UNIVERSITI PUTRA MALAYSIA

DETERMINATION OF CHLOROPHYLL-A CONCENTRATION FROM SEAWIFS DATA IN THE SOUTH CHINA SEA

ARNIS BT. ASMAT

DETERMINATION OF CHLOROPHYLL-A CONCENTRATION FROM SEAWIFS DATA IN THE SOUTH CHINA SEA

By

ARNIS BT. ASMAT

Thesis Submitted in Fulfilment of the Requirement for the Degree of
Master of Science in the Graduate School
Universiti Putra Malaysia

December 2001

Dedicated to my parents,

Asmat B. Arsat

and

Aminah Hj. Suhari

My brothers and sisters,

And my family,

Muhammad Arif B. Abd. Kadir

and

Aimi Shahirah

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DETERMINATION OF CHLOROPHYLL-*A* CONCENTRATION FROM SEAWIFS DATA IN THE SOUTH CHINA SEA

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Chairman : Assoc. Prof. Dr. Shattri B. Mansor

Faculty : Engineering

The use of satellite remote sensing to provide synoptic measurements of the ocean is becoming increasingly important in the fishing industry. The evolving capabilities of satellite sensors and data processing techniques provide a promising tool towards the development of fish forecasting and management techniques. Mapping phytoplankton distribution and growth are important in fisheries and physical oceanographic studies. The light absorbing pigments collectively known as chlorophyll-*a* are commonly used by oceanographers as an index of phytoplankton concentration.

The objective of this study is to measure the concentration of chlorophyll-*a* in the Exclusive Economic Zone (EEZ) of East Coast Peninsular Malaysia, based on remotely sensed data. In order to achieve this objective it is

essential to determine an empirical relation between the chlorophyll-*a* and the radiances values recorded by the sensor and to measure the concentration chlorophyll-*a* from remotely sensed data. This study used in-situ data of concentration chlorophyll-*a* to measure the concentration of chlorophyll-*a* from SeaWiFS data. Models to estimate the chlorophyll-*a* concentration were generated by computation based on empirical method using radiance ratio of SeaWiFS channels.

The data from the sea truth campaigned of 24th August 2000 until 29th August 2000 were applied to obtain the correlation between chlorophyll-*a* concentration $\left(mg/m^3\right)$ and the radiance values in chosen channel of SeaWiFS. The amount of concentration of chlorophyll-*a* was calculated based on blue, blue-green and green (442nm, 490nm and 555nm) reflectance ratios, this was done by selecting representative radiance values corresponding to in-situ data measurements.

The study proved that the remote sensing technique is a very useful tool for studying chlorophyll-*a* distribution in a large water body area such as the EEZ. In this work, channel 2, channel 3 and channel 5 of SeaWiFS data have been found to be the most suitable channel to extract the chlorophyll-*a* concentration. Correlation analysis between remotely sensed data and chlorophyll-*a* in-situ data indicates the possibility of mapping chlorophyll-*a* concentration with some degrees of success. The strong correlation of radiance ratio corresponding to above channel with in-situ

data provides the basis for the development of equation and constant for the estimation of chlorophyll-*a* concentration in South China Sea.

The results show that the empirical model has significantly highest correlation to the in-situ data. SeaWiFS level 1 data gives correlation of $r^2 = 0.6882$ and level 2 data gives correlation of $r^2 = 0.6677$. The ratio between channel 2, channel 3 and channel 5 shows good combination to extract chlorophyll-*a* from SeaWiFS data. For SeaWiFS data, ratio derived using blue channel (443nm), blue-green channel (490nm) and green channel (555nm) was used to extract the chlorophyll-*a* concentration from SeaWIFS data. The ratio of $\left(\frac{R443 - R555}{R490}\right)$ was used for implementing the empirical algorithm (linear regression) and Morel algorithm. For SeaBAM algorithm, the ratio of $\log_{10}\left(\frac{R443}{R555}\right)$ was applied. The Morel and SeaBAM algorithms were modified to suit with the tropical area.

From this study, it can be concluded that remote sensing techniques with suitable extracting chlorophyll-*a* concentration algorithm offers a useful technique for estimating of chlorophyll-*a* concentration in study area.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia
untuk keperluan Ijazah Sarjana Sains

PENENTUAN KONSENTRASI KLOROFIL-A DARI DATA SEAWIFS DI LAUT CHINA SELATAN

Oleh

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Penggunaan satelit penderiaan jauh menjadi ukuran bagi bidang kelautan yang penting dalam industri perikanan. Peningkatan keupayaan penderia satelit dan teknolgi pemprosesan data dengan gabungan metod tradisional pengumpulan data telah mewujudkan satu peralatan yang berguna kearah pembangunan peramalan perikanan dan teknik pengurusan. Pemetaan taburan fitoplankton dan perkembangannya amat penting dalam bidang perikanan dan kajian tentang fizikal oseonografi. Pigmen yang menyerap cahaya yang dikenali sebagai klorofil-*a* digunakan sebagai indeks untuk mengkaji kepadatan fitoplankton.

Objektif penyelidikan adalah mengukur kepadatan klorofil-*a* di kawasan Zon Ekonomi Eksklusif Pantai Timur Semenanjung Malaysia

berasaskan imej data SeaWiFS. Hubungan empirikal di antara klorofil-*a* dan nilai radiasi adalah penting untuk menganggar taburan kepadatan klorofil-*a* dari data satelit. Penyelidikan ini juga turut menggunakan data in-situ kepadatan klorofil-a untuk mengukur kepadatan klorofil-a di kawasan kajian. Model untuk menganggar kepadatan klorofil-*a* adalah berdasarkan metod empirikal menggunakan nisbah radiasi pada jalur SeaWiFS.

Data lapangan yang diperolehi pada 24th Ogos 2000 sehingga 29th Ogos 2000 digunakan untuk mendapatkan korelasi di antara kepadatan klorofil-*a* dan nilai nisbah pantulan pada jalur SeaWiFS. Jumlah kepadatan klorofil-*a* diukur berdasarkan pantulan nisbah ke atas jalur biru, biru-hijau dan hijau (442nm, 490nm dan 555nm). Ini dapat dilakukan dengan memilih nilai radiasi pada imej yang mewakili nilai in-situ.

Kajian menunjukkan teknik penderiaan jauh merupakan alat yang berguna untuk mengkaji taburan klorofil-a di kawasan badan air yang luaş seperti Zon Ekonomi Eksklusif. Didapati, jalur 2, jalur 3 dan jalur 5 merupakan jalur yang sesuai untuk mengekstrak kepadatan klorofil-*a* dari data SeaWiFS. Analisis korelasi antara data derian jauh dan data in-situ menunjukkan kebarangkalian yang tinggi untuk memetakan kepadatan klorofil-*a*. Hubungan korelasi yang kuat ke atas radiasi nisbah yang mewakili jalur yang dipilih dengan data in-situ boleh

menjadi asas perkembangan persamaan dan nilai angkatap untuk mengukur kepadatan klorofil-*a* di kawasan kajian.

Hasil analisis menunjukkan model empirikal memberi nilai korelasi yang signifikan dengan data in-situ. Data SeaWiFS peringkat 1 dengan nilai $r^2 = 0.6882$ dan data peringkat 2 dengan nilai korelasi $r^2 = 0.6677$. Nisbah antara jalur 2, jalur 3 dan jalur 5 merupakan kombinasi yang baik untuk mengekstrak klorofil-*a* dari data SeaWiFS. Nisbah telah diterbitkan menggunakan jalur biru (443nm), jalur biru-hijau (490nm) dan jalur hijau (555nm) untuk mengekstrak kepadatan klorofil-*a* dari data SeaWiFS. Nisbah $\left(\frac{R443 - R555}{R490}\right)$ telah digunakan untuk menjana model empirical dan model Morel. Bagi model SeaBAM, nisbah $\log 10\left(\frac{R443}{R555}\right)$ telah digunakan. Model Morel dan SeaBAM telah diubahsuai untuk disesuaikan dengan kawasan tropika.

Hasil kajian menunjukkan bahawa teknik penderiaan jauh dengan model mengekstrak nilai klorofil-*a* menawarkan satu teknik yang berguna untuk mengukur kepadatan klorofil-*a*.

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To my supervisors, my parents, my family, my friends and all who helped me throughout my studies, "May Allah s.w.t rewards you for your good deeds, *Ameen*".

I certify that an Examination Committee met on 13th December 2001 to conduct the final examination of Arnis bt. Asmat on her Master of Science thesis entitled "Determination of Chlorophyll-a Concentration from SeaWiFS in the South China Sea" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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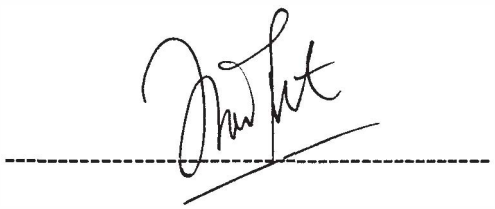
DECLARATION

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 or concurrently submitted for my other degree at UPM or other institutions.



Arnis Bt. Asmat

Date: 29 January 2002

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LIST OF ABBREVIATIONS

ADEOS	Advanced Observing Satellite
AO	Announcement Opportunity
CDOM	Chromophoric dissolved organic materials
Chlorophyll-*a*	Pigment present living plants responsible for photosynthesis
CZCS	Coastal Zone Color Scanner
DOF	Department of Fisheries
DN	Digital Number
EEZ	Exclusive Economic Zones
ENVI	The Environment for Visualizing Images
FOV	Field -of- View
GAC	Global Area Coverage
HDF	Hierarchical Data Format
HRPT	High Resolution Picture Transmission
IFOV	Instantaneous Field-of-View
LAC	Local Area Coverage
LANDSAT	Land Satellite
L_w	Water leaving radiances
MOS	Marine Observation Satellite
MSS	Multi-spectral sensor
NASA	National Aeronautics and Space Administration
NASDA	National Space Development Agency of Japan

NOAA	National Oceanic and Atmospheric Administration
OCTS	Ocean Colour and Temperature sensor
ODAS	Ocean Data Acquisition System
RDN	Ratio value in the ratio image
SeaBAM	SeaWIFS Bio-Optical Algorithm Mini Workshop
SeaWiFS	Sea Wide Field-of-view Sensors
SPOT	Satellite Probaitoire d'observation de la terre
TDI	Time Delay and Integration
TM	Thematic Mapper

CHAPTER I

INTRODUCTION

1.1 Background

Oceanographic research is important for proper exploitation of fishery resources. The fishery resources are closely related to the conditions of the ocean environmental. The natures of environmental and physical conditions of the ocean also determine the types of organism present and the possible carrying capacity of an area. The nutrients, plankton and benthos distributions will indicate the presence of the pelagic and demersal fish. If the relationships between these organisms are known especially in terms of their food requirements then the abundance and the biomass of the fish could be estimated and predicted. This constitutes partially the assessment of fish stocks using the ecosystem approach. Detailed studies of oceanographic parameters could explain the variability of the presence of fish stock in specific areas (Department of Fisheries, 2001).

With the declaration of the 200 nautical miles of Economic Exclusive Zone (EEZ) in 1980, Malaysia has a sea area about 138 700 sq nautical miles. This vast area imposes a big challenge to the relevant authorities to effectively monitor and manage the fisheries resources. Since 1960 the industry has undergone rapid development in the fish production sector (Seafdec, 2001).

1.1.1 Fishery Industry in Malaysia

The fisheries sector in Malaysia plays a significant role with regards to the economic and food. Basically, fisheries industry in Malaysia can be categorized into marine fisheries, aquaculture and public water bodies. However, currently public water bodies do not contribute significantly to the fisheries industry. For management purposes, the marine fisheries are categorized into the inshore sector and deep-sea sector. Aquaculture on the other hand covers freshwater and brackish water culture. The inshore fisheries are already heavily exploited and there is evidence that fishing is over saturated. However, a deep-sea fishery has a full potential for development (Seafdec, 2001).

The potential of deep-sea fishery will be exploited and developed at a faster pace towards the year 2020 (Seafdec, 2001). The fishery resources