

RIVER MOUTH STABILITY OF SUNGAI PAPAR, SABAH

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To my supportive husband, my loving family and friends

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ABSTRAK

Kuala Papar terletak di pesisir pantai yang mempunyai bentuk muka bumi menyerupai sebuah tanjung. Ia terdedah kepada ombak dari Laut China Selatan. Kedudukan Kuala Papar ini menyebabkan muara sungainya terdedah kepada pengaliran mendapan. Dalam beberapa dekad ini, beting pasir telah dikenalpasti di Kuala Papar. Pergerakan aktif beting pasir ini boleh menutup muara sungai dan mengganggu lalu lintas kapal. Kajian ini dilakukan untuk menganggarkan kadar pemedapan dan mengkaji keadaan kestabilan muara Sungai Papar. Kestabilan muara sungai ini diselidik melalui analisis perubahan jujuran pantai dan analisis perubahan kedalaman laut di sekitar kawasan Kuala Papar. Keputusan analisis menunjukkan bahawa lokasi dan orientasi muara Sungai Papar mengalami perubahan dalam masa 23 tahun kerana pertumbuhan aktif beting pasir. Kadar pemedapan di muara sungai dan di dalam zon littoral juga telah dianggarkan. Analisis bajet sedimen telah dilakukan dan keputusan menunjukkan bahawa hampir 97 071 m³/tahun pemedapan berlaku di Kuala Papar.

ABSTRACT

Kuala Papar is located at a protruding coastline which is directly exposed to waves coming from South China Sea. Sediment bypass take place at this river mouth due to the interference nature of its protruding coastline. In recent years, sand spits have been identified at Kuala Papar. Rapid migration of this sand spit could close up the river mouth and may interrupt navigation activities. This study is conducted to estimate the rate of sedimentation and to determine stability of the river mouth of Kuala Papar. The river mouth stability was investigated by an analysis of the historical shoreline changes and bathymetric changes maps. The shoreline changes map was derived and showed that the location and orientation of the river mouth experience some changes over 23 years due to the sand spit actively growing. Sediment transport rates in the river and within the littoral zone were also estimated. A sediment budget analysis was carried out and resulted in approximately 97071 m³/year of sediment deposited in front of Kuala Papar.

TABLE OF CONTENTS

CHAPTER		PAGE
	REPORT STATUS VALIDATION FORM	i
	SUPERVISOR’S DECLARATION	ii
	TITLE PAGE	iii
	STUDENT’S DECLARATION	iv
	DEDICATION	v
	ACKNOWLEDGEMENT	vi
	ABSTRAK	vii
	ABSTRACT	viii
	TABLE OF CONTENTS	ix
	LIST OF TABLES	xii
	LIST OF FIGURES	xiii
	LIST OF SYMBOLS AND ABBREVIATIONS	xv
	LIST OF APPENDICES	xvi
CHAPTER 1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Problem Statement	3
	1.3 Objectives of Study	3
	1.4 Scope of Study	3

1.5	Significance of Study	4
1.6	Limitation of Study	5
CHAPTER 2 LITERATURE REVIEW		
2.1	Introduction	6
2.2	Wave Analysis	6
2.3	Shoreline Changes	10
2.4	Bathymetric and Volume Changes	12
2.5	Sediment Transport	13
2.6	River Load due to Tidal Prism	18
2.7	Sediment Budget	19
2.8	River Mouth Stability	23
2.9	Previous Studies	25
CHAPTER 3 STUDY AREA SETTING		
3.1	Introduction	27
3.2	Description of Study Area	27
3.3	Sand Spit Growth	29
3.4	Soil Conditions	30
3.5	Beach Profiles	30
CHAPTER 4 RESEARCH METHODOLOGY		
4.1	Introduction	34
4.2	Data Collection and Analysis	35
4.3	Estimation of Longshore Sediment Transport	39

4.4	Application of Geographic Information System for Shoreline Changes Mapping	40
4.5	Application of Digital Shoreline Analysis System for Shoreline Rates-of-Change Computation	41
4.6	Application of SURFER to analyse Bathymetric Changes	43
4.7	Sediment Budget Analysis	43
 CHAPTER 5 ANALYSIS, RESULTS AND DISCUSSION		
5.1	Introduction	47
5.2	Wave Analysis	47
5.3	Longshore Sediment Transport	54
5.4	Shoreline Changes	56
5.5	Bathymetric Changes	61
5.6	Sediment Budget Analysis	64
 CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS		
6.1	Introduction	70
6.2	Conclusion	70
6.3	Recommendation for Future Study	72
 REFERENCES		73
 APPENDICES		77
Appendix A		
Appendix B		

LIST OF TABLES

No	Title	Page
4.1	Summaries of Data Collected and their Applications	35
5.1	Significant Wave Heights and Wave Periods	51
5.2	Incident Wave Height from Wave Transformation (East coastline of Kuala Papar)	52
5.3	Incident Wave Height from Wave Transformation (West coastline of Kuala Papar)	52
5.4	Summary of Breaker Parameters (East Coastline)	53
5.5	Summary of Breaker Parameters (West Coastline)	53
5.6	Longshore Sediment Transport Computation (East Coastline)	54
5.7	Longshore Sediment Transport Computation (West Coastline)	55
5.8	Summary of Shorelines Changes Rate	60
5.9	Volume of Material from Beach Erosion and Accretion	66
5.10	Summary of Sediment Sources and Sinks in the Study Area	68

LIST OF FIGURES

No	Title	Page
3.1	Location of Kuala Papar and Pulau Tiga	28
3.2	Shoreline Orientation Northeast and Southwest of Kuala Papar	28
3.3	Sand Spit Identified at the River Mouth	29
3.4	Beach Profiles Transect Lines taken along Coast of Study Area	30
3.5	Cross-section Profiles of the Transect Lines (Section 1-1)	31
3.6	Cross-section Profiles of the Transect Lines (Section 2-2)	31
3.7	Cross-section Profiles of the Transect Lines (Section 3-3)	32
3.8	Cross-section Profiles of the Transect Lines (Section 4-4)	32
3.9	Cross-section Profiles of the Transect Lines (Section 5-5)	33
3.10	Cross-section Profiles of the Transect Lines (Section 6-6)	33
4.1	Methodology Flowchart	34
4.2	Flowchart of data collection and analysis	37
4.3	Wave Analyses and the expected Wave Parameters	38
4.4	Flowchart of Wave Transformation	39
4.5	Flowchart of GIS application for delineation of Historical Shorelines	40
4.6	Flowchart of DSAS application for Shoreline rates-of change Computation	41
4.7	Flowchart of SURFER application for Bathymetric Changes Analysis	43
4.8	Simplified Methodology for Sediment Budget Analysis	44
5.1	Offshore Wave Rose (Annual)	48

5.2	Offshore Wave Rose (Northeast Monsoon)	49
5.3	Offshore Wave Rose (Southwest Monsoon)	50
5.4	Net Longshore Transport along the coast of Study Area	56
5.5	Historical Shoreline Map of Kuala Papar	57
5.6	Evolutions of Sand Spit at Kuala Papar	58
5.7	Shoreline Changes Map of Kuala Papar	59
5.8	Digitized Bathymetry of Kuala Papar in 1912 based upon The 1991 Hydrographic Chart	62
5.9	Digitized Bathymetry of Kuala Papar in 2009 based upon Hydrographic Survey	62
5.10	Residual Map of Kuala Papar showing areas of accretion and erosion between 1912 and 2009	63
5.11	Schematic Representation of the Sediment Budget	67

LIST OF SYMBOLS AND ABBREVIATIONS

λ	Wave length
ξ	Iribarren's Surf Similarity Parameter
m	Slope
γ	Breaker index
α	Angle of Approach
q_t	Volumetric total transport rate per unit width (m^3/ms)
u	Velocity of flow
u_*	Friction velocity
F_{gr}	Function of shear stress/immersed weight of grains
D_*	Dimensionless particle size number
d	Water depth
s	Sediment density ratio
ν	Kinematic Viscosity
g	Acceleration due to gravity
ρ_s	Density of sediment
ρ_d	Dry bulk density of sediment
V_t	Volume of tidal prism
w	Fall velocity
C_{in}	Mean sediment concentration
T_r	Retention time

LIST OF APPENDICES

No	Title	Page
A	Offshore Wave Climate Details	77
B	Details of Wave Transformation	94

CHAPTER 1

INTRODUCTION

1.1 Introduction

River mouth is a special environment where water from the land and sea meet. According to Hughes and Kraus (2006), a coastal inlet or river mouth connects an ocean, sea, or lake through a typically narrow landmass to the water body behind it, such as a bay, estuary, lagoon, or river. Hydrodynamic forcing contributing to the water exchange that maintains the coastal inlet or river mouth may be the tide, river flow, wind, or seiching. River mouth is the location of human population and human activities that have significant impacts on the coastal processes. Human activities within the river mouth area include navigation, agriculture, fisheries, aquaculture, transportation and communication, recreation, and etc. These activities promote economic growth of the area and it is important to maintain the river mouth to ensure that all activities can be conducted safely.

There are several problems associated with a river mouth such as water quality, erosion, and sedimentation. Water quality problem usually occurs due to the human activities such as fisheries, aquaculture, agriculture, oil spill from the navigation, and industrial discharge to the river. Erosion and sedimentation problems are also often associated with the human interference in the physical system such as the construction of hard structures or the dredging of sediment from the bed to increase the flow depth or width. However, erosion and sedimentation may arise naturally due to current

and wave actions. Natural sedimentation areas are known as shoals, flats, banks, bars, etc.

To come out with a comprehensive solution to the erosion and sedimentation problem, a complete engineering assessment and study should be conducted. This includes analysis of the physical system and determination of the factors that contribute to the problem. Studies may be conducted using rules of thumb, simplified models, and application of tools available nowadays. As a river mouth is a complex hydrodynamic and geomorphologic system, in many studies several types of tools are required to answer specific problems.

This study is aimed to estimate the rate of sedimentation at Kuala Papar and to determine the stability of the river mouth system. To meet the objective of this research, several tools are applied besides manual calculation based on simple model and formula. The main tools used are Geographic Information System (GIS), Digital Shoreline Analysis System (DSAS) and Golden Software SURFER 7. GIS is applied for delineation of historical shoreline position. Meanwhile, DSAS is used for calculation of shoreline changes rate based on the historical shoreline map. SURFER 7 on the other hand, is applied to conduct the bathymetric volume and changes analysis to obtain the residual map as well as the volume of seabed erosion and accretion.

A sediment budget system is constructed within the study area. The sediment inflows and outflows are quantified based on the sediment transport calculation within the river system and coastal region. The outputs from the three softwares application also define the inflow and outflow of the sediment budget system. Sediment budgets provide a conceptual and quantitative model of the magnitudes and pathways of sediment transport at inlets and adjacent beaches for a given time period (Rosati and Kraus 1999, 2001). It gives a framework for understanding complex river mouths and coastal systems and their responses to coastal processes.

1.2 Statement of Problem

Navigation is an important activity because most of the trade between countries is carried out by ship. Furthermore, water transportation system can boost local economic activities. Several rivers in Malaysia including Sungai Papar are becoming more important for navigation activities. Sungai Papar waterway currently is busy with fishing boats and barges carrying the agricultural produce to Sabah Port at Kota Kinabalu. Recently, construction of a new fish landing jetty has been proposed to cater for bigger size boats. Due to the expansion of navigation activities at the study area, the future condition of the river is of great concern. Siltation may reduce the depth of the river and results in inadequate draft for big vessels. The sand spit that is identified growing at the river mouth could migrate extensively in several years and close up the river mouth.

1.3 Objectives of Study

The objectives of this study are as follows:

- a) To estimate the rate of sedimentation at Kuala Papar
- b) To determine the river mouth stability of Kuala Papar

1.4 Scope of Study

- a) Study area definition.
- b) Data collection and analysis.

- c) Determination of longshore sediment transport within the study area.
- d) Application of Geographical Information System (GIS) to delineate historical shoreline position.
- e) Application of Digital Shoreline Analysis System (DSAS) to determine the shorelines rates-of-change.
- f) Application of Golden Software SURFER for bathymetric volume and changes analysis.
- g) Sediment Budget Analysis.

1.5 Significance of Study

Sungai Papar is an important river in Sabah. It supports a large percentage of population and it is also the centre of economic activities encompassing urbanisation, agriculture, fisheries, transportation and communication, recreation, and logging activities upstream. Shoreline and seabed changes analysis together with sediment budget studies are useful to predict the stability of the river mouth. Stability of a river mouth is significant to maintain the depth as well as the location of the river mouth. Inadequate water depth for navigation and a migrating or closed river mouth may interfere the navigation activities. This could result in serious economic losses to the commercial, recreational and local fishing activities. Thus, this study is important because the output of the study may be used to plan for mitigation measures to ensure effectiveness of the navigational system within the study area.

The use of GIS for delineation of historical shoreline position based on a series of aerial photographs and satellite images is practical and effective, in terms of time and cost. The application of DSAS and SURFER to compute shoreline rates-of-change and

the volumetric rate of seabed changes, respectively can reduce complexity in the calculation process thus, saving a lot of time. Moreover, the results produced from the analysis are more accurate than manual calculation because less human errors are expected.

1.6 Limitation of Study

- a) Deepwater wave data are only available from 1949 to 1983.
- b) Shoreline rates-of-change computation is conducted only based upon four historical shoreline positions that cover the period between 1986 and 2009.
- c) There are only two sets of bathymetry available for Kuala Papar which is 1912 bathymetry and 2009 bathymetry. There is no bathymetry data in between these periods. Besides that, 1912 bathymetry based on admiralty chart contains sparse depth points.
- d) Calibration of sedimentation rate at Kuala Papar cannot be conducted due to data limitation