



# **Manual for Scientific Monitoring of Seagrass Habitat**

*Worldwide Edition*

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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.

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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](http://www.SeagrassNet.org). At this workshop in Kosrae, Federated States of Micronesia, 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

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## SeagrassNet = Seagrass monitoring Network

### *Goal: To measure change in seagrass:*

<b>Distribution</b>	<i>via</i>	Position of seagrass relative to permanent transect (from the shore outward, with three 50m cross transects)
<b>Species composition</b>	<i>via</i>	Collection along permanent transect
<b>Abundance</b>	<i>via</i>	Measurements of cover, canopy height, density, & biomass

### *Parameters to monitor and monitoring methods*

- ↪ Photographic record (one photo of each 0.25 m<sup>2</sup> quadrat)

Email photos to [SeagrassNet@unh.edu](mailto: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 m<sup>2</sup> 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 m<sup>2</sup> 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<sup>-2</sup>), 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) -- Hobo® Light-temperature logger
2. Salinity (measure at every visit and determine the range, ppt) -- refractometer
3. Light level (% surface light at deep and shallow depths vs. land) -- Hobo® Light-temperature logger

4. Surface sediment characteristics quarterly samples 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*
- percent cover standard and species ID sheet*
- herbarium supplies and press*
- underwater digital camera*
- GPS unit (Garmin ETrek)*
- compass*
- quadrat identification number labeler*
- 0.25 m<sup>2</sup> quadrat (50 x 50 cm) (2)*
- 0.0625 m<sup>2</sup> 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 (3)*
- recording temperature and light logger (7 Onset HOBO)*
- 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*
- Also needed: use of a drying oven and a computer with internet access*

## ***Sampling intervals***

4 times/year (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 loggers, 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 predetermined 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 (or the position of the quadrat may be already marked in red on the tape).
  - 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](http://www.SeagrassNet.org)
6. Submit the photographs, temperature and light data to: [www.SeagrassNet.org](http://www.SeagrassNet.org) or mail on CD to the address below.
7. Mail original datasheets (and keep a photocopy), dry sediment samples, and herbarium sheets to:
 

SeagrassNet  
Attn: Fred Short  
Jackson Estuarine Laboratory  
85 Adams Point Road  
Durham NH 03824 USA
8. Wrap up
  - Wash all gear in fresh water and dry
  - Review supplies for next quarter's sampling and request new supplies
  - Store gear for next quarterly monitoring

# Chapter 1

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## General Introduction

In the second 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 assemble 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 monitor seagrasses globally. The monitoring is underway worldwide on every continent except Antarctica (where there are no seagrasses). Monitoring is conducted on a quarterly basis at these sites. Sites are chosen to be representative of the dominant seagrass habitat existing in that country. SeagrassNet has established generic methodologies that can be expanded to monitor seagrasses anywhere, adaptable to programs that are either research-based or community-based.

## **1.2. Goals & objectives**

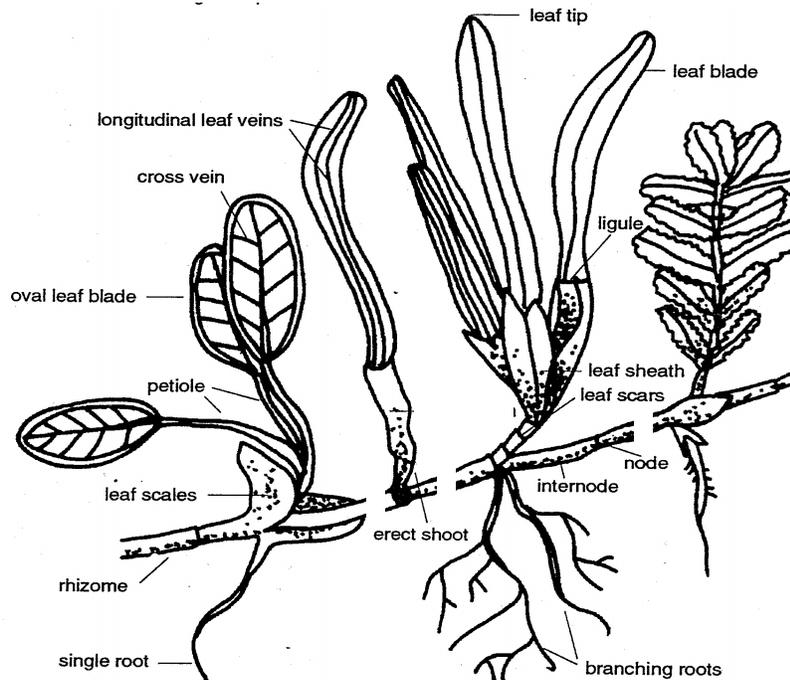
The objectives of the SeagrassNet monitoring program include:

- 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

# 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 leaves extending into the water 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 73 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 as well as direct disturbances like dredging). 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. At the shallow edge, exposure at low tide, wave action and associated turbidity and low salinity from fresh water inflow determine seagrass species survival. 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.

Even 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, sedimentation or land reclamation and other 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.

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 scientifically 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.



# Chapter 3

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## 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 capture 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

### 3.2. Why monitor?

Environmental 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 the 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 act as sentinels in place because these plants, whether as individuals, populations or communities, can be relatively easily measured and rapidly reflect their environmental influences.

Altered seagrass depth distribution in Chesapeake Bay, USA (Dennison *et al.*, 1993) was the “indicator” when runoff impacts on water clarity caused changes in light penetration and consequently affected seagrass abundance and distribution patterns, particularly at their deeper locations. 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 may change; or change may comprise a combination of some or all of these factors. Some changes occur naturally and on a regular, seasonal basis. Environmental 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 relatively 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 to be collected. Increased requirements for accountability in coastal management decisions have 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.

# Chapter 4

## SeagrassNet Monitoring Methods

Monitoring programs aim to detect change. Environmental monitoring programs which are designed to detect change enable coastal management agencies to make decisions on scientific basis. 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.

### SAFETY FIRST

**In all SeagrassNet activities, safety must come first** in undertaking seagrass monitoring and working in the natural environment, especially in coastal waters. Please use common sense and best practices at all times. It is better to postpone field work than to take a risk. Always know how to obtain emergency help, if needed. Carry a radio, cell phone or walkie talkie for communication and keep these in a waterproof container.

**Some important things to consider include:**

**Health status** of all personnel – are they fit enough for a day in the field? Make sure everyone is sufficiently conditioned, is hydrated, and takes breaks. Avoid excess exposure to the sun (the best sun protection is a hat and long-sleeved lightweight shirt and pants). Also, wear sunscreen.

**Tides and currents** which can change rapidly and be very powerful, creating dangerous conditions.

**Weather**, especially lightening but also winds and heavy rain. Either heat or cold can be debilitating.

**Sediment conditions**, particularly soft muds, where someone can get stuck.

**Water safety**. Follow local boat regulations and carry safety equipment as well a reliable “floating platform” (such as a kayak, paddleboard, boogie board, inner tube, etc.).

**If wading or swimming**, wear a personal flotation device at all times. Do not wade or swim alone.

**Carry a first aid kit** at all times. If someone is injured or not feeling well, stop the monitoring and get them to medical help. If anyone is cut (on coral, rocks, or gear), make sure all cuts are treated to prevent infection.

**If SCUBA** is involved, absolutely follow best SCUBA practices at all times, use experienced divers and never let anyone dive alone, however briefly or however shallow the dive may be. Know how to get emergency help.

**To restate: Safety first, then monitoring, at all times.**

## 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 step – and a very 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 repeated 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.

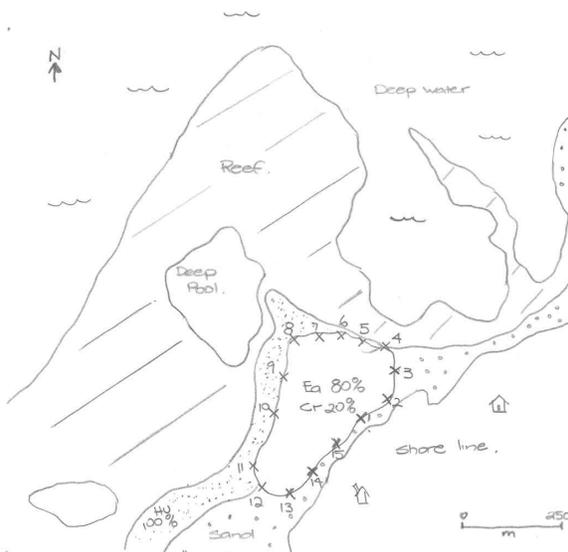
#### *Points to consider:*

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

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

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

SKETCH MAP



COUNTRY: Federated States of Micronesia  
 LOCATION: Anon Reef TRANSECT#: 1

DESCRIPTION OF SITE: \_\_\_\_\_  
*A large intertidal reef flat, which extends to a reef slope with deep water drop off. A dense continuous meadow dominated by *Enhalus* with some *Cymodocea* is near shore. This meadow is surrounded seawards by a patchy meadow of *Halodule uninervis* which extends into the coral.*  
 (continue over back of page)

**GPS WAYPOINTS**

DATE: 6/15/2001 Time start: 9:00am Time finish: 12:30pm

MAP REFERENCE	LATITUDE	LONGITUDE	NOTES/ COMMENTS
1	5° 20.2356	162° 57.072	
2	5° 20.2644	162° 57.1056	
3	5° 20.304	162° 57.1146	
4	5° 20.3322	162° 57.1056	
5	5° 20.3388	162° 57.0702	
6	5° 20.349	162° 57.0426	
7	5° 20.3478	162° 57.0102	
8	5° 20.3486	162° 56.9778	
9	5° 20.2956	162° 56.9622	
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.
- 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.



Turn GPS unit on



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



Check GPS settings

- Units
- Datum
- Altitude
- True or north



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



Either record positions directly onto data-sheet or download to

- 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 minimize 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 longitude/latitude coordinates often include WGS (World Geodetic System). The SeagrassNet program uses WGS84.

### **4.1.3. Community interactions and opportunities**

Once you have identified a suitable site for SeagrassNet monitoring, make sure that the local community/village/residents/citizens are informed about the planned seagrass monitoring activity. If appropriate, hold an event to describe the planned monitoring, give some background on seagrasses, describe the international nature of SeagrassNet and the benefits of participation. Over time, make sure that the community is informed of the SeagrassNet findings.

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. Be sure not to trespass and be sure to clean up any trash after monitoring.

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. All of these community-related efforts will lead to a more successful long-term monitoring program.

One of the long-term objectives of the monitoring program is to involve and inform members of the local community in the monitoring activities. It is important to get the community involved for many reasons. The local community consists of 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.

## 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.

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

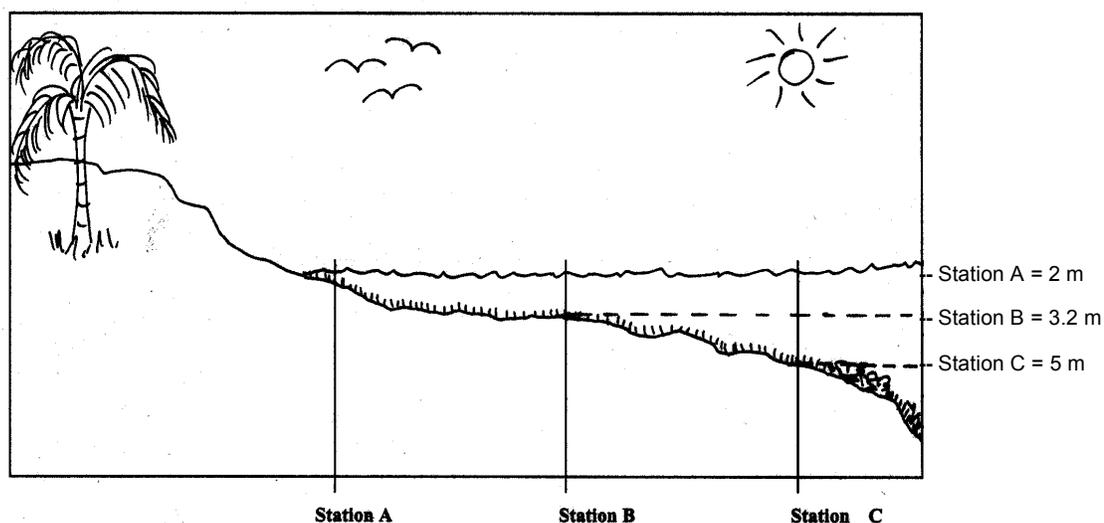


Figure 2. Example of the profile of a transect layout for a monitoring site.

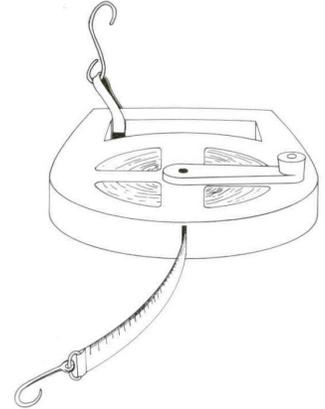
- ↪ Record the actual depth of the mid-depth (B) station, locate the site on the bearing between stations A and C, record the GPS position. Measure and record the distances between A and B, and B and C. Install the permanent marker for Station B. The Station B permanent marker will be the center point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

↪ 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).

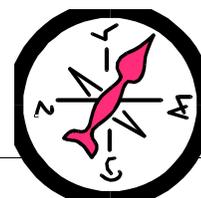
↪ At completion of sampling Station A, roll up the tape measure and repeat for Stations B and C.

### **Taking a Compass Bearing**

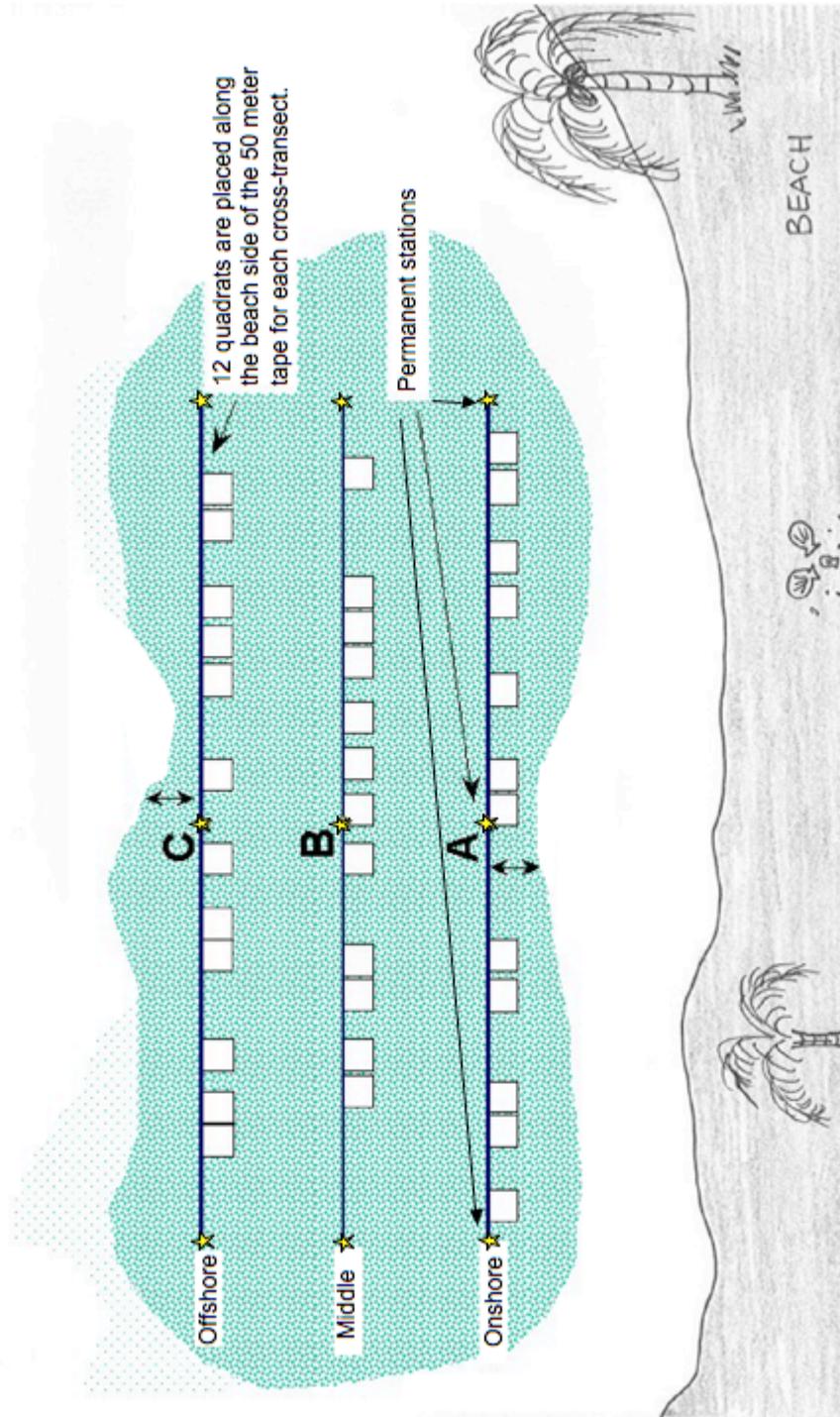
- Hold the compass in front of you at chest height and flat to allow the needle to travel freely.
- Turn to the direction for which you want to take a bearing.
- Allow the needle to stabilize.
- Move the bezel (wheel) on the compass until the bezel arrow is over the needle and pointing to zero degrees, 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 a local, reliable tide table or a web-based tide chart ([www.wxtide32.com/](http://www.wxtide32.com/) for PCs or [www.MrTides.com](http://www.MrTides.com) for Macs) 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)
- Sketch map for site location
- 7 Hobo® light 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.

Figure 4. SeagrassNet Field datasheet – e.g., Caribbean version.

SeagrassNet Field Sampling Form (one sheet per station)		SeagrassNet = Seagrass Monitoring Network		IV. Caribbean Region									
Location:	Transsect code & no.:	Researchers:		Sampling date and time:	1400 hrs								
State/Country:	Station (circle one):	Comments:											
	A. Nearshore, B. Middle, C. Offshore												
<b>PARAMETERS</b>													
<b>Quadrat Measures</b> at pre-selected random distances	Example	Cross-transsect 0-25 m		Cross-transsect 26-50 m									
Photograph (1 per quadrat)	Quadrat 2	1	2	3	4	5	6	7	8	9	10	11	12
Voucher Specimen (1 of each species/Station)	V	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat	Quadrat
All Species Cover	60												
Species = S1	40												
Species =													
Species =													
Species =													
Species = I1	20   32												
Canopy Height (cm) Grazing Evidence? (y/n)	20   3												
Flower/Fruit Count by species	4   11												
Leaf Biomass Core	6   S1												
	Size (m <sup>2</sup> )												
	V 0.0035												
		Pre-selected Random Distances for 0-25m		Pre-selected Random Distances for 26-50m									
A. Nearshore	2	7	8	16	17	18	25	26	33	38	40	44	46
B. Middle	9	10	15	17	22	25	25	28	31	35	37	39	45
C. Offshore	5	19	7	10	18	19	22	26	34	35	38	43	44
		Left (0m)		Center (25m)		Right (50m)							
<b>Cross-transsect Measures</b>		Dist. to edge (m)		Dist. to last (m)		Water Depth (m) at time (hrs)		Surface sediment observation / sample					
GPS: Latitude	8.6	at		at		2:35 @ 1524		fine sand / yes					
Longitude	112												
<b>Station Measures</b>		L-light -- Hobo (day in - day out)		Water temp. logger (day out)		Salinity (ppt)		Tidal Stage (high or low / spring or neap)					
		6 Jan - 30 Jan		30 Jan		25.8		low spring					
		Hd - <i>Halophila decipiens</i>		He - <i>Halophila engelmanni</i>		Hj - <i>Halophila johnsonii</i>		Hi - <i>Halophila baillonii</i>					
		Hw - <i>Halodule wrightii</i>		Rm - <i>Ruppia maritima</i>		Sf - <i>Syringodium filiforme</i>		Tt - <i>Thalassia testudinum</i>					
		Un - Unknown											

↪ Next, record the four Station Measures (bottom of the data sheet).

- Light-temperature Hobo® (day in - day out)
- Temperature Hobo® (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 Haurert 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 Haurert 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® Light-temperature loggers to measure and log light and temperature levels at each site (<http://www.onsetcomp.com>).



#### *General procedure*

- ↪ 3 Hobo® Light-temperature loggers are deployed two (2) weeks before the quarterly seagrass sampling to measure light levels and take temperature levels at comparable intervals.
- ↪ Hobo Light-temperature 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® Light-temperature loggers in the SeagrassNet Kit have been calibrated at the University of New Hampshire.

## **Deployment**

- ↪ The first step is to launch the light sensor before deployment. Launching should be done immediately before deployment. See section 4.7.3 of this manual for launching instructions.
- ↪ In the field, locate the permanent station marker for station A.
- ↪ Using cable ties, fix the Hobo® Light-temperature logger to the permanent marker, ensuring the light sensor is horizontal and facing skyward.
- ↪ Record the date of deployment on the datasheet.
- ↪ Repeat procedure for station C and the land station using units marked C and “Land”, respectively.

## **Collection**

- ↪ In the field, after two weeks of deployment of the Light-temperature logger, locate the permanent station markers at A and C.
- ↪ Cut the cable ties to release the Hobo® Light-temperature unit from the permanent marker.
- ↪ Record the date of collection on the datasheet.
- ↪ Rinse in fresh water and dry thoroughly.
- ↪ For downloading instructions for the Hobo® Light-temperature logger, see section 4.7.4.
- ↪ Upon completion of downloading, with the Hobo® Light-temperature logger turned off, place it in the storage case 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*

- ↪ 2 Hobo® Light-temperature loggers are deployed in the field for three months at a time to monitor temperature long-term at hourly intervals just above the sediment. The other two Hobo® Light-temperature loggers are spares that will be swapped out at each quarterly sampling.
- ↪ Before going to the field, launch the spare set of two Hobo® Light-temperature loggers, record the numbers of the loggers on the data sheet and replace the loggers in the field with the newly launched loggers on the day of quarterly SeagrassNet sampling.
- ↪ The Hobo® Light-temperature logger 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 Hobo® Light-temperature loggers from the field, on the datasheet.
- ↪ At each monitoring event (every 3 months) the Hobo® Light-temperature logger are removed and replaced with a fresh set of 2 loggers.
- ↪ The Hobo® Light-temperature logger should be checked regularly and carefully cleaned of any debris.
- ↪ For downloading and re-launching of the Hobo® Light-temperature logger, see section 4.7.2 and 4.7.4.



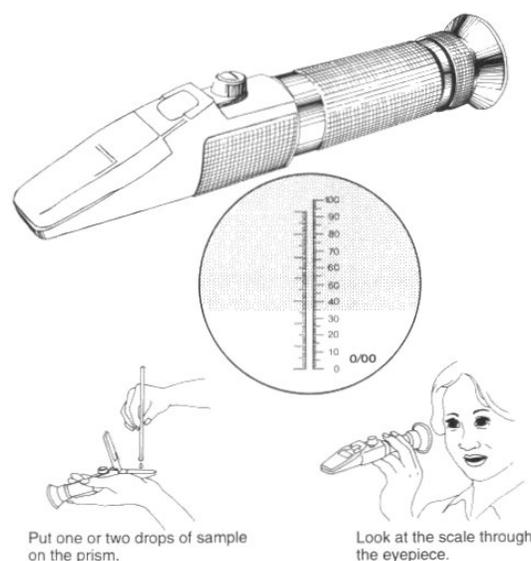
## 4.3.4. Salinity

### *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 influencing the seagrass bed (oceanic or riverine). Salinity also affects the presence and abundance of associated species such as 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 free from a web program: [www.MrTides.com](http://www.MrTides.com) (Mac) and [www.wxtide32.com](http://www.wxtide32.com) (PC) or a local tide table) to identify the phase of the tide at the time of sampling.
- ↪ 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. Second and subsequent monitoring visits to the transects

- ↪ Find Station A with a Global Positioning System (GPS), using the site coordinates and your sketch map of the area.
- ↪ Using your GPS, find 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 needed.



### 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.*

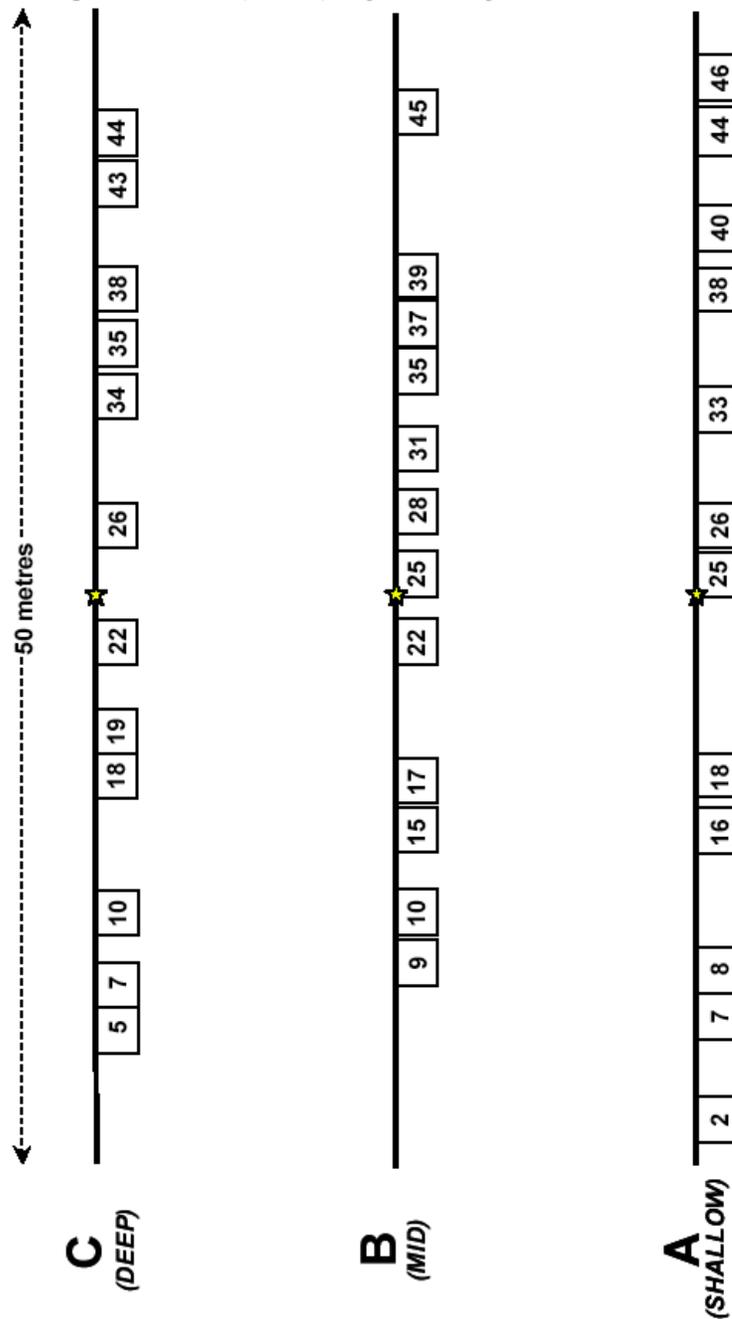
- ↪ You can now start the seagrass monitoring (Go to sections 4.3, 4.4 and 4.5).
- ↪ At completion of station A sampling, roll up the tape measure and repeat for Stations B and C, using the GPS to find Stations B and C.

## 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.

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



## 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 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.
- ↳ Submit the photographs to [www.SeagrassNet.org](http://www.SeagrassNet.org) 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 correctly, the specimens will provide a record that supports data and published reports.

### *Collecting the sample*

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

## ***Pressing the sample***

- ↪ The voucher specimen is pressed as soon as possible after collection. If it is going to be more than 2 hours before you press the sample, 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 for printing from the SeagrassNet website: [www.SeagrassNet.org](http://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 (% 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.

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

↪ **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.

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

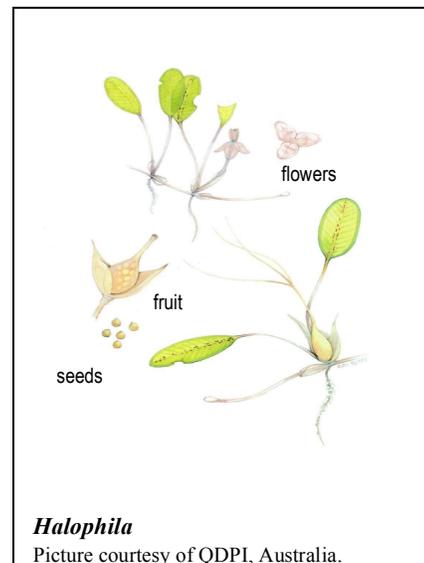
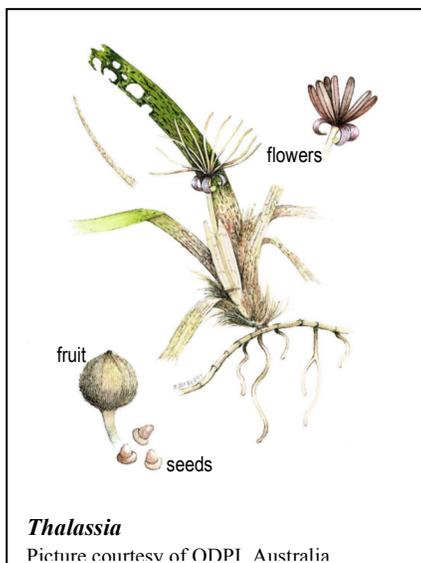
#### 4.5.5. Canopy height and grazing

↪ 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, fish, 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*

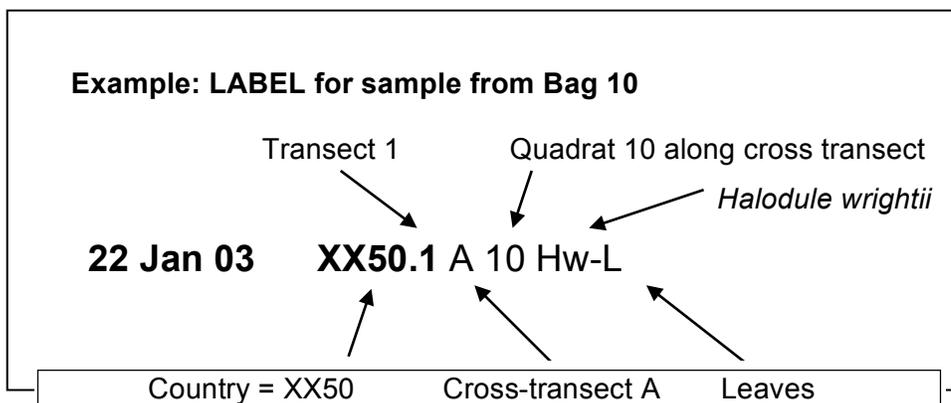
- ↪ Finally, select a few shoots more than 0.5m landward of the quadrat that are similar to those inside the quadrat (of the same dominant seagrass species and average size plants) and take a biomass core.
- ↪ Place the corer on the sediment. You will need to push the leaves into the corer first to avoid 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 and their density. 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 all 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 cover 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 all 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 plant 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° Celsius (120° 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 correct 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).

## 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, or four times a year).

**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*

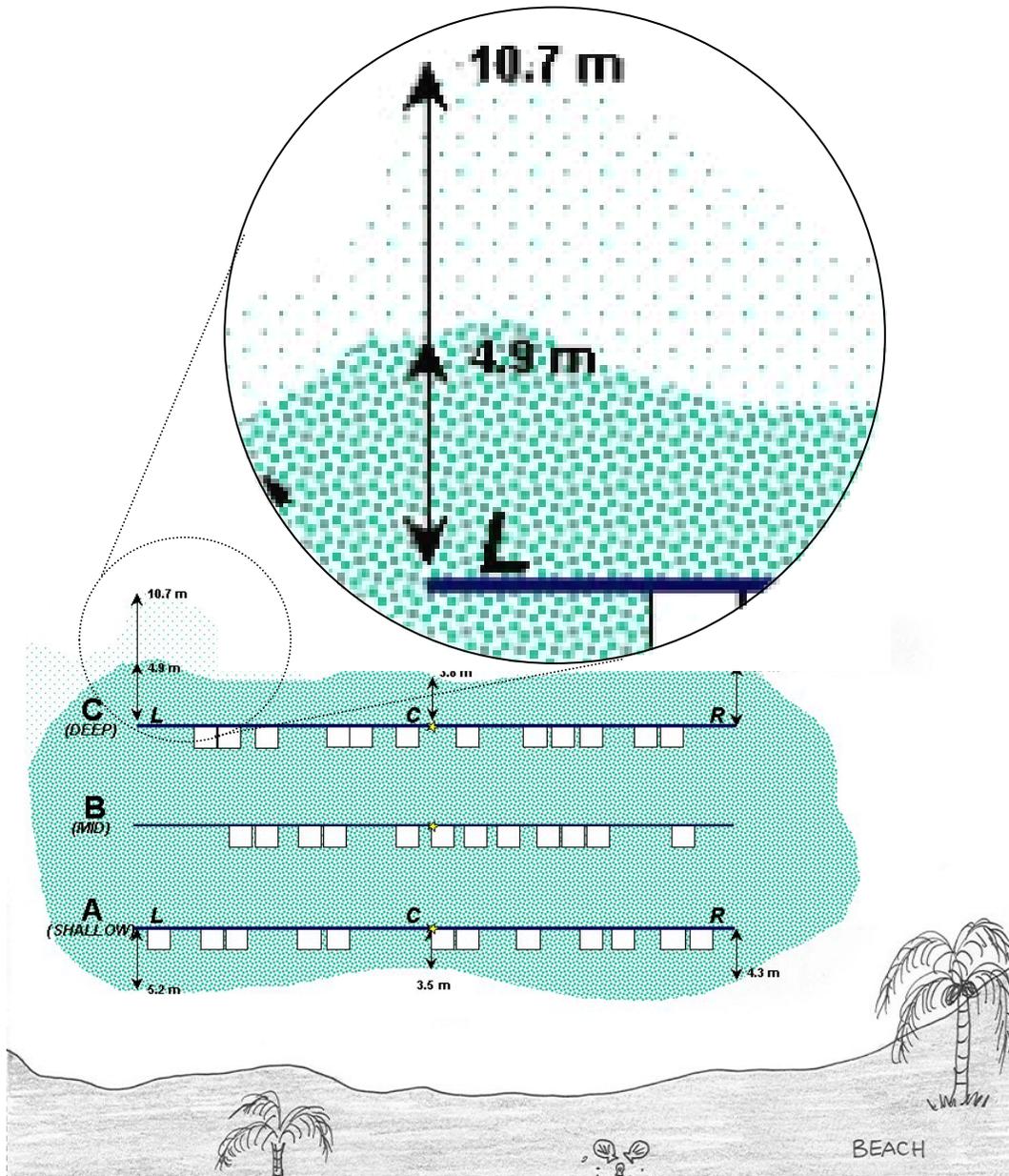
You will need:

- 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 each of 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, A, B, and C. Samples are collected with a syringe corer.
- ↪ Remove the plunger from the 30cc syringe barrel. Place the cut-off end of the barrel on the sediment surface, twist gently while pressing the syringe into the sediment until the barrels fills with sediment completely. Place the plunger on the top of the barrel, press the plunger in as you pull the barrel up out of the sediment.
- ↪ Extrude a small amount of sediment until the plunger is even with the marked line on the syringe. Cap 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, one each from the center of A, B, and C.
- ↪ Empty the entire contents of the syringe into a sealable plastic bag.
- ↪ In the lab, obtain a wet weight for the sample to the nearest gram, and write it in indelible marker on the bag. Then open 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

✎ To [www.SeagrassNet.org](http://www.SeagrassNet.org):

- 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: 603-659-3313

#### 4.6.5. Electronic data submission to [www.SeagrassNet.org](http://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](http://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.

## 4.7 SeagrassNet Data Logger Launching and Downloading

### 4.7.1 Instructions for the HOBO Pendant light and temperature logger

The HOBO Pendant light and temperature logger has a waterproof housing and can record both temperature and light intensity. Each SeagrassNet site receives 5 HOBO Pendants, to be used as follows:

- ↪ 3 HOBO Pendants are used to collect light and temperature data. These loggers are launched and placed in the field 2 weeks before SeagrassNet sampling (on Land/Air and in the water at cross-transects A and C). All three of these HOBO Pendants are retrieved and downloaded after 2 weeks (as described for HOBO LI light loggers, Section 4.3.2 Light Level).
- ↪ 2 HOBO Pendants are used to collect temperature data only. These loggers are attached at the base of the center screw anchors on cross-transects A and C. The HOBO Pendants used to measure temperature remain in the field and are replaced every 3 months (as described for the iButton loggers, Section 4.3.3 Temperature).
- ↪ 2 extra HOBO Pendants are kept with the SeagrassNet kits and used to exchange with the 2 loggers measuring temperature that are already in the field.



**Materials (for 1 site):** 7 HOBO Pendant loggers, HOBOWare Lite CD, HOBO Pendant Coupler and USB cable, 2 PVC support brackets, 7 desiccant packets (keep sealed), extra pendant casing, and 4 extra batteries.

#### ***Loading HOBOWare onto your computer (PC or Macintosh):***

- You must have administrative access on your computer to install HOBOWare Lite.
- Insert the HOBOWare Lite CD into your computer's CD-ROM drive.
- *PC Users:* Please double-click "HOBOWareLite\_Setup.exe" and follow the instructions. (If you do not have a supported version of Java (1.4.2 or later) installed, the installer will download and install it for you. HOBOWare will inform you if your Java version is not up to date.)
- *Mac Users:* Please double-click "HOBOWareLite.pkg" and follow the instructions. When you reach the final screen of the installation program, click **Restart**.

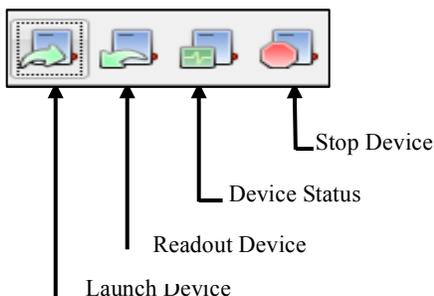
## ***Launching HOBO Pendant with HOBOWare***

### **Start the HOBOWare program:**

- *PC Users:* HOBOWare should open automatically after the first time it is installed. At other times, you can start the program in two ways: 1) double-click the HOBOWare icon on your desktop or on your C drive > Program Files > Onset Computer Corporation > HOBOWare, 2) in the lower left hand corner of the screen click the “Start” menu, then select “Applications” and “HOBOWare.”
- *Mac Users:* Open HOBOWare by double-clicking the HOBOWare icon in your computer’s Applications folder. You may also place the HOBOWare icon in the desktop’s dock for easy access.

### **Connect your HOBO Pendant to your computer:**

- Open HOBOWare Lite.
- Plug the HOBO interface USB cable into your computer.
- Insert the Optic USB Base Station into the Pendant Coupler (a black plastic casing). The Optic USB Base Station looks like a HOBO Pendant, but it is black and has a USB cable coming out of one end. The raised strip on the Optic Base Station must be matched to the groove inside the Pendant Coupler (the coupler and the base station may already be connected).
- Insert the HOBO logger into the Pendant Coupler. Match the raised strip to the Pendant Coupler’s groove. It may take a moment for your computer to recognize the HOBO logger. (Note: Your computer may tell you to reboot before you can use the logger. It is not necessary to reboot.)
  - Check the desiccant packet on the inside cover of the HOBO Pendant. The desiccant packet has a blue band if it is still good. If the band is no longer blue, remove the desiccant packet and dry until the blue band is restored. To remove the desiccant packet, remove set screws and remove the lid. When replacing the lid, make sure you have a watertight seal.
- As soon as your computer recognizes the HOBO logger, the message at the bottom of the HOBOWare Lite screen will change from “No device connected” to indicate the model, serial number, and number of HOBO Pendants connected



### **Launch your HOBO Pendant logger:**

- When you launch a logger, it acquires the date and time from your computer. Prior to launching the loggers, please make sure that your computer is set to the correct, local date and time.
- These symbols (left) are used to launch, download, and stop your HOBO Pendant and are located at the top left of the HOBOWare Lite window.

## 4.7.2 Launch data loggers

### *Launch for Light and Temperature:*

- The 3 Pendant sensors will log both light and temperature data for the 2 week duration before SeagrassNet sampling, in addition to the designated sensors logging temperature for the 3 months between sampling dates.
- To launch the logger, click on the “Launch Device” icon. A window appears similar to the “Launch Logger” window (right).
- Check the battery level. Replace battery if less than 25%.
- Enter the Pendant logger information inside the Launch Logger window.
- In the Description box, enter your site name, site number, L (meaning light and temperature), cross-transect (A, C, or LAND), and the launch date (month year).
- In the “Channels to Log” box: for light, put a check mark next to 1) Temperature 10K Thermistor and 2) Light Intensity when launching the three HOBO Pendants marked “L.” Two Pendant loggers are attached to the side of the screw anchors on transects A and C, and 1 Pendant logger is attached to a pole (or other tall object) on land (in the air) where it is not shaded during the day. Do NOT put a check next to 3) Logger’s Battery Voltage.
- Set the Logging Interval to record every 10 minutes: put a “10” in the middle box (Min) and “0” in the other boxes.
- Set the Launch Options to “At interval”: this setting makes each logger record on the minute mark.
- After you have changed the settings, your window should look similar to the one above (the window above was set for a Pendant logger to record light and temperature in New Hampshire site 9.2, cross-transect A in April 2008).
- Select the “Launch” button in the bottom right-hand corner of the window. Do not unplug the logger until instructed. At this time, you can click the “Status...” button to determine if the logger is working.
- When instructed by HOBOware Lite, remove the HOBO Pendant and observe that the red light blinks intermittently.
- Repeat the above sequence until you have launched light/temperature loggers for cross-transect A, cross-transect C and LAND.
- If you get an error message when launching (e.g., “no device connected”), please try again.
- Label the HOBO Pendants being deployed so they can be distinguished from the HOBO Pendants being retrieved (DO NOT write on the upper surface, over the sensor).

Launch Logger

Logger Type: HOBO UA-002-08 Pendant Temp/Light  
Serial Number: 2237557  
Deployment Number: 3  
Battery Level: 100 %  
Description: NH9.2A\_L\_Aug09

Channels to Log:  
 1) Temperature 10K Thermistor  
 2) Light Intensity  
 3) Logger's Battery Voltage

Logging Interval: 0 Hr 10 Min 0 Sec  
Maximum logging interval: 18 Hr 12 Min 15 Sec

Logging Duration: 24 Days, 05 Hr 20 Min 00 Sec  
(Approx. time to fill logger)  
This value is based on the logging interval and channel(s) selected above; it does not account for memory used by events.

Launch Options:  
Now:  08/03/09 11:08:38 AM GMT-04:00  
At Interval:  08/03/09 11:10:00 AM GMT-04:00  
Delayed:  8/3/09 12:00:00 PM GMT-04:00  
Maximum delay: 194 Days 4 Hr 20 Min 15 Sec  
Trigger:  See Help or Manual for Coupler Start Instructions

Help Cancel Status... Launch

## Launching for Temperature:

- To launch the logger, click on the “Launch Device” icon. A window appears similar to the “Launch Logger” window (right).
- Check the battery level. Replace battery if less than 25%.
- Enter the temperature logger information inside the Launch Logger window.
- In the Description box, enter your site name, site number, T (meaning temperature), cross-transect (A, C), and the launch date (month and year).
- “Channels to Log” box: For temperature, put a check mark next to 1) Temperature 10K Thermistor when launching the two HOBO Pendants marked “T.” Do NOT check the box for 2) Light Intensity or 3) Logger’s Battery Voltage.
- Set the Logging Interval for the temperature HOBO Pendants to record every hour: put a “1” in the first box (Hr) and “0” in the other boxes.
- Set the Launch Options to “At Interval”; this setting makes each logger record on the hour.
- After you have changed the settings, your window should look similar to the one above (the window above was set for temperature at New Hampshire site 9.2, cross-transect A in April 2008).
- Select the “Launch” button in the bottom right hand corner of the window. Do not unplug the logger until instructed. At this time you can click the “Status...” button to determine if the logger is working.
- When so instructed, remove the HOBO Pendant, and observe that the red light blinks intermittently and label each logger.
- Repeat the sequence until you have launched temperature loggers for both cross transects, A and C.
- If you get an error message when launching (e.g., “no device connected”), please try again.

Launch Logger

Logger Type: HOBO UA-002-08 Pendant Temp/Light  
Serial Number: 2245993  
Deployment Number: 3  
Battery Level: 100 %  
Description: NH\_9.2A\_T\_Apr08  
Channels to Log:  
 1) Temperature 10K Thermistor  
 2) Light Intensity  
 3) Logger's Battery Voltage  
Logging Interval: 1 Hr 0 Min 0 Sec Maximum logging interval: 18 Hr 12 Min 15 Sec  
Logging Duration: 261 Days, 16 Hr 00 Min 00 Sec (Approx. time to fill logger) This value is based on the logging interval and channel(s) selected above; it does not account for memory used by events.  
Launch Options:  
Now: 06/09/09 02:28:01 PM GMT-04:00  
At Interval: 06/09/09 03:00:00 PM GMT-04:00  
Delayed: 6/9/09 03:00:00 PM GMT-04:00 Maximum delay: 194 Days 4 Hr 20 Min 15 Sec  
Trigger: See Help or Manual for Coupler Start Instructions  
Buttons: Help, Skip launch window next time, Cancel, Status..., Launch

### 4.7.3 Deploying data loggers

#### *Deploying the HOBO Pendants (Light/Temperature):*

- HOBO Pendants (3) to log light and temperature should be deployed 2 weeks prior to quarterly sampling. Two Hobo Pendants programmed for light/temperature are deployed in the water, on the center screw anchor of cross-transects A and C, and one is deployed on land (in the air), attached to a post or other un-shaded, permanent structure.
- Put a strip of clear tape evenly over the flat surface of the pendant (the green side that says “Hobo”), wrap the tape around the case, with ends of the tape overlapping on the back of the case with the raised strip. The tape protects the pendant light sensors from scratching. Make sure there are no air bubbles or debris obstructing the light sensing area.
- Send two zip (cable) ties through the HOBO Pendant bail, in opposite directions.
- Slide both ends of both zip ties through the PVC support bracket.
- In the field, using the zip ties, attach the HOBO Pendant to the eye of the screw anchor at cross-transects A and C, orienting the HOBO Pendant toward the Equator (i.e., facing south in the Northern Hemisphere and facing north in the Southern Hemisphere). Sunlight reaching the HOBO Pendant should not be obstructed by shadows; the horizontal surface with sensors and flashing light should be level and face the sky. Cut off the unused ends of the cable ties (see picture at right). Deploy the third HOBO Pendant programmed for light and temperature collection on land (in the air) in a convenient but protected location without shadows throughout the day.
- After the HOBO Pendants have been deployed for 2 weeks, collect them and download the data.

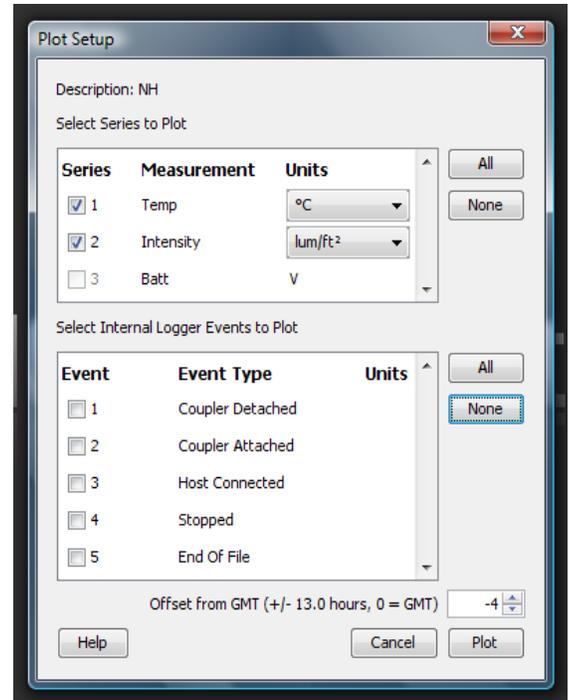


#### *Deploying the HOBO Pendant (Temperature only):*

- HOBO Pendants (2) programmed to log temperature are deployed at the time of the quarterly SeagrassNet sampling and exchanged with the loggers which have been in place for the past 3 months.
- Put a strip of clear tape evenly over the flat surface of the pendant, again wrapping the tape around the case, with ends of the tape overlapping on the side of the pendant with the raised strip. The tape protects the sensors.
- Send two zip ties through the HOBO Pendant bail in opposite directions (see picture above).
- Clip off the used sensor and attach a fresh HOBO Pendant at the base of the screw anchor, near the sediment surface at cross-transects A and C.

#### 4.7.4 Downloading light/temperature data from the HOBO Pendant logger:

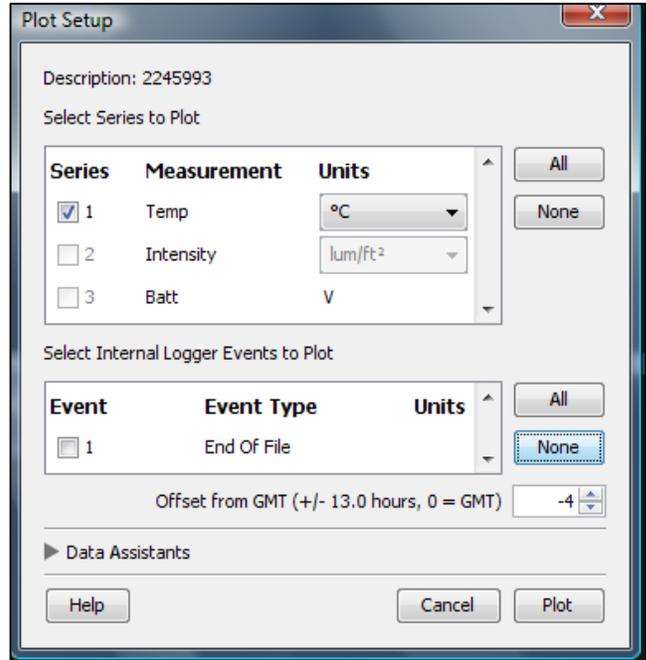
- After retrieving all three light/temperature sensors from the field, wash them in fresh water and clean any debris or encrusting material from the cases.
- Allow the pendant sensors to dry completely before downloading. When dry, remove the clear tape.
- Insert the HOBO Pendant in its case and the Optic USB Base Station into the Pendant Coupler (aligning the raised strip and groove). Plug the USB cable from the Base Station into your computer. Open HOBOWare Lite.
- Click the “Readout device” icon in the upper left hand corner of the window. You will be asked, “Do you wish to stop logging before reading out the logger?” Press “Stop”.
- Save the file using the file name for your site (for example: NH\_9.2A\_L\_Apr08.hobo). The file will be saved with a “.hobo” at the end of the file name so that HOBOWare Lite can identify it.
- You will then be prompted to select the plot setup features. Please check the Temperature box and select degrees C. Also check the box for Intensity and select “lum/ft<sup>2</sup>” for units. None of the Events should be checked.
- Click “Plot” to view a graph of the light/temperature data.
- Export the data as an Excel file. In the “File” menu select “Export Points as Excel Text...”, then select “Export to a single file” and select the destination file.



#### *Downloading temperature data from the HOBO Pendant logger:*

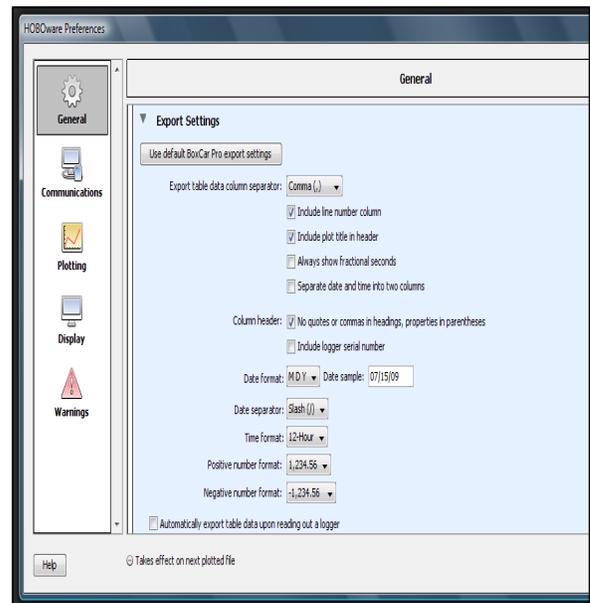
- After retrieving both temperature sensors from the field, wash them in fresh water and clean any debris or encrusting material from the cases.
- Allow the pendant sensors to dry completely before downloading. Once they are dry, remove the clear tape.
- Insert the HOBO Pendant and Optic USB Base Station into the Pendant Coupler (aligning the raised strip and groove). Plug the USB cable into your computer. Open HOBOWare Lite.
- Click the “Readout device” icon in the upper left hand corner. You will be asked, “Do you wish to stop logging before reading out the logger?” Press “Stop”.

- Save the file using the file name for your site (for example: NH\_9.2A\_T\_Apr08.hobo). The file will be saved with a “.hobo” at the end of the file name so that HOBOWare Lite can identify it.
- You will then be prompted to select the plot setup features. Please check the box for Temp and select “°C” for units. None of the Events should be checked.
- Click “Plot” to view a graph of the temperature data.



***Exporting your data for submission to the website:***

- In order to submit the light or temperature data to the SeagrassNet website, it must be exported from HOBOWare Lite as a .csv file as follows:
- The export preferences (found in the upper left menu, below “HOBOWare” and “Preferences”) must be set in order for the data to be in a format compatible with the website.
  - The “export data column separator” should be set to Comma (,).
  - Check only the boxes for:
    - “Include line number column”
    - “Include plot title in header”
    - “No quotes or commas in headings, properties in parentheses”
  - Date Format should be set to [MDY]
  - Date Separator should be set to [Slash]
  - Time Format should be set to [ 12 Hour]
  - When these settings are specified, click “OK” at the bottom right-hand side of the “HOBOWare Preferences”, “General” screen.
- Next click “File”, “Export Points as Excel Text...”
- Make sure the circle next to “Export to a single” is filled in, then click “Export”
- Save the file using the file name for your site (for example: NH\_9.2A\_T\_Apr08.csv



(/)  
file”

## 4.7.5 Submitting your data to the SeagrassNet website:

The light/temperature (3 files: cross-transects A and C, plus "Land/Air") and temperature data (2 files: cross-transects A and C) are uploaded separately.

### *For Light/Temperature Data:*

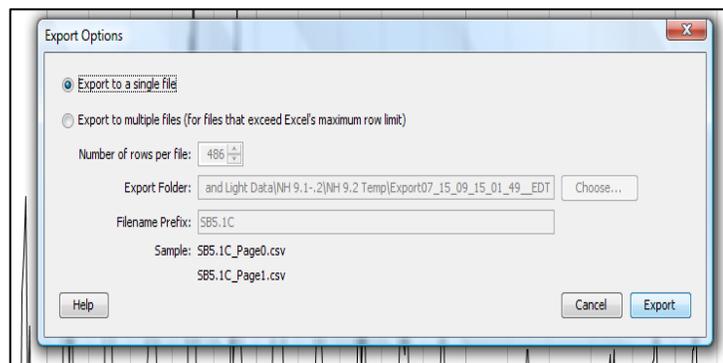
1. Please upload the text data files for light/temperature data to the SeagrassNet website: [http://www.seagrassnet.org/data-test/insert\\_light\\_temp.php](http://www.seagrassnet.org/data-test/insert_light_temp.php)
  2. Enter the site name and transect code using the drop-down menu. For light/temperature, all 3 text data files ("Air"= "Land" and cross-transects A and C) must be uploaded separately. If several sites share a single Land/Air light sensor, the Land/Air data file must be uploaded multiple times, once for each site.
- Select the correct "Country, Location and Transect" and "Station". For "Data file type", select "Hobo Pendant – Light and Temperature"
  - Select the data file to upload and click "Submit".

### *For Temperature Data:*

3. Please upload the text data files for temperature data to the SeagrassNet website: [http://www.seagrassnet.org/data-test/insert\\_light\\_temp.php](http://www.seagrassnet.org/data-test/insert_light_temp.php)
4. Temperature data (2 files: cross-transects A and C) are uploaded separately.
5. Enter the site name and transect code using the drop-down menu.
6. Select the correct "Country, Location and Transect" and "Station". For "Data file type", select "Hobo Pendant - Temperature"
7. Select the data file to upload and click "Submit".

### *After data submission:*

- Make sure the Pendant sensor is turned off (no flashing red light). Then cover the sensor side of the Pendant with clear plastic tape to protect the logger in storage and during the next deployment.
- If you are unable to upload the data via the web site, your data can be emailed. Send the data file as an attachment to: [Seagrass.Net@unh.edu](mailto:Seagrass.Net@unh.edu)



# Chapter 5

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## SeagrassNet Data Policy

### 5.1 Data policy goals & definitions

#### 5.1.1 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

#### 5.1.2 Definitions

- ↪ SeagrassNet Project Director – Dr. Frederick T. Short, who directs the global SeagrassNet program.
- ↪ 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

### 5.2.1 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.

### 5.2.2 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 Name(s)*} and was made available through the database at [www.seagrassnet.org](http://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 the SeagrassNet Director for access to the database.

# Glossary

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<b>Anthropogenic</b>	produced or caused by humans.
<b>Baseline</b>	first assessment of a situation against which subsequent changes are measured.
<b>Biomass</b>	the total amount of living organisms or plant material in a given area, expressed in terms of living or dry weight per unit area.
<b>Canopy</b>	the covering afforded by the tops of the plant structure serving as a sheltered area.
<b>Canopy height</b>	in seagrasses, usually defined as the length from substrate to leaf tip of 80% of the leaves within a given area.
<b>Community</b>	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.
<b>Core sample</b>	a cylindrical sample of benthos and substratum obtained by the use of a hollow tube/drill.
<b>Datasheet</b>	a paper form used to record field data in a set format.
<b>Density</b>	a measure of the compactness of a substance (e.g. number of plants) within a given area.
<b>Disturbance</b>	change caused by an external agent, which could be natural (e.g. weather) or human-induced (e.g. pollution).
<b>Diversity</b>	variety, often expressed as a function of a number of species in a sample, sometimes modified by their relative abundances.
<b>Ecosystem</b>	a dynamic complex of plant, animal and micro-organism communities and the associated non-living environment interacting as an ecological unit.
<b>Epiphyte</b>	plants growing on the surface of other plants.
<b>Global Positioning System (GPS)</b>	satellite-based navigation system.
<b>Internode</b>	the part of a plant rhizome between two nodes.
<b>Landward</b>	in the direction of the land.
<b>Leaf scars</b>	the marks remaining on the rhizome or stem of a plant after a leaf has died.
<b>Leeward</b>	side protected from the wind.
<b>Macrofauna</b>	the animals retained by a 0.5 mm sieve.
<b>Methodology</b>	collection of methods used in a particular activity.
<b>Monitoring</b>	repeated observation of a system, usually to detect change.
<b>Nearshore</b>	close or closest to the coastline.
<b>Nodes</b>	the point on a plant rhizome from which the leaves and lateral shoots grow.

<b>Percent cover</b>	the proportion of a hundred parts of a given area (e.g. quadrat) this has plants present.
<b>Petiolate</b>	having a stalk or stem.
<b>Population</b>	all individuals of one or more species within a prescribed area.
<b>Population structure</b>	the composition of a population according to age and sex of the individuals.
<b>Primary production</b>	organic mater created through photosynthetic processes of plants.
<b>Productivity</b>	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.
<b>Quadrat</b>	a fixed unit, usually square, used for sampling.
<b>Qualitative</b>	descriptive, non-numerical.
<b>Quantitative</b>	numerical; based on counts, measurements or other values.
<b>Refractometer</b>	optical instrument used to measure salinity.
<b>Replicate</b>	a repeated sample from the same location and time.
<b>Salinity</b>	measure of the total concentration of dissolved salts in water.
<b>Sample</b>	any subset of a population; a representative part of a larger unit used to study the properties of the whole.
<b>Sample size</b>	the number of observations in a sample.
<b>Sand</b>	cohesionless sediment particles measuring 2.0-0.0625mm in diameter.
<b>SCUBA</b>	Self-Contained Underwater Breathing Apparatus.
<b>Seagrass meadow</b>	a large expanse of seagrass plants.
<b>Seagrass community</b>	a group of seagrass plants belonging to a number of different species that co-occur in the same area.
<b>Seaward</b>	in the direction of the open sea.
<b>Secchi depth</b>	the distance between the water surface and Secchi disc at which point the disc marking are no longer distinguishable.
<b>Secchi disc</b>	device used to estimate the transparency of water.
<b>Sediment</b>	matter that settles to the bottom of a water body.
<b>Sedimentation</b>	process of deposition of particulate matter.
<b>Station</b>	the place or position at which the transect and cross-transects intersect.
<b>Substrate</b>	another word for substratum, the ocean floor.
<b>Substrate type</b>	the composition of sediments, usually distinguished by the grain size.
<b>Substratum</b>	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.
<b>Subtidal</b>	beneath the low watermark.
<b>Survey</b>	organised inspection.
<b>Transect</b>	a line or narrow belt used to survey the distributions of organisms across the given area.
<b>Variable</b>	any measurable aspect of a sample that is not constant.

<b>Vein</b>	the clearly defined vascular bundle in a leaf, usually seen as slightly darker lines forming the framework of a leaf.
<b>Visibility</b>	distance at which objects may be sighted during a survey.
<b>Water column</b>	a volume of water between the surface and the bottom.
<b>Windward</b>	side exposed to the wind.

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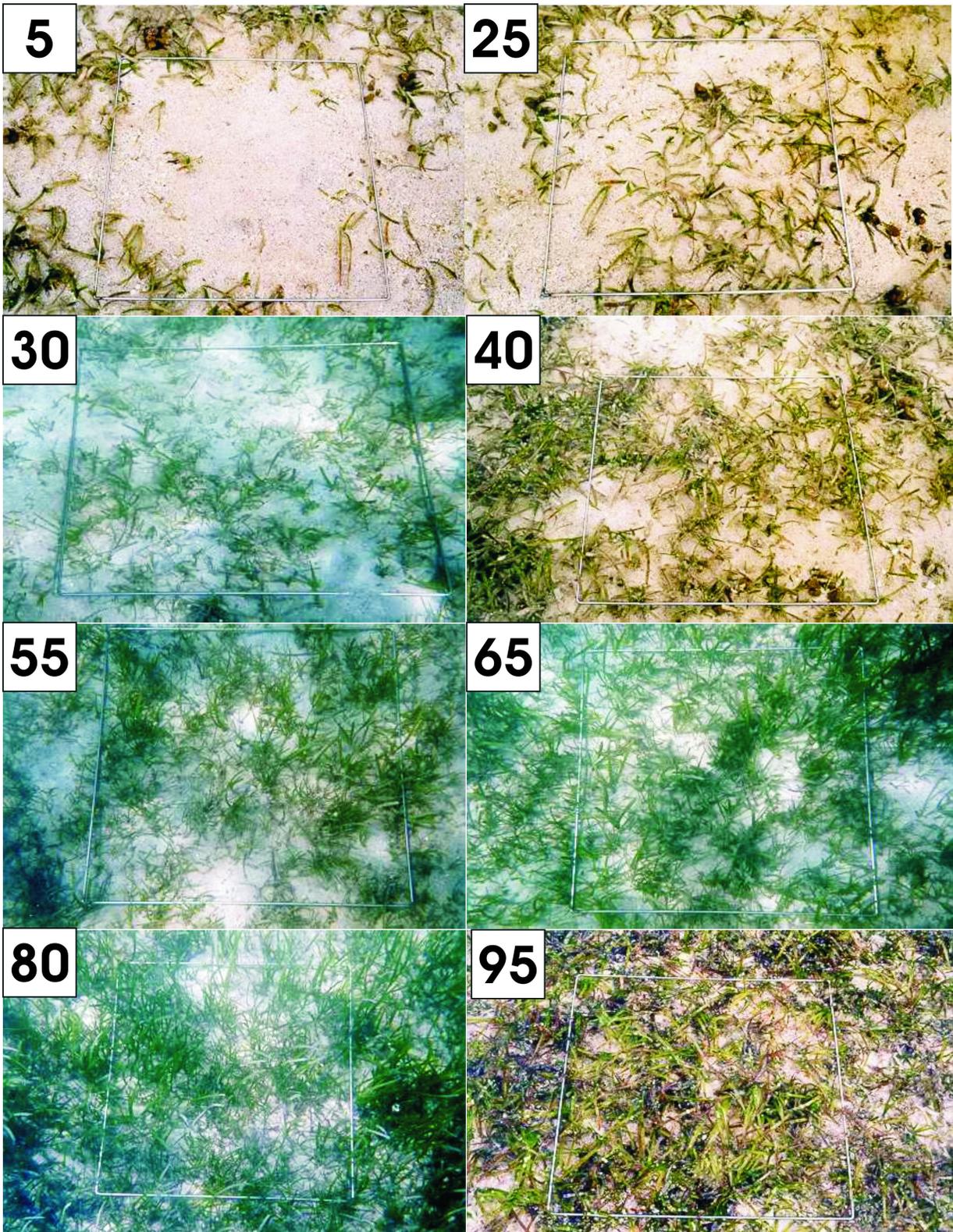
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# Attachment 1:

## Seagrass percentage cover (% cover) photo guide





SeagrassNet = Seagrass Monitoring Network

<b>SeagrassNet Biomass Form (one sheet per station)</b> Location:		Transsect code & no.:		Researchers:		Sampling date and time:																					
State/Country:		Station (circle one): A. Nearshore, B. Middle, C. Offshore		Comments:																							
<b>PARAMETERS</b>				1		2		3		4		5		6		7		8		9		10		11		12	
Species # 1 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									
Species # 2 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									
Species # 3 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									
Species # 4 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									
Species # 5 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									
Species # 6 =		Shoot count																									
		Leaf weight (g)																									
		Stem/Sheath weight (g)																									
		Root/Rhizome weight (g)																									

## Attachment 3:

### Seagrass species (73) & abbreviations

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

- SeagrassNet monitoring manual*
- percent cover standard and species ID sheet*
- herbarium supplies and press*
- underwater digital camera*
- GPS unit (Garmin ETrek)*
- compass*
- quadrat identification number labeler*
- 0.25 m<sup>2</sup> quadrat (50 x 50 cm) (2)*
- 0.0625 m<sup>2</sup> 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 (3)*
- recording temperature and light logger (7 Onset HOBO)*
- 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*