# Spectral Characteristics of Seagrass with Landsat TM in Northern Sabah Coastline, Malaysia

Mazlan Hashim, Ridzwan Abd. Rahman[1], Mazlani Muhammad and Abd Wahid Rasib
Department of Remote Sensing
Faculty of Geoinformation Science & Engineering
**Universiti Teknologi Malaysia (UTM)**
81310 UTM, Skudai, Johor Malaysia
Email: mazlan@fksg.utm.my

[1] Borneo Marine Research Institute
**Universiti Malaysia Sabah (UMS)**
Locked Bag 2073, 88999 Kota Kinabalu
Sabah, Malaysia

**ABSTRACT**

*The spectral characteristics of Landsat TM bands 1, 2 and 3 were examined over identified seagrass area in the South China Sea, off northern coastline of Kota Kinabalu, Sabah, Malaysia. Two seagrass types namely the low and high dense classes were used in this study. Two main extraction techniques employed were the spectral transform based on band ratioing and radiative transfer model. Results of this study indicated that band ratio of band 2/band 1 gave a better high dense and low dense seagrass distribution than band 3/band 1 whereas band ratioing after applying radiative transfer model could not detect any seagrass in the study area.*

## 1.0 INTRODUCTION

Seagrass are marine plants found near-shore waters. They are one of the most highly productive tropical ecosystems and act as shelter and food for near shore fisheries, marine reptiles and mammals (EPU *et. al*, 2000). It is important to extract the sea-grass for monitoring of their features (Hardy *et al.* 1992). Remote sensing technique has been successfully utilized for extraction of submerged substrates namely coral reef and seagrass in shallow clear water. Over the pass two decades, the short visible bands of Landsat Thematic Mapper and SPOT multispectral data have been widely used to derived coral reef and seagrass, and the techniques employed can be grouped into three general categories: (i) using spectral transform (Holden *et. al*, 2000), (ii) ratioing technique (Hyland *et. al*, 1989), and (iii) based on radiative transfer model (RTM) (Bierwirth *et. al*, 1993 and Hashim *et. al*, 2000). In the first method, the extraction of substrate information is carried out by using spectral transform to enhance the spectral pattern of the water-leaving radiance, which then visual analyze on the display system for the final output. Amongst, the spectral transforms used are the canonical analysis (Fadda *et al*. 1996 and Allen *et al*. 1990) principal component transform (Zainal *et al*. 1993) and contrast enhancements (Lennon *et al.* 1989). The second method is based on band ratioing between the shortest wavelengths with the next wavelength in the band sequence of the data system that is ratioing band 2 with band 1 of the Landsat TM. The simple ratioing method is able to normalized the scattering due to the water surface effect (Hyland *et al.* 1989), hence enhance the submerged substrates. Final information of the substrate are again analyse from display system. The last method is based on the use of the radiative transfer model which the water leaving radiance and the contributing factors such as atmospheric perturbations including, the path radiance, scattering within surface and sub-surface have been minimized. The latter method requires elaborate in-situ samples including substrate's reflectance and its corresponding depth. All the above-mentioned techniques, however, have been so far derive only "one-type" of substrate such seagrass or coral reef. Subsequently, this paper will examine second and third methods to enhance seagrass type at selected test sites in the case one water in South China Sea off northern coastline of Kota Kinabalu, Sabah, Malaysia. The ratioed of the first three bands of the Landsat TM were used as input into the radiative transfer model. Two seagrass types examined in this study are the high and low dense classes of seagrass. The classes are the combination of different species of seagrass.

Apart from the extraction method, there are always problems when analyzing multispectral image data due to the existence of extensive inter-band correlation. It will produce data from various wavelength bands appear similar.

The ratioing of the bands is one of the simplest mean to minimize these effects that were largely influenced by the atmospheric perturbations (Lillesand *et al*. 2000). In addition, the atmospheric corrections were also applied to the raw image prior to the extraction of seagrass information. The spectral characteristics of seagrass occurance in the band 1, 2 and 3 of Landsat TM were also analysed prior and after the atmospheric correction. This paper is a part of preliminary results obtained in the study undertaken jointly by UTM and UMS to map distribution of seagrass along coastline of Sabah.

## 2.0 MATERIAL AND METHODS

### 2.1 Study area

The study area is situated in the west coast of Sabah's state capital, Kota Kinabalu. This includes small islands in the vicinity such as Pulau Gaya, Pulau Sapi, Pulau Mamutuk, P. Sulug and Pulau Sapi as shown in Figure 1. Geographical coordinates of 645000 m bound this area to 718000m latitude and 673000m to 736500m longitudes. The islands have meadows of dense seagrass and also in patches of varying density. They are found at depths between 0.5 m to 18 m (mean sea level) (Japar Sidik *et al*. 1997).

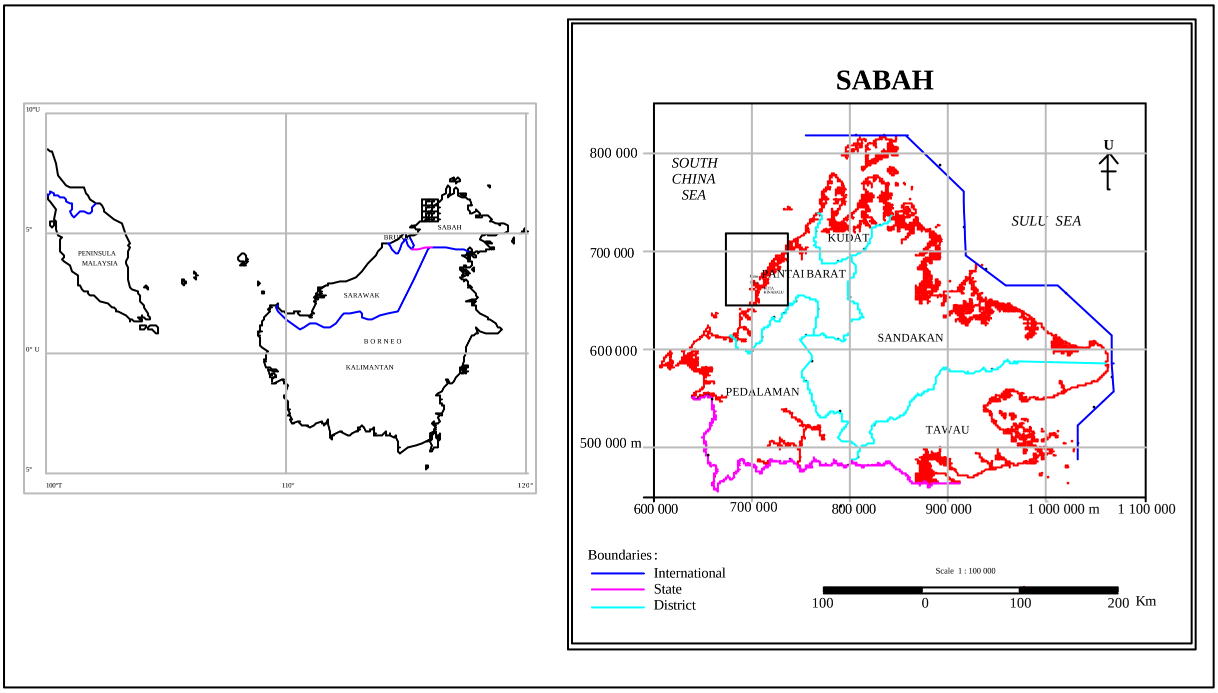



Figure 1: Study Area

The latest seagrass found in Police Beach 1, Pulau Gaya is *Halophila Spinulosa* and the total number of seagrass species known in Sabah becomes eleven (Japar Sidik, 1999). The other seagrasses are *Enhalus acoroides* (L.f.) Royle, *Halophila decipiens* Ostenf., *Halophila ovalis* (R. Br.) Hook. F., Halophila *minor* (Zoll.) Den Hartog, *Halodule uninervis* (Forssk.) Aschers., *Halodule pinifolia* (Miki) Den Hartog, *Cymodocea rotundata* Ehrenb. & Magnus, *Thalassia hemprichii* (Ehrenb.) Aschres. And *Syringodium isoetifolium* (Aschers.) Dandy (Japar Sidik *et al*. 1997).

Plant size and shoot densities are the measurement of seagrass biomass and leaf growth (Fortes, 1990). For the purpose of this study, plant size and shoot density were not taken into consideration for identification of seagrass density but seagrass meadow and patches were considered as high dense seagrass and low dense seagrass respectively.

## 2.2 Satellite Data

The Landsat-5 TM data used in this study were acquired on 12 February 1999. Three visible bands, band 1 (0.45 – 0.52 µm), band 2 (0.52 – 0.60 µm) and band 3 (0.63 – 0.69 µm) were selected because of their water penetration characteristic. Band 4 (0.75 – 0.90 µm) were used for masking of water from land.

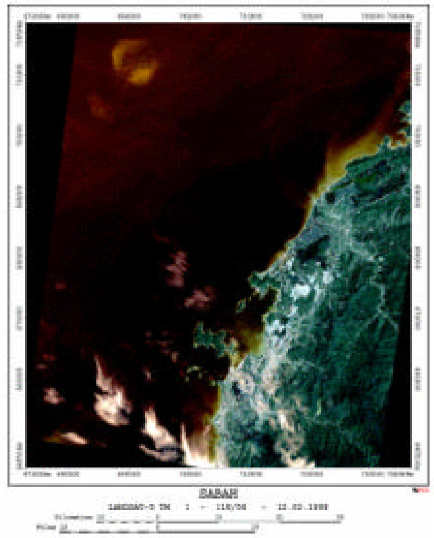



Figure 2: Landsat-5 TM

## 2.3 Preprocessing

a) Atmospheric correction

The image were corrected using 'Fast Atmospheric Correction" (Richter, 1990) which also can address the adjacency effect of water-leaving radiances from the neighboring pixels. Since the nature of sea-grass dwellings is "clustered " in the case of the dense type and "scattered" for the low dense type, the adjacency effect within "sea-grass pixels" is significant.

b) Geometric correction

This image was registered to a digitized map of the corresponding area using second-order polynomial transformation, nearest neighbour resampling scheme. The root mean square error of the geometric correction was ± one pixel using a total number of 13 ground control points.

## 2.4 Data Processing

Three main tasks were carried out: (1) to enhance seagrass using band ratioing and RTM methods; (2) spectral analysis of seagrass within Landsat TM bands used (original and enhanced data); and (3) the extraction of seagrass by thresholding the spectral occurance in accordance to the dynamic range of the respective bands. In the first task, two band ratioing were carried out, namely ratio of band 2/band 1 and band 3/band 1. These ratio bands performed to enhance chlorophyll presents in the seagrass. With regards to the second task, univariate standard of seagrass occurance in the band used. This is achieved by overlying the image with ground truth data collected from the corresponding area shown in Figure 3 compiled from survey conducted by Borneo Marine Research Institute, UMS. The last task is the extraction of seagrass based on thresholding..

## 3.0 RESULT AND DISCUSSION

(a) Spectral analysis

The spectral analysis of Landsat TM bands 1, 2 and 3 were tabulated in Table 1 and the seagrass extracted using the thresholds values indicated by the individual DN. In the pre-processed data, there were significant improvements in the overall DN recorded in the water covered area. This is evident by the least variance shown in the range of the pre-processed data especially in most penetrable band 1. The large variance in the range in the raw data is largely attributed to the path radiance that have contributed about 66% over selected land use class upon cursory examination over in the land area nearby. The best delineation of seagrass based on Table 1 best shown which involving band 1, in both pre-processed and enhanced bands (Figure 4 (a) and (b)) except RTM. The RTM processing however, does not able to exhibit any seagrass classes where the RTM is the most reliable technique. The only reason for this outcome is the assumption used in the estimation of the wet substrate which have been based on pre-located approximately determine from seagrass map, using relatively coarse accuracy GPS receiver (±100m or equivalent to 3.5 pixels). This could certainly can be overcomed when accurate in-situ measurement can be made, then transferred the determined position to the geometric corrected image. Works are now undertaken to established this.

Table 1: Spectral Analysis of Seagrass Occurance

| Site No. | Seagrass species # | DN value of raw data ♣ | | | DN value after Pre-processing | | | DN values of band ratio | | DN values after RTM | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 1 | 2 | 3 | 2/1 | 3/1 | 1 | 2 | 3 |
| 1 | *Halophila Spinolusa*<br>*Cymodocea Rotundata*<br>*Cymodocea Serrulata*<br>*Halodule Pinifolia*<br>*Halodule Uninervis*<br>*Enhalus Acoroida*<br>*Halophila Ovalis*<br>*Thalassia Lewprichi* | 107 | 48 | 38 | 19 | 28 | 16 | 1.47 | 0.8 | - | - | - |
| 2* | *Halodule Pinifolia*<br>*Halophila Ovalis* | 79 | 31 | 24 | 11 | 19 | 13 | 1.72 | 1.18 | - | - | - |
| 3 | *Cymodocea Rotundata*<br>*Cymodocea Serrulata*<br>*Halodule Uninervis*<br>*Halophila Ovalis*<br>*Thalassia Haeprichii* | 101 | 49 | 58 | 25 | 41 | 38 | 1.64 | 1.52 | - | - | - |
| 4 | *Cymodocea Rotundata*<br>*Enhalus Acoroida*<br>*Thalassia Hemprichii* | 104 | 45 | 45 | 23 | 32 | 20 | 1.39 | 0.87 | - | - | - |
| 5 | *Halodule Uninervis*<br>*Halophila Ovalis* | 97 | 46 | 53 | 21 | 31 | 16 | 1.48 | 0.76 | - | - | - |
| 6* | *Cymodocea Serrulata*<br>*Halodule Pinifolia*<br>*Halodule Uninervis*<br>*Halophila Ovalis* | 79 | 31 | 23 | 13 | 15 | 4 | 1.15 | 0.30 | - | - | - |
| 7* | *Cymodocea Rotundata*<br>*Cymodocea Serulata*<br>*Halodule Pinifolia*<br>*Halodule Uninervis*<br>*Halophila Minor*<br>*Halophila Ovalis* | 79 | 32 | 32 | 18 | 28 | 14 | 1.56 | 0.78 | - | - | - |
| 8 | *Cymodocea Rotundata*<br>*Cymodocea Serrulata*<br>*Halodule Pinifolia*<br>*Enhalus Acoroida*<br>*Halophila Ovalis* | 103 | 47 | 45 | 24 | 39 | 31 | 1.63 | 1.29 | - | - | - |
| 9* | *Thalassia Hemprichii* | 75 | 28 | 20 | 15 | 33 | 17 | 2.20 | 1.12 | - | - | - |
| 10 | *Halophila Ovalis*<br>*Thalassia Hemprichii* | 110 | 51 | 40 | 22 | 34 | 40 | 1.54 | 1.82 | - | - | - |
| 11 | *Enhalus Acoroida*<br>*Halophila Ovalis*<br>*Thalassia Hemprichii* | 107 | 51 | 55 | 17 | 23 | 9 | 1.35 | 0.53 | - | - | - |
| 12 | *Enhalus Acoroida*<br>*Halophila Ovalis*<br>*Thalassia Hemprichii* | 108 | 50 | 37 | 26 | 38 | 19 | 1.46 | 0.73 | - | - | - |
| 13 | *Cymodocea Serrulata*<br>*Halophila Ovalis*<br>*Halophila Decipiens* | 103 | 48 | 35 | 39 | 55 | 28 | 1.41 | 0.72 | - | - | - |

Note: * indicates high dense seagrass, # class mixed, ♣ only geometric correction is carried out.

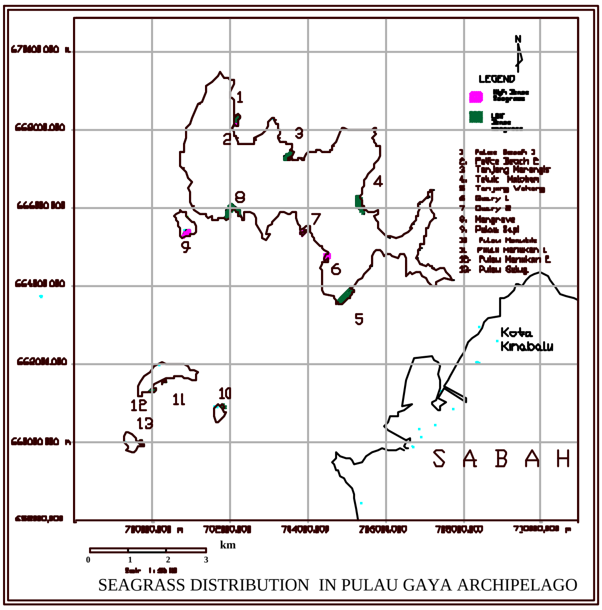
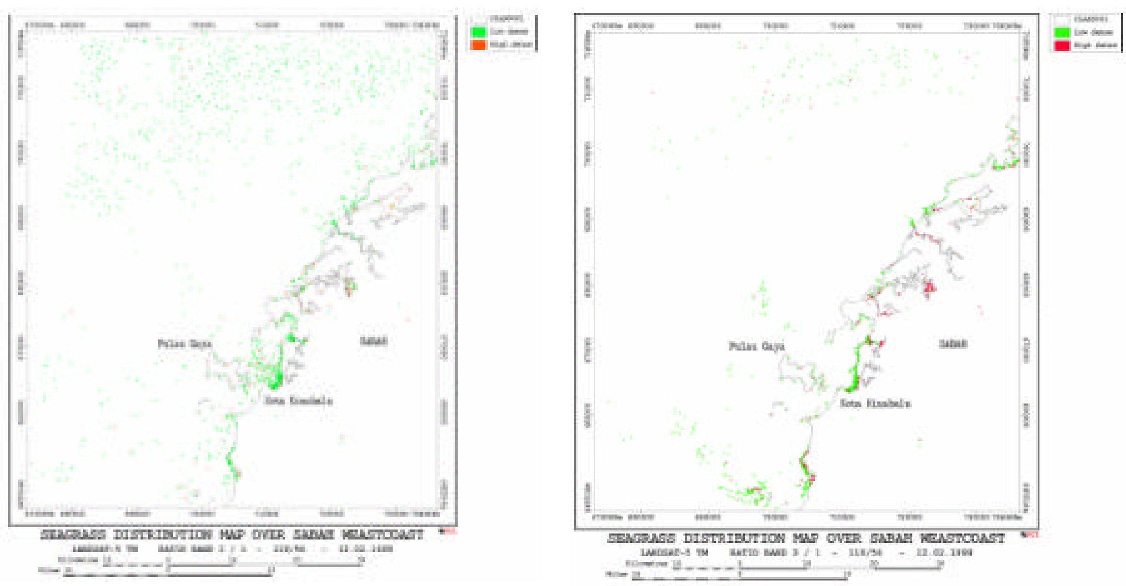



Figure 3: Ground thruth showing the distribution of seagrass classes used in the study (source: Borneo Marine Research Institute, UMS, 2001)




(a) (b)

Figure 4 (a) : Ratio band 2 / band 1; (b) ratio band 3 / band 1

## 4.0 CONCLUSION

This study has shown the spectral characteristics of seagrass occurance. Of all the technique tested, seagrass in Sabah water adequately can be extracted successfully using short band of the Landsat TM.. However, in RTM model, rely heavily on approximate in-situ wet substrates. Relative approximation based on image is rather restricted. Works is now underway to establish the relationship of substrate types and reflectance to enable the seagrass mapping for the entire coastline.

**REFERENCES**


Allen, M.F.M and G. Ellis. (1990). The Mapping and Monitoring of Seagrass at Corner Inlet using Remote Sensing Techniques. *Proc. Of 5th Australian Remote Sensing Conference*. Perth. **2**. 746-754.

Bierwirth, P.J., T.J. Lee and R.V. Burne. (1993). Shallow Sea-floor Reflectance and Water Depth Derived by Unmixing Multispectral Imagery. *Photogrammetry Engineering and Remote Sensing*. **59**. 331-338.

Economic Planning Unit and Danish Cooperation on Environment and Development (DANCED). (1999). *Integrated Coastal Zone Management – Status Document*. Prime Minister's Department Malaysia, Kuala Lumpur. 2-18.

Fadda, E.H and R.A, Vughan. (1996). A Geo-environmental Assessment of Coral Reefs in the Gulf of Aqaba using Integrated Remotely Sensed Data. *Proc. Of the 16th EARSeL Symposium*. Malta. In: Spiteri (ed.) (1997). *Remote Sensing '96*. Balkema, Rotterdam. 167-171.

Fortes, M.D (1990). *Seagrass: A Resource Unknown in the ASEAN Region*. Manila International Centre for Living Aquatic Resources Management on behalf of the Association of Southeast Asian Nations/US Coastal Resources Management Project.

Hardy, J., F. Hoge, J. Yungel and R. Dodge. (1992). Remote Detection of Coral Bleaching using Pulsed-Laser Fluorescence Spectroscopy. *Marine Ecology*. **88**. 247-255.

Hashim, M; A.Abdullad and A.W. Rasib (2000). Extracting Ocean Colour and Seagrass Information from Remote Sensing data: Opportunities and Limitations. *Malaysian Journal of Remote Sensing*. **1**. 13-20.

Holden, H and E. LeDrew. (2000). Accuracy Assessment of Hyperspectral Classification of Coral Reef Features. *Geocarto International*. **15**. 5-11.

Hyland, S., P. Lennon and P. Luck. (1989). An Assessment of Landsat Thematic Mapper for Monitoring Seagrasses in Moreton Bay, Queensland, Australia. *Asian-Pacific Remote Sensing Journal*. **2**. 35-40.

Japar Sidik, B., A. Lamri., Z. Muta Harah, S. Muhamad Saini, A. Mansoruddin, G. Josephine and A.R. Fazrullah Rizally, (1997). *Halophila decipiens* (*Hydrocharitaceae)*, a new seagrass for Sabah. *Sandakania* **9**. 67-75.

Japar Sidik, B., Z. Muta Harah, A. Lamri, F. Liew, G. Josephine and A.R. Fazrullah Rizally. (1999). *Halophila spinulosa* (R.Br.) Aschers – An unreported seagrass in Sabah, Malaysia. *Sabah Parks Nature Journal*. **2**. 1-9.

Japar Sidik. B., Z. Muta Harah, A. Mohd Pauzi and Suleika Madhavan. (1999). *Halodule* species from Malaysia – Distribution and Morphological Variation. *Aquatic Botany*. **65**. 33-45.

Japar Sidik. B., Z. Muta Harah, A. Lamri, F. Liew, G. Josephine and A.R. Fazrullah Rizally. (2000). Notes on *Halodule pinifolia* (Miki) Den Hartog from Tunku Abdul Rahman Park, Sabah. *Sabah Parks Nature Journal*. **3**. 29-39.

Japar Sidik, B., Z. Muta Harah and K. Fadzrullah . (2000). New Observaions on *Halophila spinulosa* (R. Br.) Aschers in Neumayer, Malaysia. *Biologia Marina Mediterranea*. **7**. 75-78.

Lennon. P.J and P. Luck. (1989). Seagrass Mapping using Landsat TM Data. *Proc. Of the 10th Asian Conference on Remote Sensing*. Kuala Lumpur. A-1-2-1 - A-1-2-6.

Lillesand, T.M and R.W Kiefer. (2000). Remote Sensing and Image Interpretation (4th Ed*.). John Wiley and Sons, Inc*. New York. 513.

Richter, R. (1990). A Fast Atmospheric Correction Algorithm Applied to Landsat TM Images. International Journal of Remote Sensing. **11**. 159-166.

Zainal, A.J.M, D.H Dalby and I.S Robinson. (1993). Monitoring Marine Ecological Changes on the East Coast of Bahrain with Landsat TM. *Photogrammetric Engineering and Remote Sensing Journal*. **59**. 415-421