

**SEAGRASS MAPPING AND DISTRIBUTION IN
RELATION TO WATER QUALITY USING GIS IN
SUNGAI JOHOR, PENINSULAR MALAYSIA**

NOOR AINI BINTI AHMAD

**FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR**

2011

**SEAGRASS MAPPING AND DISTRIBUTION IN
RELATION TO WATER QUALITY USING GIS IN
SUNGAI JOHOR, PENINSULAR MALAYSIA**

NOOR AINI BINTI AHMAD

**DISSERTATION SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF TECHNOLOGY
(ENVIRONMENTAL MANAGEMENT)**

**INSTITUTE OF BIOLOGICAL SCIENCES
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR**

2011

UNIVERSITY OF MALAYA
ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **NOOR AINI BINTI AHMAD** (I.C. No: **660414-02-5034**)

Registration/Matric No: **SGH040016**

Name of Degree: **Master of Technology (Environmental Management)**

Title of Project Paper/Research Report/Dissertation/Thesis ("this Work"):
Seagrass Mapping and Distribution In Relation To Water Quality Using GIS in Sungai Johor, Peninsular Malaysia

Field of Study: **Seagrass Distribution - GIS**

I do solemnly and sincerely declare that:

- (1) I am the sole author/writer of this Work;
- (2) This Work is original;
- (3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
- (4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
- (5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
- (6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature

Date

Subscribed and solemnly declared before,

Witness's Signature

Date

Name:

Designation:

ACKNOWLEDGEMENTS

First of all, a very grateful to Allah SWT who gives me the ability to finish up my final master project. While I was working on this project, I often dreamt of the moment when I would get to this part: when the manuscript would be written, the final stress would be gone and I would look back at this period of my life with pleasure, nostalgia and gratitude. Finally, this moment has come. The result of this work will be judged by the others, but I can definitely say that the process was enjoyable. So I am glad to complete it by remembering many wonderful people who have contributed to it in various ways.

I would like to express my deep gratitude to my project supervisor, Dr. Rosmadi Fauzi for his encouragement, guidance, advice, patience and critics throughout the course of this study. Also a million thanks to my co-supervisor Professor Phang Siew Moi for her valuable time and guidance in fulfil the study. I would also like to acknowledge the advice and guidance of Ms. Jillian Ooi Lean Sim, who helped me a lot with the proposal and everything during the early stage of the project. My deep felt thanks to these three experts who kindly facilitated access to the data from the University Malaya Maritime Research Centre (UMMReC) project on the conservation and protection of endangered dugongs in Johor.

I am also grateful to Zizah and Safiah, my good friends who have always been very supportive, gave suggestions and advised on technical aspects and help me along the way with GIS tools and methods. I also like to thank my old classmate Rozita and Suhaila for always praying for my success.

Finally, I would like to express special thanks to my husband, Wan who has always been a source of inspiration. He helped me to concentrate on completing this report and supported mentally during the course of this work. Without his help and encouragement, this study would not have been completed. I cannot thank him enough for my entire life. And last but not least, my loving children Yana, Izzah, Izzat, Ami and Deena; for the incredible amount of patience they had with me in the last three months. It's time to start on that list of things to do "Yes, after your thesis, mama".

ABSTRACT

Seagrass meadows are noted for their extremely high productivity and contribution of valuable ecosystem functions and services to coastal zone. Seagrasses which are vulnerable to the changes of water and environmental quality are increasingly threatened by human activities resulting in a deterioration of water quality. An environmental study on seagrass was conducted at Sungai Johor, Peninsular Malaysia. The purpose of this study was to examine the relationship between species diversity and distribution of seagrasses and various environmental (water quality) factors. Three (3) seagrass species were found along Sungai Johor which identified as *Halophila ovalis*, *Halophila spinulosa* and *Enhalus acoroides*. *Halophila ovalis* which occur at all study sites was the most dominant species. The study gives a conclusive results that water quality has significant relations and effects to the seagrass present and distribution in the study area. Seagrass areas have a greater value for salinity, conductivity and Total Nitrogen (TN), while having a very much lower value for Total Suspended Solid (turbidity), *E. coli* and Cuprum, compared to the area without seagrass. In terms of seagrass diversity and abundance, the most significant water quality parameters are those that influence light penetration and aquatic nutrient levels. Tanjung Kopok (S3) which has the best water clarity exhibit the highest DW biomass, whereas Tanjung Surat (S4) which has the most turbid water exhibit the lowest DW biomass and species diversity; and Pasir Gogok (S5) which has the highest TN value exhibit the highest number of species, thus S4 which has the lowest TN value exhibit only one species in the area. There is no doubt about the capabilities and advantages of Geographical Information Systems (GIS) which were demonstrated in this study, as a powerful tool in environmental research and coastal management.

ABSTRAK

Kawasan rumput laut terkenal dengan produktiviti yang tinggi dan sumbangannya yang bernilai kepada perkhidmatan dan fungsi ekosistem pantai. Rumput laut yang amat mudah dipengaruhi oleh perubahan kualiti air dan alam sekitar semakin terancam oleh aktiviti manusia yang menyebabkan kemerosotan kualiti air. Kajian terhadap rumput laut telah dijalankan di Sungai Johor, Semenanjung Malaysia, bertujuan untuk mengkaji hubungan antara kepelbagaian spesies dan taburan rumput laut dengan pelbagai faktor alam sekitar (kualiti air). Tiga (3) spesies rumput laut yang dijumpai di Sungai Johor dikenalpasti sebagai *Halophila ovalis*, *Halophila spinulosa* dan *Enhalus acoroides*. *Halophila ovalis* yang dijumpai di semua kawasan kajian adalah spesies yang paling dominan. Penemuan kajian menunjukkan bahawa kualiti air mempunyai hubungan yang signifikan dengan kewujudan dan taburan rumput laut. Kawasan rumput laut mempunyai nilai yang lebih tinggi untuk saliniti, konduktiviti dan Jumlah Nitrogen, dan nilai yang jauh lebih rendah untuk Jumlah Pepejal Terampai (kekeruhan), *E. coli* dan Kuprum, berbanding dengan kawasan tanpa rumput laut. Dari segi kepelbagaian dan banyaknya rumput laut, parameter kualiti air yang paling signifikan adalah yang mempengaruhi penembusan cahaya dan tahap nutrien akuatik. Tanjung Kopok (S3) yang mempunyai air yang paling jernih memberikan nilai biomas tertinggi, manakala Tanjung Surat (S4) yang mempunyai air yang paling keruh memaparkan nilai paling rendah dari segi biomas dan kepelbagaian spesis; dan Pasir Gogok (S5) dengan nilai tertinggi bagi Jumlah Nitrogen mempunyai bilangan spesies tertinggi, manakala S4 yang mempunyai nilai Jumlah Nitrogen terendah hanya mempamerkan satu spesies di kawasan itu. Keupayaan dan kelebihan Sistem Maklumat Geografi (GIS) yang telah ditunjukkan dalam kajian ini tidak diragui boleh dimanfaatkan dalam penyelidikan dan pengurusan alam sekitar pantai.

TABLE OF CONTENT

CHAPTER	TITLE	PAGE
	TITLE	
	DECLARATION	ii
	ABSTRACT	iii
	ABSTRAK	iv
	ACKNOWLEDGEMENTS	v
	TABLE OF CONTENTS	vi
	LIST OF TABLES	ix
	LIST OF FIGURES	x
	LIST OF ABBREVIATIONS	xii
1	INTRODUCTION	1
	1.1 Significance of the Study	1
	1.2 Research Background	3
	1.2.1 Definition of Seagrasses	3
	1.2.2 The Importance of Seagrasses	3
	1.2.3 Threats to Seagrasses	6
	1.2.4 Issues and Problems	7
	1.2.5 Limitations of the Study	9
	1.3 Objective of Study	10
	1.4 Scope of the Study	10
	1.5 Dissertation Structure	11
2	LITERATURE REVIEW	12
	2.1 Global Seagrass Distribution	12
	2.2 Seagrass Diversity and Distribution in Malaysia	13
	2.3 Factors Determining the Distribution of Seagrasses	14
	2.3.1 Light	18
	2.3.2 Turbidity	18
	2.3.3 Temperature	19
	2.3.4 Salinity	19
	2.3.5 pH	20
	2.3.6 Nutrient	20

2.3.7	Heavy Metal	21
2.4	Geographic Information System	22
2.4.1	Basic Concept	22
2.4.2	GIS Functions	23
2.4.3	GIS Application in Biological Diversity	24
2.5	Application of GIS in Seagrass Habitat Management	26
2.5.1	Mapping the Seagrass Distribution	26
2.5.2	Modelling with GIS	27
2.5.3	Geodatabase	28
3	MATERIALS AND METHODS	30
3.1	Data Acquisition	30
3.2	Study Area	30
3.3	Water Quality Data from DOE	33
3.4	Marine Water Quality Standards	34
3.5	Preparation of Geospatial Data with ArcGIS	36
3.6	Selection of DOE Water Quality Monitoring Stations	37
3.7	Statistical Analysis	42
3.7.1	Data Availability	42
3.7.2	Descriptive and Inferential Statistics	43
3.7.3	Descriptive Statistic on DOE Data	44
3.7.4	Inferential Statistics	45
3.8	Building Geodatabase	46
3.8.1	Designing Geodatabase	48
4	RESULTS AND DISCUSSION	49
4.1	Introduction	49
4.2	Geospatial data	49
4.3	Selected Data for Analysis	49
4.4	Seagrass Diversity	51
4.5	Seagrass Abundance	52
4.6	Statistical Analysis	56
4.6.1	Physical Parameters	57
4.6.2	Nutrient, Biological and Metal Parameters	61

4.6.3	Correlation and Regression between the UMMReC Project and the DOE Water Quality Data	65
4.6.4	Correlation and Regression between Dry Weight Biomass (DW) and Physical Parameters	68
4.6.5	Correlation and Regression between Dry Weight Biomass (DW) and Selected Nutrient, Biological and Heavy Metal Parameters	70
4.7	Discussion on Seagrass and Water Quality	72
4.7.1	Seagrass Distribution	73
4.7.2	Biomass	74
4.7.3	Temperature and pH	75
4.7.4	Salinity and Conductivity	77
4.7.5	Light	78
4.7.6	Nutrient	80
4.7.7	Heavy Metal	81
4.8	Results for Geodatabase	82
4.9	Discussion on the Usage of GIS in Coastal Management	87
4.9.1	Utilizing the Geographic Database	88
5	CONCLUSIONS	91
5.1	Introduction	91
5.2	Seagrass Diversity and Distribution	92
5.3	Seagrass and Water quality	92
5.4	GIS	94
5.5	Recommendations	95
	REFERENCES	96
	APPENDICES	105
	Appendix I: Marine water quality data for the year of 2005	105
	Appendix II: Preparation of Geospatial Data with ArcGIS	115
	Appendix III: Point Distance Analysis	129
	Appendix IV: Designing Geodatabase	137

LIST OF TABLES

TABLE NO.	TITLE	PAGE
1.1	Expected role of marine biodiversity	2
2.1	Species of seagrasses recorded from Malaysia waters	15
3.1	Malaysia Marine Environmental Quality Parameters	33
3.2	Marine Environmental Quality Parameters (data released for this study only)	34
3.3	Malaysia Interim Marine Water Quality Standards	34
3.4	Marine Water Quality Criteria for the ASEAN Region	35
3.5	Johor Water Quality Monitoring Stations	37
3.6	List of locations (WGS84) and dates of survey	40
3.7	Selected DOE WQMS and the availability of data	42
3.8	Water Quality from the Field Work (UMMReC Project)	46
4.1	Selected UMMReC Project Study Sites and DOE WQMS	50
4.2	Seagrass Diversity in Transect Studies	51
4.3	Cover of Seagrass in Transect Studies	53
4.4	Biomass (gDW.m ⁻²) of Seagrass in Transect Studies	54
4.5	Descriptive statistic results of for six (6) physical parameters	58
4.6	Descriptive statistic results for nutrient, biological and metal parameters	62
4.7	Correlation and Regression between UMMReC Project (FW) and DOE Water Quality Data	65
4.8	Correlation and Regression between Dry Weight Biomass and Physical Parameters	68
4.9	Correlation and Regression between Dry Weight Biomass and Selected Nutrient, Biological and Metal Parameters	70

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1 (a)	Map of seagrass species in Peninsular Malaysia	16
2.1 (b)	Map of seagrass species in East Malaysia	17
3.1	Map showing the locations of surveys in Sungai Johor	31
3.2	Johor Water Quality Monitoring Stations	36
3.3	Locations of survey by the UMMReC Project Team	39
3.4	Distribution of seagrass in the study area	41
3.5	Dataset support by Geodatabase	47
3.6	Output of Personal Geodatabase for the seagrass study	48
4.1	Seagrass Diversity and Abundance in the Study Area	55
4.2	Graph for selected physical parameter in S1 to S5	59
4.3	Selected physical parameters in the study area	60
4.4	Graph for selected nutrient, biological and metal parameters	63
4.5	Selected nutrient, biological and metal parameters in the study area	64
4.6	Regression Line for UMMReC Project (FW) versus DOE Water Quality Data	66
4.7	Regression Line for Dry Weight Biomass versus Physical Parameters	69
4.8	Regression Line for Dry Weight Biomass versus Selected Nutrient, Biological and Metal parameters	71
4.9	Seagrass database at SEAGRASS.mdb	82
4.10	To export Table Data into .dbf format	83
4.11 (a)	Export Output: Field_biomass in .dbf format.	84
4.11 (b)	Export Output: Field_biomass data preview in ArcCatalog	84

4.11 (c)	To Open Field_biomass database through Excel	85
4.11 (d)	Field_biomass Output database through Excel	85
4.11 (e)	Preview of Field_biomass Output database through Excel	86
4.12	Contexts for exploiting the geodatabase in a GIS	89

LIST OF ABBREVIATIONS

AMWOC	ASEAN Marine Water Quality Criteria
CBD	Convention on Biological Diversity
CO ₂	Carbon Dioxide
Cu	Copper
DO	Dissolved Oxygen
DOE	Department of Environment Malaysia
GIS	Geographic Information System
GPS	Global Positioning System
HCO ₃ ⁻	bicarbonate
IMWQS	Interim Marine Water Quality Standards
NPBD	National Policy on Biological Diversity
O ₂	Oxygen
TSS	Total Suspended Solid
UMMReC Project	University Malaya Maritime Research Centre Project
WGS84	World Geodetic System 1984