Effect of Internal Wave at Lombok Strait to Chlorophyll Area at Southern Coastline off Bali Island

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Abstract- Internal wave with a soliton-like, large amplitudes within several kilometers, is frequently observed in the sea surface caused by tidal rectification due to sill or rough topographic changes. Internal waves can perturb current and density field, initiate bottom sediment re-suspension and mix nutrients to photic zone. Previous studies indicate that the appearance of internal wave in the Lombok Strait have been detected in SAR image data. This paper studies effect of internal wave in the Lombok Strait on distribution of chlorophyll in the surrounded areas using SeaWiFS and ERS SAR images data during 1996-2001 period. The preliminary result concludes that the internal waves presumably affect chlorophyll distribution spreading southeastward in the coast off Bali Island.

Keywords- Internal wave detection, wavelet analysis, phytoplankton area.

I. INTRODUCTION

As the biggest archipelago country, Indonesia has good opportunity in international fishing market. Recently, to uplift the export quantity, fishing ground is searched through phytoplankton distribution and its chlorophyll concentration with remote sensing technology. This paper investigated the effect of internal wave to the phytoplankton distribution and chlorophyll concentration, considering that the distribution can be effected with current, temperature, and other sea-atmospheric process. Southern area of coastline of Bali Island is chosen as study area since this area is the location of upwelling area and enroute of internal wave propagation from Indonesian Ocean to Pacifik Ocean through Lombok Strait. For this purpose, ERS SAR image and SeaWiFS image data is observed during 1996-2001 periods.

II. WAVELET ANALYSIS FOR MONITORING OF INTERNAL WAVE

Internal wave is a soliton-like wave with large amplitudes within several kilometers, which is generally produced in upper layer of sea surface by tidal and atmospheric condition. Internal waves perturb current and density field, initiate bottom sediment re-suspension and mix nutrients to photic zone (1). Previous study shows that the appearance of internal wave in Lombok Strait can be detected in SAR image data (2, 3). SAR image is used to monitor internal wave because of the capability in large scales area of monitoring by using near real time data. In shallow waters, internal waves are visible in SAR image because it modulate sea surface,

increase/decrease sea surface roughness, which is affected to radar backscatter through Bragg scattering process (2). In the valleys of modulation waves, diffuse scattering occur more than in its crest lowering backscattering coefficient. Then, in SAR image the valley of wave appears darker than crest. In a wave packet, internal wave appears as dark and white strips in image. The packet of internal wave is detected by Symlet wavelet on horizontal and vertical detail coefficient from level 3 (3). The result of internal wave monitoring is described in table 1.

III. MONITORING OF CHLOROPHYLL AREA IN SEAWIFS IMAGE

Chlorophyll data is derived by SeaWiFS images by variation of surface ocean color. The absorption and scattering of solar radiation by phytoplankton gives difference color captured by satellite sensor. The chlorophyll concentration is measured by using In-water Bio-optical Algorithm, which calculated the relationship between radiance captured by satellite sensor and in-water constituents as follows:

$$Ca = 10^{(0.3410 - 3.0010R + 2.8110R^2 - 2.0410R^3)} - 0.0400 \quad (1)$$

$$R = \frac{R_{RS}(490)}{R_{RS}(555)} \quad (2)$$

where, Ca is Chlorophyll concentration and R is band ratio (5). Then, the distribution of phytoplankton can be measured. In multi-temporal SeaWiFS data, this distribution is compared with the data when internal wave at Lombok Strait is occurs based on table 1.

IV. SUMMARY

The result of internal wave monitoring in SAR image with Symlet wavelet analysis shows that the internal wave creates elongated pattern on horizontal coefficient at level 5 of image (figure 1). Monitoring result is shown as below.

Table 1. The occurrences of internal wave at Lombok Strait (3).

No.	Location of incidence of internal wave	
	Lombok Strait	near Kanggean Island
1.	1996/4/23	1996/4/23
2.	1996/4/24	-
3	-	1996/12/25
4.	1997/7/7	-
5.	1997/9/30	-
6.	1997/10/1	-
7.	1997/11/5	1997/11/5
8.	1998/11/4	1998/11/4
9.	1999/12/15	1999/12/15
10.	1999/12/31	-
11.	2000/1/19	-
12.	2001/8/20	-
13.	2001/9/5	-

The distribution of chlorophyll area from February to August 2001 (figure 2) shows that the chlorophyll area during transitional monsoon from north to west to southeast (from February to March) is less then the area during dry season (June to August). In February, the chlorophyll area is located from northern of Bali Island to the southern of Lombok Strait. In March, the distribution slightly increases. It distributed further to the south. From April to August the chlorophyll area increased at southern of East Java Island, Bali Island and Lombok Strait. The maximum concentration is located at southern coastline of Bali Island. In July, the area near coastline of Java is influenced by upwelling area occurs during east wind.

Meanwhile figure 3 shows the distribution with the effect of internal wave on August 8th, 2001 compared with the data on August 2000. The distribution of chlorophyll at southern coastline off Bali Island when internal wave occurred is elongated and distributed further to westward (from 8.8^o to 10.7^{o}LS) than the area when internal wave did not occur on August 2000 (from 9.25^o to 10.25^{o}LS) as shown in figure 3. It shown that

the surface chlorophyll concentration near coastal area, i.e. from 8.8° to 9.25° LS, increased when internal wave is occurred.

ACKNOWLEDGEMENTS

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REFERENCE

[1]. Colossi, J.A., Beardsley, R.C, Lynch, J.F., Gawakiewicz, G., Chiu, C., and Scotti, "A., Observation of Nonlinear Inernal Waves on the Outer New England Continental Shelf during summer Shelfbreak Primer Study", Journal of Geophysical Research, Vol. 106, No. C5, Pages 987-9601, May 15, 2001.

[2]. L.M., Mitnik and W. Alpers, "Sea Surface Circ"ulations through the Lombok Strait studied by ERS SAR, PORSEC Proceeding, 2000.

[3]. Y., Arvelyna, M., Oshima, "Wavelet Analysis for Internal Wave Monitoring in SAR Image", Proceeding of Pan Ocean Remote Sensing Conference (PORSEC) 2002.

[4]. O`Reilly, J.E., S. Maritorena, B.G. Mitchell, D.A, Siegel, K.L. Carder, S.A., Garver, M., Kahru, and McClain, "Ocean Color Chlorophyll Algorithm for SeaWiFS", J. Geophysics Res., 103, 1998.

[5]. "Principles and Applications of Ocean Remote Sensing: Visible, IR & Microwave", PORSEC 2002 Training Course Modul, 2002.

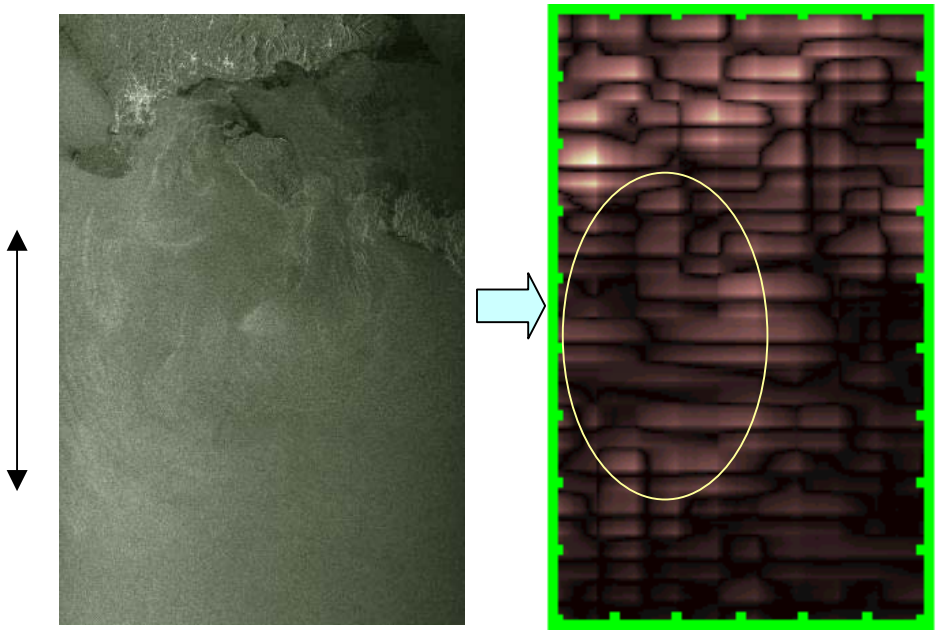

Figure 1. Internal wave detection result with Symlet Analysis on August 2001. In original image, internal wave position is pointed with arrow. Internal waves create elongated pattern in horizontal detail coefficient of level 5 of image.

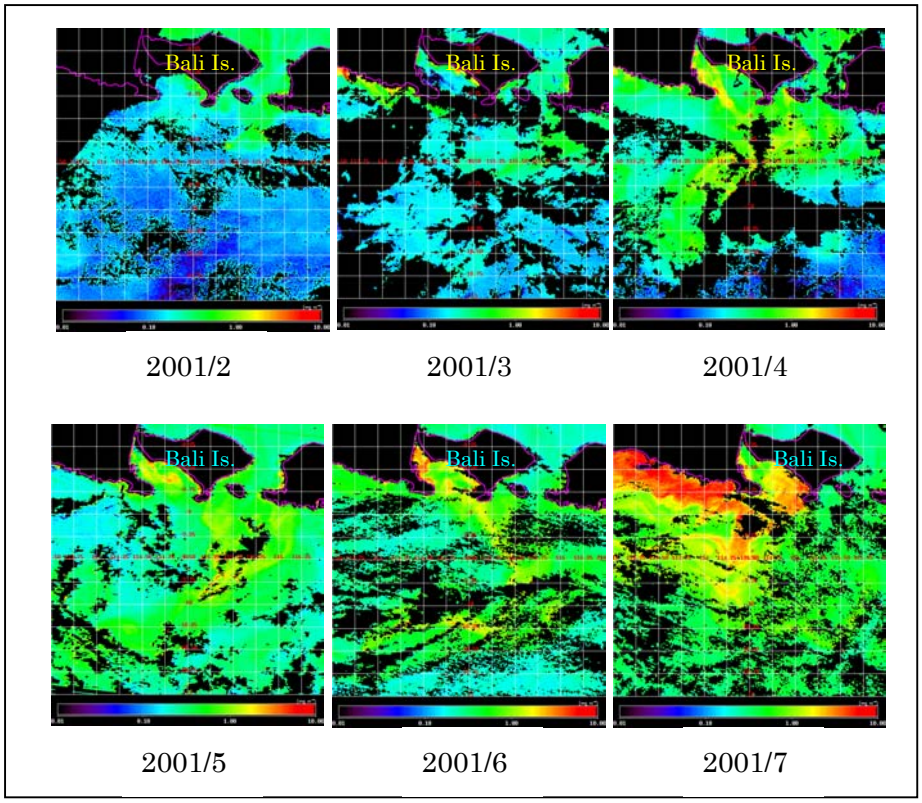

Figure 2. The distribution of phytoplankton at southern coastline off Bali Island from February to July 2001.

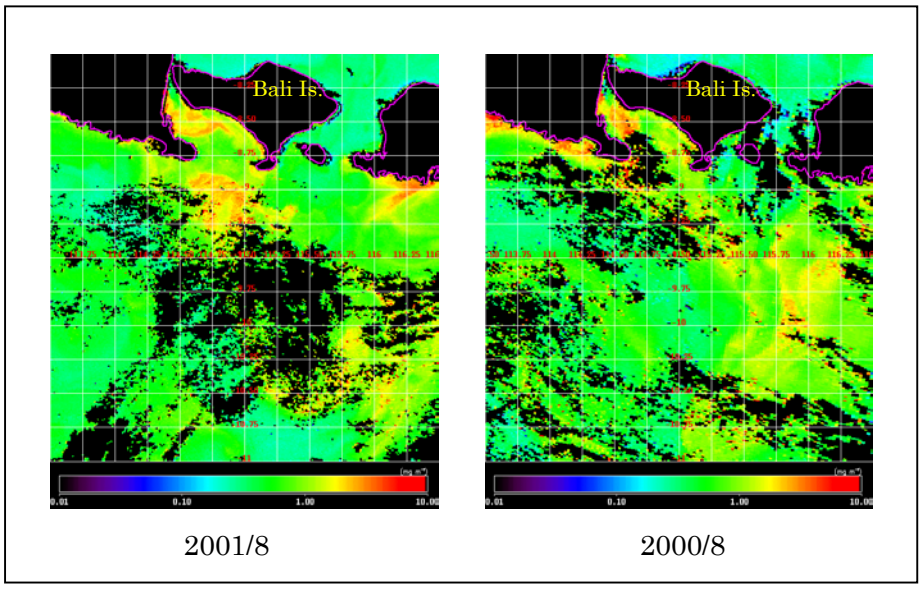

Figure 3. The distribution of phytoplankton at southern coastline off Bali Island on August 2001 (with the occurrence of internal wave) and August 2000 (without internal wave effect).