APPLICATIONS OF LANDSAT TM DATA
FOR MAPPING OF RED TIDE DISTRIBUTION IN BUOHAI BAY

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ABSTRACT

Red tides are usually caused by dinoflagellates and inflict great damages to coastal fisheries, especially to prawn culture in the west coastal area of Buohai bay. A remote sensing technique by use of Landsat TM data for mapping of red tides in their stages has been developed using phytoplankton pigment and red colored material as the indicators. Pigments and red colored material in near surface sea water were measured in the Buohai bay by thematic mapper on Landsat. Sea truth data were simultaneously collected during the red tide occurred. TM data digital image was processed to abstract thematic information i.e. pigment and red colored material. The thematic images indicated the highest correlation with sea truth data employed. The most reliable procedure for the two indicator's distribution were determined to be $(TM_2-TM_1)/(TM_2+TM_1)+TM_5$ and $(TM_3-TM_1)/(TM_3+TM_1)+TM_5$. Detailed distribution maps of them in near surface water were obtained. The red tide area was classified with the two indicators from the compared clear water area from the two thematic images. Even though further study should be necessary, it shows a strong applicability of remote sensing data on the problems of red tide.

KeyWords: Red Tide, Landsat TM, Remote Sensing

1. INTRODUCTION

Monitoring of ocean phenomena from space became an important field of oceanography because of the great advantages of covering a large area and an easy grasp of changes. Using remote sensing technique in detecting water pollution such as turbidity and red tide in the coastal area where aquaculture are very active has great interesting (Yoo, et al. 1990 and Uhno, 1989). Buohai bay, located in the east of China, there was a serious red tide occurred during August 4 to October 15, 1989 in west coastal area. It began from August 4 and started from Chiko river delta. It appeared dull brown and extended over 55 km long and 15~20 km wide along Huanghua city coast (Fig.1). It ended at October 15 and inflicted a great damage of prawn culture of the coastal area.

Dinoflagellates such as Chattonella or Gymnodinium were the main species of the red tide. These dinoflagellates like red tide do not have a distinct red color, but dull brown. There is a little difficulties to distinguish between a red tide and other types of colored water. Information of red tide distribution in the stages of development would be useful in protecting shrimp culture in the area.

Mapping red tide distribution was tried by means of Landsat TM remote sensing techniques for this Area in this study.

2. METHOD AND MATERIALS

Remote sensed data i.e. Landsat TM over Buohai bay were collected on August 24, 1989 when there was an enormous red tide occurred. All of the TM data,

which consists of seven channels were used in this study. Among these seven channels, channel 1, 2, and 3 are for the visible spectrum; channel 4 and 5, 7 are for the near-inferred and channel 6 is for infrared spectrum. During the period of red tide occurred,some insitu sea truth data were also collected by Huanghua bureau of fisheries. The sea truth data were taken from the sea surface and included the pigment numbers of phytoplankton and zoneplankton. Weather conditions were also considered in the analysis.

The TM Image data was wide enough to cover most area of Buohai bay and show details of the river
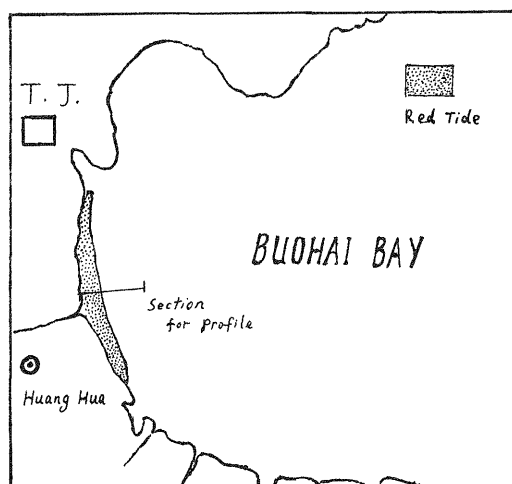

Figure 1. Geographic location of the sdudy area and red tide distribution

discharges.

A VAX 11/750 computer with DIPX ARIES-II image processing system was mainly used for the remote sensed digital TM data processing. TM digital image and the processed images were monitored on the Hihtach terminal which is with both spatial and gray level high resolution. Several stages of processed images including the final classified red tide images were copied using Ink-Jet plotter and QCR hardcopy peripherals.

Software used in this image processing are mainly developed by Canadian DIPX Ltd. except reading TM BSQ format data, Chlorophyll and turbidity calculation etc. (J., Li, et al., 1991).

The pigment and red colored material values of the red tide area were obtained by matching the sea truth data to the relevant remote sensed TM original data. Regression modules were carried out firstly and then the processed remote sensed TM data were converted into mg/l or No./l.

Visible data TM_2, TM_1 and near infrared TM_5 were used to calculate chlorophyll pigments (Li, et al., 1991). Visible data TM_3, TM_1 and near infrared TM_5 data were used to get the indicator of red colored materials. Near infrared TM_4 data was also used as an indicator of the turbidity pattern.

The equation used for calculation chlorophyll and red colored turbid materials are as following:

$$C_{hl} = A_1 * [(TM_2-TM_1)/(TM_2+TM_1) + TM_5] + B_1 \quad (1)$$
$$T_{ur} = A_2 * [(TM_3-TM_1)/(TM_3+TM_1) + TM_5] + B_2 \quad (2)$$

where

TM_i — Landsat TM data
C_{hl} — chlorophyll concentration
T_{ur} — turbidity for red colored materials
A_i — constant
B_i — constant

Finally, TM near infrared data TM_4 and C_{hl}, T_{ur} processed images were used to classify the red tide area.
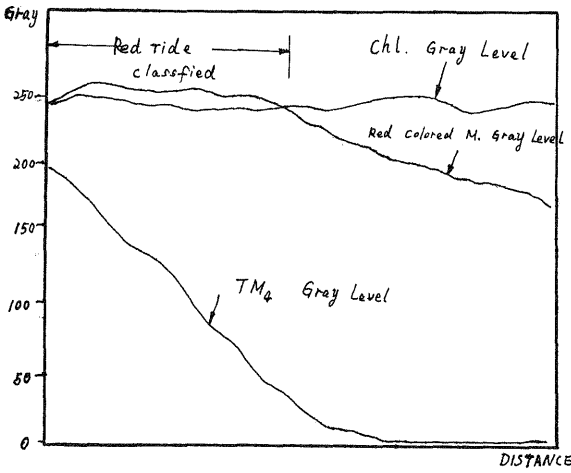

Figure 2. Profile of chlorophyll concentration, red colored material and TM_4 at the cross section in figure 1
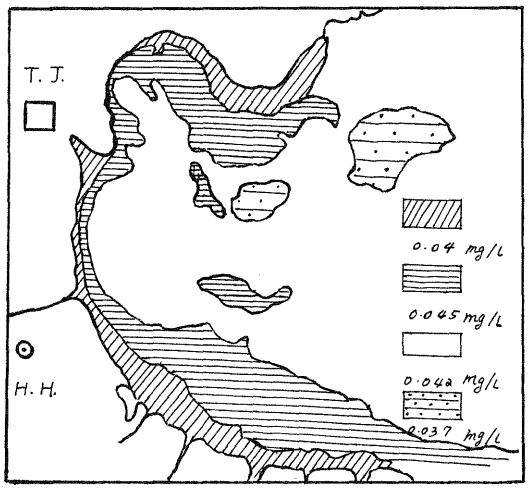

Figure 3. Chlorophyll distribution derived from Landsat $TM_{1,2,5}$

However, the turbidity image data were not converted and quantified to mg/l because of limited availability of field data.

3. RESULTS AND DISCUSSION

3.1 The differences between the red tide intruded water area and clear water with the mean of chlorophyll pigment and red colored materials

Fig. 2 shows the profile of chlorophyll pigment, red colored materials and TM_4 image data crossing the red tide area. It suggest that red colored material has a greater value in the area during the red tide blooming period than in the area where red tide didn't occurred. Contras to that, there is no sharp increase of the chlorophyll pigment from clear water area to red tide area but fluctuation. Moreover, the red colored materials (in red tide area) is much greater than chlorophyll pigment. It reversed in the clear water area and there is a sharp decrease
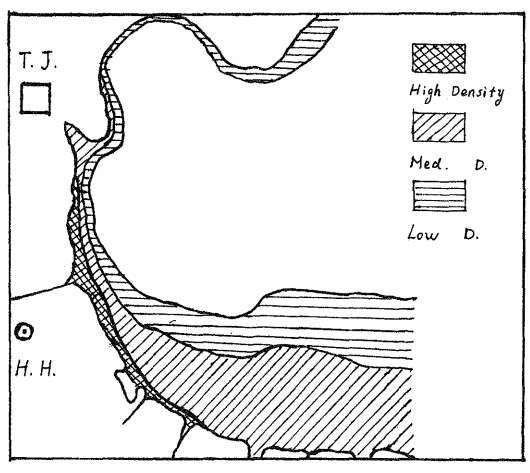

Figure 4. Red colored material distribution derived from Landsat $TM_{1,3,5}$

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of red colored material from red tide area to clear water area. It indicate that why the red tide turbid water looked dull brown.

3.2 Detected Area of Red Tide

Fig. 3,4,5 shows the chlorophyll, red colored material and turbidity distribution observed on the TM image of August 24, 1989.
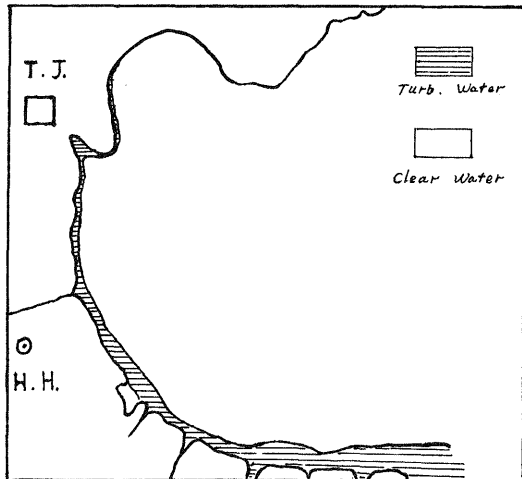

Figure 5. Turbidity distribution derived from Landsat TM_4

According to these images, the red tide area is limited to the coastal area from the lower part of Tianjing to Chaojia Bao. It totally concrete with the sea truth survey. Its shape looks like an up side down carrot (Fig.6).

Generally, the turbidity area was almost totally matched with the red tide area in the part where red tide happened even though there are some relatively smaller area of turbid water found in the up part along northwest coast of Buohai bay.

Chlorophyll pigment distribution in Fig. 4 gives the idea that higher chlorophyll pigment concentration level is not the only one indicator of red tide (specially in this kind of red tide). It also shows that there is water area with similar chlorophyll concentration where red tide occurred area. These Water areas with similar chlorophyll concentration level are distributed in other part of Buohai bay even off the coastal area. This result proved the chlorophyll distribution concentration level of 1986 in the area (Li, J. and Ping, Z., 1991).

3.3 The Indicators

The indicators used in this study of mapping red tide area by use of Landsat TM remote sensed data are chlorophyll, red colored materials and turbidity sensed by TM channel 4. Even there are more indicators such as COD and nutrition salt (PO_4-P, NO_3-N, etc.) which can be used as parameters to determine red tide (Yuang, H. et al., 1990), but these three indicators are the most applicable parameters which can be abstracted from TM data.
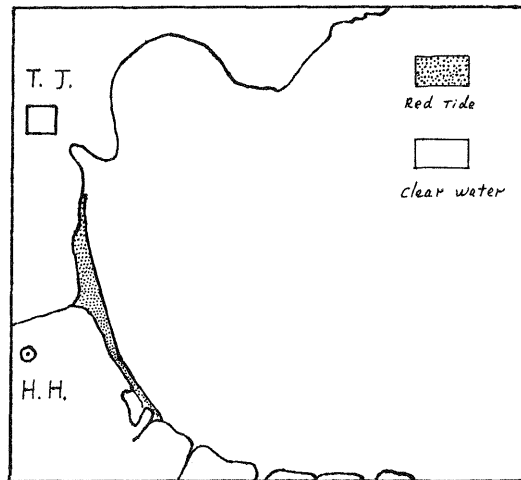

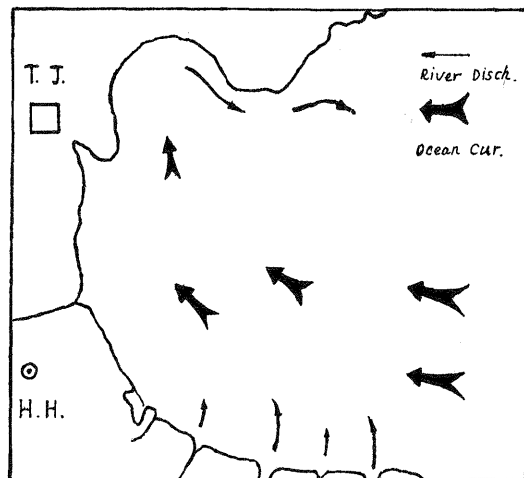Figure 6. Red tide distribution derived from Landsat TM

Figure 7. Current movement and river water discharges derived from Landsat TM data

3.4 Possible Mechanism of the Red Tide

Red tide occurred in this area contained two major species i.e. Noctticuta Miliars and Gymnodin. Recruitment and breeding of these two species are mainly depends on the nitration salt like P, N etc.. Fig 7 Shows several rivers and fish pound discharges bringing lots of nitration material into this area. Neap and tide force the water mass with higher nitration toward the west coast where red tide occurred. Before and during red tide occurred in the area, there was lower precipitation and no strong winds, which can not exchanged the high notoriousness with offshore water (with lower notoriousness). In this case, these two species bred and increased in great amount with longer sunshine and higher temperature.

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4. CONCLUSION

The results of this study prove that Landsat TM digital data has a great potential application in these field i.e. monitoring coastal environment such as red tide and waste water discharges. These environment information sometime are urgently needed by the coastal aquaculture. Even though Landsat TM remote sensing data can not give much detail information(DO, PH, COD, PO_4-P, NO_3-N etc.) as field survey does, but it really can show the overall environment information with a comparable huge area and higher time frequency. However, this study does not include other type red tide. As the types of red tide vary a lot, it is necessary to conduct these studies in order to prevent these kind of disasters or protect fishermen from them.

5. ACKNOWLEDGMENT

REFERENCES

Li, J., L. Zhang, M. Jin, 1991. The Study of Using Landsat TM to Quantify Chlorophyll and Lake Weed, Asia and Pacific Remote Sensing Journal, 4:1-14

Li, J., Ping, Z., in editing, Mapping Chlorophyll Distribution in East China Sea by means of CZCS

Uhno, Shiron and Michio Yokota, 1989. Applications of Remote Sensing Techniques for the Mapping of Red Tide Distribution in Coastal Area, Elservier Science Publishing Co., Inc. Tokyo, pp.189-192

Yang, H., Q. Zhu and G. Dai, 1990. The Primary Survey and Study of Red tide in Yangzhi River Delta and Hangzhou Bay, Marine Environmental Science (China), 9:23-27

Yoo, H., Ahn, C. and Lee, H., 1990. Application of Remote Sensing on Sea Water Pollutions in Jinhae Bay of Korea, Symposium of Asian and Pacific Region Remote Sensing applications to Oceanography and Fishery Sciences, Bangkok, pp.307-315