RED-TIDE DETECTION BY USING MODIS/AQUA DATA

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ABSTRACT: Red-tide, caused by *Cochlodinium polykrikoides* (C. polykrikoides) that causative fishery mortality, impact on aquaculture and economic loss appear particularly in summer and fall seasons in the coastal waters of Korea. Many researchers have been performed to reduce these kinds of damage. This study proposes an algorithm to detect large *C. polykrikoides* red tide event that was appeared in the coastal waters of Korea. We propose a method to detect the area of red-tide occurrence by analyzing MODIS sensor image from Aqua satellite. Chlorophyll_*a* concentrations were calculated using MODIS images by an Ocean Chlorophyll 4 (OC4) algorithm. And then removes the non-active red-tide area by sea-surface temperature (SST).

Ⅰ. INTRODUCTION

Red tides became natural disasters which have serious effects on human life and exerting serious influences on marine ecosystems. The latest red tides' concentration gets higher and the duration does longer because optimal conditions that they are activated more continued as sea surface temperatures rise due to global warming (Kitaura *et al.*, 2006).

Red tides mean the phenomena that plankton which lives in the ocean reproduces, changes colors of seawater to brown or red, and destroys ecosystems. And even though it doesn't change the colors of seawater, organisms which physically damage other living things are being used by naming them Harmful Algal Blooms (HAB) newly. The many parts of ecophysiological characteristics of causative organisms of main red tides have been studied and identified and a large portion of their response to environmental changes is reaching the level that utilization possible. But the latest red tides' occurrence and progress aspects became complicated because they are influenced by complicated factors including changes of marine environment, abnormal climate, and pollution load by men's excessive development. Furthermore, as seasonal succession is clear in the red tides which occur in the Korean coasts whose sea water temperatures are different from one another by season, it can be much more difficult to expect their occurrence. According to the characteristics of these red tides, it can be effective to detect their occurrence promptly and minimize damages by coping with them fast rather than expecting them in advance. Therefore, the necessity to build systems to monitor red tides is more urgent.

There has not been any technology which satisfies artificial, economical, and environment-friendly conditions and can remove red tide organisms until now. And for the best solution, the method to reduce damages by grasping the characteristics of oceanography and weather conditions and information that red tides occur exactly with remote sensing is most realistic (The National Environmental Protection Institute, 1996; Yoon, 1999). The sensing method which was generally applied to reduce damage of red tides is to use drawings which are investigated through field investigation with vessels or airplanes. This has the disadvantages that it is difficult to grasp the flow and route of red tides because it costs high and the wide seas cannot be observed. The necessity of remote sensing with satellites was on the rise to solve these disadvantages and demand of remote sensing technologies are a growing trend due to the technological development.

Many studies related to red tides utilizing the remote sensing technique have been carried out (Tyler and Stumpt, 1989; Ahn, 2000; Suh *et al*., 2000; Tester *et al*., 1991). For the studies on occurrence of red tides until now, the taxonomic, physiological, ecological, and molecular biological studies have been mainly done (Lee *et al*., 2002; Yang *et al*., 2000; Wade and Quinn, 1980). The red tides which occur in the coast are closely connected to the characteristics of oceanography and weather conditions of the seas that they occur except biological and chemical factors (Choi, 2001; Yoon *et al*., 2002; Sharples, 1997). The remote sensing technique which uses satellite image with space time resolution has mainly been used in the field to detect occurrence and distribution of red tides in the studies on them. The most commonly used technique is the one to detect red tides using Chlorophyll information. This technique detects the seas that Chlorophyll's concentration is high using the correlation between red tides and it as them. The studies which detect the red tides using the Chlorophyll information that the ocean color sensors of visible rays including MODIS or SeaWiFS based on this correlation have been very actively arranged (Ishizaka, 2003; Knee *et al*., 2006; Kitaura *et al*., 2006). But it has the disadvantage that the technique to detect red tides using Chlorophyll's concentration only has errors because the seas with the one cannot be considered as the one that they always occur.

Therefore, this study suggests the method to raise accuracy to detect red tides using images of the band to detect Chlorophyll of MODIS/Aqua satellite and the surface sea temperature band to remove the errors which occur in the technique to detect the red tides using Chlorophyll.

Ⅱ. DATA AND METHODS

This study selected the study area and the test date based on the geographic information data of the red tides that National Fisheries Research and Development Institute (NFRDI) provides. NFRDI makes out report data of red tides using preconsideration and acquisition information about the seas that they occur in the Korean coasts. The report data of red tides provide information including the date and time that they occur, types and density of red tide organisms, and water temperatures.

The coasts of Jeollanam-do in the South Sea of Korea were set as the study area based on the red tide data which occurred on Aug. 26th, 2012. The used data were the images which were photographed on Aug. 26th, 2012 as MODIS/Aqua satellite ones that NASA provides. The data which were used in this study are the ones that the MODIS data were changed to the level 2 and also the ones of Chlorophyll and Sea surface temperatures (SST).

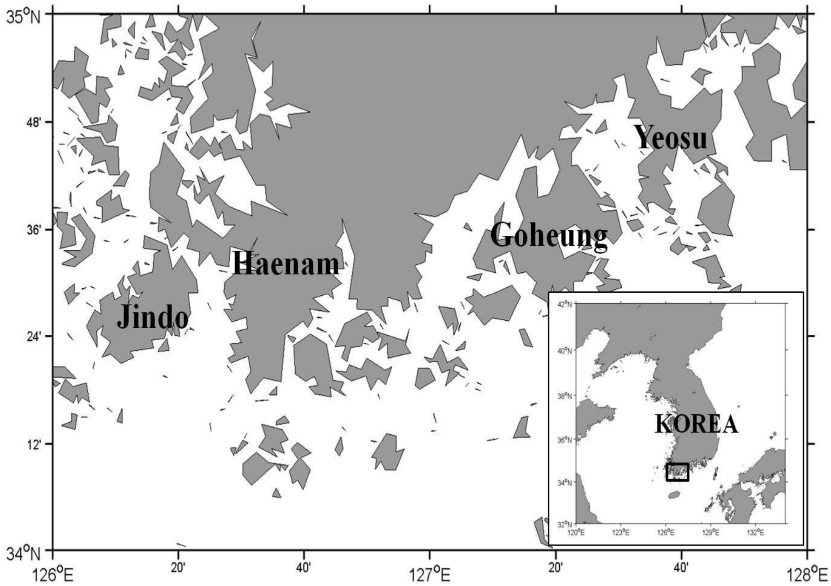

Figure 1. Study area is the coasts of Jeollanam-do in the South Sea, Korea.

Ⅲ. RESULTS AND DISCUSSIONS

The result which analyzed Chlorophyll with the MODIS images photographed on Aug. 26th, 2012 has found that there was the distribution of 0 ~ 5 ㎎/㎥ in the study area. But Chlorophyll's concentration is more than 15 ㎎/㎥ in the coastal areas.

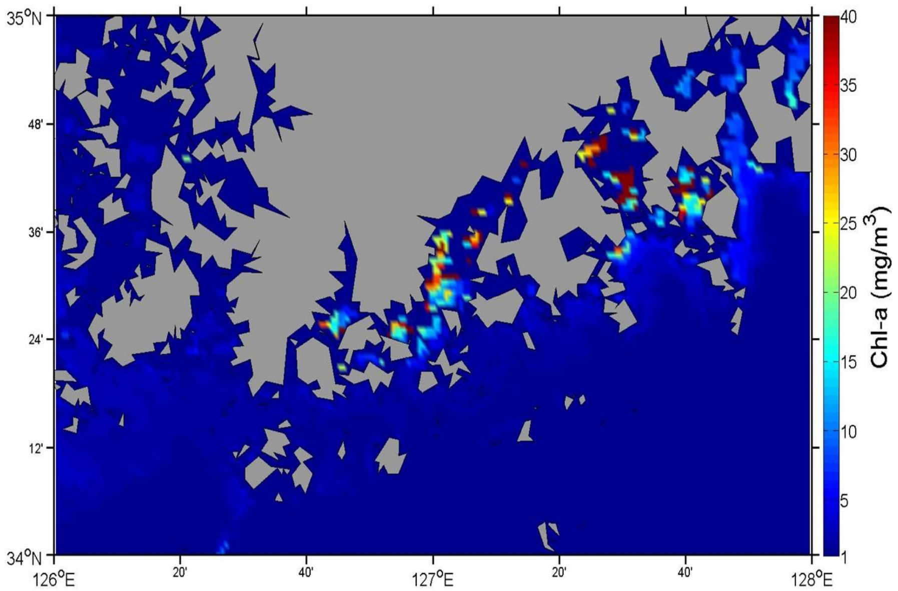

Figure 2. The distributions of Chlorophyll on Aug. 26th, 2012.

Figure 2 is the distribution of Chlorophyll in the study area using the MODIS Chlorophyll data. The zone except the blue color pixel values can be the location that red tides occurred. But it is judged with Chlorophyll's concentration as mentioned in the early beginning, the Korean southern coasts include the errors that most of them are judged as the red tide areas. Therefore, if the concentration scope of Chlorophyll is limited and applied by the more than values of 6 ㎎/㎥, it is thought that more detailed results can be obtained (Fig. 3).

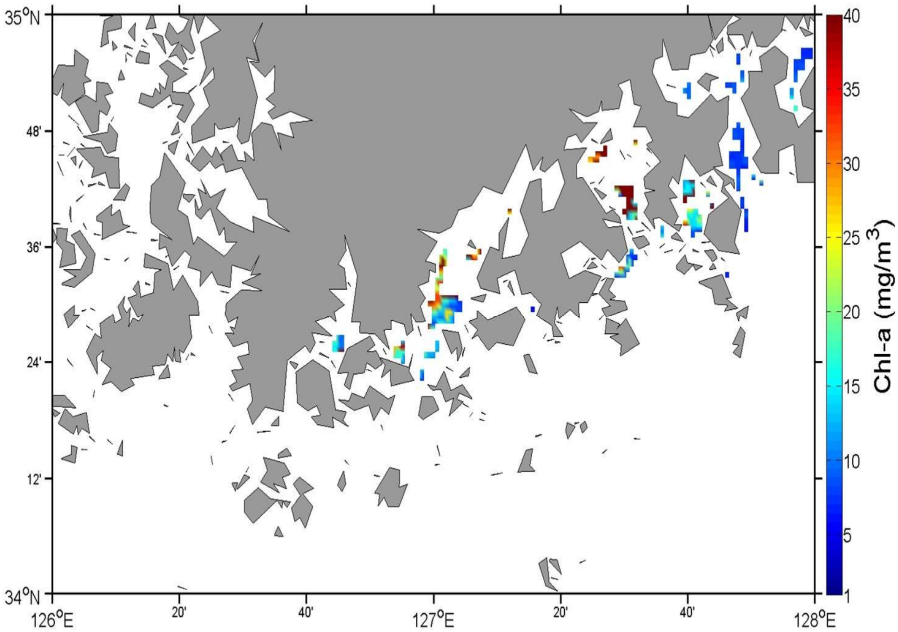

Figure 3. The data which extract Chlorophyll. The only pixel with the concentration values of more than 6 ㎎/㎥ which was considered as the one that red tides occur.

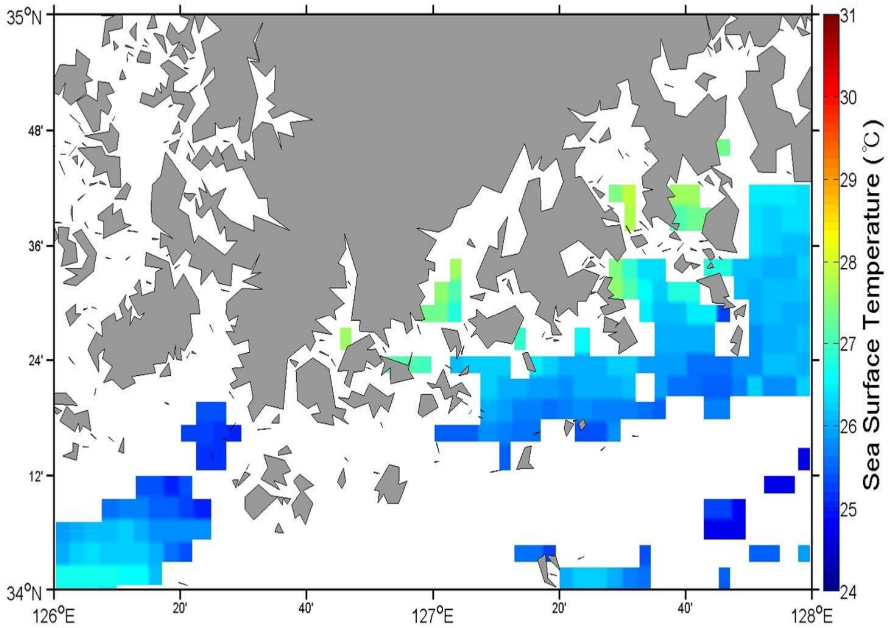

Figure 4. The data which extract SST. The only pixel with the temperature values of between 24℃ and 31℃ which was considered as the one that red tides occur.

Chlorophyll's concentration is set as the concentration that red tides can occur and the MODIS SST data photographed on the same date were also limited and extracted by the temperature that they can do (Fig. 4).

It tried to extract the only seas that red tides occur by adding the data of Figure 4 to indicate water temperatures that they can do in the analytical data of Chlorophyll's concentration which can be thought to cause the red tides shown in Figure 3.

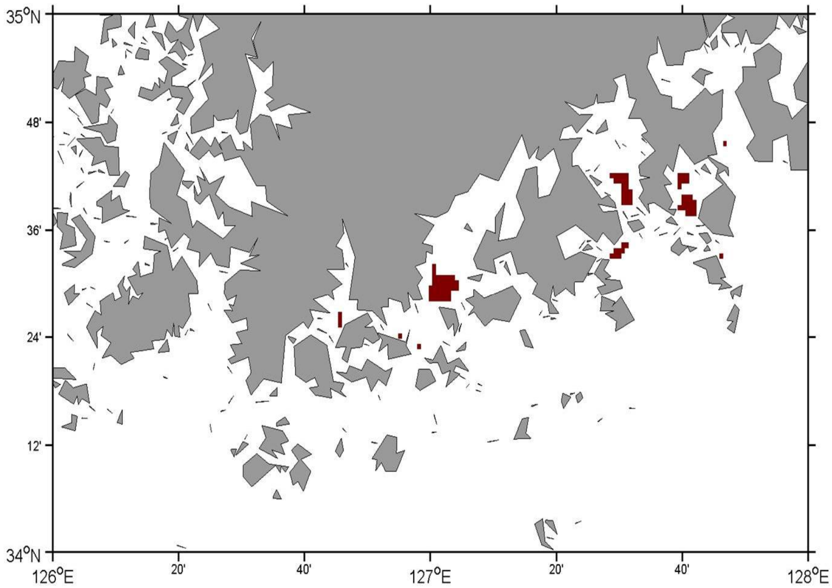

Figure 5. The area that red tides can occur which Chlorophyll and SST were added and analyzed.

The results were shown in Figure 5. The results which applied Chlorophyll's concentration and the optimal SST have found that a considerable portion of Chlorophyll was removed from the data that it was first extracted. But when it was compared to the geographic information data of the red tides that NFRDI provides, there was no the result which exactly accorded with the distribution of the red tides that actually occurred. It is thought to be because many factors including weathers, suspended solid, nutrient salts, and salinity which have the effect on occurrence of the red tides were not considered.

Figure 6. The data to monitor red tides on Aug. 26th, 2012 that NFRDI provides.

Ⅳ. CONCLUSIONS

Increase of the red tides' concentration and temporal and spatial diffusion become the problems as one of the results of global warming, abnormal climate according to it, and climate changes. It is expected to be connected to economical and environmental problems and preparation of measures to reduce damages is urgent. This study tried to detect red tides utilizing the satellite to suggest an alternative to monitor them as it is time-consuming and expensive and was carried out to reduce errors of Chlorophyll which was suggested as the existing problem.

The result which limited, added, and analyzed Chlorophyll's concentration and SST to be considered that red tides can occur in the existing studies has found that a considerable portion of errors could be more removed compared to the cases that they are detected with Chlorophyll only but there was the difference between it and the scope of the red tides observed from the field. It is thought to be because various natural factors which have effects on their occurrence and the duration were not considered.

This study was carried out to detect red tides exactly and promptly with the satellite and showed the primary result. Next studies which consider the characteristics of MODIS Satellite by band and organisms, inorganic matters, and suspended solid detected from the sea surface will be carried out. It is thought that the detected result needs to be quantitatively evaluated.

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REFERENCES

Ahn, Y. H., 2000. Development of remote sensing reflectance and water leaving radiance models for ocean color remote sensing technique. Journal of the Korean Society of Remote Sensing, 16(3), pp. 243-260.

Chol, H. Y., 2001. Oceanographic Condition of the Coastal Area between Narodo Is. and Solido Is. in the Southern Sea of Korea and Its Relation to the Disappearance of Red-Tide Observed in Summer 1998. 'The Sea' Journal of the Korean Society of Oceanography, 6(2), pp. 49-62.

Ishizaka, J., 2003. Present status of red tide detection in Japan by ocean color satellite. Workshop on Red Tide Monitoring in Asian Coastal Waters, March 10-12, 2003, Tokyo, Japan.

Kitaura, Y., Y, Touke, H. Sasaki, A. Tanaka, H. Murakami, T. Suzuki, K. Matsuoka, H. Nakata, and J. Ishizaka, 2006. Satellite Detection of Red Tide in Ariake Sound, 1998-2001. Journal of Oceanography, 62, pp. 37-45.

Knee, T. C., J. Ishizaka, V. Ransi, T. P. H. Son, S. C. Tripathy and E. Siswanto, 2006. Oceanographic events at northern borneo and their relationship to harmful algal blooms. Scientific paper presented at ISRS 2006 PORSEC, November 2006, Busan, Korea.

Lee, Y. S., 2002. An Influence of Inflowing Freshwater on the diatom Blooms in the Eastern Coast of Dolsan, Yosu, Korea. Journal of Korean Society of Environmental Engineers, 24(3), pp. 477-488.

National Institute of Environmental Research, 1996. marine pollution and red tides. National Institute of Environmental Research, pp. 191.

Sharples, J., 1997. Cross-shelf intrusion of subtropical water into the coastal zone of northeast New Zealand. Cont. Shelf Res., 17(7), pp. 835-857.

Suh, Y. S., J. H. Kim and H.G. Kim, 2000. Relationship between sea surface temperature derived from NOAA satellites and Coclodinium polykrikoides red tide occurrence in Korean coastal waters. J. Korean Environ. Sci. Soc, 9, pp. 215-221.

Tester, P. A., R. P. Stumpt, F. M. Vukovich, P. K. Flower and J. T. Turner, 1991. An expatriate red tide bloom: transport, distribution, and persistence. Limnol. Oceanogr., 36, pp. 1053-1061.

Tyler, M. A. and Stumpf, R. P., 1989. Feasibility of using satellite for detection of kinetics of small phytoplankton blooms in estuaries: tidal and migrational effects. Remote Sens. Environ., 27, pp. 233-250.

Wade, T. L. and Quinn, J. G., 1980. Incorporation distribution and fate of saturated hydrocarbones in sediments from a controlled marine ecosystem. Mar. Envirom. Res., 3, pp. 15-33.

Yang, J. S., H. Y. Choi, H. J. Jeong, J. Y. Jeong, J. K. Park, 2000. The Outbreak of Red Tides in the Coastal Waters off Kohung, Chonnam, Korea: 1. Physical and Chemical Characteristics in 1997. 'The Sea' Journal of the Korean Society of Oceanography, 5(1), pp. 16-26.

Yoon, H. J., 1999. Satellite Remote Sensing and Earth Science-Satellite Oceanography. The Korean Society of Remote Sensing, 15(1), pp. 51-60.

Yoon, H. J., S. C. Kim, Y. S. Kim, S. W. Kim, 2002. Study on monitoring and prediction for the occurrence of red tide in the middle coastal area in the South Sea of Korea. International journal of maritime information and communication sciences, 6(1), pp. 333-337.