PHOTOSYNTHESIS OF PHYTOPLANKTON IN THE SOUTHERN MARINE REGIONS OF VIETNAM FROM MODIS DATA

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ABSTRACT

Photosynthesis of phytoplankton in marine region was contributed by light intensive profiles, biomass of phytoplankton as well as response of phytoplankton with light intensive. Based on data from MODIS images, marine primary production in the southern marine regions of Vietnam was estimated. The results provided the data series of primary production in the study regions. Distribution of primary production was impacted by upwelling phenomenon, suspended sediment from Mekong River and nutrients supporting from human activities. The primary production data could be a potential application for fisheries in Vietnamese marine regions.

1. INTRODUCTION

Photosynthesis or primary production of phytoplankton plays an important role of supporting living materials for marine water bodies. In the southern marine regions of Vietnam, several research on primary production as well as pigments biomass have been carried out for 1960s (Wyrtki, 1961; Nguyễn Tác An, 1985; Nguyen Tac An, 1989; Nguyen Tac An, 1994; Nguyễn Tác An, 2009; Nguyen Tac An and Phan Minh Thu, 2007; Tan and Shi, 2009; Phan Minh Thụ and Nguyễn Tác An, 2005; Phan Minh Thụ and Nguyễn Tác An, 2011). However, these results provided in-situ values of primary production and phytoplankton biomass at separate stations and/or water layers. In some specific case, integrated primary production (IPP) (An and Son, 2010, Nguyễn Tác An, 2009) and integrated phytoplankton pigment (Phan Minh Thụ and Nguyễn Tác An, 2005, Phan Minh Thụ and Nguyễn Tác An, 2011) were estimated, but in-situ data was not provided a full screen of primary production and phytoplankton biomass. Nguyen Tac An & Tong Phuoc Hoang Son (2004) used MODIS data interpretation of IPP in Bien Dong with the Vertically generalized production model (VGPM) (Behrenfeld and Falkowski, 1997). The VGPM is a common model to estimate IPP from ocean color images. P^B_{opt} (optimum primary production), an important parameter of VGPM, was a 7^{th} order polynomial function of sea surface temperature (SST). However, if SST was higher than 20°C, P^B_{opt} was slightly reduced (Behrenfeld and Falkowski, 1997). As the results, the SST applying for P^B_{opt} function would increase error value of IPP. Thus, applying in-situ P^B_{opt} (or P^B_{max}) from P-I curve could help to increase value of IPP from VGPM.

The paper shows the result of combining the results of P-I curve experiments with MODIS data to estimate IPP in the southern marine regions of Vietnam.

2. MATERIALS AND METHODS

The study area was a marine regions covered from Phu Yen to Ca Mau, including two upwelling regions. MODIS data level 3 were collected from http://oceancolor.gsfc.nasa.gov/cgi/l3 with products of chlorophyll-a at the surface water, PAR (Photosynthetically Available Radiation) at the surface water and K490 in 4km-resolution.

Estimation of primary production in the southern marine regions of Vietnam was applied VGPM (Behrenfeld and Falkowski, 1997):

$$IPP = 0.66125 \times P^{B}_{opt} \times [E_0/(E_0 + 4.1)] \times Z_{eu} \times Chl_0 \times DL \quad (1)$$

Where: IPP: integrated daily primary production (mgC m^{-2} day^{-1})
P^{B}_{opt}: Chl-a normalized maximum primary production in the vertical profile (mgC (mgChl a)$^{-1}$ h^{-1}),
E_0: PAR at sea surface water (E m-2 d-1),
Z_{eu}: depth (m) of the euphotic zone (the depth where E_Z reduces to 1% of E_0)
Chl_0: sea surface Chl a (mg m^{-3})
DL: daylength (h) calculated as method of Meeus (1991).

P^{B}_{opt} (P^{B}_{max}) was calculated from P-I curve experiments (Mackey *et al.*, 1997).

3. RESULTS AND DISCUSSIONS

3.1. P^{B}_{opt} and/or P^{B}_{max} in study areas

With P-I curve in the in-situ condition (Fig. 1), primary production ranked from 1.08 to 32.36 mgC (mg Chl-a)$^{-1}$ h^{-1}, and P^{B}_{opt} ranked from 11.00 to 12.15 mgC (mg Chl-a)$^{-1}$ h^{-1} for 0.35 – 0.56 mg Chl-a m^{-3} (An and Son, 2010).

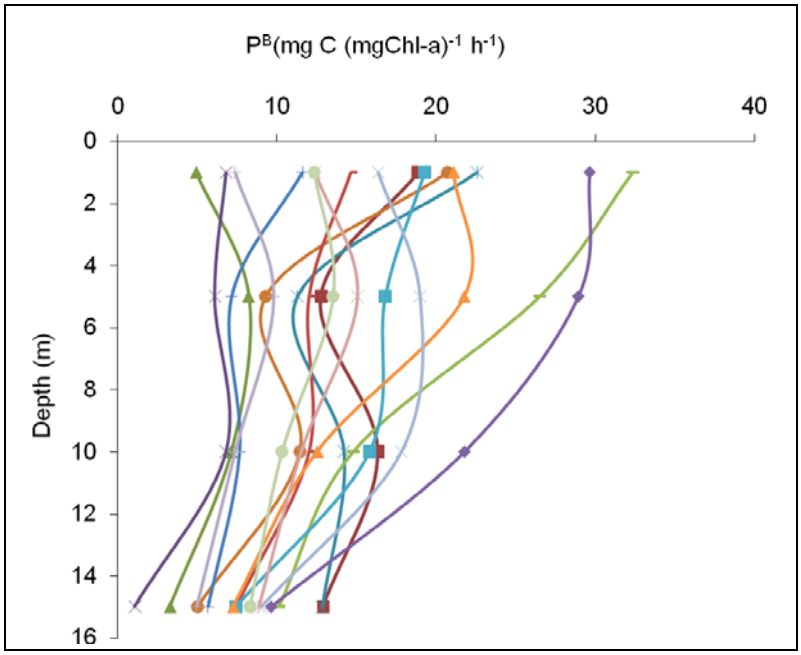

Fig. 1: Chl-a normalized Primary production in the vertical profile

By P-I curve in-door experiments with 20 difference light intensive value in the range of 0 – 600 µE m^{-2} s^{-1}, the results indicated that P^B_{max} varied strongly and have relationship with Chl-a concentration. Chl-a of experiment water samples ranked 0.43 – 24.66 mg Chl-a m^{-3} and P^B_{max} ranked 4.66 – 46.68 mgC (mg Chl-a)$^{-1}$ h^{-1} (Phan Minh Thụ *et al.*, 2012). Our study found that P^B_{max} was a 3rd order function of Chl-a (equation 2) (Fig. 2).

$$P^B_{max} = 0.018\ Chl^3 - 0.782\ Chl^2 + 8.567\ Chl + 5.261 \qquad R^2 = 0.655 \qquad (2)$$

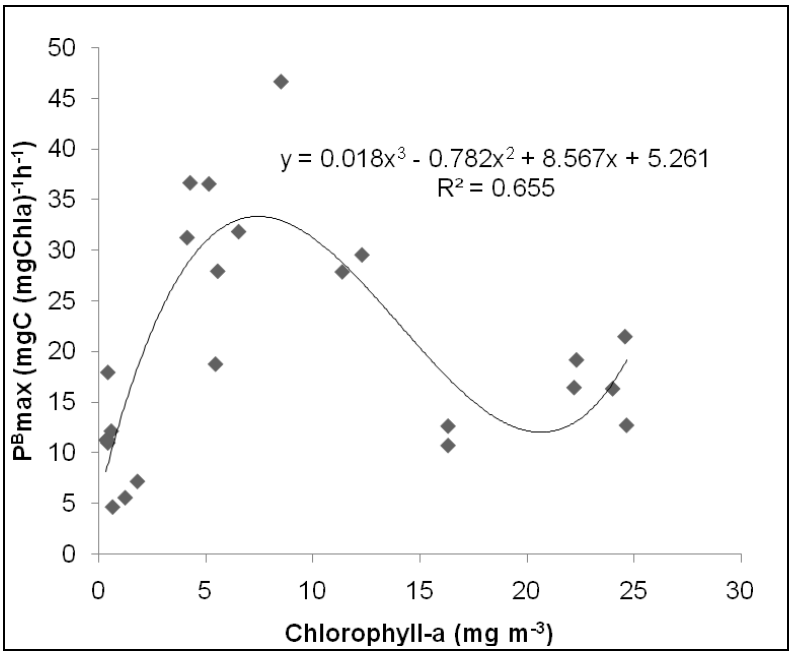

Fig. 2: P^B_{max} as the function of Chl-a concentration (n=25)

3.2. Primary production in the southern marine regions of Vietnam

Results of remote sensing analysis of MODIS images show in Fig. 3.

Full screen of IPP in study areas can read in Feb, Apr, May, Jun, Jul, Aug and Oct of 2011. In other months (Jan, Mar, Sep, Nov and Dec), several missing pixels were impacted in the estimating results.

In general, IPP ranked from 1.5 gC m^{-2} day^{-1} (offshore waters of centre regions of Vietnam in Jan 2011) to 10.0 gC m^{-2} day^{-1} (coastal waters of Mekong Delta in whole year). In Northeastern monsoon season, materials from Mekong River moving to the south of waters of Ca Mau Peninsula caused the increases of primary production. Other high primary production regions were located in the offshore regions of Binh Thuan – Vung Tau. These regions were displayed in Aug and Sep of 2011 where having upwelling events. In addition, nutrients input from human activities in coastal regions also contributed to high IPP in coastal waters.

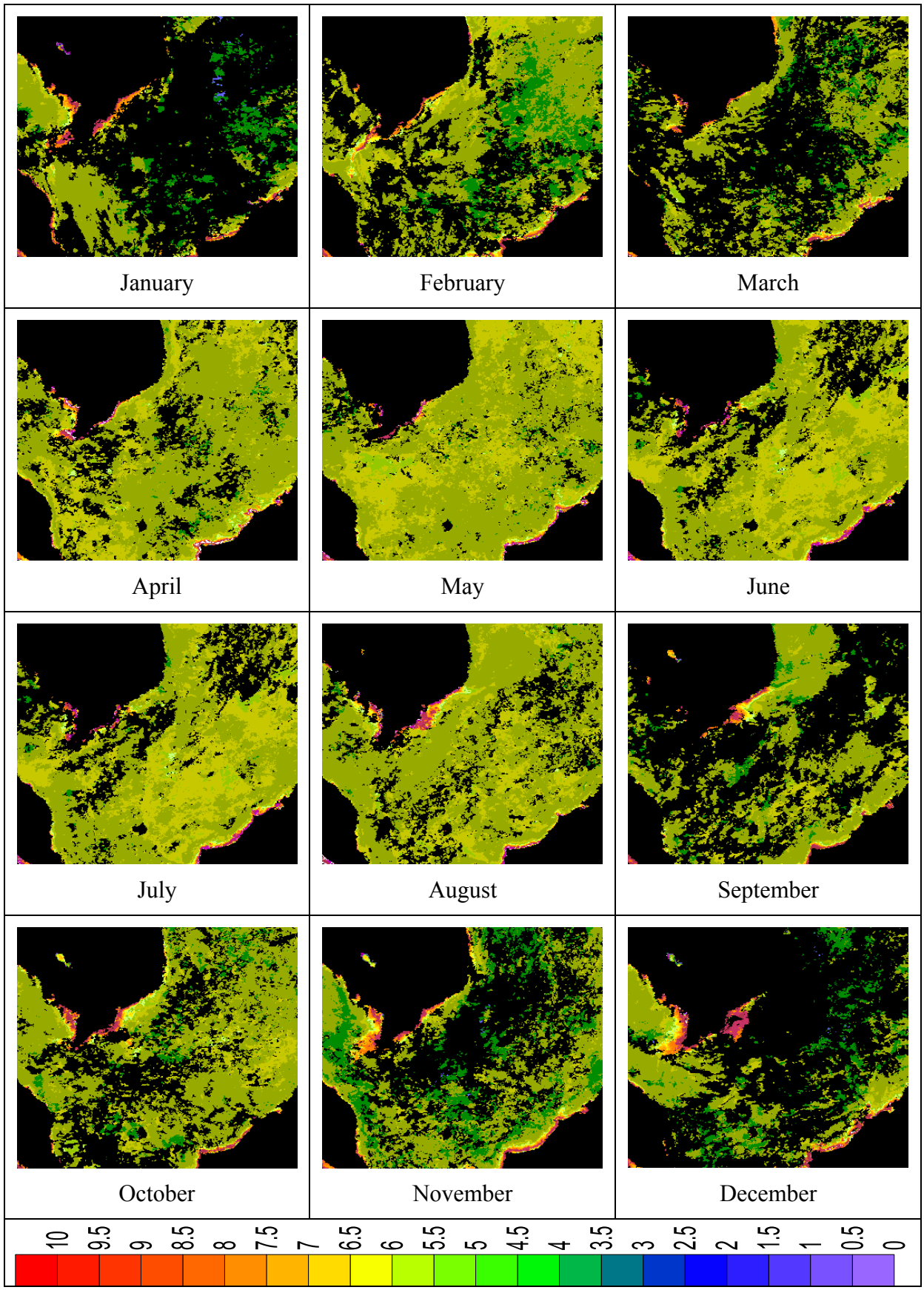

Fig. 3: Integrated daily primary production (gC m^{-2} day^{-1}) in the southern marine region of Vietnam in 2011

With in-situ and modeling data, Phan Minh Thu et al. (2012) indicated that IPP in whole Vietnamese marine regions varied in 0.04 – 11.07 gC m^{-2} day^{-1}. That means the estimated IPP in this study was the similar with in-situ IPP. Therefore, combine VGPM with P^B_{max} of P-I curve experiments could improve the estimation of IPP in the southern marine regions of Vietnam.

4. CONCLUSION

IPP in the southern marine regions of Vietnam were estimation based on MODIS data with VGPM method. The reducing P^B_{opt} of the 7th order function of temperature, as temperature was higher than 20°C, was applying the value of P^B_{max} from P-I curve experiments. P^B_{max} was the 3rd order function of Chl-a concentration. The similar of estimation and in-situ data of IPP demonstrated that the P^B_{max} equation (2) applying for VGPM was better method using for estimating IPP in the southern marine regions of Vietnam.

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