A POTENTIAL TOOL FOR DETECTING HABs THROUGH REMOTE SENSING DATA

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Occurrence of Harmful Algae Blooms poses an emerging threat to Eastern Boundary Upwelling Ecosystems. By combining satellite-derived data and in situ measured physicochemical parameters, we assessed the possibility of detecting HAB occurrence and explored the scope of a colorimetric index (Red Tide Index, RTI). The index was able to distinguish those areas affected by the HAB during an event reported in the Humboldt Current System south of Chile during October 2003.

1. Introduction

The red tide phenomenon occurs naturally and is produced by the exaggerated increase and mass concentration of phytoplankton generating a color change of water by highly toxic cells (Hallegraeff, 1993, 2010). Those blooms of dinoflagellates associated with the production of natural toxins, depletion of dissolved oxygen and other negative effects are known as Harmful Algal Blooms (HABs). HABs can affect various water systems, being particularly prevalent in coastal marine ecosystems (Kudela *et al*. 2005), specially in Easter Boundary Upwelling systems (Fig. 1).

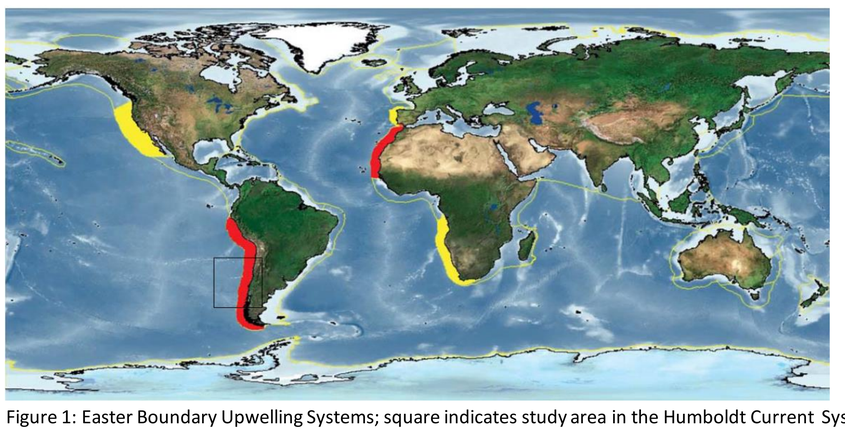

Figure 1: Easter Boundary Upwelling Systems; square indicates study area in the Humboldt Current System.

Goal

- ✓ Explore the detection of HABs through the use of satellite images.

2. Data and methods

Satellite and *in situ* (Fig. 2) data considering the period of HAB's bloom reported by Rodríguez-Benito & Haag (2004) in the Pacific (41°S-45°S) were analyzed to achieve the objectives.

HAB occurrence in the Humboldt Current System (Fig. 1) was investigated using a RTI based on Ahn and Shnmugam (2006), which is defined as:

$$RTI = \frac{\frac{nLw_{531}}{nLw_{547}} - nLw_{488}}{\frac{nLw_{531}}{nLw_{547}} + nLw_{488}}$$

where nLw_{λ} is normalized water leaving radiance at wavelength λ.

MODIS AQUA RRS 5-day composites were used to create at time series of the RTI.

Database: CDIAC - Carbon Dioxide Information Analysis Center (http://cdiac.ornl.gov/)

CARINA Project - CARbon dioxide IN the Atlantic Ocean (http://odv.awi.de/en/data/ocean/carina_bottle_data/)

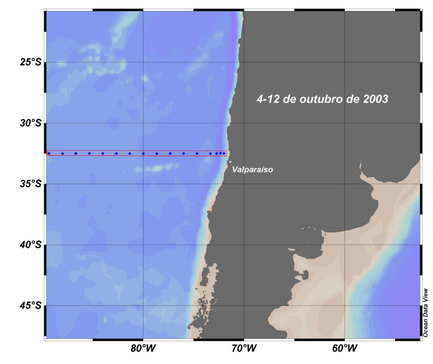

Figure 2: *in situ* data

3. Results - Satellite

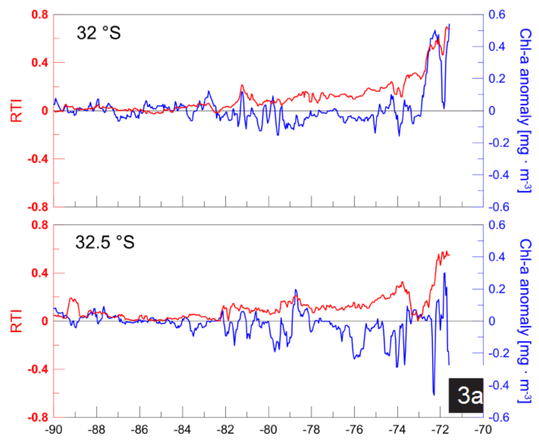

Figure 3 indicates chl-a and RTI at two zonal transects: 32°S and 32.5°S. The 3a bottom panel correspond to in situ data and shows a linear correlation of 0.67 between those parameters.
The 3b shows significant values of chl-a anomaly near the coast and 3c indicates that a HAB has occurred in the same place that the section of in situ data, but without signal offshore.

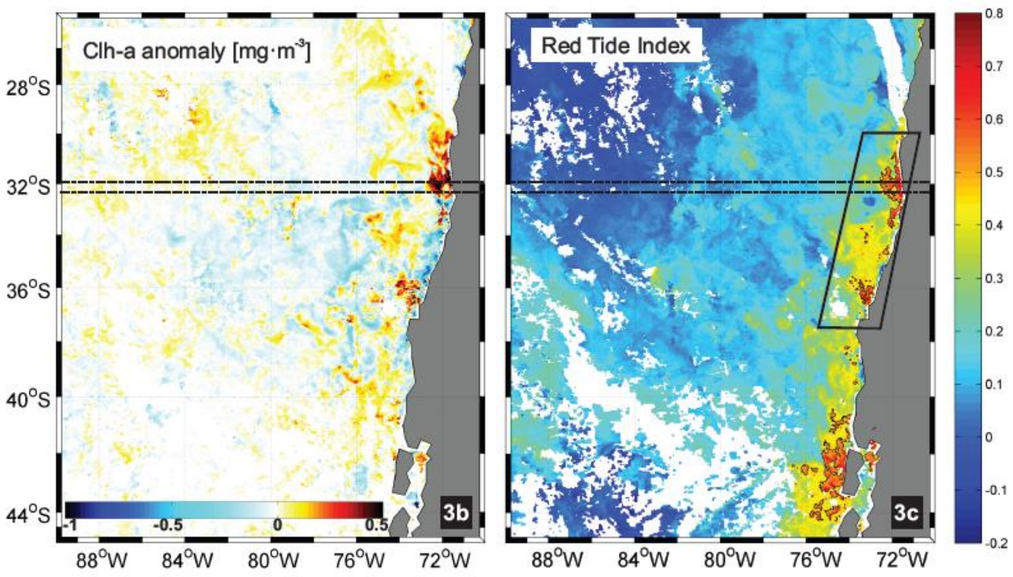

Figure 3: RTI and Chl-a anomaly for two transects: upper at 32°S and bottom at 32.5°S (3a); Chl-a anomaly (3b); RTI at study area, black contour indicates 0.5 (3c) and the black box correspond to the region analyzed in the Figure 4 The two lines at 3b and 3c indicate 32°S and 32.5°S.

To investigate the occurrence of HABs in the area of study, the percentage of pixels with RTI > 0.5 within the region depicted in Fig 3c was estimated for each 5-day composite between 2002- 2015 (Fig 4).

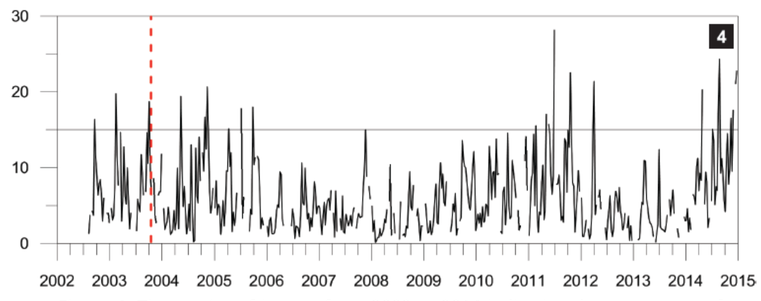

Figure 4: Time series of images from 2002 to 2014 indicating the percentage of pixels with RTI>0.5 for the region bounded by the black box in Figure 3c. The red line indicates the period when the *in situ* data were collected.

The HAB event documented during October 2003 exhibit ~20% of pixels with RTI > 0.5. In addition, 10 other periods exhibit more than 15% of pixels with RTI>0.5, which, indicating on average one potential HAB event in this area. Even though there is no significant trend associated with a climate change scenario, a low frequency signal of 8-10 years is apparent.

3. Results - *in situ* data

According to the *in situ* data , the occurrence areas were characterized by a low subsurface percentage of oxygen saturation and high concentrations of nitrates, phosphates and total inorganic carbon near the coast.

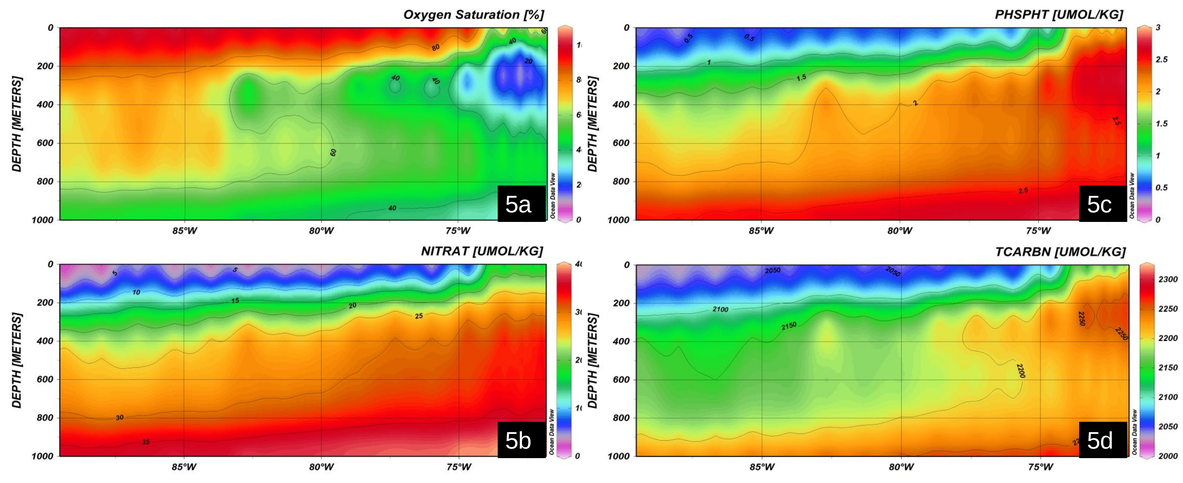

Figure 5: Vertical sections of the first 1000m of the study area for: oxygen saturation (5a), nitrate (5b), phosphate(5c) and total inorganic carbon (5d).

4. Prospects

- ➔ Analysis of CHL and SST data results in a powerful tool for the identification of potential upwelling and HAB events.
- ➔ *in situ* data are consistent with the results obtained from the analysis of satellite images.
- ➔ RTI suggests that CHL data can be good to distinguish those areas affected by the HAB as observed with *in situ* data.
- ➔ Satellite remote sensing can be a powerful tool to obtain a higher frequency and integration of measurements, with a large number of images available in near real time (Hu *et al*. 2005).
- ➔ Multidisciplinary studies and methodologies are required due to the complexity and variable characteristics of these oceanographic phenomena.

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5. References

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