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Research Article

Seagrass Meadow Impacts on Universiti Malaysia Sabah (UMS) Beach, Kota Kinabalu Sabah (Malaysia)

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Abstract

Seagrass meadow is known for its contribution as a habitat, ability to attenuate the wave's energy and as natural protection for the beach. The coastline of Universiti Malaysia Sabah (UMS) consists of important coral reef and seagrass ecosystems. Seagrass meadow is found at the northern part of the UMS beach at an area known as the Outdoor Development Centre (ODEC) while patchy coral reefs are found at the deeper part of the shoreline. The objectives of this study are to determine the beach profile and sediment characteristics of UMS-ODEC beach during the Southwest and Northeast monsoons and to compare the beach profile at areas where seagrass meadow is present and exposed beach area to the open sea. Beach profiling measurement was done at the three transects placed perpendicular to the UMS-ODEC beach. Transects 1 was with presence of seagrass and transects 2 and 3 were without seagrass. Sediment samples were taken at each transect for sediment characteristics identification. The assessment was done at an interval of every two month starting from May 2016 to March 2017. Beach profile elevation of UMS-ODEC Beach is higher during the Northeast monsoon than during the Southwest monsoon. It was also identified that large accretion happened at transects 1 and 2 between the month of July 2016 and September 2016 and between the month of January 2017 and March 2017. The erosion process happened at all transects between the month of September 2016 and November 2016 during the peak of the Southwest monsoon and continued to erode between the month of November 2016 and January 2017 during the Northeast monsoon.

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Sediment characteristics of mean, sorting, skewness at all transects were categorized under fine sand, moderately sorted and coarsely skewed, respectively during the Northeast monsoon and vary sediment characteristics except skewness of at all transects during the southwest monsoon. Based on this one year measurement of beach profile and sediment characteristics, there is no clear impact of the seagrass meadow as a natural coastal protection for the UMS-ODEC beach.

Keywords: seagrass, beach profile, seasonal monsoon, sediment characteristics, Universiti Malaysia Sabah

Introduction

Seagrass beds are known for their ability to attenuate the wave's energy at coastal areas. It contributes to the protection of shorelines from strong waves and current. The extensive root systems and leaves help to control subtidal sediment erosion (Fronseca & Fisher, 1986). Development of coastal protection by incorporating ecology and ecosystem services has gained a strong interest over the last decades (Borsje et al., 2011). There is a need to minimize the impacts of coastal protection structure on ecosystems and also a strong need for an innovative, sustainable and cost-effective way to control subtidal erosion. Based on a nearshore numerical model done, there is a significant reduction of wave energy flux at the shoreline where seagrass is present (Chen et al., 2007). Thus, in certain coastal environments, seagrasses can be established at a much lower cost as a non-structural alternative for shoreline protection compared to man-made structures such as jetties and bulkheads. Seagrass meadow could also bring in added benefits by producing a highly productive biological community.

Universiti Malaysia Sabah (UMS) beach is located in Sepanggar Bay, Kota Kinabalu at the west coast of Sabah, Malaysia (Figure 1). Sepanggar Bay plays an important role for the coastal ecology socio-economic development of the area. The marine ecosystem within the UMS beach is characterised by coral reefs and seagrass meadow. Seagrass species identified are *Enhalus acoroides, Cymodocea rotundata, Halodule uninervis, Halophila ovalis* and *Thalassia hemprichii*. The coverage area is approximately 2,700 m^2 scattered around Tg. Tarak Tarak (Yang, 2017). However, rapid urbanization along the coastal area such as the expansion of UMS and Sepanggar Port contribute to the degradation of marine ecosystems.

Generally, the west coast of Sabah is affected by two seasonal monsoons. The Northeast Monsoon occurs from the months of November to March, while the Southwest monsoon occurs during the months of May to September while the

Inter-monsoons occur successively between the months of April to May and September to October (Suhaila, et al., 2010). Ho, et al. (2013) reported that Kota Kinabalu is not directly affected by winds during the Northeast monsoon due to blockage by the Crocker Range. The seasonal monsoons that occur in this area contribute in a change of the beach profile and variation of sediment characteristics. However, the profile of the beach and sediment characteristics may vary at the seagrass meadows area and the beach directly exposed to an open area of the South China Sea. The objectives of this study are to (i) determine the beach profile and sediment characteristics of the UMS Outdoor Development Centre (ODEC) beach during the Southwest to Northeast monsoons, and to (ii) compare the beach profile at area where seagrass meadow is present and area where the beach is exposed to the open sea.

Materials and Methods

Study area

The UMS shoreline forms a sandy beach that is approximately 1,407 m in length. The beach is divided into two parts; the beach located between the ODEC and Tg Tarak Tarak located in the North; and the beach near the UMS Hatchery building in the South (Figure 1).

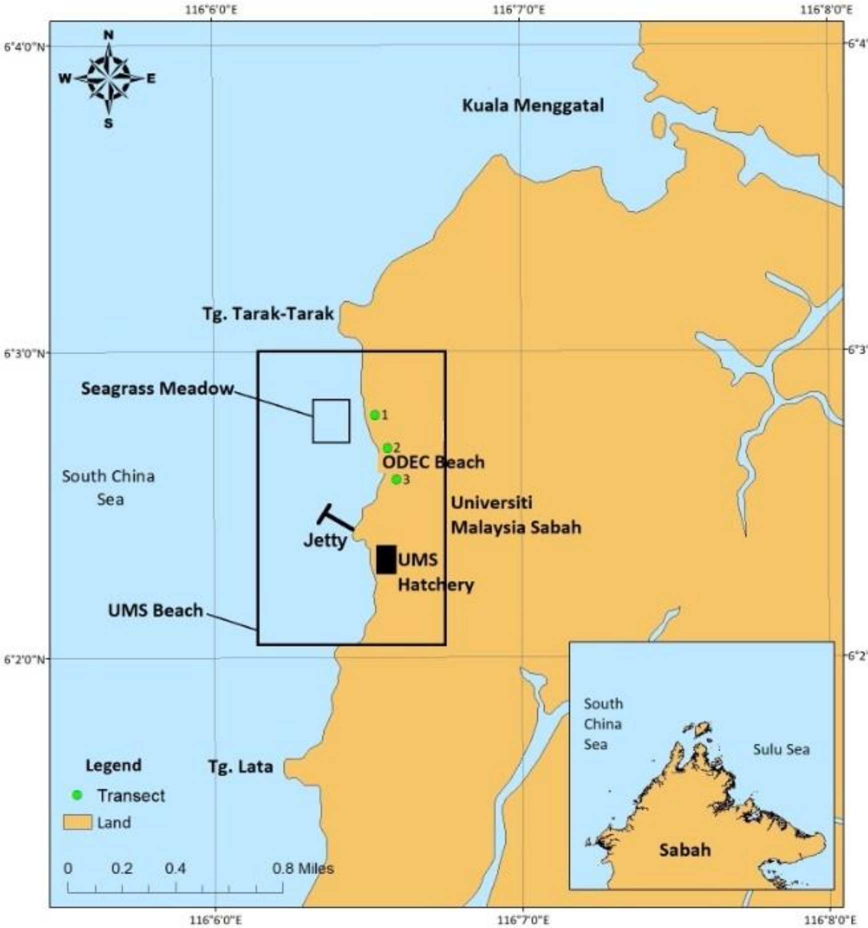

Figure 1. Location of the study area and sampling station.

The seagrass meadow is present only at northern part of ODEC beach and this is an area that accommodates picnics, beach sports and retreat programmes. The main threat to the beach is erosion. Currently, coastal protection such as stone revetments have been built nearby to reduce the impact of beach erosion. Seagrass meadow is located at transect 1 near the Tg. Tarak Tarak (North 6° 2'51.25", East 116° 6'35.98").

Beach Profile Measurements and Sample Collection

Beach profiling measurements are set up perpendicular to the UMS-ODEC beach. The measurements start from the high tide zone to the low tide zone area. Three replicates of beach profiling were done in each transect (Table 1) to increase accuracy. The locations of each transect replicates were marked and recorded using a Global Positioning System (GPS).

Table 1. Coordinates of beach profile transects at UMS ODEC Beach.

Transect	Replicate	Latitude (N)	Longitude (E)
1	1	006°002'79"	116°006'67"
	2	006°002'83"	116°006'67"
	3	006°002'89"	116°006'66"
2	1	006°002'68"	116°006'69"
	2	006°002'71"	116°006'68"
	3	006°002'74"	116°006'67"
3	1	006°002'58"	116°006'70"
	2	006°002'62"	116°006'70"
	3	006°002'63"	116°006'69"

Permanent markers such as trees or structural landmarks (lamp post) were identified as landmarks for the beach profiling transect. The Automatic level type TOPCON series AT-G6 sighting staff was set up at high tide mark and the 3 m intervals reading of the measuring rod along the transects line were recorded using data sheet. The procedures were repeated for each beach profile transect. Sediment samples for sediment characteristics analysis were also collected at the middle tidal zone and in the lower tidal zone of the beach. The samples were labelled according to the point of each sampling transect and were brought to the Borneo Marine Research Institute laboratory for further analysis.

The beach profile measurement was taken at an interval of every 2 months starting from May 2016 to March 2017. Measurements were done on 19th May 2016, 14th July 2016 and 13th September 2016 to represent the Southwest monsoon and on 19th November 2016, 13th January 2017 and 25th March 2017 for the Northeast monsoon.

Data Analysis

Beach profile measurement was plotted to determine the changes of the beach during the Northeast and Southwest monsoons. A decline of the beach profile based on the previous measurement would indicate that the erosion process is taking place while an increase of the beach profile would indicate the accretion process. The beach's profiling was also compared among three transects to identify the role of seagrass meadow for shoreline protection.

The sediment samples were analysed for mean, sorting, skewness and kurtosis parameters to describe the sediment characteristics using the dry sieving method. All sediment samples were dried in the open air. Dry sediment samples were placed at 850 µm, 500 µm, 355 µm, 250 µm, 125 µm, 106 µm and 63 µm sieve size then sieved and filtered in the automatic shaker for 10 minutes. The sediment samples on each sieve were removed and weighed using the analytical balance. The raw grain-size date was run in the GRADISTAT program version 8.0 software. This software would determine the fraction of sediment from each sample by size category based on the modified Wentworth (1922) size scale. The sediment samples were then characterized in terms of mean size, sorting, skewness and kurtosis following the Folk and Ward (1957) method for the Southeast and Northeast monsoons.

Results

Beach Profile Measurement

The ODEC beach has a higher beach profile level during the Southwest monsoon compared to the Northeast monsoon (Figure 2). A steeper high tide zone followed by flatter mid to low tide zones were identified at transects 1 and 2 (Figure 2a-b) while beach profile at high and mid tide zones of transect 3 was at a higher level compared to the other two transects (Figure 2c). The width of the beach profiles were about 45 m during the Southwest monsoon and decreased to 35 m during the Northeast monsoon.

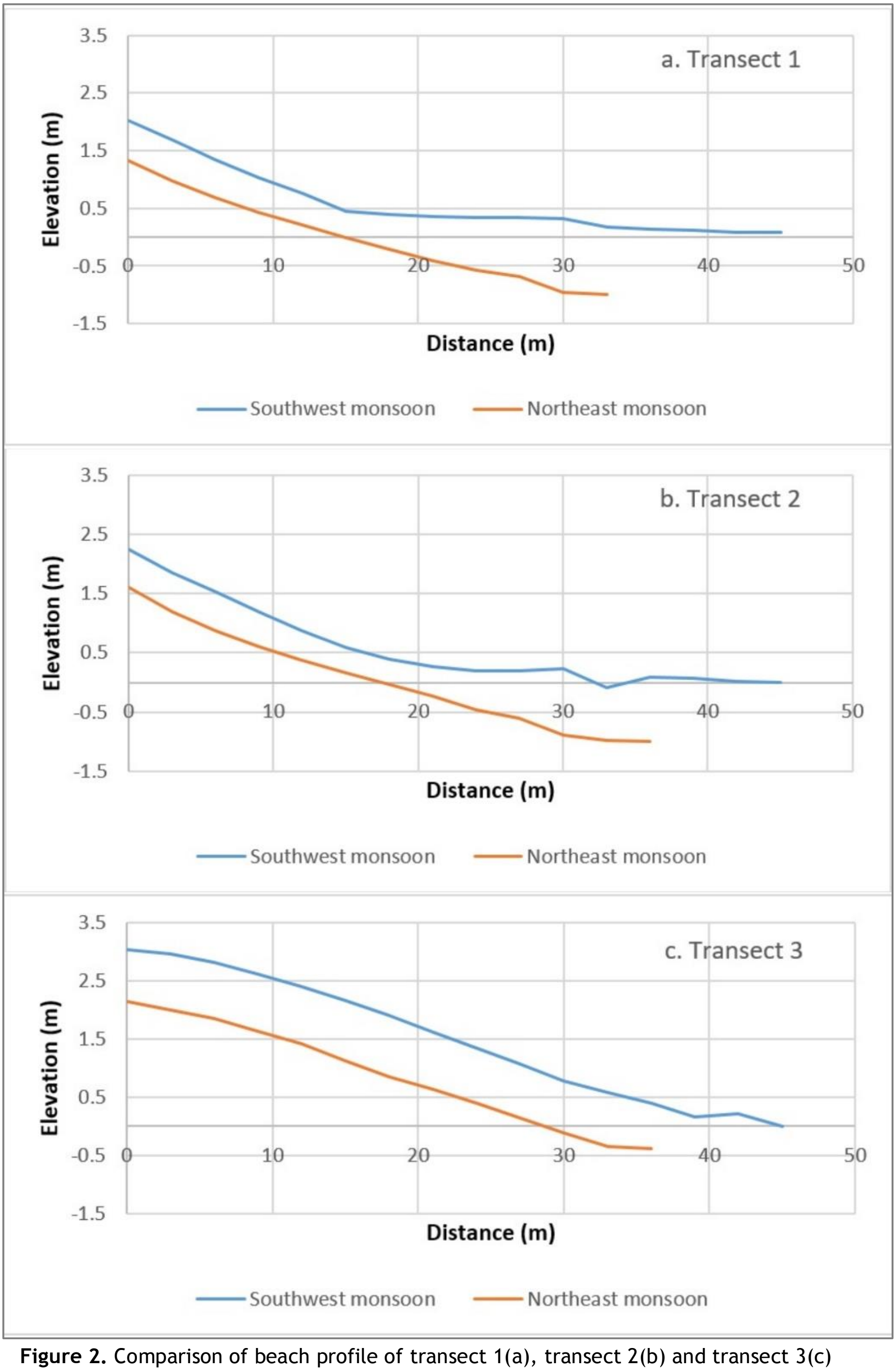

Figure 2. Comparison of beach profile of transect 1(a), transect 2(b) and transect 3(c) during the Northeast and Southwest monsoon.

The comparison of every two months beach profiles measurement are summarized in Table 2. Beach erosion happened between the month of May and July at all transects. There was a small sign of erosion that had occurred at transect 3 (Table 2). However, between the month of July and September, the accretion process took place at all transects with a large amount of sediment accumulated at transects 1 and 2. There was a large amount of sand loss (erosion) at all transects between the month of September and November (peak of Southwest monsoon). Loss of beach sediment continued between the months of November and January at all transects. Accretion took place again between the month of January and March for all transects with a large accumulation of sediment at transects 1 and 2.

Table 2. Summary of beach profile changes between two months of samplings.

Transects	May-July	July-September	September-November	November-January	January-March
1	Erosion (Small)	Accretion	Erosion (Large)	Erosion	Accretion
2	Erosion	Accretion (Large)	Erosion (Large)	Erosion	Accretion (Large)
3	Erosion	Accretion (Large)	Erosion (Large)	Erosion	Accretion (Large)

Sediment Characteristics of UMS-ODEC Beach

The average values of mean size, standard deviation (sorting), skewness and kurtosis of sediments in each transect was tabulated to see the dynamics of the UMS-ODEC beach (Table 3). Mean size of sediments for all transects during the Southwest monsoon is fine sand (FS), while during the Northeast monsoon the mean size of sediments is FS in transect 1 and very fine sand (VFS) in other transects. Sediment during the Southwest monsoon is moderately sorted (MS) in all transects (Table 3). However, during the Northeast monsoon, the sorting of sediment is MS in transect 1 and moderately well sorted (MWS) in transects 2 and 3. The skewness of sediments for both monsoons in all transects is coarsely skewed (CSk). Kurtosis of sediment is leptokurtic (LK) in transects 1 and 3 while in transect 2 is mesokurtic (MK) during the Southwest monsoon. There was LK kurtosis type in transects 1 and 2 while transect 3 had MK during the Northeast monsoon (Table 3).

Table 3. Average values of mean size standard deviation (sorting), skewness and kurtosis of sediments in each transect during the Southwest Northeast monsoons.

Transect	Sediment Character	Southwest Monsoon		Northeast monsoon	
1	Mean	2.84	FS	2.68	FS
	Sorting	0.74	MS	0.87	MS
	Skewness	-0.27	CSk	-0.25	CSk
	Kurtosis	1.35	LK	1.26	LK
2	Mean	2.69	FS	3.28	VFS
	Sorting	0.91	MS	0.61	MWS
	Skewness	-0.27	CSk	-0.10	CSk
	Kurtosis	0.92	MK	1.43	LK
3	Mean	2.75	FS	3.08	VFS
	Sorting	0.71	MS	0.65	MWS
	Skewness	-0.19	CSk	-0.25	CSk
	Kurtosis	1.15	LK	1.07	MK

Notes: FS-fine sand, VFS-very fine sand, MS-moderately sorted, MWS-moderately well sorted, CSk-coarsely skewed, LK-leptokurtic

Discussion

Beach profile comparison

Erosion and deposition of sediment are natural processes at the beach. Beach erosion is the offshore movement of sediment from the upper part (high tide zone) of the beach during storms as waves move sand from the beach and dunes to offshore storm bars (DLWC, 2001). When the calm weather comes back and deposition begins, the sand from the offshore bar moves back onshore to establish the beach. Generally, monthly erosion and deposition process occurs at UMS-ODEC beach mainly due to natural forces such as wave action generated by the seasonal monsoon.

The beach profile elevation of ODEC Beach is higher during the Northeast monsoon compared to the Southwest monsoon (Figure 2). Hoque et al. (2010) reported that the water current during the Northeast monsoon shows less steady current velocity compared to the Southwest monsoon measurement. This indicates that generally stronger and more severe wave conditions are found during the Northeast monsoon. Similar condition applied to UMS-ODEC Beach where higher wave energy reached the beach thus bringing out more sediment to the sea during this season. Yakof (2008) recorded the width of the UMS-ODEC beach can be up to 70 m at transects 1 and 2 and only 25 m at transect 3 during low neap tides.

Transects 1 and 2 have almost the same beach morphology (Figure 2a-b). The beach profile is steeper on the high tide zone and is flattened towards the low tide zone. These two transects might be naturally protected by the nearby Tg. Tarak Tarak and islands (Gaya and Sepanggar islands). Higher usage of the beach also affects the beach's geomorphology. The erosion process of this beach may not only be caused by the natural phenomenon but also by sea traffic at Kota Kinabalu coastal waters that produce wake waves at surrounding area (Jalihah & Nor-Hafizah, 2016; Bilkovic, et al. 2017). Transect 3 located in front of the UMS ODEC is exposed to the open sea and shows steeper and higher elevation compared to the other two transects (Figure 2a-b).

It was identified that large accretion happened at transects 1 and 2 between the months of July and September and between January and March. Deposition process could be due to seasonal monsoon and local longshore transport. The erosion process happened at all transects between September and November during the peak of the Southwest monsoon and continued to erode between November and January during the peak of the Northeast monsoon. Based on Yakof (2008), the UMS-ODEC Beach in September 2007 had a higher elevation compared to November 2007. This indicates that the beach experienced beach erosion within this time period.

Based on this one year observation, the impact of seagrass meadow at ODEC Beach is not clear. The beach profile of transect 1 (presence of seagrass) and transect 2 (absence of seagrass) is similar during both monsoons. Chen et al.(2007) reported that larger seagrass bed width in the direction of wave propagation would result in higher wave attenuation and less energy on the shoreline. However, the seagrass meadow located in transect 1 is too patchy or too small to attenuate the waves action. The seagrass canopy height is also too short to prevent the wave energy reaching the beach. Yang (2017) reported that the average canopy height of the seagrass meadow is estimated at 11.47 cm. The potential of seagrass beds to protect shorelines is probably influenced by the timing between wave events and seagrass growth. The greater the proportion of the water column that the seagrass canopy occupies, the more effective it is at reducing unidirectional water flows (Manca et al., 2012).

Beach Sediment Characteristics

Beach sediment characteristic at all transects are dominated by moderately sorted fine sand (FS) during the Southwest monsoon but are finer and more sorted in transects 2 and 3 during the Northeast monsoon (Table 3). The source of sediment supply, transporting medium and the energy conditions of the depositing environment could influence the value of mean size sediments (Folk & Ward, 1957). Folk (1980) suggested that as the energy of the transporting medium decreases, the sediments deposited become finer. Lower current energy would produce better sediment sorting (Blott & Pye, 2001).

Skewness measures the asymmetry of the frequency distribution. The value of skewness at all transects in both the Southwest and Northeast monsoons show that the sediments are negatively skewed (Table 3). Friedman (1961) identified that the water turbulence caused by incoming waves and outgoing wash, characteristics of beach environments, winnow away the fines and skew the frequency curve to coarser sizes or negative sides. Negatively skewed curves could also indicate an erosion or non-deposition area, whereas positively skewed curves could indicate deposition and a mixture of both would indicate a region in a state of flux.

Kurtosis is the peakedness of the distribution and measures the ratio between the sorting in the tails and the centre. In UMS beach, it is mostly leptokurtic in both the Southwest and Northeast monsoons. The sediment characteristics of UMS-ODEC beach in September 2007 was fine sand similar to this study but sorting, skewness, kurtosis was different (Yakof, 2008).

The average values of mean size, standard deviation (sorting), skewness and kurtosis of sediments of the UMS-ODEC beach in September 2007 (Southwest monsoon) were fine sand, poorly sorted, extremely negative skewed, very leptokurtic respectively (Yakof, 2008). The sediment analysis was continued in November 2007 and the findings were almost similar with that of September 2007. These sediment characteristics may be influenced by the extreme events of tropical cyclones Mitag and Hagibis tails that occurred during that year.

Conclusion

Erosion and deposition of sediment is a continuous process which occurs along UMS-ODEC beach. The elevation of the beach profiling is higher during the Southwest monsoon than during the Northeast monsoon. This indicates that beach sediment was eroded during the Northeast monsoon. Similar beach profile formation at transects 1 and 2 where both transects have steeper beach at the high tide zone and a flattened beach from the mid to low tides zone. Findings show steeper and higher beach elevation at transect 3 in both monsoons. The three transects have similar sediment characteristics during the Northeast monsoon, where mean, sorting, skewness falls under fine sand, moderately sorted and coarsely skewed, respectively. However only skewness of sediment has similar characteristics at all transects during the southwest monsoon. Based on this one year observation, there is no clear impact of the seagrass meadows as a natural coastal protection for the UMS-ODEC beach. The seagrass meadow condition is short leaves while the distribution and abundance are too patchy or too small compared to the size of Sepanggar Bay.

A combination of a natural conditions such as those present at Tg. Tarak Tarak and natural (islands) and man-made structures (UMS jetty and stone revetment near the jetty) could contribute to beach profile change and sediment characteristics variation of UMS-ODEC beach. Hydrodynamics within the Sepanggar Bay should be taken into account for future studies on the role of seagrass meadow for shoreline protection. Coastal modelling and simulation would help in detecting changes in water current, waves and shoreline in the coastal area, particularly at seagrass meadow sites.

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