

BATHYMETRY MAPPING FROM FINE SPATIAL RESOLUTION
SATELLITE IMAGERY AT LANG TENGAH ISLAND

CHUAH SIAK KHOON

FACULTY OF MARITIME STUDIES AND MARINE SCIENCES
UNIVERSITI MALAYSIA TERENGGANU

2010

LP
5
FMSM
1
2010

Ch. 0310

1100088935



LP 5 FMSM 1 2010



1100088935
Bathymetry mapping from fine spatial resolution satellite sensor
imagery at Lang Tengah Island / Chuah Siak Khoon.

PUSAT PEMBELAJARAN DIGITAL SULTANAH NUR ZAHIRAH
UNIVERSITI MALAYSIA TERENGGANU (UMT)
21030 KUALA TERENGGANU

1100088935		

Lihat Sebeilah

HAK MILIK
PUSAT PEMBELAJARAN DIGITAL SULTANAH NUR ZAHIRAH

**Bathymetry mapping from fine spatial resolution satellite sensor imagery at
Lang Tengah Island**

CHUAH SIAK KHOON

**Research Proposal submitted in partial fulfilment of
the requirements for the degree of
Bachelor of Science (Marine science)**

**Department of Marine Science
Faculty of Maritime Studies and Marine Science
UNIVERSITI MALAYSIA TERENGGANU
2010**

This project should be cited as:

Chuah S.K., 2010. Bathymetry mapping from fine spatial resolution satellite imagery at Lang Tengah Island. P58.

No Part of this project report may be produced by any mechanical, photographic, or electronic process, or in the form of phonographic recording, nor may it be stored in a retrieval system, transmitted, or otherwise copied for public/private use, without written permission from the author and supervisors of the project.

Appendix 7 : Final Research Project Report Declaration and Verification Form



**DEPARTMENT OF MARINE SCIENCE
FACULTY OF MARITIME STUDIES AND MARINE SCIENCE**

DECLARATION AND VERIFICATION REPORT

FINAL YEAR RESEARCH PROJECT

It is hereby declared and verified that this research report entitled:
Bathymetry mapping from fine spatial resolution satellite imagery at Lang Tengah Island by Chuah Siak Khoon, Matric No. UK15236 have been examined and all errors identified have been corrected. This report is submitted to the Department of Marine Science as partial fulfillment towards obtaining the Degree of Bachelor Science (Marine Science), Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu.

Verified by:

Principal Supervisor

Name: **PROF. MADYA DR. AIDY @ MOHAMED SHAWAL M. MUSLIM**
Pensyarah
Institut Oseanografi
Universiti Malaysia Terengganu
21030 Kuala Terengganu, Terengganu.

Date: 11/4/2010

Second Supervisor (where applicable)

Name: **MUHAMMAD KHAEL**
Pensyarah
Jabatan Sains Marin
Official stamp: Fakulti Pengajian Maritim dan Sains Marin
Universiti Malaysia Terengganu (UMT)
21030 Kuala Terengganu.

Date: 11/4/2010

Head of Department of Marine Science

Name: **Dr. Razak bin Zakariya**
DR. RAZAK ZAKARIYA
Ketua Jabatan Sains Marin
Fakulti Pengajian Maritim dan Sains Marin
Universiti Malaysia Terengganu
(UMT)

Date: 11/4/10

ACKNOWLEDGEMENT

Final year project was a tough project for me. It is tough not only because of the understanding in doing the research, but is more on the management of the daily schedule to finish the project on time. From the sampling of the ground data, preparing the proposal, progress presentation, processing the data, and preparing this final report, various skills and knowledge were acquire. The time management, daily schedule arrangement, making appointment with those expects in the related field, social interaction with them were learnt throughout the implementation of the project. UMT surely was a great place for learning, with lot of intellectuals from various filed gather here and willing to share their knowledge with me. Prof. Madya Dr Aidy @ M.Shawal Bin M.Muslim, an expert in the remote sensing field, also is my first supervisor in my final year project, does help me a lot in my research and my project would not be success without him, surely his knowledge and helpfulness are much more appreciated. En Idham bin Khalil, my second supervisor and also was my lecturer in UMT. His expertise in the physical part of oceanography had taught me and strengthens my basic in physical oceanography and remote sensing field, specially thanks to both of them on their advices and guidance. In this project, sampling of the ground data make memorable, and thanks to Dr. Zainudin Bachok, who scarified his precious time and accompany me to the Lang Tengah Island although he is not my supervisor in my project, but his willingness and helpful knowledge during sampling are much more appreciated.

TABLE OF CONTENT

	Page
Acknowledgement	i
List of Content	ii
List of Tables	iv
List of figures	v
List of Equations	vi
List of Appendices	vii
Abstract	viii
Abstrak	x
Chapter 1 Introduction	
1.0 Introduction	1
1.1 Objective	3
Chapter 2 Literature Review	
2.1 The theory behind measuring bathymetry using remote sensing	5
2.2 Background/History	6
2.3 Current situation	6
2.4 Problem Statement	7
2.5 Benny and Dawson (1983)Method	8
2.6 Ratio Method	9
Chapter 3 Methodology	
3.1 Study Site	10

3.2 Overall Procedure Flowchart	11
3.3 Atmospheric correction	12
3.3.1 Dark Pixel Subtraction	12
3.4 Geometric Correction	13
3.5 Masking	13
3.6 Bathymetry	14
3.6.1 Benny and Dawson (1983) method	14
3.6.2 Ratio Method	16
3.7 Analysis	17
Chapter 4 Results	
4.1 Atmospheric Correction	18
4.2 Masking	21
4.3 Benny and Dawson Method	24
4.4 Ratio Method	28
4.5 Accuracy assessment	30
Chapter 5 Discussion	
5.1 Atmospheric correction	32
5.2 Masking	35
5.3 Benny and Dawson Method	36
5.4 Ratio Method	39
5.5 Comparison of Both Method	42
Chapter 6 Conclusion	
References	45
Appendices	47

List of Table

1. Table 4.1 Input parameters for the atmospheric correction by using ATMOSC module with dark pixel subtraction method	18
2. Table 4.2 New DN value for the reclass image	21
3. Table 4.3 Parameters require for the Benny and Dawson method to map bathymetry	24
4. Table 4.4 Input parameters and constants for the ratio method	28
5. Table 4.5 The accuray of the bathymetry map derive.	31
6. Table 5.1 The lowest DN value and the DN haze selected for image band 1, 2 and 3	32
7. Table 5.2 New value assign to reclass the image band 4	36
8. Table 5.3 Coefficient k and the R^2 calculated for band 1, 2 and 3	37
9. Table 5.4 The accuracy of the Benny and Dawson method with band 1, 2 and 3	37

List of Figures

1. Figure 3.1 Image of the Lang Tengah Island and the sampling points	10
2. Figure 3.2 An overall flowchart that show the main step in bathymetry	11
3. Figure 3.3 Flowchart that show the step for Bennyand Dawson method	14
4. Figure 3.4 Flowchart that show the step in ratio method	16
5. Figure 4.1 Atmospheric correction of band 1	19
6. Figure 4.2 Atmospheric correction of band 2	19
7. Figure 4.3 Atmospheric correction of band 3	20
8. Figure 4.4 Before atmospheric correction of raw image of RGB band	20
9. Figure 4.5 After atmospheric correction of image with RGB band	21
10. Figure 4.6 New reclass image with only two DN values, that is 0 for the land and 1 for the water	22
10. Figure 4.8 Masking of band 2 image	23
11. Figure 4.9 Masking of band 3 image	23
12. Figure 4.10 Graph of regression of log depth against log band 1	25
13. Figure 4.11 Graph of regression of log depth against log band 2	25
14. Figure 4.12 Graph of regression of log depth against log band 3	26
15. Figure 4.13 Image of bathymetry map with Benny and Dawson method for band 1	27
16. Figure 4.14 Image of bathymetry map with Benny and Dawson method for band 2	27
17. Figure 4.15 Image of bathymetry map with Benny and Dawson method for band 3	27
18. Figure 4.16 Graph of regression of ratio of band 1 and band 2 against actual depth	28
19. Figure 4.17 Bathymetry map acquire by the ratio method	29
20. Figure 4.18 Graph of actual depth against predicted depth for Benny and Dawson method, band 1.	30
21. Figure 4.19 Graph of actual depth against predicted depth for Benny and Dawson method, band 2	30
22. Figure 4.20 Graph of actual depth against predicted depth for Benny and Dawson method, band 3	31
23. Figure 4.21 Graph of actual depth against predicted depth for ratio method	31
24. Figure 5.1 Before atmospheric correction (left) After atmospheric correction(right)	32
25. Figure 5.3 Raw image of band 4 (left) Reclass image of band 4 (right)	35
26. Figure 5.5 Bathymetry map acquire by Benny and Dawson method with band 1(left) and band 2 (right)	38
27. Figure 5.6 Graph of regression of ratio of band 1 to band 2 against actual Depth	40
28. Figure 5.6 Bathymetry map acquire by ratio method	41
29. Figure 5.7 Graph showing the accuracy with the regression of predicted depth against actual depth	42
30. Figure 5.7 Bathymetry map acquire by ratio method (left) and Benny and Dawson method with band 1(right).	43

List of Equation

1. Equation 2.1	5
2. Equation 2.2	8
3. Equation 2.3	9
4. Equation 5.1	33
5. Equation 5.2	33
6. Equation 5.3	34
7. Equation 5.4	39

List of Appendices

1. Appendix 1 Raw data	46
2. Appendix 2 Calculated regression data	50
3. Appendix 3 Image metadata file	53
4. Appendix 4 Data accuracy assessment	58

Abstract

Optical remote sensing offers an alternative to traditional hydrographic surveys for measuring water depth, with the advantage that data are collected synoptically over large area. Just one limitation of the remote sensing in the bathymetry field, this technique is only capable applied to the shallow water whereas for the deeper part of the water, remote sensing technique is not capable to map the bathymetry accurately. Bathymetry can only be derived from remote sensing to a maximum depth of 25m in the clearest water, and considerably less in turbid water. Different satellite had been used to derive bathymetry since 1970 such as Landsat and Ikonos. But the high spatial resolution of the satellite has limit the detection and analysis of bathymetry. QuickBird satellite imagery which it has 2.4m of spatial resolution for multispectral image was used in this study to acquire the bathymetry of Lang Tengah Island. The fine spatial resolution of the QuickBird satellite has improve the results of the bathymetry acquire as it can discern small object up to 2.4m. There are a lot of method develop to derive bathymetry, this study is only emphasize on two methods, which are linear method (Benny and Dawson method) and ratio method. Both methods require the same pre-processing, that is, geometric correction, atmospheric correction (Dark pixel subtraction method) and masking. But due to some problem encounter, geometric correction was not done in this project. Comparison was made to compare the accuracy of both methods above to map the bathymetry of various bottom types, which is bottom type with different albedo, at Lang Tengah Island. Accuracy was compare by the actual depth and the bathymetry depth acquire by both methods mention above. The results show that the highest accurate band for Benny and Dawson method was band 2 among the three band compare, which it's R^2

achieve 0.7036. But ratio method is much more robust than the linear method as its R^2 achieve 0.9825. Ratio method is better in mapping the water depth with different albedo than the linear method. It is more robust than the linear method as it is require only two tunable parameters whereas for the linear method, it is require more than 2 tunable parameters.

Abstrak

Penderiaan jauh optik menawarkan alternatif untuk membuat survei mengenai kedalaman air selain daripada cara tradisional, dengan kelebihan bahawa data yang lebih luas dapat dikumpulkan. Hanya satu sekatan kepada penderiaan jauh di bidang batimetri, teknik ini hanya mampu mengukur kedalaman air cetek manakala untuk bahagian luat yang lebih dalam kedalaman, teknik penderiaan jarak jauh tidak mampu untuk mengukur batimetri dengan tepat. Batimetri hanya boleh diperolehi dengan menggunakan penderiaan jarak jauh ke kedalaman maksimum 25m di air jernih, dan kurang daripada 25m di air keruh. Satelit yang berbeza telah digunakan untuk mengukur batimetri sejak tahun 1970 seperti Landsat dan Ikonos. Tetapi resolusi spasial tinggi daripada satelit tersenut telah menyekat pengesanan dan analisis batimetri. Satelit Quickbird yang mempunyai resolusi spasial 2.4m digunakan dan gambar multispectral digunakan dalam kajian ini untuk mendapatkan batimetri Pulau Lang Tengah. Kehalusan spasial resolusi dari satelit Quickbird telah meningkatkan kejituan keputusan diperolehi kerana ia dapat membezakan benda-benda kecil sehingga 2.4m. Terdapat banyak cara untuk mengukur batimetri, kajian ini hanya menekankan pada dua kaedah, iaitu kaedah linear (Benny and Dawson) dan kaedah ratio. Kedua-dua kaedah ini juga memerlukan pra-pemprosesan, iaitu, pembetulan geometrik, pembetulan atmosfera (Dark pixel subtraction) dan masking. Namun, disebabkan oleh beberapa masalah yang dihadapi, pembetulan geometri tidak dilakukan dalam projek ini. Perbandingan dibuat untuk membandingkan ketepatan daripada kedua-dua kaedah di atas untuk mengukur batimetri dengan dasar laut yang mempunyai pelbagai jenis di Pulau Lang Tengah. Akurasi akan dibandingkan dengan kedalaman yang sebenar dan kedalaman yang diperolehi dengan kedua-dua kaedah di

atas. Keputusan kajian menunjukkan bahawa band yang tepat untuk Benny and Dawson adalah band 2 di antara tiga band yang dibandingkan, yang itu R2nya mencapai 0,7036. Tetapi kaedah ratio jauh lebih kuat daripada kaedah linear dengan R2nya mencapai 0,9825. Kaedah ratio ini lebih baik dalam pemetaan kedalaman air dengan Albedo berbeza daripada kaedah linier. Ia lebih kuat daripada kaedah linear kerana hanya memerlukan dua parameter sedangkan untuk kaedah linear, itu memerlukan lebih daripada 2 parameter .