CHARACTERIZATION OF BIO-OPTICAL PROPERTIES AND THEIR INTERRELATIONSHIPS IN SOUTHERN SOUTH CHINA SEA

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I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Ramli Jusoh and Wan Rahimah whose words of encouragement and push for tenacity ring in my ears. My sisters and brothers have never left my side and are very special.

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This study focuses on the variability and relationships of bio-optical properties with optically active constituents in the southern South China Sea. On these bases, the applicability and the limits of reliability of satellite ocean colour algorithm in this study area were also assessed. To achieve this goal, two study areas with distinct bio-optical conditions: Brunei Bay (BB) coastal water which characterized by high riverine discharge, strong phytoplankton blooms and suspended particles, and east coast of peninsular Malaysia (ECPM) water with relatively low chlorophyll and suspended particle concentrations; were intensively investigated. In both study areas, in-situ measurements of underwater radiation fields, in-water constituents and absorption properties were conducted during bio-optical cruises in January and May 2014. The analyses of data revealed a significant variation in bio-optical properties between BB and ECPM waters. High concentrations in both constituents and optical properties were observed in BB while ECPM is characterized by relatively low concentration of constituents and weak optical signals. Differences in bio-optical properties between both study areas are clearly showed by variation in phytoplankton specific absorption coefficients; very high values for low chlorophyll in ECPM and low values for relatively high chlorophyll in BB, an indicator of strong package effect. In both areas, the result found that coloured dissolved organic matter (CDOM) is the most dominant absorber, contributing about 65% in ECPM and 77% in BB, and this suggests the significant important of CDOM in determining the reflectance signal in this study area. Due to very high concentrations of non-pigmented particles in BB, the shape and magnitude of absorption properties and reflectance signal are found to be significantly different as compared to results observed in ECPM.

The general pattern in bio-optical relationships in both areas were also examined and compared with the trends observed in the global ocean. Results from our analysis revealed that the reflectance signals in BB generally show poor relationships with in-water constituents and absorption properties, these scenarios however, show differently in ECPM with strong relationships were observed in almost all optical constituents. Lastly, evaluation of the global

chlorophyll algorithm revealed two different trends; a relatively good estimation in ECPM and the overestimated of chlorophyll in BB. The results also indicate that the application of locally tuned algorithm could provide more accurate estimate of chlorophyll in both study areas. Based on the overall findings, we conclude that the bio-optical properties in the study area vary with seasons and under different hydrographic conditions, which in turn determine their bio-optical relationships and applicability of this space-based measurement in the southern South China Sea.

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PENCIRIAN SIFAT-SIFAT DAN SALING PERHUBUNGAN BIO-OPTIK DI SELATAN LAUT CHINA SELATAN

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Kajian ini memberi tumpuan kepada kepelbagaian dan hubungan antara sifat-sifat bio-optik dengan unsur-unsur aktif optik di selatan Laut China Selatan. Berdasarkan premis ini, kesesuaian dan had kebolehpercayaan algoritma warna laut satelit di kawasan kajian ini juga telah dinilai. Untuk mencapai matlamat ini, dua kawasan kajian dengan keadaan bio-optik yang berbeza: Teluk Brunei (BB) perairan pantai yang mempunyai ciri-ciri pelepasan sungai tinggi, fitoplankton dan zarah terampai yang tinggi, dan perairan pantai timur Semenanjung Malaysia (ECPM) dengan klorofil dan kepekatan zarah terampai yang rendah; telah disiasat secara intensif. Dalam kedua-dua kawasan kajian, pengukuran *in situ* medan radiasi bawah air, juzuk-juzuk air dan sifat penyerapan telah dijalankan sepanjang pelayaran bio-optik pada bulan Januari dan Mei 2014. Analisis data menunjukkan perubahan ketara dalam sifat bio-optik antara perairan BB dan ECPM. Kepekatan yang tinggi dalam kedua-dua juzuk dan sifat-sifat optik diperhatikan di BB manakala ECPM dicirikan oleh kepekatan juzuk yang rendah dan isyarat optik yang lemah. Perbezaan sifat bio-optik antara kedua-dua kawasan kajian dengan jelas ditunjukkan oleh variasi dalam pekali penyerapan spesifik fitoplankton; nilai yang sangat tinggi untuk kepekatan klorofil yang rendah di ECPM dan nilai penyerapan yang rendah untuk klorofil berkepekatan tinggi di kawasan BB, adalah penunjuk bagi kesan pakej yang kuat. Di kedua-dua kawasan, hasil kajian mendapati bahan organik terlarut berwarna (CDOM) adalah penyerap yang paling dominan, menyumbang kira-kira 65% di kawasan ECPM dan 77% di BB, dan ini menunjukkan CDOM adalah komponen yang penting dalam menentukan isyarat pantulan di kawasan kajian ini. Oleh kerana kepekatan yang sangat tinggi zarah yang tidak berpigmen di kawasan BB, bentuk dan magnitud sifat penyerapan dan isyarat pantulan didapati tidak jauh berbeza berbanding dengan keputusan yang diperhatikan di kawasan ECPM.

Pola umum dalam hubungan bio-optik di kedua-dua kawasan juga telah dikaji dan dibandingkan dengan trend yang berlaku di lautan global. Keputusan daripada analisis menunjukkan isyarat pantulan di BB secara umumnya mempunyai hubungan yang lemah antara juzuk air dan sifat penyerapan, senario ini bagaimanapun, menunjukkan ianya berbeza di kawasan ECPM

dengan hubungan yang kuat dapat diperhatikan dalam hampir semua juzuk optik. Akhirnya, penilaian algoritma global klorofil mendedahkan dua trend yang berbeza; anggaran yang agak baik di ECPM dan terlebih anggaran bagi klorofil di BB. Keputusan juga menunjukkan bahawa penggunaan algoritma talaan setempat boleh memberikan anggaran klorofil yang lebih tepat di kedua-dua kawasan kajian. Berdasarkan keseluruhan kajian, kami membuat kesimpulan bahawa sifat-sifat bio-optik di kawasan kajian berubah mengikut musim dan bergantung kepada keadaan hidrografi yang berbeza, seterusnya menentukan hubungan bio-optik dan kebolehgunaan pengukuran berasaskan ruang di selatan Laut China Selatan.