UNIVERSITI PUTRA MALAYSIA

SEASONAL PATTERN OF WATER MASSES IN THE SOUTH CHINA SEA

ABD MUHAIMIN BIN AMIRUDDIN

FPAS 2011 7

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By:

ABD MUHAIMIN BIN AMIRUDDIN

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

October 2011

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

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October 2011

Chairman : Assoc. Prof. Dr. Zelina Zaiton Ibrahim, PhD

Faculty : Faculty of Environmental Studies

The purpose of this study is to investigate the seasonal pattern and movement of water masses and their relation to the currents and circulations in the South China Sea (SCS). Prior studies of water masses, currents and circulations mainly focus only on the winter and summer seasons and on the deep basin of the SCS. This study is carried out over the whole SCS region for the four seasons of winter, spring, summer and fall. The hydrographic dataset from World Ocean Database 2009 is used. The dataset is processed, analyzed and visualized using the software Ocean Data View. The quality control procedure carried out comprised removal of duplicate stations, visual inspection and standard deviation checks. The data quality controlled dataset is analyzed using descriptive statistics, seasonal water mass visualization plots, seasonal variation and water mass analyses. The results indicate that seasonal variation of water mass mainly occurred in the surface layer. The sea surface temperature is generally lowest in winter and highest in summer. The sea surface salinity is highest in spring and lowest in fall. In winter, the water mass is cold and salty in the northern SCS. The cold Taiwan Strait water and salty, surface Luzon

Strait water flow into the northern SCS. The Northeast Monsoon induced the intrusion of these waters into the SCS. In spring, the water mass generally becomes warmer and saltier. The inflow of surface Luzon Strait water into the SCS remains. The warm water from southern SCS propagates into the central SCS. In spring and summer, the saline SCS water intrudes into the Gulf of Thailand. During summer, the water mass is generally warmer and fresher. The warm and fresher Karimata Strait waters flow into the southern SCS. The Southwest Monsoon induced the flow of Karimata Strait water into the SCS and the flow of SCS waters into the Gulf of Thailand. In fall, the water mass cools and freshens. The Taiwan Strait water starts to intrude into northern SCS. In general, the circulation is cyclonic over the SCS basin in winter. In spring, the cyclonic circulation occupies the north and south of SCS whereas anticyclonic circulation emerged in the central SCS. During summer and fall, the circulation is cyclonic in the northern SCS whereas anticyclonic circulation occurs in the southern SCS. In conclusion, the water mass pattern in the SCS changes over the seasons in relation to the monsoon system. The surface water masses of the SCS are generally colder in winter, saltiest in spring, warmest in summer and fresher in fall. As a result of analyzing the seasonal changes over the whole year instead of only in winter and summer; it was found that in spring, there is propagation of water from the southern SCS into the central SCS. In addition, the anticyclonic circulation emerged in the central of SCS. During fall, there is start of water intrusion from Taiwan Strait into northern SCS and the retreat of Karimata Current in the southern SCS. These addition seasonal changes of water mass, currents and circulations plots can contribute to ocean climate research, marine resources management and submarine operations in the SCS.

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

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Oleh

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Faculty : Faculty of Environmental Studies

Kajian ini bertujuan untuk mengetahui pola bermusim dan pergerakan jasad air dan hubungannya dengan arus dan peredaran di Laut China Selatan (SCS). Kajian terdahulu berkenaan jasad air, arus dan peredaran hanya tertumpu kepada musim sejuk dan musim panas dan di kawasan laut dalam SCS. Kajian ini dilakukan di seluruh kawasan SCS untuk empat musim iaitu musim sejuk, musim bunga, musim panas dan gugur. Data hidrografi dari 'World Ocean Database 2009' digunakan. Dataset diolah, dianalisis dan divisualisasikan dengan menggunakan software 'Ocean Data View'. Prosedur kawalan kualiti yang dilakukan terdiri daripada pembuangan stesen yang duplikasi, pemeriksaan visual dan pemeriksaan sisihan piawai. Data yang telah dikawal kualitinya dianalisis dengan menggunakan statistik deskriptif, plot visualisasi jasad air bermusim, variasi mengikut musim dan analisa jasad air. Keputusan analisis menunjukkan bahawa variasi jasad air mengikut musim berlaku terutamanya pada lapisan permukaan. Suhu permukaan laut di musim sejuk pada amnya adalah yang terendah dan di musim panas adalah yang tertinggi. Kemasinan paras laut tertinggi di musim bunga namun yang terendah di musim gugur. Di musim

sejuk, jasad air adalah sejuk dan masin di utara SCS. Air sejuk dari Selat Taiwan dan air masin pada permukaan dari Selat Luzon mengalir masuk ke utara SCS. Angin monsun Timur Laut menyebabkan pengaliran masuk air tersebut ke dalam SCS. Pada musim bunga, jasad air menjadi panas dan masin. Kemasukan air permukaan dari Selat Luzon ke SCS kekal. Air memanas dari selatan SCS bergerak ke tengah SCS. Pada musim bunga dan musim panas, air masin dari SCS mengalir ke kawasan Teluk Thailand. Di musim panas, jasad air pada amnya lebih panas dan kemasinan berkurang. Air memanas dan lebih tawar dari Selat Karimata mengalir ke selatan SCS. Angin Barat Laut mempengaruhi aliran air Selat Karimata ke kawasan SCS dan aliran air SCS ke Teluk Thailand. Pada musim gugur, jasad air menjadi lebih dingin dan kemasinan semakin berkurangan. Air dari Selat Taiwan mulai mengalir masuk ke utara SCS. Pada amnya, peredaran laut adalah siklon di musim sejuk di SCS. Pada musim bunga, peredaran siklon menempati di kawasan utara dan selatan SCS manakala peredaran antisiklon muncul di tengah SCS. Semasa musim panas dan gugur, peredaran adalah siklon di utara SCS manakala peredaran antisiklon berlaku di selatan SCS. Sebagai kesimpulan,pola jasad air di SCS berubah mengikut musim berdasarkan sistem monsun. Jasad air permukaan di SCS amnya menjadi lebih sejuk di musim sejuk, sangat masin di musim bunga, menjadi lebih panas di musim panas dan menjadi lebih tawar di musim gugur. Hasil analisis perubahan bermusim sepanjang tahun, dibandingkan dengan yang tertumpu pada musim sejuk dan musim panas sahaja, adalah didapati bahawa pada musim bunga, terdapat pergerakan air dari selatan SCS ke tengah SCS. Selain itu, peredaran antisiklon muncul di tengah SCS. Di musim gugur, air dari Selat Taiwan mula mengalir masuk ke utara SCS dan aliran keluar arus Selat Karimata di selatan SCS. Pertambahan maklumat berkenaan

perubahan jasad air mengikut musim, arus dan peredaran ini boleh menyumbang kepada kajian iklim laut, pengurusan sumber laut dan operasi kapal selam di SCS.

ACKNOWLEDGEMENTS

Alhamdulillah, thanks to the Allah, Al-Mighty, for giving me all His blessing, 'mehnah', 'ibrah', courage and strength to finish my study.

I would like to put across my utmost gratitude to my project supervisor, Assoc. Prof. Dr. Zelina Zaiton Ibrahim for all her supervision, guidance, and dedication. Her constructive criticism, endless ideas and useful comments has been very precious. I would like to thank my co-supervisor, First Admiral (R) Assoc. Prof. Dr. Sutarji Kasmin for his positive comments and helpful suggestions.

I am grateful to Mr. Nabeel Gazzaz for his guidance in thesis writing. Thanks to Dr. Tingting Zu, for providing me some literatures from China. Appreciation also goes to Assoc. Prof. Dr. Latifah Ibrahim, Head of Department of Environmental Management for her constant support and encouragement. Thanks are also extended to all my colleagues, especially Mr. Syazwan Aizat, Mrs. Fershteh Jaderi, Mr. Milad Bagheri and Ms. Khairiyah Rahim for valuable discussions and meaningful assistance.

Finally, special appreciations to my parents, Mr. Amiruddin Fakih and Mrs. Fatimah Kamaludin and my loving wife, Ms. Rashidah Ismail, for their patience, understanding and support.

I certify that an Examination Committee has met on 6 October 2011 to conduct the final examination of **Abd Muhaimin Bin Amiruddin** on his thesis entitled **"Seasonal Pattern of Water Masses in the South China Sea"** in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the students be awarded the **Master of Science.**

Members of the Examination Committee were as follows:

Mohd Bakri Ishak, Ph.D
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohamad Ibrahim Mohamed, Ph.D
Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Wan Nor Azmin Sulaiman, Ph.D
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Tetsuo Yanagi, Ph.D
Professor
Research Institute for Applied Mechanics
Kyushu University
(External Examiner)

_____
SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 20 December 2011

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science Environmental Systems and Processes. The members of the Supervisory Committee were as follows:

Zelina Zaiton Ibrahim, Ph.D
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

First Admiral (R) Sutarji Kasmin, Ph.D
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

_____

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

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

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ABD MUHAIMIN BIN AMIRUDDIN

Date: 6 October 2011

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