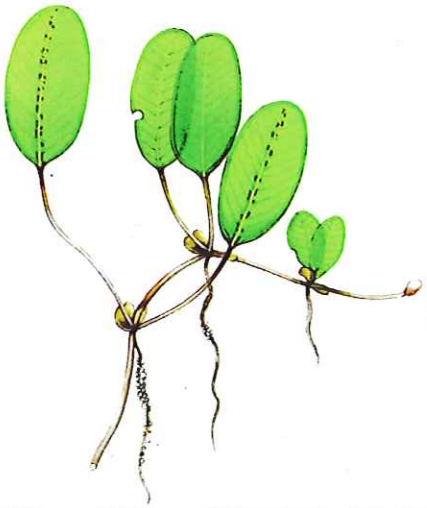
SEAGRASS-WATCH

Guidelines for Community Groups & Volunteers in the Hervey Bay and Great Sandy Straits Region



Coasts & Clean Seas

CRC Reef Research Centre

Queensland Government

DPI Queensland Department of Primary Industries

Queensland Department of Environment and Heritage

Marine Plant Ecology Group

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OVERVIEW

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

The ultimate aim of the **SEAGRASS-WATCH** program is to collect information 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 specific methodologies for the **SEAGRASS-WATCH** program will be developed with co-operation of community groups, volunteers and government departments.

SEAGRASS-WATCH 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 aim of the training exercise is to give community groups & volunteers an understanding of the principles behind the techniques which are being proposed for the **SEAGRASS-WATCH** program. The success of the participants in the training program will dictate the methods that are adopted. We envisage that the methods that are finally used in the program will be modifications from what participants will experience during the training exercises.

The following information is provided as

- training guide and
- basis from which a monitoring manual can be developed.

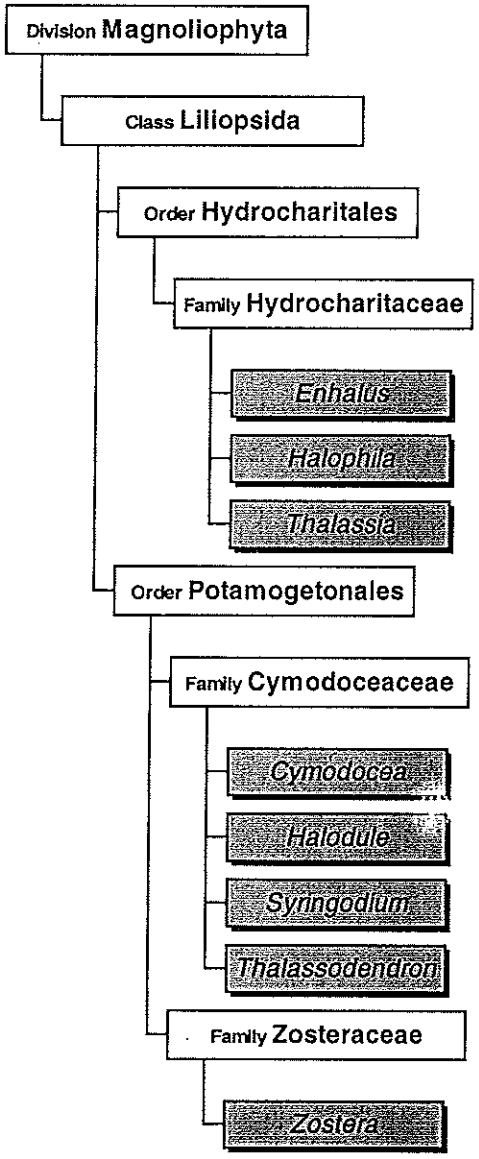
GENERAL INTRODUCTION

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.



Taxonomic classification of Queensland's seagrasses.

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 ^{1994}US$ 19,004 ha^{-1} yr^{-1} (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 [1992]AUS$3,687 ha^{-1} yr^{-1} (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.

Destruction or 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.

HERVEY BAY & GREAT SANDY STRAITS SEAGRASSES.

Seagrass meadows in the Hervey Bay and Great Sandy Straits 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 southern Great Barrier Reef and Hervey Bay Region.

The importance of seagrass in Hervey Bay to commercial and recreational fisheries production, and threatened species such as dugong and turtle populations is widely recognised. Prior to the seagrass die-off of 1992, Hervey Bay contained approximately 24% of the known area of seagrass along Queensland's eastern coast. (Preen *et. aL* 1995). Following the seagrass die-off, the dugong population decreased by 73%. Hervey Bay and the Great Sandy Strait is recognised as supporting the largest dugong population surviving south of the Stacke region of Cape York Peninsula and the area is declared as a Dugong Protection Area.

There are extensive and diverse seagrass meadows in the Hervey Bay 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.

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

* The State of the Marine Environment Report
* The Draft Conservation Plan for Dugong in Queensland
* The Great Barrier Reef Ministerial Council Dugong Review Group
* The Mary River Catchment Strategy
* Environment Australia - Coastal Monitoring Program, Seagrass Project

PROPOSED FUNDING FOR HERVEY BAY & GREAT SANDY STRAITS SEAGRASSES.

In late 1997, an application to fund a project titled *"Seagrasses habitat issues, and management - Hervey Bay & Great sandy Straits region"* was submitted to the Natural Heritage Trust, Coast & Clean Sea, Monitoring Program. The application supported inviting local community groups, in early 1998, to attend a workshop to develop community seagrass monitoring methods. . This would provide a group of local people trained in the methods required for scientifically rigorous assessment. These people will be available for the first phase of the project, to assist with remapping the extent of Hervey Bay region seagrasses and to conduct ongoing monitoring.

The training program was envisaged to sustain community interest and educate community groups in how to assess/map intertidal seagrass meadows in the Hervey Bay and the Great Sandy Straits region. After training, volunteers and community groups could collect data from the region to give some indication of the overall extent, and to identify any areas which may need particular attention/focus in the main project (co-ordinated via the Hervey Bay DoE). A training manual and video will be developed for future reference.

A scientifically based ongoing monitoring program is proposed to be implemented after the extent Hervey Bay region seagrasses have been mapped. The monitoring program will be designed to provide an early warning of change in the seagrasses of Hervey Bay region 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 specific question to be answered and will be decided in collaboration with the community and research scientists (including peer review). The purpose of monitoring is to provide an early warning of change to alert management agencies.

The programs 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.

The monitoring program will be ongoing using volunteers and community groups of the Hervey Bay and Great Sandy Straits region. This program would be coupled with the current ongoing water quality monitoring by the Hervey Bay City Council and DoE.
Also, reactive monitoring of catastrophic events, such as floods, would be established, modelled on the GBRMPA contingency program. A response protocol and personnel/equipment would be established.

Finally, research projects would 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 Hervey Bay and Great Sandy Straits including up-to-date results of subtidal and intertidal seagrasses.
* Assessment of present status of seagrass meadow area and relative density 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 Hervey Bay region.

THE APPLICATION IS STILL PENDING!!

TRAINING EXERCISE

Training will be conducted over 2 days:

DAY 1. FIELD TRAINING

Saturday 28th March

Where:
All participants are asked to meet at the beach at the southern end of the Urangan marina.

When:

To be assembled by 1:00pm for training instructions.

What to bring:
* hat, sunscreen *(Slip! Slop! Slap!)*
* dive booties or old shoes *(for walking in mud!)*
* drink/refreshments
* polaroid sunglasses *(not essential)*
* enthusiasm

What to expect:
Participants will be instructed in the techniques currently used by the Seagrass Ecology Group (NFC) to survey seagrass. You will first be given an instructional talk, then proceed to survey a seagrass meadow along transects with a DPI staff member. You will be walking across a seagrass meadow exposed with the tide, through shallow water. There will also be digging involved. It may be muddy!

We welcome your children, but please keep them under close supervision (they may enjoy the digging).

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

Duration:
Please allow approximately 21/2 hours for the field training.
QDPI staff members will be on the site between 12:30 - 5:00pm

DAY 2. LABORATORY TRAINING

Sunday 29th March

Where:
All participants are asked to meet at the University of Southern Queensland, Wide Bay Campus, Hervey Bay *(old Maryborough Rd).*

When:
QDPI staff members will be at the Campus between 10:30am - 3:00pm.

What to bring:
- You will be in a laboratory and will therefore require suitable dress (covered shoes, no thongs).
- Enthusiasm

You will learn:
- how to measure above-ground seagrass biomass
- seagrass taxonomy and how to make a seagrass press
- how the data collected from a survey is put into a GIS (Geographic Information System), interpreted and used for management.

Duration:
Please allow approximately 2 hours for the laboratory training.

DPI staff..

Rob Coles *(Senior Principal Scientist)*
Len McKenzie *(Senior Research Scientist)*
Chantal Roder *(Fisheries Biologist)*

Coasts & Clean Seas

QUEENSLAND GOVERNMENT

CRC Reef Research Centre

Queensland Department of Environment and Heritage

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES FISHERIES

FIELD TRAINING EXERCISE

Please sign the attendance sheet with you name and address.

A short talk will be given prior to the field exercise

In this exercise you will learn how to estimate seagrass biomass using the method of **Mellors (1991).** This method visually estimates above-ground dry weight biomass. The method calibrates these standing crop estimates against a set of pre-selected quadrats which are harvested at the end of the exercise. The visual technique is more precise than some traditional harvesting methods due to the larger number of replicates that can be taken.

SITE SELECTION

- Aerial photographs will help identify the location and extent of seagrass meadows.
- A preliminary (general) visual survey of the area is required to map out, establish and adequately represent differences and the real extent of the seagrass meadows.

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 and kept as a permanent record.
- ☐ Pencils.
- ☐ Waterproof labels. Pre- printed labels ensure that all required data are recorded for each sample.
- ☐ Plastic bags
- ☐ 50-100 metre fibreglass measuring tapes.
- ☐ Dive knife.
- ☐ Diving mesh bags.

GENERAL PROCEDURE

- Select **5 reference quadrats,** we will help!. The quadrats should represent the range of seagrass biomass (most to least) likely to be encountered during sampling. Remember to estimate **dry weight biomass** and not percent cover. You must consider the area of bare ground between plants, plant height and the moisture content of each species.
- Rank the 5 reference quadrats on a linear scale, 1 (least) to 5 (most).

- Select the reference quadrats for Rank 1 and Rank 5 first, followed by Rank 3, and finally Rank 4 and Rank 2

Rank	Estimate
0	Nil
1	Least
2	Half-way between Ranks 1 and 3
3	Half-way between Ranks 1 and 5
4	Half-way between Ranks 3 and 5
5	Most

- The reference quadrats must be agreed to by all observers *(photograph for future reference).*
- Leave the reference quadrats in place until the entire exercise is completed.
- Select the position *for* a transect after a *visual survey* of the area, we will help!. The transect should be representative of the entire seagrass area.
- Record the position of the transect on the map provided. The origin (inshore end) of the transect is the most useful reference.
- A GPS (Global Positioning System) can be very useful if available, or a hand-held compass to determine the bearing, 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, and should extend to outer limits of the bed (where the seagrass disappears).
- The transects should be separated from each other by a reasonable distance (50 to 1 00 metres).
- Starting at the transect origin, haphazardly toss 3 quadrats within an area of approximately 5 metre radius.
- For each quadrat, first estimate (rank) the above-ground biomass as per the 5 reference quadrats *(you may want to check to refresh your memory).* Then determine the seagrass

species present and their respective percent covers. Record all data legibly onto the data sheets provided.

- Record the sediment code and write any comments if any (eg. *Lots of algae).*

- Proceed along the transect recording the ranks in 3 quadrats at each site. Sites should be taken at regular intervals (usually 20 metres) along the transect, so that gradients in community structure are described.

☞ *In a large unifonn (homogeneous) seagrass meadow which extends out from the shore for more than 100 metres, the sample interval may be every 15 to 20 metres. In mixed (heterogeneous) 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.

- You will be provided with photographs of seagrass quadrats (labelled A to 1). Rank the above-ground biomass of the seagrass in each photograph, and record on **calibration data sheet.**

- As a group, we will select 1 0 quadrats at the completion of the transect surveys, to represent the ranks (1 to 5) encountered along the transect. These 1 0 **calibration quadrats** cover the range of biomasses at the location.

- Rank the above-ground biomass of the seagrass within each of the labelled calibration quadrats, the same as you did when surveying along the transect.

- Photograph each of the calibration quadrats for future reference.

- Collect ail the seagrass from the 10 representative quadrats, for calibration of the rank estimates. First cut around the inner edge of each quadrat using a dive knife and then carefully loosen the vegetation inside the quadrat. Collect all the vegetation inside the quadrat (including roots and rhizomes).

- Place the sample from each quadrat inside a separate plastic bag with a waterproof label clearly identifying the sample.

- Take the seagrass samples back to the laboratory for analysis.

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

Before you leave, there are limited copies of **SEAGRASS WATCH:** Guidelines for Community Groups & Volunteers *available.*
Just ask a DPI staff member if you would like a copy.

LABORATORY EXERCISE

The laboratory exercise follows directly 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 learn how to measure seagrass biomass, how to identify seagrass species using a taxonomic key, how to make a seagrass press specimen and how the data you collected is analysed and interpreted.

TO DETERMINE ABOVE-GROUND SEAGRASS BIOMASS:

- Process individual calibration quadrat samples.
- Rinse the plant sample from each quadrat in water, and work on sample in sorting tray. Always keep the label with the sample.
- Clean adhering debris off the samples.
- Separate sample into above ground (leaves & sheaths) and below ground (roots & rhizomes) portions. Check with instructor if unsure.
- Blot above-ground portion of sample dry with paper towel, place in labelled paperbag dish and weigh (wet weight in grams to 2 decimal places). Record wet weight on data sheet.
- Blot below-ground portion of sample dry and weigh (wet weight in grams to 2 decimal places). Record wet weight on data sheet. Discard below-ground portion.
- To obtain dry weight of above-ground portion, place the labelled paper bag in an oven at 40 to 50 'C to constant weight (dry weight in grams).

SEAGRASS TAXONOMY AND MAKING A HERBARIUM PRESS:

- Wash voucher seagrass specimen and carefully remove any debris or epiphytes.
- Identify specimen to species level if possible with keys provided. Most of the gross morphological characters used can be seen with the naked eye. A hand lens is useful for some minute features.
- Layout 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,]at/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.

ANALYSING THE DATA.

Demonstration of how to convert field biomass estimates (ranks) into dry-weight:

- Calibration curves will be establish for each observer by regressing the aboveground dry weights against the corresponding rank for the 1 0 calibration quadrats. We will do this in groups with a DPI staff member

- Regressions for each observer will be used to transform field biomass estimates (ranks) into dry-weights.

Demonstration of Geographic Information System and mapping.

PLEASE DO NOT HESITATE TO ASK A DPI STAFF MEMBER FOR ASSISTANCE OR INFORMATION.

WE VALUE YOUR FEEDBACK.

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

APPLICATION OF THE VISUAL ESTIMATES TECHNIQUE

A DETAILED WORKED EXAMPLE FOR ADVANCED PARTICIPANTS:

A group of 3 observers was asked to map the distribution and abundance of seagrass meadows within a bay. 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 biomasses 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 "linea?' 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 1 1 00 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 (g dry wgt m-') (see Table 1).

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

Calibration Quadrat	Above ground Biomass (g dry wgt 0.25m-2)	Observer 1	Observer 2	Observer 3
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
R2		**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 9 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).

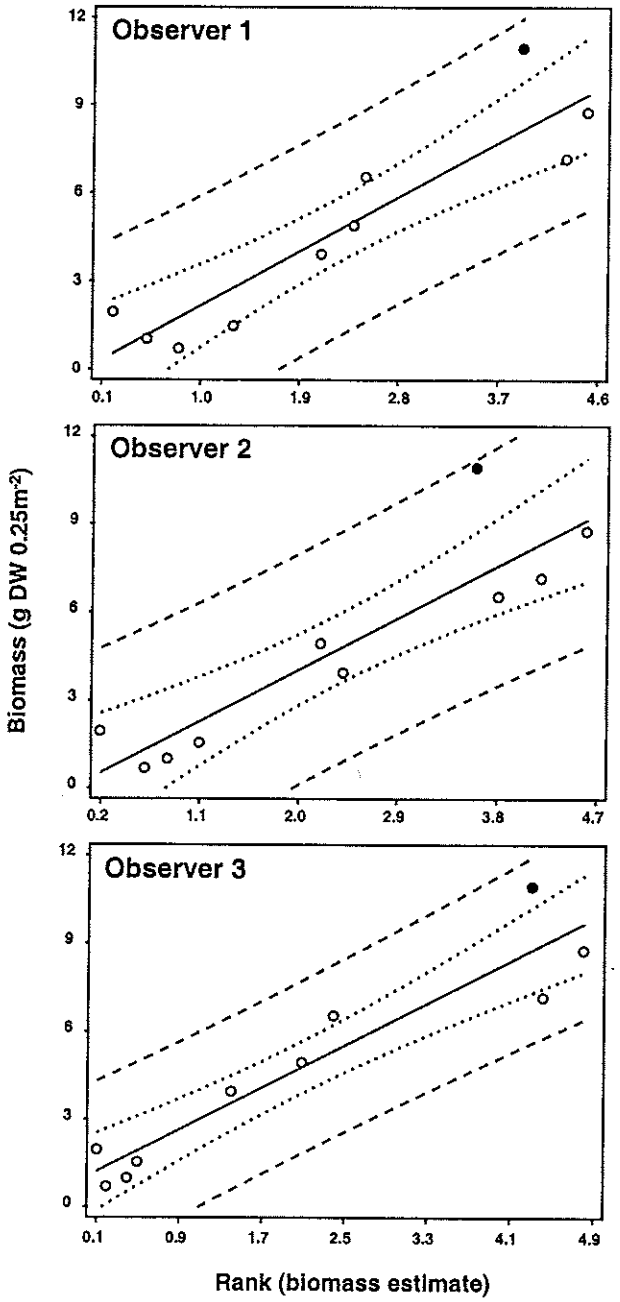


Figure 1. Linear regressions to explain the relationship between observer rank and aboveground seagrass biomass. (filled circles signify outlier).

Table 2. Regression of observers ranks

Observer	Regression
Observer 1	*Biomass* = 1.7908 x *Rank* + 0.3601
Observer 2	*Biomass* = 1.7227 x *Rank* + 1.2520
Observer 3	*Biomass* = 1.5888 x *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'). All calculations of seagrass abundance within the bay were then done using the g dry wgt m-' 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-'). 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),* 2nd set for high abundance meadows (eg. *Zostera))* as this allows greater accuracy for biomass estimates.

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) Hydrochadtaceae) 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 *spinulosa*
     3 leaves per erect lateral shoot node; blade with sparse serrated margin *tricostata*
   - C. Leaf blade longer than petiole; blade margin finely serrated, blade surface usually hairy *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 1 cm 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 *Thlalassia hemprichii*
4. Leaf blade more or less terete *Syringodium isoetifolium*
   Leaf blade linear, flat, not terete 5

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 failing 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 capiicornii*

7. Leaf blade with 3 veins Halodule 8
   Leaf blade with more than 7 veins *Gymodocea* 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. pinifloia*
9. Leaf scars closed; blade apex rounded with no or weakly serated *C. rotundata*
   Leaf scars open; blade apex blunt with strongly to moderately serrated *C. serruluta*

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

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The Seagrass Ecology Group, based at the Northern Fisheries Centre, Cairns, is an internationally recognised and industry-funded team deeply committed to the QDPI's 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 nine staff focus on seagrass management and research and in May 1997, the Seagrass Ecology Group were presented one of the eight 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 and for Marine Park zoning plans (GBRMPA), and monitoring change in fisheries productivity and marine plants. Seagrass habitat maps have:

- enabled the prawn trawling industry to avoid trawling on these sensitive habitats and protect juvenile prawn nursery grounds and recruitment 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 to 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 asked to develop the Australian Standard for monitoring change in seagrasses and has developed 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 two 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, 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 a reputation as the leading advisers on seagrass management in north-eastern Queensland. The Group is about 80% externally funded. Almost all research is to a contract timetable and the Group has delivered a quality product on time.

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 timely publication of reports; by excellent quality control; and by many public appearances to maintain commercial acceptance and goodwill.

The Seagrass Ecology Group always 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. Group publications always include those staff that contributed to the science. The Group has a strong commitment to provide information to schools and public awareness programs. The Group provides information for Integrated Catchment Programs and is currently 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 (Temp. Biologist)
Ms Wendy Baker (Scientific Assistant)

REPRINTS OF RELEVANT ARTICLES

The following reprints are provided for further reading

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Preen, A.R., Lee Long, W.J. and Coles, R.G. (1995) Flood and cyclone related loss, and partial recovery, of more than 1000 km' of seagrass in Hervey Bay, Queensland, Australia. *Aquatic Botany* **52:** 3-17.

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Daniel, P.A. (1 997) Wasting Disease in seagrass - review of current literature.

Wasting Disease in seagrass - review of current literature.

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Massive die-back or wasting of seagrasses has been recorded around the coasts of the world since the 1930's. A marine slime mold, *Labyrinthula sp.* was identified as the suspected pathogen in this wasting disease. *Labyrinthula* usually plays a non-aggressive role in the senescence of seagrass leaves. Small brown spots which develop in lesions and spread, becoming much darker, throughout the leaf are characteristic symptoms of this disease. It is believed that one or a combination of external influences, both natural and anthropogenic, stress the health of seagrass communities triggering these events. Transmission is most likely via direct contact of infected leaves with healthy ones. The die-back of seagrasses has been recorded right around Australia.

The occurrence of a wasting disease or dieback, in seagrass meadows has been recorded worldwide (Muehlstein et al, 1988; Wnuczynski, 1996). It was initially and most dramatically observed in the eelgrass, *Zostera marina,* in the early 1930's along the coasts of North America and Europe. By 1933, in virtually one year, the disease had decimated 90% of the eelgrass in the North Atlantic (Anon, 1997).

Similar events where noted in eelgrass populations along the US Pacific coast in the late 1930's, New Zealand in the early 1960's and has re-occurred since 1984 in specific localities along both the east and west coasts of the USA and Europe (Muehlstein *et al.,* 1988). This disease has been particularly studied in the turtle grass, *Thalassia testudinum* in Florida Bay, southern Florida, USA., where rapid and widespread recurring mortality has been found since 1987 (Durako and Kuss, 1994).

In Australia, losses of seagrass have been extensive since the 1960's, but documented as principally human-induced (Walker and McComb,1992). The presence of *Labyrinthula* however was found throughout Lake Macquarie and the Tuggeron(?) lakes in NSW in the mid 1970's without any signs of a wasting event (West, pers. comm).

More recently in Great Sandy Strait, south-east Queensland, a decline of seagrass began in the early to mid 1980's, with a loss of *Zostera capricorni* in the upper region of Tin Can Bay. This loss had spread extensively out into large seagrass meadows of the straits by 1988. Five of the predominant species of seagrass present in Great Sandy Strait; *Zostera capricorni, Halodule uninervis, Halophila spinulosa, H. ovalis* and *Cymodocea serrulata,* have undergone periodic decline over the past three years and the symptoms associated with wasting disease noted (McLeod pers comm., in Wnuczynski, 1996). Wnuczynski(1997), isolated *Labyrinthula* from seagrass meadows of the Great Sandy Strait and Moreton Bay in 1995.

Reports of seagrass die back have also come from Torres Strait (Pitcher and Bishop, 1994). An unusually large run-off of freshwater from the Papuan mainland is suspected to be the cause of this event (Long and Skewes, 1996). Although the presence of *Labyrinthula* was not recorded in this location, it has been recorded in

tropical mangrove ecosystems (Ulken, 1986; Ulken *et al.*, 1990; Bremer, 1993).

Species of *Labyrinthula*, commonly referred to as marine slime molds, are widely distributed in coastal areas around the world (Vergeer and den Hartog, 1994). They have been isolated from a variety of marine habitats and substrates including organic detritus, diatoms, macro-algae and marine vascular plants. Infection experiments have shown isolates to be genus specific. *Labyrinthula zosterae* for example, has only been isolated from species of *Zostera* (Short *et al.*, 1993). The *Labyrinthula sp.* isolated from *H. ovalis* is the most aberrant and may represent another genus. Currently eight to nine species of *Labyrinthula* have been recognised (Porter in Vergeer and den Hartog, 1994), with one freshwater species reported (Zopf in Muehlstein *et al.*, 1991).

Labyrinthula spp. are characterized by spindle or fusiform shaped cells surrounded by an ectoplasmic network which serves a role in cell adhesion, motility, communication and nutrition (Porter, in Muehlstein *et al.*, 1991). The development of wasting disease symptoms have been recorded and most recognized in *Z. marina.* Lesions develop which cause some air lacunae to fill with water. Small brown spots and stripes develop in these lesions which then spread along the leaf and become darker. In very diseased plants, these characteristics are evident in even the youngest leaves but are usually restricted to the oldest leaves in most populations. Similar lesions have been found on almost every seagrass investigated (Vergeer and den Hartog, 1994).

Cytological studies of the pathogen have shown it to be most frequently associated with marginal areas of the disease symptoms. In early stages of infection, *Labyrinthula* cells were located in the mesophyll cells taken from marginal areas of necrosis of small necrotic spots. *Labyrinthula* cells were rarely observed in epidermal cells. The mesophyll cells may be nutritionally more advantageous or easier to penetrate. They appeared to move rapidly through the tissue, directly penetrating the cell walls of the host. The ectoplasmic network that surrounds *Labyrinthula* cells appears to have an important role in the enzymatic degradation of the host plant cell walls and then presumably a role in the destruction of cells contents. In leaf pieces from marginal areas of larger necrotic patches, *Labyrinthula* cells had invaded the vascular tissue. Later phases of infection are characterised by leaf tissue that is completely brown, with pathogen cells more common in the epidermal cells and occasionally in the lacunae (Muehlstein, 1992).

Direct contact of diseased leaves with healthy leaves is thought to be the most probable mechanism of disease transmission. In laboratory conditions, direct contact was necessary for disease symptoms to appear. In nature, water currents could facilitate a diseased leaf coming in contact with healthy tissue. The pathogen was never isolated from the roots or rhizomes (Muehlstein, 1992).

Durako and Kuss (1994), recorded the pathogenic effect of *Labyrinthula* on *T. testudinum.* They noted that when *Labyrinthula* infected lesions where present, there was a reduction in photosynthetic capacity. The maximum photosynthetic rate decreased to below zero when lesions covered 25 % or more of the leaf tissue. At the same time the oxygen demand of the leaves increased, with respiration rates being up to three times higher in infected leaves than in non infected leaves. Severely infected tissues exhibited net respiration, even in high light levels. This may then reduce the availability of oxygen for transport to below ground tissues, possibly making *Thalassia* more susceptible to hypoxia, a proximal cause of death.

The presence and activity of a slime mould, *Labyrinthula zosterae*, was initially generally thought to be the pathogen and

the sole agent responsible for this massive wasting of seagrass communities world wide (Muehlstein *et al.,* 1991; Short et al 1993). Although wasting disease has been recognised as a natural event (den Hartog, 1987), further studies have shown *Labyrinthula* spp., to be associated with seagrasses, without necessarily large scale epidemics comparable to the 1930's (Muehlstein *et al.,* 1988), or no damage at all (Vergeer and den Hartog, 1994). The occurrence of the disease does not always result in the death of the plant (Short *et al.,* 1993).

The omnipresence of Labyrinthulacae in seagrasses has suggested it has a functional role. Labyrinthulacae was found in all 11 seagrass species investigated, belonging to nine genera (See Appendix One). In all species, *Labyrinthula* was isolated only from wasting disease like lesions in the oldest leaves. The only exception to this was with *H. ovalis*, where it was found on healthy green leaves. Thus it is thought that *Labyrinthula* normally plays a part in the senescence of the leaves. This supports the view that other factor(s) are also required to catalyze an outbreak of the wasting disease. This could be through increasing the susceptibility of the seagrass or stimulating the growth of the slime mold (Vergeer and den Hartog, 1994).

That *Labyrinthula* is normally a non-aggressive secondary decomposer of seagrasses is well accepted within the scientific literature (Young, in den Hartog 1987, Wnuczynski 1996, Landsberg *et al.,* 1996). Exactly what triggers an outbreak of a wasting or die back event though still remains unclear (den Hartog 1987, Nienhuis 1994, Vergeer *et al.,* 1995). A local explanations appear to be necessary, rather than a global cause (den Hartog, 1987).

Natural phenomena such as floods, droughts or hurricanes produces stress in specific localities. The decline of *Zostera* in the US, for example coincided with a period of very low precipitation, while conversely another more localised decline in seagrass correlated with extremely high rainfall. The decline of *Zostera* in Denmark in the 1930's, related to high summer water temperatures which supported the drought correlations, where drought is accompanied by high water temperatures, salinity and light intensity (Martin, in den Hartog, 1987).

However due to the surprisingly virulent and aggressive nature of *Labyrinthula* in a wasting event, many researchers see anthropogenic influences as the primary catalyst (den Hartog 1987, Wnuczynski 1996). Reduction in water quality through eutrophication, chemical input, thermal and sewerage effluent and such events as oil spills, increased turbidity from dredging and salinity changes are some man induced factors that cause a reduction in seagrass meadows (Wnuczynski, 1997). The initial die back of seagrass communities in the Great Sandy Straits region, coincided with township development and population increases along the adjacent coast. The development of sewage treatment plants, rubbish dumps and industrial estates are thought to more than likely have had a negative influence on coastal aquatic ecosystems (Wnuczynski, 1996).

Any environmental circumstances prevailing at the time of the wasting events that altered light intensity and water temperature may as in the case of *Zostera* make the seagrass more susceptible to *Labyrinthula.* Phenolic compounds in eelgrass for example act in the chemical defence of the plant against invading organisms. Plants grown under high light intensity show higher levels of these phenolic compounds, than those in low light. Whereas an increase in water temperature leads to a decrease in these compounds. An infection with *Labyrinthula* itself also greatly effects the phenolic compounds (Vergeer *et al.,* 1995).

The one element in the wasting disease enigma that is uniformly agreed upon is the link between salinity and disease severity.

In a Wasting Index developed by (Burdick et al, 1993), the disease was found to rapidly spread above a certain salinity threshold. Declines below this salinity, due to rainfall or run off allowed recovery. Tests at various salinities have demonstrated that below 10 ‰ the disease symptoms rarely appear, and not at all below 5% (Muehlstein *et al.*, 1988).

In the example of Durako and Kuss (1994), density-dependant studies on *Thalassia*, drought conditions in addition to diversion of upland run off, had resulted in the lagoon becoming hypersaline. This was compounded by a reduction in the frequency of hurricanes in the region, reducing low salinity pulses through the system and allowed an increased accumulation of sediments. These changes allowed *Thalassia* to develop to high densities. When the outbreak of wasting disease occurred it was absent in the lower salinity basins in the northeast of the bay even though these populations where chronically stressed. This study suggests that a combination of factors trigger a wasting event.

Little information was available on recovery seagrass. In the North Atlantic, it was noted that recovery of eelgrass from the 1930's epidemic was slow taking several decades. Even then it did not reappear in all of its previous locations. In 1988, the symptoms of wasting disease was again noted in many widespread eelgrass populations. There have been several local declines but non-comparable to the earlier epidemic (Muehlstein *et al.*, 1988). It has been suggested that this may be a developmental cycle of 50-55 years (Glemarc, in den Hartog, 1987). As already discussed a sufficient decline in salinity would facilitate inactivating the pathogen and allow recovery (Burdick *et al.*, 1993) but no time frame has been investigated to date.

Muehlstein *et al.* (1991) found *Labyrinthula* easy to isolate using modified techniques of Watson and Ordal (1957) and Koch's postulates (Brock, 1961) to test its pathogenicity. Species identification is facilitated primarily by substrate or host specificity, growth patterns and cell morphology.

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Appendix One

List of 11 species of seagrass and their locations from which *Labyrinthula* was isolated during investigations by Vergeer and den Hartog (1994).

Zostera marina	Exmouth, England
Zostera mucronata	**Swan River, Perth, Western Australia**
Heterozostera tasmanica	**Whitfords area, Mullaloo pl. Western Australia**
Posidonia oceanica	Gallipoli, Italy
Halodule uninervis	Mombasa, Kenya
Cymodocea nodosa	Taranto, Italy
Syringodum isoetifolium	Mombasa, Kenya
Thalassodendron ciliatum	Mombasa, Kenya
Ruppia cirrhosa	The Fleet, England
Thalassia testudinum	Curacao, Netherlands Antilles
Halophila ovalis	**Whitfords area, Mullaloo pl. Western Australia**

FEEDBACK

We value your suggestions or any comments you may have to improve our **SEAGRASS-WATCH** program.

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