# Preliminary Study of Effect of Internal Wave to Phytoplankton Distribution in the Lombok Strait and Adjacent Areas

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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 to chlorophyll distribution in the surrounded areas using SeaWiFS and ERS SAR images data during 1996-2001 periods. The preliminary result concludes that the internal waves presumably affect phytoplankton distribution spreading southeastward in the coast off Bali Island. The distribution of phytoplankton at southern coastline off Bali Island when internal wave occurred is elongated and distributed further to westward (from 8.8° to 10.7°LS) than the area when internal wave did not occur on August 2000 (from 9.25° to 10.25°LS) as shown in figure 3. It shown that the surface phytoplankton concentration near coastal area, i.e. from 8.8° to 9.25° LS, increased when internal wave is occurred。

**Keywords:** Internal wave detection, wavelet analysis, phytoplankton area, SAR image, SeaWiFS image。

## 1. 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 with remote sensing technology. This paper investigated the effect of internal wave to phytoplankton distribution and 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 en-route 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.

## 2. 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 to allow the symmetric extension of data at the image boundaries and prevents discontinuities by a periodic wrapping of data (3). The monitoring result of internal wave during 1996-2001 period data is described in table 1.

## 3. Monitoring of Phytoplankton Area in SeaWiFS Image

Phytoplankton 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 phytoplankton 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 Phytoplankton concentration and R is band ratio (4), then the distribution of phytoplankton can be measured. The distribution of phytoplankton area at southern Java and Bali Island is retrieved from SeaWiFS image data during 2000-2001 period. The distribution on August 20, 2001 and 2000 is compared to analyze the effect of internal wave to phytoplankton distribution and concentration.

## 4. Summary

The result of internal wave monitoring in SAR image with Symlet wavelet analysis (table 1) shows that the internal waves can be detected as elongated pattern in horizontal and vertical coefficient at level 5 (Figure 1).

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 phytoplankton area from February to August 2001 (figure 2) shows that the phytoplankton 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 phytoplankton 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 phytoplankton 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 phytoplankton at southern coastline off Bali Island when internal wave occurred is elongated and distributed further to westward (from 8.8° to 10.7° LS) than the area when internal wave did not occur on August 2000 (from 9.25° to 10.25° LS) as shown in figure 3. It shown that the surface phytoplankton concentration near coastal area, i.e. from 8.8° to 9.25° LS, increased when internal wave is occurred.

## Acknowledgements

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## References

[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 Phytoplankton Algorithm for SeaWiFS", J. Geophysics Res., 103, 1998.

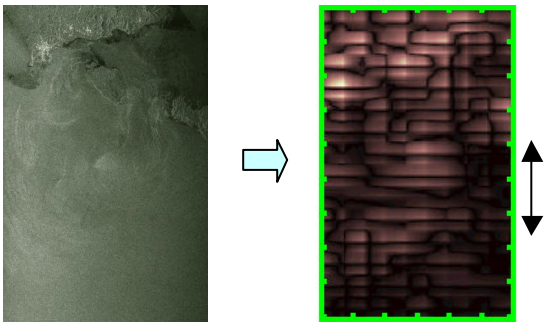

Fig. 1. Internal wave detection result with Symlet Analysis on August 2001. In original image, internal wave position is pointed with arrow. Internal waves create elongated pattern in horizontal detail.

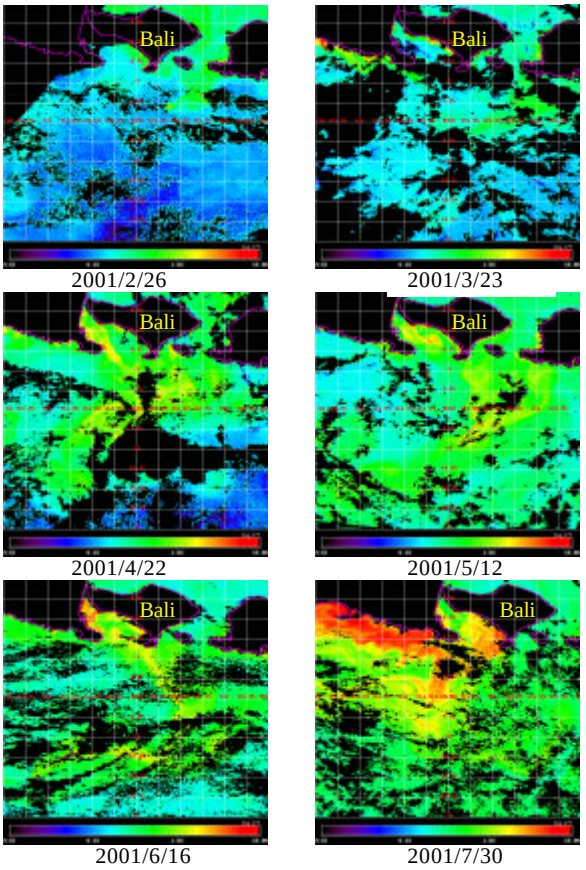


Fig. 2. The distribution of phytoplankton at southern coastline off Bali Island from February to July 2001

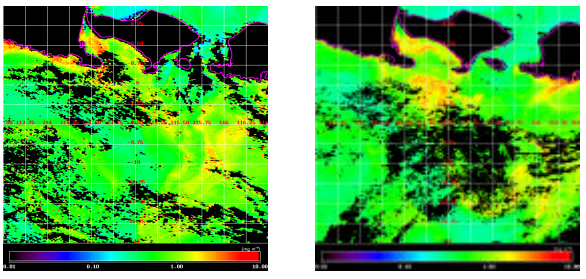


Fig. 3. The distribution of phytoplankton at southern coastline off Bali Island on August 2001 (with the occurrence of internal wave) and August 2000 (without internal wave effect).