

**SHORELINE CHANGES AT MANTANANI
BESAR ISLAND, KOTA BELUD, SABAH
MALAYSIA**

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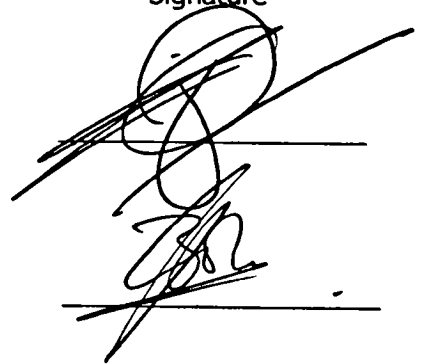
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ABSTRACT

Mantanani Besar Island is located about 30 km from the nearest point of Kota Belud mainland. Increasing development and usage of its beach has proven that the island is very important to the local community and has a high potential for a tourism destination. However, communities have stated that the island experienced beach erosion especially during the peak northeast monsoon (NEM) and southwest monsoon (SWM). Limitation of baseline data regarding shoreline changes and beach erosion at the island leads to the objectives of this study which are to determine the long-term shoreline changes, evaluate beach morphologies (beach profile, width, angle, slope condition and beach sediment volume) and sediment characteristics at different seasonal monsoons and as well as identification of erosion based on the communities observation and opinions. The island was divided into four zones and five sampling stations (st) based on the cardinal direction. Zone 1 located at the west (st 1), zone 2 at southern (st 2), zone 3 at eastern (st 3 and 4) and zone 4 at northern (st 5) part of the island. Aerial photos (1986, 1990, 2001 and 2013) and satellite images (2010) of Mantanani Besar Island were used to detect long-term changes by overlapping the images in ArcGIS 9.3 software. Field trips for beach profile and sediments collection were done twice to represent NEM and SWM in 2013, 2014 and 2015. The beach morphologies calculations were based on beach profiles data while collected sediment undergoes sand sieve analysis to calculate the sediment mean, sorting, skewness and kurtosis. Interviews with the community were done based on a structured questionnaire to assess the beach erosion. Results show that the size of Mantanani Besar Island was decreased with estimated total land loss of 170, 838 m² since 1986. The highest land loss is located in zone 2 with 71, 590 m² (43%) while zone 3 was the most dynamic area based on the obvious changes on the maps and the highest occurrence of beach erosion and accretion (16 identified beach changes). The total average value of beach morphologies was higher at the NEM than the SWM indicating accretion during NEM and erosion during SWM. Mantanani Besar Island beaches dominated with medium sand size with the excess of finer sediment whereas the exposures of environmental forces were medium with slightly higher in SWM. The sediment sorting was achieved through cross-shore (NEM) and longshore transport (SWM). Communities observation and opinions were in line with the results of long-term shoreline changes where Mantanani Besar Island experienced beach erosion since the past 20 years and it occurs at all zones (highest land loss at zone 2). Beach erosion has affected the residential areas in terms of properties destruction including personal and public properties with few uprooted trees. The local communities are aware of the continuous shoreline erosion and preferred to wait for the government actions to protect the island. The findings of this study provide baseline data (erosion and accretion area with beach dynamic during seasonal monsoon) and can be utilized by community, tourist operators and government as a guideline for future developments and integrated management plan of the island.

ABSTRAK

(PERUBAHAN PESISIRAN PANTAI DI PULAU MANTANANI BESAR, KOTA BELUD, SABAH MALAYSIA)

Pulau Mantanani Besar terletak kira-kira 30 km dari daerah Kota Belud. Pembangunan dan penggunaan pantai yang semakin pesat membuktikan bahawa pulau ini amatlah penting kepada penduduk dan mempunyai potensi yang tinggi sebagai destinasi pelancongan. Walau bagaimanapun, masyarakat telah menyatakan bahawa pulau ini menghadapi hakisan pantai terutamanya pada puncak monsun timur laut (MTL) dan monsun barat daya (MBD). Data asas yang terhad mengenai perubahan garis pantai dan hakisan pantai di pulau ini telah membawa kepada objektif kajian ini iaitu menentukan perubahan garis pantai jangka panjang, mengenal pasti morfologi pantai (profil pantai, kelebaran, sudut, keadaan cerun dan isi padu pantai) dan anggaran ciri-ciri mendapan pada monsun yang berbeza dan juga mengenal pasti hakisan berdasarkan pemerhatian dan pendapat masyarakat pulau. Pulau ini telah dibahagikan kepada empat zon dan lima stesen (st) persampelan berdasarkan arah angin. Zon 1 terletak di barat (st 1), zon 2 di selatan (st 2), zon 3 di timur (st 3 dan 4) dan zon 4 di utara (st 5) pulau tersebut. Foto udara (1986, 1990, 2001 dan 2013) dan imej satelit (2010) digunakan untuk mengesan perubahan jangka panjang dengan menindihkan imej-imej tersebut dalam perisian ArcGIS 9.3. Kerja lapangan untuk penilaian profil pantai dan pengutipan mendapan dilakukan dua kali bagi mewakili kedua-dua monsun pada tahun 2013, 2014 dan 2015. Pengiraan morfologi pantai yang lain adalah berdasarkan data profil pantai manakala mendapan yang dikutip menjalani analisis penapis pasir untuk mendapatkan mean, sorting, skewness dan kurtosis. Temubual bersama masyarakat tempatan telah dilakukan menggunakan borang soal selidik untuk menilai hakisan pantai. Keputusan menunjukkan bahawa saiz Pulau Mantanani Besar adalah berkurangan di mana jumlah kawasan tanah yang terhakis dianggarkan 170, 838 m² sejak tahun 1986. Hakisan pantai yang tertinggi terletak di zon 2 dengan 71, 590 m² (43%) manakala zon 3 merupakan kawasan yang paling dinamik berdasarkan perubahan jelas dalam setiap peta dan menerima hakisan dan penambahan pantai yang paling tinggi (16 perubahan pantai yang dikenal pasti). Jumlah purata morfologi pantai lebih tinggi pada MTL daripada MBD menunjukkan pertambahan pantai semasa MTL dan hakisan semasa MBD. Pantai di Pulau Mantanani Besar mempunyai purata pasir yang bersaiz sederhana dengan lebih mendapan halus manakala pendedahan daya semulajadi adalah sederhana dengan sedikit tinggi pada MBD. Sorting mendapan adalah secara sejajar (MTL) dan selari (MBD). Pemerhatian dan pendapat masyarakat adalah selaras dengan keputusan perubahan garis pantai jangka panjang di mana Pulau Mantanani Besar mengalami hakisan pantai sejak 20 tahun yang lalu dan ianya berlaku pada semua zon (zon 2 menerima hakisan pantai yang tertinggi). Hakisan pantai telah memberi kesan pada kawasan perumahan dari segi kemusnahan harta benda peribadi dan awam serta beberapa pokok tumbang. Masyarakat tempatan sedar dengan masalah hakisan pantai yang berterusan ini dan lebih suka menunggu tindakan kerajaan untuk melindungi pulau itu. Hasil kajian ini menyediakan data asas (kawasan hakisan dan pertambahan dengan dinamik pantai semasa monsun bermusim) dan boleh digunakan oleh masyarakat, pengusaha pelancongan dan kerajaan sebagai garis panduan untuk pembangunan masa depan dan pelan pengurusan bersepadu bagi pulau ini.

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LIST OF SYMBOLS

$^{\circ}$	- Degree
$^{\circ}\text{C}$	- Degree Celsius
$\%$	- Percentage
\sim	- Approximately
$-$	- Negative/Minus
$+$	- Positive/Add
$=$	- Equals to
θ	- Degree of slope
$<$	- Greater than
$>$	- Less than
\geq	- Greater than or Equal to
\emptyset	- Ogive
∞	- Infinity

LIST OF ABBREVIATIONS

µm	- Micrometers
A	- Accretion
avg	- Average
BMRI	- Borneo Marine Research Institute
cm	- Centimeters
DHI	- Danish Hydraulic Institute
DID	- Department of Irrigation and Drainage
E	- Erosion
ECD	- Environmental Conservation Department
EPD	- Environmental Protection Department
EPU	- Economic Planning Unit
Eq	- Equation
f	- Frequency
g	- Gram
GCP	- Ground Control Points
GIS	- Geographic Information System
GPS	- Global Positioning System
GRADISTAT	- Grain size distribution and statistics
IOC	- Intergovernmental Oceanographic commission
IPCC	- Intergovernmental Panel on Climate Change
km	- Kilometers
km/h	- Kilometers per hour
Kg.	- Kampung
KP	- Kampung Padang
KSB	- Kampung Siring Bukit
m	- Meters
MACRES	- Malaysian Centre for Remote Sensing
MDE	- Maryland Department of the Environment
mm	- Millimeters
m²	- Meters square
m²/y	- Meters square per year
m³/m	- Meters cube per meter

NCES	- National Coastal Erosion Study
NEM	- Northeast Monsoon
NSRC	- National Remote Sensing Committee
PCS	- Projected Coordinate System
PGA	- Pasukan Gerakan Am (General Operation Force)
R&D	- Research and Development
RCM	- Reef Check Malaysia
SACREC	- Swedish Agency for Research Cooperation
St.	- Station
SWM	- Southwest Monsoon
UNEP	- United Nations Environment Programme
WMO	- World Meteorological Organization
WCRP	- World Climate Research Programme

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Shore or shoreline is a boundary that separating the land and water body. Along the shore, there are beaches which are the extension of land that formed in any island, country or any landform in the world. Beaches can be found covered with rocks, sands and vegetation. Rocky beach is a formation and accumulation of rocks along the shore. The presences of rocks prevent the wave from hitting directly to the beach sediment and avoid sediment loss. Mangroves are among coastal vegetation that can tolerate saline water. Such tolerance enables the mangroves to grow along the beach. The roots of mangroves spread widely and tightly intact to the beach sediment make it very suitable as a buffer from extreme waves. Sandy beach is an accumulation of sand along the beach with varies in size ranging from fine to coarse.

Study of shoreline changes is related to the beach processes. It is the beach formation (accretion) and destruction (erosion) that happened along the shore. It is further divided into three parts which are long-term changes, short-term changes and episodic changes. These changes can provide the pictures on how the shoreline has changed on a certain period of time and shows the most dynamic area along the shoreline (Gibeaut, Hepner, Waldinger, Andrews, Gutierrez, Trembley, Smyth and Xu, 2001). Comparison of shoreline can be done by analyzing remote sensing images that have available since the 1930s (aerial photographs). Further improvement of the remotely sensed imagery data has developed the satellite platforms which provide images that highly consistent and in digital form. Both aerial photos and satellite images are the best imagery data used in detecting landscape changes over the time (Rocchini and Rita, 2005).

Studies on long-term shoreline changes are time-consuming and become apparent only after a significant lapse of a period. Weathering process and human intervention are the examples of beach processes that take a long period of time. Cliffs and rocky covered beaches experienced changes or erosion through weathering while human interventions (planting and cutting down trees) especially at mangrove covered beaches take years for the growth and mortality of the plants. Thus shoreline changes at rocky and mangrove beaches are suitable for long-term changes study. In contrary, short-term changes only happened within several days or months. It is usually affected the most in sandy beaches. Movement of sands is very dynamic due to the loose arrangement and the size variation at the beach. The disturbed sand can be easily moved out or in from the beach by any factors acting on the sandy covered beach. Shoreline changes at sandy beaches are suitable to be detected by short-term changes.

Beach morphology constantly change due to the hydrodynamics forces involving waves, currents, winds and sediments transport that continually interact with the beach sediments. These two terms (beach morphology and hydrodynamics forces) are usually studied together as it is the result and the effect of each other (Scott, Masselink and Russell, 2011). Sedimentologists have widely use sediments size analysis to classify sedimentary environments and elucidate transport dynamics (Jamil, Norsila and Asraf, 2009). The sediments are able to provide clues to the sediment provenance, transport history and depositional conditions (Folk and Ward, 1957; Friedman, 1979; Bui, Mazullo and Wilding, 1989; Dora, Kumar, Johnson, Philip and Vinayaraj, 2012). Results from the sediments size analysis can be related to the hydrodynamics forces at the nearshore area.

Hydrodynamics forces are influenced by the seasonal monsoons where it is able to change the energy intensity and movement. Throughout a year, a different energy of waves, currents and winds occurred at different directions depends on the types of the monsoon in one year cycle. Malaysia affected by the northeast monsoon (NEM) and the southwest monsoon (SWM). During NEM (November to March), the coastal currents flow southward bringing heavy rain and rough sea while the currents on SWM (May to September) flows northwards with calmer weather (Nakajima, Yoshida, Bin and Toda, 2015). Effects of monsoons on

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