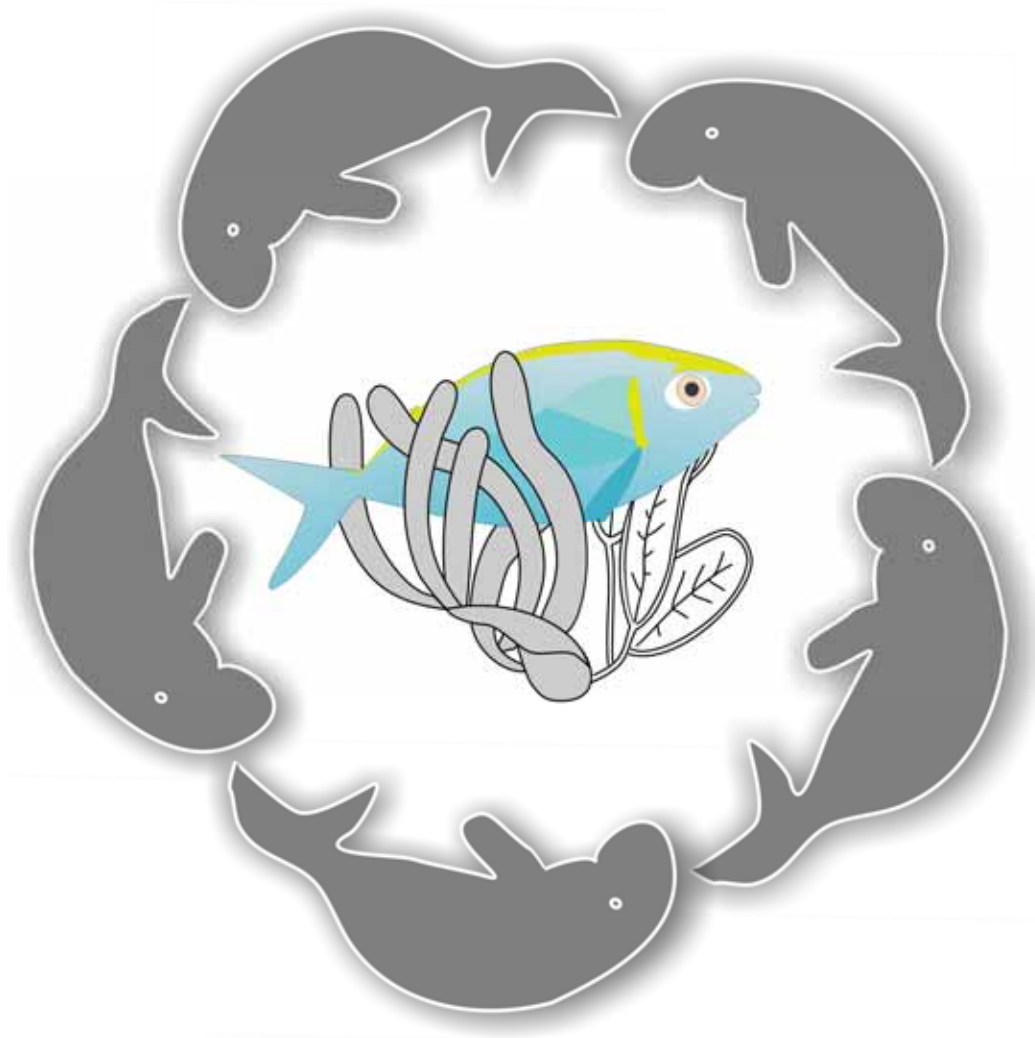


# Seagrass-Watch

Guidelines for Philippine Participants



Bolinao Marine Laboratory, University of the Philippines

9<sup>th</sup> – 10<sup>th</sup> April 2007

Len McKenzie



First Published 2007

©Seagrass-Watch HQ, 2007

Copyright protects this publication. Except for purposes permitted by the Copyright Act, reproduction by whatever means is prohibited without the prior written permission of Seagrass-Watch HQ, Queensland.

*Disclaimer*

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

Seagrass-Watch HQ has taken all reasonable steps to ensure the information contained in this publication is accurate at the time of the survey. Readers should ensure that they make appropriate enquires to determine whether new information is available on the particular subject matter.

The correct citation of this document is

*McKenzie, L.J. (2007). Seagrass-Watch: Guidelines for Philippine Participants. Proceedings of a training workshop, Bolinao Marine Laboratory, University of the Philippines, 9th – 10th April 2007 (DPI&F, Cairns). 36pp.*

Produced by Seagrass-Watch HQ, QDPI&F

Northern Fisheries Centre, Cairns, 2007.

Enquires should be directed to:

Len McKenzie  
Northern Fisheries Centre,  
PO Box 5396  
Cairns, QLD 4870 Australia  
[hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)



# Overview

Seagrass-Watch is the largest scientific, non-destructive, seagrass assessment and monitoring program in the world.

Often governments are unable to protect and conserve seagrass meadows without the assistance of local communities (e.g., local residents, schools, tertiary institutions, non-government organisations). Seagrass-Watch is a monitoring program that brings citizens and governments together for seagrass conservation. It identifies areas important for seagrass species diversity and conservation. The information collected can be used to assist the management of coastal environments and to prevent significant areas and species being lost.

Monitoring seagrass resources is important for two reasons: it is a valuable tool for improving management practices; and it allows us to know whether resource status and condition is stable, improving or declining. Successful management of coastal environments (including seagrass resources) requires regular monitoring of the status and condition of natural resources.

Early detection of change allows coastal management agencies to adjust their management practices and/or take remedial action sooner for more successful results. Monitoring is important in improving our understanding of seagrass resources and to coastal management agencies for:

- *Exposing coastal environmental problems before they become intractable,*
- *Developing benchmarks against which performance and effectiveness can be measured,*
- *Identifying and prioritising future requirements and initiatives,*
- *Determining the effectiveness of management practices being applied,*
- *Maintaining consistent records so that comparisons can be made over time,*
- *Developing within the community a better understanding of coastal issues,*
- *Developing a better understanding of cause and effect in land/catchment management practices,*
- *Assisting education and training, and helping to develop links between local communities, schools and government agencies, and*
- *Assessing new management practices*

A rapid method for monitoring seagrass resources is used in the Seagrass-Watch program. Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. To protect the valuable seagrass meadows along our coasts, everyone must work together.

The goals of the Seagrass-Watch program are:

- *To educate the wider community on the importance of seagrass resources*
- *To raise awareness of coastal management issues*
- *To build the capacity of local stakeholders in the use of standardised scientific methodologies*
- *To conduct long-term monitoring of seagrass & coastal habitat condition*
- *To provide an early warning system of coastal environment changes for management*
- *To support conservation measures which ensure the long-term resilience of seagrass ecosystems.*

This workshop is supported by UNEP/GEF South China Sea Project, Bolinao Seagrass Demonstration Site, the Marine Science Institute, College of Science, University of the Philippines, and Seagrass-Watch HQ. As part of this workshop we will

- *learn seagrass taxonomy*
- *discuss the present knowledge of seagrass ecology,*
- *discuss the threats to seagrasses*
- *learn Seagrass-Watch techniques for monitoring seagrass resources*
- *look at examples of how Seagrass-Watch assists with the management of impacts to seagrass resources and provides an understanding of their status and condition*
- *learn to use a Global Positioning System (GPS), and*
- *learn how to map a seagrass meadow.*

The following information is provided as a training guide and a reference for future Seagrass- Watch monitoring activities. For further information, please do not hesitate to contact us at

**Seagrass-Watch HQ**

Northern Fisheries Centre  
Queensland Department of Primary Industries & Fisheries  
PO Box 5396  
Cairns QLD 4870  
AUSTRALIA  
Telephone (07) 4035 0131  
Fax (07) 4035 4664  
E-mail [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)

*or visit*

**[www.seagrasswatch.org](http://www.seagrasswatch.org)**



# Workshop leaders



## Len McKenzie

Len is a Principal Scientist with the Queensland Department of Primary Industries & Fisheries and Seagrass-Watch Program Leader. He is also chief investigator for the MTSRF task on the condition, trend and risk in coastal seagrass habitats, task leader of the Great Barrier Reef Marine Monitoring Programme - Seagrass Monitoring and project leader for a series of projects involving the assessment and sustainable use of coastal fisheries habitat. Len has 19 years experience as a research scientist on seagrass ecology, assessment and fisheries habitats. This includes experience within Australia and overseas in seagrass research, resource mapping/ assessment and biodiversity. He has provided information on seagrass communities that has been vital in management of seagrass resources of the Great Barrier Reef and also at the state, national and international levels. He has also advised on fisheries and coastal resource-use issues for managers, fishing organisations, conservation and community groups. Len is also the Secretary of the World Seagrass Association.

### ***Current Projects***

- Seagrass-Watch
- Status and mapping of seagrass resources in Queensland
- Assessment of primary and secondary productivity of tropical seagrass ecosystems
- Investigations on the macrofauna associated with seagrass meadows
- Great Barrier Reef Water Quality Protection Plan – marine monitoring program: seagrass



# Agenda

## Monday 09<sup>th</sup> April 2007

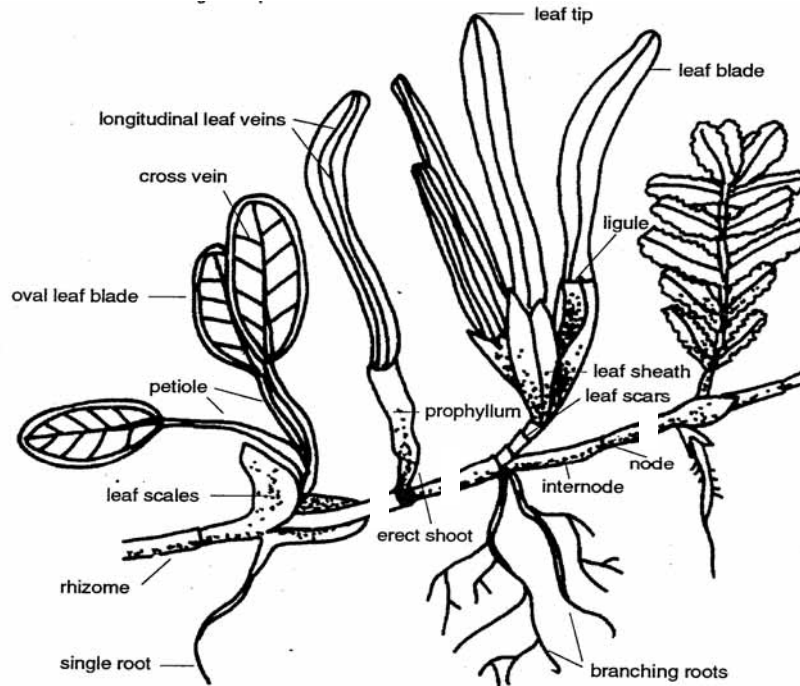
Morning	900 - 910	Welcome & Introduction – <i>Tutu Almonte &amp; Mike Fortes</i>
	910 - 940	Presentation 1: Seagrass Biology & Identification
	940 - 1015	<b>Field &amp; Laboratory exercise:</b> Seagrass Identification & how to prepare a seagrass press specimen
	1015 - 1030	Morning Tea
	1100 - 1145	Presentation 2: Seagrass Ecology and Threats
	1145 - 1200	Presentation 3: Seagrass monitoring
Afternoon	1200 - 1300	Presentation 4: Seagrass-Watch
	1300 - 1500	Lunch
	1500 - 1520	Presentation 5: Seagrass Mapping Pt 1
	1520 - 1545	Presentation 6: Global Position Systems
	1545 - 1600	Afternoon Tea
	1600 - 1640	<b>Field exercise:</b> Using a GPS – Easter egg hunt
	1640 - 1700	Presentation 7: Seagrass Mapping Pt 2

## Tuesday 10<sup>th</sup> April 2007

Morning	0800 - 1200	<b>Field exercise:</b> Seagrass-Watch monitoring <i>What to bring:</i> <ul style="list-style-type: none"> <li>• <i>hat, sunscreen (Slip! Slop! Slap!)</i></li> <li>• <i>dive booties or old shoes that can get wet</i></li> <li>• <i>drink/refreshments</i></li> <li>• <i>polaroid sunglasses (not essential)</i></li> <li>• <i>enthusiasm</i></li> </ul>
	1200 - 1300	Lunch
Afternoon	1300 - 1430	<b>Field exercise:</b> Mapping a seagrass meadow
	1530 - 1700	Wrap-up & farewell

# Background

Seagrasses are specialised marine flowering plants that have adapted to the nearshore environment of most of the world's continents. Most are entirely marine although some species cannot reproduce unless emergent at low tide. Some seagrasses can survive in a range of conditions encompassing fresh water, estuarine, marine, or hypersaline. There are relatively few species globally (about 60) and these are grouped into just 13 Genera and 5 Families.



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

from Lanyon (1986)

Various common names are applied to seagrass species, such as turtle grass, eelgrass, tape grass, spoon grass and shoal grass. These names are not consistently applied among countries. Coastal communities would almost certainly recognise the term “dugong grass” as referring to the shallow subtidal and intertidal seagrasses.

There is now a broad understanding of the range of species and seagrass habitats. Areas less well known include the southeast Pacific reefs and islands, South America, the southern Atlantic, the Indian Ocean islands, the west African coast, and Antarctica. Shallow sub-tidal and intertidal species distributions are better recorded than seagrasses in water greater than 10 m below MSL. Surveying deeper water seagrass is time consuming and expensive and it is likely that areas of deepwater seagrass are still to be located.

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

Tropical seagrasses occupy a variety of coastal habitats. Tropical seagrass meadows typically occur in most shallow, sheltered soft-bottomed marine coastlines and estuaries. These meadows may be monospecific or may consist of multispecies



communities, sometimes with up to 12 species present within one location. The stresses and limitations to seagrasses in the tropics are generally different than in temperate or subarctic regions. Temperature related 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 most likely to be controlled at its deepest edge by the availability of light for photosynthesis. Exposure at low tide, wave action and associated turbidity and low salinity from fresh water inflow determines seagrass species survival at the shallow edge. Seagrasses survive in the intertidal zone especially in sites sheltered from wave action or where there is entrapment of water at low tide, (e.g., reef platforms and tide pools), protecting the seagrasses from exposure (to heat, drying or freezing) at low tide.

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

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

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

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

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

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

It is important to document seagrass species diversity and distribution and 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 are still too limited and general for broad scale protection and management. Such information is needed to minimize future impacts on seagrass habitat worldwide. With



global electronic communication it is now possible to begin the process of assembling both formally published and unpublished notes 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.

With well-recorded events of seagrass loss from many coastal environments it is important to map and record the distribution of not only the location of existing seagrass but also areas of potential seagrass habitat. Such areas are generally shallow, sheltered coastal waters with suitable bottom type and other environmental conditions for seagrass growth. Potential habitat may include areas where seagrass was known to grow at some time in the past but from which it has recently been eliminated.

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.



**Notes:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



# Seagrasses of the Philippines

Seagrasses are a prominent component of Philippine coastal ecosystems (Fortes, 1995), where they sustain high primary production (Vermaat *et al.*, 1995; Agawin *et al.*, 1996) and provide habitat and food for economically important species (Fortes, 1995). The seagrasses of the Philippines are also important food for marine green turtles and dugongs.

The seagrass flora of Philippines is characterized by a high species richness and mixed meadows are common (Tomasko *et al.*, 1993; Vermaat *et al.*, 1995). There are 13 seagrass species found in the country, *Cymodocea rotundata*, *Cymodocea serrulata*, *Enhalus acoroides*, *Halodule pinifolia*, *Halodule uninervis*, *Halophila beccarii*, *Halophila decipiens*, *Halophila minor/ovata*, *Halophila ovalis*, *Halophila spinulosa*, *Syringodium isoetifolium*, *Thalassodendron ciliatum* and *Thalassia hemprichii* (Spalding 2000). These species present contrasting growth forms and growth capacities, from the small, fast-growing *Halophila* species to the large *E. acoroides*. The contrasting growth strategies have been postulated to confer on them differential capacities to survive disturbance (Terrados *et al.*, 1998). Large shoots (*E. acoroides*) or fast vertical growth (*C. serrulata*) may allow the plants to get closer to the water surface thereby overcoming light reduction or enhanced sedimentation under high suspended silt loads (Terrados *et al.*, 1998). Conversely, species with slow growth (*T. hemprichii*), will be more sensitive to environmental deterioration (Terrados *et al.*, 1998).

The contrasting sizes and growth strategies of SE Asian seagrasses suggest that these species respond differently to the same environmental forcing. Such species-specific responses have been documented for *E. acoroides*, *Thalassia hemprichii* and *Cymodocea rotundata*, three co-occurring seagrass species, which responded differently to nutrient enrichment (Agawin *et al.*, 1996), disturbance (Vermaat *et al.*, 1997; Duarte *et al.*, 1997a), and the elimination of neighbour species (Duarte *et al.*, 2000). Additionally, differences in pigment content and thickness of photosynthetic tissues explain most part of the variance in light harvesting (Agusti *et al.*, 1994), photosynthetic performance (Enriquez *et al.*, 1995), and maximum growth rates (Nielsen *et al.*, 1996) among aquatic macrophytes. Hence, temporal patterns in photosynthetic performance, biomass and growth rates might be strongly species-specific in mixed seagrass meadows in Southeast Asia.

There is some confusion regarding the distribution of seagrass in the Philippines. Some estimate only 975 km<sup>2</sup>, however others based on remote sensing estimate approximately 22,000 km<sup>2</sup> (Mike Fortes, Pers. Comm). Nevertheless, mapping of seagrass distribution is limited and ad-hoc.

In the Philippines, *Enhalus* is one of the most prominent seagrass species in mixed seagrass beds (Vermaat *et al.*, 1995). In the reef flats off Cape Bolinao, this species is able to colonize various habitat types (Vermaat *et al.*, 1995; Rollón *et al.*, 1998): muddy to coarse sandy substratum, turbid to clear waters and splash zones above zero datum to ca. 3m depth. Across this range in environmental conditions, *Enhalus* shoots differ in morphology, biomass and density (Rollón, 1998). Flowering occurs year-round, but the intensity varies temporally and correlates with mean water temperature (Rollon *et al.*, 2003b). Spatially, differences in flowering intensity correlated with available light as affected by turbidity and water depth. Exposure duration of female flowers to air seems to be crucial for pollination and subsequent seed setting, resulting in higher numbers of fruits in shallower sites. Based on reconstruction techniques (Duarte *et al.*, 1994), Duarte *et al.*, (1997) estimated that at Cape Bolinao, *Enhalus* produces 2.8 flowers per shoot per year on average and allocates up to 20% of its aboveground production to flowering and fruiting. Contrary to most seagrass species, *E. acoroides*



invests substantial resources in reproduction (Duarte *et al.*, 1997: 20% of annual aboveground productivity), and pollination occurs at the water surface. The length of the female peduncle limits successful pollination to low tide depths shallower than ca. 0.5 m. Vegetatively, the species occurs substantially deeper (Rollon, 1998). Rhizome branching frequency and longevity of shoots and rhizomes give rise to a patchy distribution of clonal fragments, with the gaps filled by other seagrasses, macroalgae or bare sediment. It has been suggested that production of gas bubbles in photosynthesis plays a key role in the release of male flowers, rather than the generally accepted belief that release of male flowers is a result of low spring tidal level. Allocation of biomass and nutrients (N, P) over various plant components suggests that sexual reproduction involves high cost in *E. acoroides* (Rollon *et al.*, 2003b).

Similar to other tropical seagrasses, *Enhalus acoroides* in Cape Bolinao are limited by the availability of nitrogen (Terrados *et al.*, 1999). The extent of nutrient limitation of *E. acoroides* is high variability both in space and time.

The other prominent seagrass species in Bolinao is *Thalassia hemprichii*. However, no persistent seed bank has been reported to be the present (Rollon *et al.*, 2003a). The survival of buried seeds was assessed experimentally since such a capacity is a prerequisite for the formation of seed bank. Rollon *et al.* (2003a) found a rapid germination of non-dormant seeds and development into seedlings. Such seedlings could not survive under buried conditions (5 and 10 cm) for longer than a week.

One of the most significant threats to seagrasses in SE Asia and the Philippines includes increased siltation from deforestation (Fortes, 1988, 1995). Philippine seagrass species richness and community leaf biomass decline sharply when the silt and clay content of the sediment exceeds 15% (Terrados *et al.*, 1998). *Syringodium isoetifolium* and *Cymodocea rotundata* are generally only present in multispecific meadows, while *Enhalus acoroides* is the only species which can remain in heavily silted sediments. The following ranking of species sensitivity to siltation is (from the least to most sensitive): *S. isoetifolium* → *C. rotundata* → *Thalassia hemprichii* → *Cymodocea serrulata* → *Halodule uninervis* → *Halophila ovalis* → *Enhalus acoroides*. Positive correlations have been found between species richness and both community leaf biomass and the leaf biomass of individual seagrass species. The relationships between percent silt and clay in the sediment and seagrass community leaf biomass and species richness provides useful dose–response relationships which can be used to set allowable or threshold siltation loads in SE Asian coastal waters, and indicate that species loss from seagrass meadows is an early warning of detrimental siltation loads (Terrados *et al.*, 1998).

Seagrass meadows in Bolinao and the Philippines are of significant importance to artisanal fisheries. One of the most important fishes includes the rabbitfish. Seagrass landscape patterns have been shown to influence fish abundance in Bolinao, but only in terms of continuity of vegetation (Salita *et al.*, 2003).

In the Philippines, production ecology of seagrasses (Estacion and Fortes, 1988, 1989) and seagrass epiphytes (Klumpp *et al.*, 1992) has been quantified. *Thalassia hemprichii* accounted for 80-93% of seagrass leaf biomass at Bolinao (Klumpp *et al.*, 1993). Growth rate of seagrass was 6.6 mm per shoot per day, or 2.3 mg AFDW per shoot per day. Production of seagrass leaves per unit area of seagrass bed varied with location from 870 to 1850 mg AFDW m<sup>-2</sup> day<sup>-1</sup>. Between 20 and 60% of the highly productive periphyton assemblage at Bolinao, is grazed by an epifaunal community dominated by gastropods (Klumpp *et al.*, 1992). Approximately 24% of annual seagrass production is grazed by urchins, but owing to large changes in urchin population structure and density, grazing impact is expected to vary from < 5% to > 100% at different times of year.



# Bolinao, Philippines - Seagrass Demonstration Site UNEP/GEF South China Sea Project

The project recognises the ecological and economic roles of seagrasses in Bolinao, and that the maintenance of their ecology and integrity will, in both the long and short term contribute to uplifting the lives of the citizens of this municipality. It also recognises that sustained efforts in this direction should involve local participation and initiatives. The project aims to establish functional linkages between and among community groups, academic institutions, with local and national government support, so that the seagrass ecosystems that form the resource base of local livelihoods will be enhanced, protected and managed. In addition, it will preserve the biodiversity in the seagrass meadows, marine fauna and flora alike, restore the degraded areas, and reduced threats and provide preventive actions to these threats.

## RATIONALE AND OBJECTIVES

The seagrass meadows of Cape Bolinao form the base of fishery resources for 35 barangays (a Philippine political unit). The seagrass meadows of Bolinao are seriously threatened through the direct and indirect effects of human settlement and coastal development leading to intense pressure and anthropogenic disturbances to the said habitat.

There is real need to take initiatives to protect, conserve and maintain the resources. Seagrass meadows play a very important role in the community since many of their livelihoods rely heavily on the seagrass beds. At present, most people in the community understand that the existing resource provides their livelihood. But the importance of linkage of seagrass beds with the other two major components of the marine ecosystem, mangroves and coral reefs, is not seriously considered.

Experience from other community-based initiatives shows that self-management of local resources is sustained and effective if user-communities take on ownership of management activities.

The objectives of the project are:

- To enhance resource management, particularly for seagrasses based on comprehensive data and information;
- To intensify and increase public awareness through information, education and communication campaign;
- To strengthen stakeholders' capacity in management of resources; and
- To design and implement alternative/supplemental livelihood program.

## OUTCOMES

With the implementation of the seagrass demonstration site in Bolinao, the following management outcomes are expected:

- A functional linkage among stakeholders;
- Increased public awareness;
- Strengthened capacity building among stakeholders;
- Improved legislation and enforcement practices from project recommendations
- Community establishment of protected sites;
- Sustained monitoring through Seagrass-Watch;
- Improved seagrass cover and maintenance of biodiversity;
- Developed and improved livelihood skills of coastal communities to protect and manage seagrass and related reef resources.

For more information, please contact Demonstration Site Manager  
Ms. Tutu B. Almonte  
City Agriculture Office  
Puerto Princesa City  
Palawan, Philippines  
Fax: (63 48) 433 2106  
E-mail: [tutualmonte@yahoo.com](mailto:tutualmonte@yahoo.com)



# A guide to the identification of western Pacific Seagrasses

Adapted from Waycott, M, McMahon, K, Mellors, J., Calladine, A., and Kleine, D (2004) A guide to tropical seagrasses in the Indo-West Pacific. (James Cook University Townsville) 72pp.

## Leaves cylindrical



cylindrical

### *Syringodium isoetifolium*

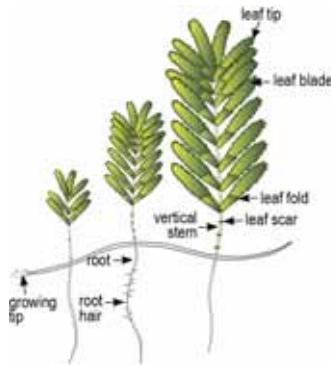
- Leaf tip pointed
- Leaves contain air cavities
- Inflorescence a “cyme”

## Leaves oval to oblong



oval to oblong

### obvious vertical stem with more than 2 leaves



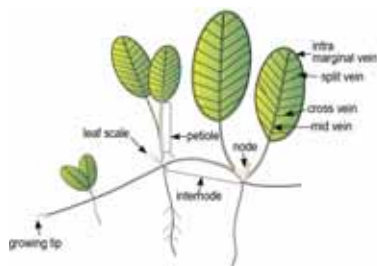
#### *Halophila spinulosa*

- leaves arranged opposite in pairs
- leaf margin serrated

#### *Halophila beccarii*

- leaves arranged in clusters of 5-10, at a node on vertical stem
- short vertical stem between clusters
- leaf clusters do not lie flat
- leaves elongate, with mid-vein and no obvious cross-veins
- leaf margin finely serrated

### leaves with petioles, in pairs



#### *Halophila decipiens*

- leaf margins serrated
- fine hairs on both sides of leaf blade
- male & female flowers on same plant

#### *Halophila minor*

- Leaf less than 5mm wide
- cross veins up to 10 pairs
- leaf margins smooth
- no leaf hairs
- separate male & female plants

#### *Halophila ovalis*

- cross veins more than 10 pairs
- leaf margins smooth
- no leaf hairs
- separate male & female plants

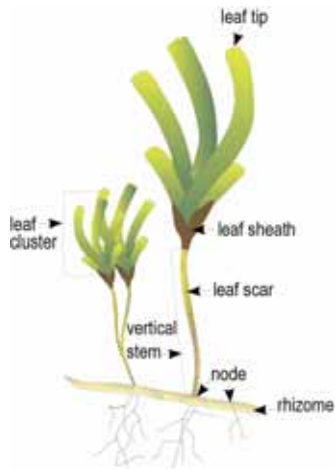


## Leaves strap-like

### Leaves can arise from vertical stem



strap-like



#### *Thalassia hemprichii*

- Leaf with obvious red flecks, 1-2mm long
- Leaf tip rounded may be slightly serrated
- Leaf often distinctly curved
- Distant scars on rhizome

#### *Cymodocea serrulata*

- Leaf tip rounded with serrated edge
- Leaf sheath broadly flat and triangular, not fibrous
- Leaf sheath scars not continuous around upright stem

#### *Cymodocea rotundata*

- Leaf tip rounded with smooth edge
- Leaf sheath not obviously flattened
- Leaf sheath scars continuous around upright stem

#### *Halodule uninervis*

- Leaf tip tri-dentate or pointed, not rounded
- Leaf with 3 distinct parallel- veins, sheaths fibrous
- Rhizome usually white with small black fibres at the nodes

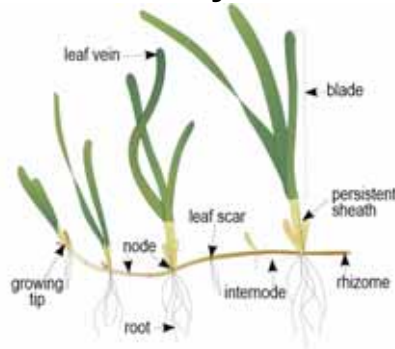
#### *Halodule pinifolia*

- Leaf tip rounded
- Leaf with 3 distinct parallel- veins, sheaths fibrous
- Rhizome usually white with small black fibres at the nodes

#### *Thalassodendron ciliatum*

- distinct upright stem
- clusters of curved leaves (>5 mm wide), margins serrated
- stem and rhizome woody

### Leaves always arise directly from rhizome



#### *Enhalus acoroides*

- large plant, leaves >30 cm long, >1 cm wide
- inrolled edges of leaves
- long, black bristles protruding from thick rhizome





# Monitoring a seagrass meadow

Environment monitoring programs provide coastal managers with information and assist them to make decisions with greater confidence. Seagrasses are often at the downstream end of catchments, receiving runoff from a range of agricultural, urban and industrial land-uses.

Seagrass communities are generally susceptible to changes in water quality and environmental quality that make them a useful indicator of environmental health. Several factors are important for the persistence of healthy seagrass meadows, these include: sediment quality and depth; water quality (temperature, salinity, clarity); current and hydrodynamic processes; and species interactions (e.g., epiphytes and grazers). Seagrass generally respond in a typical manner that allows them to be measured and monitored. In reporting on the health of seagrasses it is important to consider the type of factors that can effect growth and survival. Factors include:

- increased turbidity reduces light penetration through the water, interfering with photosynthesis and limiting the depth range of seagrass;
- increased nutrient loads encourages algal blooms and epiphytic algae to grow to a point where it smothers or shades seagrasses, also reducing photosynthetic capacity;
- increased sedimentation can smother seagrass or interfere with photosynthesis;
- herbicides can kill seagrass and some chemicals (e.g., pesticides) can kill associated macrofauna;
- boating activity (propellers, mooring, anchors) can physically damage seagrass meadows, from shredding leaves to complete removal;
- storms, floods and wave action can rip out patches of seagrasses.

## Seagrass-Watch

A simple method for monitoring seagrass resources is used in the Seagrass-Watch program. This method uses 50m by 50m sites established within representative intertidal meadows to monitor seagrass condition. The number and position of sites can be used to investigate natural and anthropogenic impacts.

Seagrass-Watch is one of the largest seagrass monitoring programs in the world. Since its genesis in 1998 in Australia, Seagrass-Watch has now expanded internationally to 18 countries. Monitoring is currently occurring at over 168 sites. To learn more about the program, visit [www.seagrasswatch.org](http://www.seagrasswatch.org).

Seagrass-Watch aims to raise awareness on the condition and trend of nearshore seagrass ecosystems and provide an early warning of major coastal environment changes. Participants of Seagrass-Watch are generally volunteers from a wide variety of backgrounds who all share the common interest in marine conservation and sustainability. Most participants are associated with established local community groups, schools, universities & research institutions, government (local & state) or non-government organisations.

Seagrass-Watch integrates with existing education, government, non-government and scientific programs to raise public awareness of these important marine ecosystems for the benefit of the community. The program has a strong scientific underpinning with an emphasis on consistent data collection, recording and reporting. Seagrass-Watch identifies areas important for seagrass species diversity and sustainability and the

information collected is used to assist the management of coastal environments and to prevent significant areas and species being lost. Seagrass-Watch is also a component of the Global Seagrass Monitoring Network.

Seagrass-Watch monitoring efforts are vital to assist with tracking global patterns in seagrass health, and assess the human impacts on seagrass meadows, which have the potential to destroy or degrade these coastal ecosystems and decrease their yield of natural resources. Responsive management based on adequate information will help to prevent any further significant areas and species being lost. To protect the valuable seagrass meadows along our coasts, the community, government and researchers have to work together.

THE GOALS OF THE PROGRAM ARE:

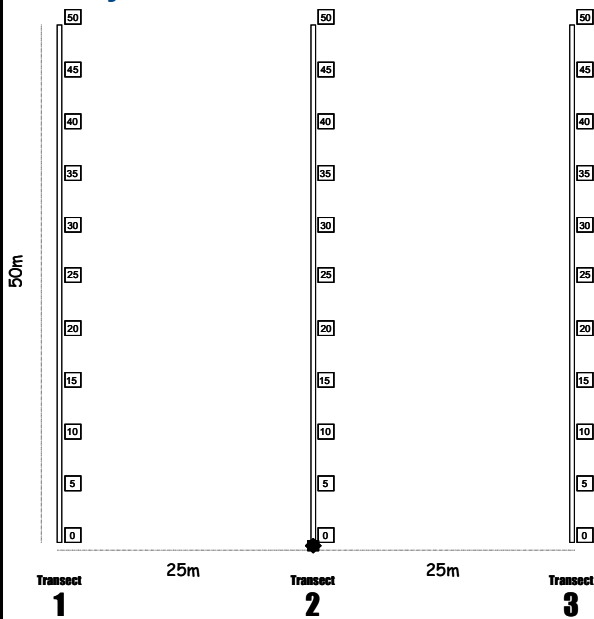
- To educate the wider community on the importance of seagrass resources
- To raise community awareness of coastal management issues
- To develop community participation and ownership
- To build the capacity of local communities in the use of standardised scientific methodologies
- To conduct long-term & broad-scale monitoring of seagrass & coastal habitats, and
- To provide an early warning system of coastal environment changes for management.



# Seagrass-Watch Monitoring Summary

Source: McKenzie, L.J., Campbell, S.J. & Roder, C.A. (2001) *Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers*. (QFS, NFC, Cairns) 100pp ([www.seagrasswatch.org/manuals.html](http://www.seagrasswatch.org/manuals.html))

## Site layout



**Quadrat code = site + transect+quadrat**

**e.g., CJ1225 = Chek Jawa site 1, transect 2, 25m quadrat**

## Pre-monitoring preparation

### Make a Timetable

Create a timetable of times of departure and arrival back, and what the objective of the day is and what is to be achieved on the day. Give a copy of this to all volunteers involved in advance so they can make their arrangements to get to the site on time. List on this timetable what the volunteers need to bring.

### Have a Contact Person

Arrange to have a reliable contact person to raise the alert if you and the team are not back at a specified or reasonable time.

## Safety

- Assess the risks before monitoring - check weather, tides, time of day, etc.
- Use your instincts - if you do not feel safe then abandon sampling.
- Do not put yourself or others at risk.
- Wear appropriate clothing and footwear.
- Be sun-smart.
- Adult supervision is required if children are involved
- Be aware of dangerous marine animals.
- Have a first aid kit on site or nearby
- Take a mobile phone or marine radio

## Necessary equipment and materials

- 3x 50metre fibreglass measuring tapes
- 6x 50cm plastic tent pegs
- Compass
- 1x standard (50cm x 50cm) quadrat
- Magnifying glass
- 3x Monitoring datasheets
- Clipboard, pencils & 30 cm ruler
- Camera & film
- Quadrat photo labeller
- Percent cover standard sheet
- Seagrass identification sheets

## Quarterly sampling

Within the 50m by 50m site, lay out the three 50 transects parallel to each other, 25m apart and perpendicular to shore (see site layout). Within each of the quadrats placed for sampling, complete the following steps:

### Step 1. Take a Photograph of the quadrat

- Photographs are usually taken at the 5m, 25m and 45m quadrats along each transect, or of quadrats of particular interest. First place the photo quadrat labeller beside the quadrat and tape measure with the correct code on it.
- Take the photograph from an angle as **vertical** as possible, which includes the entire quadrat frame, quadrat label and tape measure. Avoid having any shadows or patches of reflection off any water in the field of view. Check the photo taken box on datasheet for quadrat.

### Step 2. Describe sediment composition

- To assess the sediment, dig your fingers into the top centimetre of the substrate and feel the texture. Describe the sediment, by noting the grain size in order of dominance (e.g., Sand, Fine sand, Fine sand/Mud).

### **Step 3. Estimate seagrass percent cover**

- Estimate the total % cover of seagrass within the quadrat – use the percent cover photo standards as a guide.

### **Step 4. Estimate seagrass species composition**

- Identify the species of seagrass within the quadrat and determine the percent contribution of each species to the total cover. Use seagrass species identification keys provided.

### **Step 5. Measure canopy height**

- Measure canopy height of the seagrass ignoring the tallest 20% of leaves. Measure from the sediment to the leaf tip of at least 5 shoots.

### **Step 7. Estimate algae percent cover**

- Estimate % cover of algae in the quadrat. Algae are seaweeds that may cover or overlie the seagrass blades. Use “Algal percentage cover photo guide”.

### **Step 8. Estimate epiphyte percent cover**

- Epiphytes are algae attached to seagrass blades and often give the blade a furry appearance. First estimate how much of the blade surface is covered, and then how many of the blades in the quadrat are covered (e.g., if 20% of the blades are each 50% covered by epiphytes, then quadrat epiphyte cover is 10%).

### **Step 9. Describe other features and ID/count of macrofauna**

- Note and count any other features which may be of interest (eg. number of shellfish, sea cucumbers, sea urchins, evidence of turtle feeding).

### **Step 10. Take a voucher seagrass specimen if required**

- Seagrass samples should be placed inside a labelled plastic bag with seawater and a waterproof label. Select a representative specimen of the species and ensure that you have all the plant part including the rhizomes and roots. Collect plants with fruits and flowers structures if possible.

## **At completion of monitoring**

### **Step 1. Check data sheets are filled in fully.**

- Ensure that your name, the date and site/quadrat details are clearly recorded on the datasheet. Also record the number of other observers assisting.

### **Step 2. Remove equipment from site**

- Remove all tent pegs and roll up the tape measures. If the tape measures are covered in sand or mud, roll them back up in water.

### **Step 3. Wash & pack gear**

- Rinse all tapes, pegs and quadrats with freshwater and let them dry.
- Review supplies for next quarterly sampling and request new materials
- Store gear for next quarterly sampling

### **Step 4. Press any voucher seagrass specimens if collected**

- The voucher specimen should be pressed as soon as possible after collection. Do not refrigerate longer than 2 days, press the sample as soon as possible.
- Allow to dry in a dry/warm/dark place for a minimum of two weeks. For best results, replace the newspaper after 2-3 days.

### **Step 5. Submit all data**

- Data can be entered into the MS-Excel file downloadable from [www.seagrasswatch.org](http://www.seagrasswatch.org). Email completed files to [hq@seagrasswatch.org](mailto:hq@seagrasswatch.org)
- Mail original datasheets, photos and herbarium sheets

Seagrass-Watch HQ  
Northern Fisheries Centre  
PO Box 5396  
Cairns QLD 4870 AUSTRALIA



# Seagrass mapping

Seagrass-Watch activities initially map the distribution of seagrass meadows at a locality or in a region to better understand the seagrass resources of an area. Mapping is often limited to the accessible intertidal seagrasses, although in some cases subtidal seagrass meadows can be included.

The most important information that is required for management of seagrass resources is their distribution, ie. a map. It would be inappropriate to set up a monitoring program if the most basic information is unavailable - that is, whether seagrass is present or absent.

When planning a mapping task, there are several issues that need to be considered, including:

## *Scale*

Mapping requires different approaches depending on whether survey area is relative to a region (tens of kilometres), locality (tens of metres to kilometres) or to a specific site (metres to tens of metres). Scale includes aspects both of extent and resolution. In both broad and large scale approaches, the intensity of sampling will be low (low resolution), with a statistical sampling design that allows the results to be extrapolated from a few observations to the extent of the study area. For finer scale examinations of seagrass meadows, the sampling intensity required can be high with greater precision (high resolution). Scale also influences what is possible with a limited set of financial and human resources. The financial, technical, and human resources available to conduct the study is also a consideration.

## *Accuracy*

Determining the level of detail required when mapping an area also depends on the level of accuracy required for the final map product. Errors that can occur in the field directly influence the quality of the data. It is important to document these. GPS is a quick method for position fixing during mapping and reduces point errors to <3m in most cases. It is important for the observer to be as close as possible to the GPS aerial receiver to minimise position fix error.

## *Choosing a Survey/Mapping strategy*

The selection of a mapping scale represents a compromise between two components. One is the maximum amount of detail required to capture the necessary information about a resource. The other is the logistical resource available to capture that level of detail over a given area. Generally, an area can be mapped using a grid pattern or a combination of transects and spots. When mapping a region of relatively homogenous coastline between 10 and 100 km long, we recommend that transects should be no further than 500-1000 m apart. For regions between 1 and 10 km, we recommend transects 100-500 m apart and for localities less than 1 km, we recommend 50-100 m apart. This however may change depending on the complexity of the regional coastline, i.e., more complex, then more transects required.

To assist with choosing a mapping strategy, it is a good idea to conduct a reconnaissance survey. An initial visual (reconnaissance) survey of the region/area will give you an idea as to the amount of variation or patchiness there is within the seagrass meadow. This will influence how to space your ground truthing sites.



When mapping, ground truthing observations need to be taken at regular intervals (usually 50 to 100m apart). The location of each observation is referred to a point, and the intervals they are taken at may vary depending on the topography.

When ground truthing a point, there are a variety of techniques that can be used depending on resources available and water depth (free dives, grabs, remote video, etc). First the position of a point must be recorded, preferably using a GPS. Otherwise use a handheld compass to determine the bearing, triangulating to at least 3 permanent landmarks or marker established as reference points. A point can vary in size depending on the extent of the region being mapped. In most cases a point can be defined as an area encompassing a 5m radius. Although only one observation (sample) is necessary at a ground truth point, we recommend replicate samples spread within the point (possible 3 observations) to ensure the point is well represented.

Observations recorded at a point should ideally include some measure of abundance (at least a visual estimate of biomass or % cover) and species composition. Also record the depth of each point (this can be later converted to depth below mean sea level) and other characteristics such as a description of the sediment type (eg. shell grit, rock, gravel, coarse sand, sand, fine sand or mud), or distance from other habitats (reefs or mangroves).

For details on the necessary materials & equipment and the general field procedure for mapping a seagrass meadow, please see Chapter 4 of the Seagrass-Watch manual ([www.seagrasswatch.org/manuals.html](http://www.seagrasswatch.org/manuals.html)).

## Creating the map

The simplest way to map the distribution of seagrasses is to draw the meadows on a paper marine chart from the GPS positions of the ground truth sites. The problem with this type of mapping is that the final map is in a format that does not allow manipulation and transformation. The layout of a paper map is permanent, which makes it difficult for future seagrass mapping studies to be compared, queried and analysed. If resources are available, we recommend that the data be transferred to a digital format and a Geographic Information System (GIS) be used. A detailed description of using and mapping with GIS is beyond the scope of this manual, and we recommend consulting with a scientist experienced in mapping and reading McKenzie *et al.* (2001b).





## Using Global Positioning System (GPS) to map the meadow edge/boundary

The meadow boundary is mapped by recording (or marking) a series of waypoints along the edge of the meadow from which a line representing the meadow boundary can then be drawn.

To map the boundary you should:

- Walk along the meadow edge, stopping to record (mark) waypoints on your GPS approximately every 10 steps or where there is a change in direction of the meadow boundary.
- Alternatively, you can use the “track” feature if the meadow boundary is clear.
- Only record a waypoint when you are sure you are on the edge of the meadow. For meadows where the edge is patchy you may have to do some reconnaissance to make sure you are at the edge of the seagrass meadow before recording a waypoint.
- Keep in mind that others may be using the points that you record on the GPS to draw a line (*“join the dots”*) that represents the meadow boundary, so it is better to have too many points than too few.
- Stand still for approximately 10 seconds on a point before recording (marking) a waypoint. It is good to keep checking the accuracy (in the top right of the screen) to ensure the point is as accurate as possible (generally less than 5m).
- As waypoints are labelled by sequential numbers, ensure you record the label of the first and last waypoint. If you make an error, either delete the waypoint or note the erroneous waypoint.
- At the conclusion of the sampling trip the waypoints you record should be downloaded onto your computer (see later section)

## Using the GARMIN GPS 72

### Turn GPS Receiver On.

Hold down the Red button for 2 seconds. Wait a few seconds and the GPS unit will begin to track available satellites. Make sure to hold the GPS in a vertical position (top to the GPS pointing to the sky) for best reception of satellite signals.



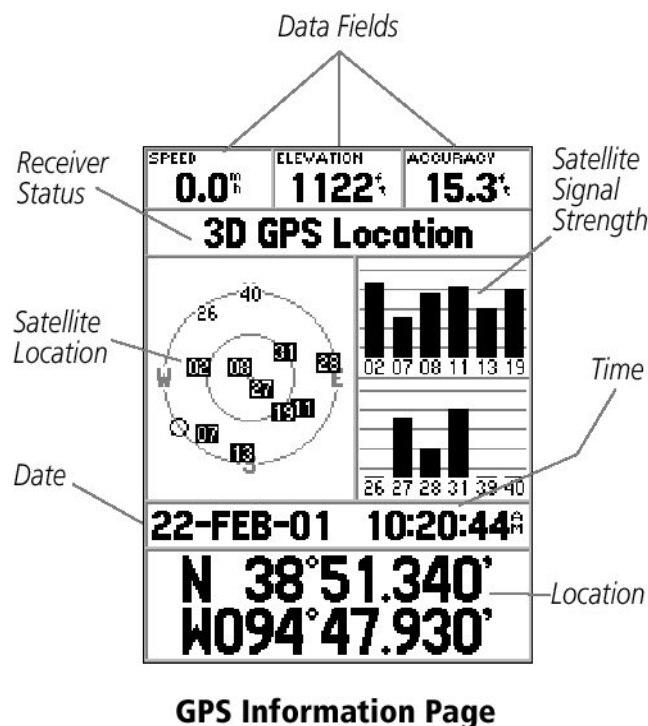


## Using the Interface Keys on the GPS

- **IN & OUT** keys – used on the Map Page to zoom in and out.
- **GOTO/MOB** key – used to begin or stop navigation to a waypoint.
- **PAGE** key – used to cycle through the five main display pages in sequence.
- **POWER** key – used to turn the GPS on or off by holding the button down for 2 seconds.
- **MENU** key – used to display a variety of GPS options which can be altered to suit usage. Press the Menu key twice to access the Main Menu.
- **QUIT** key – used to cycle in reverse to the Page key. Also used to cancel operation in progress.
- **ENTER/MARK** key – used to activate or confirm a selection. To record a Waypoint, press and hold down the ENTER/MARK key.
- **ROCKER** key – used to move up/down and left/right to access and change menu options, and for data entry. The ROCKER key is always used to scroll through the different menu options and the ENTER key is used to activate or confirm the selection.

## Tracking satellites.

Continue to press the PAGE key until the GPS Information Page appear (the Information Page looks like the diagram just below). When the GPS receiver is tracking enough satellites (minimum four), the GPS Information appears.



Receiver is now ready to record Waypoints. It is recommended that there are at least four satellites are present and have a strong signal when marking the waypoints. The more satellites available the better the accuracy.

Before any waypoints are to be collected, you must check that the GPS settings are correct. The settings are in the Main Menu.





## Setting up the correct properties in the Main Menu

- To get to the Main Menu you must press the **Menu** key twice.
- Scroll down to highlight “Setup” and press **Enter**.
  1. You must use the **ROCKER** key and move to the appropriate field and use the **ENTER** key to activate the field.
  2. Then use the **ROCKER** key (to move up/down and left/right) to access the appropriate setting and use the **ENTER** key to confirm selection.
  3. Once changes are made, use the **QUIT** to exit each of the option or menu.
- Scroll across to the “Time” tab and change to the Time settings.

### Time Setup

Time Format : 24 Hour  
 Time Zone : Other  
 UTC Offset: +8:00

- Scroll across to the “Location” tab and change to the Time settings.

### Units Setup

Elevation : Meters  
 Distance and Speed: Metric  
 Temperature: Celsius

- Scroll across to the “Location” tab and change to the Time settings.

## Location Setup

Location Format : hddd.ddddd  
 MAP DATUM : WGS84

- Scroll across to the “Interface” tab and change to the Time settings.

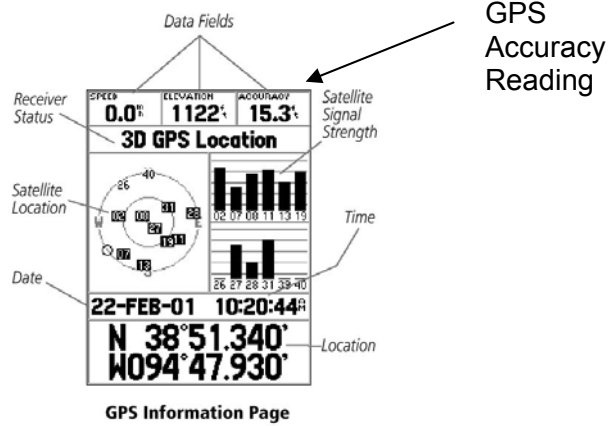
### Interface Setup

Serial Data Format: Garmin

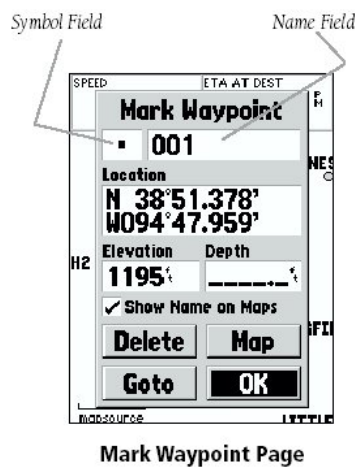
## Mark Location as Waypoints

Mark Waypoints are stored as point locations.

To record Waypoints, it is best to be in the Information Page (continue to press the PAGE button until the Information page appears). Before you record a Waypoint, you must look at the accuracy reading on the GPS Information Page. An acceptable accuracy should be less than 15 metres (<15 m)



**Step 1.** Press and hold the **ENTER** key. The following screen appears:



To save the waypoint without any changes, press **ENTER** on the OK button to save the waypoint.

- Step 2.** You can choose to rename the waypoint number to another name by using the **ROCKER** key to highlight the Name field, then press **ENTER**.
- Step 3.** Use the **ROCKER** key as an Alpha-numeric key selection to type in the new waypoint name. Press the **ENTER** key to accept the name.
- Step 4.** You can choose to delete the waypoint by highlighting 'DELETE?', press **ENTER** and then highlight the 'Yes' prompt and press **ENTER** again to confirm.

### Use the Goto option to get to a location.

- Press the **GOTO** key.
- Highlight the "Waypoint" then press the **ENTER** key.
- Use the **ROCKER** key to highlight the waypoint you want to go to, press the **ENTER** key.
- Press the **PAGE** key until you get to the Map Page to see where you are (use the **IN** or **OUT** key to zoom in or out). Press the **PAGE** key until you get to the Compass Page to see where you need to be heading to get to the waypoint.



## Installing the program MAPSOURCE to download information from your GPS to your computer

### Step 1: Installing MapSource

*Before installing MapSource, all programs should be closed.*

1. Put CD into the CD Drive (Place the CD in with CD labels facing up)
2. If the MapSource setup menu does not appear automatically, Go to **Windows Explorer** (Select Start, Programs, Windows Explorer)
  - Double Click on CD Drive (This could either be D: or E: drive on your computer)
  - Double click on "**Setup.exe**" (To startup the setup program [about 70kb])
    - i. Click **Next** (To say OK to the Welcome Page)
    - ii. Click **Yes** (To accept License Agreement)
    - iii. Click **No** (When ask to check GPS)
    - iv. Click **No** (To confirm not checking the GPS)
    - v. Click **Next** (To select typical install)
    - vi. Click **Finish** (To complete installation)

### Step 2: Installing Updated files for Mapsource

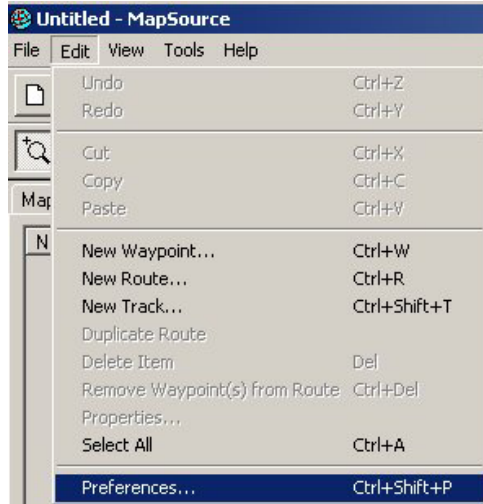
1. While the **CD** is still in the CD drive,
3. Go to **Windows Explorer** (Select Start, Programs, Windows Explorer)
2. Double Click on CD Drive (This could either be D: or E: drive on your computer)
3. Double Click the **Mapsource Upgrade** folder (You will see a MapSource\_680.exe file)
4. Double Click on the file **mapsource\_680.exe** (This will startup the setup program to MapSource)
5. Click **Next** (To choose English language)
6. Click **Next** (To accept MapSource Version 6.8)
7. Click **Yes** (To accept License Agreement)
8. Click **Finish** (To complete installation)
9. Eject CD and take disc out



### Step 3: Setting the correct Properties for MapSource

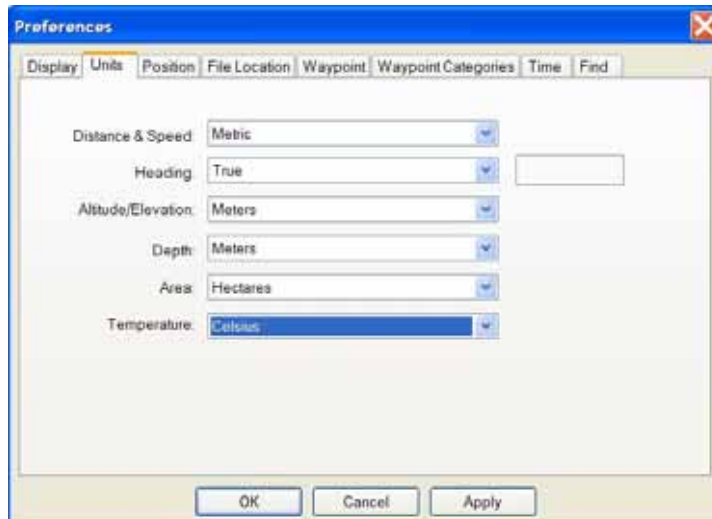
Before using MapSource you must set up some map properties to view the data.

1. Start MapSource (Click the MapSource Icon on the desktop)
2. Go to the **Edit** menu and select **Preferences**



3. The Preferences window will appear.

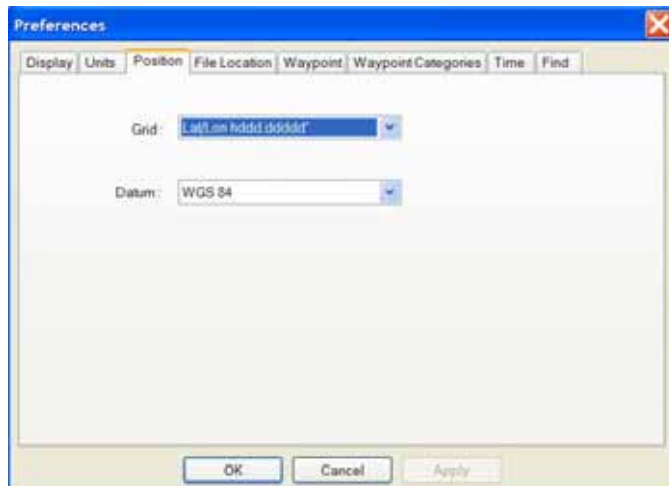
Go to the **Units** tab



You must set the following properties:

- Distance & Speed      Metric
- Heading                True
- Altitude/Elevation    Meters
- Depth                   Meters
- Area                    Hectares
- Temperature           Celsius

4. Go to the **Position** tab



You must set the following properties:

- Grid                    Lat/Lon hddd.ddddd
- Datum                 WGS 84

5. Click OK to finish.

6. MapSource is now correctly set up for use.



## Downloading information from your GPS using the MapSource program

### Step 1: Downloading GPS data using MapSource (download software)

1. Start MapSource (Double click on the MapSource Icon) or (start, programs, MapSource, MapSource)
2. Plug the Garmin serial cable from your GPS unit to the communications port on your computer.
3. On the GPS unit, make sure that the Garmin interface is set to “**GARMIN**” on the GPS 72. To Check this, go to the “Setup menu”, select “Interface”, select “GARMIN”.
4. In the MapSource program, go to the **Transfer** menu and select “**Receive from Device..**”. The following menu will appear.

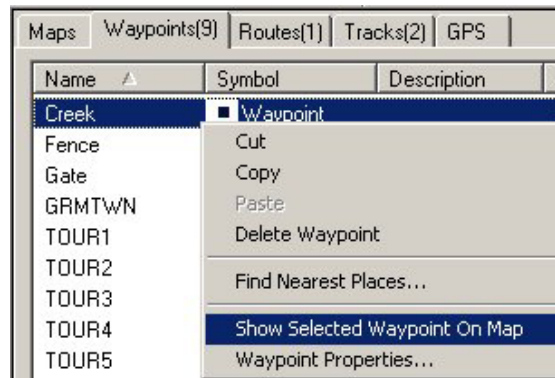


5. Click on the **Receive** button.
6. The GPS data will begin to download to the MapSource software. Click OK after data is successfully opened.

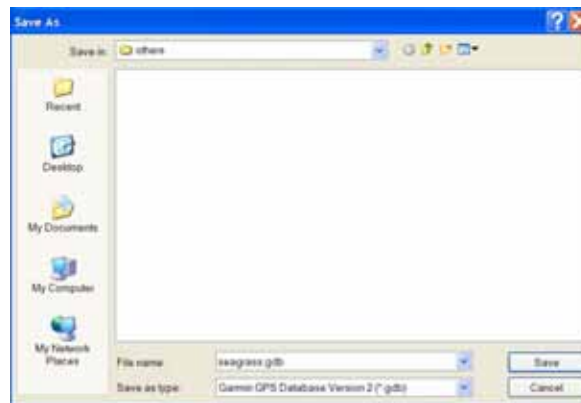


## Saving GPS data in MapSource

1. To Check the GPS data that has just been downloaded, click on the “Waypoints” tab (the full list of all waypoints are listed).
2. To view the waypoints on the MapSource map area, right click on any of the waypoints (a context menu will appear) and select “**Show Selected Waypoint On Map**”. The waypoint will be shown on the map



3. You must always save the GPS data that has been downloaded to MapSource. To save the GPS data in MapSource, Click on “**File**” menu, then select “**Save**”. A “Save As” window will appear. Browse to the directory where you want to save the file in and type in a file name. Click “Save” and the MapSource file is save (this file contains all the GPS data).



The advantages for saving the GPS data are:

- GPS data will not be lost when the data is save in a MapSource file (\*.mps) to your PC.
- The GPS data on the GPS unit can be deleted. The GPS unit will have the maximum memory space available for any further data capture use.
- Once the GPS data is saved as a MapSource file, the data can always be uploaded back onto the GPS unit.



---

**Notes:**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....





# Managing seagrass resources

## Threats to seagrass habitats

Destruction or loss of seagrasses have been reported from most parts of the world, often from natural causes, e.g., "wasting disease" or high energy storms. However, destruction commonly has resulted from human activities, e.g., as a consequence of eutrophication or land reclamation and changes in land use. Increases in dredge and fill, construction on the shoreline, damage associated with commercial overexploitation of coastal resources, and recreational boating activities along with anthropogenic nutrient and sediment loading have dramatically reduced seagrass distribution in some part of the world. Anthropogenic impacts on seagrass meadows continue to destroy or degrade coastal ecosystems and decrease seagrass functions and values, including their contribution to fisheries. It is possible global climate change will have a major impact. Efforts are being made toward rehabilitation of seagrass habitat in some parts of the world: transplantation, improvement of water quality, restrictions on boating activity, fishing and aquaculture, and protection of existing habitat through law and environmental policy.

## Management

Seagrasses do not exist in nature as a separate ecological component from other marine plants and 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. In temperate waters, algae beds, salt marshes, bivalve reefs, and epiphytic plant communities are closely associated with areas of seagrass. Many management actions to protect seagrasses have their genesis in the protection of wider ecological systems or are designed to protect the overall biodiversity of the marine environment.

Seagrasses are also food for several marine mammal species and turtles, some of which (such as the dugong *Dugong dugon*) are listed as threatened or vulnerable to extinction in the IUCN Red List (IUCN 2000). Seagrasses are habitat for juvenile fish and crustaceans that in many parts of the world form the basis of economically valuable subsistence and/or commercial fisheries. The need to manage fisheries in a sustainable way has itself become a motivating factor for the protection of seagrasses.

Coastal management decision making is complex, and much of the information on approaches and methods exists only in policy and legal documents that are not readily available. There may also be local or regional Government authorities having control over smaller jurisdictions with other regulations and policies that may apply. Many parts of South East Asia and the Pacific Island nations have complex issues of land ownership and coastal sea rights. These are sometimes overlaid partially by arrangements put in place by colonising powers during and after World War II, leaving the nature and strength of protective arrangements open for debate.

Both Australia and the United States have developed historically as Federations of States with the result that coastal issues can fall under State or Federal legislation depending on the issue or its extent. In contrast, in Europe and much of South East Asia, central Governments are more involved. Intercountry agreements in these areas such as the UNEP Strategic Action Plan for the South China Sea and the Mediterranean Countries Barcelona Convention (<http://www.unep.org/>) are required to manage marine issues that encompass more than one country.



Approaches to protecting seagrass tend to be location specific or at least nation specific (there is no international legislation directly for seagrasses as such that we know of) and depend to a large extent on the tools available in law and in the cultural approach of the community. There is, however, a global acceptance through international conventions (RAMSAR Convention; the Convention on Migratory Species of Wild Animals; and the Convention on Biodiversity) of the need for a set of standardised data/information on the location and values of seagrasses on which to base arguments for universal and more consistent seagrass protection.

We suggest that there are six precursors to successful management of coastal seagrasses:

1. Important fish habitat is known and mapped
2. Habitat monitoring is occurring
3. Adjacent catchment/watershed impacts and other threats are managed
4. Some level of public goodwill/support is present
5. Legal powers exist that are robust to challenge
6. There is effective enforcement and punishment if damage occurs

The key element is a knowledge base of the seagrass resource that needs to be protected and how stable/variable that resource is. It is also important to know if possible any areas that are of special value to the ecosystems that support coastal fisheries and inshore productivity. It is important as well that this information is readily available to decision makers in Governments in a form that can be easily understood.





## References

- Agawin, N. S. R., Duarte, C. M. & Fortes, M. D. 1996 Nutrient limitation of Philippine seagrasses (Cape Bolinao, NW Philippines): in situ experimental evidence. *Marine Ecology Progress Series* 138, 233–243.
- Agawin, N. S. R., Duarte, C. M. & Fortes, M. D., Uri, J.S. and Vermaat, J.E. (2001). Temporal changes in the abundance, leaf growth and photosynthesis of three co-occurring Philippine seagrasses. *Journal of Experimental Marine Biology and Ecology*. **260**: 217–239
- Carruthers TJB, Dennison WC, Longstaff BJ, Waycott M, Abal EG, McKenzie LJ and Lee Long WJ. (2002). Seagrass habitats of northeast Australia: models of key processes and controls. *Bulletin of Marine Science* 71(3): 1153-1169.
- Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neil RV, Paruelo J, Raskin RG, Sutton P and van der Belt M. (1997). The Value of the world's ecosystem services and natural capital. *Nature* 387(15): 253-260.
- David W. Klumpp, J.T. Salita-Espinosa and M.D. (1993) Fortes Feeding ecology and trophic role of sea urchins in a tropical seagrass community. *Aquatic Botany*, 45 205-229.
- den Hartog C. (1970). The seagrasses of the world. (North-Holland Publishing, Amsterdam). 293pp.
- Duarte, C.M., Marbà, N., Agawin, N., Cebrián, J., Enríquez, S., Fortes, M., Gallegos, M.E., Merino, M., Olesen, B., Sand-Jensen, K., Uri, J., Vermaat, J., 1994. Reconstruction of seagrass dynamics: age determinations and associated tools for the seagrass ecologist. *Mar. Ecol. Progr. Ser.* 107, 195–209.
- Duarte, C.M., Uri, J.S., Agawin, N.S.R., Fortes, M.D., Vermaat, J.E., Marbà, N., 1997. Flowering frequency of Philippine seagrasses. *Bot. Mar.* 40, 497–500.
- Estacion, J.S. and Fortes, M.D., 1988. Growth rates and primary production of *Enhalus acoroides* (L.f.) Royle from Lag-It, north Bais Bay, the Philippines. *Aquat. Bot.*, 29: 347-356.
- Fortes, M.D., 1989. Seagrasses: A resource unknown in the ASEAN region. ICLARM Education Series 5, ICLARM, Manila, 46 pp.
- Fortes, M. D. 1995 Seagrasses of East Asia: Environmental and Management Perspectives. RCU/EAS Technical Report Series No. 6. United Nations Environment Programme, Bangkok.
- Green EP. and Short FT (Eds) (2003). World Atlas of Seagrasses. Prepared by the UNEP World Conservation Monitoring Centre. (University of California Press, Berkeley. USA). 298pp.
- Klumpp, D.W., Salita-Espinosa, J. and Fortes, M.D., 1992. The role of epiphytic periphyton and macroinvertebrate grazers in the trophic flux of a tropical seagrass community. *Aquat. Bot.*, 43: 327-349.
- Lanyon JM, Limpus CJ and Marsh H. (1989). Dugongs and turtles: grazers in the seagrass system. In: *Biology of Seagrasses: A treatise on the biology of seagrasses with special reference to the Australian region.* (AWD Larkum, AJ McComb and SA Shepherd eds). (Elsevier: Amsterdam, New York). pp 610-34.
- McKenzie LJ, Campbell SJ, Roder CA (2001). Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community (citizen) volunteers. (QFS, NFC, Cairns) 94pp.



- McKenzie LJ, Finkbeiner MA and Kirkman H (2001b). Methods for mapping seagrass distribution. Chapter 5 pp. 101-122 In: Short FT and Coles RG (eds) 2001. Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam. 473pp.
- Phillips, R.C, E.G Menez. (1988). Seagrasses. Smithsonian Institution Press, Washington, D.C. 104 pp.
- Rollón, R.N., de Ruyter van Steveninck, E.D., van Vierssen, W., Fortes, M.D., 1998. Contrasting recolonization strategies in multi-species seagrass meadows. *Mar. Poll. Bull.* 37, 450–459.
- Rollón, R.N., Vermaat, J.E. and Nacorda, H.M.E. (2003a). Sexual reproduction in SE Asian seagrasses: the absence of a seed bank in *Thalassia hemprichii*. *Aquatic Botany* **75**: 181–185
- Rollón, R.N., de Ruyter van Steveninck, E.D. and van Vierssen, W. (2003b). Spatio-temporal variation in sexual reproduction of the tropical seagrass *Enhalus acoroides* (L.f.) Royle in Cape Bolinao, NW Philippines. *Aquatic Botany* **76**: 339–354
- Salita, J.T., Ekau, W. and Saint-Paul, U. (2003). Field evidence on the influence of seagrass landscapes on fish abundance in Bolinao, northern Philippines. *Mar Ecol Prog Ser* **247**: 183–195.
- Short, FT and Coles, RG. (Eds.) Global Seagrass Research Methods. Elsevier Science B.V., Amsterdam. 473pp.
- Terrados, J. C. M. Duarte, M. D. Fortes, J. Borum, N. S. R. Agawin, S. Bach, U. Thampanya, L. Kamp-Nielsen, W. J. Kenworthy, O. Geertz-Hansen and J. Vermaat (1998). Changes in Community Structure and Biomass of Seagrass Communities along Gradients of Siltation in SE Asia. *Estuarine, Coastal and Shelf Science* **46**: 757–768
- Terrados, J., Agawin, N.S.R., Duarte, C.M., Fortes, M.D., Kamp-Nielsen, L. and Borum, J. (1999). Nutrient limitation of the tropical seagrass *Enhalus acoroides* (L.) Royle in Cape Bolinao, NW Philippines. *Aquatic Botany* **65**: 123–139.
- Tomasko, D. A., Dawes, C. J., Fortes, M. D., Largo, D. B. & Alava, M. N. R. 1993 Observations on a Multi-species Seagrass Meadow Offshore of Negros Oriental, Republic of the Philippines. *Botanica Marina* 36, 303–311.
- Vermaat, J. E., Agawin, N. S. R., Duarte, C. M., Fortes, M. D., Marba', N. & Uri, J. S. 1995 Meadow maintenance, growth and productivity of a mixed Philippine seagrass bed. *Marine Ecology Progress Series* 124, 215–225.
- Waycott, M, McMahon, K, Mellors, J., Calladine, A., and Kleine, D (2004) A guide to tropical seagrasses in the Indo-West Pacific. (James Cook University Townsville) 72pp.

**Please complete the following statements in your own words**

1. Hindi koakalain na [*I did not realize that*] .....

.....  
.....  
.....  
.....

2. Ngayon ko nain tendihau [*Now I understand that*] .....

.....  
.....  
.....  
.....

3. Pagbalik ko sa area [*When I go back to my area, I will*].....

.....  
.....  
.....  
.....

4. Sana [*It could have been better if*] .....

.....  
.....  
.....  
.....



# Notes:

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....