UNIVERSITI PUTRA MALAYSIA

SATELLITE FISH FORECASTING IN TROPICAL WATERS

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SATELLITE FISH FORECASTING IN TROPICAL WATERS

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2002

To my Dearest Father, Mother and Brother.

&

To my dearest Swee Swee & My Sweet Baby

All of your sacrifices, support and encouragement

will be in my heart forever…

Abstract of the thesis submitted to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science.

SATELLITE FISH FORECASTING IN TROPICAL WATERS

By

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March 2002

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South China Sea off the east coast of Peninsular Malaysia is shallow, semi-enclosed tropical sea. Most of the fishing activities in this area are concentrated in the inshore waters where marine resources are optimally exploited. However, the offshore waters still harbour a potential for fishery development. This study was carried out to assist the nation to develop offshore fisheries through sustainable development of the fisheries resources in the Malaysian Exclusive Economic Zone (EEZ) and thus harvest the fishery resources effectively and sustainably.

The integration of remote sensing and GIS modeling has provided a powerful tool in fish forecasting. Understanding the relationship between oceanographic conditions and fish behavior can lead towards forecasting of fish migration and

aggregation. Fish forecasting technology has been applied successfully in many countries. Findings of this study showed that some of the forecasting methods used in temperate water were unsuitable to be applied in this region.

A fish forecasting model was developed in this study. The model was primarily based on the description of oceanographic phenomena from two major parameters, namely sea surface temperature and chlorophyll *a*. An oceanography and acoustic survey was conducted in year 2000 to verify the Potential Fishing Zone forecast. The survey's results showed that abundance of fish was located close to the upwelling boundaries, which agreed with the forecast results. For the ease of fish forecasting using GIS, ArcView interface was customized and named as the Tropical Fish Forecasting System (TroFFS).

The Tropical Fish Forecasting System was simple, easy to use, and less time consuming. Furthermore, it was able to detect the warm temperature front and the boundaries of upwelling areas. However, it had some limitations. Firstly, it was non-species selective. Secondly, the precision was dependent on the sensor spatial resolution. Thirdly, low chlorophyll *a* content in the offshore waters limited the forecasting of the potential fishing zones in these areas.

As the conclusion, this research had demonstrated that the developed fish forecasting model was able to predict the fishing grounds in South China Sea. Further refinement needs to be done on the fish forecasting model in order to develop the National Fish Forecasting System.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

RAMALAN IKAN DI LAUTAN TROPIKA DENGAN SATELIT

Oleh

TAN CHUN KNEE

Mac 2002

Pengerusi: Profesor Madya Dr. Shattri Bin Mansor

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Laut China Selatan di Semenanjung Malaysia merupakan laut tropika yang cetek dan separuh tertutup. Kebanyakan kegiatan perikanan di kawasan ini adalah tertumpu kepada pinggiran pantai di mana sumber perikanannya telah dieksploitasi pada tahap optimum, malahan sumber di laut dalam masih mempunyai potensi untuk diterokai. Kajian ini bertujuan untuk membantu negara kita membangunkan perikanan laut dalam Zon Eksklusif Economik (EEZ) Malaysia bagi pentadbiran sumber perikanan yang berkesan dan berjangka panjang.

Integrasi antara teknologi penderiaan jauh dan sistem informasi geologi merupakan alat yang berkesan untuk ramalan ikan. Pengetahuan dalam kaitan antara keadaan lautan dengan tabiat ikan dapat meramalkan pergerakan dan pengumpulan kumpulan ikan. Banyak kajian telah dijalankan di luar negara, tetapi kaedah yang diguna kurang sesuai untuk keadaan di rantau ini.

Satu model ramalan ikan telah dihasilkan dalam kajian ini. Model tersebut lebih tertumpu kepada ramalan ikan dengan fenomena lautan yang menggunakan parameter suhu permukaan laut dan klorofil a. Untuk menghasilkan peta zon potensi perikanan, parameter ini telah diimpot ke dalam ArcView untuk diproses dan analisis. Satu siasatan telah dijalankan pada tahun 2000 untuk mengesahkan zon potensi perikanan yang dihasilkan. Keputusannya menunjukkan bahawa kawasan sekitar fenomena "upwelling" yang diramal memang merupakan zon perikanan yang sesuai. Untuk memudahkan proses ramalan ikan, program ArcView telah diubahsuai dan dinamakan sebagai Sistem Ramalan Ikan Tropika (TroFFS).

Kebaikan model ini adalah ia mudah, senang diguna dan tidak memerlukan masa yang lama untuk memproses. Selain itu, ia amat berkesan untuk meramalkan ikan pada kawasan upwelling. Sebaliknya, batasan model ini adalah ia tidak boleh meramalkan spesis ikan yang tertentu. Kejituan ramalannya adalah bergantung kepada resolusi satelit. Selain itu, kandungan klorofil yang rendah di laut dalam juga akan menghadkan ramalan di kawasan tersebut.

Kesimpulannya, kajian ini telah menunjukkan bahawa model ramalan ikan yang dihasil dapat mengesan kawasan perikanan dengan berkesan. Kajian ini boleh digabung dengan sistem penerimaan data satelit dan kemudahan penyebaran zon potensi perikanan untuk membentuk Sistem Ramalan Ikan Nasional.

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I certify that an Examination Committee met on 19th July 2001 to conduct the final examination of Tan Chun Knee on his Master of Science thesis entitled "Satellite Fish Forecasting in Tropical Waters" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 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 any other degree at UPM or other institutions.

TAN CHUN KNEE

Date: 18. 3. 2002

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LIST OF ABBREVIATIONS

ADEOS/OCTS	Advance Earth Observing Satellite/Ocean Color and Temperature Scanner
APT	Automatic Picture Transmission
AVHRR	Advance Very High Resolution Radiometer
CD	Compact Disc
CZCS	Coastal Zone Color Scanner
DBMS	Database Management System
DN	Digital Number
DOF	Department of Fisheries
EEZ	Exclusive economic zone
FAD	Fish Aggregation Devices
GAC	Global Area Coverage
GIS	Geographic Information System
IDW	Inverse Distance Weighted
IRS	Indian Remote Sensing Satellite
ITS	Ideal Thermal Scenario
JAFIC	Japan Fishery Information Centre
JERS	Japanese Earth Resources Satellite
LAC	Local Area Coverage
MACRES	Malaysian Centre for Remote Sensing
MFRDMD	Marine Fishery Resource Development and Management Department
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	Modular Optoelectronic Scanner
NAS	National Agriculture Policy
NE	Northeast
NOAA	National Oceanic and Atmospheric Administration
PC	Personal Computer
PFZ	Potential Fishing Zone
R. V.	Research Vessel
ROFFS	Roffer's Ocean Fishing Forecasting Service
RS	Remote Sensing
SEAFDEC	Southeast Asian Fisheries Development Centre
SeaWiFS	Sea-Viewing Wide Field-of-View Sensor
SPOT	Satellite Pour l'Observation de la Terra
SST	Sea Surface Temperature
SW	Southwest
T	Transect
TroFFS	Tropical Fish Forecasting System
TSS	Total Suspended Solids
UPM	Universiti Putra Malaysia
US	United States
VNIR	Visible and near infrared
VTMS	Vessel Traffic Management System
W	Week

CHAPTER I
INTRODUCTION

Fisheries Sectors in Malaysia

The fisheries sector plays an important role in the economy as a major source of food, employment, income and foreign exchange. Fish intake represents almost two-third of the total animal protein consumption of the population. The demand for fish is expected to rise with the increasing population and, present demand of 36 kg per capital is expected to increase to over 796,100 tones by the end of the century (Mazlan, 1998).

On 25 April 1980, Malaysia claimed its Exclusive Economic Zone (EEZ) from her coast extend to 200 miles belt of the ocean adjacent. With these declaration made by the government, the water under our jurisdiction have been extended from 40,000 square miles to 160,000 square miles (approximately 332,673 km^2). By the increment of the EEZ, it provided greater potential to explore the offshore marine resources especially in the South China Sea.

The National Agriculture Policy (NAP) had been established for the objective to maximize income through efficient and optimum utilization of the natural resources and revitalization of the fisheries sector in contributing to the economic development of the country. Under this policy, clear guidelines were spelt out for the fisheries sector, viz.:

- Fish is another important source of protein and the country's fish requirement will be met through the use of modern methods to fully exploit the fisheries resources.
- Offshore fishing will be stepped up through the utilization of both local and foreign expertise and setting up of adequate fishing fleets.

According to Mohd. Mazlan (1998), coastal fishing activities accounting for about 85% of the total landings in Malaysia. It is a general consensus that the coastal fisheries are already fully exploited. Decline in total catch, decrease in catch per unit effort, increase in trash fish component and general decline in body size in catches are all indicators of declining fish stock.

By geological distribution, the west coast contributed about 56% of the total catch of Peninsular Malaysia. Due to heavy exploitation in the west coast and coupled with limited fishing grounds, more deep sea vessels are now based in the east coast regions (Mahyam, 1994).

Table 1.1 shows the estimated biomass and potential yield of pelagic fish resources in Peninsular Malaysia by R. V. Rastrelliger (1986-1987). The result showed that potential yield of 92900 metric tonnes is available from the survey portion of the Malaysian EEZ. The most promising locality is off the east coast of Peninsular Malaysia where the potential yield was 66850 metric tonnes (Mahyam, 1994). However, the deep-sea offshore fisheries are still relatively new and underdeveloped with only about 15% contribution to the total landings.

Table 1.1 The estimated of pelagic fish biomass and potential yield (Metric tonnes) for Peninsular Malaysia.

Area	Biomass	Potential Yeild
East Coast:		
12-30 nm	24500	12250
More than 30 nm	109200	54600
Total	133700	66850
West Coast:		
12-30 nm	18200	9100
More than 30 nm	33900	16950
Total	52100	26050

Source: Department of Fisheries, 1989

Fishing effort must be concentrated in areas of known high density to make the operations economically feasible. These fishing grounds must be located to ensure greater chances of full utilization of the available potential. In order to optimally exploit the potential of fish resource in our EEZ, several strategies may be applied, such as improve fishing vessel and fishing gears, regulate fisheries law and fishing grounds forecasting.

According to Laevastu and Hela (1970), implementation of the fish forecasts in which the environmental analysis and forecasts is the easiest, the most efficient and the cheapest means of improving the catch per effort. To accomplish this, the behaviour of fish in relation to the conditions and changes in the environment must be known.

Remote Sensing

Remote Sensing (RS) is defined as the science and technology by which the characteristics of objects of interest can be identified, measured or analysed the characteristics without direct contact. Electro-magnetic radiation, which is reflected or emitted from an object, is the usual source of remote sensing data.

A device to detect the electro-magnetic radiation reflected or emitted from an object is called a "sensor". A vehicle to carry the sensor is called a "platform". Aircraft or satellites are used as platforms. The technical term "remote sensing" was first used in the United States in the 1960's, and encompassed photogrammetry, photo-interpretation, photo-geology etc. Since Landsat-1, the first earth observation satellite was launched in 1972; remote sensing has become widely used.

The characteristics of an object can be determined, using reflected or emitted electro-magnetic radiation, from the object. That is, "each object has a unique and different characteristics of reflection or emission if the type of object or the environmental condition is different. "Remote sensing is a technology to identify and understand the object or the environmental condition through the uniqueness of the reflected or emitted energy.

Remote sensing is classified into optical remote sensing and microwave remote sensing. Examples of the optical RS satellites are Landsat, SPOT, MOS, ADEOS, IRS, SeaWiFS, NOAA, IKONOS etc. In optical RS, optical sensors detect solar radiation in

the visible and near infrared wavelength regions (commonly abbreviated as VNIR) reflected or scattered from the earth, forming images resembling photographs taken by a camera high up in space.

Most of the microwave RS satellites carry an active sensor. The active sensors emit pulses of microwave radiation to illuminate the areas to be imaged. Earth surface images are formed by measuring the microwave energy scattered by the ground or sea back to the sensors. These satellites carry their own "flashlight" emitting microwaves to illuminate their targets. Some example of the microwave RS satellites are ERS, JERS, Radarsat etc.

Satellite Oceanography

Satellite oceanography is the title that encompasses all aspect of the study of the ocean, which use surveillance of the sea from platforms orbiting the earth in space (Robinson, 1994). The launch of Seasat in 1978 saw the first satellite specifically designed for and dedicated to ocean surveillance. In the same year, an experimental satellite in the Nimbus series carried a visible wavelength scanner designed to observe ocean colour- the Coastal Zone Colour Scanner (CZCS) – which has supplied a wealth of synoptic view of the colour of large areas of the world ocean. The same satellite has observed sea surface temperature by microwave measurement (Robinson, 1994).

Today, satellites are being built and planned which exploit and improve the observation methods already developed to survey the colour, temperature, surface

height, and surface roughness parameters of the sea (Robinson, 1994). Generally, the equipment used has become progressively more sophisticated enabling greater images to be captured in a more detailed spatial resolution. This in turn has led to a greater utility of RS as a viable data gathering medium (Meaden and Thang, 1996).

Satellite oceanography is to play an important role in fishery research and fishery management by providing synoptic and oceanic measurements for use in evaluating environmental effects on the abundance and availability of fish population (Nath, 1993). Most satellite remote sensing applications in fisheries have concentrated on using measurements of sea surface temperature (SST) made primarily from the infrared wavelength.

There have also been many operations that have used ocean colour measurement made in visible bands. Synoptic data on SST and ocean colour are hardly the complete spectrums of marine environmental information necessary for fisheries application. However, these data are often used to deduce information about key oceanographic conditions, features and processes, which affecting the recruitment, distribution, abundance, availability, and harvest of marine fishery resources (Laurs, 1993).

Geographic Information System (GIS)

Over century, people had used maps for sailing, town planning and management, problem solving and decision making, where, there is an old adage, which says, " A map is worth of thousand words". Today, the major challenges we face in the world such as

overpopulation, pollution, deforestation, natural disasters, have a critical geographic dimension. Whether siting a new business, finding the best soil for growing bananas, or figuring out the best route for an emergency vehicle, local problems also have a geographical component.

Geographic information system (GIS) is a computer-based tool for mapping and analysing things that exist and events that happen on earth. It is an information system, which stores, retrieves, analyses and displays both spatial and non-spatial data. Mapmaking and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision-making and problem solving.

Since the first digital mapping programme were developed in Canada as the Canadian Geographic Information System in 1962, over the past three decades, there has gradually evolved a branch of information technology, which is specifically dedicated to mapping and spatial analysis.

GIS emerged as very powerful technologies because they support traditional forms of geographical analysis e.g. map overlay analysis. Besides, it also provides for new types of sophisticated analysis and modeling where extremely large quantities of data can be analyzed.