SeagrassNet

Manual for Scientific Monitoring of Seagrass Habitat

Western Pacific Edition



F T Short
L J McKenzie
R G Coles &
J L Gaeckle

April 2004



Manual for Scientific Monitoring of Seagrass Habitat

Western Pacific Edition

April 2004

The University of New Hampshire, United States of America and State of Queensland, Department of Primary Industries, Australia.

Copyright protects this publication. Except for purposes permitted by the Copyright Act, reproduction by whatever means is prohibited without the prior written permission of the University of New Hampshire, United States of America and Department of Primary Industries, Queensland, Australia. Updated 26 June 2006.

Based on: Short, F.T., McKenzie, L.J., Coles, R.G. and Vidler, K.P. (2001) SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat. (QDPI, QFS, Cairns). 56pp.

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

The University of New Hampshire and Department of Primary Industries have taken all reasonable steps to ensure the information contained in this publication is accurate at the time of publication. Readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

The correct citation of this document is

> *Short, F.T., McKenzie, L.J., Coles, R.G., Gaeckle, J.L. (2004) SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat – Western Pacific Edition. (*University of New Hampshire, USA; QDPI, Northern Fisheries Centre, Australia). 71pp.

Inquiries should be directed to:
Fred Short
SeagrassNet, Director
University of New Hampshire
Jackson Estuarine Laboratory
85 Adams Point Road
Durham NH 03824 USA
fred.short@unh.edu
or
Len McKenzie / Rob Coles
Northern Fisheries Centre,
PO Box 5396
Cairns, QLD 4870 Australia
Len.McKenzie@dpi.qld.gov.au
Rob.Coles@dpi.qld.gov.au

Table of Contents

OVERVIEW 5

SEAGRASSNET MONITORING SUMMARY 7

SEAGRASSNET = SEAGRASS MONITORING NETWORK 7

CHAPTER 1. GENERAL INTRODUCTION 13

1.1. SEAGRASSNET PROGRAM AIMS 13

1.2. GOALS & OBJECTIVES 13

CHAPTER 2. SEAGRASSES 15

CHAPTER 3. THE MONITORING PROCESS 19

3.1. WHAT IS MONITORING? 19

3.2. WHY MONITOR? 19

3.3. MEASURING CHANGE IN SEAGRASS MEADOWS. 20

CHAPTER 4. SEAGRASSNET MONITORING METHODS 21

4.1. SITE SELECTION & MAPPING 21

4.1.1. Background 21

4.1.2. In the field 22

4.1.3. Using a GPS 24

4.1.4. Local community issues 25

4.2. SEAGRASSNET TRANSECT ESTABLISHMENT & MARKING 27

4.2.1. Background 27

4.2.2. In the field 27

4.3. SEAGRASSNET STATION MEASURES 31

4.3.1. Monitoring event details 31

4.3.2. Light Level 33

4.3.3. Temperature 35

4.3.4. Salinity 36

4.3.5. Tidal stage 37

4.4. RE-ESTABLISHING THE CROSS TRANSECTS 38

4.4.1. Finding the transect (second and subsequent monitoring visits) 38

4.4.2. Laying out the cross-transects for subsequent monitoring events 38

4.5. SEAGRASSNET QUADRAT MEASURES 39

4.5.1. General field procedure 40

4.5.2. Photographs 40

4.5.3. Voucher seagrass specimen 41

4.5.4. Species, Percent Cover and Shoot Density 42

4.5.5. Canopy height and grazing 43

4.5.6. Flower and fruit count 43

4.6. SEAGRASSNET CROSS-TRANSECT MEASURES 47

4.6.1. Distance to seagrass edge and last shoot 47

4.6.2. Depth 48

4.6.3. Surface sediment observation/sample 49

4.7. SEAGRASSNET DATA LOGGER LAUNCHING AND DOWNLOADING 50

4.7.1 Instructions for iButton Temperature Sensors 50

4.7.2 Instructions for HOBO Light Intensity Sensors 55

GLOSSARY 59

REFERENCES 62

ATTACHMENTS 67

Overview

Global monitoring of seagrasses was affirmed at the 3rd International Seagrass Biology Workshop (ISBW-3) in the Philippines in 1998 as a priority goal. It was acknowledged by scientists and coastal managers attending the meeting that there is a lack of information on the status and health of seagrasses worldwide, particularly in the less economically developed parts of the world. Natural resources are being lost due to lack of basic knowledge of their existence. The efforts to monitor known seagrass areas and to find uncharted seagrasses were affirmed as important first steps in an understanding of the extent of the seagrass resource and in sustaining the resource worldwide. It was acknowledged at ISBW-3 that adequate monitoring of seagrasses would necessitate including not only scientists and researchers but reaching beyond them to incorporate community monitors of seagrass. The problem in the past has been not knowing how to initiate community-based monitoring that is reliable and comparable to research-based efforts.

SeagrassNet is a global seagrass monitoring effort with two components, one research-oriented and the other community-based. The research-oriented monitoring methods presented in this manual are based on recently compiled seagrass research techniques for global application (Short and Coles 2001). The community-based seagrass monitoring effort was modelled after Seagrass-Watch, an award-winning Australian seagrass community (or citizen) monitoring program, and will be conducted simultaneously with research-based monitoring so that we can compare the resulting data. The manual for community-based monitoring has been published separately (McKenzie and Campbell 2002). The SeagrassNet monitoring program is the first undertaking in the global monitoring effort envisioned in the Philippines in 1998.

The manual presented here is designed to provide procedures to be followed by teams undertaking research-based SeagrassNet monitoring to insure comparable results and consistent techniques over a large geographical area. The manual is being used in the Western Pacific and in other areas. It has received review and updating after almost a year of field use in participating countries. The manual will be produced both as a bound handbook and as a CD-ROM (with photos and video).

Fred Short (UNH)
Rob Coles (QDPI&F)
Len McKenzie (QDPI&F)
Jeff Gaeckle (UNH)

SeagrassNet monitoring summary

*Seagrass*Net = Seagrass Monitoring Network

Goal: To measure change in seagrass:

Distribution	*via*	Position of seagrass bed relative to permanent transect
Species composition	*via*	Collection along permanent transect
Abundance	*via*	Measurements of cover, canopy height, density, & biomass

Parameters to monitor and monitoring methods

- Photographic record (one photo of each 0.25 m^2 quadrat)

  Email photos to Seagrass.Net@unh.edu

- Voucher specimen

  Prepare a herbarium sheet of each seagrass species (with flowering parts if present) for the International Seagrass Herbarium. Send to SegrassNet at the University of New Hampshire for verification, which will forward the sheets to the Smithsonian, Washington, DC, USA.

- Seagrass cover (visual estimate of 0.25 m^2 quadrat)

  Estimate seagrass cover (first total cover and then for each species) on a percent cover scale (0-100%) in each of the predetermined quadrats along the cross transects. Use the "Seagrass percentage cover photo guide" in the back of the Manual.

- Canopy height

  Measure canopy height, ignoring the tallest 20% of leaves, and identify any grazing evidence. Express results as canopy height for the dominant species in the quadrat.

- Biomass: 0.0035 m^2 core

  Take a biomass core outside each quadrat by selecting an area approximately 0.5 meter landward of the quadrat in an area of the same seagrass species and cover as the quadrat (to your best judgement). Place the corer over the selected shoots, making sure that leaves rooted in the corer are on the inside of the corer and those rooted outside are outside of the corer. Wash the sediments from the core sample, separate into leaves, stems, and root-plus-rhizome. When processing, scrape epiphytes from the leaves and rinse the leaves in a weak acid if calcareous epiphytes are present. Rinse plant parts in fresh water, dry to constant wt (60° C for 24hr) and weigh. Calculate biomass (g dry wt m^{-2}), enter on data forms, and submit data to

SeagrassNet. Send the original of all data sheets to UNH; save a copy of the data sheet for your files.

- Shoot density by species

  From the biomass core, count the number of leaf meristems (points of leaf initiation on the shoot) occurring within the core sample and enter this number as the shoot density on the data sheet. For large seagrass species (e.g., *Enhalus acoroides*) a 25 cm x 25 cm quadrat is placed on the transect line, and all shoots of the large species in the quadrat area are counted. Express results as total shoots m^{-2} by species.

- Sexual reproduction

  Count the number of flowers, fruits and seeds or flowering stems in a core for all seagrass species. Express results as flower/fruit/seed per area.

- GPS: latitude and longitude

  Take new GPS readings at the left, center, and right of each cross transect at every sampling event.

- Distance to the seagrass edge and distance to the last shoot

  The deep edge of the seagrass bed is defined as the deepest edge of the continuous meadow and the last shoot is the deepest occurring strap-bladed seagrass shoot. (For locations with very deep *Halophila* spp. the deep edge for this monitoring is defined as the deepest growing strap-bladed seagrass.)

  - Measure distance from the two ends and the center of the offshore cross transect (C) to the deepest edge and the last shoot

  The shallow edge for the seagrass bed is defined as the shallowest (most onshore) edge of the continuous meadow and the last shoot is the shallowest occurring seagrass shoot.

  - Measure distance from the two ends and the center of the onshore cross transect (A) to the shallowest edge and the last shoot.

- Depth

  Water depth is measured at 9 places (when the entire site is submerged) and the time is recorded.

  - Using a depth measure (e.g., depth sounder, weight on a rope marked with depth, *etc.*) measure the depth from the top of the substrate to the water surface at each of the nine cross-transect sites (left, center, and right on the three cross transects).

- Tidal information

  Record what type of tides (diurnal, semi-diurnal) are found in the area and the tidal range (spring high to spring low) for the site (obtained from tide charts).

  Record whether the minimum depth of distribution is in the intertidal (between the spring high and spring low tidal levels) or subtidal zone (below the spring low tide level).

- Environmental data

  1. Water temperature (continuously measure temperature, °C) -- iButton® temperature data logger
  2. Salinity (measure at every visit and determine the range, ppt) -- refractometer

3. Light level (% surface light at deep and shallow depths) -- Hobo® LI light logger
4. Surface sediment characteristics quarterly at the center of the three cross-transects -- syringe corer
   - grain size (% gravel/sand/silt+clay)
   - organic content (% loss on ignition)
   - carbonate content (% loss after acidification)

Necessary equipment and materials

- ❑ *herbarium supplies and press*
- ❑ *0.25 m^2 quadrat (2)*
- ❑ *0.0625 m^2 quadrat (2)*
- ❑ *digital underwater camera*
- ❑ *GPS unit*
- ❑ *permanent station marker (screw anchors, 9)*
- ❑ *recording thermometer, iButton® temperature loggers (2)*
- ❑ *refractometer*
- ❑ *light unit, Hobo® LI light loggers with case (3)*
- ❑ *core tube (6.7 cm diameter) with caps*
- ❑ *plastic bags, marking pens etc.*
- ❑ *20cc syringe sediment sampler*
- ❑ *drying oven*
- ❑ *paper bags for drying plant samples*
- ❑ *computer with Internet access*

Sampling intervals

4 times/yr (including times of maximum/minimum cover, preferably 6 months apart)

Establishing permanent sampling transects

1. Locations ranging from pristine (1 required) to stressed (optional)
2. One transect per location

   Perpendicular to shore at the center of a 50m band running to the deep edge

   3 cross-transects per transect each 50m long with center points at:
   - Deep station (1 m into the bed from the offshore edge of the continuous meadow) mark with a permanent marker and record GPS location
   - Shallow station (1 m into the bed from the onshore edge of the continuous meadow) mark with a permanent marker and record GPS location

- Mid depth station (between deep and shallow or at an interesting transition between species) mark with a permanent marker and record GPS location (with the assumption that cross transects are independent)

Quarterly sampling

1. Go to your sampling site and find the three permanent markers along the transect.
2. Retrieve the light and temperature sensors, take a salinity sample, and note the tidal stage on the data sheet (section 4.3).
3. At one of the center permanent markers, set up the cross transect using the 50m measuring tape to prepare for the sampling procedure along that cross transect (section 4.4). Avoid walking on the shoreward side of the measuring tape, as this is the area to be sampled.
4. Record information in the header of the datasheet and include any interesting observations (e.g., depth limit of species, etc.)
5. Sampling procedure for SeagrassNet quadrat measures (section 4.5)
    - Place a sampling quadrat (using the random distances provided on the datasheet) on the cross transect on the shoreward side. Position the quadrat so that the lower right corner of the quadrat is on the random distance mark when the person placing the quadrat is facing the shore.
    - Take a photograph of the quadrat.
    - Identify the seagrass species present in the quadrat and enter the species codes on the data sheet.
    - Estimate total % cover & % cover of each species in the quadrat using the "Seagrass percentage cover photo guide" in the back of the Manual.
    - Measure canopy height, ignoring the tallest 20% of leaves. Enter on the data sheet and also enter evidence of grazing, if present.
    - Count the flowers and fruits, if present, and enter on the data sheet.
    - Collect a biomass core outside the quadrat more than 0.5m landward of quadrat and of the same seagrass species and cover as the quadrat (to your best judgement).
    - Repeat (5. Sampling procedure) for each quadrat on the cross transect.
6. SeagrassNet cross-transect measures (section 4.6)
    - Collect voucher specimens (if not collected in the course of quadrat sampling) to create permanent herbarium samples, a minimum of one per species, with fruits and flowers if possible.
    - Measure the water depth at the 0m, 25m, and 50m points on the cross transect and, from these points, measure the distance to the edge of the seagrass bed. Record the water depths, the time, and the distances on the data sheet.
    - Collect a sediment core sample at the permanent marker at the middle of the cross transect (20 cm from the marker). Note on the data sheet.

7. Repeat steps 3 - 6 for each station until all three cross transects have been sampled.

Post-sampling procedures

Number of samples per cross-transect is 12

Number of samples per site is 36

1. Count the density of leaf meristems for each core
2. Measure leaf, stem, and root-plus-rhizome biomass for each core
3. Press the voucher specimens
4. Dry the sediment samples
5. Submit all data to SeagrassNet via the WEB site: www.SeagrassNet.org
6. Email the photographs, temperature and light data to <Seagrass.Net@unh.edu>
7. Mail original datasheets (and keep a photocopy), dry sediment samples, and herbarium sheets to:



SeagrassNet
Attn: Fred Short
Jackson Estuarine Laboratory
85 Adams Point Road
Durham NH 03824 USA

8. Wrap up
    - Wash all gear in fresh water and dry
    - Review supplies for next quarter's sampling and request new materials
    - Store gear securely for the next quarterly SeagrassNet monitoring

Chapter 1

General Introduction

In the first decade of the new millennium it is clearly time to approach seagrass ecology issues from a global perspective and to understand the contributions each country can make. The need for such an approach is encapsulated in the 1992 Rio Declaration on Environment and Development Principle 7 which says: –

> *"States shall cooperate in a spirit of global partnership to conserve, protect, and restore the health and integrity of the earths ecosystems. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command".*

It is important to document seagrass species diversity and distribution and to identify areas requiring conservation measures before significant areas and species are lost. Determining the extent of seagrass areas and the ecosystem values of seagrasses is now possible on a local scale for use by coastal zone managers to aid planning and development decisions. Knowledge of regional and global seagrass distributions is still too limited and too general for broad scale protection and management. Such information is needed to minimize future impacts on seagrass habitat worldwide. It is possible now with global electronic communication to begin the process of assembling both formally published as well as unpublished information on the distribution of the world's seagrasses with the eventual aim of providing a global "report card" on the distribution and status of seagrass (Green and Short 2003).

1.1. SeagrassNet program aims

The aim of the SeagrassNet program is to initiate global monitoring of seagrasses. Quarterly monitoring is underway in the Western Pacific, Brazil, Tanzania, the USA and Belize. Sites were chosen to be representative of the dominant seagrass habitat existing in that country. The intent of SeagrassNet is to establish generic methodologies that can be expanded into a broad global seagrass monitoring program of both research-based and community-based monitoring.

1.2. Goals & objectives

The objectives of the SeagrassNet monitoring program include:

- To develop a monitoring protocol, standardized methodologies for monitoring seagrass worldwide (Completed)

- To provide training to SeagrassNet participants, building the capacity of monitoring teams and local communities in the use of the seagrass monitoring protocol (Completed in many countries)

- To establish permanent monitoring sites in each participating country (Completed)

- To conduct regular quarterly monitoring of the sites in each participating country (Ongoing)

- To adopt a simplified and effective monitoring protocol for community monitoring of seagrass habitat (Completed)

- To expand SeagrassNet within the Western Pacific and globally to add second monitoring sites in participating countries and to add new countries to the program (Ongoing)

Further Reading:

Short, FT, CA Short, RG Coles. 2001. Introduction. pp. 1-4. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

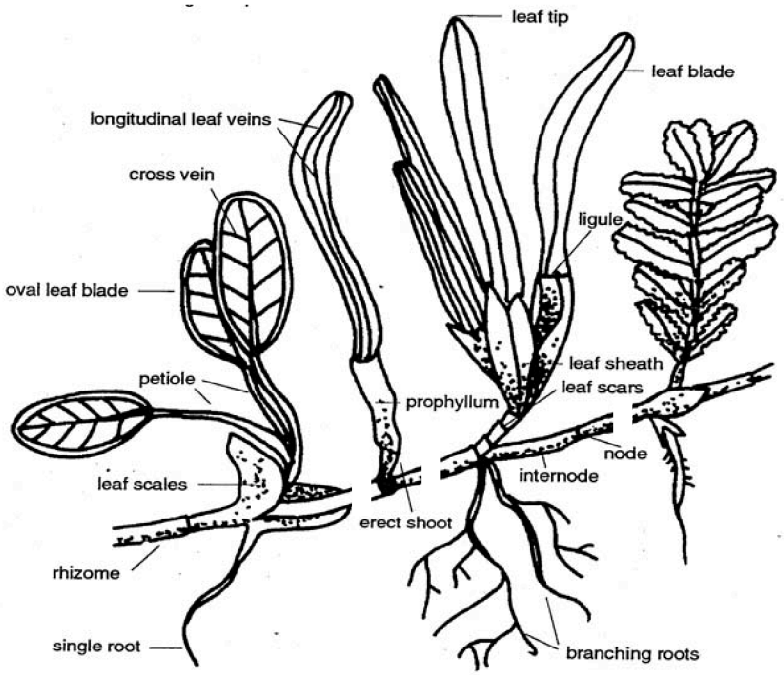
Short, FT, RG Coles. (eds.) 2001. Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam, 473 pp.

Green, E.P. and Short, F.T. (eds.). 2003. World Atlas of Seagrasses. University of California Press, Berkeley, USA. 324 pp.

Chapter 2

Seagrasses

Seagrasses are angiosperms (flowering plants) more closely 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).



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

from Lanyon (1986)

There are 60 described species of seagrasses worldwide, within 12 genera, and 4 families and orders. Seagrasses are unique amongst flowering plants, in that all but one genus can live entirely immersed in seawater. *Enhalus acoroides* is the exception, as it must emerge to the surface to reproduce; all other seagrasses 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.

Seagrasses are often closely linked to other community types. In the tropics the associations are likely to be complex interactions with mangrove communities and coral reef systems. Temperate water algae beds and epiphytic plant communities are closely associated with areas of seagrass, as well as salt marshes and bivalve beds.

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

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

The depth range of seagrass is usually controlled at its deepest edge by the availability of light for photosynthesis. Exposure at low tide, wave action and associated turbidity and low salinity from fresh water inflow determine seagrass species survival at the shallow edge. Seagrasses survive in the intertidal zone especially in sites sheltered from wave action or where there is entrapment of water at low tide, (e.g., reef platforms and tide pools), protecting the seagrasses from exposure (to heat, drying) at low tide.

Tropical seagrasses are important in their interactions with mangroves and coral reefs. All these systems exert a stabilizing effect on the environment, resulting in important physical and biological support for the other communities (Amesbury and Francis 1988).

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

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

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

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

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


Seagrass Habitat picture courtesy of QDPI

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 will help to 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 (both man-made and natural), it is necessary to first map the distribution and density of existing seagrass meadows. These findings 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 seagrass communities are essential to understand the role of these communities and the effects of disturbance on their composition, structure and rate of recovery.

Further reading:

Short, FT, RG Coles, C Pergent-Martini. 2001. Global seagrass distribution. Chapter 1, pp. 5-30. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Creed, JC, Phillips, RC, and Van Tussenbroek, BI. 2003 Seagrasses of the Caribbean. pp. 234 - 242. In: Green, E.P. and Short, F.T. (eds.). World Atlas of Seagrasses. University of California Press, Berkeley, USA.

Kuo, J, C Den Hartog. 2001. Seagrass taxonomy and identification Key. Chapter 2. pp. 31-58. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Chapter 3

The Monitoring Process

3.1. What is monitoring?

Monitoring is the repeated observation of a system, usually to detect change. The level of change and accuracy of the detection will vary according to the methodology. Environmental monitoring programs should ideally be designed to quantify the causes of change; examine and assess acceptable ranges of change for the particular site; and to measure critical levels of impacting agents. Monitoring usually focuses on a specific organism or habitat, with ancillary data collected on environmental conditions that may be influential as well as associated organisms. Intensive monitoring of large areas or large suites of parameters is often prohibitively expensive and requires considerable expertise in the systems being studied. Monitoring is most successful when used to examine a specific environmental concern such as the change likely to occur in seagrasses resulting from a particular port or harbor development.

3.2. Why monitor?

Environment monitoring programs provide coastal management agencies with information and assist them to make decisions with greater confidence. Seagrasses are often at the downstream end of catchments, receiving runoff from a range of agricultural, urban and industrial land-uses. Their ecological values and location in areas likely to be developed for harbours and ports have made seagrasses a useful monitoring target for assessing environmental health and impacts on coastal systems. The ideal "bio-indicator" must show measurable and timely responses to environmental impacts. Seagrass habitats provide sessile plants - individuals, populations and communities - which can all be easily measured. Seagrass plants generally remain in place so that the prevailing anthropogenic impacts can be monitored.

Altered seagrass depth distribution in Chesapeake Bay, USA (Dennison *et al.,* 1993) was the "indicator" when runoff impacts on water quality caused changes in light penetration and consequently affected seagrass abundance and distribution patterns. Improved knowledge of the relationships between various seagrass growth characteristics and environmental parameters such as light and nutrients (e.g., Dennison *et al.*, 1993; Short, 1987) provide very useful tools for monitoring environmental impacts on coastal seagrass systems.

Coastal zone managers increasingly recognise the importance of seagrasses in coastal marine communities for supporting diverse flora and fauna, in supporting coastal fisheries productivity (Coles *et al.,* 1993; Watson *et al.* 1993), and in stabilising sediments and maintaining coastal water quality and clarity (Short and Short, 1984; Fonseca and Fisher, 1986). In the tropics, turtles and sirenians (*Dugong dugon*) are direct grazers of seagrasses (Lanyon *et al.* 1989).

3.3. Measuring Change in Seagrass Meadows.

Seagrass meadows can change in several ways. There can be a change in biomass without a change in area; a change in area, or shape, depth or location of a meadow; a change in species composition, plant growth and productivity; the fauna and flora associated with the meadow; or a combination of some or all of these. Some changes will also occur naturally and on a regular seasonal basis. Environment monitoring programs require knowledge of these patterns of natural change. They also require cost-effective data collection, selection of appropriate parameters and scales, and measures of change which are statistically appropriate for determining if management action is required.

Mapping the extent of seagrass distribution in a given area of coastline can provide a basis from which loss or gain in seagrass habitat is quantified. Such maps can be created from ground surveys using GPS or from aerial photography combined with ground-truthing when available. Comparison of maps from two or more dates can quickly document the change in seagrass distribution and provide notice of a local impact (Short and Burdick, 1996).

Choosing the most efficient and appropriate parameter(s) to monitor is equally important. Seagrass species composition and its abundance, e.g., biomass (above-ground and below-ground), total area, or percent ground cover, can be measured quickly, and these have been the most commonly chosen parameters. Seagrass growth parameters (e.g., plant growth rates, plant tissue C:N:P, carbohydrate composition) are proving useful for obtaining insight into the causes and mechanisms of change in seagrass abundance. At the "meadow level", measures of species composition, and estimates of means and variances for parameters such as biomass or percent cover, can be easily obtained. Physical parameters measured usually include depth (below mean sea level, MSL) and sediment composition. Turbidity, light, salinity and temperature should ideally be 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). Depth at which seagrasses occur can be a useful indicator of impact and may change according to light attenuation in the water column.

The next step is to choose biological and physical parameters that are relevant and logistically possible and to design of sampling programs which enable the minimum monitoring effort required to detect changes which are statistically and biologically meaningful. The expected use of the data, the questions likely to be asked of the data, and the accuracy and precision of the answers required determine the type of information we collect from coastal seagrass habitats. Increased requirements for accountability in coastal management decisions has caused greater need for statistical rigour in design of sampling programs for monitoring environmental impacts. Government agencies and coastal zone managers need to know the extent of natural change in seagrasses. The impacts - particularly habitat losses - from catchment and human activities can then be separated from normal background variation.

Further Reading:

McKenzie, LJ, SJ Campbell, CA Roder. 2001. Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) Volunteers. Queensland Fisheries Service, NFC, Cairns. 94pp.

Short, FT, RG Coles. (eds.) 2001. Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam, 473 pp.

Chapter 4

SeagrassNet Monitoring Methods

Monitoring programs aim to detect change. Environment monitoring programs designed to detect realistic levels of change, enable coastal management agencies to make decisions with greater confidence. SeagrassNet is designed to provide comparable information on the health and status of seagrasses at a site over time. Below the actual monitoring methods of SeagrassNet are described in detail.

4.1. Site selection & mapping

4.1.1. Background

The SeagrassNet monitoring site is selected to be representative of the seagrass communities in that location. It is useful to review any available information on the distribution and status of seagrass meadows in the area, region, or country before you start. Good sources of baseline information include aerial photographs or earlier maps of seagrass habitat. It is important to use care in choosing a place to establish a site for monitoring.

A good monitoring site is

- a seagrass meadow which is typical/ representative of the location
- a seagrass meadow that is relatively homogeneous
- a seagrass meadow in a place which you can come back to and monitor again at regular intervals
- a seagrass meadow that is removed from any large obvious impact such as a marina, a dredge channel, or a sewage outfall

Selecting a good monitoring site is the first critical step in any monitoring effort. For a site to be typical or representative, it should contain the same assemblage of seagrass species found throughout the area, reflect the depth range where seagrasses are typically found, and in general not be exceptional in any characteristic. A homogeneous seagrass site has a fairly even seagrass distribution without large empty patches or physical disruptions such as reefs or tidal channels. The need for a homogeneous seagrass meadow is to enable the collection of replicate samples reflecting the natural conditions but not incorporating a high degree of variability. In this way, long term change can more easily be detected. Clearly, a site that can be visited without problems is preferred, since repeat access over the long term will be required. Choosing a site away from any large human or natural impact is important to insure long-term repeated monitoring without total loss of the seagrass habitat in that location. Also, for the monitoring of representative conditions in

an area, it is important to avoid an immediate or point source of impact. The aim of the monitoring is to pick up any broad changes in a seagrass community, not necessarily changes between stations within the seagrass community.

4.1.2. In the field

Once you have decided on the approximate location, you will need to choose the site for the transect and prepare a sketch map of the area around the transect site, this may be for the whole seagrass meadow or for a geographically defined area (e.g., bay, reef top).

Necessary materials & equipment

To choose the site and mark the transect, you will need:

- ❑ *Geographic Positioning System (GPS)*
- ❑ *Datasheets and pencil*
- ❑ *Suitable field clothing & footwear (e.g., hat, dive booties, etc)*
- ❑ *Aerial photographs or marine charts (if available)*
- ❑ *Temporary markers (e.g., sticks, flags, plastic tent pegs)*

- Go to the general area that you have identified as a potential seagrass location to map and monitor. The aim is to create a sketch map (with or without GPS coordinates) that describes the general pattern of seagrass in the area. Use GPS to map the boundaries of the bed, if possible (Fig. 1). Otherwise, draw a map using a nautical chart or whatever is available.

- If mapping can be conducted at low tide when the seagrass meadow is exposed, the boundaries can be mapped by walking or wading around the perimeter of the meadow and making observations every 5 – 25 meters depending on size of the area and time available. If the meadow is too large, this will not be feasible; a rougher map will have to suffice.

- Find and put a temporary marker at the inner (near to the beach) and outer (towards the open sea) edges of the seagrass meadow. The outer edge is defined for SeagrassNet monitoring as the seaward limit of the strap-leaved seagrasses; the petiolate (seagrasses with a stalked leaf) seagrasses often extend to depths not accessible (beyond access by SCUBA) and thus cannot be reliably sampled in our monitoring effort.

- Decide on where you think would be the best location for the SeagrassNet monitoring transect.

  Points to consider:

  - Is seagrass the dominant habitat at the site?.....*Yes*
  - Is the seagrass community representative of that area?.....*Yes*
  - Is the seagrass coverage similar along a contour of constant depth?.....*Yes*
  - Are there any large sand/ mud banks or other physical disruptions in the middle of the transect location?.....*No*
  - Is the site logistically (e.g., weather, access, safety) feasible?.....*Yes*

- In the area that you think will be suitable for the SeagrassNet monitoring transect, place a temporary marker or flag in the sediment within the continuous seagrass meadow approximately 1 meter inside the meadow. Walk, paddle or swim out from the shore to the outer edge of the seagrass meadow and place a temporary weighted marker (a rock with a rope and float attached) within the seagrass approximately 1 meter inshore of the continuous seagrass meadow edge.

Figure 1. An example of monitoring site description with sketch map of seagrass meadows and GPS reference waypoints (WGS84).

SKETCH MAP



COUNTRY: Federated States of Micronesia

LOCATION: Anon Reef TRANSECT#: 1

DESCRIPTION OF SITE:

A large intertidal reef flat which extends to a reef slope with deep water drop off. A dense continuous meadow dominated by Enhalus with some Cymodocea is near shore. This meadow is surrounded seawards by a patchy meadow of Halodule uninervis which extends into the coral.

(continue over back of page)

GPS WAYPOINTS

DATE: 6 / 15 /2001 Time start: 9 am Time finish: 12.30 pm

MAP REFERENCE	LATITUDE	LONGITUDE	NOTES/ COMMENTS
1	5° 20.2356	162° 57.072	
2	5° 20.2644	162° 57.1056	
3	5° 20.304	162° 57.1146	
4	5° 20.3322	162° 57.1056	
5	5° 20.3388	162° 57.0702	
6	5° 20.349	162° 57.0426	
7	5° 20.3478	162° 57.0102	
8	5° 20.3486	162° 56.9778	
9	5° 20.2956	162° 56.9632	
10	5° 20.2458	162° 56.9496	
11	5° 20.1726	162° 56.9226	
12	5° 20.145	162° 56.9228	
13	5° 20.1378	162° 56.9718	
14	5° 20.1648	162° 57.003	
15	5° 20.2068	162° 57.0342	

4.1.3. Using a GPS

The GPS system is a small handheld unit which allows accurate positioning by using satellite transmissions to determine its position on the earths surface. When a GPS records a position it is called a fix or waypoint. Most GPSs store waypoints in their memory so that the unit can be used to navigate back to that point.



- Check that the GPS is providing Latitude and Longitude coordinates in decimal minutes. To do this, turn the GPS on. PAGE to the MENU screen that shows a list of options (Mark, Waypoints, Route, Tracks, Setup, battery level icon, time and date). Arrow down to the SETUP option and press ENTER. The SETUP page appears listing the following options (Time, Display, Units, Interface, System, battery level, time and date). Arrow down to the UNITS option and press ENTER. Highlight the POSITION FRMT and press ENTER. This will provide you with a number of format options for the Latitude and Longitude coordinates. Arrow down to hddd°mm.mmm' (decimal minutes) and select ENTER. Press the PAGE button to return to the main screen.

Turn GPS unit on

↓

Give GPS time to track sufficient satellites and download almanac *(if necessary)*

↓

Check GPS settings
- Units
- Datum
- Altitude
- True or magnetic north

↓

To record a position either mark waypoint or if boundary mapping set waypoint mark to Stream/Poll

↓

Either record positions directly onto data-sheet or download to computer via cable.

Tips:

- When position fixing it is important to give the GPS antenna a clear signal of the sky. A GPS needs to receive signals from a number of satellites (usually more the 4) to take an accurate fix. When using a GPS amongst high terrain, signals from some the satellites may be blocked or unclear.
- It is important to give the GPS sufficient time to position fix. If you are moving when the position is fixed, it may add error. The less movement, the greater the accuracy. Give the GPS at least 5-10 seconds to position fix.
- GPSs that are more accurate when moving, are those which have the ability to "stream" or "poll". These can be useful when boundary mapping. If the GPS does not "stream" then the operator will need to take a waypoint every few meters.
- Ensure the GPS units are known to the user, as it is often common to mis-read decimal minutes as minutes and seconds (e.g., 14° 36.44' is not the same as 14° 36' 44").
- When using a GPS for the first time or in a new region (world zone), ensure the almanac is set correctly. Most GPSs today will detect that they are in a new region, and will automatically download the new almanac which may take approximately 15 minutes.
- When position fixing a subtidal ground truth site with a GPS, it is important for the observer to be as close as possible to the GPS antenna to minimise position fix error. This can be difficult in small boats under conditions of strong wind and current.
- When downloading the data, check the GPS settings and take note of the datum. GPSs have the ability to record your location on the earth's surface using different datums (different fixed starting points). Datums that record positions in longitudes/latitudes coordinates often include WGS (World Geodetic System). The SeagrassNet program uses WGS84..

- When purchasing a GPS, consider not only the accuracy of the unit, but also its robustness. Field conditions can be demanding on equipment, and water-resistant units may be better.

4.1.4. Local community issues

Once you have identified a suitable site for SeagrassNet monitoring, make sure that the local community/village/residents/citizens are informed about the seagrass monitoring activity

It is common courtesy to visit and inform local leaders about the program, provide them with a background on the program, discuss the monitoring objectives, the importance of seagrass and answer any questions they may have. In some cases you may need to secure an official permit (e.g., marine park) BEFORE you first visit the site. Find out the local requirements and follow them.

In most countries you will need to seek approval from local authorities to conduct the monitoring program BEFORE you can establish the site, especially considering that the SeagrassNet program will require permanent markers to be placed at the site.

Suggested Steps To Initiating Community Involvement In Seagrassnet.

Find out if there are any existing community groups in the area who deal with coastal issues, it is unlikely that there will be a Seagrass group but there may be others. eg. local fisher organization, village council, peoples organization, peoples cooperative, local environment club, *etc. Be sensitive to the local politics and culture.*

Contact the group and request if you could give a short presentation about seagrass and the Tropical Indo-Pacific SeagrassNet Monitoring Program at their next meeting or hold a special meeting and invite the different organizations. Encourage participation from all sectors.

Prepare some visual materials, attend the meeting and give your presentation. Your presentation should include:

- *A brief **introduction to seagrass** and the importance of seagrass*
- *An **overview of SeagrassNet monitoring program**.*
- *The **SeagrassNet monitoring activity in the field**. For this you could take along a temperature logger, light meter, and station marker, and explain how they are used, what they do, and the importance of them to the program.*
- ***Open Discussion**. Ask the group about the history of the area, what changes do they notice about the seagrass meadows. Discuss ways that the community would like to be involved and how is the best way to keep them informed of upcoming monitoring activities.*

Maintain open communication lines with the community, provide them with a phone number, contact address so they can contact you if they notice anything interesting at the site, or if one of the loggers disappears.

Incorporate the suggestions and outcomes of the meeting into your monitoring program.

Recognize appropriately the efforts that community people provide to the success of the monitoring program.



One of the long-term objectives of the monitoring program is to involve members of the local community in the monitoring activities. It is important to get the community involved for many reasons. The local community includes more than just the local leaders; it includes all local stakeholders, that is, those with an interest in the seagrass habitat or the local coastal environment. So while it is important and a formal requirement to involve the leaders, it is just as important to get the broader community involved from the start of the program.

Communities are becoming increasingly sensitive to 'outsiders' coming into their area and ignoring the local situation/culture and only coming to talk to the community when the 'outsiders' need or want something. For this reason, it is important to communicate well and openly with the community from the very start.

The benefits of a community being involved include the following:

(1) **The community will provide you with advice and may make recommendations based on their local knowledge at the start of the program that could save you a lot of time and effort.** The community may know that the seagrass meadow changes seasonally and may recommend a better location for the site, or that the area will be dredged soon to make way for a new marina.

(2) **You will establish a communication link between the community and scientists.** The sharing of knowledge between scientists and local experts is equally valuable and may lead to numerous different types of benefits for both groups.

(3) **Community awareness about seagrass will be increased.** Raising awareness on environmental issues and the wise use of natural resources is always a positive outcome.

(4) **The monitoring site will be left undisturbed.** If the community is aware of the program and the importance of not interfering with markers or monitoring site, then the monitoring program will not be compromised by curious people removing station markers or data loggers.

(5) **You will be treated with respect and welcomed as a visitor and a friend.** Mutual respect is the most comfortable working environment. To gain respect as a visitor, you must first give respect. Bear in mind that at first, the community will respond to you past experiences with scientists/visitors; this needs to be handled with care.

(6) **An increased likelihood of long-term continuation/sustainability of the monitoring after formal support is completed**. It is always difficult to ensure sustainability of a program after the money is finished; however programs which have gained community support and comprehensive community involvement have shown a higher level of success than those that have not.

Further Reading:

IIRR. (1998). "Introductory Papers - Volume 1". Participatory methods in community-based coastal resource management. International Institute of Rural Reconstruction, Silang, Cavite, Philippines.

Crawford, B, M Balgos, CR Pagdilao. 2000. Community-Based Marine Sanctuaries in the Philippines: A Report on Focus Group Discussions. Coastal Management Report #2224. PCAMRD Book Series No. 30. Coastal Resources Center, University of Rhode Island, Narragansett, RI, USA, and Philippine Council for Aquatic and Marine Research and Development, Los Banos, Laguna, Philippines. ISBN # 1-995454-37-6.

4.2. SeagrassNet transect establishment & marking

4.2.1. Background

Transect establishment is important to ensure consistency of the monitoring program, and is done once you have identified the most appropriate monitoring site. Transect establishment should be achieved with minimum disturbance of the surrounding seagrass meadow. The transect will be marked with nine permanent station markers on cross-transects A, B and C in the middle and at either end (0, 25 and 50 m). These permanent station markers will be kept throughout the monitoring program regardless of changes in the seagrass community.

Finding the transect for subsequent samplings will be made easier by ensuring that the permanent markers are secure, and preparing a good sketch map and description of the site, ideally using GPS to identify the exact coordinates. When you prepare the map and description, write it in a way that someone who has never been to the site could still find it.

4.2.2. In the field

Necessary materials & equipment

You will need:

- ❑ *50m fiberglass measuring tape*
- ❑ *9 permanent markers (e.g., screw anchors)*
- ❑ *Geographic Positioning System (GPS)*
- ❑ *Hand held compass*
- ❑ *Sketch map for site location*
- ❑ *SeagrassNet datasheet*
- ❑ *Notebook and pencil*

Transect establishment



The transect will typically be placed in the direction of beach to sea. Take note of any landmarks or features which will help you find the site easily. If possible mark a tree on the land to help you relocate the site.

- Go to the temporary marker that you placed about 1 m inside the continuous seagrass meadow seaward from the beach/ inner edge of the seagrass meadow. Station A must be established so that the 50 meter cross-transect will have Station A at its center and will lie within the continuous seagrass meadow. Hammer or screw a permanent post or marker into the sediment so that only a 7 - 10 centimeters remain above the sediment. Station A will be the center point for the cross transect at the shallow edge of the seagrass bed.

Refer to Figure 2. Example of the profile of a monitoring transect layout and Figure 3. An example of a monitoring transect layout.

- Take the GPS reading for Station A (shallow) and record the position clearly and legibly on the

datasheet. Use your sketch map to draw the position of the station; this will be valuable when you or someone else has to come back to find the transect in 3 month's time. Record the depth, time, date, and tidal status.

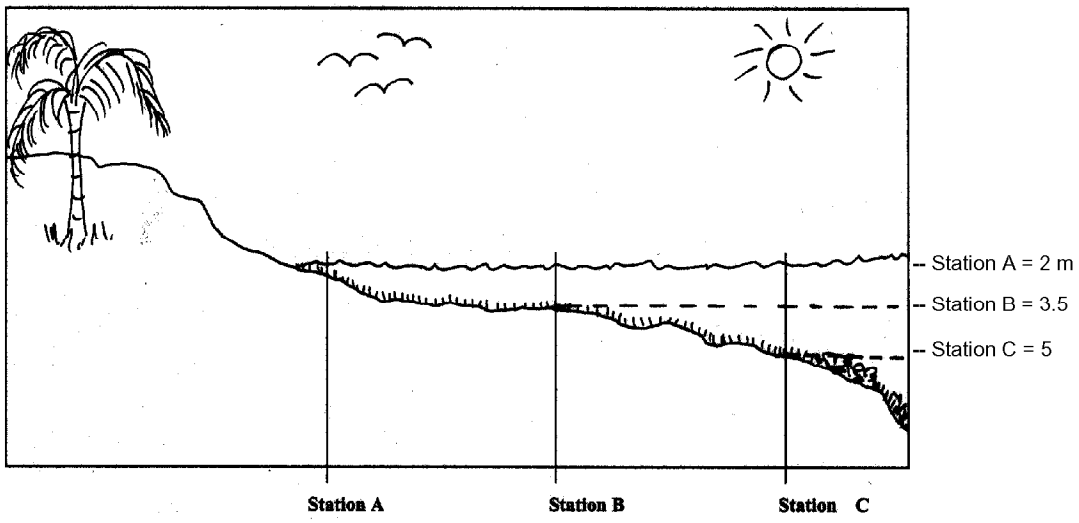
- To establish Station C take a compass bearing from the Station A permanent marker to the outer/ deep seagrass edge temporary marker. The transect should be approximately perpendicular (at right angles) to the water's edge; that is, the transect will run from the beach (at Station A) toward the sea (Station C). Station C is established so that the 50 meter cross transect through Station C lies within the continuous seagrass meadow. *Remember that the outer edge is defined for SeagrassNet monitoring as the seaward limit of the strap-leaved seagrasses.*

- If the transect is being established on a reef flat, then the offshore station (C) and the mid-depth station (B) will be chosen differently. Station C is inside the continuous seagrass meadow of the reef flat, and is not necessarily the deepest station. Station B is halfway between A and C, regardless of depth, or Station B may be located at an interesting seagrass species transition, i.e., adjacent to a zone of species change.

- Install a permanent marker at station (C). Record the bearing between C and A on the datasheet. Record the GPS position and water depth. Station C will be the center point for the cross transect at the deep, or offshore, end.

- The position of Station B is between stations A and C.

Figure 2. Example of the profile of a transect layout for a monitoring site.



- Record the actual depth of the mid-depth (B) station, locate the site on the bearing between stations A and C, record the GPS position. Measure and record the distances between A and B, and B and C. Install the permanent marker for Station B. The Station B permanent marker will be the center point of cross-transect B.

Laying out the cross-transects for the first monitoring event

- Start at Station A. The permanent station marker is the center of your 50 meter cross transect (refer to Fig. 3).

- Laying out the cross transects will require 2-3 people, commitment and a sense of humour!

- First, one person should stand at the center permanent station marker facing out to sea, holding the tape measure.



- Next, the second person takes the loose end of the tape measure and walks/ wades/ swims 25 meters to the left of the station marker, keeping roughly parallel to the beach. The aim is to create a straight 50m transect with permanent marker Station A at the center that follows the same depth contour as closely as possible. At 25m from the permanent marker (center), place a permanent marker (screw anchor) and secure the tape measure. This is cross transect position L (left, facing the sea).

- Then, take the other end of the tape measure and walk/ wade/ swim 25 meters to the right of the station marker keeping parallel to the beach and place a permanent marker at the end of the the tape measure. This is cross transect position R (right, facing the sea).

- The person at the station marker in the center (C) should ensure that the cross transect is roughly parallel to the beach, is a 50 m straight line, and lies entirely within the seagrass meadow. To insure that the cross transect is running straight, the people at the left and at the right pull the tape tight and the person at the center directs them until the 25 m mark is exactly over the center marker.

- Attach the measuring tape to the permanent markers at L and R using a cable tie or other fastener that can be removed when the sampling is completed. Take a compass bearing of each cross-transect.

- Record the GPS positions for L, C and R anchors. You can now start the seagrass monitoring (Go to sections 4.3, 4.4 and 4.5).

- At completion of sampling cross-transect A, roll up the tape measure and repeat for Stations B and C.

Taking a Compass Bearing

- Hold the compass in front of you at chest height and flat to allow the needle to travel freely.
- Turn to the direction for which you want to take a bearing.
- Allow the needle to stabilize.
- Move the bezel (wheel) on the compass until the bezel arrow is over the needle and pointing to zero degrees indicating north.
- Your bearing is the intersection of the bezel and the red arrow on the base plate.
- Record the bearing on your data sheet, e.g. 80°.

Finding a Compass Bearing

- Alternatively, if you have been given a bearing to follow, turn the bezel until the bearing is in line with the red arrow on the base-plate.
- Now turn your body until the bezel arrow lines up with the needle.
- You should now be facing your bearing.

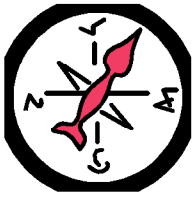
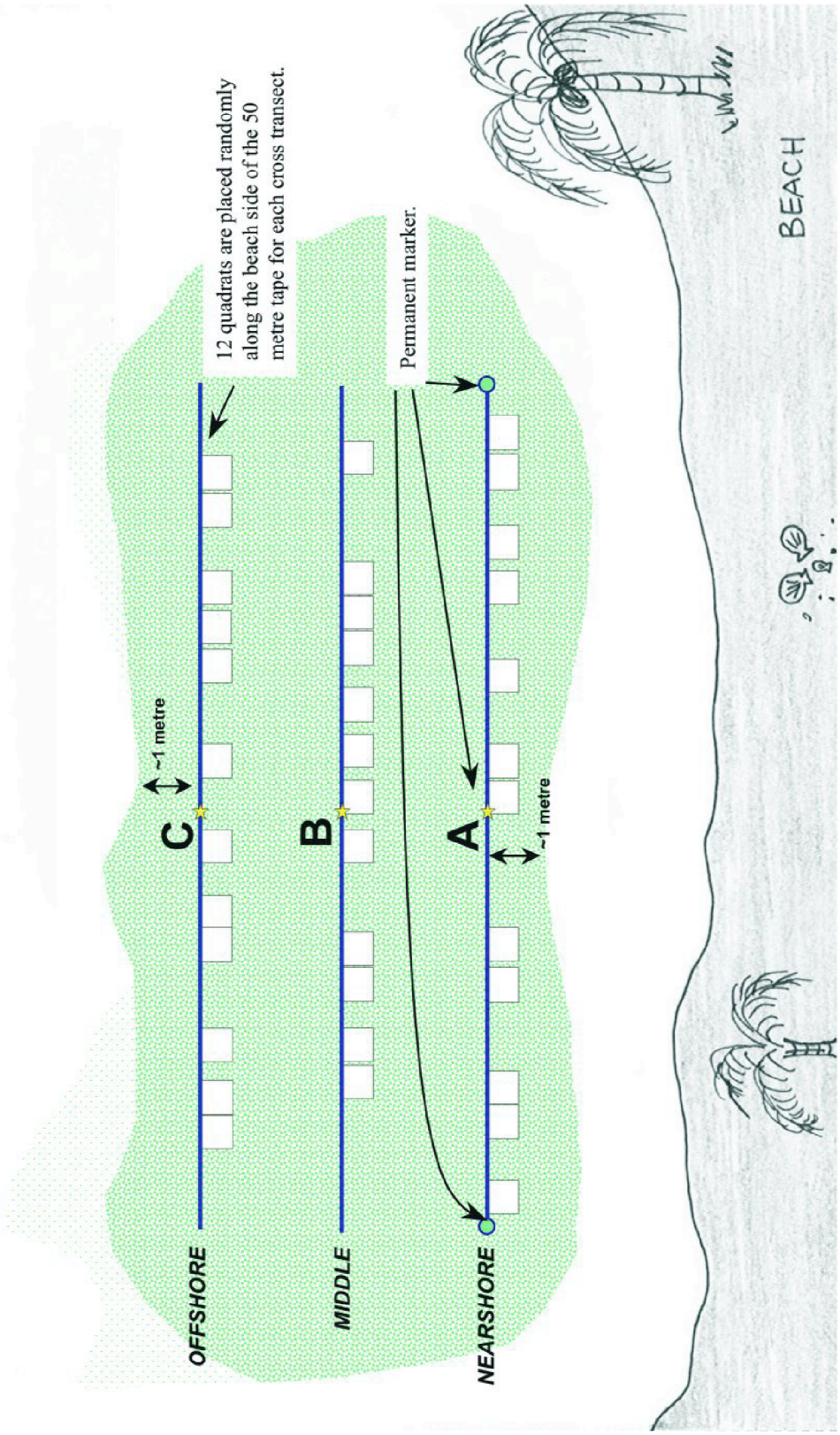


Figure 3. Example of a monitoring transect layout, viewed from above.



4.3. SeagrassNet station measures

Monitoring of the SeagrassNet transect is conducted every three months. Use the Palm Pilot with the program Tide Tools (http://www.toolworks.com/bilofsky/tidetool/) or a local, reliable tide table (http://www.wxtide32.com/) to identify a good daytime low spring tide for sampling.

After finding the site and laying out the 50 meter tape measure at the first cross-transect, the actual monitoring begins. During any monitoring activity it is important to ensure consistency of information as much as possible, ensure that you are well prepared for the monitoring activity and you are focused on completing the monitoring. Before going to the field you need to assemble and check all the equipment and re-familiarize the monitoring team with the data sheet and the methodology for the transect, station and quadrat level observations.

Necessary materials & equipment

You will need:

- ❑ *2 50m fibreglass measuring tapes*
- ❑ *Depth measuring device (e.g., measured length of rope with weight, or a meter stick)*
- ❑ *Geographic Positioning System (GPS)*
- ❑ *Sketch map for site location*
- ❑ *3x Hobo® LI light loggers*
- ❑ *2x iButton® temperature loggers*
- ❑ *Refractometer*
- ❑ *3 vials or small sterile bottles for salinity water sample*
- ❑ *Waterproof datasheets, clipboard and pencil*
- ❑ *Palm Pilot with Tide Tools program*

4.3.1. Monitoring event details

Information recorded at the start of each quarterly monitoring (Fig. 4 SeagrassNet Datasheet).

- First, record on the datasheet information in the first header two rows:
  - Location (the geographical name of the transect location, e.g., name of the bay, reef, harbor or island, plus nearest city)
  - Transect number (an assigned code for each sampling location)
  - Researchers (name of observers and data recorders)
  - Sampling date and time. Specify day of the month, month initials, and the year (e.g., 27 Jan 02).
  - Country (also state or province as needed)
  - Station (circle appropriate letter)
  - Comments (compass bearings, special conditions or observations)



Sampling is done to the beach side of the tape, therefore you should always walk to the seaward of a transect to avoid footprints where you will be sampling.

SeagrassNet = Seagrass Monitoring Network

***Seagrass*Net Field Sampling Form (one sheet per station)** **Western Pacific Region**

Location:	Transect code & no.:	Researchers:	Sampling date and time: e.g., 20 Jan 2004 1400 hrs.
State/Country:	Station (circle one): **A**. Nearshore, **B**. Middle, **C**. Offshore	Comments:	

PARAMETERS	Example	Cross-transect 0-25 m						Cross-transect 26-50 m					
		1	2	3	4	5	6	7	8	9	10	11	12
Quadrat Measures at pre-selected random distances	Quadrat 2	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat
Photograph (1 per quadrat)	√												
Voucher Specimen (1 of each species/Station)	√												
All Species Total % Cover	60												
Species = Hu % Cover	40												
Species = % Cover													
Species = % Cover													
Species = % Cover													
Species = Ea % Cover | Density (Ea density per 25x25 cm quadrat)	20 | 32												
Canopy Height (cm) Grazing Evidence? (y/n)	20 y												
Flower/Fruit Count by species	4 Hu 6 Cr												
Leaf Biomass Core Size (m^2)	√ 0.0035												

	Pre-selected Random Distances for 0-25m						Pre-selected Random Distances for 26-50m					
A. Nearshore	2	7	8	16	18	25	26	33	38	40	44	46
B. Middle	9	10	15	17	22	25	28	31	35	37	39	45
C. Offshore	5	7	10	18	19	22	26	34	35	38	43	44

Cross-transect Measures

				Left (0m)		**Center** (25m)		**Right** (50m)	
GPS: Latitude	Dist. to edge (m)	_ _ _ _ . _ _ _ "	8.6						
Longitude	Dist. to last (m)	_ _ _ _ . _ _ _ "	11.2						
Water Depth (m) at time (hrs)		2.35 @ 1524		at		at		at	
Surface sediment observation / sample		fine-sand / yes							

Station Measures

			Region IX species			
Light -- Hobo (day in - day out)	6Jan - 20Jan	-	**Cr** - *Cymodocea rotundata*	**Hx** - *Halodule* complex	**Ha** - *Halophila ovata*	**Th** - *Thalassia hemprichii*
Water temp. logger (day out)	20Jan		**Cs** - *Cymodocea serrulata*	**Hb** - *Halophila becarii*	**Hs** - *Halophila spinulosa*	**Tc**-*Thalassodendron ciliatum*
Salinity (ppt)	25.8		**Ea** - *Enhalus acoroides*	**Hd** - *Halophila decipiens*	**Hy** - *Halophila* complex	
Tidal Stage (high or low / spring or neap)	high spring		**Hp** - *Halodule pinifolia*	**Hm** - *Halophila minor*	**Rm** - *Ruppia maritima*	
			Hu - *Halodule uninervis*	**Ho** - *Halophila ovalis*	**Si** -*Syringodium isoetifolium*	**Un** - Unknown

Figure 4. SeagrassNet Field datasheet – Western Pacific version.

- Next, record the four Station Measures (bottom of the data sheet).
    - Light - Hobo® (day in - day out)
    - Water temperature iButton® (day out)
    - Salinity (ppt)
    - Tidal stage (high or low/ spring or neap)
- Directions and information for the four Station Measures follow:

4.3.2. Light Level

Background

The maximum depth limit for seagrasses is determined largely by the depth to which sufficient light intensity for sustaining plant growth reaches the bottom, known as "compensation depth" (Bay 1984, Dennison 1987, Duarte 1991, Kenworthy and Haunert 1991).

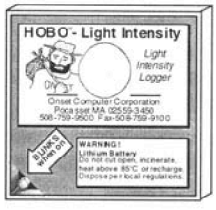
The minimum light requirement for seagrasses has been identified at 10-20% of surface light (Duarte 1991), higher than other marine plants, presumably because of the high photosynthetic demand to survive rooted in anoxic sediments. Below the minimum light requirements, seagrasses will die; as light intensity increases seagrass growth will increase linearly (Short *et al.* 1995).

Water color (particularly in locations influenced by river discharges and other areas of increased humic acid release) may also play a role in determining the maximum depth limit of seagrass growth (Kenworthy and Haunert 1991). Decreased light ultimately reduces areal plant productivity (plant production per unit area of bottom). Different species of seagrass have different light requirements and depth distributions; a reduction in light reaching the substrate may change seagrass species composition by enhancing growth of species having lower light requirements (Pulich 1985) or may reduce depth of distribution. The deepest known seagrass is of the genus *Halophila* found off the Great Barrier Reef in very clear water at a depth of 58 m (Lee Long *et al*. 1999).

In shallow and intertidal areas, seagrass photosynthesis and production are inhibited by exposure to high light conditions (Hanelt 1992, Masini et al. 1995). Such photo-inhibition can prevent the proliferation of some species and result in a distribution that favours more high light tolerant species.

The SeagrassNet program uses Onset- Hobo® LI light loggers to measure and log light levels at each site (http://www.onsetcomp.com).

General procedure



- The Hobo® LI light loggers are deployed two (2) weeks prior to the quarterly seagrass sampling.
- The three (3) Hobo® LI light loggers are deployed at Stations A and C, and above the high tide mark on the beach above Station A at a site which has no obstructions from trees, houses, *etc*.
- The Hobo® LI light loggers are calibrated at the University of New Hampshire every two years. UNH will return the Hobo® LI light units ready to be installed in the clear plastic field chambers.

Deployment

- The first step is to launch the light sensor before deployment. Launching should be done immediately before deployment. See section 4.7.2 of this manual for launching instructions.

- Once the light sensor is launched, open the clear plastic field chamber marked A and remove the black rubber O-ring. Apply a thin film of silicon grease onto the surface of the O-ring with your fingertips. You need only a very small amount of grease, enough so that the O-ring appears shiny. Replace the O-ring.

- Slide the Hobo® LI light logger labelled A into one side of the clear plastic chamber, ensuring the unit will face up when deployed.

- Place a small packet of dry silica gel into the chamber. The silca gel is blue when dry and pink if damp. The gel can be dried by placing the packet in an oven briefly at low temperature until blue.

- Screw the two sections of the chamber firmly together (do not overtighten).

- In the field, locate the permanent station marker for station A.

- Using cable ties, fix the clear plastic chamber (containing the Hobo® LI light logger and silica gel pack) to the permanent marker, ensuring the light sensor itself is horizontal and facing directly skywards.

- Record the date of deployment on the datasheet.

- Repeat procedure for station C and the land station using chambers and units marked C and "Land", respectively.

Collection

- In the field, after two weeks of deployment (and at the time of quarterly sampling), locate the permanent station marker.

- Cut the cable ties to release the clear plastic chamber (containing the Hobo® LI light unit and silica gel pack) from the permanent marker.

- Record the date of collection on the datasheet.

- In the laboratory, before opening the chamber, rinse in fresh water and dry thoroughly. Then open the field chamber and remove the Hobo® LI light logger.

- The clear plastic chamber should be cleaned to remove fouling with a dilute acid (HCl or vinegar). Do not scrub the plastic container with any material, as it will scratch the plastic.

- For downloading instructions for the Hobo® LI light logger, see section 4.7.2.

- Upon completion of downloading, with the Hobo® LI light logger turned off, place them in the storage case with dry silica gel packs, ready for the next quarterly sampling.

4.3.3. Temperature

Background

Water temperature has a strong influence on plant metabolism and photosynthesis, as well as the associated plant and animal populations of seagrass meadows. In many cases, the distribution of seagrass is limited by the maximum temperature the plants can withstand. Thus it is important to determine the temperature range of the seagrass meadows being monitored.

General procedure



- iButton® temperature loggers will be placed at the sampling site three months prior to monitoring, at the nearshore and offshore station markers.
- Before going to the field, launch the spare set of two iButton temperature loggers, record the numbers of the loggers on the data sheet (where the SSS.. is located in the photo at right) and replace the loggers in the field with the newly launched loggers on the day of quarterly sampling.
- The iButton® temperature loggers are attached to the permanent station markers at the center of cross-transects A and C just above the sediment-water interface. This location insures that the sensors are not exposed to air unless the seagrass flat is completely drained and places them out of sight of curious people.
- Record the date and time of logger deployment/collection on the datasheet.
- Every time you monitor (every 3 months), the iButton® temperature loggers are removed and replaced with a fresh set of 2 loggers.
- The iButton® temperature logger should be checked regularly and carefully cleaned of any debris.
- For launching and downloading the iButton® temperature logger, see section 4.7.1.

4.3.4. Salinity

Background

Salinity of the water affects the distribution (Orth and Moore, 1984; Fletcher and Fletcher, 1995) and growth (Adams and Bate, 1998; Kamermans *et al.*, 1999) of seagrasses. Water salinity can also be an environmental stress (Zieman *et al.*, 1999) and make seagrasses more or less vulnerable to diseases (Burdick *et al.*1993). Additionally, salinity information can be a good indicator of the origin of the water mass that was influencing the seagrass bed (oceanic or riverine) at that point in time. Salinity will also affect the presence and abundance of associated species like epiphytes and macro-algae.

General procedure

- The water samples for measuring salinity are collected once during the monitoring from the center permanent station marker (A, B, C). The time and tide status are important when measuring the salinity. Samples must be collected close to the same stage of tide and when the entire site is submerged.

- Record the tidal stage indicating whether the sampling is done at high or low tide and whether the sampling occurs during the spring or neap tidal period, e.g., enter "high/spring" if tide is high during the spring tides.

- Collect a small water sample using a small clean bottle from a well-mixed area within the seagrass canopy. The water masses within and above the vegetation may have quite different salinities, so ensure that you are within the seagrass canopy, i.e., below the top of the seagrass leaves.

- Submerge the bottle (with lid on) into the seagrass canopy, carefully remove the lid to fill the bottle and replace the cap on the bottle, before removing it from within the seagrass canopy.

- The salinity is measured using the refractometer from the SeagrassNet kit (Fig. 5) as soon as possible after the sample is taken, and at the same temperature at which it was sampled.

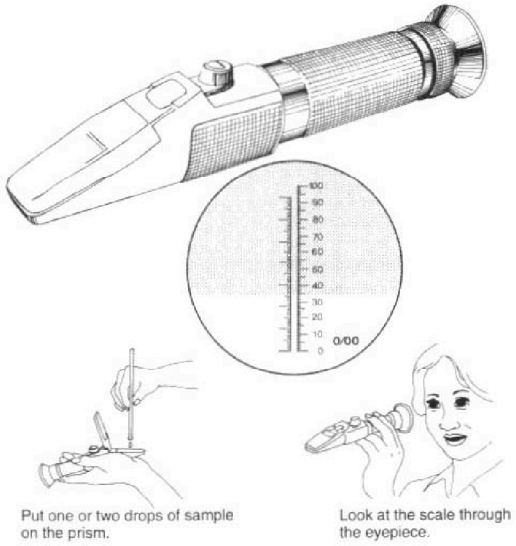


Figure 5. A diagram of a refractometer showing its use for measuring salinity.

From English et al. (1997)

- Make sure the glass cell of the refractometer is clean by removing particles or grease using distilled water (if possible) and wiped dry with tissue paper.

- Place a few drops of the water onto the glass cell of the refractometer and close the plastic cover. Hold the cover down, and looking through the eyepiece, face the instrument to sufficient light (sunlight or strong indoor lights).

- Read the salinity according to the instructions for that specific refractometer (usually the line separating a black and a white area) and record the salinity on the data sheet as parts per thousand.

- Wipe the glass surface with soft absorbent paper (microscopy paper is appropriate), rinse the surface with distilled water and wipe it off again.

- All refractometers should be calibrated on a regular basis by adjusting the baseline (0 ppt). To do this, check if the salinity of deionized water reads 0 ppt. If not, the baseline can be easily adjusted by turning a small screw on most refractometer models

- Additionally, refractometers should also be checked against other salinity measuring devices on a regular basis and sent back to the manufacturer for recalibration every 5 years or as needed.

4.3.5. Tidal stage

The best time to sample is at low tide during the spring phase, when the lowest water levels occur. Identify the tidal stage on the data sheet:

- High or low to identify the condition of the tide when the sampling is conducted.

- Spring or neap (determined from the Palm Pilot Tide Tool program or a local tide table) to identify the phase of the tide at the time of sampling.

Using the Palm Pilot Tide Tool

It cannot be over-emphasized that SeagrassNet sampling should be done during a daytime low spring tide, if at all possible. Low tide makes finding the permanent markers and taking the photographs much easier. For intertidal sites, the entire sampling procedure is quicker and easier at low tide.

- Determine the best spring low tide (the lowest low of the month) that occurs during daylight hours by launching the Tide Tool program on the Palm Pilot.

- Press the Place button to identify your sampling location. Press the Graph button for visual tidal display. Then press the Date button and select the first day of the correct month and year of your next quarterly sampling. Using the scroll button at the bottom of the Palm, scroll through the days of the month until you locate a low tide during daylight hours. Note the day and tidal height of the low tide. Continue to scroll through the month, searching for any lower tide that occurs during daylight hours.

- Schedule your quarterly SeagrassNet field sampling trip to match the best low tide of the month.

4.4. Re-establishing the cross transects

4.4.1. Finding the transect (second and subsequent monitoring visits)



- Find Station A with a Global Positioning System (GPS), using the site co-ordinates and your sketch map of the area.
- Using your GPS, find the permanent marker for Stations B and C. When you have found Stations B and C and the six permanent cross-transect markers, attach a float or flagging to each to make your transect field work easier.
- Clean any algal growth or other fouling material off the permanent station markers. Check that the light and temperature loggers are still in place and working. Replace any components of field equipment if necessary.

4.4.2. Laying out the cross-transects for subsequent monitoring events

- Using the GPS, find the permanent marker at Station A, the station closest to the beach. This is the center of your 50 meter cross-transect (refer to Fig 3).
- Lay out the first cross transects through Station A, attaching the measuring tape to the left side of the transect (facing the sea) and stretching the tape through Station A to the permanent marker at the right side of the cross transect. Attach the tape with cable ties to the permanent markers.

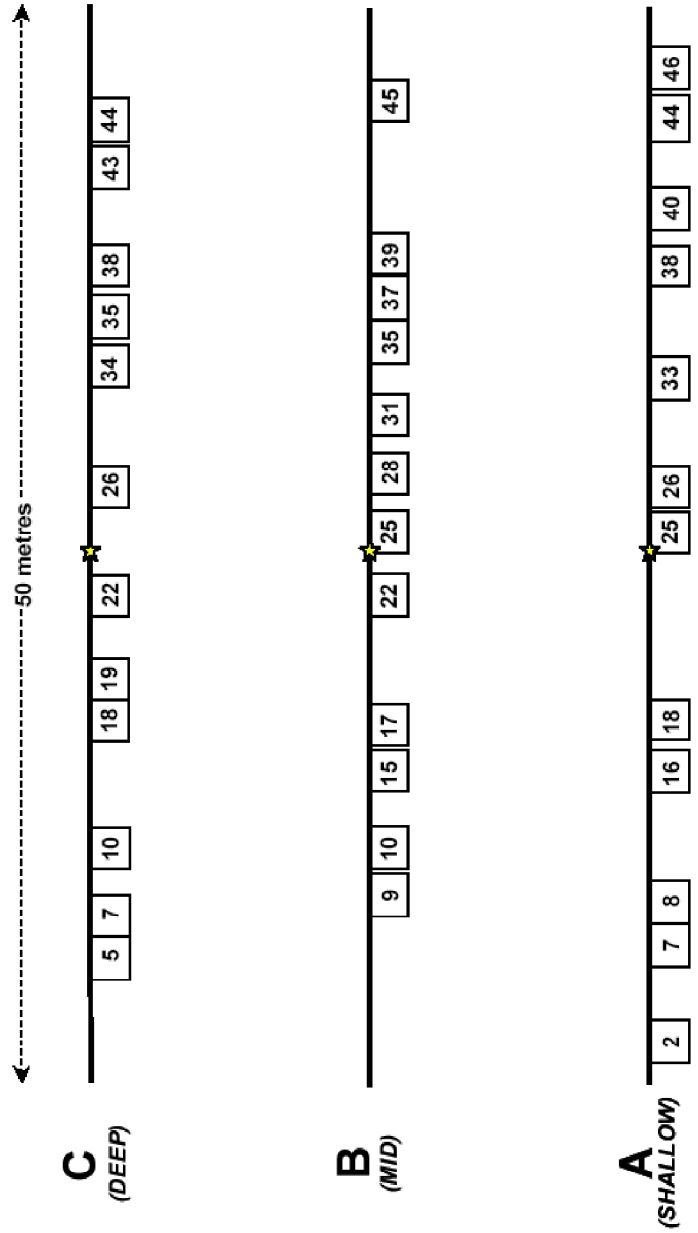
  NOTE: If the edge of the seagrass meadow at permanent Station A or C has shifted so that all of a cross transect no longer has seagrass, establish a new Station A' or C' one meter inside the new edge of the continuous bed. Conduct the sampling from cross transects based on these new stations and note the change on the data sheet. Measure and record the distance from A to A' or C to C'. Record on the data sheet that all quadrats on the original cross transect are now "0" -- i.e., no seagrass is present.
- You can now start the seagrass monitoring (Go to sections 4.3, 4.4 and 4.5).
- At completion of station A sampling, roll up the tape measure and repeat for Stations B and C, using the GPS to find B and C.

4.5. SeagrassNet quadrat measures

Quadrat positions

For each of the three cross-transects, you will measure 12 quadrats. The position of the quadrats will be on the beach side of the measuring tape at selected locations (Figs. 3 & 6). The locations are shown below (Fig. 6, not to scale); they were predetermined using random numbers.

Figure 6. Location (distance) of quadrats along each cross-transect



Necessary materials & equipment

You will need:

- ❑ *2x large (50cm x 50cm) quadrats*
- ❑ *2x small (25cm x 25cm) quadrats*
- ❑ *Seagrass 0.0035m^2 biomass corer*
- ❑ *30 cm ruler*
- ❑ *Underwater digital camera*
- ❑ *Quadrat labeller (+ marker pen)*
- ❑ *12 mesh bags (labelled 1 to 12)*
- ❑ *36 sealable plastic bags*
- ❑ *Seagrass percentage cover standard sheet*
- ❑ *Waterproof datasheets & clipboard & pencil*
- ❑ *Paper bags for drying plants*
- ❑ *Scissors/ forceps*
- ❑ *Drying oven*
- ❑ *Laboratory electric weighing scale (accuracy to 3 decimal points)*

4.5.1. General field procedure

- The best time for monitoring your transect is at low tide.
- At each cross transect, start at the first **quadrat** closest to the 0 meter mark on the tape measure. The quadrat should be placed to the beach side of the tape measure and, while facing the beach, with the bottom right corner on the randomly selected number on the tape measure (e.g,. for quadrat 1 on cross-transect A, quadrat is positioned 2.0m to 2.5m). Avoid walking on the beach side of the cross transects in order to avoid damaging the seagrass sampling area. Also, avoid resuspending sediments that may be carried over the cross transect by current or tide.

  Sampling is done to the beach side of the tape, therefore you should always walk seaward of a transect to avoid footprints where you will be sampling.
- On the datasheet, enter the pre-selected random distance number for each quadrat.
- Remove any unattached algae or large mobile animals (noting their presence in the comments) from the quadrat **before** collecting the following quadrat measures:

4.5.2. Photographs

- Take a **photograph** of the quadrat. Photos are taken before other sampling is done to avoid resuspending sediments by walking or swimming in the area, which would affect the photo quality.

- First place the photo quadrat labeller beside the quadrat with the correct transect, cross-transect, and quadrat number on it (e.g., quadrat number is PH4.1B04 at 17m on cross-transect B on site PH4.1).
- Next, take the photograph from an angle as **vertical** as possible, which includes the entire quadrat frame, the quadrat label and the tape measure. Try to avoid having any shadows or patches of reflection in the field of view. Ideally, photos should be taken either when the seagrasses are exposed at the surface (intertidal plants) and the photographer is standing, or when the seagrasses are submerged (subtidal and flooded intertidal plants) and the photographer is swimming. Intermediate depths make obtaining clear vertical photographs difficult. Mark the "Photograph" box on the datasheet for that quadrat.
- In some instances (due to tide height), you may also need to take a second photograph from an **oblique** angle (e.g., 45 degrees), which includes the entire quadrat frame and the quadrat label. Similarly, try to avoid having any shadows or patches of reflection in the field of view. Mark the Photograph" box a second time on the datasheet for that quadrat to indicate a second photo has been taken.
- Email the digital photographs to Seagrass.Net@unh.edu

4.5.3. Voucher seagrass specimen

Background

Properly pressed and preserved seagrass specimens are invaluable for future reference material. If stored correctly, the specimens will provide a record that supports data and published reports.

Collecting the sample

- A seagrass voucher specimen will be collected of each species present within the overall transect at every monitoring event. As the quadrat sampling is done, voucher specimens of the various seagrass species, with flowering parts if present, are collected.
- When collecting the seagrass voucher specimen, select a representative specimen of the species and ensure that you have all the plant parts including the rhizomes and roots. Target plants with reproductive structures (fruits or flowers) if possible. Only take a small sample, you do not need a handful, but at least 2 or 3 complete plants.
- The seagrass sample is placed inside a labelled plastic bag with seawater and a waterproof label.
- Indicate with a check mark the general area on the cross transects where voucher specimens are collected.

Pressing the sample

- The voucher specimen is pressed as soon as possible after collection. If it is going to be more than 2 hours before you press the sample then you should refrigerate to prevent any decomposition. Do not refrigerate longer than 2 days and press the sample as soon as possible.
- Rinse seagrass sample in fresh water and carefully remove any debris, epiphytes or sediment

particles. Divide the sample into two complete specimens.

- Lay out specimen on a clean sheet of white paper, spreading leaves and roots to make each part of the specimen distinctly visible.

- Fill out specimen labels (2) with site information (including: location & transect code, lat/long, depth, %cover, substrate, other species present, collector, comments) and place the label on the lower right hand corner of the paper. Labels can be filled out online and downloaded from the SeagrassNet website: www.SeagrassNet.org

- Place another clean sheet of paper over the specimen, and place within sheets of newspaper.

- Place the assemblage of specimen/paper within two sheets of cardboard and then place into the press, winding down the screws until tight (do not over-tighten).

- Allow to dry in a dry/warm/shaded and well-ventilated place for a minimum of two weeks.

- For best results, replace the newspaper after 2-3 days.

- Send one specimen per species, with a complete label to:

SeagrassNet
Attn: Fred Short
Jackson Estuarine Laboratory
85 Adams Point Road
Durham NH 03824 USA

- Keep the other sample in your own herbarium for reference (and in case the other one gets lost in the mail!).

4.5.4. Species, Percent Cover and Shoot Density

- Determine the total percentage cover of seagrass within each quadrat – use the percentage cover photo guide (Attachment 1). Attached algae and non-mobile live or dead animals should be included as part of the percent cover estimates as non-seagrass. Record the percentage cover on your data sheet. If the quadrat lands on an area with no seagrass this should be recorded as 0 (zero). If seagrass is present, record the appropriate % cover for all species combined within the quadrat under "All Species".



Composition of all species must equal the total, eg. *TOTAL* = 25%, *Thalassia hemprichii* 5% *Halodule uninervis* 20%

- Identify which seagrass **species** are found inside the quadrat and record the species on the datasheet using the species abbreviations.

- Next, determine the **percent cover by species** of each of the species and record this on the data sheet. We suggest determining the % cover for the species with the lowest % cover first and then work up from there.

- **Shoot density by species** is determined in two ways. In some cases, you may need to use both

ways on a given quadrat.

- For most seagrasses, shoot density is determined from the biomass cores, back in the laboratory, by counting the number of leaf meristems within the core sample. Record the results for each species on the Biomass Form next to the % cover measures and indicate the sample size (0.0035m^2).

- For very low density large plants, shoot density is determined using a smaller quadrat positioned at the lower right corner of the large quadrat. Using a 25 cm x 25 cm quadrat placed adjacent to the transect line, count all shoots of the large species in the 0.0625 m^2 area. Record results for the large species on the last species entry of the Field Sampling Form next to the % cover measures.

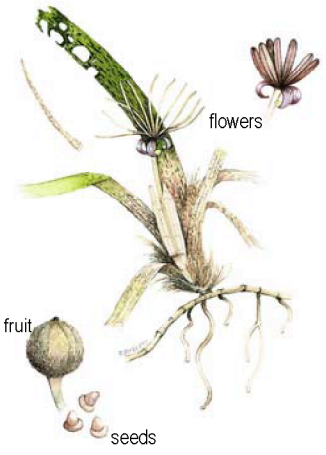
4.5.5. Canopy height and grazing

- Using the ruler, measure in centimeters the height (length of the seagrass leaf blades) for the dominant species (the species with the highest percent cover). Do this randomly by selecting a clump of seagrass blades from within the quadrat and measuring its height, ignoring the tallest 20% of leaves. Extend the leaves to their maximum length/height, without uprooting, and measure from the substrate to the leaf tip. If seagrass density is very low and a clump of blades cannot be grouped, make measurements on five individual shoots of the dominant species within the quadrat and calculate the average. Record the **canopy height** (average leaf length) on the data sheet.

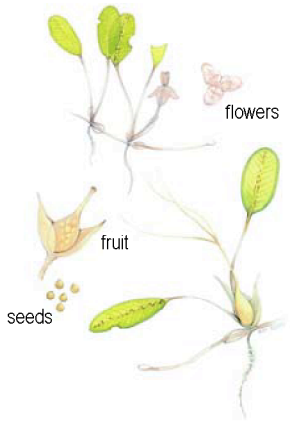
- Check the seagrass in the quadrat for evidence of grazing, e.g., turtle, siganid, dugong feeding trails, *etc*. Record if there is grazing evidence, and write in the notes what type of grazing you think it is under Comments.

4.5.6. Flower and fruit count

- Check each seagrass species present within the quadrat to see if they have any flowers or fruit. If they do, count the number of sexually reproductive parts (the sum of all flowers or fruits) of each species and record it on the datasheet, e.g., 1Hu, 2Ea, 2Th. (For some species, this information may only become available on processing the biomass cores in the laboratory).



Thalassia hemprichii
Picture courtesy of QDPI, Australia.



Halophila ovalis
Picture courtesy of QDPI, Australia.

4.5.7. Leaf, stem and root-plus-rhizome biomass

Field collection

- Finally, select an area more than 0.5 meter landward of the quadrat and of the same seagrass species and percentage cover as inside the quadrat, and take a biomass core.

- Place the corer over the selected area. You will need to push the leaves into the corer first to avoid chopping the leaves. Move your finger around the edge of the corer, putting leaves rooted in the corer on the inside of the corer and those rooted outside to the outside of the corer. There should be at least one full shoot within the core if there is seagrass present in the quadrat; the number of shoots within the core sample will vary depending on the species present. The most important step is to insure that shoots within the core be sampled in such a way that they emerge intact with all their leaves.

- Push the sharpened end of the corer vertically into the substrate to a depth of 10cm below the horizontal rhizomes.

- If intertidal, fill the top, open end, of the corer with seawater while it is still pushed into the sediment and place the cap on the top end. This helps to create suction.

- Gently pull the corer out of the substrate, capping the bottom end as it comes out of the sediment.

- Empty entire contents of the corer into the net bag labelled with the quadrat number. Rinse sample to remove any mud and as much sediment as possible.

- If percent cover is very low, a biomass core should not be taken and the entry on the data sheet should be 0.0001. If the percent is actually zero, a biomass core should not be taken and the entry should be 0.

Laboratory procedure

Each biomass core is rinsed in fresh water to remove salt and sorted into species and plant components:

- Empty the contents of the net bag into a sorting tray or on a clear area.

- Remove intact shoots and all below ground material.

- Separate the seagrass shoots into the different species.

- Count the number of leaf meristems (the base of the shoot where the leaves attach to the stem or rhizome) for each species and record on the datasheet under **Density**

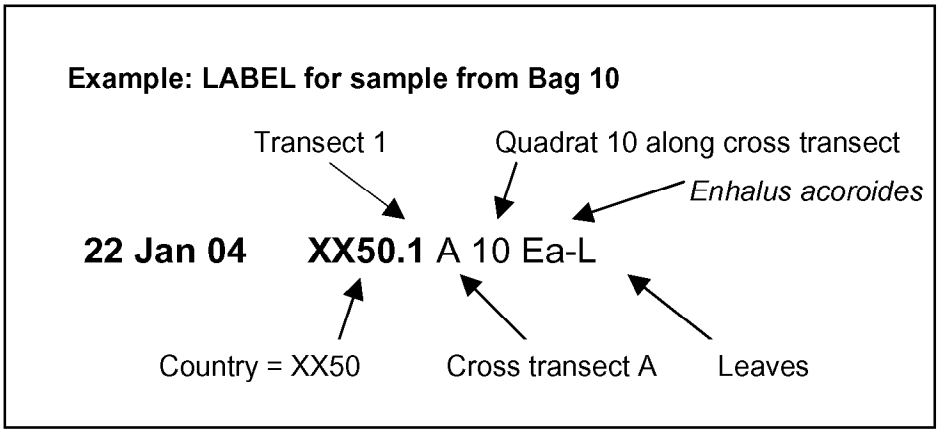
- Separate the shoots for each species into:

  Leaves – green intact shoots connected to a stem or rhizome, however brown/ dead attached leaves should also be included. The leaf biomass sample should have the same number of leaf clusters as meristems (reported under Density)

  Sheaths & stems - these can vary from whitish (e.g., *Halophila*) to greenish (e.g., *Syringodium*) in color. Include fruits and seeds in the sample with "Sheaths & stems."

Below ground - includes all the horizontal rhizomes (can be whitish to brown in color) and roots.

- Place each component for each species in separate, paper bags with an open top and clearly label each envelope with a permanent marking pen as follows:
  - Site abbreviation, site number, transect letter (A, B, C), quadrat number (1-12) e.g., "XX50.1A01" or "XX50.1A02" or "XX50.1A03"
  - Species abbreviation - Plant part (L, S, R) e.g., Ea – L, Ea – S, Ea - R
  - Date – write month out (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec). Dates will read, e.g., 27 Jan 04, 15 Aug 04, *etc*.



- Place the biomass sample paper bags in the drying oven at 50 – 60 degrees celsius (120 degrees Farenheit) for 24 – 48 hours or until the plant material is completely dry.

- Allow to cool, take the sample from the paper bags and weigh the sample on electronic scale in grams to an accuracy of 3 decimal places. Record the information on a datasheet or Excel spreadsheet.

- After weighing the sample, rewrap it in the paper bag with the label and date weighed and keep stored in a plastic bag. DO NOT THROW OUT the sample until you have received confirmation from SeagrassNet that the data has been entered into the electronic database and verified.

4.5.8. General field procedure *continued*

- Check that you have completed the data sheet for that quadrat. If complete, move the quadrat to the next randomly chosen location until you have completed the information for twelve quadrats along the cross transect.

- At the completion of the 12 quadrats, record the finish time and move on to the next cross-transect.

- At the completion of all three cross-transects, check that the data sheets are filled out completely and correctly. Make sure that your name, the date, and transect, cross-transect (station) and quadrat details are filled out completely.

- Roll up the tape measures. Check the site for any other equipment. Make sure you leave the site as undisturbed as possible (this includes taking home any rubbish!!). Ensure that the data loggers to be left in the field are secured.

- When you arrive back at shore, rinse all of the equipment thoroughly in fresh water and store properly.

- Check the datasheets and make a photocopy for the file.

- Send original field datasheet and laboratory biomass datasheets to:



SeagrassNet
Attn: Fred Short
Jackson Estuarine Laboratory
85 Adams Point Road
Durham NH 03824 USA

Further Reading:

Burdick, DM. GA Kendrick. 2001. Standards for seagrass collection, identification and sample design. Chapter 4. pp. 79-100. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Koch, EW, JJ Verduin. 2001. Measurements of physical parameters in seagrass habitats Chapter 17. pp. 326-344. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

McKenzie, LJ, SJ Campbell, CA Roder. 2001. Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) Volunteers. Queensland Fisheries Service, NFC, Cairns. 94pp.

4.6. SeagrassNet cross-transect measures

There are three cross-transects per transect (or site). Each cross-transect is 50 meters in length.

WHEN? The measurements for each cross-transect will be recorded during each quarterly monitoring event (every three months).

WHERE? The cross-transect measures will be taken at the 0 meter mark (referred to as L or left), 25 meter mark (referred to as C or center), and 50 meter mark (referred to as R or right) of each of the three cross-transects.

Necessary materials & equipment

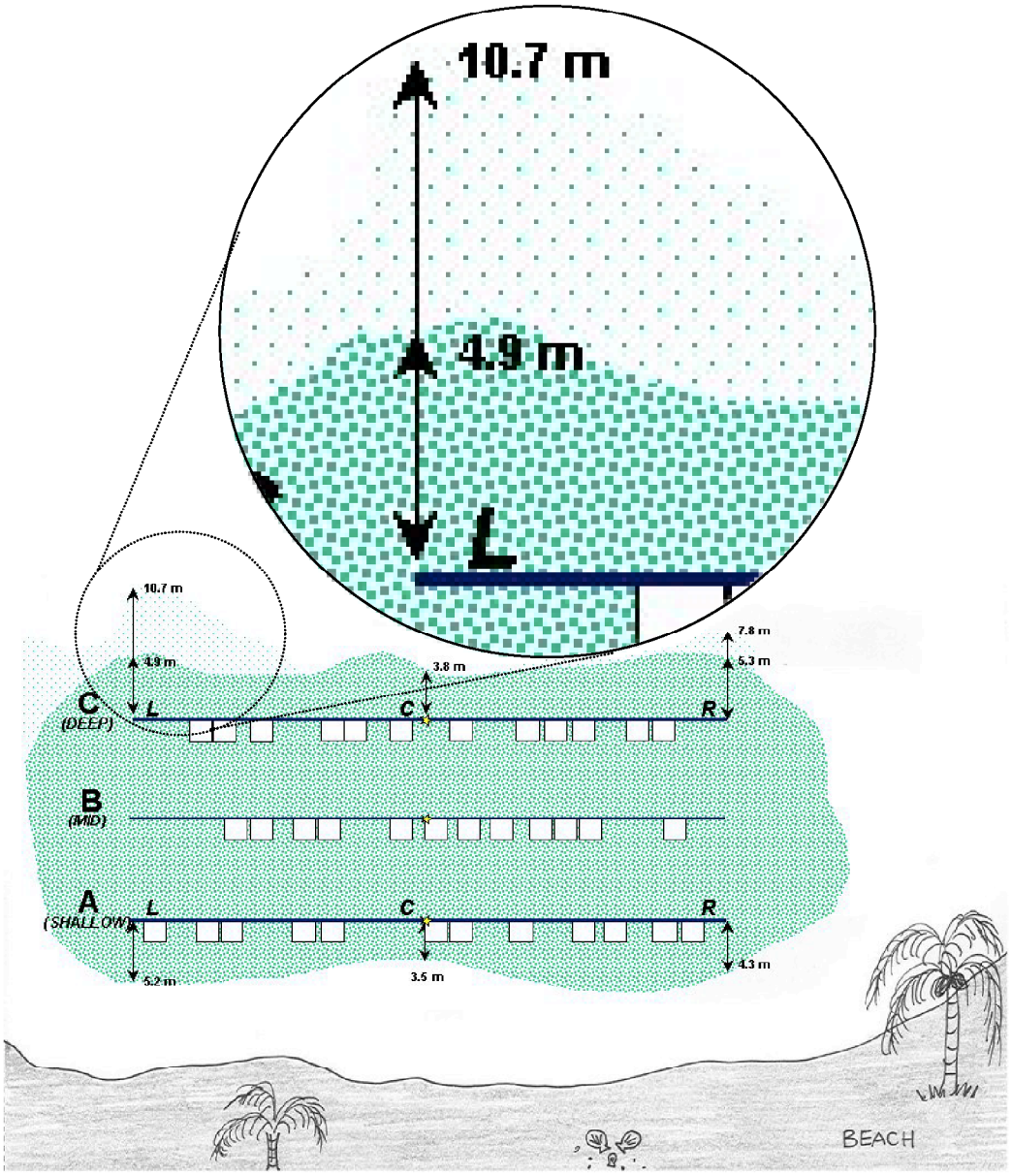
You will need:

- ❑ *2 50m fiberglass measuring tapes*
- ❑ *Depth measuring device (e.g., depth sounder, measured length of rope with weight)*
- ❑ *Geographic Positioning System (GPS)*
- ❑ *Sketch map for site location*
- ❑ *Tide information*
- ❑ *Syringe sediment core sampler and plastic bags*
- ❑ *Waterproof datasheets, clipboard and pencil*

4.6.1. Distance to seagrass edge and last shoot

- Using a 50m tape, measure the distance from the left, center, and right positions perpendicularly to the limit of seagrass from the shallow (A) and deep (C) cross transects. To define the extent of the seagrass growth at the time of sampling, 2 measures are taken
  - Dist. to edge (m) = Distance to the edge of the continuous meadow
  - Dist. to last plant (m) = Distance to the most inshore shoot from cross-transect A and the most offshore shoot from cross-transect C (see Figure 7)
- The outer edge is defined for SeagrassNet monitoring as the seaward limit of the strap-leaved seagrasses; the petiolate seagrasses often extend too deep to monitor.
- Record the distance on the datasheet in meters to the nearest tenth of a meter.
- If the edge of the seagrass has contracted inside the position of the cross-transect, record the distance as negative.
- Finally, on the back of the datasheet, provide a thorough site description (diagram/picture) of the site, specifying where the inner and outer edges of the meadow are located.

Figure 7. Example of how to determine and measure the distance to edge for both the continuous meadow and furthest, or last, shoot



4.6.2. Depth

- Water depth is measured at 9 places (when the entire site is submerged) and the time is recorded.
- Using a depth measure (e.g., depth sounder, weight on a rope marked with depth, etc.) measure the depth from the top of the substrate to the water surface at each of the nine cross transect sites (left, center, and right on the three cross transects).
- Record the depth and the time on the datasheet.

4.6.3. Surface sediment observation/sample

- The surface sediment assessment requires the observer to describe the substrate in that location as one of the following:
  - mud
  - fine sand
  - sand
  - coarse sand
  - shell
  - gravel
  - coral rubble
  - rock
- To assess the sediment, dig your bare hand into the top centimeters of the substrate and feel the texture.
- Remember that you are assessing the surface sediment so don't dig too deep!!
- If you find that there are also small shells mixed in with the substrate – you can make a note of this in the note section.
- Record the sediment type for left, center, and right of each cross transect.

Sediment samples

- The sediment samples will be collected with every sampling event (4 times per year) from each permanent station marker. Samples are collected with a syringe corer.
- Place the cut off end of the 20cc syringe barrel at the sediment surface, hold the plunger at a constant height above the sediment, and push the barrel into the substrate.
- Gently extract the syringe now filled with sediment from the substrate, capping the cut off end of the syringe barrel with a rubber stopper.
- Note on the data sheet a "yes" to indicate that the sample was collected from the center of the cross transect. A total of 9 samples are collected
- Empty the entire contents of the syringe, including any water at the top of the core, into a clip seal plastic bag.
- In the lab, open one end of the bag and allow the sample to air-dry.
- When dry, close the bag and send the sample to SeagrassNet for processing:



SeagrassNet
Attn: Fred Short
Jackson Estuarine Laboratory
85 Adams Point Road
Durham NH 03824 USA

Further Reading:

Burdick, DM. GA Kendrick. 2001. Standards for seagrass collection, identification and sample design. Chapter 4. pp. 79-100. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

4.7. SeagrassNet Data Logger Launching and Downloading

4.7.1 Instructions for iButton Temperature Sensors



iButton Thermochron

Installing the iButton Viewer software

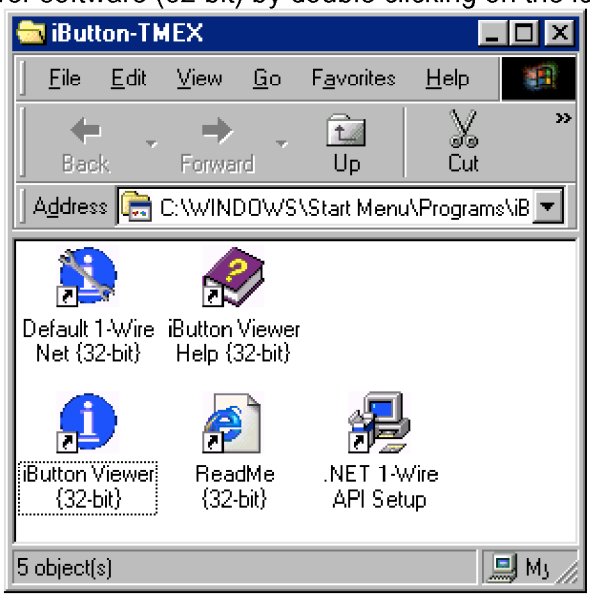
- Double click on the application tm321b3_32.exe in the Temperature Sensor folder on the SeagrassNet CD, or download the software version 3.21 beta 3 from the website: http://www.ibutton.com/software/tmex/index.html.

- Follow the software installation instructions.

Launching iButton Viewer software

- Connect the Blue Dot Receptor (DS1420D-DR8) and the 1-Wire to RS-232 Adapter (DS9097U-S09) to the Com 1 port on the computer. If you have been provided with a USB to 1-Wire Adapter (DS9490R) then you will connect this adapter to the USB port.

- Launch the iButton Viewer software (32 bit) by double clicking on the icon.



- Connect the iButton to the Blue Dot Receptor and the iButton serial number (number on bottom of iButton) will appear in the left hand column of the iButton Viewer32 dialog box.

- Click on (highlight) the serial number of the iButton and a box will appear in the lower right hand corner that states, Click Here for Viewer. A left mouse click in this box will bring up Thermochron Viewer and TMEX File Structure Viewer. Click on the Thermochron Viewer.

  [An alternate way to get to the Thermochron Viewer is to highlight the serial number of the iButton and right click the mouse anywhere on the dialog box and select Viewer and then Thermochron Viewer (usually located in lower right hand corner of dialog box).]

  The Thermochron Mission Wizard dialog box will appear, listing the steps necessary to launch the iButton sensors. The iButton sensor is already launched if the Status dialog box appears instead of the Thermochron Mission Wizard dialog box and you will have to download the data, if the iButton contains important data, and stop the current mission before launching the iButton. See instructions on Downloading the iButton.

- The Thermochron Mission Wizard Dialog box will appear, listing the steps necessary to launch the iButton sensors.

Launching the iButton

- Introduction dialog box – select Next

- Time Set dialog box – select time from PC clock and select Next

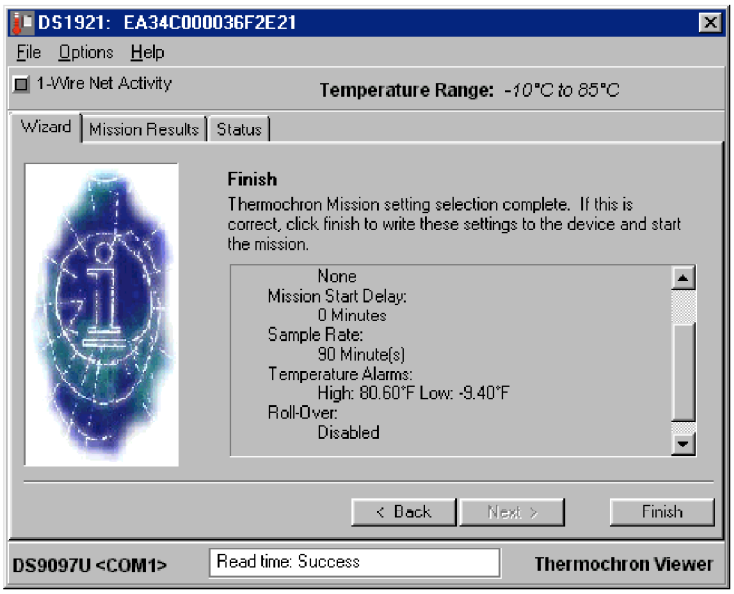
- Time Alarm – select None and select Next

- Mission Start Delay – input the days, hours and minutes of the time delay from now until the desired start time of the iButton for recording temperatures. The program will compute the total minutes. It is not necessary that the delay time be precise, as the time and date that the sensors are deployed in the field will be recorded on the field data sheet. Select Next after entering the preferred time delay.

- Sample Rate – scroll down and select 90 minutes, then select Next.

- Temperature Alarms – set the High Threshold at 80.60°C (iButton does not record any higher than 85°C) and set the Low Threshold at –9.60°C (iButton does not record any lower than –10.0°C). Deactivate the Respond to Conditional Search on Alarm buttons (High and Low). Select Next.

- Roll-Over – this dialog box indicates the total number of days (128.0 days) that the iButton will record temperatures based on the Sampler Rate selected. It also provides an option to write over previously collected data. DO NOT select this option, since it is only necessary for the iButton to be in the field for 90 – 120 days based on SeagrassNet quarterly sampling intervals. After de-activating the Enable Roll-Over button, select Next.



- Finish – the Finish dialog box provides a summary of the iButton launch parameters.

- Check carefull that all parameters are correct, then select Finish.

- A Status dialog box will automatically appear reviewing the launch parameters. Check that the Mission Status: reads “in progress”. Before preparing the iButton for deployment you should make sure the sensor is launched and will start recording temperature data after the designated start delay. To do this, write down the Start Delay (minutes) under the Status dialog box for the sensor. Now remove the iButton from the Blue Dot Receptor and wait some time, then reconnect the iButton to the Blue Dot Receptor.

  After reconnecting the iButton to the Blue Dot Receptor, the iButton serial number (number on the bottom of the iButton) will appear again in the lefthand column of the iButton Viewer32 dialog box.

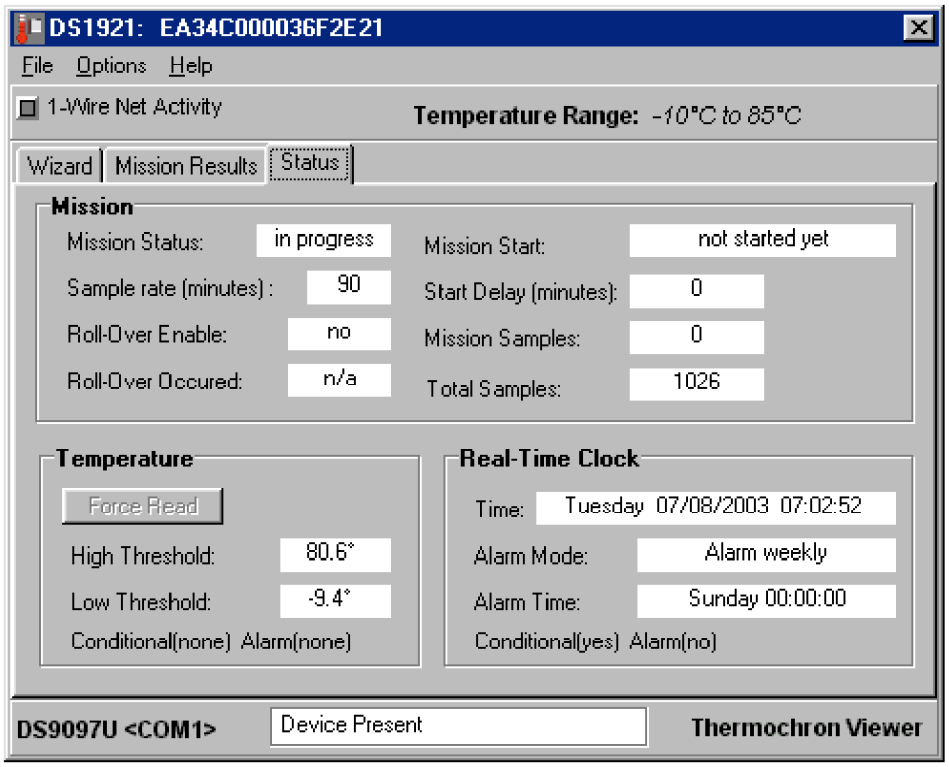
  Click on (highlight) the serial number of the iButton and a box will appear in the lower right hand corner that states, Click Here for Viewer. A left mouse click on this box will bring up Thermochron Viewer and TMEX File Structure Viewer. Click on the Thermochron Viewer.

  [An alternate way to get to the Thermochron Viewer is to highlight the serial number of the iButton and right click the mouse anywhere on the dialog box and select Viewer and then Thermochron Viewer (usually located in lower righthand corner of dialog box).]

  The Thermochron Status dialog box should appear instead of the Wizard dialog box. At this point, you can compare the Start Delay (minutes) that you recorded earlier with the current value. If there is a difference then you know for sure that the iButton is launched and ready to be deployed. If the Start Delay (minutes) is not different, then the iButton did not launch properly and needs to be relaunched and rechecked as instructed above.

- The iButton is now launched and ready to be sealed with rubber tubing and silicone grease. Coat the metallic part of the iButton with silicone grease and slide a small (2.54 cm, 1.0 inch) section of rubber tubing over the sensor. Pack the ends of the rubber tubing with silicone grease filling any air pockets with grease.

- iButton is now ready to be deployed. Use a zip (cable) tie to attach the iButton to the Station marker. Be sure to record the exact time and date when deploying the iButton sensors.



Downloading the iButton

- Collect the iButtons from the field, rinse in fresh water and remove any algal overgrowth. Remove the rubber tubing and wipe the iButton clean of silicone grease with paper towels or tissue. An old toothbrush is effective at removing any sand between the iButton and the fob (holder).

- Connect the Blue Dot Receptor (DS1420D-DR8) and the 1-Wire to RS-232 Adapter (DS9097U-S09) to the Com 1 port on the computer. If you have been provided with a USB to 1-Wire Adapter (DS9490R) then you will connect this adapter to the USB port.

- Launch the iButton Viewer software (32bit) by double clicking on the icon.

- Connect the iButton to the Blue Dot Receptor, and the iButton serial number will appear in the left hand column of the iButton Viewer32 dialog box. Click on the iButton serial number. Connect the iButton to the Blue Dot Receptor and the iButton serial number (number on the bottom of the iButton) will appear again in the lefthand column of the iButton Viewer32 dialog box.

Click on (highlight) the serial number of the iButton and a box will appear in the lower right hand corner that states, Click Here for Viewer. A left mouse click on this box will bring up the Thermochron Viewer and TMEX File Structure Viewer. Click on Thermochron Viewer.

[An alternate way to get to the Thermochron Viewer is to highlight the serial number of the iButton and right click the mouse anywhere on the dialog box and select Viewer and then Thermochron Viewer (usually located in lower righthand corner of dialog box).]

- Mission Result tab to the left of the Status tab.

- There will be a short delay before the Export Results button becomes active while data are being downloaded from the sensor. Click on the Export Results button and a Save Device Contents dialog box appears.

- Save the data as a text file labelled as site abbreviation (e.g., XX), site number (e.g., 50), T (for Temperature), A or C (for transect), and the date (month year). For example: XX50_1_T_A_Jul03.txt

- On the Mission Results or Status tab, select Stop Current Mission under the Options pull down menu to stop the iButton from recording data. The Mission Status box on the Mission tab will read, "ended," if stopping the current mission was successful. The iButton is now off and can be stored until next deployment.

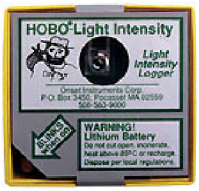
- Launch Microsoft Excel and open the text file.

- Edit data according to the time and date the sensor was deployed and retrieved in the field and save in Excel as: site abbreviation, site number, T (for Temperature), A or C (for transect), and the date (month year). For example: XX50_1_T_A_Jul03.xls

Data submission

- Email data to Seagrass.Net@unh.edu as a Text or Excel file.

4.7.2 Instructions for HOBO Light Intensity Sensors



Using IBM Computers to Launch and Download HOBO Light Intensity Logger Data

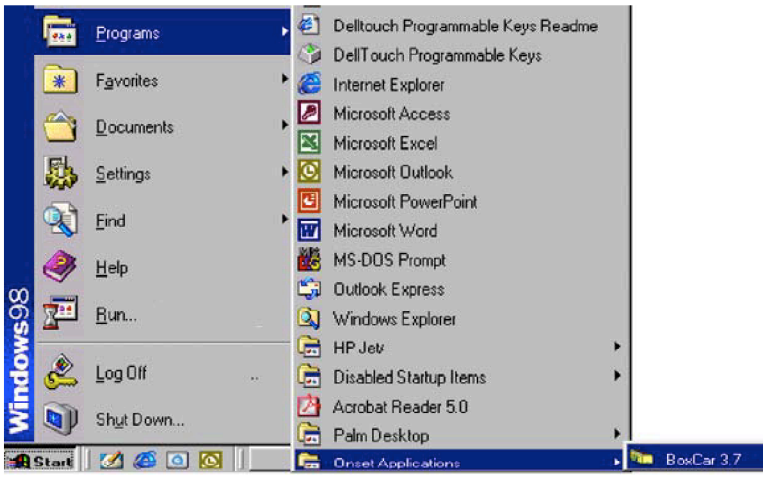
Loading BoxCar 3.7 software onto your PC

- Insert the BoxCar 3.7 floppy disk into the drive on your computer.
- Click on the **START** button () in the bottom left hand corner of computer screen and then choose the **RUN** option ().
- Type a:/setup in the space provided and select **OK** (press **ENTER**) (the BoxCar 3.7 program will begin to load).
- **Welcome** dialog box. You will be prompted with a **Welcome** dialog box, select **NEXT**.
- **Information** dialog box. The next screen will be an **Information** dialog box, select **NEXT**.
- Choose **Destination Location** dialog box. The installer prompts you for the destination folder (BOXCAR3 is the default) to install the program. Select **NEXT**.
- Select **Program Folder** dialog box. The installer prompts you for the location to add the program icons. The default folder is Onset Applications; therefore, select **NEXT** and BoxCar 3.7 will begin to load.
- The **Setup Complete** dialog box. Select **Finish**. Now BoxCar 3.7 is installed and ready to run.

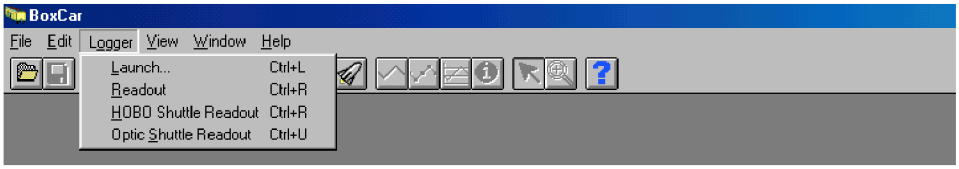
Launching HOBO Light Intensity Logger with BoxCar 3.7

- Click on the **Start** button in the bottom left hand corner of the computer screen. Move the mouse to the **Programs** tab and then to the Onset Applications folder and click on the BoxCar 3.7 program in that folder. [If you wish to copy the BoxCar 3.7 icon ()

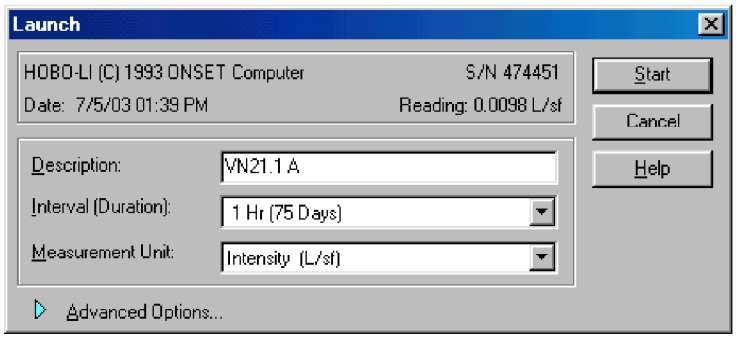
to the desktop you can right click on the BoxCar 3.7 program and select **Copy**. Then click on your desktop and right click the mouse to **Paste** the BoxCar 3.7 icon to your desktop.] Double click on the BoxCar 3.7 icon () to start BoxCar 3.7.



- Connect the HOBO-PC interface cable (provided in the light logger packet) to the communications port (COM 1) in the back of your computer.
- Check to see if Communications Port is working properly by following the instructions on page 26 of the BoxCar (Version 3.7+ for Windows) software User's Manual.
- Connect the HOBO Light Intensity Logger to the HOBO-PC interface cable. Now you are ready to launch the HOBO Light Intensity Logger.
- To Launch a HOBO Light Intensity Logger, select **Launch** from the **Logger** menu (or press **Ctrl L**).



- A dialog box appears with the words "Connecting…" and then "HOBO Found". A **Launch** dialog box will appear shortly thereafter.



- Enter the appropriate country abbreviation, country number, site number, and cross transect letter. Look over the Launch dialog box to be sure the fields are as follows:

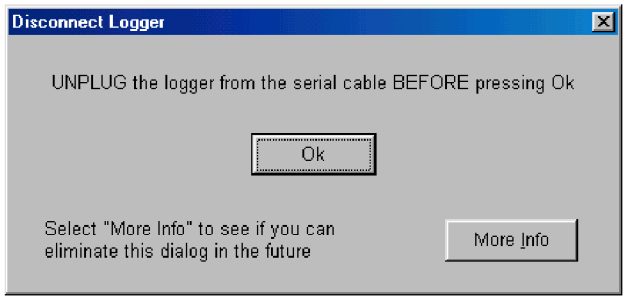
Description: Country abbreviation, country number.site number and cross transect letter (A, C or LAND) (for example: XX50.1A, XX50.1C, XX50.1LAND)

Interval: 1 Hr (75 days)

Measurement: Intensity (L/sf)

Do not use **Advanced Options**. The only advanced option with this software version is **Wrap around when full** (which overwrites the oldest data) and it should NOT be checked.

- Select **Start** after the Launch fields are updated. A dialog box appears with a status bar of the launching process.
- **Disconnect Logger** dialog box. Disconnect the logger from the HOBO-PC interface cable before selecting **Ok**. You may eliminate this dialog box in the future by selecting the **More Info** button and following the directions that follow.



- At this point the HOBO Light Intensity Logger is launched and is recording data as indicated by a blinking LED (red light in corner of logger).

blinking red light



- Seal logger in clear waterproof case with a silica (desiccant) packet enclosed. The stripe on the side of the silica should be blue, indicating that it is dry. If the stripe is pink, the silica packet should be placed in a warm oven (<60°C) for an hour. Deploy the logger in the field to the site for which it is labelled.

Downloading data from the HOBO Light Intensity Logger after field deployment

- Start BoxCar 3.7
- Connect the Logger to the HOBO-PC interface cable.
- Select **Readout** from the **Logger** menu. A dialog box will appear that says "Connecting…" and then "HOBO Found".
- **Disconnect Logger** dialog box. Disconnect the logger from the PC interface cable and select **Ok**. You may eliminate this dialog box in the future by selecting the **More Info** button and following the directions. Be sure that the logger's LED is no longer blinking to save battery life when it is not in use.
- After selecting **Ok**, the data appears with a **Save As** dialog box. The **File name** is the same as the **Description** input with the country abbreviation, country number.site number and cross transect letter information used earlier when launching the logger with underscores (_) in place of decimals (.) and spaces ( ). **Save file as type:** Data File (*.dtf). For example: XX50_1_A.dtf
- Select a specific folder in which to save the file (for example: SeagrassNet Light Data) and then select **OK.** After selecting **OK**, the data should be available to view and analyze on the screen.

Emailing Data as a BoxCar 3.7 file (*.dtf extension)

- After the light data file has been saved, it is ready to be emailed. Send the light data file as an attachment to Seagrass.Net@unh.edu

- Please specify the HOBO Light Intensity sensor deployment dates (for example: Light 12 July 03 – 18 July 03) in the subject line of the email.

Glossary

Anthropogenic	produced or caused by humans.
Baseline	first assessment of a situation against which subsequent changes are measured.
Biomass	the total amount of living organisms or plant material in a given area, expressed in terms of living or dry weight per unit area.
Canopy	the covering afforded by the tops of the plant structure serving as a sheltered area.
Canopy height	in seagrasses, usually defined as the length from substrate to leaf tip of 80% of the leaves within a given area.
Community	any group of organisms belonging to a number of different species that co-occur in the same area and interact through trophic and spatial relationships.
Core sample	a cylindrical sample of benthos and substratum obtained by the use of a hollow tube/drill.
Datasheet	a paper form used to record field data in a set format.
Density	a measure of the compactness of a substance (e.g. number of plants) within a given area.
Disturbance	change caused by an external agent, which could be natural (e.g. weather) or human-induced (e.g. pollution).
Diversity	variety, often expressed as a function of a number of species in a sample, sometimes modified by their relative abundances.
Ecosystem	a dynamic complex of plant, animal and micro-organism communities and the associated non-living environment interacting as an ecological unit.
Epiphyte	plants growing on the surface of other plants.
Global Positioning System (GPS)	satellite-based navigation system.
Internodes	the part of a plant rhizome between two nodes.
Landward	in the direction of the land.
Leaf scars	the marks remaining on the rhizome or stem of a plant after a leaf has died.

Leeward	side protected from the wind.
Macrofauna	the animals retained by a 0.5 mm sieve.
Meristem	growing part at the base of the leaf (leaf meristem)
Methodology	collection of methods used in a particular activity.
Monitoring	repeated observation of a system, usually to detect change.
Nearshore	close to the coastline.
Nodes	the point on a plant rhizome from which the leaves and lateral shoots grow.
Percent cover	the proportion of a hundred parts of a given area (e.g. quadrat) this has plants present.
Petiolate	having a stalk.
Population	all individuals of one or more species within a prescribed area.
Population structure	the composition of a population according to age and sex of the individuals.
Primary production	organic mater created through photosynthetic processes of plants.
Productivity	the potential rate of incorporation or generation of energy or organic matter by an individual or population per unit area or volume; rate of carbon fixation.
Quadrat	a fixed unit, usually square, used for sampling.
Qualitative	descriptive, non-numerical.
Quantitative	numerical; based on counts, measurements or other values.
Refractometer	optical instrument used to measure salinity.
Replicate	a repeated sample from the same location and time.
Salinity	measure of the total concentration of dissolved salts in water.
Sample	any subset of a population; a representative part of a larger unit used to study the properties of the whole.
Sample size	the number of observations in a sample.
Sand	cohesionless sediment particles measuring 2.0-0.0625mm in diameter.
SCUBA	Self-Contained Underwater Breathing Apparatus.
Seagrass meadow	a large expanse of seagrass plants.
Seagrass community	a group of seagrass plants belonging to a number of different species that co-occur in the same area.
Seaward	in the direction of the open sea.

Secchi depth	the distance between the water surface and Secchi disc at which point the disc marking are no longer distinguishable.
Secchi disc	device used to estimate the transparency of water.
Sediment	matter that settles to the bottom of a water body.
Sedimentation	process of deposition of particulate matter.
Station	the place or position at which the transect and cross-transects intersect.
Substrate	another word for substratum.
Substrate type	the composition of sediments, usually distinguished by the grain size.
Substratum	the base to which a stationary animal or plant is fixed, but can be any benthic surface; the layer of sediment on the bottom of the ocean.
Subtidal	beneath the low watermark.
Survey	organized inspection or monitoring process.
Transect	a line or narrow belt used to survey the distributions of organisms across the given area.
Variable	any measurable aspect of a sample that is not constant.
Vein	the clearly defined vascular bundle in a leaf, usually seen as slightly darker lines forming the framework of a leaf.
Visibility	distance at which objects may be sighted during a survey.
Water column	a volume of water between the surface and the bottom.
Windward	side exposed to the wind

References

Chapter 1

Green, E.P. and Short, F.T. (eds.). 2003. World Atlas of Seagrasses. University of California Press, Berkeley, USA. 324 pp.

Orth, RJ, KA Moore. 1983. Chesapeake Bay: an unprecedented decline in submerged aquatic vegetation. Science 22: 51-52.

Mukai, H. 1993. Biogeography of the topical seagrasses in the Western Pacfic. Aust. J. Mar. Freshwater Res. 44: 1-17.

Pasqualini, V, P Clabaut, G Pergent, L Benyoussef, C Pergent-Martini. 1998. Contribution of side scan sonar to the management of Mediterranean littoral ecosystems. Int. J. Remote Sensing, 21: 367-378.

Short, FT, RG Coles, C Pergent-Martini. 2001. Global Seagrass Distribution. Chapter 1, pp. 5-30. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Chapter 2

Bridges, KW, C McMillan. 1986. The distribution of seagrasses of Yap, Micronesia, with relation to tide conditions. Aquatic Botany 24: 403-407.

Coles, R, J Kuo. 1995. Seagrasses. Chapter 3. pp. 39-57. *In:* JE Maragos, MNA Peterson, LG Eldredge, JE Bardach, HF Takeuchi (eds.) Marine/Coastal Biodiversity in the Tropical Island Pacific Region: Vol 1. Species Systematics and Information Management Priorities. East-West Center, Honolulu.

Coles, RG, WJ Lee Long, BA Squire, LC Squire, JM Bibby. 1987. Distribution of seagrasses and associated juvenile commercial penaeid prawns in northeastern Queensland waters, Australaia. Aust. J. Mar. Freshwater Res. 38: 103-120.

Coles, RG, WJ Lee Long, LJ McKenzie, AJ Roelofs, G De'ath. 2000. Stratification of seagrasses in the Great Barrier Reef world heritage area, northeastern Australia, and the implications for management. Biol. Mar. Medit. 7: 345-348.

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

Fortes, MD. 1998. Indo-West Pacific affinities of Philippine seagrasses. Bot. Mar. 31:237-242.

Kuo, J, C Den Hartog. 2001. Seagrass Taxonomy and identification Key. Chapter 2. pp. 31-58. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Lee Long, WJ, JE Mellors, RG Coles. 1993. Seagrasses between Cape York and Hervey Bay, Queensland, Australia. Aus. J. Mar. Fresh. 44:19-31.

Lee Long, WJ, RG Coles, LJ McKenzie. 1996. Deepwater seagrasses in Northeastern Australia – how deep? How meaningful? pp. 41-50. *In:* J Kuo, RC Phillips, DI Walker, H.Kirkman (eds.) Seagrass Biology. Proceedings of an International Workshop. Sciences UWA. 385pp.

Lee Long, WJ, RG Coles, LJ McKenzie. 2000. Issues for seagrass conservation management in Queensland. Pacific Conservation Biology 5: 321-328.

McKenzie, LJ, SJ Campbell, CA Roder. 2001. Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) Volunteers. Queensland Fisheries Service, NFC, Cairns. 94pp.

McKenzie, L.J. & Campbell, S.J. (2002) Seagrass-Watch: Manual for Community (citizen) Monitoring of Seagrass Habitat - Western Pacific Edition (QFS, NFC, Cairns) 43pp

Short, FT, RG Coles, C Pergent-Martini. 2001. Global Seagrass Distribution. Chapter 1, pp. 5-30. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Short, FT, S Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrasses. Environmental Conservation 23(1): 17-27.

Tsuda, RT, S Kamura. 1990. Comparative review on the floristics, phytogeography, seasonal aspects and assemblage patterns of the seagrass flora in Micronesia and the Ryukyu Islands, Galaxea 9:77-93.

Chapter 3

Dennison, WC, RJ Orth, KA Moore, JC Stevenson, V Carter, S Kollar, PW Bergstrom, RA Batiuk. 1993. Assessing water quality with submersed aquatic vegetation: Habitat requirements as barometers of Chesapeake Bay health. BioScience. 43: 86-94.

Coles, RG, WJ Lee Long, RA Watson, KJ Derbyshire. 1993. Distribution of seagrasses, and their fish and penaid prawn communities, in Cairns Harbour, a tropical estuary, Northern Queensland, Australia. Australian Journal of Marine and Freshwater Research, 44, 193-210. 1993.

Fonseca, MS, JS Fisher. 1986. A comparison of canopy friction and sediment movement between four species of seagrass with reference to their ecology and restoration. Mar. Ecol. Prog. Ser. 29: 15-22.

Lanyon, J, CJ Limpus, H Marsh. 1989. Dugongs and turtles; grazers in the seagrass system. pp. 610-634. *In:* AWD Larkum, AJ McComb, SA Shepherd (eds.) Biology of

seagrasses. A treatise on the biology of seagrasses with a special reference to the Australian region. Elsevier, Amsterdam.

Short, FT. 1987. Effects of sediment nutrients on seagrasses: Literature review and mesocosm experiments. Aquatic Botany 27:41-57.

Short, FT, CA Short. 1984. The seagrass filter: purification of coastal water. *In* VS Kennedy (ed.) The Estuary as a Filter. Academic Press. pp. 395-413.

Watson, RA, RG Coles, WJ Lee Long. 1993. Simulation estimates of annual yield and landed value for commercial penaeid prawns from a tropical seagrass habitat, northern Queensland, Australia. Aust. J. Mar. Freshwater Res. 44: 211-221.

Chapter 4

Adams, JB, GC Bate. 1998. The ecological implications of tolerance to salinity by *Ruppia cirrhosa* and *Zostera capensis*. Bot. Mar. 37: 449-456.

Bay, D. 1984. A field study of the growth dynamics and productivity of *Posidonia oceanica* in Calvi Bay, Corsica, France. Aquat. Bot. 20: 43-64.

Burdick, DM. GA Kendrick. 2001. Standards for seagrass collection, identification and sample design. Chapter 4. pp. 79-100. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Burdick, DM, FT Short, J Wolf. 1993. An index to assess and monitor the progression of wasting disease in eelgrass, *Zostera marina*. Mar. Ecol. Prog. Ser. 94: 83-90.

Dahl, AL. 1981. Coral reef monitoring handbook. South Pacific Commission, Noumea, New Caledonia. 22pp.

Dennison, WC. 1987. Effects of light on seagrass photosynthesis, growth and depth distribution. Aquat. Bot. 27: 15-26.

Dennison, WC, RS Alberte. (1985) Role of daily light period in the depth distribution of *Zostera marina* eelgrass. Mar. Ecol. Prog. Ser. 25: 51-62.

Duarte, CM. 1991. Seagrass depth limits. Aquat. Bot. 40: 363-377.

English, S, C Wilkinson, V Baker. (eds.) 1997. Survey manual for tropical marine resources 2nd Edition. Australian Institute of Marine Science, Townsville, Australia.

Fletcher, SW, WW Fletcher. 1995. Factors affecting changes in seagrass distribution and diversity in the Indian River lagoon complex between 1940 and 1992. Bull. Mar. Sci. 57: 49-58.

Hanelt, D. 1992. Photoinhibition of photosynthesis in marine macrophytes of the south China sea. Mar. Ecol. Prog. Ser. 82: 199-206.

IIRR. 1998. Participatory methods in community-based coastal resource management. 3 vols. International Institute of Rural Reconstruction, Silang, Cavite.

Kamermans, P, MA Hemminga, DJ de Jong. 1999. Significance of salinity and silicon levels for growth of a formerly estuarine eelgrass (*Zostera marina*) population (Lake Grevelingen, The Netherlands). Mar. Viol. 133: 527-539.

Kenworthy, WJ, D Haunert. 1991. Results and recommendations of a workshop convened to examine the capability of water quality criteria, standards and monitoring programs to protect seagrasses from deteriorating water transparency. NOAA's Coastal Ocean Program, Estuarine Habitat Studies, NOAA Workshop Report, 181 pp.

Koch, EW, G Gust. 1999. Water flow in tide- and wave-dominated beds of the seagrass *Thalassia testudinum*. Mar. Ecol. Prog. Ser. 184: 63-72.

Koch, EW, JJ Verduin. 2001. Measurements of physical parameters in seagrass habitats Chapter 17. pp. 326-344. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Komatsu, T, H Ariyama, H Nakahara, W Sakamoto. 1982. Spatial and temporal distribution of water temperature in a Sargassum forest. J. Oceanogr. Soc. Japan 38: 63-72.

Lee Long, WJ, RG Coles, LJ McKenzie. 1996. Deepwater seagrasses in Northeastern Australia – how deep? How meaningful? pp. 41-50. *In:* J Kuo, RC Phillips, DI Walker, H Kirkman (eds.) Seagrass Biology. Proceedings of an International Workshop. Sciences UWA.

Masini, RJ, JL Cary, CJ Simpson, AJ McComb. 1995. Effects of light and temperature on the photosynthesis of temperate meadow-forming seagrasses in Western Australia. Aquat. Bot. 49: 239-254.

McKenzie, LJ, SJ Campbell, CA Roder. 2001. Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) Volunteers. Queensland Fisheries Service, NFC, Cairns. 94pp.

Montague, CL, JA Ley. 1993. A possible effect of salinity fluctuation on abundance of benthic vegetation and associated fauna in Northeastern Florida Bay. Estuaries 16: 703-717.

Orth, RJ, KA Moore. 1984. Distribution and abundance of submerged aquatic vegetation in Chesapeake Bay: an historic perspective. Estuaries 7: 531-540.

Pulich, WM. 1985. Seasonal growth dynamics of *Ruppia maritima* and *Halodule wrightii* in southern Texas, USA and evaluation of sediment fertility status. Aquat. Bot. 23: 53-66.

Vidler, KP. 1995. Coastal resource management: providing for the present and future. RR Forum quarterly publication, July – September, 1995, Philippine Rural Reconstruction Movement.

Zieman, JC,, JW Forqurean, TA Frankovich. 1999. Seagrass die-off in Florida Bay: long-term trends in abundance and growth of turtle grass, *Thalassia testudinum*. Estuaries 22: 460-470.

General

Burdick, DM. GA Kendrick. 2001. Standards for seagrass collection, identification and sample design. Chapter 4. pp. 79-100. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Coles, R, J Kuo. 1995. Seagrasses. Chapter 3. pp. 39-57. *In:* JE Maragos, MNA Peterson, LG Eldredge, JE Bardach, HF Takeuchi (eds.) Marine/Coastal Biodiversity in the Tropical Island Pacific Region: Vol 1. Species Systematics and Information Management Priorities. East-West Center, Honolulu.

Den Hartog, C. 1970. The sea grasses of the world. North-Holland Publication Co., Amsterdam, 275pp.

Green, E.P. and Short, F.T. (eds.). 2003. World Atlas of Seagrasses. University of California Press, Berkeley, USA. 324 pp.

Koch, EW, JJ Verduin. 2001. Measurements of physical parameters in seagrass habitats Chapter 17. pp. 326-344. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

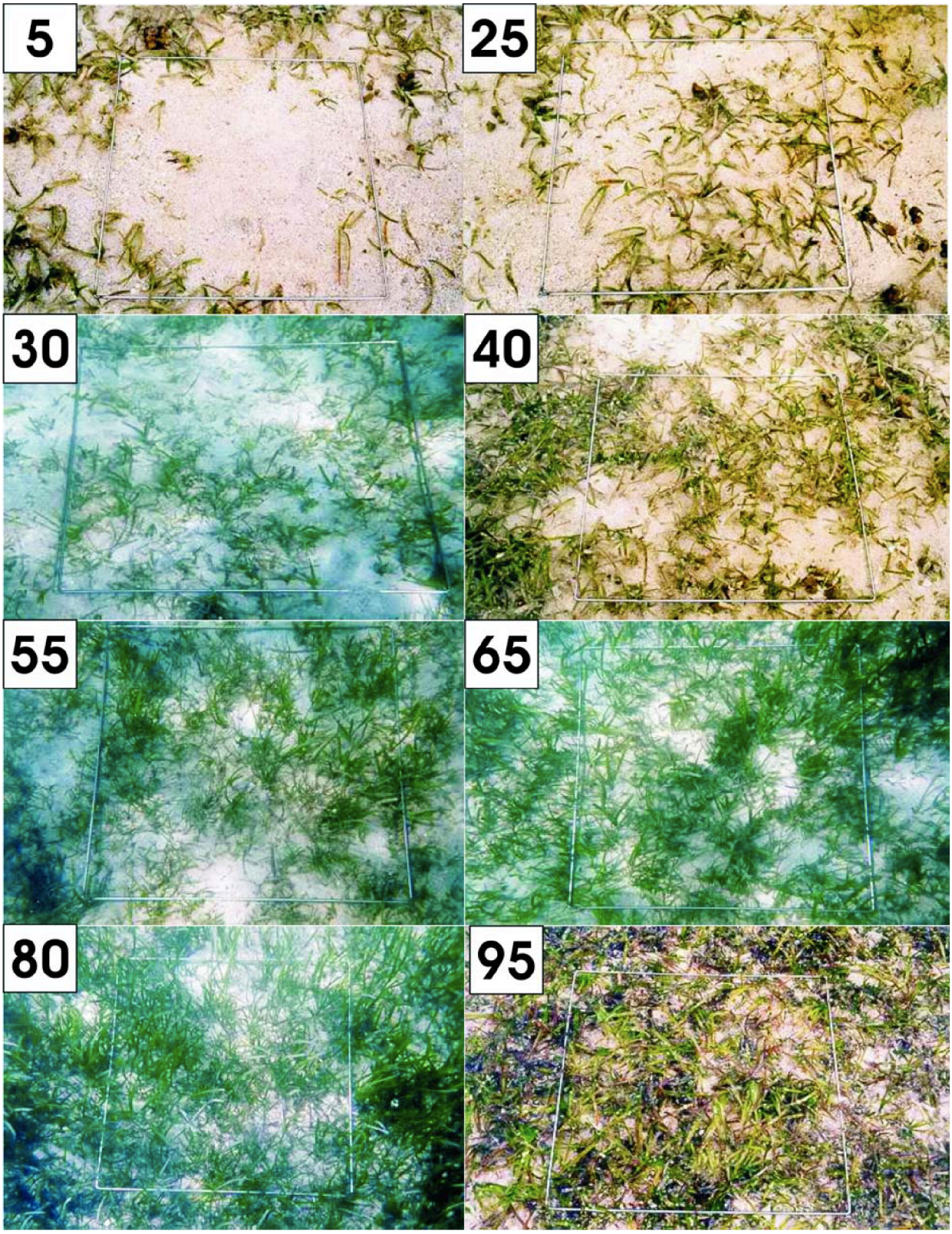
Kuo, J, C Den Hartog. 2001. Seagrass Taxonomy and identification Key. Chapter 2. pp. 31-58. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

McKenzie, L.J. & Campbell, S.J. (2002) Seagrass-Watch: Manual for Community (citizen) Monitoring of Seagrass Habitat - Western Pacific Edition (QFS, NFC, Cairns) 43pp

Short, FT, RG Coles, C Pergent-Martini. 2001. Global Seagrass Distribution. Chapter 1, pp. 5-30. *In:* FT Short, RG Coles (eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam.

Attachments

Seagrass percentage cover photo guide



SEAGRASS SPECIES CODES

Ea *Enhalus acoroides*



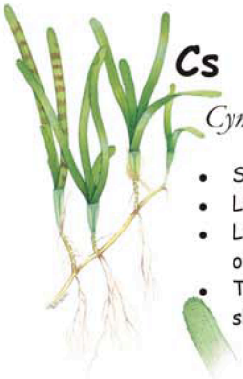
- Very long strap-like leaves with inrolled leaf margins
- Thick rhizome with long black bristles and cord-like roots
- Leaves 30-150 cm long

Th *Thalassia hemprichii*



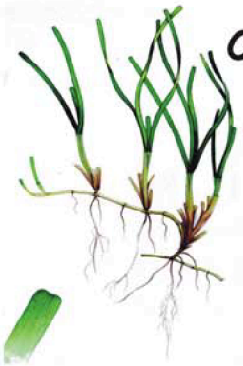
- Small dark spots of tannin cells on leaf
- Thick rhizome with scales between shoots
- Sickle shaped leaves
- Leaves 10-40 cm long

Cs *Cymodocea serrulata*



- Serrated leaf tip
- Leaf blade 4-9mm wide
- Leaves 6-15cm long & often striped
- Triangular shaped leaf sheath

Cr *Cymodocea rotundata*



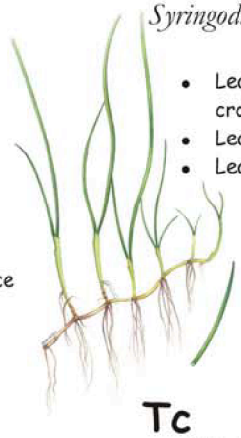
- Rounded leaf tip
- Narrow leaf blade (2-4mm wide)
- Leaves 7-15 cm long
- Well developed leaf sheath

Hd *Halophila decipiens*



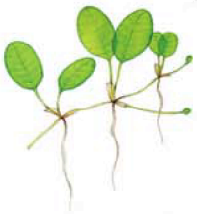
- Leaf blade 1-2.5cm long
- Leaf hairs on both sides
- Leaf margins serrate

Si *Syringodium isoetifolium*



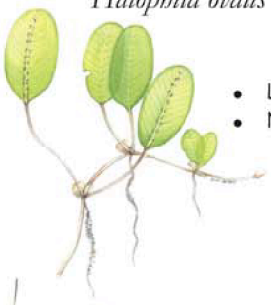
- Leaves cylindrical in cross section
- Leaf tip tapers to a point
- Leaves 7-30cm long

Hm *Halophila minor*



- Less than 4-8 cross veins
- Small oval leaf blades 0.8-1.3 cm long
- No hairs on leaf surface

Ho *Halophila ovalis*



- Leaves have 10 or more cross veins
- No hairs on leaf surface

Hy

Ho or **Hm** species cannot be distinguished (i.e., not sure of the ID)

Tc *Thalassodendron ciliatum*



- Cluster of leaves on an erect stem
- Sickle shaped leaves with serrated tip
- Rhizome woody

Hu *Halodule uninervis*



- Trident leaf tip
- 1 central leaf vein
- Usually pale rhizome, with clean black leaf scars

Hp *Halodule pinifolia*



- Rounded leaf tip
- 1 central leaf vein
- Usually pale rhizome, with clean black leaf scars

Hx

Hu or **Hp** species cannot be distinguished (i.e., not sure of the ID)

Compiled by the Marine Plant Ecology Group, Northern Fisheries Centre CAIRNS, AUSTRALIA April 2004

SeagrassNet = Seagrass Monitoring Network

***Seagrass*Net Field Sampling Form (one sheet per station)** **Western Pacific Region**

Location:	Transect code & no.:	Researchers:	Sampling date and time: e.g., 20 Jan 2004 1400 hrs.
State/Country:	Station (circle one): **A.** Nearshore, **B.** Middle, **C.** Offshore	Comments:	

PARAMETERS	Example	Cross-transect 0-25 m						Cross-transect 26-50 m					
		1	2	3	4	5	6	7	8	9	10	11	12
Quadrat Measures at pre-selected random distances	Quadrat 2	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat
Photograph (1 per quadrat)	√												
Voucher Specimen (1 of each species/Station)	√												
All Species Total % Cover	60				|							
Species =Hu % Cover	40												
Species = % Cover													
Species = % Cover													
Species = % Cover													
Species =Ea % Cover | Density (Ea density per 25x25 cm quadrat)	20 | 32	|	|	|	|	|	|	|	|	|	|	|	|
Canopy Height (cm) Grazing Evidence? (y/n)	20 y												
Flower/Fruit Count by species	4 Hu 6 Cr												
Leaf Biomass Core Size (m^2)	√ 0.0035												

	Pre-selected Random Distances for 0-25m						Pre-selected Random Distances for 26-50m					
A. Nearshore	2	7	8	16	18	25	26	33	38	40	44	46
B. Middle	9	10	15	17	22	25	28	31	35	37	39	45
C. Offshore	5	7	10	18	19	22	26	34	35	38	43	44

Cross-transect Measures

				Left (0m)		**Center** (25m)		**Right** (50m)	
GPS: Latitude	Dist. to edge (m)	_ _ _ _._ _ _ "	8.6						
Longitude	Dist. to last (m)	_ _ _ _._ _ _ "	11.2						
Water Depth (m) at time (hrs)		2.35 @ 1524		at		at		at	
Surface sediment observation / sample		fine-sand / yes							

Station Measures

Light -- Hobo (day in - day out)	6Jan - 20Jan
Water temp. logger (day out)	20Jan
Salinity (ppt)	25.8
Tidal Stage (high or low / spring or neap)	high spring

Region IX species

-	**Cr** - *Cymodocea rotundata*	**Hx** - *Halodule* complex	**Ha** - *Halophila ovata*	**Th** - *Thalassia hemprichii*
	Cs - *Cymodocea serrulata*	**Hb** - *Halophila becarii*	**Hs** - *Halophila spinulosa*	**Tc**-*Thalassodendron ciliatum*
	Ea - *Enhalus acoroides*	**Hd** - *Halophila decipiens*	**Hy** - *Halophila* complex	
	Hp - *Halodule pinifolia*	**Hm** - *Halophila minor*	**Rm** - *Ruppia maritima*	
	Hu - *Halodule uninervis*	**Ho** - *Halophila ovalis*	**Si** -*Syringodium isoetifolium*	**Un** - Unknown

SeagrassNet = Seagrass Monitoring Network

***Seagrass*Net Biomass Form (one sheet per station)** **Western Pacific Region**

Location:	Transect code & no.:	Researchers:	Sampling date and time:
State/Country:	Station (circle one): **A.** Nearshore, **B.** Middle, **C.** Offshore	Comments:	

PARAMETERS		Cross-transect 0-25 m						Cross-transect 26-50 m					
		1	2	3	4	5	6	7	8	9	10	11	12
Species # 1 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												
Species # 2 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												
Species # 3 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												
Species # 4 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												
Species # 5 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												
Species # 6 =	Shoot count												
	Leaf weight (g)												
	Stem/Sheath weight (g)												
	Root/Rhizome weight (g)												

SeagrassNet

Manual for Scientific Monitoring of Seagrass Habitat

Western Pacific Edition
April 2004



WORLD SEAGRASS ASSOCIATION

Queensland Government Department of Primary Industries

CRC Reef Research Centre

University of New Hampshire