Annex X - 3

Interim review of NPEC Guideline for Eutrophication Monitoring by RS in Korea

Chapter/Section	Contents and Points to check	Item to be deleted and reason for deletion	Item to be revised and reason for revision	Item to be added and reason for addition
I. Background and purpose	Outline of NOWPAP, WG4 and intended use - Check if the purpose fit in the situation of your country.			The definition of coastal area should be required. The reason why the scale of coastal area is different at each countries.
II. Eutrophication and satellite remote sensing	-			

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1. Introduction	Outline of eutrophication monitoring by remote sensing and its benefits - Check if the reason to use remote sensing for monitoring of eutrophicaion is clearly explained.		In the coastal water body -> in the coastal water mass.	.
2. Satellite data	-			The coastal area related to the monitoring eutrophication should be also required the high resolution satellite imagery such as Landsat and SPOT. Even though the observation frequency has less, the resolution has higher than other ocean color. It is

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				necessary for the coastal area to develop the local algorithm using high resolution remote sensing data.
2.1 Monitoring parameters	Satellite data Products that can be applied to eutrophication monitoring (Chl-a, SST, K490). - Confirm if the satellite data product are appropriate as parameters for monitoring of eutrophication.		Appropriate satellite data products are included.	The parameter as –Ln(0.01)/K490 can be added to other parameters of the satellite data product. An example of such a function is the euphotic depth, which is commonly defined as the 1% light-penetration depth. Using the level-2 variable K490 and applying Beer's Law, this depth may be defined as Z = –Ln(0.01)/K490, which represents the 1% light-penetration depth at λ=490nm.

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2.2 Sensors	Sensors that can monitor the aforementioned variables (SeaWiFS, MODIS, AVHRR). - Confirm if the appropriate sensor is included.		Appropriate sensors are included.	
2.3 Obtaining data	How and where to obtain the satellite data products - Check if the explanation on how and where procedures to acquire the data is clear. - Check if the procedure of obtaining data include the entire data product listed in 2-2) Sensors.	NASA is classifying these data as evaluation products since improvement of accuracy is still on going.	<MODIS> MODIS Chl-a data has been received by NFRDI of Korea since 2001. MODIS data can be obtained the RGB composite images, opened to the public via the Internet (http://www.nfrdi.re.kr). <AVHRR> NOAA AVHRR has	OCM (Ocean Color Monitor) of IRS-P4 Chl-a concentration data has been received from May 2001 through October 2004 at the NFRDI. IRS-P4 OCM Chl-a data are processed by NASA OC2 algorithm. The spatial resolution is 360m. But the data did not open to the public via the

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			been received by NFRDI since 1989. The data will be opened to the public via the internet homepage in 2007. Now NFRDI is going to construct a satellite data backup system including NOAA AVHRR data.	Internet.

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2.4 Data processing method	Description of data processing methods and computational environment (SeaDAS, WIM, Excel). - Check if computational requirement are explained clearly. - Confirm if the algorithm can be applied to the situation of your country.		<CZCS> Data Product Name: CZCS Level 2 data Data ~~source:~~ Source	Surfer program from Golden software can be used for contouring and gridding of images etc. b. Extraction of physical values <SeaWiFS> Data Product: SeaWiFS Level 2 data Data Source: Ocean Color Web, NFRDI Recommended software application: NASA SeaDAS, WIM, TeraScan <MODIS> Data Product: MODIS Level 2 data Data Source: Ocean Color Web, NFRDI Recommended software application: NASA SeaDAS, WIM, TeraScan

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				(2) Sea Surface Temperature <AVHRR> Data Product: AVHRR SST Data Source: Marine Watch Homepage, NFRDI Recommended software application: NASA SeaDAS, WIM, Microsoft Excel, TeraScan Data Product: MODIS SST Data Source: Ocean Color Web, NFRDI Recommended software application: NASA SeaDAS, WIM, TeraScan (3) Turbidity (k490) <SeaWiFS> Data Product: SeaWiFS Level 2 data

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				Data Source: Ocean Color Web, NFRDI Recommended software application: NASA SeaDAS, WIM, TeraScan <MODIS> Data Product: MODIS Level 2 data Data Source: Ocean Color Web, NFRDI Recommended software application: NASA SeaDAS, WIM, TeraScan
3. *In situ* data	-			

Chapter/Section	Contents and Points to check	Item to be deleted and reason for deletion	Item to be revised and reason for revision	Item to be added and reason for addition
3.1 Monitoring parameters and measuring method	Monitoring parameters (Chl-a, Nutrients, Temperature, Salinity, Transparency, COD, SS, Water-Leaving Radiance Other items.) and measurement methods - Check if monitoring parameters are appropriate for monitoring of eutrophication - Check if monitoring parameters should be what is commonly used in your country. -		Appropriate parameters are included. However CDOM has not been analyzed in the Lab. of NFRDI.	Observation items at NFRDI are temperature, salinity, nutrients (N, P, Si), DO, SS, Chl-a, transparency, phyto- and zoo-plankton etc. COD has been observed in the coastal area of the South Sea of the Korean Peninsula.
3.2 Determination of monitoring site and sampling points	How to determine the sampling points for utilizing satellite data (number of sampling points, locations, etc). - Check if the criteria for selecting monitoring site are adequate to clear out eutrophic area in your country.			The serial oceanographic observations, consisting with 25 lines 191 oceanographic stations, have been conducted every other month since 1961 by NFRDI in Korea.

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3.3 Monitoring frequency and timing	How to determine the monitoring frequency and timing (periodical/non-periodical, etc). - Check if the frequency and timing is appropriate enough for understanding seasonal variability of oceanic phenomena of your country.			The serial oceanographic observations, consisting with 25 lines 191 oceanographic stations, have been conducted every other month since 1961 by NFRDI in Korea. However, if more match-up data set is needed, the monitoring shall be specialized in obtaining more sea truth data, and the monitoring timing could be focused on short terms under good conditions.

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3.4 Requisites for monitoring and analysis	Systems and equipment required for monitoring and analysis (Personnel, vessels, etc). - Check if the system and equipment fully comply with all the monitoring parameters in 3-1) Monitoring parameters and measuring method		CDOM has not been analyzed in the coastal area at NFRDI. We don't know whether other countries (Russia and China) will analyze or not.	
4. Monitoring and assessment of eutrophication	-			

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4.1 Accuracy evaluation	Accuracy evaluation of satellite data (analysis of correlation to *in situ* data). - Confirm if the necessary evaluation method is included. - Indicate specific procedures. - Indicate special notes for analysis (exclusion of abnormal values, etc). - Make a note of other useful perspectives for evaluating analysis results.		a. Analysis …. CDOM analysis is very difficult in current state. b. This analysis can clarify if there are any discrepancies, whether in atmosphere.	
4.2 Integration with the existing monitoring system	Evaluation method for understanding the status and cause of eutrophication (correction of satellite data, analysis of interannual variability, etc). - Check if the evaluation method is appropriate - Indicate specific procedure. - Make a note of other useful perspectives for evaluating analysis results.			We will go to construct the monitoring system for understanding of eutrophication based on RS and GIS.

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5. Appendix 5.1 Table of satellite data product for marine environmental monitoring	List of products that can be utilized for marine environmental monitoring by remote sensing. - Try to prioritize satellite data product by its importance for monitoring of eutrophication. - Indicate costs and organizations that provide the products, etc.			The parameter as –Ln(0.01)/K490 should be added to other parameters of the satellite data product. Unit is m (meter), the priority is C.

Annex 3

A case study in the South Sea of the Korean Peninsula

1. Objective and Background

In order to evaluate the usefullness of remote sensing techniques as a monitoring tool for the marine environment including coastal area, a case study was conducted in the southern waters of the Korean Peninsula and northern part of the East China Sea. In this study, SeaWiFS chlorophyll-a (Chl-a) data were analyzed with sea-truth data for validating in-water algorithms for estimating Chl-a concentration and for understanding spatio-temporal variations of water qualities in these regions.

2. Method

2.1 Monitoring survey

a. Observed factors with vessel

Temperature, Salinity, SS (Suspended Solid), Transparency, DO, Chl-a, Nutrients (Phosphate, Silicate, Nitrogen etc), Phytoplankton, Zooplankton etc.

2.2 Obtaining ocean color satellite data

SeaWiFS Chl-a data were obtained through KEOC (Korea Earth Observation Center). The data was processed based on the OC2 algorithm, which was developed by NASA.

SeaWiFS Chl-a data in the South Sea of the Korean Peninsula and northern part of the East China Sea from 1998 to 2005 were also obtained and processed for the coverage with the South Sea (125-130°E, 32.5-36.5°N) in the northern part of the East China Sea (120-128°E, 28-36°N) (Fig. 1).

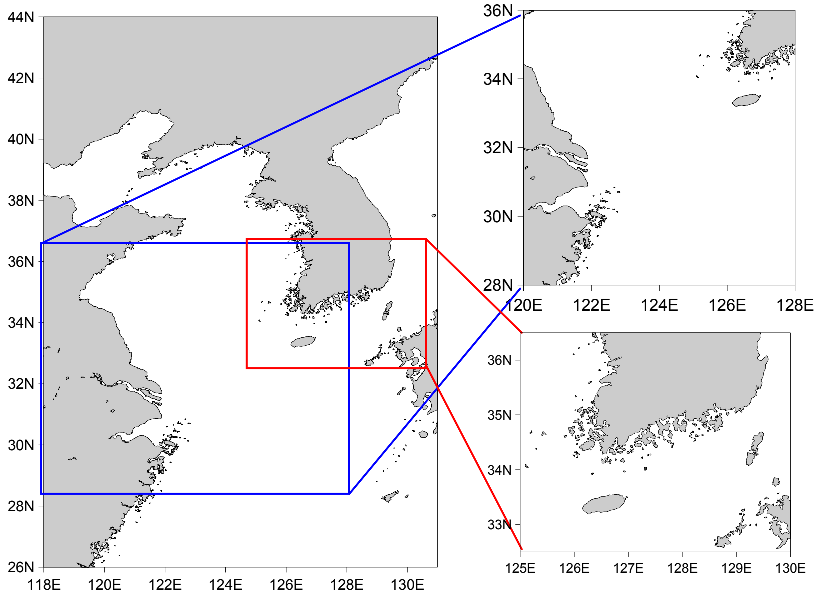


Fig.1 Location of study area.

3. Analysis and discussion

3.1 Analysis of time series Chl-a concentration derived from ocean color satellite

a. Analysis of ten days Chl-a concentration imageries

Chl-a concentration patterns in the South Sea of the Korean Peninsula from January to December of 2000 were observed. Fig. 2 shows the calendar of the Chl-a using SeaWiFS data from the early in January to the last ten days in December, 2000. We can detect the spring bloom of phytoplankton in April and May of 2000. However, we can not notice any special features from August to September while the *Cochlodinium polykrikoides* red tide blooms occurred frequently (Suh et al., 2004). As described later, satellite Chl-a concentrations tended to be over estimated than those of in-situ data, when high concentration of SS occurred from the discharge of murky waters in the southern coast of Korea.

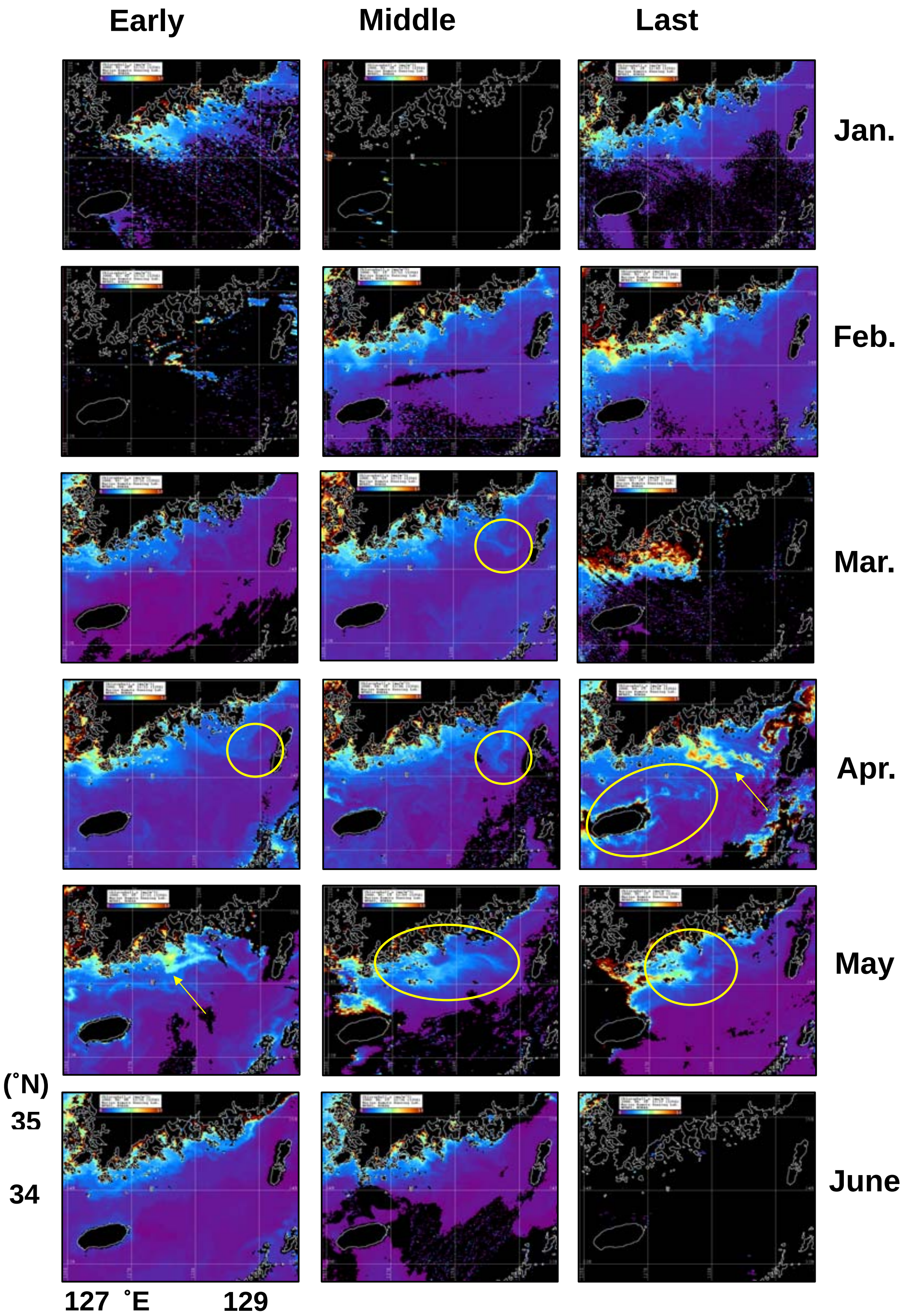


Fig. 2a. Ten days images of the estimated Chl-a derived from SeaWiFS from January to June 2000 in the South Sea of Korea (Suh et al., 2004).

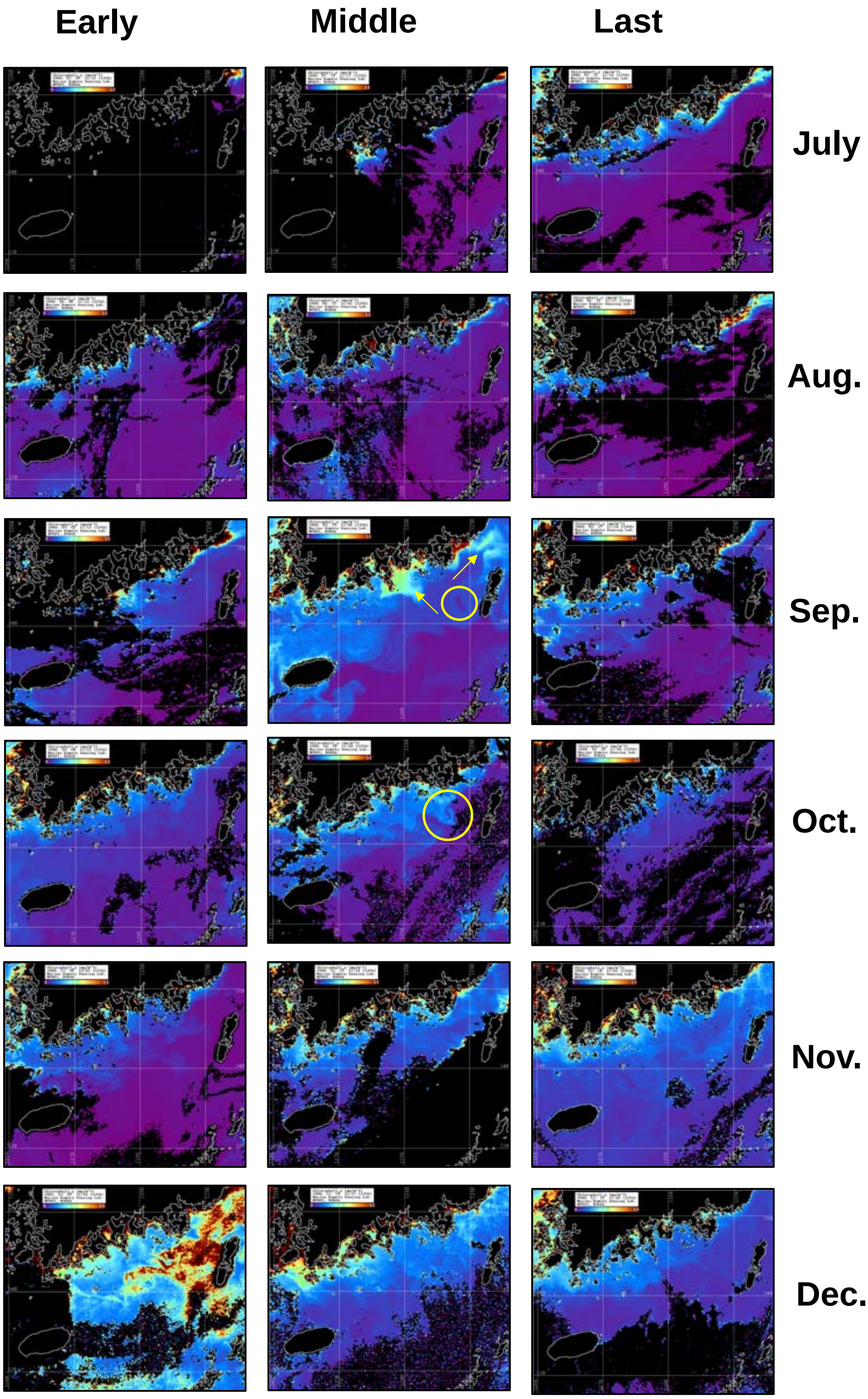


Fig. 2b. The same as Fig. 2a, except for July to December 2000.

b. Analysis of monthly Chl-a concentration imagies

The monthly average SeaWiFS Chl-a concentration imagies are as below Fig. 3. The concentrations of indicates high Chl-a more than 5 mg/m^3 occurred in the coast water of China every year. In the northern part of the East China Sea, the Chl-a concentrations are higher in summer (July, August and September) than those in the other seasons (Fig. 3).

Fig. 4 shows temporal and spatial distributions of Chl-a derived from SeaWiFS and in situ Chl-a along the 32 °N and 124-127.5 °E in August from 2000 to 2005 (Fig. 4). The high concentration of Chl-a more than 2mg/m^3 appeared in the near the coast of China (32 °N, 124-125 °E), low concentration of Chl-a less than 1.0 mg/m^3 appeared in the eastern parts of 126 °E. The satellite Chl-a concentrations tended to be over estimated than those of in situ Chl-a.

The Chl-a concentrations around the bay in the South Sea of Korea are higher in summer and early fall (October) than those in the other seasons (Fig. 5). Two peaks of Chl-a concentration occurred, one was in spring (March, April and May) and the other was in fall (October and November).

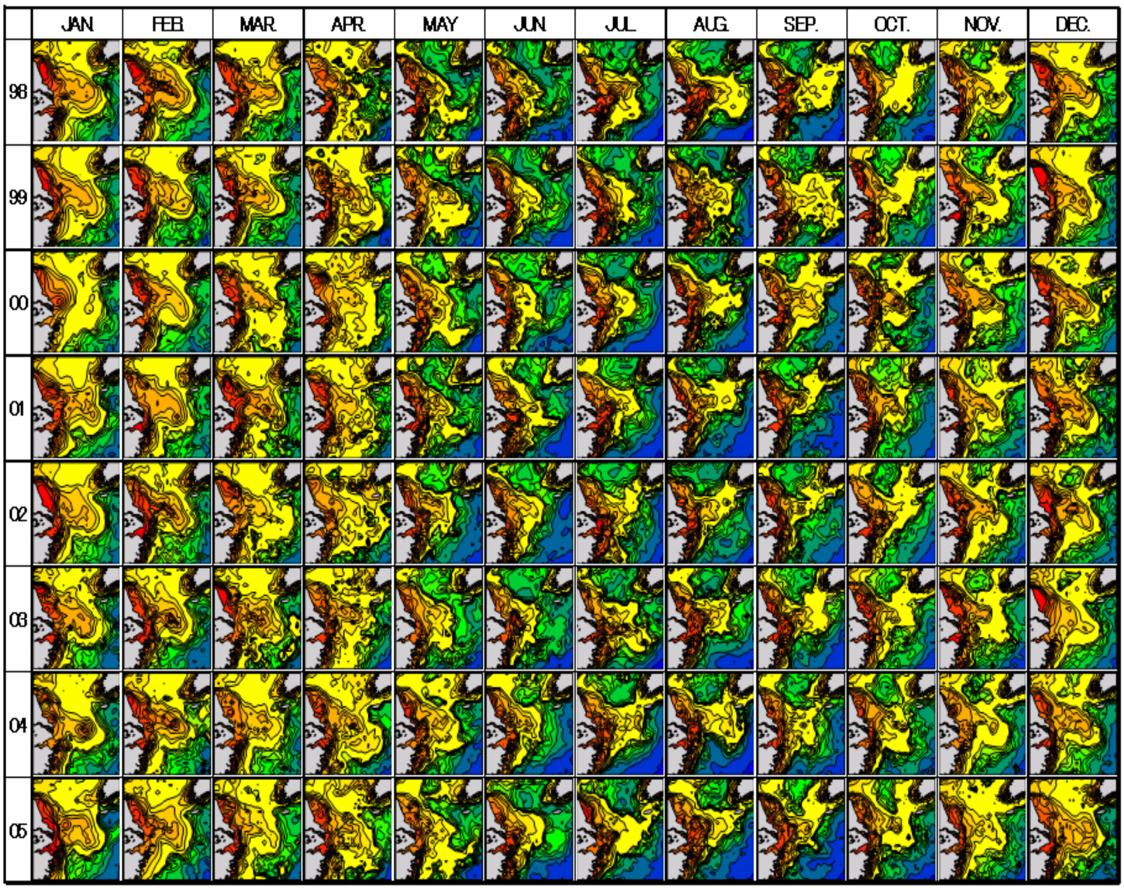


Fig. 3 Monthly average SeaWiFS Chl-a image in the East China Sea from 1998 to 2005.

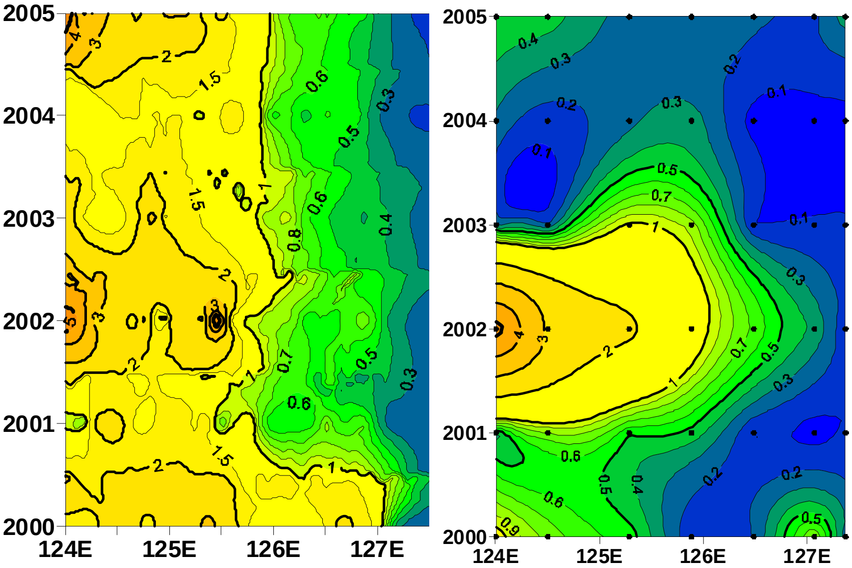


Fig. 4. Temporal and spatial distributions of Chl-a derived from SeaWiFS and in situ Chl-a along the line (32 °N, 124-127.5 °E) in August form 2000 to 2005

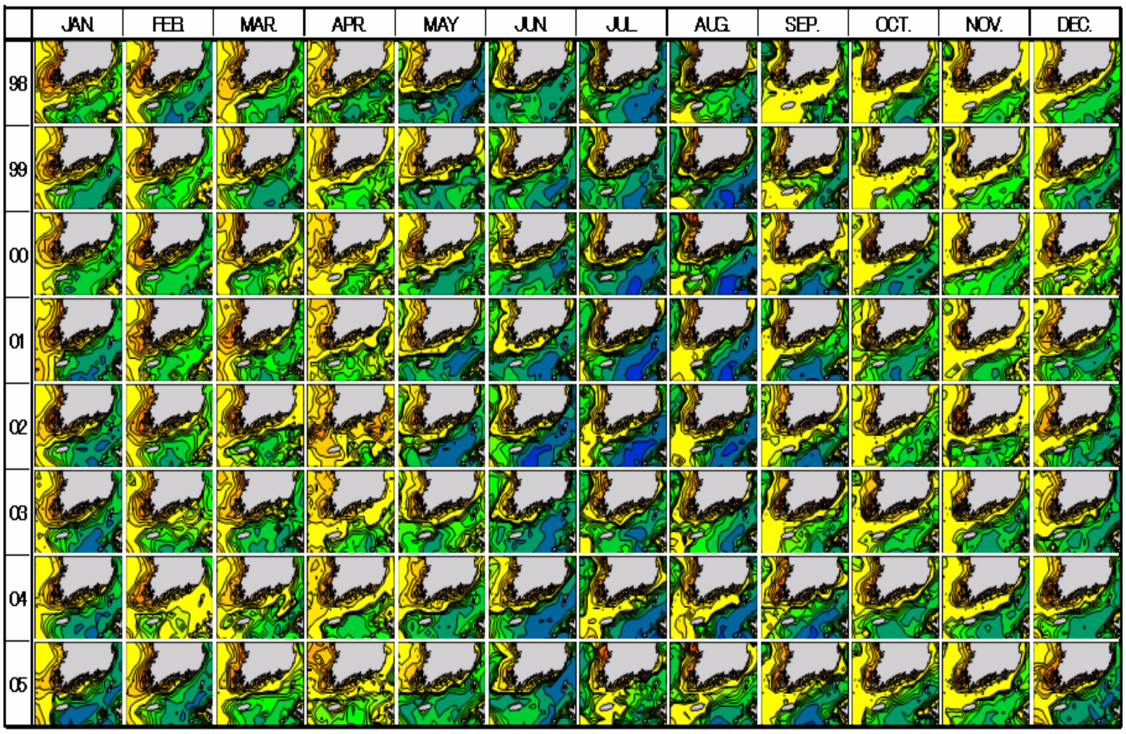
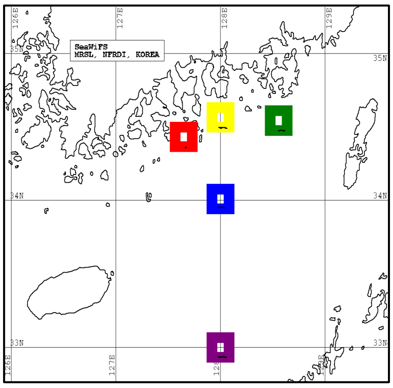


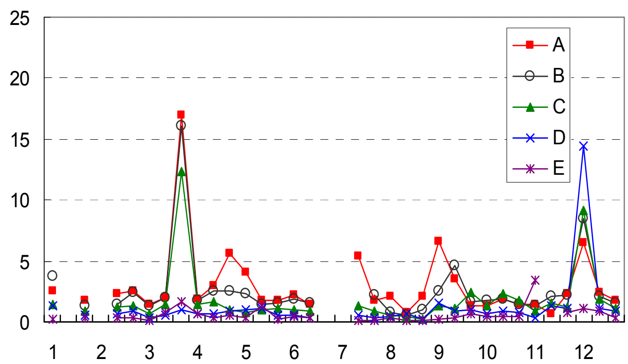
Fig. 5. Monthly average SeaWiFS Chl-a imagies in the South Sea of Korea from 1998 to 2005.

c. Seasonal variability of Chl-a concentration in five different areas

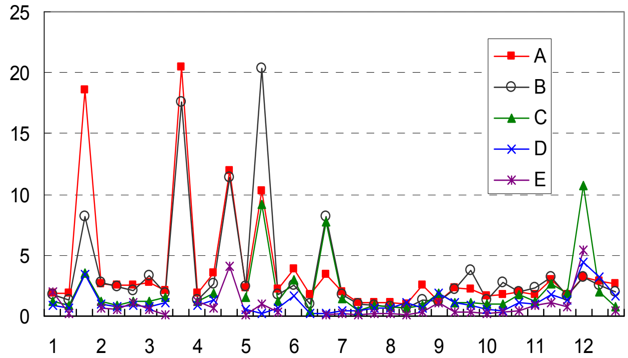
Time series of ten days SeaWiFS Chl-a concentration in five different areas showed different characteristic of seasonal variations (Fig. 6). The stations as below were selected to extract the time series data from the SeaWiFS chlorophyll *a* imageries from 2000 to 2001. Chl-a values are averaged in 18×18km area to avoid some noise on the imageries. It is also quantified the seasonal variations of SeaWiFS chlorophyll *a*. It was able to detect the spring bloom in March, May and the late fall bloom in December, 2000-2001. However, it was not able to detect the high chlorophyll *a* density during the summer even though huge red tides occurred in 2000 and 2001 (Suh et al., 2004).



(a)



(b)



(c)

Fig. 6. (a) Study map in the southern part of the Korean waters. Ten days variations of the estimated Chl-a derived from SeaWiFS in (b) 2000 and (c) 2001 (Suh *et al.*, 2004).

3.2 Validation of satellite Chl-a concentration

The correlation between in situ Chl-a concentrations and those derived from three existing in-water algorithms of SeaWiFS was investigated, using data observed in the southern coastal region of Korea, the northern part of the East China Sea (Figs. 7and 8). The results showed good the coefficient of correlation 0.56 and 0.82 in all data. The above results indicate that there is no unique characteristic in the Korean waters, thus, existing in-water algorithms can be applied to estimate Chl-a concentration in southern coastal waters of Korea. It also suggested that there might be a problem in atmospheric correction.

We would like to talk about the estimated suspend solids (SS) in the southern part of Korean waters. We developed the empirical formula from the relationship between the in situ SS and SeaWiFS band ratio (nLw490/ nLw555) as in Fig. 9. We were able to regenerate the suspended solid distributions in the southern part of Korean waters using the empirical formula [Estimated SS=-11.51Ln(x) + 14.38, R^2=0.58, here x is the SeaWiFS band ratio (normalized water leaving radiance 490nm/555nm)].

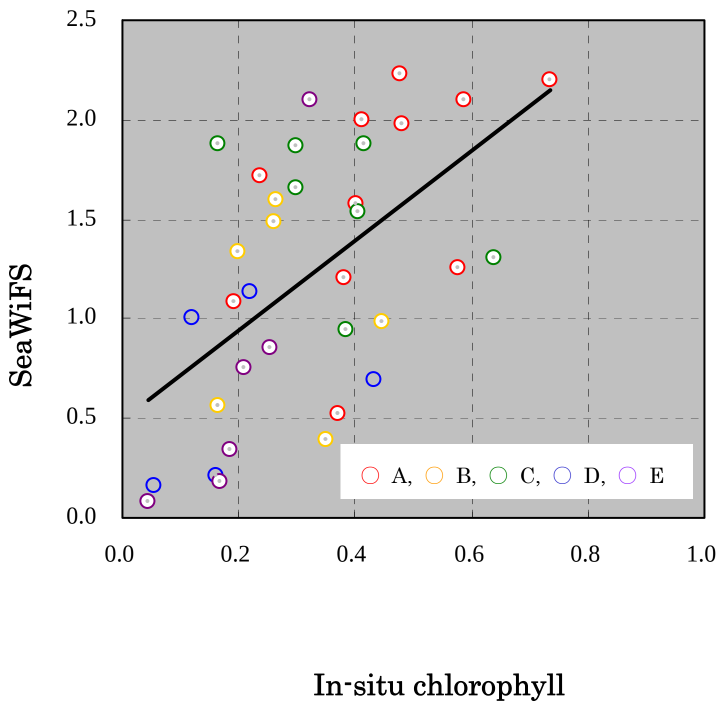


Fig. 7. Relationship between the in situ Chl-a and Chl-a derived from SeaWiFS in the areas as shown in Fig. 6-a for four years (1999-2002).

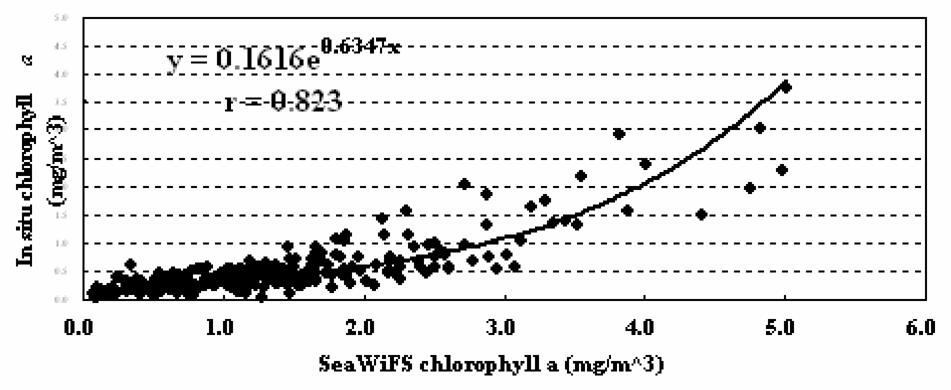


Fig. 8. Relationship between the in situ Chl-a and Chl-a derived from SeaWiFS in February, May, August, November for 6 years (2000-2005)

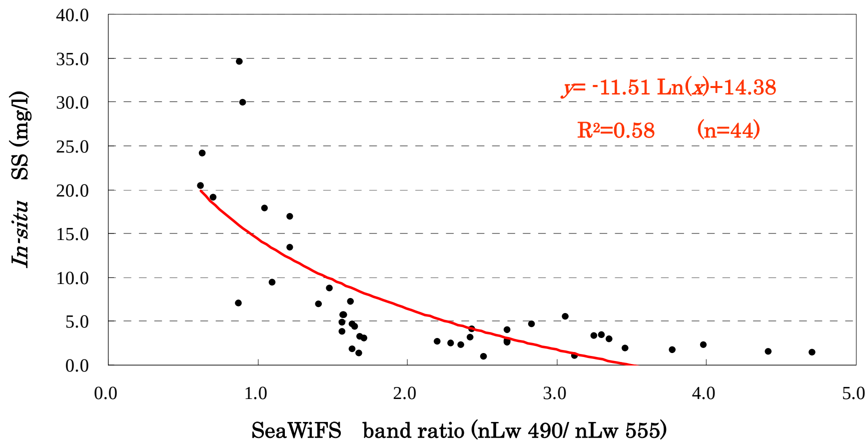


Fig. 9. Empirical relationship between in situ suspended solid in the southern part of the Korean waters and the band ratio of SeaWiFS satellite from October 1999 to June 2002.

4. Assessment of eutrophication with remote sensing

Liner regression was made in relationship between in situ and SeaWiFS Chl-a concentration data (Figs. 7-9). The characteristics of variation pattern were represented well, as Chl-a concentrations in inner area of the bay in the South Sea of Korean Peninsula and the eastern coast of China are higher every summer, through analyzing of time series of satellite Chl-a concentration data (Figs. 3-5).