Red Tide Prediction in the Korean Coastal Areas by RS and GIS

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ABSTRACT : Red tide(harmful algae) in the Korean Coastal Waters has a given a great damage to the fishery every year. However, the aim of our study understands the influence of meteorological factors (air and water temperature, precipitation, sunshine, solar radiation, winds) relating to the mechanism of red tide occurrence and monitors red tide by satellite remote sensing, and analyzes the potential area for red tide occurrence by GIS. The meteorological factors have directly influenced on red tide formation. Thus, We want to predict and apply to red tide formation from statistical analyses on the relationships between red tide formation and meteorological factors. In future, it should be realized the near real time monitoring for red tide by the development of remote sensing technique and the construction of integrated model by the red tide information management system (the data base of red tide - meteorological informations). Finally our purpose is support to the prediction information for the possible red tide occurrence by coastal meteorological information and contribute to reduce the red tide disaster by the prediction technique for red tide.

Key words: Red tide, Meteorological and marine factors, Statistical relationship, Remote sensing & GIS technique, Real time red tide prediction

1. Introduction

This red tide has destructed the marine ecology and environments, and has given the great damage of coast fisheries and the national problems of socio-economics(NFRDI, 1996 and 1997). Especially it is considered to serious matter that red tide is appearing frequently to the southern coastal area and is extending gradually to the all coastal areas in the Korean peninsula. Thus, it is necessary to know beforehand the characteristics of the meteorological and oceanographic conditions, and the possibility of satellite monitoring and prediction for the prevention of disasters related red tide in this study area(Yoon, 1999). Many studies for red tide have carried out at the limited fields as taxonomy, physiology, ecology and molecular biology(Iizuka and Mine, 1979; Wade and Quinn, 1980; Park, 1991, Kim, 1998), but they have not given a full and satisfying answers. Recently a few papers have studied for the mechanism related red tide in the fields of physics, dynamics, remote sensing and GIS(Tyler and Stumpt, 1989; Tester *et al.*, 1991; Keafer and Anderson, 1993; Ahn, 2000; Suh *et al.*, 2000).

Generally the important meteorological factors for red tide occurrence were known air temperature, precipitation, sunshine and winds(Yanagi *et al.*, 1992; Yamamoto and Okai, 1996; Yamamoto *et al.*, 1997, Yoon *et al.*, 2002), and the oceanographic factors for red tide formation were known water temperature, salinity, nutrients, chemical substances(Sharples, 1997; Choi, 2001; Yoon *et al.*, 2003). The basic object of this study is in order to understand the mechanism and favorable condition for red tide occurrence and formation on their related meteorological and oceanographic factors, and additionally find the potential area for red tide occurrence in the middle coastal area of the South Sea of Korea.

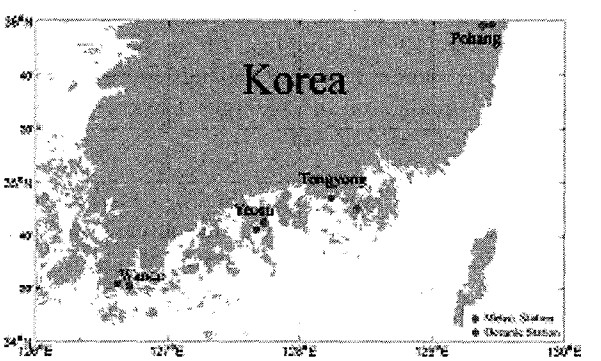

Fig. 1. Coastal area in the South Sea of Korea.

2. Field observation data

The study area is the Coastal area in the South Sea of Korea(Wanso, Yeosu, Tongyong and Pohang, Fig. 1). The reported monitoring data are used as follows; the meteorological factors are air temperature, precipitation, sunshine and winds for the periods of 1990 to 2001 years and the observed intervals of 3hour. the oceanographic factors are water temperature, salinity, chlorophyll_a, suspended solids, phosphorus, nitrogen for the periods of 1996 to 2001 years and the observed times of February, May, August and November, respectively. The chloroohyll_a concentrations on August 22, 2000 was calculated from the ocean chlorophyll 2 algorithm(O'Reilly *et al.*, 1998). The red tide occurrence data is in-situ data for the periods of 1984 to 2001 years, respectively.

3. Results and Consideration

Fig.2 shows the annual variations of red tide occurrence. the occurrence of red tide commonly increased each year from 1993 until now because of supernutrition in coastal waters and appeared in all coastal areas from 1995. In monthly variations(Fig. 3), red tide mostly occurred from July to October. It mainly concentrated on August and September in summer time. This season has high temperature and heavy precipitation.

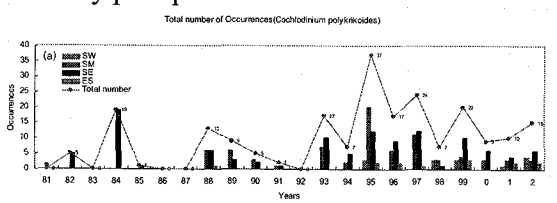

Fig. 2. Annual variations of red tide occurrence.

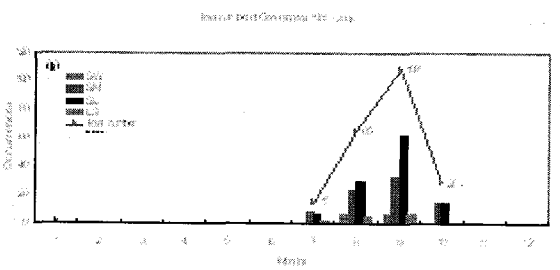

Fig. 3. Monthly variations of red tide .

Fig. 4 shows the daily variations of meteorological factors in monthly data. This is the case studies for the days in the red tide occurrence from June to August, 2000. The first case is the Gamak bay. In July 1, 2000 before the red tide occurrence, the daily accumulated precipitation was 23.4mm. In July 3, 2000 in red tide occurrence, the daily average air temperature was 24.66℃(max.: 27.3℃), the daily accumulated precipitation was 0mm, the daily accumulated sunshine was 2h and the main winds was 0.25m/s & SW(max.: 5.5m/s & 200°). The second case is the Yosu~Dolsan coast. In July 14, 2000 before the red tide occurrence, the daily accumulated precipitation was 54.4mm. In July 18, 2000 in red tide occurrence, the daily average air temperature was 26.48℃(max.: 29.4℃), the daily accumulated precipitation was 0mm, the daily accumulated sunshine was 6.9h, and the main winds was 0.25m/s & SW(max.: 5.1m/s & 200°). Finally, the third case is the Dolsan coast. In August 20, 2000 before the red tide occurrence, the daily accumulated precipitation was 27.5mm. In August 22, 2000 in red tide occurrence, the daily average air temperature was 25.85℃ (max.: 28.7℃), the daily accumulated precipitation was 0mm, the daily accumulated sunshine was 10.3h and the main winds was 0.46m/s & SW(max.: 7.7m/s & 180°), respectively.

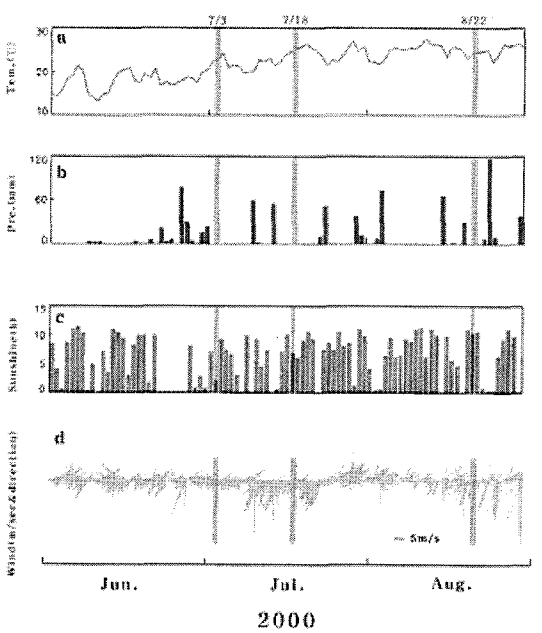

Fig. 4. Daily variations in Yeosu during June~July 2000. Shadow regions denote the time when the red tide was occurred.

Fig 7 shows the results of the statistical characteristics for air & water temperature (Fig.

7a), precipitation (Fig. 7b), sunshine duration (Fig. 7c)and wind velocity (Fig. 7d), respectively. From these Figures, we can properly predict red tide occurrence before 1～4 days in real time by Buoy system (red tide monitoring buoy, Fig. 8).

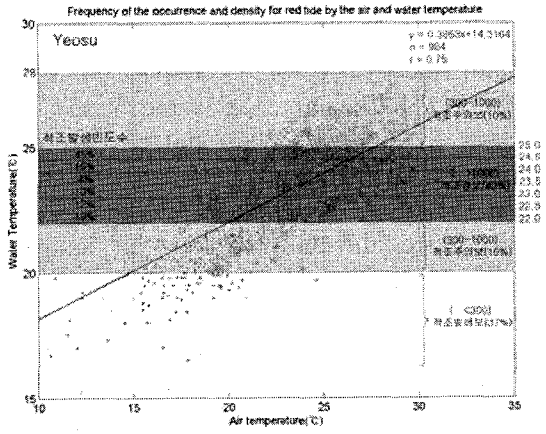

Fig. 7a. Frequency of the occurrence and density for red tide by the air and water temperature.

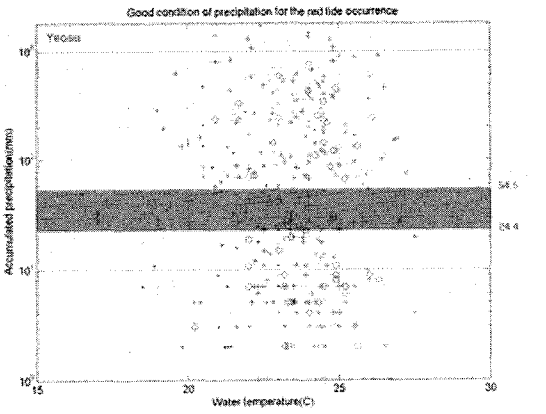

Fig. 7b. Good condition of precipitation for the red tide occurrence.

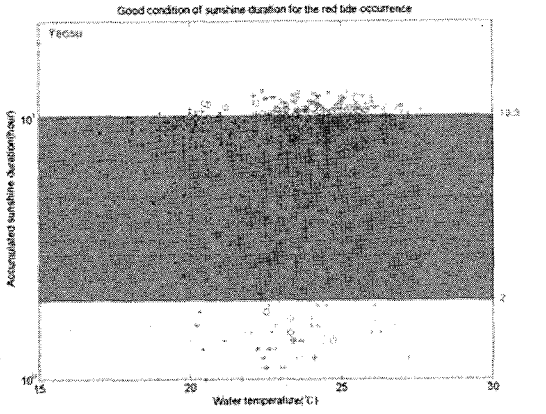

Fig. 7c. Good condition of sunshine duration for the red tide occurrence.

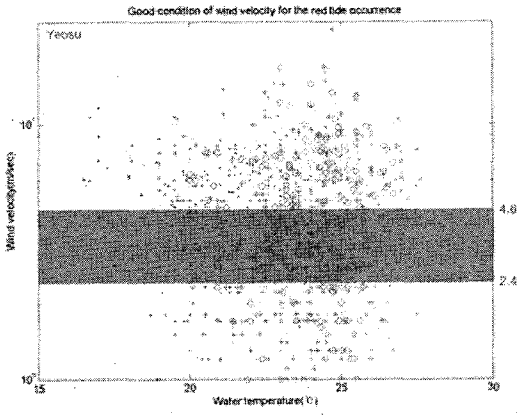

Fig. 7d. Good condition of wind velocity for the red tide occurrence.

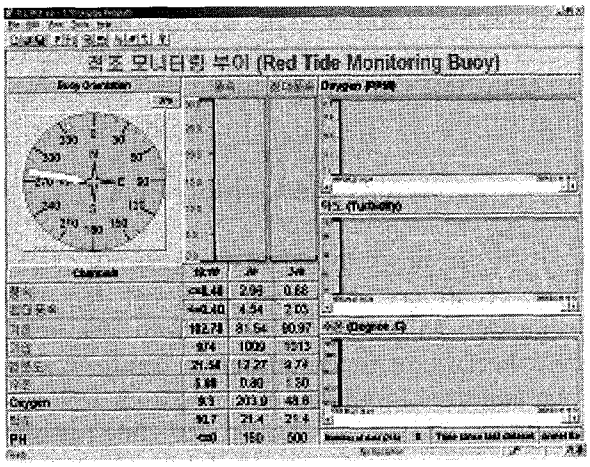

Fig. 8. Red tide monitoring buoy.

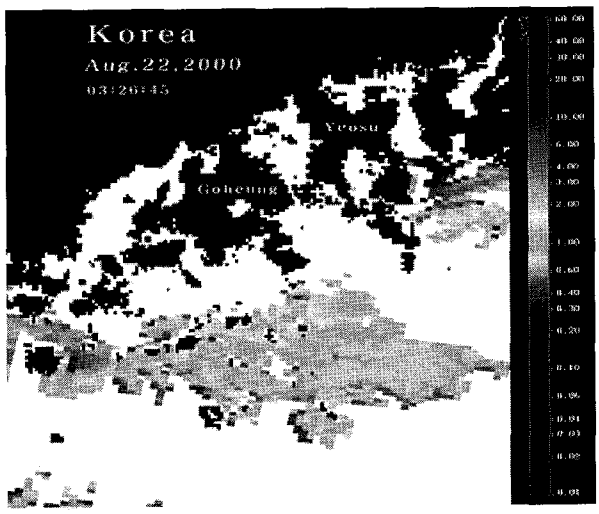

Fig. 5. Areal distributions of Chlorophyll_a from SeaWiFS image on August 22, 2000.

Chlorophyll_a in August 22, 2000 was obtained from SeaWiFS image by using the ocean chlorophyll 2 algorithm(OC2)(Fig. 5).

In the distributions of oceanographic

factors(here, the figures were not shown in this paper), the proper oceanic condition for the red tide formation in August, 2000 is considered as follows; the calm weather(25.93℃ & 199.7h) increases sea water temperature(23～28℃), the heavy precipitation(305.7mm) brings some riverine water, nutrients and other chemical substances to ocean: low salinity(22～32‰), high suspended solid(10～35mg/l), low phosphorus(0.025～0.070mg/l) and high nitrogen(0.04～0.18mg/l), respectively.

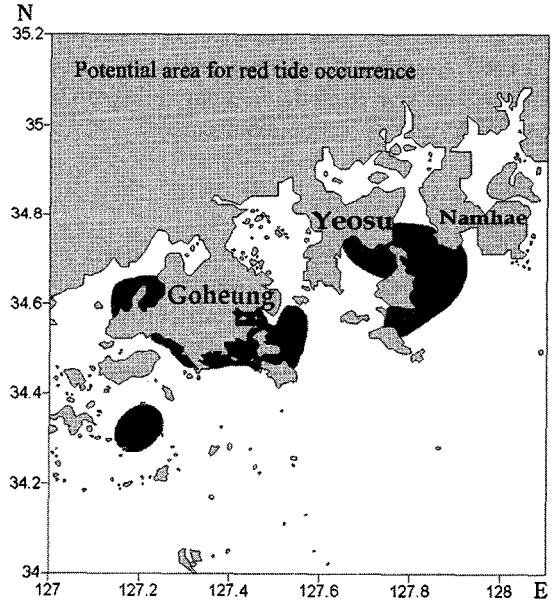

Fig. 6. Areal distributions of potential area for red tide occurrence on August 2000.

It was decided to the potential area in the coastal zones for the red tide occurrence from the limited factors for the growth of phytoplankton. Then, the representative criteria for selection are nutrients(phosphorus and nitrogen) and suspended solids(chemical substances; Fe, Mn, Vitamins, etc.) in the ocean. By using GIS conception through the overlap for three subject figures(phosphorus, nitrogen and suspended solids), It was obtained potential area for red tide occurrence on August 2000(Fig. 6). It was founded that the potential area are the Yeosu～Dolsan coast, the Gamak bay, the Namhae coast, the Narodo coast, the Goheung and the Deukryang bay. This result is very well coincided to the results of the satellite and in-situ data.

4. Conclusions

The important meteorological factor governing the mechanisms of the increasing in number of red tide occurrence is heavy precipitation. This appeared to bring nutrients and other chemical substances required for growth of phytoplankton from land through river discharge(ex: Sumjin river near Yeosu～Dolsan coast). Also wind is considered to play a important role in the accumulation of red tide. The commonly good conditions for the red tide occurrence is heavy precipitation(23.4～54.5mm) before 2～4 days. The commonly favorable conditions for the red tide formation was as follows; high air temperature(24.64～25.85℃), proper sunshine(2～10.3h) and light winds(2～4.6m/s & SW) in the day in red tide occurrence. The calm weather with warm temperature and low wind velocity gives less dispersion of the vegetative cells of red tide organisms. This means the possible prediction involved increasing in number of red tide occurrence. In the comparison between satellite and in-situ data, the same trend appears the possible monitoring involved the spatial distribution in concentrations of red tide occurrence. Finally, It was possible to choose for the potential area related the red tide occurrence by the overlap of three subject figures(phosphorus, nitrogen and suspended solids) as the limited factors.

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