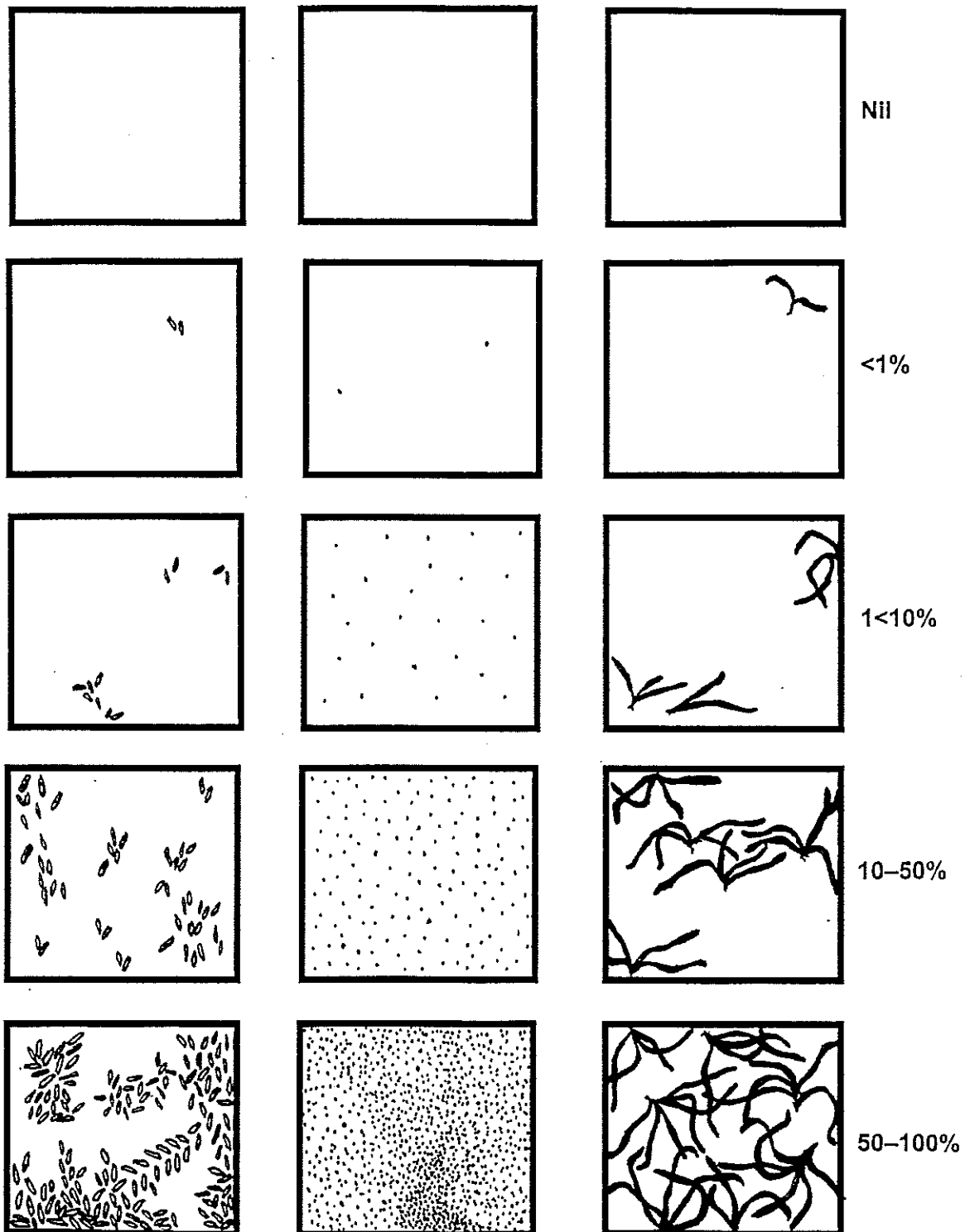
6. If you have a permit, collect a voucher specimen of each seagrass species you encounter for the day (only 1 or 2 shoots which have the leaves, rhizomes and roots intact). Label each specimen clearly and put into a plastic bag.

Examine the specimens again when you return to confirm your field identification using the taxonomic key. Specimens for your area can then be pressed and lodged with the DPI Northern Fisheries Centre

7. Move on to the next survey site and start all over again. The number of sites you survey will be entirely up to you. If you need to accurately monitor an area, then we recommend intensive surveying (*do lots of sites*). It is also beneficial to try to get a good spread of sites over the area as some of the changes in the seagrass meadow will not necessarily be obvious.
8. When you return from the field *even though you will be tired* it is worth checking through the information you have gathered to make sure there are no data gaps.

# *Seagrass-Watch*

A GUIDE FOR RANKING PERCENTAGE SEAGRASS COVER  
(after Dahl, 1981)



# Seagrass Identification in the Field

Identification of seagrass in the field can be confusing at the start, however practise makes for improvement. The first step in identifying which species of seagrass you are looking at is to rule out the possibility that it may be a seaweed/ algae. The figure below shows some of the key features of a typical seagrass, following this are some extracts which will assist you in field identification. The voucher specimens which you collect should be verified using the 'Key for sterile material of Queensland seagrasses' by John Kuo (refer to page 19).

**Extracts from Lanyon, J. (1986) Seagrasses of the Great Barrier Reef. Special Publication Series (3). Great Barrier Reef Marine Park Authority.**

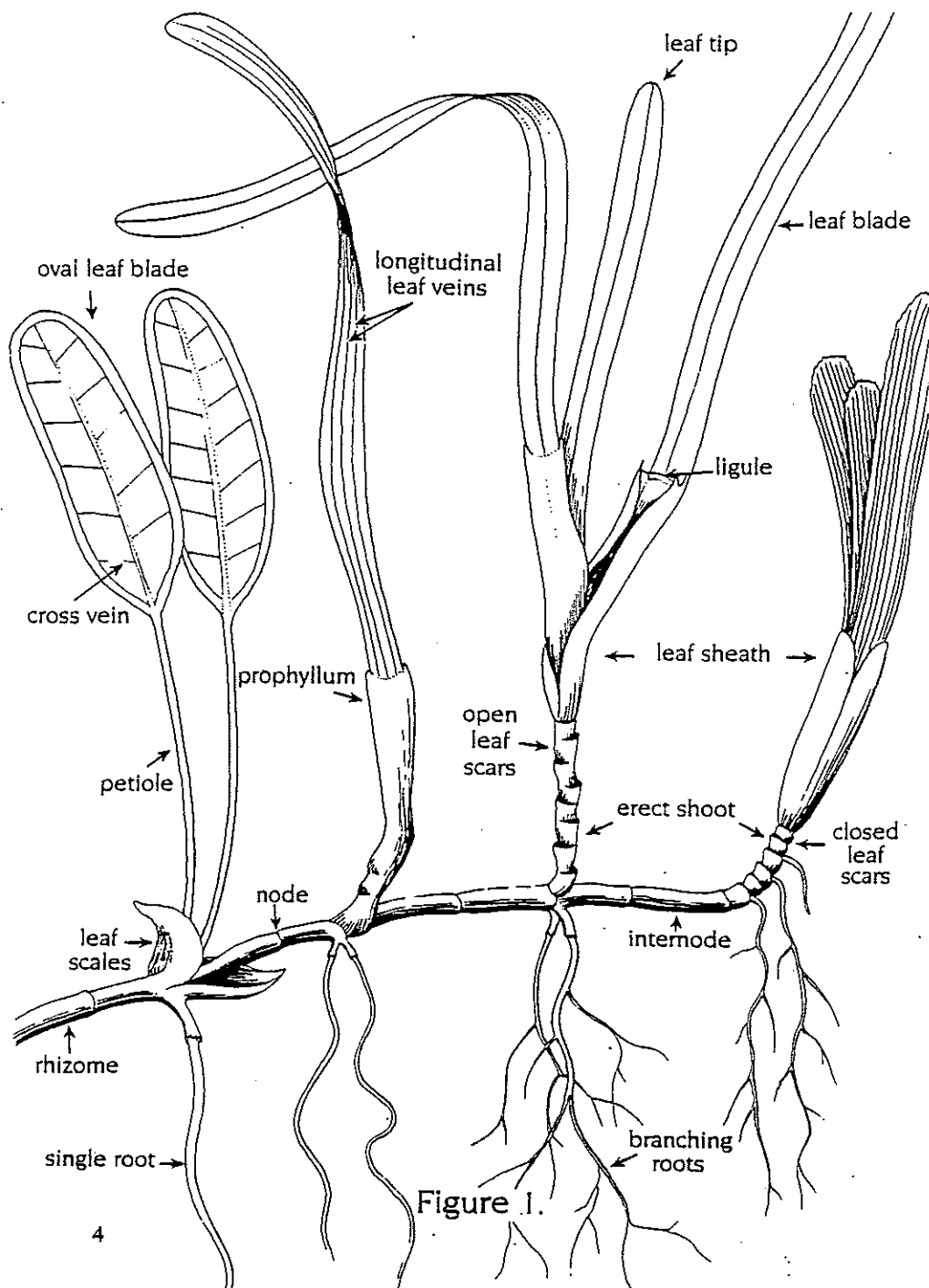


Figure 1.





Figure 15. *Zostera capricorni*

1 cm

## GENUS ZOSTERA

FAMILY: Potamogetonaceae  
SPECIES: *Zostera capricorni*

### *Zostera capricorni*

#### Morphology

*Z. capricorni* has an herbaceous rhizome system with a short lateral shoot at each node, each of which bears up to six leaves (Figure 15). The rhizome has elongate internodes with 1-2 or more groups of long, thin roots at each node. The linear leaf blade is thin and translucent. There is a total of five main longitudinal veins, however three very distinct dark green intramarginal veins are especially visible when held against the light. Cross veins, if present, run at right angles to the longitudinal veins. Leaves are 2-5 mm wide and vary in length from several centimetres to over half a metre. The leaf tip is blunt and the leaf margin generally smooth, but rarely slightly denticulate (with 'teeth') (Plate 2f). A ligule is present. *Z. capricorni* is characterised by the presence of a prophyllum, i.e. a single leaf originating from the rhizome instead of from the vertical, leafbearing shoot. This is the only seagrass to exhibit this feature.

#### Diagnostic features

Prophyllum present. Thin, translucent leaf blade with five main longitudinal veins.

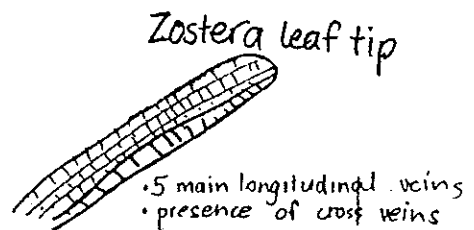
#### Likely to be confused with

##### *Halodule uninervis*

*Z. capricorni* is superficially quite similar to *H. uninervis* but can always be distinguished by the possession of the prophyllum. The three-toothed leaf tip of *H. uninervis* is similarly unmistakable. *H. uninervis* characteristically has three longitudinal veins and lacks distinct cross veins. *Z. capricorni*, on the other hand, has five main veins, although three are more conspicuous than the other two, and cross veins, if present, run at right angles to the longitudinal veins.

##### *Cymodocea rotundata*

*Z. capricorni* may be distinguished from thin-leaved *C. rotundata* by its possession of a prophyllum, and thin translucent leaf blades, which *C. rotundata* lacks. There are between 9 and 15 longitudinal veins in *C. rotundata*, but only five in *Z. capricorni*.



## *Halophila ovalis*

### Morphology

*Halophila ovalis* could be described as a delicate 'cloverlike' seagrass. Leaves have petioles, occur in pairs and can be morphologically very variable, with leaf blades oval to elliptical in shape, and ranging from 1-4 cm in length; the leaf blade is 0.5-2.0 cm wide (Figure 8). Leaves have 10-25 pairs of cross veins ascending at 45-60 degrees to the mid vein. Intramarginal veins are present and the leaf margin is smooth (Plate 1f). The rhizomes are thin, pale and smooth, and although the leaves often appear to arise directly off the rhizome, there is in fact a very short lateral shoot enclosed in two membranous scales. Fine roots originate at the base of each shoot.

#### Diagnostic features

Oval-elliptical leaf blade on petiole. 10-25 pairs of cross veins.

#### Likely to be confused with

##### *Halophila ovata*

Generally the leaves of *H. ovalis* are more elongate /elliptical (approximately 2.0-2.5 times longer than broad) than the smaller, more oval leaves of *H. ovata* (approximately 1-2 times longer than broad). These species also differ in the number and angle of cross veins relative to the mid vein. Various authors have questioned the legitimacy of separating *H. ovata* and *H. ovalis*. Although these species are typically distinguished on the basis of leaf length and width, ranges of leaf lengths and widths can show quite a degree of overlap, and it is therefore often difficult to classify intermediate forms. Similarly, the number of cross veins is variable. For these reasons, many workers tend to group these two forms together under the species *H. ovalis*, or classify to generic level only.

##### *Halophila decipiens*

The leaf of *H. ovalis* is readily distinguishable from *H. decipiens* by its smooth or entire margin, compared to the finely serrated margin of *H. decipiens*, and perhaps less reliably, on the basis of the length to width ratio. *H. ovalis* leaves are 2.0-2.5 times longer than broad, compared to the leaves of *H. decipiens* which are 2.75-3.25 times longer than broad. In addition, the leaf blade of *H. decipiens* is hairy rather than smooth, and the marginal and mid veins are prominent compared with *H. ovalis*.

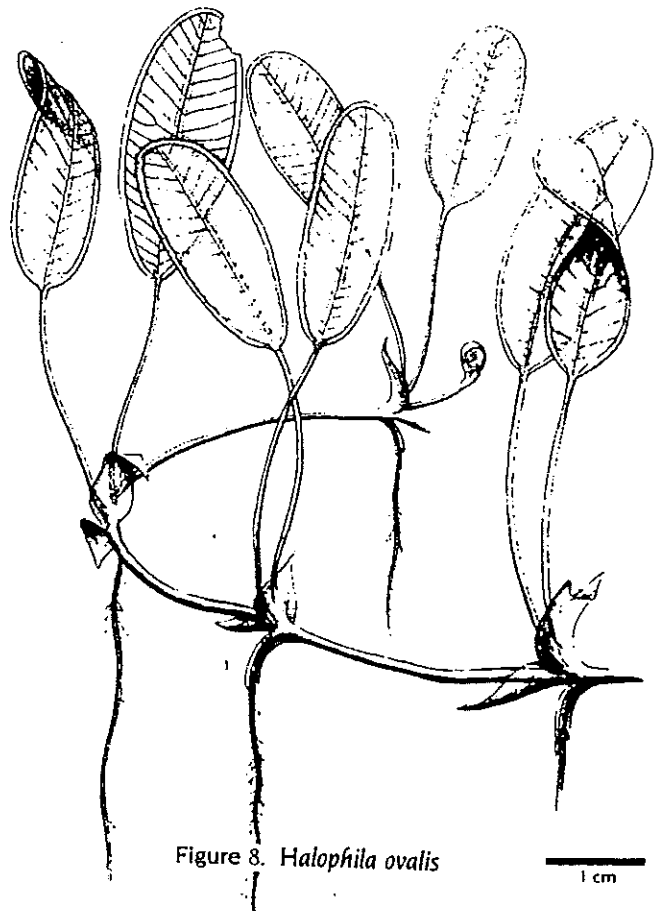
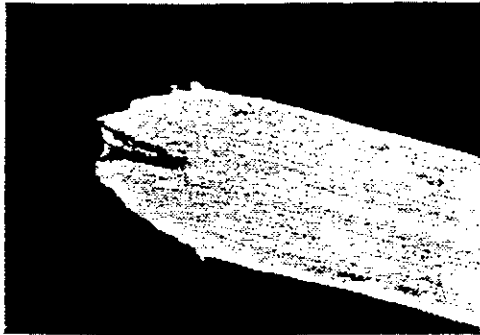


Figure 8. *Halophila ovalis*

1 cm



d. *Halodule pinifolia*

## *Halodule pinifolia*

### Morphology

The smaller of the *Halodule* species, *H. pinifolia* has leaf widths ranging from 0.25 mm to a maximum width of approximately 1.20 mm. Leaf lengths are generally less than 20 cm. The simplest feature to use in identification is the undamaged leaf tip as the black central vein usually splits into two at the tip. In those cases where the vein is not obviously split, the shape of the leaf tip must be examined. *H. pinifolia* always has a more or less rounded, somewhat irregularly serrated leaf tip (Plate 1d), and this consistently distinguishes it from *H. uninervis*, the leaf apex of which has three distinct points. However, because of the variation in leaf tip morphology, it is advisable to examine several tips.

### Diagnostic features

Small, delicate appearance, thin linear leaves, more or less rounded leaf tip, often with the central vein splitting into two at the apex.

### Likely to be confused with

#### *Halodule uninervis*

*H. pinifolia* can generally be distinguished from *H. uninervis* on the basis of leaf tip morphology as described above and to a lesser degree on leaf width. This species is unlikely to be confused with any other.

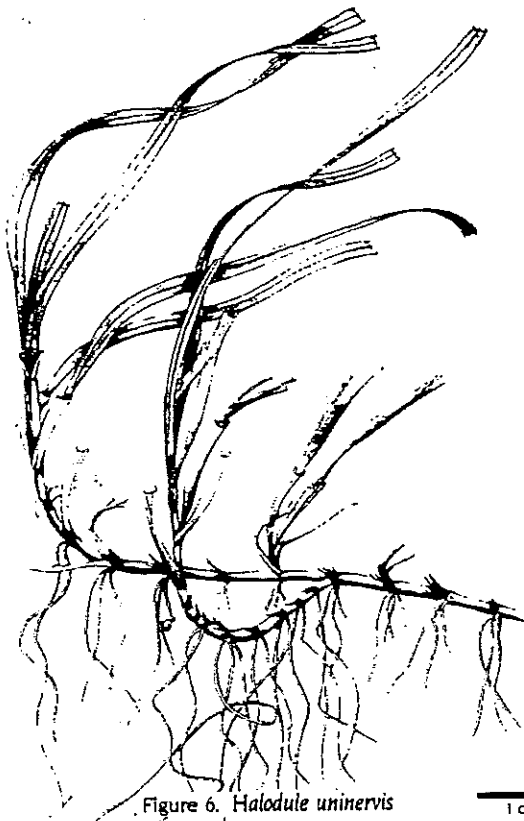
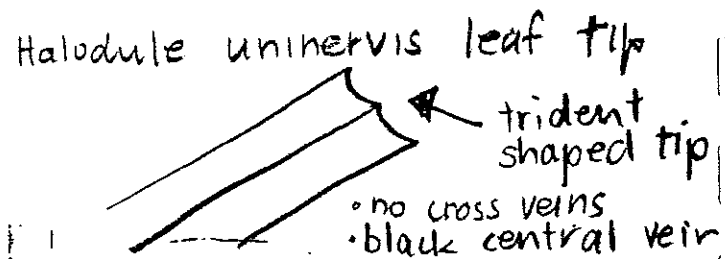


Figure 6. *Halodule uninervis*



## *Halodule uninervis*

### Morphology

*H. uninervis* exhibits quite variable growth forms (in terms of leaf length and width) but is usually larger than *H. pinifolia*. Some workers have divided *H. uninervis* into two or even three forms, generally on the basis of leaf width, which may range from 0.25-5.00 mm. Although structurally similar to *H. pinifolia*, *H. uninervis* differs markedly in the leaf tip region, where the leaf always ends in three distinct points or teeth (Plate 1e). The lateral teeth are well developed whereas the middle tooth is blunt. Unlike *H. pinifolia*, the black central vein does not usually split into two at the leaf tip.

### Diagnostic features

Leaf tip with three distinct points. Black central vein does not usually split into two at leaf tip.

### Likely to be confused with

#### *Halodule pinifolia*

*H. uninervis* can usually be distinguished on the basis of leaf tip morphological differences, as described above.

#### *Zostera capricorni*

There is a possibility that *H. uninervis* (wide-leaved form) could be confused with *Z. capricorni* as the leaf size and shape of the two species are similar. However, the leaves of *Z. capricorni* tend to be thinner and more translucent than *H. uninervis*, often with distinct cross veins running perpendicular to the five longitudinal veins. In comparison, *H. uninervis* characteristically has three longitudinal veins, and lacks cross veins. *H. uninervis* lacks a prophyllum at each node, a feature limited to the genus *Zostera*.

#### *Cymodocea rotundata*

Amongst other characters, *H. uninervis* may be distinguished from *C. rotundata* by the number of longitudinal leaf veins (three in *H. uninervis*, compared to 9-15 in *C. rotundata*). Leaf tip morphology can also be used since *H. uninervis* has three distinct points at the leaf apex compared to *C. rotundata*'s more rounded tip.

#### *Thalassia hemprichii*

There is only a remote possibility of confusing *T. hemprichii* with *H. uninervis*. *T. hemprichii* has 10-17 longitudinal leaf veins whereas *H. uninervis* has a characteristic three. *T. hemprichii* also has a thicker rhizome, larger leaves and distinct bars of tannin cells in the leaf blades, which *H. uninervis* lacks.

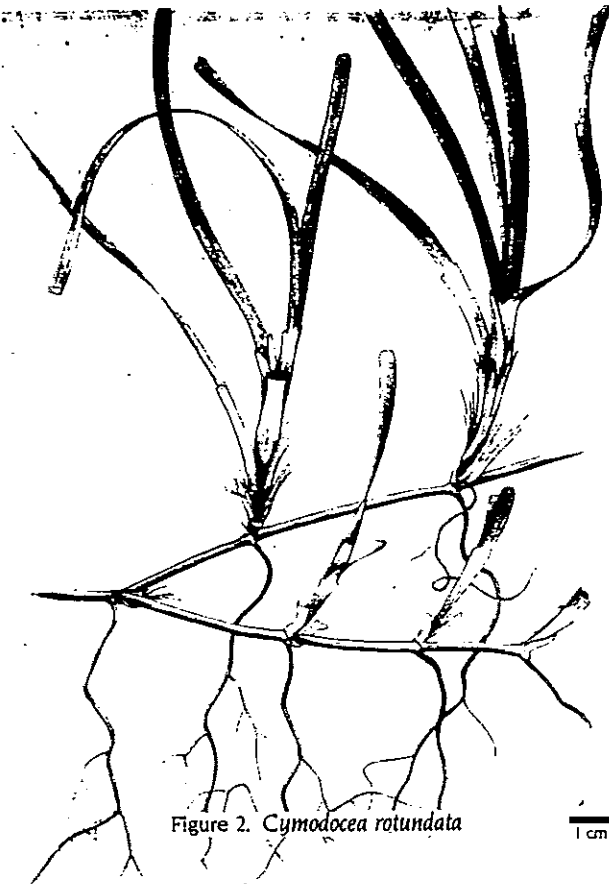


Figure 2. *Cymodocea rotundata*

## GENUS CYMODOCEA

FAMILY: Potamogetonaceae  
SPECIES: *Cymodocea rotundata*  
*Cymodocea serrulata*

### CYMODOCEA SPP

#### Morphology

The two *Cymodocea* species are rather robust seagrasses with ribbon-like curved leaves, smooth herbaceous rhizomes and well developed leaf sheaths. There are a number of features which easily separate the two species.

#### Diagnostic features

Smooth rhizome with no scars between successive shoots. Linear strap-like leaves.

### *Cymodocea rotundata*

#### Morphology

*C. rotundata* has a smooth, herbaceous rhizome with a short erect lateral shoot at each node, bearing 2-7 leaves (Figure 2). The leaf sheath is well developed (1.5-5.5 cm long), often pale purple in colour and is not shed along with the blade. When the leaf sheaths are shed, they leave closed circular scars on the shoot. A ligule is present. The leaves are linear to somewhat curved, flat and strap-shaped, 7-15 cm long and 2-4 mm wide. There are 7-15 longitudinal veins in the leaves, and often numerous tannin cells in circular-shaped aggregations. The leaf tip is bluntly rounded (or obtuse) and sometimes appears slightly heart-shaped to the naked eye, often with very faint serrations (Plate 1a). Little phenotypic variation has been recorded in this species.

#### Diagnostic features

Leaf sheath scars form a continuous ring around the shoot — annular appearance. Well developed leaf sheath. Rounded leaf tip, 7-15 veins.

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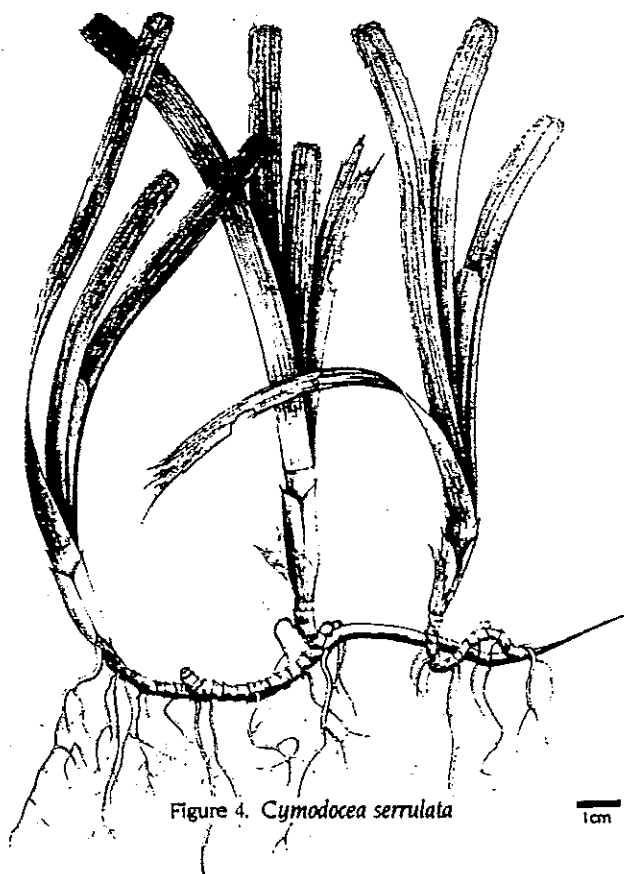


Figure 4. *Cymodocea serrulata*

### *Cymodocea serrulata*

#### Morphology

*C. serrulata* has, like *C. rotundata*, a smooth, herbaceous (if a little more robust) rhizome system, which produces short, erect shoots often with fibrous rootlets at each node, each shoot bearing 2-5 leaves (Figure 4). Unlike *C. rotundata*, the leaf sheath of *C. serrulata* is broadly triangular and narrowed at the base. It is often a purple colour in the living plant. When shed, the sheaths leave open circular scars on the shoot. A ligule is present. The leaf blade is linear to somewhat curved, 6-15 cm long and 4-9 mm wide, with 13-17 longitudinal veins. The leaf is narrowed at the base and the leaf tip is bluntly rounded and distinctly serrated. (Plate 1b). Tannin cells are present in circular-shaped groups. Phenotypic variation is generally minimal.

#### Diagnostic features

Shoot with distinctive open leaf scars, i.e., scars are not continuous around the shoot. Triangular, flat leaf sheath. Fibrous roots on shoot. Serrated leaf tip. 13-17 longitudinal leaf veins.

#### Likely to be confused with

##### *Cymodocea rotundata*

*C. serrulata* may be distinguished on the basis of leaf tip morphology and differences in shoot and leaf sheath form (Figure 3).

##### *Thalassia hemprichii*

*C. serrulata* is commonly confused with this species, however it may be distinguished by differences in the shape of the tannin cell aggregations — round in *C. serrulata*, rod-shaped in *T. hemprichii*. More conspicuous are the rhizome differences. *T. hemprichii* has a rhizome with scars between successive erect shoots while the rhizome of *C. serrulata* is smooth between shoots.

##### *Thalassodendron ciliatum*

*C. serrulata* has short erect shoots, compared to the elongate 10-65 cm shoots of *T. ciliatum*; also an herbaceous rhizome, compared to *T. ciliatum*'s tough 'woody' rhizome. *T. ciliatum* has scars on the rhizome between successive erect shoots; *C. serrulata* lacks these.

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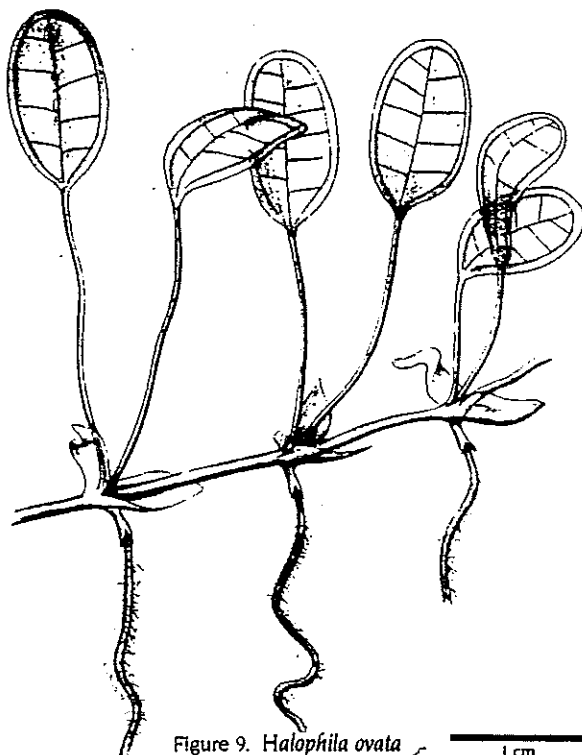


Figure 9. *Halophila ovata*

## *Halophila ovata* minor

### Morphology

Within the Great Barrier Reef region, *H. ovata* is a relatively rare seagrass compared to the more commonly encountered *H. ovalis*. Structurally it is very similar to *H. ovalis*, i.e. petiolate leaves and a smooth rhizome, however it is generally smaller all over. The leaf blade is oval, 0.5-1.5 cm long and less than 5 mm wide, possessing 3-10 pairs of cross veins ascending at 70-90 degrees to the mid vein (Figure 9).

### Diagnostic features

Small, oval leaf blades on petioles. Generally less than 10 pairs of cross veins.

### Likely to be confused with

#### *H. ovalis*

See *H. ovalis* 'Likely to be confused with' section.

#### *H. decipiens*

*H. ovata* has a small, oval leaf blade with a smooth margin. This in direct contrast to the leaf of *H. decipiens* which is usually larger and oval-elliptical, with fine serrations along its margin.

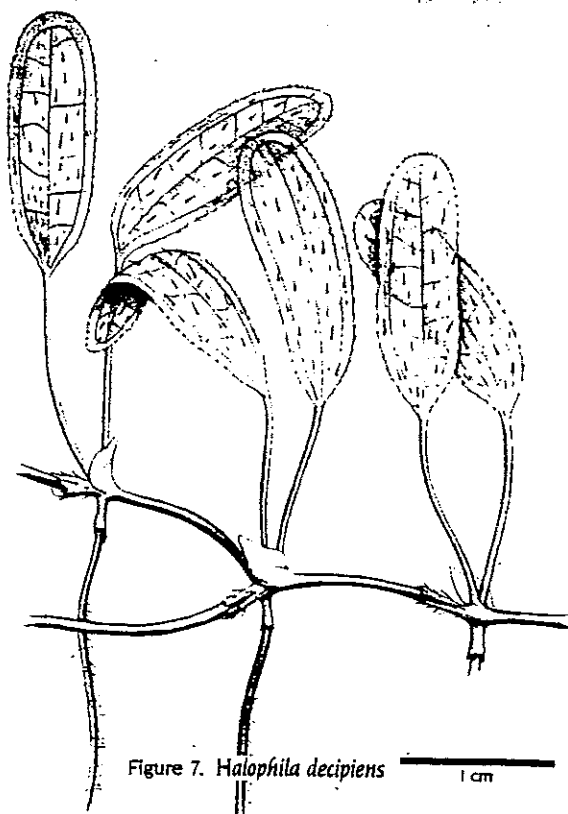


Figure 7. *Halophila decipiens*

## *Halophila decipiens*

### Morphology

The leaves of *H. decipiens* occur in pairs and consist of a distinct blade and petiole (Figure 7). The leaf blades are typically oval/elliptical in shape, 5 mm wide or narrower and approximately 1.0-2.5 cm in length. The leaf blade is hairy and translucent with prominent marginal and mid veins, the mid vein being most conspicuous. There are 6-9 pairs of cross veins. The margin of the leaf blade is finely serrated along its length; this feature is best observed with a hand lens or low power microscope. The rhizome scales are hairy. *Halophila decipiens* often has a 'dirty' appearance due to sediment entangled in the hairs of the leaves.

### Diagnostic features

Translucent, hairy, oval leaves with serrated margin. Prominent venation. Hairy rhizome scales.

### Likely to be confused with

Other *Halophila* species, particularly *H. ovalis* and *H. ovata*.

The leaves of *H. decipiens* are generally three times longer than broad, whereas the leaves of *H. ovalis* and *H. ovata* are less elongate, i.e. up to 2.5 times longer than broad. A more obvious feature is the margin of the leaf blade, which is smooth in *H. ovalis* and *H. ovata*, but finely serrate in *H. decipiens*.



Figure 13. *Thalassia hemprichii*

## GENUS THALASSIA

FAMILY: Hydrocharitaceae  
SPECIES: *Thalassia hemprichii*

### *Thalassia hemprichii*

#### Morphology

*T. hemprichii* exhibits some variation in leaf width and length and as a result workers sometimes attempt to describe several growth forms. However the basic structure remains the same (Figure 13). The rhizome is thick (up to 5 mm thick), and distinctive, since the nodes, where the old shoots joined the leaf-bearing branch, are plainly visible with a prominent scale at each. The pale basal leaf sheath is 3-7 cm long and well developed. Leaves are generally 10-40 cm long, ribbon-like and often slightly curved laterally. Leaf width is generally in the range of 0.4-1.0 cm. There are 10-17 longitudinal leaf veins. The leaves have numerous large tannin cells grouped in short black bars running parallel to the long axis of the leaf. These 'bars' are clearly visible to the naked eye and are one of the diagnostic features of this species. The leaf tip is rounded and sometimes slightly serrated (Plate 2d). No ligule is present.

#### Diagnostic features

Short black bars of tannin cells on leaf blade. Thick rhizome with conspicuous scars between successive erect shoots.

#### Likely to be confused with

##### *Cymodocea* species

*T. hemprichii* is commonly mistaken for one or other of the *Cymodocea* species, particularly *C. serrulata*. The most obvious difference lies in the structure of the rhizome. In *T. hemprichii* there are a number of shoot scars on the rhizome between successive erect shoots. In contrast, the rhizome of *Cymodocea* is smooth between shoots. *T. hemprichii* lacks a ligule, which the *Cymodocea* species possess.

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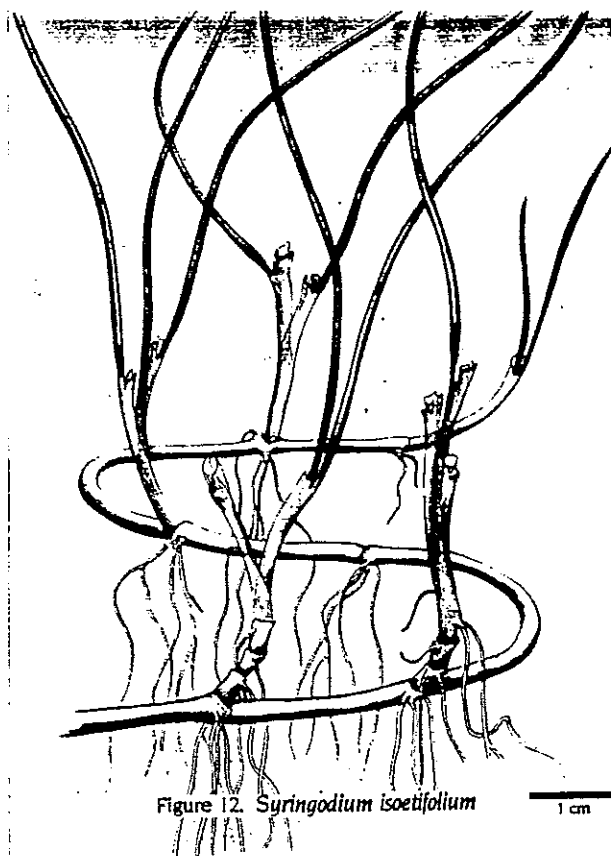


Figure 12. *Syringodium isoetifolium*

## GENUS SYRINGODIUM

FAMILY: Potamogetonaceae  
SPECIES: *Syringodium isoetifolium*

### *Syringodium isoetifolium*

#### Morphology

*S. isoetifolium* is the only north Queensland seagrass whose leaves are round in cross-section and thus it is easily recognized (Figure 12). The leaves of *S. isoetifolium* are quite thin (1-2 mm diameter), narrowed at the base and gradually taper off to a point at the leaf tip (Plate 2c). Leaves typically range in length from 7-30 cm. The rhizomes are thin and herbaceous, and at each node is a short erect shoot bearing 2-3 leaves. The leaf sheath is 1.5-4.0 cm long. A ligule is present.

#### Diagnostic features

Leaf narrow and round in cross-section, gradually tapering to a point.

#### Likely to be confused with

In a field situation, thin-leaved forms of *Halodule* species, *Z. capricorni*, *C. rotundata* or *T. hemprichii* may superficially resemble *S. isoetifolium*. However, upon closer examination, the cylindrical nature of *S. isoetifolium* leaves facilitates accurate identification.

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# AN ALTERNATIVE METHOD FOR SEAGRASS MAPPING

## A detailed worked example:

A group of 3 experienced observers were requested to map the distribution and abundance of seagrass meadows within a bay. The group had been requested by DPI to use the seagrass biomass ranking method of Mellors (1991). The survey was conducted over a 1 week period. At the beginning of the survey, the 3 observers gathered together to decide on the "standard ranks" for the study. As one of the observers had been to the area before, they went to a meadow which had both the greatest and lowest above-ground biomass that they expected to see within the bay. They placed a quadrat over an area they all agreed was the highest biomass (referred to as "standard rank 5") then another quadrat over an area they all considered was comparatively low biomass (referred to as "standard rank 1"). Then using this approach they found an area they all agreed was mid-way between the 5 and 1 (referred to as "standard rank 3"), and similarly set up standard ranks 2 and 4. The standard ranks they set up were what they believed to be a "linear" relationship between the ranks and the above-ground seagrass biomass. They also took photos of the standard rank quadrats so they could refer back during the week of surveying if required.

The observers then proceeded to survey the bay. Each observer recorded their own visual estimate ranks independently of the other observers estimates, and ranks were each estimated to one decimal place. The observers surveyed 1100 sites with 3 biomass estimates at each site (a site was agreed to be an area of 5 m radius). **At the end of the survey** the observers gathered at another meadow which had the highest and lowest biomasses, **similar to those found during the survey**. At this location the observers threw down 10 quadrats, spread over the range of biomasses observed. Each observer then **independently** ranked the above-ground biomass in each quadrat, in the same way as they did during the survey. After each observer had ranked each quadrat (being careful not to discuss and compare ranks with other observers), each quadrat was harvested and taken back to the laboratory for sorting.

In the laboratory, the above-ground biomass was separated from the below-ground biomass for each harvested calibration sample (the entire sample was separated, no subsampling). The above-ground component was then dried and weighed to 2 decimal places.

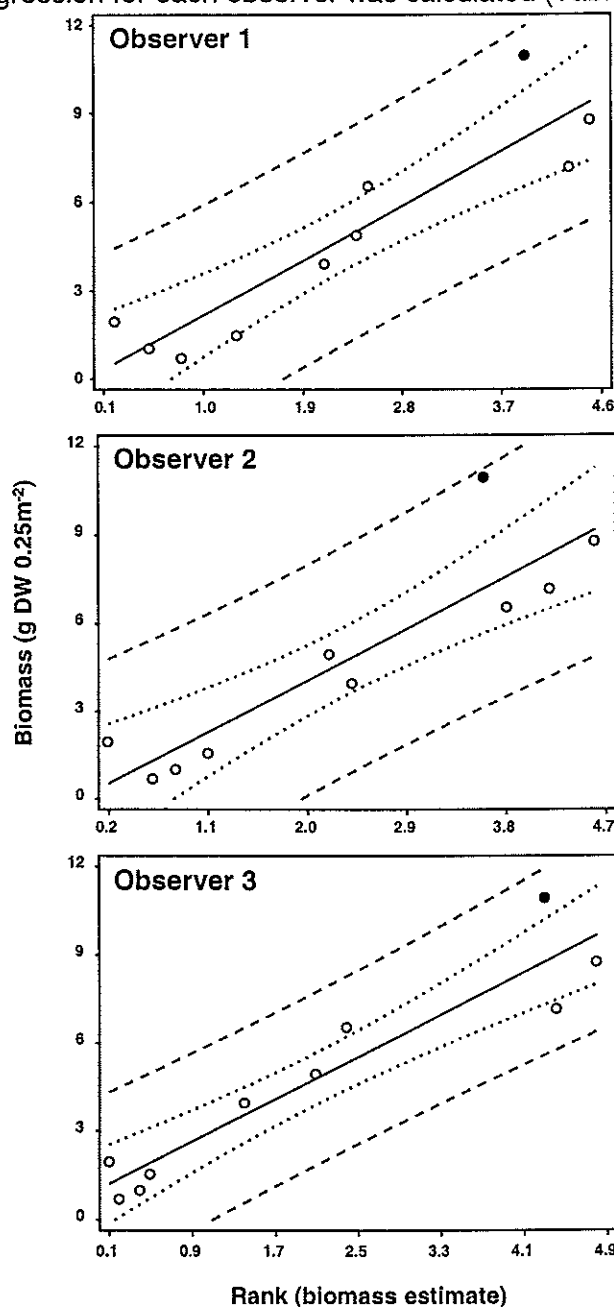
The observer's ranks of the calibration quadrats were then regressed against the actual above-ground biomass for the calibration quadrats ( $\text{g dry wt m}^{-2}$ ) (see Table 1).

**Table 1.** Biomass and respective observer ranks for each calibration quadrat.

Calibration Quadrat	Above ground Biomass ( $\text{g dry wt } 0.25\text{m}^{-2}$ )	Observer1	Observer2	Observer3
1	1.55	1.3	1.1	0.5
2	1.95	0.2	0.2	0.1
3	8.75	4.5	4.6	4.8
4	10.93	3.9	3.6	4.3
5	7.18	4.3	4.2	4.4
6	4.93	2.4	2.20	2.1
7	6.53	2.5	3.8	2.4
8	3.95	2.1	2.4	1.4
9	0.7	0.8	0.6	0.2
10	1.01	0.5	0.8	0.4
$r^2$		0.89	0.94	0.92

A regression is a mathematical equation that allows us to predict values of one dependent variable (in this case the actual above-ground biomass) from known values of one or more independent variables (ie. the observers ranks).

From a plot of each observers ranks against actual above-ground biomass (Figure 1), it appears that quadrat # 4 was an outlier (it was well outside the 95% confidence limits). This means that all the observers had ranked quadrat # 4 too low - possibly because many of the shoots may have been covered with sediment, making estimation difficult, *etc*). After quadrat # 4 was removed, a regression for each observer was calculated (Table 2).



**Figure 1.** Linear regressions to explain the relationship between observer rank and above ground seagrass biomass. (filled circles signify outlier).

**Table 2.** Regression of observers ranks

Observer	Regression
Observer1	$Biomass = 1.7908 \times Rank + 0.3601$
Observer2	$Biomass = 1.7227 \times Rank + 0.2520$
Observer3	$Biomass = 1.5888 \times Rank + 1.1836$

Using the regression for each observer, the field ranks estimated by each observer were converted to above-ground biomass (g dry wgt m<sup>-2</sup>). All calculations of seagrass abundance within the bay were then done using the g dry wgt m<sup>-2</sup> values.

**Further comments:**

- Mellors (1991) *does not recommend using integers, or categories*. An observer can estimate to 1 decimal place without difficulty (I suppose if you rank on a scale from 0.1 to 5.0 you in fact have 50 categories??)
- There is no need for observers to agree in the field after the standard ranks have been established. You do not want a single regression for all observers pooled. This is because *observers will always differ* - there is no point observers practicing to get the same rank. What is important is that **each observer has their own regression**, and that **each observer rank the same way each time**. In fact it is best that observers do not compare ranks at all when surveying an area, as this causes *bias*.
- The only values you are concerned with in the end is the above-ground biomass (g dry wgt m<sup>-2</sup>). The ranks only mean something to the particular observer who estimated them. **Only the converted biomass estimates should be used for analysis.**
- Re-calibration should be done for each sampling/survey event (*what an observer ranks this week may differ from what they rank next month*) and at different locations.
- There are instances when 2 sets of standard ranks have to be used within the same survey (1 set for low abundance meadows (eg. *Halophila*), 2<sup>nd</sup> set for high abundance meadows (eg. *Zostera*)) as this allows greater accuracy for biomass estimates.





## FEEDBACK

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

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

.....

What did you enjoy most about the training ?? .....

.....

How can the Seagrass Watch training be improved ?? .....

.....

.....

How do you think this manual can be improved ?? .....

.....

.....

What issues are there in your community which can potentially affect seagrasses?? .....

.....

.....

How do you think Seagrass Watch can help your community?? .....

.....

Other Comments .....

.....

.....

.....

*If you would like us to reply please include your name & address on the back.*

*Thanks.....*

Please send your comments to:

Seagrass Watch Coordinator  
Seagrass Ecology Group  
Northern Fisheries Centre  
PO Box 5396  
Cairns Q 4870



*You can contact us on:*



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## REPRINTS OF RELEVANT ARTICLES

The following reprints are provided for further reading

Coles, R.G., Lee Long, W.J. and McKenzie, L.J. (1995) A Standard for Seagrass Resource Mapping and Monitoring in Australia. ERIN, National Marine Information System, Data Collection and Management Guidelines - Marine Biology and Fisheries. <http://www.erin.gov.au/marine/natmis/standards/biology/leelon.htm>

Lee Long, W.J., McKenzie, L.J., Rasheed, M.A. and Coles, R.G. (1996) Monitoring seagrasses in tropical ports and harbours. Proceedings of the International Seagrass Biology Workshop, Rottnest Island, Western Australia 25-29 January, 1996. Eds. J. Kuo, R.C. Phillips, D.I. Walker and H. Kirkman. University of Western Australia. pp. 345-50.

Lee Long, W.J., Mellors, J.E. and Coles, R.G. (1993) Seagrasses between Cape York and Hervey Bay, Queensland, Australia. *Australian Journal of Marine and Freshwater Research*. **44**: 19-31.

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Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P. and van den Belt, M. (1997) The value of the world's ecosystem services and natural capital. *Nature* **387**: 253-260.

**WE VALUE YOUR FEEDBACK.**

**ANY COMMENTS OR SUGGESTIONS ON WAYS TO IMPROVE THE  
SEAGRASS WATCH PROGRAM WOULD BE GRATEFULLY  
APPRECIATED.**

## A Standard for Seagrass Resource Mapping and Monitoring in Australia

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### Abstract

Seagrass habitat loss and recognition of the value of seagrass habitats to fisheries in the 1970's and 1980's were the cause for early growth in seagrass research. Developments in seagrass research and data collection standards quickened in pace from the mid-1980's. Turbid, low visibility waters of much of Australia's tropical north coast require different data collection and data protocols to those of clear-water temperate regions. Further differences in approaches between temperate and tropical Australia are also necessary because of differences in seagrass species and habitat types. Measures of seagrass depth range, plant productivity, tissue condition/ nutrient content, biomass, shoot density, etc., can be chosen or adapted to suit the habitat types of any particular region. Regardless of locality, a minimum set of data required for seagrass collection would include:- a sample of seagrass plant lodged with a herbarium for future reference; a latitude and longitude; collector; depth; sediment type; samples of reproductive material and other species present. If collected in addition, seagrass biomass is recorded as g dw m<sup>-2</sup>. Biomass may be recorded separately for above- and below-ground parts of the plant, although the components measured depend on the species and its growth habit. It may be necessary to record separately leaves and stems for some large species. Other useful measures of abundance include shoot density and leaf-area index or a simple estimate of percentage cover of the bottom. Change in seagrasses can be measured as a change in shoot density; a change in biomass, above- or below-ground; increase or decrease in productivity; species composition; depth range or location of a meadow; change in area or shape of meadows and in associated flora and fauna. Sampling designs for monitoring can include:- stratified; random; systematic or adaptive approaches; and transects, randomised or fixed location of sampling sites according to local conditions and needs. A sampling design for monitoring is tailored to the question being asked, the precision required and the parameters of the habitat being studied. Baseline surveys may need intensive data collection so that initial estimates of spatial variability are available for developing an effective monitoring program. Collection of data on physical attributes such as temperature, salinity, light and nutrients are useful in interpreting changes. Satellite and aerial photo-imagery and use of rectified digital images on GIS basemaps makes for quicker, more precise, drafting and mapping, and more useful data presentation, analysis, interpretation and storage. Differential GPS is a quick method for position fixing during mapping and reduces point errors to <3m in most cases. It is essential that estimates of error and reliability accompany each seagrass map, measure of seagrass aerial extent, and other seagrass parameter estimates. Metadata should be attached to GIS archives to describe data source, data reliability, conditions of use, limits on interpretation and use-by date, and usually includes the correct form of citation to be used for acknowledging the data source.

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## Introduction

Seagrasses play a vital role in supporting coastal marine communities and in maintaining diverse flora and fauna. They support coastal fisheries productivity and play a role in maintaining coastal water quality and clarity. Fisheries and coastal zone planners in Australia today take into account these values in planning for conservation management of seagrass resources.

Seagrass research in Australia has only recently included a range of studies from cellular to organism, population, community and regional resource level. There has been little formal development and testing for national data collection standards. A standard for seagrass data collection was developed for the ASEAN-Australia Marine Science Project: Living Coastal Resources workshops (English *et al.*, 1994) and a UNESCO guide to seagrass research methods (Phillips and McRoy, 1990) describes techniques for a wide range of research needs from applied to theoretical applications.

We draw on this information for the present paper which addresses the protocols for seagrass resource mapping and monitoring and comments on the collection of essential voucher or reference specimens for taxonomy. Earlier standards for seagrass mapping (e.g., Walker 1989) are now part of a growing selection of alternative approaches as improvements in navigation and remote sensing technology and sampling design lead to more efficient and precise methods for mapping. In particular, accessibility to differential global positioning system (GPS) technology has given easy access to more precise position fixes. New methods of assessing seagrass abundance (e.g., estimates of biomass techniques, *cf.* Mellors, 1991) enable more sites to be sampled within less time and with considerably less destructiveness. Modifications of grab designs (e.g., Long *et al.* 1994) may improve opportunities for sampling in localities where diving is unsafe because of sharks or crocodiles or ineffective because of poor visibility. New equipment for improving divers' visual range in turbid conditions will have impacts on sampling in tropical coastal waters.

The present paper summarises and discusses methods for seagrass data collection and resource mapping and monitoring in Australian waters. The issues, methods and techniques detailed are also relevant to macroalgae.

## Sampling Strategy

Published descriptions of methods for mapping and monitoring coastal seagrasses are very recent, e.g., Kirkman (1996), Coles and Lee Long (1995) and Lee Long *et al.* (1996). Recognising the differences between tropical and temperate seagrass biology, there will be differences in sampling design and methodology. Our suggested national standard sampling strategy for seagrass resource mapping and monitoring is based on the following background principles.

### **Background principles for sampling strategies**

Baseline mapping programs are best designed with monitoring in mind, and include intensive sampling to allow for the possibility of high levels of temporal and spatial variability. Measures of spatial variability calculated within baseline mapping will influence the design of monitoring programs and the statistical rigour of any tests for detecting change. Baseline data sets must therefore include sufficient density of seagrass data points to enable a reasonable measure of the natural spatial, and temporal variability within the habitat. Monitoring (routine measuring to determine status or condition) requires a different set of information to mapping, and the temporal and spatial scales most suitable for monitoring depend on the questions asked.

Techniques used for sampling aquatic vegetation are variations of those used for terrestrial communities. The difference is that for seagrasses and algae a sampling strategy takes into account the problems of working on the sea-bed. These include limited time for sampling (based on dive tables, or exposure at low tide), limited visibility, difficulty in relocation of sites, high costs of vessel charter and variable sea states. Typically, seagrass habitats in Australia can be in remote locations

and biological parameters to be monitored, and provides examples of field sampling design, sampling methodology, sample processing, data recording, processing and analysis, with notes on safe procedures. Sampling methodologies detailed in the UNESCO monograph 'Seagrass Research Methods' (Eds. Phillips and McRoy 1990) are also recommended.

### **Equipment and Field Techniques**

Remotely captured (satellite and vertical air-photo) images for seagrass distribution and abundance can be digitised and rectified to geo-coordinates for use on a Geographic Information System (GIS). Acoustic survey techniques are showing promise for mapping and monitoring densely vegetated meadows, but require much more improvement to detect low vegetation cover.

We have regularly used methodologies developed by Mellors (1991) to measure and record change in seagrass biomass and species composition (McKenzie *et al.*, 1995). Other methods are described by Long *et al.* (1994) and Saito and Atobe (1970). The method adopted by any particular study will depend on the biological, logistic, cost-benefit, environmental and safety priorities of the study.

A technique developed for intertidal algae (Saito and Atobe, 1970) uses ranked estimates of vegetation cover in quadrats, including detailed assessments of species composition, for each sampling site. Rank estimates of above-ground biomass can also be used, as in Mellors (1991), and this technique is recommended for collecting seagrass biomass estimates from numerous sites, without harvesting large numbers of samples. 5 to 10 reference quadrats can be harvested at the end of a sampling event, to calibrate each persons' visual estimates against actual seagrass biomass measures. Incorporating estimates of species composition in quadrats (Saito and Atobe, 1970), makes the Mellors (1991) method even more useful. Care is required during every estimation of vegetation biomass and composition, but the errors inherent in visual estimates are acceptable if a sufficiently large number of sites are observed.

Where poor visibility prohibits visual estimates, grabs are an alternative for sampling seagrasses. Long *et al.* (1994) tested the use/efficacy of a modified "orange-peel" grab in different sediment and vegetation types, and report acceptable results. We have recently however developed an apparatus for making visual estimates in low visibility waters in northeastern Queensland and expect to publish this method in the near future.

### **Equipment needed for sample collection**

Satellite and aerial-photo images are commercially available, or special aerial photo runs can be arranged. Minimum requirements for ground surveys, include maps/charts (and aerial photos), GPS units (with differential capability if possible), depth measuring instruments, compass, quadrats and data sheets. We regularly use quadrats 50 cm x 50 cm as they are the largest size comfortable for diving operations, although smaller quadrats may be necessary in some circumstances, depending on the seagrass species. The researcher must also be aware of cumulative errors when multiplying measures from small quadrats to per metre square units. Vessels and diving gear are needed for subtidal work. Equipment for harvesting seagrass for biomass measures include:- 5 - 10 quadrats; collecting bags; knives (for cutting rhizomes around edges of quadrats); labels and plastic bags.

### **Calibration of equipment and samples**

Within the Mellors (1991) method, 5 to 10 quadrats - equal in size to the sample quadrats, and across the full range of biomasses observed during the survey - are ranked by each observer, harvested and biomass measured. Estimates of seagrass biomass are calibrated by calculating a regression equation for each observer. The regressions are for observer rank against actual dry weight biomass. Calibrations may need to be repeated for different seagrass species if plant physiology varies. As the Mellors (1991) visual estimates of seagrass biomass are calibrated to actual biomass measures within each survey, data can be cross calibrated with other surveys of seagrass biomass.

Depth measuring instruments are regularly calibrated and depth measures are standardised

and may include the added thrill of dangerous marine animals.

Seagrasses can change in several ways. There can be a change in:- shoot density; biomass; meadow area; meadow shape; species composition; plant productivity and depth distribution. There can be changes in the location of a meadow or a change in the associated fauna and flora, or a combination of some or all of these at small or large spatial and/or temporal scales. These changes may occur naturally and possibly on a regular seasonal basis. There is little information on the range of natural seasonal and year-to-year variability in seagrasses, and this information is a prerequisite to distinguishing human impacts. The seagrass parameters chosen for study depend on the questions to be answered. Seagrass parameters which represent indexes of impact can be monitored at local scales on permanent sites or throughout the meadow. These parameters can include seagrass tissue nutrients/elements (eg., Chlorophyll a, CHO's, C:N:P), plant productivity (eg., growth rates) or seagrass depth range. If it is necessary to know the changes in size of seagrass resources, distribution (maps) and abundance measures (eg., biomass, shoot density) are necessary for the whole meadow. The required precision and intensity of sampling effort will be less for regional scale studies.

### **Designing sampling programs**

We suggest a hierarchy of information is required. To scope the extent of the existing resource, remotely captured (eg. satellite or aerial photography) images combined with ground truthing and specimen collection would be a priority. Locations and areas which support seagrass resources of special importance which are under threat or areas for which more information is required could be identified from this data. At these select sites, detailed sampling would include species composition and estimates of means and variances for parameters such as above-ground biomass or percent cover. The choice of sampling designs (eg. systematic, stratified, multistaged or adaptive), and location of sites (eg. transects, haphazard, random or fixed approaches), will depend on the peculiarities of each study

situation. Attention should be drawn to the problems of pseudo-replication, spatial autocorrelation, assigning suitable controls and the difficulties in meeting all the requirements for parametric tests.

Seagrass biomass (above-ground), total area, percent ground cover, and species composition have been the most commonly chosen parameters for monitoring. Measuring seagrass growth parameters (eg. plant growth rates, plant tissue C:N:P, carbohydrate composition) provides greater insight into the causes of change in seagrass abundance. Physical environmental parameters which most often influence seagrass growth are:- light (Photosynthetically Active Radiation), turbidity, depth, temperature, salinity and sediment nutrients. Information on these parameters help in assessing the causes and scale of seagrass loss and the mechanisms for seagrass recovery. Turbidity, light (PAR), salinity and temperature are often included in monitoring, but require more frequent measurements according to the time periods over which they vary and affect seagrass growth and survival (Dennison *et al.* 1993).

The type of information to be collected on coastal habitat types such as seagrass meadows is dependent on the use expected for the data; the questions likely to be asked of the data; and the accuracy and precision of the answers required. Monitoring is easiest to apply to a specific environment concern such as the change likely to seagrasses from a port or harbour development. To measure regional changes it is our view that mapping using qualitative information on spatial distribution and repeated twice a year or at a suitable pre-determined time interval may provide a broad but sufficient indication of change. If changes in the area of seagrass measured this way continued in one direction for three or more sampling intervals, resources could be diverted to investigate the cause of change and, if possible and necessary, to remove the causal agent and at that point in time establish a more detailed monitoring program.

A useful basis for sampling is that adopted recently by the ASEAN-Australia Marine Science Project: Living Coastal Resources (English *et al.*, 1994). This details the physical

to depths relative to mean sea level (MSL), using the tidal plane information for each survey locality. The depth of the echo-sounder transducer below the water surface needs to be accounted for.

### ***Spatial resolution***

The scale decided upon for mapping or monitoring may determine the overall approach to sampling intensity and influences what is possible with a limited set of financial and human resources. If mapping for resource inventories is on a large scale (eg. the Great Barrier Reef World Heritage Area) then the intensity of sampling will be low and may detect only broadscale changes. Satellite imagery and aerial photography are useful for mapping where dense seagrasses can be seen on large scales (Kirkman, 1996; Hyland, Courtney and Butler 1989; Long *et al.*, 1994), but cannot always be used to successfully map or monitor seagrass biomass (Walker, 1989) or identify seagrasses of low density, or in water too deep or too turbid for remote sensing (Hyland, Courtney and Butler 1989). This may include vast areas of important seagrass in northern Australia.

If examination of seagrass meadows is required at a finer scale (eg., a port or harbour), the sampling intensity can be higher with greater precision than large-scale or remote areas and smaller levels of change may be detectable. If good quality remote sensing information or aerial photographs are available a stratified sampling design may be possible, requiring less field samples for the same resolution.

### ***Temporal resolution***

Seagrass abundance and distribution can change quite dramatically depending on time of year (a six-fold increase in biomass was recorded by McKenzie (1994) between seasons). This information is necessary in designing monitoring programs to measure inter-annual variability of seagrass meadows. A pilot study is recommended if time permits. Seagrass leaf turnover rates can be as quick as 15 days in tropical conditions but much slower (up to hundreds of days) in temperate regions (Hillman *et al.* 1989). Sampling during only one season may miss seasonal seagrass species,

and sampling in Winter is likely to record the smallest sustainable distribution for the year. Sampling during the period late Spring to early Summer, at least in the tropics, gives an idea of the highest abundances and greatest distributions.

It is important to ensure seagrass abundance is measured during a period of little seasonal change, and/or monitored at the same time each year and/or measured frequently. Sampling intensity can be concentrated and unevenly spread if the expected change is related to a point source or seagrass species respond differently to the same environmental change. It may be possible to monitor on a different spatial scale to that in the original baseline if sufficient information is available on the likely response of the system. In some cases it is difficult to find a statistical difference in biomass and abundance between adjacent months. Sampling twice or three times a year may be necessary.

### ***Sample storage & labelling***

Historically, seagrass voucher specimens have been stored dry pressed on herbarium paper. Specimens can be kept damp in cold storage for short term or fixed in a preservative for longer terms. Freezing larger specimens may result in a deteriorated, "mushie" end-product and is not recommended for taxonomic specimens. Standard procedure is to fix and store in 5-10% seawater formaldehyde. Specimens collected for reproductive section can be stored in 5-10% gluteraldehyde, or in alcohol : acetic acid (3:1) for chromosome analysis. Specific requirements are best discussed with the taxonomist as methods may vary with species type and size or with the investigative procedure. Minimum requirements for labelling include species name, preservative, collector, date, location, latitude and longitude, depth, sediment type and co-occurring species.

### ***Sample and data storage in the field***

Seagrass biomass samples for calibrating divers' estimates are stored refrigerated in plastic bags but should be processed within days. We use manually completed hard-copy field data sheets so that special notes and sketches can be incorporated. Total reliance on

electronic data may not be possible in a small vessel. Electronically collected GPS data can be downloaded and backed up frequently in the field.

### **Measuring problems and data quality**

It is important to be aware of possible sources of errors that can occur in the field as they directly influence the quality of the data. It is important to document these errors and ensure that this documentation travels with the data. Commonly encountered problems in the field when using the Mellors (1991) visual estimates technique require the following precautions to be taken.

1. Two sets of standard ranks may be necessary when the biomass between meadows varies greatly due to the species composition of a meadow (eg., a high biomass *Zostera* meadow verses a low biomass *Halophila* meadow). In such a circumstance it is often better to assign standard ranks to individual observers who are instructed to only examine meadows of equivalent biomass (eg., one observer ranks the *Zostera* meadows, while another observer ranks the *Halophila* meadows). This allows finer resolution of biomass estimation and finer levels of detectable change.
2. A photographic record of the standard set of ranks is useful for observers to review when mapping is over several days. This eliminates the chances of 'drift' in estimation.
3. It is necessary to calibrate after every mapping exercise, to eliminate the effects of any "drift" in estimations.
4. When position fixing with a GPS it is important for the observer to be as close as possible to the GPS aerial to minimise position fix error. This can be difficult in small boats under conditions of strong wind and current.
5. Conduct the calibration exercise in the same type of environment as the sampling was conducted so that visual estimates for calibrations reflect the conditions experienced during sampling.

### **Some Practical Guidelines for Field Work**

Guidelines for seagrass sampling are site dependant and local knowledge may be required. Safety should be foremost when sampling the marine environment, paying particular attention to tidal regimes, turbidity, sea-state, dangerous marine animals and other human activities and impacts. Local knowledge of the above factors should always be sought. We strongly recommend that diving policies be developed by each organisation and national safety standards be met.

### **Documenting physical conditions during sampling**

Climatic conditions, sea state, water visibility may effect the quality of data collected and should be recorded. Notes on any peculiarities of a site are also very useful in later validation of data and for general interpretation of patterns observed during field studies.

### **Data Processing and Reporting**

#### **Database management**

Relational databases are useful for storage and management of data. A protocol for verification of data and a reliability index is required. The data should be accompanied by any caveats on data reliability, eg., changes in data quality during sampling because of physical changes such as sea state. This is important when data is loaded into a GIS system which is used by managers. GIS data also requires a use-by date. Taxonomic data should be associated with a collector and source of reference material so species revision can be included, or species identification checked at a later date. Original (master) copies of final GIS maps should be stored in two places: the source laboratory and a regional or central archive. Always attach metadata and 'readme' files to GIS files the above-mentioned information on data source, data reliability, conditions of use, limits on interpretation and use-by date. Metadata also includes the correct form of citation to be used for acknowledging the data source.



### **Assessing change**

The size of change in the seagrass habitat that can be detected will depend on the resources available. Measuring a change induced by human activity against a background of natural variability can be difficult as little information is available on natural variability in the tropics and variability may be site and species specific. When assessing the downstream effect of coastal development the amount of change that is economically important may be different to what would be considered ecologically important. Even in countries with advanced research resources, detecting induced year-to-year changes of up to 25% in the tropics is in most cases unrealistic. A 50% year-to-year change in seagrass biomass normally would be detectable against natural change and would be important enough to prompt habitat management concern.

The level of significance (based on the Type I error) and level of assurance (based on the Type II error) in measuring and detecting changes are also important in calculating the most appropriate monitoring design. While it is preferable for the probabilities of both Type I and II errors to be as small as possible, a reduction in the probability of a Type I error inevitably results in an increase in the probability of a Type II error. In monitoring environmental factors such as seagrass abundance, accepting a high probability of Type II error is likely to be more costly in environmental terms than the risk of a Type I error (Peterman, 1990; Fairweather, 1991), i.e., it is better to say there is a difference when one does not exist (being over-cautious) than to say there is no difference when in fact a difference does exist. The probability of a Type I error is best risked in an attempt to reduce the probability of a Type II error.

### **Summary and Conclusions**

The use of standards/ guidelines for seagrass data collection and management in Australia is ad hoc and accords to regional and local conditions and available resources. Standards can be adopted across regions of similar species groups, climatic or ecological patterns. Differences between tropical and temperate seagrass systems may require minor regional

variations to the implementation of a national standard.

The recommended minimum procedure for ground surveys is use of the Mellors (1991) visual estimates of above-ground vegetation biomass, with estimates of species composition included. This has advantages of sampling numerous sites without having to harvest and process large numbers of samples. It is also the preferred method in sensitive or protected seagrass/ algae meadows. Quantitative (harvested) samples may be more appropriate for smaller experimental studies. The most commonly utilised measures for species which form high canopies still appear to be estimates of percent ground cover or shoot density. Remote sensing is less effective for mapping and monitoring for low vegetation cover, deep water or high. Cost, safety, remoteness, spatial and temporal scale and the questions being asked influence sampling design. Estimates of error and a use-by date are essential, and should where possible be attached to all archived databases and GIS maps.

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