UNIVERSITI PUTRA MALAYSIA

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**DOCTOR OF PHILOSOPHY**
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# REMOTELY SENSED CHLOROPHYLL-A VARIABILITY IN THE STRAITS OF MALACCA

**By**

**ABDEL GALEEL ALI YOUSIF**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy**

**July 2009**

## DEDICATION

*THIS WORK IS DEDICATED TO MY BELOVED FAMILY*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

**REMOTELY SENSED CHLOROPHYLL-A VARIABILITY IN THE STRAITS OF MALACCA**

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**July 2009**

**Chairman : Professor Mohd Ibrahim Bin Hj. Mohamed, PhD**

**Faculty : Environmental Studies**

Studies on the marine plankton in Malaysian waters are limited, and most of the studies have been mainly taxonomic and qualitative in nature. The present study investigates the spatial and temporal distribution of SeaWiFS derived-chlorophyll-a in the Straits of Malacca. A period of six consecutive years from 1998 to 2003 is studied. Validation of in situ chlorophyll-a measurements with their corresponding SeaWiFS chlorophyll-a data is carried out. The correlation of sea surface temperature (SST) with the temporal chlorophyll-a data is investigated. The relationship between the Southern Oscillation Index (SOI) values and chlorophyll-a data is discussed. Finally, the correlation of marine fish landings with chlorophyll-a data is revealed.

SeaWiFS Data Analysis System (SeaDAS) has been used in SeaWiFS chlorophyll-a data analysis. In its typical use for the study of chlorophyll-a variability in tropical cloudy areas, ocean colour imagery is often binned in space and time. Comparison of in situ and SeaWiFS derived chlorophyll-a reveals that there is a moderate, positive correlation ($r$ = 0.51) between the in situ and SeaWiFS chlorophyll-a observations, and the correlation is significant ($P$ <0.05) at the 0.05 level. With the six years of nearly continuous monthly images from the SeaWiFS instrument, the patterns of chlorophyll-a variability at Straits of Malacca have thus been investigated.

The results show spatial variability of chlorophyll-a in the Straits of Malacca. High chlorophyll-a concentration value (4.42 mg $m^{-3}$) has been observed along the near coastal area. Chlorophyll-a value (0.39 mg $m^{-3}$) decreased towards the offshore areas. Chlorophyll-a distribution was higher in the central (2.68 mg $m^{-3}$) and southern parts (3.80 mg $m^{-3}$) of the Straits of Malacca compared to the northern parts (1.16 mg $m^{-3}$). The results also show seasonality of chlorophyll-a and SST variations in the Straits of Malacca. Phytoplankton bloom events were also revealed during the northeast monsoon season all over the Straits of Malacca. The peak concentrations of chlorophyll-a were prevailed during the northeast monsoon months (2.73 mg $m^{-3}$).

Chlorophyll-a concentration is relatively low during the southwest monsoon (1.68 mg $m^{-3}$) and the two inter-monsoons months and was confined to the coastal areas. SST is low during the northeast monsoon months (28.31$^{o}$C) and high during the southwest monsoon (30.32$^{o}$C) and the two inter-monsoon months. A negative correlation was observed between the temporal SST and chlorophyll-a. Strong

negative SOI value (-28.5) occurred in 1998 and was associated with low chlorophyll-a values. Positive SOI values observed in 1999 were associated with high chlorophyll-a values.

It was found that the monthly marine fish landings value (39,391 metric tonnes) during the northeast monsoon months is lower than the monthly marine fish landings value (45,637 metric tonnes) during the southwest monsoon months.

The research has demonstrated that satellite remote sensing is capable of identifying, quantifying and mapping chlorophyll-a in the study area. The variability between SeaWiFS and in situ chlorophyll-a data explains the typical nature of Case II waters. The spatial chlorophyll-a distribution is associated with hydrographic features of the Straits of Malacca, and the temporal variation of chlorophyll-a concentrations is related to temporal variations in SST distributions and availability of nutrients. Strong relationships exist between ocean colour and other physical parameters such as SST. The negative correlations between chlorophyll-a and fish production with the SOI are attributed to the negative effects of the El Niño in the study area.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PERUBAHAN KLOROFIL-A SECARA PENDERIAAN JARAK JAUH DI SELAT MELAKA**

Oleh

**ABDEL GALEEL ALI YOUSIF**

**July 2009**

**Pengerusi : Professor Mohd Ibrahim Bin Hj. Mohamed, PhD**

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Kajian mengenai plankton marin di perairan Malaysia adalah terhad, dan sebahagian besar daripada kajian adalah berasaskan kajian taxonomi dan kualitatif. Kajian ini menyiasat taburan spatial dan temporal klorofil-a yang diperolehi daripada SeaWiFS di Selat Melaka. Jangka masa 6 tahun beturutan iaitu dari tahun 1998 hingga 2003 dikaji. Kesahihan sukatan in-situ klorofil-a dibandingkan dengan SeaWiFS dijalankan. Korelasi suhu permukaan laut (SST) dengan data temporal clorofil-a disiasat. Perkaitan antara nilai indeks Southern Oscillation (SOI) dan klorofil-a didincang. Akhirnya, korelasi pendaratan ikan laut dengan data klorofil-a dipaparkan.

SeaWiFS Data Analysis System (SeaDAS) telah digunakan untuk menganalisa data klorofil-a. Dalam penggunaan biasanya dalam kajian perubahan klorofil-a di kawasan tropika yang mendung, gambarajah lautan berwarna biasanya dikait dalam ruang dan masa. Perbezaan antara klorofil-a in-situ dan terbitan SeaWiFS menunjukkan terdapat korelasi positif yang sedehana ($r$ = 0.51) di antara kedsa-dua pemerhatian, dan korelasinya adala signifikan ($p$ <0.05) pada tahap 0.05. Dengan gambaran secara bulanan selama enam tahun yang diperolehi oleh peralatan SeaWiFS, corak perubahan di Selat Melaka telah disiasat.

Keputusan menunjukkan perubahan spatial klorofil-a di selat Melaka. Kepekatan klorofil-a yang tinggi (4.42 mg $m^{-3}$) diperhatikan di sepanjang kawasan persisiran pantai. Nilai klorofil-a (0.39 mg $m^{-3}$) didapati berkurangan menuju kawasan perluaran pantai. Taburan klorofil-a adalah tinggi di kawasan bahagian pertengahan (2.68 mg $m^{-3}$) dan bahagian selatan (3.80 mg $m^{-3}$) Selat Melaka berbanding bahagian utara (1.16 mg $m^{-3}$). Keputusan juga menunjukan perubahan secara bermusim untuk klorofil-a dan SST di Selat Melaka. Kejadian perkembangan plankton adalah nyata semasa musim Monsun Timur Laut di keseluruhan Selat Melaka. Kepekatan puncak klorofil-a adalah lebih nyata ketika bulan-bulan Monsun Timur Laut (2.73 mg $m^{-3}$).

Kepekatan klorofil-a adalah rendah secara perbandingan ketika Monsun Barat Daya (1.68 mg $m^{-3}$) dan kedua-dua bulan perantaraan monsun dan dihadkan kepada kawasan persisiran. SST adalah rendah pada bulan-bulan Monsun Timur Laut (28.31$^{o}$C), dan tinggi ketika Monsun Barat Daya (30.32$^{o}$C) dan kedua-dua bulan perantaraan monsun. Korelasi negatif diperhatikan di antara SST secara temporal dan

klorofil-a. Negatif korelasi yang tinggi bagi nilai SOI (-28.5) ditunjuk pada tahun 1998 dan dikaitkan dengan nilai klorofil-a yang rendah. Nilai SOI positif diperhatikan pada 1999 adalah dikaitkan dengan nilai klorofil-a yang tinggi.

Nilai pendaratan ikan marin bulanan (39,391 tan metrik) ketika bulan-bulan Monsun Timur Laut adalah lebih rendah daripada nilai pendaratan ikan marin bulanan (45,637 tan metrik) ketika bulan-bulan Monsun Barat Daya.

Kajian jelas menujuk bahawa penderiaan jarak jauh satelit mampu mengenalpasti, menghitung, dan memeta klorofil-a di kawasan kajian. Perbezaan antara data klorofil-a SeaWiFS and in-situ menerangkan ciri-ciri umum air Kes II. Taburan spasial klorofil-a berkait rapat dengan ciri-ciri hidrografik Selat Melaka, manakala perubahan temporal kepekatan klorofil-a adalah berkait rapat dengan perubahan SST dan kehadiran nutrien. Perhubungan yang kukuh wujud di antara warna laut dan parameter fizikal lain seperti SST. Korelasi negatif antara klorofil-a dan pengeluaran ikan dengan SOI menyumbang kepada kesan negatif daripada El Niño di kawasan kajian.

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I certify that a Thesis Examination Committee has met on 10th July 2009 to conduct the final examination of **Abdel Galeel Ali Yousif** on his thesis entitled "Remotely Sensed Chlorophyll-a Variability in the Straits Of Malacca" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Unversiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the **Doctoral of Philosophy**.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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Date: 14 January 2010

## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently submitted for any other degree at University Putra Malaysia or at any other institution.

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ABDEL GALEEL ALI YOUSIF

DATE: 25 November 2009

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES