NOOR HAZWANI BINTI MOHD AZMI MASTER OF SCIENCE 2019

BIO-OPTICAL PROPERTIES AND SEASONAL VARIABILITY OF PHYTOPLANKTON SIZE CLASSES IN PENINSULAR MALAYSIA

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DEDICATION

This thesis is specially dedicated to The Almighty, The Greatest, The Provider, The Opener, The All-Knowing One, The Responding One, The Loving One, The One and only, Allah SWT.

This work also dedicated to my beloved parents, Mohd Azmi and Normala, family, sisters TGG and friends for the never ending support and motivational words.

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfilment of the requirements for the degree of Master of Science

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School/Institute : Institute of Oceanography and Environment

The research of this study focuses on the variability of bio-optical properties and the seasonal distributions of phytoplankton size classes (PSC) in Peninsular Malaysia, mainly in Strait of Malacca (SoM) and east coast Peninsular Malaysia (ECPM). The applicability of bio-optical model and satellite algorithms were assessed on the basis of the bio-optical relationships between in-water constituents and optically active properties. Here, we present for the first time, the study on PSC and the derivation of this variable from satellite ocean colour data for our local region. Two different study areas with different optical characteristics were selected; highly productive areas and strong river discharge in SoM and low primary productivity with lack of river influence in ECPM. To achieve the research goal, in-situ measurements of in-water optical properties and chlorophyll (Chl) were conducted in 2015 during the onset of northeast monsoon (NEM) (end of January) in SoM and during the inter-monsoon (April) and southwest monsoon (SWM) (June) in ECPM. Results from this study revealed that high Chl concentrations associated with the microplankton dominance was observed in SoM, whereas ECPM was characterized by low Chl and mostly dominated by picoplankton. The results also revealed that both areas were characterized by different optical properties with the SoM presented stronger optical signals. The magnitude and spectral shape of the absorption properties as well as reflectance signal were found higher in SoM than in ECPM. This could be due to high riverine discharge in SoM compared to ECPM. The relationship between bio-optical

properties of phytoplankton and surface reflectance signal were also examined. Our analysis showed that SoM presented a poor bio-optical relationship at retrieving Chl concentration either due to a wide range variation in non-chlorophyll constituents or different magnitude of inherent optical properties. Consequently, the estimation of Chl in SoM deviated from the global trend. Meanwhile, ECPM showed a relatively good estimation using the global Chl algorithms. The re-parameterized of bio-optical model by Brewin et al. (2010) and Hirata et al. (2011) were evaluated. Our locally-tuned Brewin model showed a good estimation of PSC especially for micro- and picoplankton. The results of this study indicated that the locally-tuned PSC models produced low estimation errors for both phytoplankton classes, offering a great opportunity to asses a long term trend of PSC in the study area. The locally-tuned model was then applied to satellite ocean colour. Our seasonal map distributions showed that high Chl concentrations were observed during NEM and decreased gradually towards the onset of spring inter-monsoon (April-May). Microplankton showed the highest contribution in SoM, whereas picoplankton contributed high percentage in ECPM, at about 60% for both phytoplankton classes. Our findings also revealed that changes in seasonal monsoon influence the spatial-temporal distribution of PSC in ECPM but only have a little effect in SoM. In conclusion, this study highlights the optical characteristics of PSC in two different water types, the improved bio-optical model for the retrieval of PSC and provide the spatial and temporal trend of PSC for the first time in Malaysia waters.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

CIRI-CIRI BIO-OPTIK DAN VARIASI BERMUSIM BAGI KELAS SAIZ FITOPLANKTON DI SEMENANJUNG MALAYSIA

NOOR HAZWANI BINTI MOHD AZMI

2019

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Tumpuan kajian ini adalah kepada kepelbagaian sifat bio-optik dan variasi bermusim kelas saiz fitoplankton (PSC) di Semenanjung Malaysia, terutamanya di Selat Melaka (SoM) dan pantai timur Semenanjung Malaysia (ECPM). Kebolehgunaan model bio-optik dan algoritma satelit dinilai atas dasar hubungan bio-optik antara konstituen dalam air dan sifat aktif optik. Kajian terhadap PSC yang diperoleh daripada data satelit warna laut ini pertama kali dijalankan di kawasan kami. Dua kawasan kajian yang berbeza ciri-ciri optik yang telah dipilih; kawasan yang sangat produktif dan aliran sungai yang deras di SoM dan produktiviti utama yang rendah dengan kekurangan aliran sungai di ECPM. Untuk mencapai objektif penyelidikan ini, pengukuran data in-situ seperti sifat optik dalam air dan klorofil (Chl) telah dijalankan pada tahun 2015 semasa monsun timur laut (NEM) (akhir bulan Januari) di SoM dan peralihan monsun (April) serta monsun barat daya (SWM) (Jun) di ECPM. Hasil kajian menunjukkan bahawa kepekatan Chl tinggi yang turut dikaitkan dengan dominan mikroplankton diperhatikan di SoM, manakala ECPM dicirikan oleh Chl yang rendah dan kebanyakannya didominan oleh picoplankton. Hasil kajian juga menunjukkan bahawa kedua-dua kawasan tersebut dicirikan oleh sifat optik yang berbeza dengan memberikan isyarat optik yang kuat di SoM. Nilai magnitud dan bentuk spektrum penyerapan serta isyarat pemantulan didapati lebih tinggi di SoM daripada di ECPM. Ini boleh disebabkan oleh aliran sungai yang tinggi di SoM berbanding dengan ECPM. Hubungan antara sifat bio-optik fitoplankton dan isyarat pantulan permukaan juga dinilai. Analisis kami menunjukkan bahawa SoM

memperlihatkan hubungan bio-optik yang kurang baik untuk mendapatkan kepekatan Chl, sama ada disebabkan oleh pelbagai variasi dalam unsur-unsur bukan klorofil atau sifat optik yang wujud. Oleh itu, anggaran Chl di SoM menyimpang dari trend sejagat. Sementara itu, ECPM menunjukkan anggaran yang agak baik menggunakan algoritma Chl sejagat. Model bio-optik oleh Brewin et al. (2010) dan Hirata et al. (2011) yang diparameter semula juga dinilai. Model-tempatan Brewin menunjukkan anggaran PSC yang baik terutamanya untuk mikro- dan picoplankton. Hasil kajian ini menunjukkan bahawa model PSC yang ditala secara tempatan menghasilkan ralat kurang daripada 60% untuk kedua-dua kelas fitoplankton, menawarkan peluang yang baik untuk menilai trend log PSC di kawasan kajian kami. Seterusnya, model-tempatan yang sesuai diaplikasi pada satelit untuk mendapatkan data warna laut. Peta taburan bermusim kami menunjukkan Chl berkepakatan tinggi diperhatikan semasa NEM dan menurun secara beransur-ansur ke arah permulaan musim bunga antara musim hujan (April-Mei). Mikroplankton menunjukkan sumbangan tertinggi di SoM, manakala picoplankton menyumbang peratus tinggi dalam ECPM, kira-kira 60% bagi kedua-dua kelas saiz fitoplankton. Penemuan kajian kami juga menunjukkan bahawa perubahan monsun musim hujan mempengaruhi peralihan PSC di ECPM tetapi hanya sedikit kesan monsoon di SoM. Kesimpulannya, kajian ini menyoroti ciri-ciri optik PSC bagi dua jenis air yang berbeza, model bio-optik yang lebih baik untuk mendapatkan PSC dan menyediakan trend ruang dan masa peralihan PSC untuk pertama kalinya di perairan Malaysia.