



Manual for Scientific Monitoring of Seagrass Habitat

Worldwide Edition

August 2006

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Financial support provided by the David and Lucile Packard Foundation, the Oak Foundation, the New Hampshire Charitable Foundation and Tom Haas, and the University of New Hampshire.

The correct citation of this document is:

Short, F.T., McKenzie, L.J., Coles, R.G., Vidler, K.P., Gaeckle, J.L. 2006. SeagrassNet Manual for Scientific Monitoring of Seagrass Habitat, Worldwide edition. University of New Hampshire Publication. 75 pp.

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Overview

SeagrassNet: Assessing a Critical Coastal Resource Worldwide

SeagrassNet is a scientific global monitoring program based at the University of New Hampshire that investigates and documents the status of seagrass resources worldwide and the threats to this important and imperilled marine ecosystem. The program started in 2001 in the Western Pacific and now includes many sites throughout the world; a global monitoring protocol and web-based data reporting system have been established. Our ultimate aim is to preserve the seagrass ecosystem by increasing scientific knowledge and public awareness of this threatened coastal resource.



SeagrassNet monitoring on the reef flat in Manado, North Sulawesi, Indonesia

SeagrassNet teams composed of scientists and managers from participating countries conduct synchronous quarterly sampling of selected plant and environmental parameters to determine seagrass habitat status and trends. A lack of information exists on the status and health of seagrasses worldwide, particularly in less economically developed regions. SeagrassNet's efforts to monitor known seagrass areas and to reconnoiter uncharted seagrasses are important first steps in understanding and sustaining the seagrass resource. Across the globe, SeagrassNet is collecting information with the goal of elevating interest and awareness in seagrasses and providing a "global report card" on the health of the valuable seagrass coastal habitat.

Seagrasses are underwater flowering plants that often occur in vast meadows and provide nurseries, shelter, and food for a variety of commercially, recreationally, and ecologically important species (e.g., fish, sea turtle, dugong, manatee, seahorse, crustaceans). Additionally, seagrasses filter estuarine and coastal waters of nutrients, contaminants, and sediments and are closely linked to other community types: in the tropics to coral reef systems and mangrove forests, and in temperate waters to salt marshes, kelp forests, and oyster reefs. Existing at the interface of the land margin and the world's oceans, seagrasses are threatened by numerous anthropogenic impacts as well as global climate change.

Funding for various aspects of SeagrassNet has been provided by The David and Lucile Packard Foundation, The Oak Foundation, the New Hampshire Charitable Foundation and Tom Haas, the NOAA/NOS International Program, the Hai Phong Institute of Oceanology, the Brazil National Research Council, the Inter-American Institute, and the University of New Hampshire.

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SeagrassNet

SeagrassNet results are now displayed instantaneously on the worldwide web to provide an overview of our findings. In the Western Pacific, we find seagrasses are relatively healthy in many locations, except where direct human impact occurs or where ocean warming stresses the plants. Across the Americas, we see a general decline in seagrass health, particularly near centers of population, while in Vietnam, seagrass declines are related to rapidly increasing tourism. In Papua New Guinea (left) and Indonesia, seagrass beds are closely linked to coral reef species, and are a nursery for many reef fish. Here, clown fish live in a sea anemone located in a seagrass bed.

SeagrassNet Team Leaders are trained at workshops (right) where they learn sampling techniques, plant ID, and environmental monitoring. They also learn to upload their data to UNH over the web for incorporation into the global database: www.SeagrassNet.org. At this workshop in Kosrae, Federated States of Micronesia (April 2004), a group of Team Leaders from across the Pacific is analyzing local seagrasses.



Humans, through commercial and subsistence fishing, and endangered fauna worldwide depend on seagrasses for a living. Future SeagrassNet activities include expansion to new areas, among them the Indian Ocean and the Mediterranean, education of coastal managers, and synthesis of our findings in a major publication.



Project publications:

Global Seagrass Research Methods F.T. Short and R.G. Coles (eds.) 2001 Elsevier

World Atlas of Seagrasses E.P. Green and F.T. Short (eds.) 2003 Univ. of California Press.

SeagrassNet monitoring summary

SeagrassNet = Seagrass monitoring Network

Goal: To measure change in seagrass:

Distribution	via	Position of seagrass relative to permanent transect (from the shore outward, with three 50m cross transects)
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 m² quadrat)

Email photos to SeagrassNet@unh.edu

- 📷 Voucher specimen

Prepare a herbarium sheet of each seagrass species (with flowering parts, if present) for the International Seagrass Herbarium. Send to SeagrassNet 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 m² quadrat)

Estimate seagrass cover (total cover and then cover by 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."

- 📷 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.

- 📷 Biomass: For small and medium-sized seagrasses use the 0.0035 m² core

Take a biomass core to 10cm depth outside each quadrat by selecting an area approximately 0.5m landward of the quadrat in an area of the same seagrass species and cover as the quadrat (to your best judgment). Place the core over the selected shoots, making sure that leaves rooted in the core are on the inside of the core and those rooted outside are outside of the core. 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 sheets for your files.

For large seagrass species

Collect an individual shoot including rhizome approximately 0.5m landward of each quadrat. Determine shoot weight and multiply by density to obtain biomass.

↪ 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 count on the Biomass Form. For large seagrass species (e.g., large *Thalassia* plants) 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. Enter the number of shoots on the Field Sampling Form under the last Species (% Cover/Density) row.

↪ 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.

- 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 of 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 (for one SeagrassNet site)

- ☐ *SeagrassNet monitoring manual*
- ☐ *regional supplement to the manual*
- ☐ *percent cover photo guide and species ID sheet*
- ☐ *herbarium supplies and press*
- ☐ *underwater digital camera*
- ☐ *Palm Pilot (with tide prediction software)*
- ☐ *GPS unit (Garmon ETrek)*
- ☐ *compass*
- ☐ *quadrat identification number labeler*
- ☐ *0.25 m² quadrat (50 x 50 cm,) (2)*
- ☐ *0.0625 m² quadrat (25 x 25 cm) (2)*
- ☐ *water proof data sheets (3 per site)*
- ☐ *plastic clip board*
- ☐ *30 cm rulers (2), pencils, pencil sharpener, permanent markers*
- ☐ *50 m measuring tapes (2)*
- ☐ *permanent station markers (9 screw anchors)*
- ☐ *syringe sediment core samplers 20cc w/ rubber stopper (2)*
- ☐ *salinity refractometer*
- ☐ *plastic containers for salinity water samples (2)*
- ☐ *recording thermometers, iButton (4)*
- ☐ *iButton launch and download software and cables*
- ☐ *recording light sensor (Onset HOBO) with submersible plastic case (3)*
- ☐ *HOBO launch and download software and cables*
- ☐ *light sensor storage box*
- ☐ *biomass core sampling tube 7cm diameter w/ 2 end caps*
- ☐ *mesh bags for biomass (12)*
- ☐ *large plastic ziplock bags (36 for biomass)*
- ☐ *small plastic ziplock bags (3 for sediment)*
- ☐ *paper bags (for drying biomass samples)*
- ☐ *zip ties (20) and clipper for zip ties*
- ☐ *rubber bands (25)*
- ☐ *large plastic storage box for SeagrassNet kit*
- ☐ *Also needed: use of a drying oven and a computer with Internet access*

Sampling intervals

4 times/yr (January, April, July and October)

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 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 central 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 % cover and % 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 (or, for large seagrass species, individual shoot samples) outside the quadrat more than 0.5m shoreward of the quadrat in an area of the same seagrass species and cover as the quadrat (to your best judgement).
 - If large species, obtain a density count (0.25 x 0.25m quadrat) in the lower right-hand corner of the large quadrat.
 - 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 field 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 field 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 station is 12

Number of samples per site is 36

1. Count the density of leaf meristems for each core (except for large species)
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 website: www.SeagrassNet.org
6. Email the photographs, temperature and light data to Seagrass.Net@unh.edu or mail on CD.
7. Mail original datasheets (and keep a photocopy), dry sediment samples, and herbarium sheets to the Regional Node Coordinator (see SeagrassNet regional supplement) or 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 supplies
 - Store gear for next quarterly 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 and 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. The monitoring is underway worldwide on every continent except Antarctica (where there are no seagrasses). Monitoring has begun on a quarterly basis at these sites. 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 increase protection of the seagrass ecosystem worldwide by making managers, governments, and the public aware of the value of seagrass habitat and its status and trends
- To promote the SeagrassNet scientific monitoring protocol worldwide and encourage the use of its standardized methodology for monitoring seagrass
- To provide nations with a “report card” of the status of their seagrasses and to publish scientific literature documenting seagrass health trends
- To provide training to SeagrassNet participants, building the capacity of monitoring teams and local communities in understanding and protecting their coastal environments
- To expand SeagrassNet globally, adding monitoring sites and new countries to the program

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.

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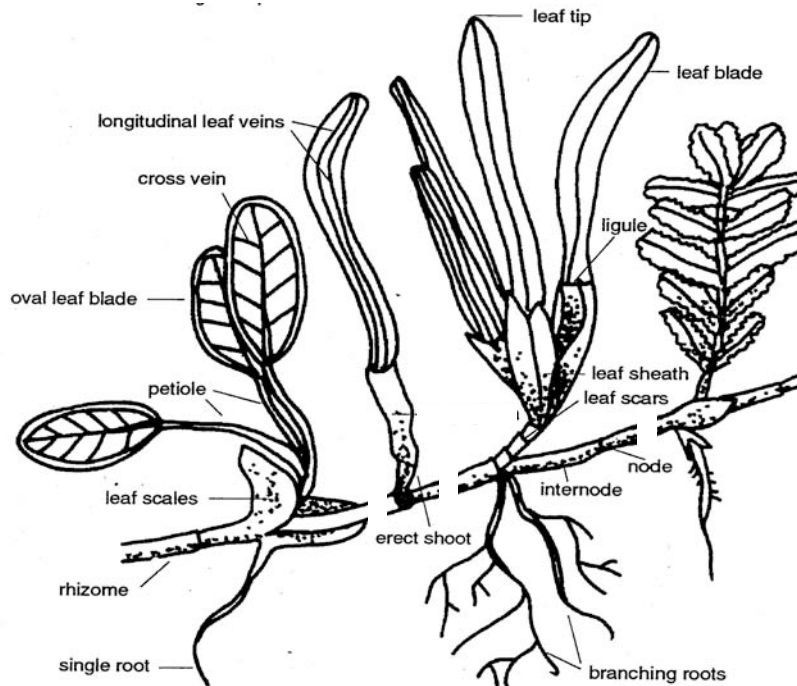
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Chapter 2

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 about 60 described species of seagrasses worldwide, within 12 genera, 4 families and orders. Seagrasses are unique amongst flowering plants, in that all but one genus can live entirely immersed in seawater. *Enhalus acoroides*, an Indo-Pacific species, is the exception, as it must emerge to the surface to reproduce; all others can flower and be pollinated under water. Adaptation to a marine environment imposes major constraints on morphology and structure. The restriction of seagrasses to seawater has obviously influenced their geographic distribution and speciation.

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

Tropical seagrasses occupy a variety of coastal habitats. Tropical seagrass meadows typically occur in most shallow, sheltered soft-bottomed marine coastlines and estuaries. These meadows may be monospecific or may consist of multispecies communities, sometimes with up to 12 species present within one location. The stresses and limitations to seagrasses in the tropics are generally different than in temperate or subarctic regions. 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. 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. The potential for widespread seagrass loss has been well documented (Short and Wyllie-Echeverria 1996). The causes of loss can be natural such as cyclones and floods, or due to human influences such as dredging, agricultural runoff, industrial runoff or oil spills.

Loss of seagrasses has been reported from most parts of the world, sometimes from natural causes, e.g., high energy storms or "wasting disease". More commonly, loss has resulted from human activities, e.g., as a consequence of eutrophication or land reclamation and changes in land use.

Anthropogenic impacts on seagrass meadows are continuing to destroy or degrade these coastal ecosystems and decrease their yield of natural resources.

It is important to document seagrass species diversity and distribution, 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.



Seagrass Habitat picture courtesy of QDPI

In order to determine the importance of seagrass ecosystems and to detect changes that occur through perturbations (both man-made and natural), it is useful to map the distribution and density of existing seagrass meadows. Most importantly, seagrasses must be monitored in a statistically valid framework 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. SeagrassNet is designed to be such a scientific monitoring tool.

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:

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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 additional 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 watershed, receiving runoff from a range of agricultural, urban and industrial land-uses. Their ecological values and location in areas likely to be developed for harbors 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 stabilizing sediments and maintaining coastal water quality and clarity (Short and Short, 1984; Fonseca and Fisher, 1986). In the tropics, sea turtles, manatees , and dugongs are direct grazers of seagrasses (Creed *et al.* 2003).

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 gains 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 rigor 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 watershed 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 which are 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 which can be visited without difficulty 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)*

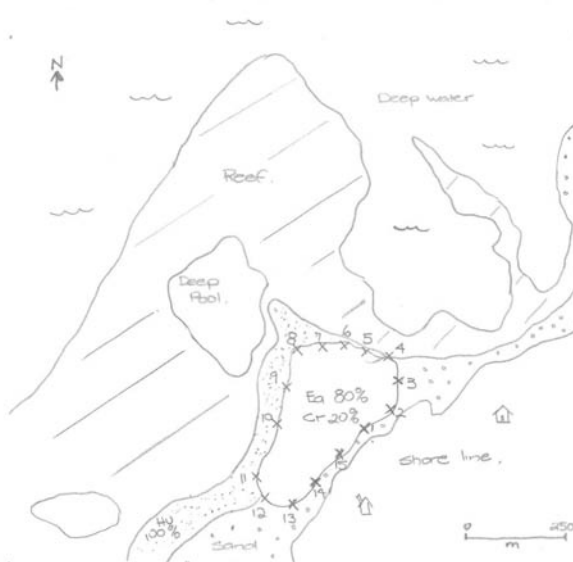
- ✎ Go to the general area that you have identified as a potential seagrass location to map and monitor. The aim is to create a sketch map (with or without GPS coordinates) that describes the general pattern of seagrass in the area. Use GPS to map the boundaries of the bed, if possible (Fig. 1). Otherwise, draw a representative 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 (having a leaf on a stem) seagrasses often extend to depths not accessible (even 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 the dominant habitat at the site seagrass?.....Yes
 - Is the seagrass community representative of the 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 Lymnospira 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: 9:00am Time finish: 12:30pm

MAP REFERENCE	LATITUDE	LONGITUDE	NOTES/ COMMENTS
1	5° 20.2356	162° 57.0724	
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° 57.0446	
7	5° 20.3478	162° 57.0102	
8	5° 20.3486	162° 56.9778	
9	5° 20.2956	162° 56.9622	
10	5° 20.2458	162° 56.9496	
11	5° 20.1726	162° 56.9226	
12	5° 20.145	162° 56.9328	
13	5° 20.1378	162° 56.9718	
14	5° 20.1648	162° 57.003	
15	5° 20.2068	162° 57.0342	

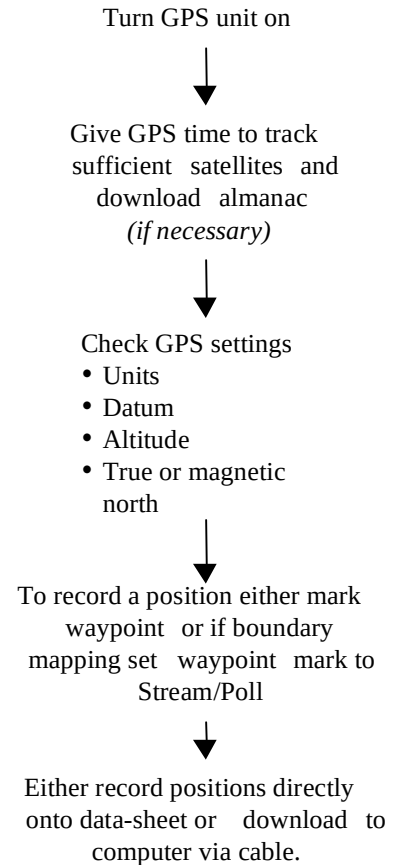
Using a GPS

The GPS system is a small handheld unit which allows accurate positioning by using satellite transmissions to determine its position on the earth's 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.

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 than 4) to take an accurate fix. When using a GPS in high terrain, signals from some of 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 misread decimal minutes as minutes and seconds (e.g., 14° 36.44' is not the same as 14° 36' 44"). **SeagrassNet uses decimal minutes.**
- 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. It 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.**



4.1.3. 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. The definition of community in this context is “*an association of people living in a given area or sharing some general commonality in addition to geographic proximity*”.

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 regulations 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. *Check that the group is not too politically controversial, be sensitive to the local politics and culture.*

Contact the group and request if you could give a short presentation about seagrass and the SeagrassNet Monitoring Program at their next meeting or hold a special meeting and invite the different organizations (encourage participation from all sectors, men and women, the young, the old, rich and poor).

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 data 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. Therefore, it is important to communicate respectfully 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 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, and is one of the goals of SeagrassNet.
- (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/ 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.
- (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 funding is completed; 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 three permanent station markers at stations A, B and C. These permanent station markers will be kept throughout the monitoring program regardless of changes in the seagrass community.

Relocating the transect 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

- ☐ 50m fiberglass measuring tape
- ☐ 6 temporary markers (e.g., plastic tent pegs or PVC pipe)
- ☐ 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

- 📍 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 that will have permanent Station A at its center will lie within the continuous seagrass meadow. Hammer or screw a permanent post/ marker into the sediment so that only a few centimeters remain above the sediment. This mark will be the permanent marker for Station A (shallow). Station A will be the center point for the cross transect at the shallow end.



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

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 months' 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 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) at the furthest distance from shore within the continuous seagrass meadow. 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.

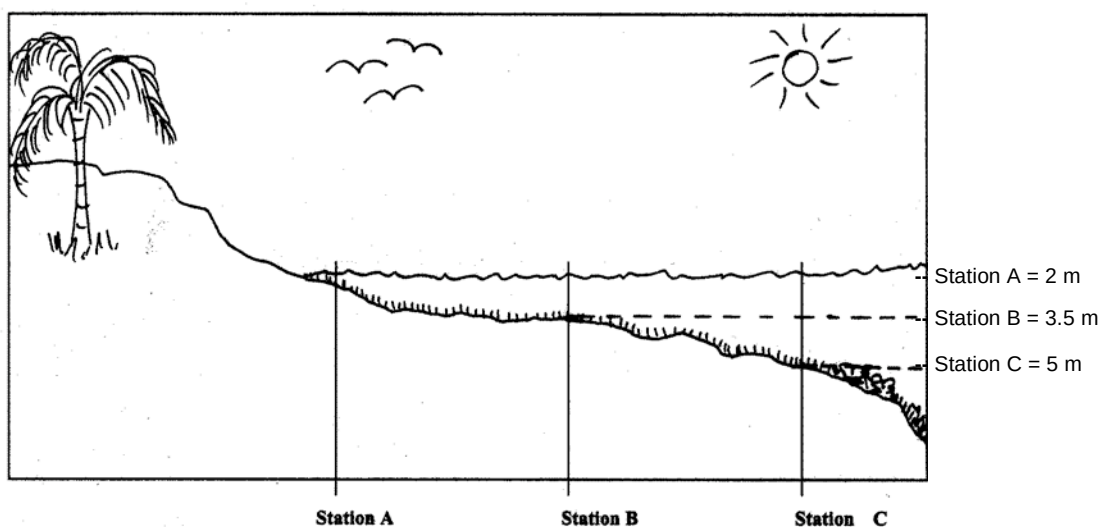


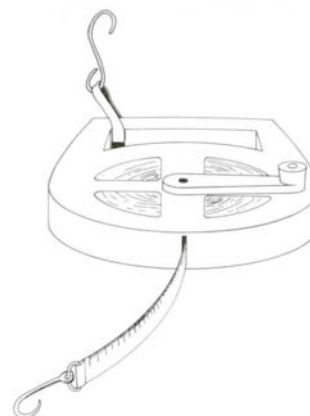
Figure 2. Example of the profile of a transect layout for a monitoring site.

- ✧ 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 50m cross transect (Fig. 3).

- ↳ Laying out the cross transects will require 2-3 people, commitment and a sense of humour!
- ↳ One person stands at the 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 temporary marker (tent peg) 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 temporary marker at the end of the tape measure to secure it in place. This is cross-transect position R (right, facing the sea)
- ↳ The person at the permanent 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 permanent marker.
- ↳ Using pegs, secure both ends and the middle of the measuring tape to the ground. Take a compass bearing of each cross-transect.
- ↳ Record the GPS positions for L, C and R pegs. You can now start the seagrass monitoring (Go to sections 4.3, 4.4 and 4.5).
- ↳ At completion of sampling Station 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.

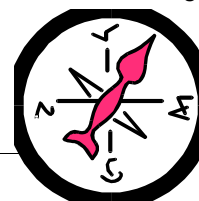
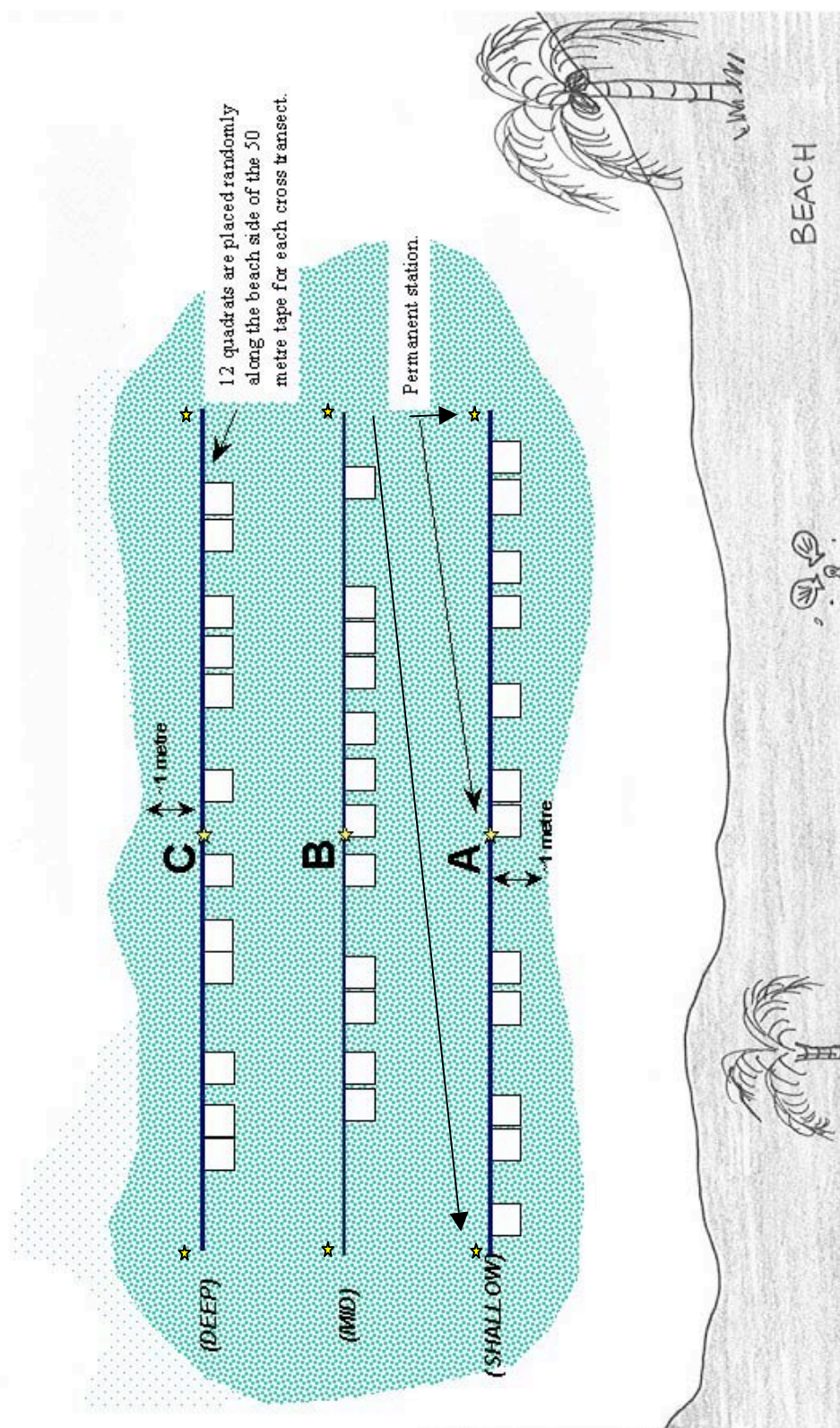


Figure 3. Example of a monitoring transect layout, viewed from above (*plan view*).



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.wxtime32.com/>) to identify a good daytime low spring tide for sampling in the correct month.

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

- ☐ 2 50m fiberglass measuring tapes
- ☐ Depth measuring device (e.g., depth sounder or a meter stick)
- ☐ Geographic Positioning System (GPS)
- ☐ Palm Pilot with tide program
- ☐ Sketch map for site location
- ☐ 3x Hobo[®] LI light loggers with clear plastic field chambers
- ☐ 2x iButton[®] temperature loggers
- ☐ Refractometer
- ☐ 3 vials or small sterile bottles for salinity water sample
- ☐ Waterproof datasheets, clipboard and pencil

4.3.1. Monitoring event details

The following information is recorded at the start of each monitoring event (refer to Fig. 4 SeagrassNet Field Datasheet and see the Regional Supplement for species-specific guidelines.).

✎ 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 06).
- 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 Field Sampling Form (one sheet per station)

SeagrassNet = Seagrass Monitoring Network

IV. Caribbean Region

Location:	Transect code & no.:	Researchers:	Sampling date and time: e.g., 30 Jan 2005 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					
Quadrat Measures	at pre-selected random distances	Quadrat 2	1	2	3	4	5	6	7	8	9	10	11	12
Photograph (1 per quadrat)		✓												
Voucher Specimen (1 of each species/Station)		✓												
All Species Cover	Total %	60												
Species = Si	% Cover	40												
Species =	% Cover													
Species =	% Cover													
Species =	% Cover													
Species = Ti	% Cover Density	20 32												
Ea density per 25x25 cm quadrat														
Canopy Height (cm)	Grazing Evidence? (y/n)	20 y												
Flower/Fruit Count by species		4 Ti												
Leaf Biomass Core	Size (m²)	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 IV species			
Light -- Hobo (day in - day out)	6 Jan - 30 Jan	-	Hi - <i>Halophila decipiens</i>	Hw - <i>Halodule wrightii</i>	Un - Unknown
Water temp. logger (day out)	30 Jan		He - <i>Halophila engelmannii</i>	Rm - <i>Ruppia maritima</i>	
Salinity (ppt)	25.8		Hj - <i>Halophila johnsonii</i>	Sf - <i>Syringodium filiforme</i>	
Tidal Stage (high or low / spring or neap)	low spring		Hi - <i>Halophila baillonii</i>	Tt - <i>Thalassia testudinum</i>	

Figure 4. SeagrassNet Field datasheet – e.g., Caribbean 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 taking 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). Light reduction ultimately reduces areal plant productivity (plant production per unit area of bottom). Different species of seagrass have varying light requirements, and depth distributions; a reduction in light reaching the substrate may vary 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 Australia 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 favors more high light tolerant species.

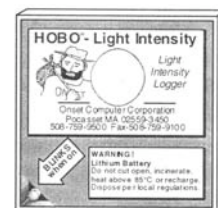
The SeagrassNet program uses Onset- Hobo® LI light loggers to measure and log light levels at each site (<http://www.onsetcomp.com>).

General procedure

✍ The Hobo® LI light loggers are deployed two (2) weeks before the quarterly seagrass sampling.

✍ Hobo® LI light loggers are deployed at Stations A and C, and one 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, just 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 silica 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 over-tighten).
- ✧ 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 is horizontal and facing 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 B respectively.

Collection

- ✧ In the field, after two weeks of deployment of the light sensor, 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.
- ✧ 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 it 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 are left out in the field for three months at a time.
- ✎ 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 A and C just above the sediment-water interface. The 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 "day out", the day you collect the iButton from the field, on the datasheet.
- ✎ At each monitoring event (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 downloading and re-calibration of the iButton® temperature logger, see section 4.7.1.



4.3.4. Salinity

Background

Salinity 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 data 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 also affects 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 each permanent station marker. 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 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.

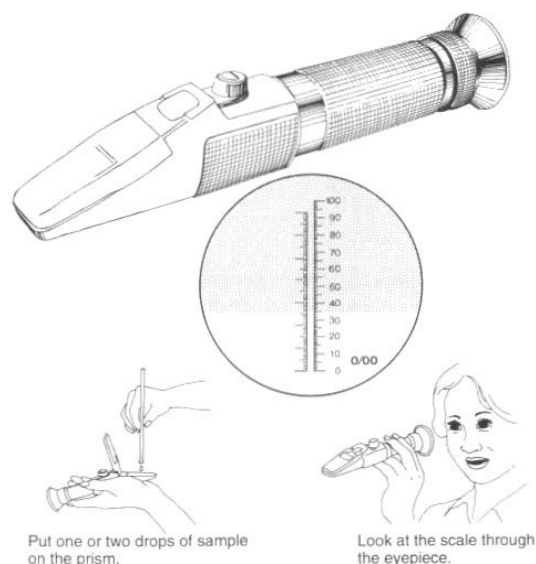


Figure 5. A diagram of a refractometer showing its use for measuring salinity. *From English et al. (1997)*

- ✎ 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 light).
- ✎ 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

For intertidal sites, the entire sampling procedure is quicker and easier at low tide. 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.

- ✎ Determine the best spring low tide (the lowest low of the month) that occurs during daylight hours in the correct month 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. Relocating the transect (second and subsequent monitoring visits)

- ✎ Find Station A with a Global Positioning System (GPS), using the site coordinates and your sketch map of the area.
- ✎ Using your GPS, relocate the permanent markers 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 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 cross transects in the same manner as the first monitoring, attaching the measuring tape to the left side of the transect (as you face 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. using seaward orientation.

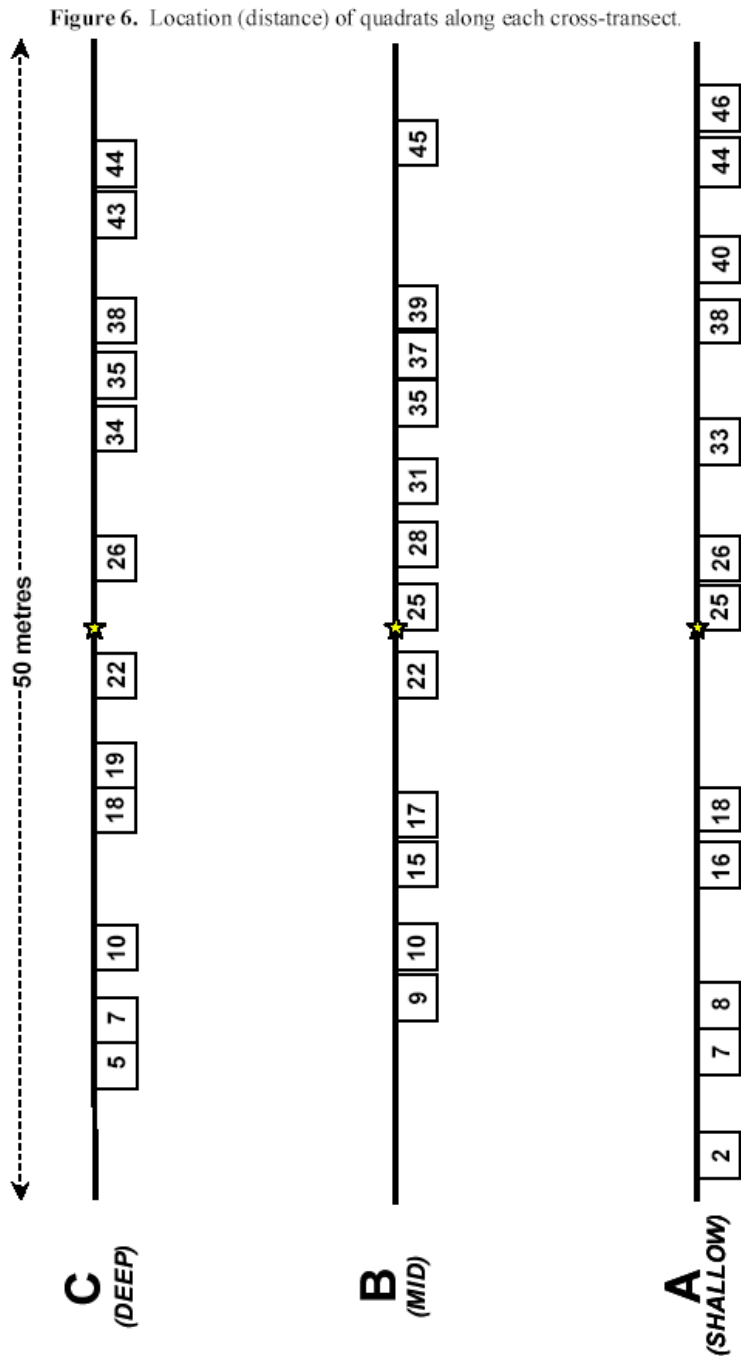
NOTE: If the edge of the seagrass meadow at permanent Station A or C has shifted so that all of a cross transect no longer has seagrass, establish a new Station A' or C' one meter inside the new edge of the continuous bed. Conduct the sampling from cross transects based on these new stations and note 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 Stations 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; they were predetermined using random numbers.



Parameters to measure for each quadrat

Necessary materials & equipment

You will need:

- ☐ 2x large (50cm x 50cm) quadrats
- ☐ 2x small (25cm x 25cm) quadrats
- ☐ Seagrass 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 & sharpener
- ☐ Paper drying bags
- ☐ Drying oven
- ☐ Laboratory electric weighing scale (accuracy to 3 decimal points)

4.5.1. General field procedure

- 📍 For intertidal sites, 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 from 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 first, 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 another 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 or send on CD to SeagrassNet (see 4.6.4 for mailing).

4.5.3. Voucher seagrass specimen

Background

Properly pressed and preserved seagrass specimens are invaluable for future reference material. If stored properly, 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, you should refrigerate it 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 and for best results, replace the newspaper after 2-3 days.
- ✚ Send one specimen per species, with a herbarium label, to SeagrassNet (see 4.6.4 for mailing).
- ✚ Keep the other sample in your own herbarium for reference.

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 in the back of the Manual. 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”.
- ✚ Identify which seagrass **species** are found inside the quadrat and record the species on the datasheet using the species abbreviations. See the Regional Supplement for species identifications guides.
- ✚ 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 working up from there.
- ✚ **Shoot density by species** is determined in two ways. In some cases, you may need to use both in a given quadrat. See the Regional Supplement for species specific guidelines.



Composition of all species must equal the total,
eg. TOTAL = 25%,
Thalassia testudinum 5%
Halodule wrightii 20%

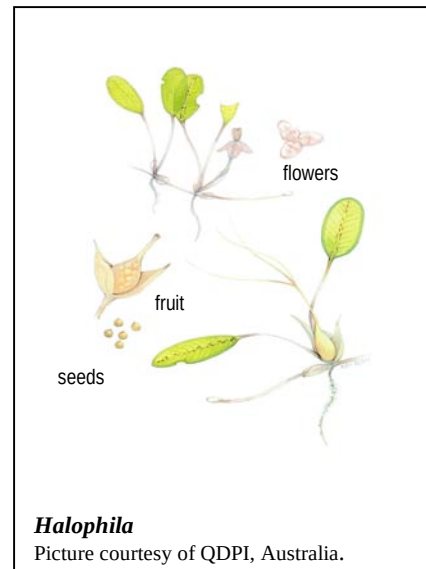
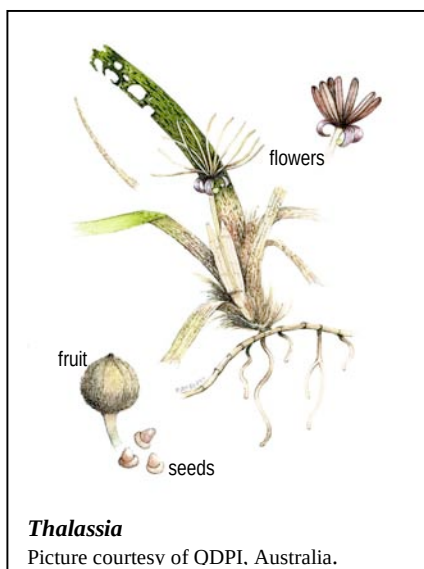
- For **most seagrasses**, shoot density is determined from the biomass cores, back in the laboratory, by counting the number of leaf meristems within the core sample. Record the results for each species on the Biomass Form next to the % cover measures and indicate the sample size (0.0035m²).
- For **very low density large plants**, shoot density is determined in the field 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 and inside the larger quadrat, count all shoots of the large species in the 0.0625 m² area. Record results for the large species on the last species entry of the Field Sampling Form next to the % cover measures. Record the size of the quadrat (0.0625) in the space on the field data sheets marked "Leaf Biomass Core..... Size (m²)."

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 or manatee 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., 1Hw, 2Sf, 2Th. (For some species, this information may only become available on processing the biomass cores in the laboratory).



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

Field collection for small and medium seagrass species, using core sampler

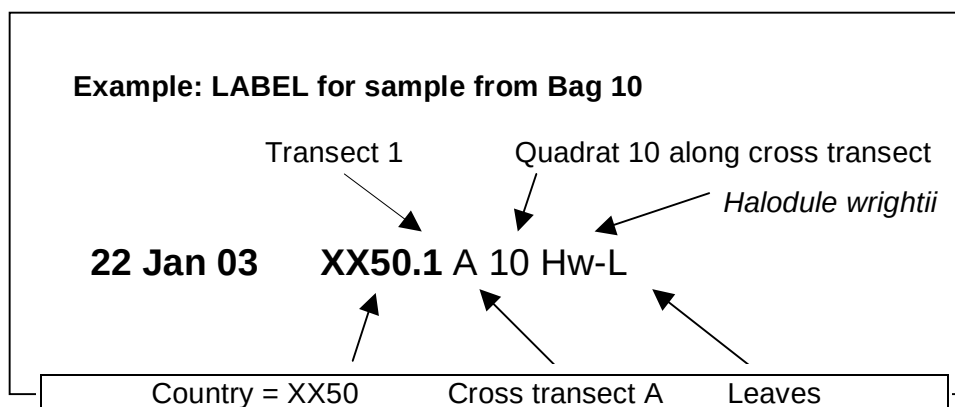
- ✎ Finally, select a few shoots more than 0.5m landward of the quadrat that are similar to those inside the quadrat (of the same dominant seagrass species and average size plants) and take a biomass core.
- ✎ Place the corer on the sediment. You will need to push the leaves into the corer first to avoid chopping the leaves. Move your finger around the edge of the corer, putting leaves rooted in the corer on the inside of the sampler and those rooted outside to the outside of the sampler. 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 that belong within the core are intact and have all their leaves.
- ✎ Push the sharpened end of the corer vertically into the substrate to a depth of 10 cm 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 mesh bag labelled with the quadrat number. Rinse sample to remove any mud and as much sediment as possible. Proceed to the next quadrat, see Section 4.5.8.
- ✎ 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.

Field collection for large seagrass species

- ✎ If the dominant seagrass species in the quadrat is a large seagrass such as large specimens of *Thalassia testudinum*, *Enhalus acoroides*, *Posidonia oceanica*, or *Zostera marina*, the procedure is different. The seagrass is considered large if fewer than 3 shoots will be obtained by the standard biomass core. If these or other species are not particularly large (i.e., at least 3 shoots can be obtained using the core sampler), use the biomass method above.
- ✎ Select a shoot more than 0.5m landward of the quadrat that is similar to those inside the quadrat (of the same dominant seagrass species and average size).
- ✎ Remove the selected shoot from the sediment so that the leaves, sheath/stem, and 7cm of horizontal rhizome with roots are taken intact. Place each shoot in the mesh bag labelled with the quadrat number. Rinse sample to remove any mud and as much sediment as possible. Proceed to the next quadrat, see section 4.5.8.

Laboratory procedure

- ✚ Rinse plants with fresh water inside the plastic bag.
- ✚ Empty the contents of the plastic 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 Biomass Form under **Shoot Count**.
- ✚ Separate the shoots for each species into:
 - Leaf** - green intact leaf blades connected to a stem or rhizome, although 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 Count)
 - Stem/Sheath** – these plant parts connect the leaves to the belowground plant parts and can vary from whitish (e.g., *Halophila*) to greenish (e.g., *Syringodium*) or brownish in color.
 - Root/Rhizome** - the belowground plant parts, including all the rhizomes (can be whitish to brown in color and are larger than roots) and roots growing below the sediment surface.
- ✚ Scrape epiphytes from the leaves only and rinse the leaves in a weak acid (vinegar) if calcareous epiphytes are present. Rinse again in fresh water.
- ✚ Remove all sediment from the sheath, roots, and rhizomes and re-rinse in fresh water.
- ✚ 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 (XX), site number (50), transect letter (A, B or C), quadrat number (1-12) e.g. "XX50.1A01" or "XX50.1A02" or "XX50.1A03"
 - Species abbreviation - Plant part (L, S, R) e.g. Hw – L, Hw – S, Hw - R
 - Date – write month out (Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec). Dates will read, e.g., 27 Jan 02, 15 Aug 02, etc.



- ✎ Place the biomass sample paper bags in the drying oven at 50 – 60 degrees Celsius (120 degrees Fahrenheit) 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.
- ✎ 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, move on to the next cross-transect.
- ✎ Before starting the next cross-transect, empty the mesh bags into the pre-labelled plastic bags for transport to the laboratory and rinse out the mesh bags for use on 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 biomass datasheets to SeagrassNet (see 4.6.4 for mailing).

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 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

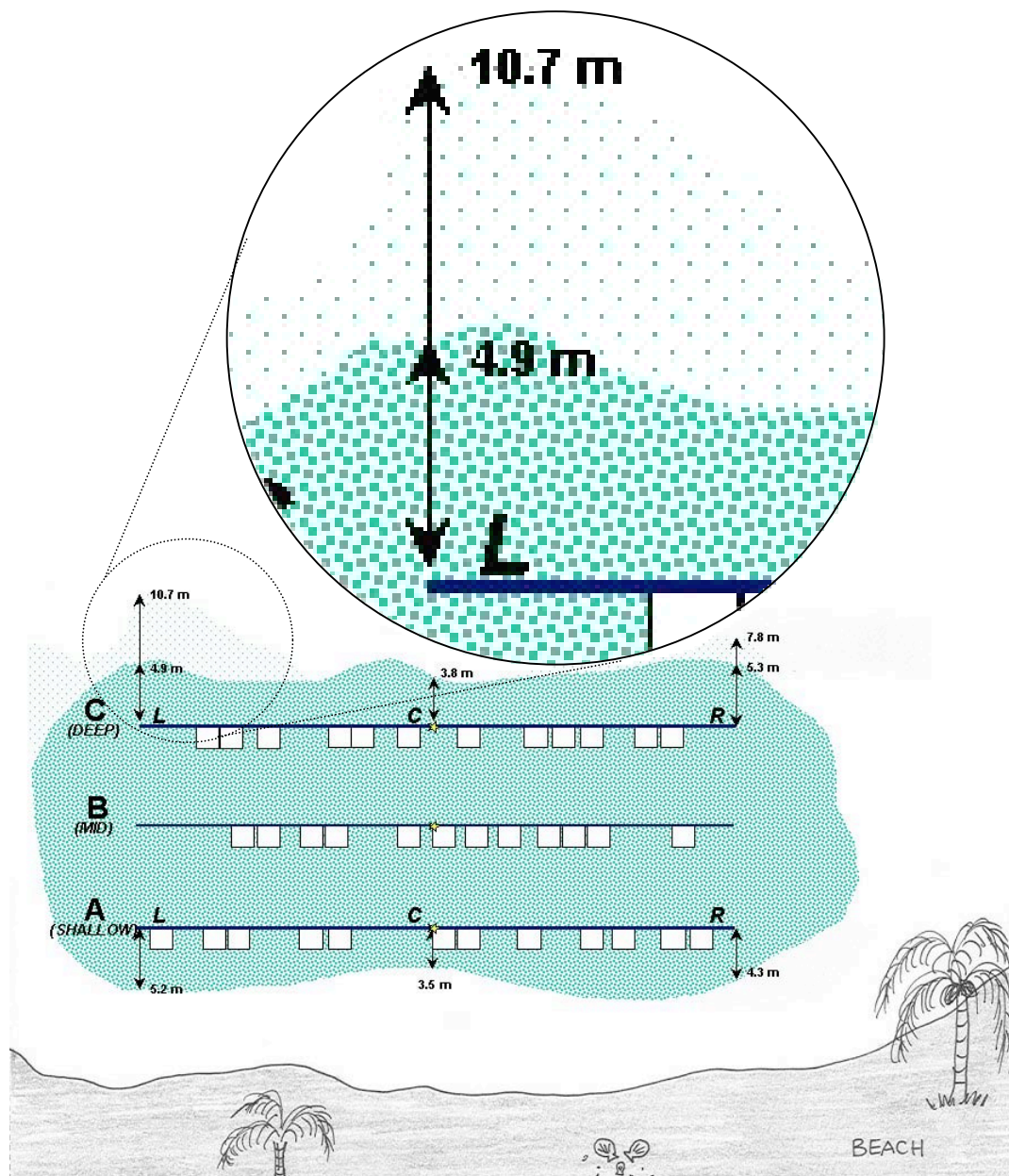
You will need:

- ☐ 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 (having a leaf on a stem) 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	shell
fine sand	gravel
sand	coral rubble
coarse sand	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 the center of each cross-transect. 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 3 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 (see 4.6.4 for mailing).

4.6.4. Mailing instructions

After the quarterly sampling and processing is completed, here is what must be sent to SeagrassNet:

- ↳ Via Air Mail
 - Field data sheets (keep a copy)
 - Biomass data sheets (keep a copy and save the plant samples)

- Dry sediment samples
- Herbarium sheets
- CD with photographs and/or temperature data and light data, and an electronic copy of field and biomass forms

✉ Via Email (if not sent on CD) to <Seagrass.Net@unh.edu>

- Photographs
- Temperature data and light data
- Electronic copy of field and biomass forms

✉ Send Air Mail to either:



the Regional Node Coordinator

(see SeagrassNet regional supplement for address)

or



SeagrassNet

Attn: Fred Short

Jackson Estuarine Laboratory

85 Adams Point Road

Durham NH 03824 USA

telephone: 603-862-5134

4.6.5. Electronic data submission to www.SeagrassNet.org

In addition to mailing data to SeagrassNet, data from the Field Data Sheets and the Biomass Data Sheets, as well as the temperature data, light data and digital photographs should be submitted directly to the web site (www.SeagrassNet.org) under the section “Global Monitoring” and the sub-section “Submit Your Data”. See the online instructions for submitting different types of data via the web site.

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



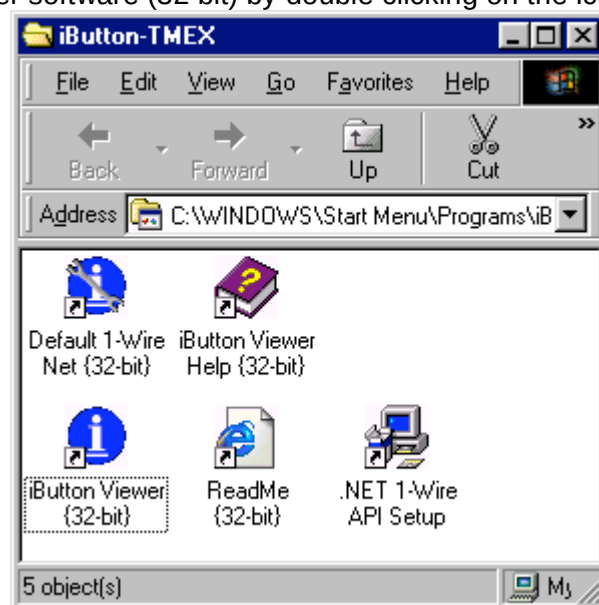
iButton Thermochron

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 (DS1402D-DR8) and the 1-Wire to RS-232 Adapter (DS9097U-S09) to the Com 1 port on the computer.
- 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 the (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.

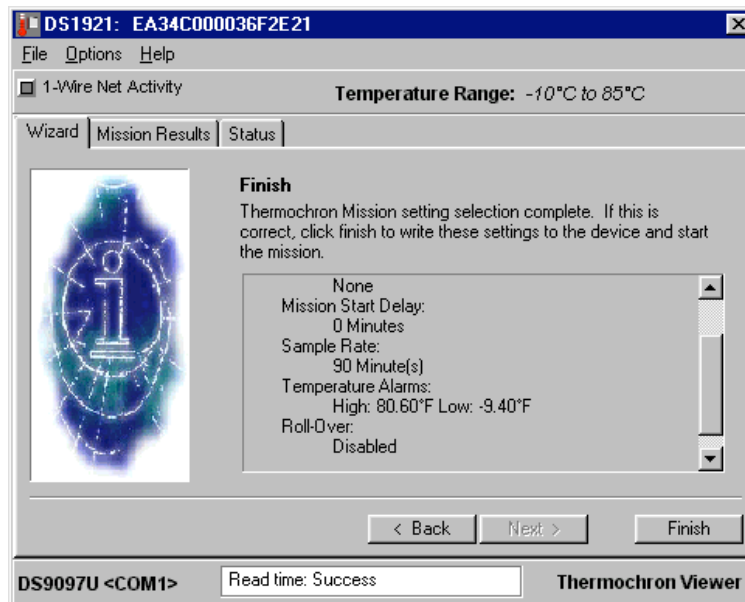
[An alternate way to get to the Thermochron Viewer is to highlight the serial number of the iButton and right click the mouse anywhere on the dialog box and select View and then Thermochron Viewer (usually located in the lower right hand corner of dialog box).]

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 parameters carefully, 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 (DS1402D-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 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 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 on this box will bring up the Thermochron Viewer and TMEX File Structure Viewer. Click on Thermochron Viewer.

[An alternate way to get 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.)]

- ↳ 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



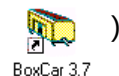
Using PC Computers to Launch and Download HOBO Light Intensity Logger Data

Loading BoxCar 3.7 software onto your PC

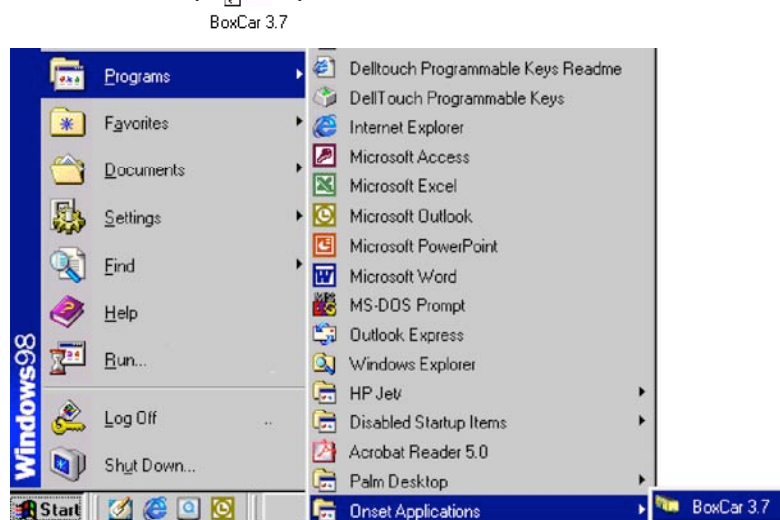
- Insert the BoxCar 3.7 floppy disk into the drive on your computer.
- Click on the **START** button in the bottom left hand corner of computer screen and then choose the **RUN** option.
- Type `a:/setup` in the space provided and select **OK** (press **ENTER**) (the BoxCar 3.7 program will begin to 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

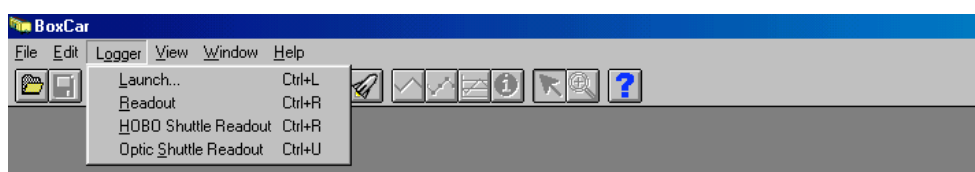
- Click on the **Start** button in the bottom left hand corner of the computer screen. Move the mouse to the **Programs** tab and then to the Onset Applications folder and click on the BoxCar 3.7 program in that folder. [If you wish to copy the BoxCar 3.7 icon (



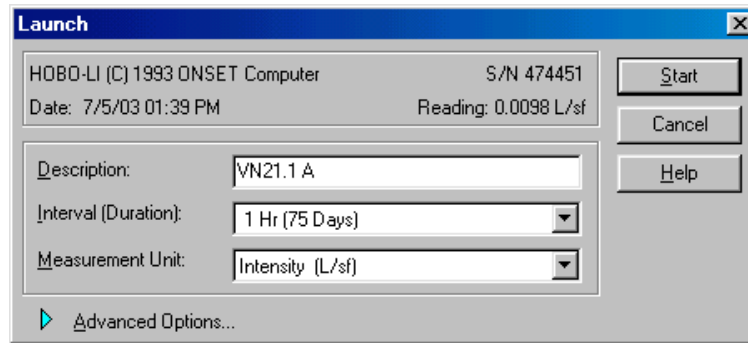
to the desktop you can right click on the BoxCar 3.7 program and select **Copy**. Then click on your desktop and right click the mouse to **Paste** the BoxCar 3.7 icon to your desktop.] Double click on the BoxCar 3.7 icon () to start BoxCar 3.7.



- 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 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)

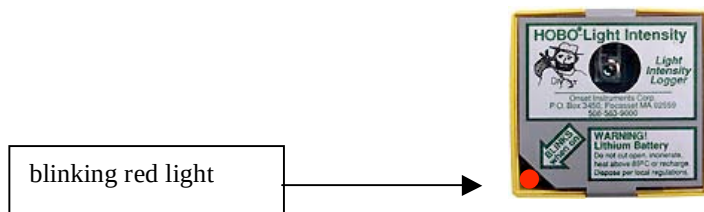
Measurement: Intensity (L/sf)

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).



- 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.

Chapter 5

SeagrassNet Data Policy

5.1 Data policy goals & definitions

Goals

- Facilitate integration of SeagrassNet data from sites around the world
- Provide regional and global assessment of seagrass conditions
- Promote synthetic analyses and reporting
- Assure that SeagrassNet data is handled and acknowledged appropriately

Definitions

- ↪ SeagrassNet Project Directors – individuals responsible for starting SeagrassNet (Short, Coles, Fortes and Koch) or for directing the global SeagrassNet program in the future.
- ↪ SeagrassNet Team Leader – individual trained in the SeagrassNet methods who is coordinating the collection and submission of SeagrassNet data for a site or a region with several sites.
- ↪ SeagrassNet Team – group responsible for collecting data using the SeagrassNet protocol under the direction of a Team Leader.
- ↪ Data Set Owner – individual or institution holding the intellectual property rights to the data generated at a given site; the data set owner is identified when a SeagrassNet Team joins the network. Note: the data set ownership for a specific site may change over time (e.g., if funding source or Team Leader affiliation changes).
- ↪ Data User – individual to whom access has been granted to a specific data set (also includes the Data Set Owner).

5.2 General Considerations

Data Ownership

- ✎ Ownership of data from each SeagrassNet site is determined by mutual agreement based on who is doing the data collection and the sources of funds that support the monitoring program. Ownership of data generated at individual SeagrassNet sites resides with one of three entities:
 - (1) ownership lies with one or more of the SeagrassNet Project Director(s) responsible for funding the monitoring, or
 - (2) ownership lies with one or more of the SeagrassNet Project Director(s) responsible for funding the monitoring as well as with the Team Leader collecting the data, or
 - (3) ownership lies exclusively with the Team Leader if the monitoring is funded by sources other than SeagrassNet.
- ✎ Data ownership for each site will be posted on the SeagrassNet web site. Ownership of the data may be transferred from one or several SeagrassNet Project Directors to a Team Leader or from a Team Leader to one or several Project Directors by mutual agreement.

Data Set Use

- ✎ Access to all data sets is available to all network participants, subject to accepting the terms of the Use Agreement.
- ✎ Access to data is available to the general scientific community, subject to accepting the terms of the Use Agreement and after receiving access from the SeagrassNet Directors.
- ✎ Any disputes will be arbitrated by the SeagrassNet Project Directors.
- ✎ Note: Under this access policy, SeagrassNet Project Directors, Team Leaders, other network participants, and the scientific community at large, are all Data Users.

5.3 Data Use Agreement

- ✎ Acceptable use of data from the SeagrassNet database will be restricted to educational, academic, research, government, or other not-for-profit professional purposes. Data users are permitted to produce and distribute derived works from SeagrassNet data provided that these data are released under the same terms as the original SeagrassNet data.
- ✎ In any publication involving SeagrassNet data, SeagrassNet will be formally acknowledged as: “The data used is part of SeagrassNet (Global Seagrass Monitoring Network), was collected by {Team

Leader Name(s) and was made available through the database at www.seagrassnet.org".

- ✧ Data Set Owners have the right to analyze and publish their own data. All data analysis, publications and SeagrassNet-based products involving other Data Set Owners must follow the rules described below.
- ✧ The Data User will notify in writing (e-mail or letter) all Data Set Owners when any work or derivative work or publication based on or derived from the Data Set is prepared, and invite consultation, collaboration and/or co-authorship as soon as the data analysis process begins.
- ✧ Active collaboration between a Data Set Owner and a Data User, including consultation on analytic methods, interpretation of results, and dissemination of results, will merit co-authorship of the Data Set Owner.
- ✧ SeagrassNet Project Directors are to be notified in a timely manner of any data use or plans for publications.
- ✧ If the Data Set Owner for a site changes, the new Data Set Owner will be invited to enter into the Data Use Agreement. Previously collected data will continue to reside in the SeagrassNet database and will be accessible subject to terms of data use. The original Data Set Owner will be acknowledged and/or involved in any appropriate publications.
- ✧ All Data Sets will be made available in the spirit of open scientific collaboration, subject to accepting the terms of the Use Agreement. Non-SeagrassNet Data Users must contact SeagrassNet Directors for access to the database.

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.
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 or stem.
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, the ocean floor.
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	organised inspection.
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

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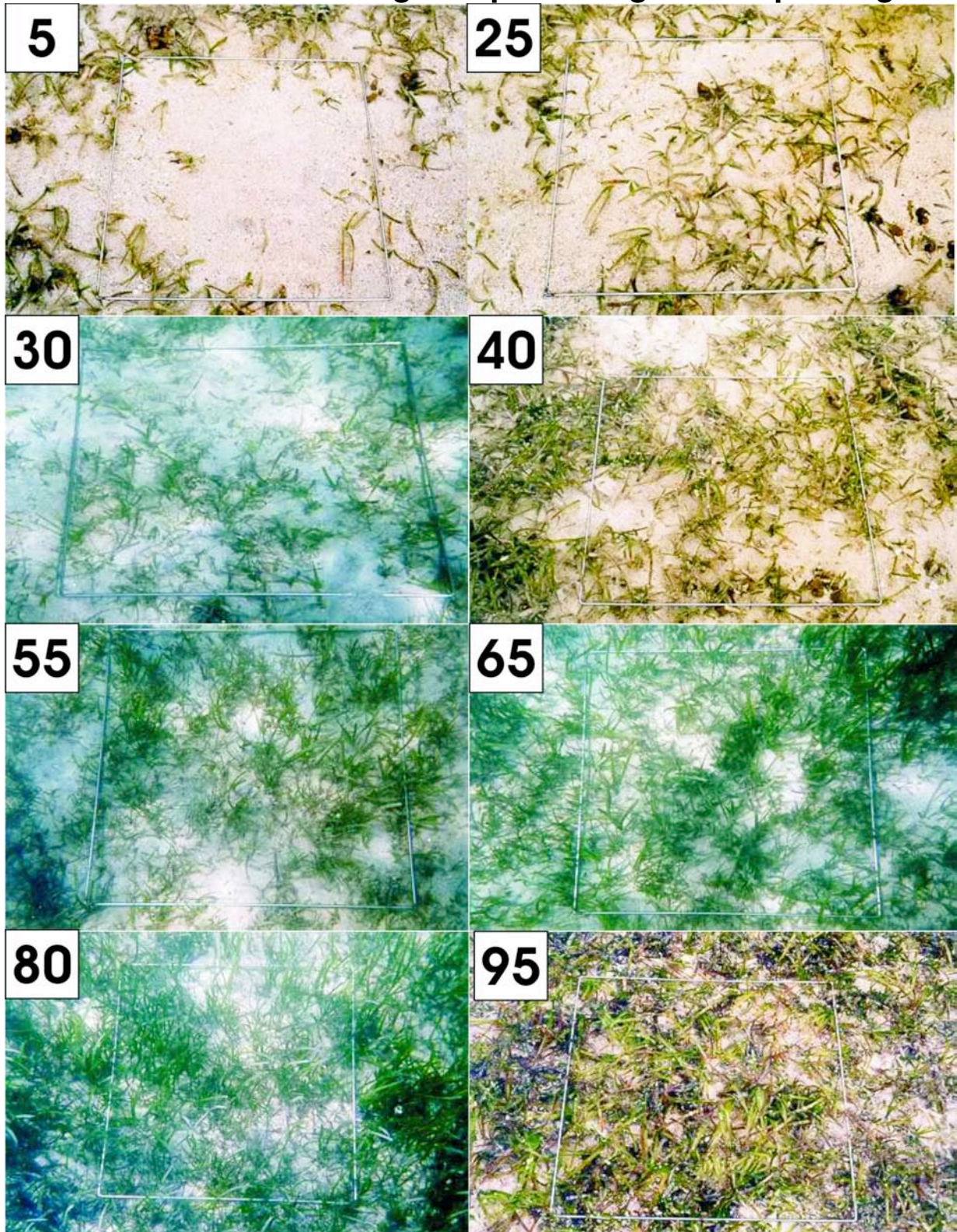
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Attachment 1

Seagrass percentage cover photo guide





Attachment 2: SeagrassNet Biomass Sheets

SeagrassNet = Seagrass Monitoring Network

SeagrassNet Biomass Form (one sheet per station)		Researchers:		Sampling date and time:											
Location:	Transect code & no.:	Station (circle one): A. Nearshore, B. Middle, C. Offshore		Comments:											
PARAMETERS															
Species # 1 =	Shoot count	1	2	3	4	Cross-transect 0-25 m		5	6	7	8	9	10	11	12
	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)														

Attachment 3: Seagrass Species Abbreviations

Aa	<i>Amphibolis antarctica</i>	Pg	<i>Posidonia angustifolia</i>
Ag	<i>Amphibolis griffithii</i>	Pi	<i>Phyllospadix iwatensis</i>
Ca	<i>Cymodocea angustata</i>	Pj	<i>Phyllospadix japonicus</i>
Cn	<i>Cymodocea nodosa</i>	Pk	<i>Posidonia kirkmanii</i>
Cr	<i>Cymodocea rotundata</i>	Pn	<i>Posidonia sinuosa</i>
Cs	<i>Cymodocea serrulata</i>	Po	<i>Posidonia oceanica</i>
Ea	<i>Enhalus acoroides</i>	Pp	<i>Potamogeton pectinatus</i>
Ha	<i>Halophila australis</i>	Pr	<i>Phyllospadix serrulatus</i>
Hb	<i>Halophila beccarii</i>	Ps	<i>Phyllospadix scouleri</i>
Hc	<i>Halophila capricorni</i>	Pt	<i>Phyllospadix torreyi</i>
Hd	<i>Halophila decipiens</i>	Rc	<i>Ruppia cirrhosa (spiralis)</i>
He	<i>Halophila engelmanni</i>	Re	<i>Ruppia megacarpa</i>
Hg	<i>Halodule emarginata</i>	Rm	<i>Ruppia maritima</i>
Hh	<i>Halophila hawaiiiana</i>	Rt	<i>Ruppia tuberosa</i>
Hi	<i>Halodule ciliata</i>	Sf	<i>Syringodium filiforme</i>
Hj	<i>Halophila johnsonii</i>	Si	<i>Syringodium isoetifolium</i>
Hl	<i>Halophila baillonii</i>	Tc	<i>Thalassodendron ciliatum</i>
Hm	<i>Halophila minor</i>	Th	<i>Thalassia hemprichii</i>
Hn	<i>Halophila spinulosa</i>	Tp	<i>Thalassodendron pachyrhizum</i>
Ho	<i>Halophila ovalis</i>	Tt	<i>Thalassia testudinum</i>
Hp	<i>Halodule pinifolia</i>	Za	<i>Zostera asiatica</i>
Hq	<i>Halophila ovata</i>	Zc	<i>Zostera capricorni</i>
Hs	<i>Halophila stipulacea</i>	Zc	<i>Zostera mucronata*</i>
Ht	<i>Halophila tricostata</i>	Zc	<i>Zostera muelleri*</i>
Hu	<i>Halodule uninervis</i>	Zc	<i>Zostera novazelandica*</i>
Hv	<i>Halodule beaudettei</i>	Zj	<i>Zostera japonica</i>
Hw	<i>Halodule bermudensis*</i>	Zl	<i>Zostera caulescens</i>
Hw	<i>Halodule wrightii</i>	Zm	<i>Zostera marina</i>
Lc	<i>Lepilaena cylindrocarpa</i>	Zn	<i>Zostera noltii</i>
Lm	<i>Lepilaena marina</i>	Zp	<i>Zostera capensis</i>
Pa	<i>Posidonia australis</i>	Zs	<i>Zostera caespitosa</i>
Pc	<i>Posidonia coriacea</i>	Zt	<i>Zostera (Heterozostera) tasmanica</i>
Pc	<i>Posidonia robertsoniae*</i>		
Pd	<i>Posidonia denhartogii</i>		
Pf	<i>Posidonia ostenfeldi</i> complex		

* indicates common species code

Attachment 4: SeagrassNet Kit

- ☐ *SeagrassNet monitoring manual*
- ☐ *percent cover standard and species ID sheet*
- ☐ *herbarium supplies and press*
- ☐ *underwater digital camera*
- ☐ *Palm Pilot (with tide prediction software)*
- ☐ *GPS unit (Garmon ETrek)*
- ☐ *compass*
- ☐ *quadrat identification number labeler and grease markers*
- ☐ *0.25 m² quadrat (50 x 50 cm)*
- ☐ *0.0625 m² quadrat (25 x 25 cm)*
- ☐ *water proof data sheets (3 per site)*
- ☐ *plastic clip board*
- ☐ *30 cm rulers (2)*
- ☐ *50 m measuring tapes (2)*
- ☐ *permanent station markers (9 screw anchors)*
- ☐ *syringe sediment core samplers w/ rubber stopper (2)*
- ☐ *salinity refractometer*
- ☐ *plastic containers for salinity water samples (2)*
- ☐ *recording thermometers, iButton (4)*
- ☐ *iButton launch and download software and cables*
- ☐ *recording light sensor (Onset HOBO)*
- ☐ *clear submersible plastic case for light sensor*
- ☐ *HOBO launch and download software and cables*
- ☐ *light sensor storage box*
- ☐ *biomass core sampling tube w/ 2 end caps*
- ☐ *mesh bags for biomass (12)*
- ☐ *large plastic ziplock bags (36 for biomass)*
- ☐ *small plastic ziplock bags (3 for sediment)*
- ☐ *paper bags (for drying biomass samples)*
- ☐ *zip ties (20)*
- ☐ *rubber bands (25)*
- ☐ *Large plastic storage box for SeagrassNet kit*