Detection and Monitoring of HAB: Remote Sensing Component & *in situ* efforts

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Introduction

The proliferation of plankton algae (so-called "algal blooms"; up to millions of cells per litre) is beneficial for aquaculture and wild fisheries operations as they are critical food source for filter-feeding bivalve shellfish (oysters, mussels, scallops, clams) as well as the larvae of commercially important crustaceans and finfish. However, in some situations algal blooms can have a negative effect (Harmful algal blooms or HAB's), causing severe economic losses to aquaculture, fisheries and tourism operations and having major environmental and human health impacts. Among the 5000 species of extant marine phytoplankton (Sournia et al., 1991), some 300 species can at times occur in such high numbers that they obviously discolour the surface of the sea (so-called "red tides"), while only 40 or so species have the capacity to produce potent toxins that can find their way through fish and shellfish to humans.

Major coastlines along the Northern Indian Ocean in recent decades have undergone a remarkable transformation to more mesotrophic and eutrophic conditions by which there is appearance, persistence and epidemic of blooms of micro algae causing severe ecological impacts. Ocean Color Remote Sensing has long been the synoptic tool to detect and monitor the blooms, however there is no bloom-specific algorithm to discriminate between blooms of dinoflagellates and diatoms. In this regard, INCOIS has modified and operationally adapted the Red Tide Indices (Ahn and Shanmugam, 2006) as Bloom Index (BI) for Indian Waters. In addition to the bloom index, four critical satellite derived parameters are being considered. They are: a) Surface Chlorophyll Concentration (Chl), b) rolling anomaly in chlorophyll (RCA), c) sea surface temperature (SST) and d) rolling anomaly in SST (ΔSST). These five parameters are further categorized as primary (anomalies of Chl and SST and Bloom Index) and secondary (chlorophyll and SST).

Description of algorithms & methodology

Bloom Index: The BI is based on the RTI of Ahn and Shanmugam (2006), and the index has the functional form as shown in Equation 1. Mathematically, the index ranges between -1 and +1, with values closer to positive unity being an HAB. In the equation, a is the normalized water leaving radiance (nLw) at 531 nm, b is nLw(547) and c is nLw(488)

$$\left(\frac{a}{b} - c\right) \Big/ \left(\frac{a}{b} + c\right) \qquad 1$$

Anomaly: A technique based on satellite derived anomalies in Chl and SST has been made operational at NOAA's ECOHAB Program (Stumpf et al., 2003). The rolling anomaly is defined as the difference of geophysical parameter measured today from the mean of 30 days with a phase lag of 5-days. For example: A Chlorophyll anomaly image for February 5th, 2011 corresponds to difference between the 30-day mean data starting from January 1 to 30th, 2011 and February 5th data, while anomaly image for February 6th, 2011 corresponds to the difference between the data of the same date from the mean of data from January 2nd, 2011 to January 31st, 2011. The 30-day mean is considered to accumulate enough cloud free satellite retrievals and a lag of 5-day is being given to avoid bias in the anomaly due to short-term biological activities (blooms lasting up to 72 hours only).

Standard algorithms: The satellite derived surface Chlorophyll values were estimated using the default ocean color algorithm (OC3M) meant for MODIS-Aqua sensor (O'Reilly et al., 2002). While the SST are empirically retrieved using the 11 and 12 micron bands in MODIS. The detailed reports on these standard data products are available in the NASA Technical Memorandum Series (available at: http://oceancolor.gsfc.nasa.gov/DOCS/TechMemo/).

Proposed framework

The HAB program is being implemented in four phases, with the service under the first two phases being information based, while the latter two being a matured advisory service. The timelines for the phased implementation is from 2011-2015. The Table 1 illustrates the service levels further.

Table 1: Timelines and service implementation strategy

Phase I (2011-12)	Information Service	• Data source: Single sensor (MODIS-Aqua).
Phase II (2012-13)		• Data source: Multi-sensor (MODIS-Aqua / MERIS / OCM-II / AVHRR).
Phase III	Advisory Service	• Incorporation of sea surface current & wind data from various available sources. • Tracking bloom movement using NRT wind data.
Phase IV		• Incorporation of modeling component (Hydrodynamic, Optical and Ecological). • Decision support system. • Prediction system for fate and transport processes.

The proposed methodology integrates the three primary bloom indicators: BI, RCA and SST anomaly as shown in Figure 1, and it is currently being implemented as a pilot project for seven areas in the Indian Waters: Goa, Mangalore, Kochi, Gulf of Mannar, Perrangipetai, Vizag and North Arabian Sea (NAS).

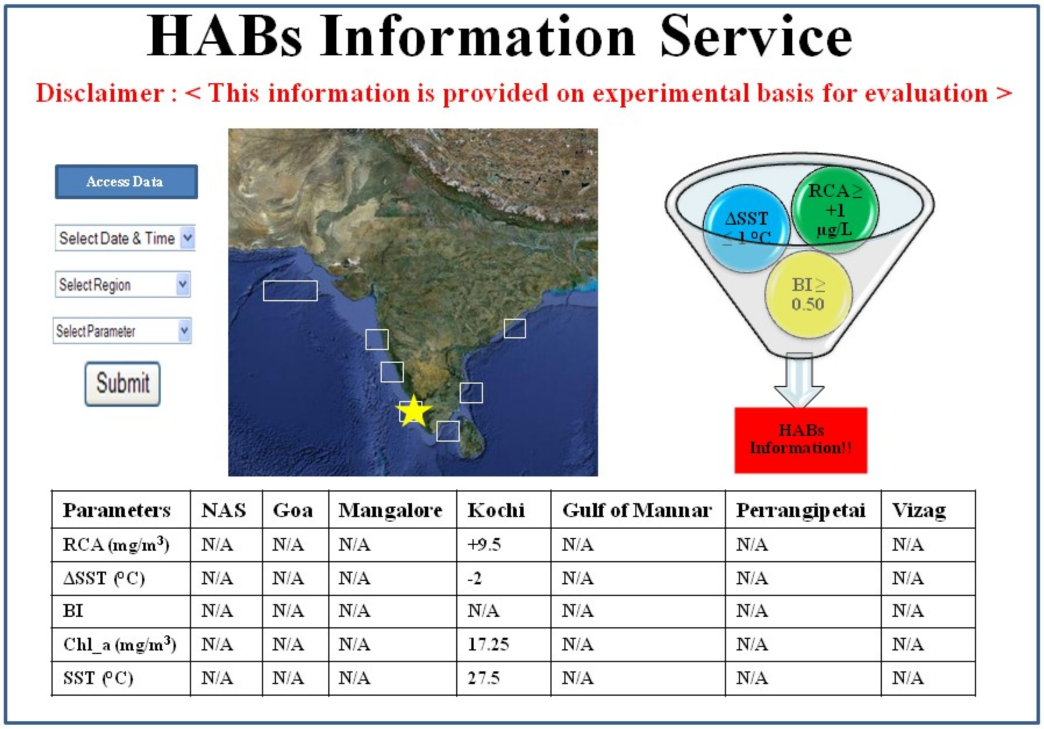

Figure 1 Conceptual Framework for operational monitoring and dissemination of HAB information in Phase I.

<u>Performance of detection capability</u>

The adopted framework was validated with limited dataset (courtesy: CMLRE). The results (see Figure 2) show that combining the three proxy indicators; the detection capability can be improved. However, the major stumbling block is the lack of cloud-free imagery.

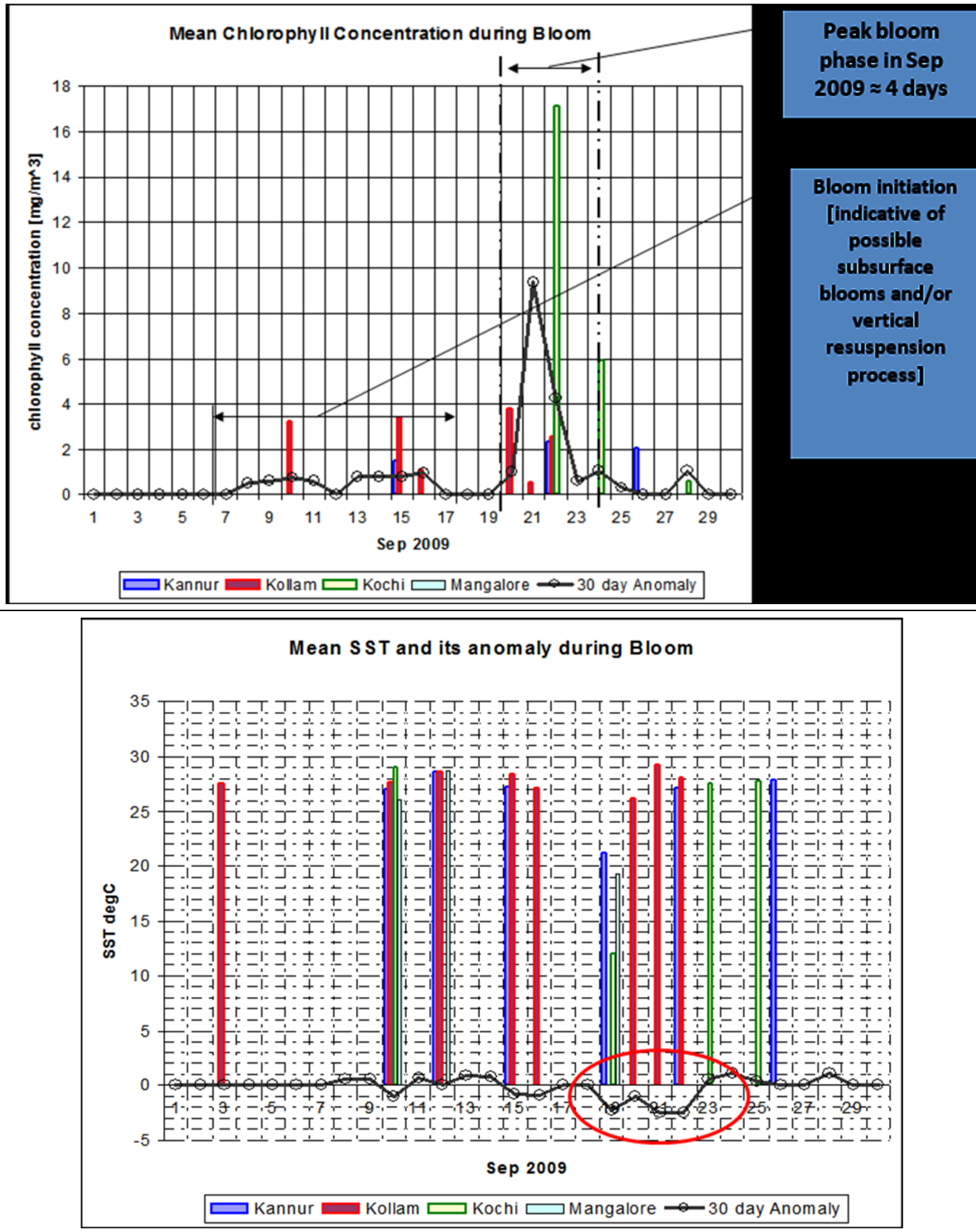

Figure 2 Detection capability of the proposed framework; top row corresponds to anomaly in chlorophyll; bottom row corresponds to anomaly in SST.

<u>Performance of discrimination capability:</u>

With the help of optical modeling (WASI, Peter Gege 2000), detection thresholds were established and also the discrimination capability between blooms of diatoms and dinoflagellates were established as shown in Figure 3.

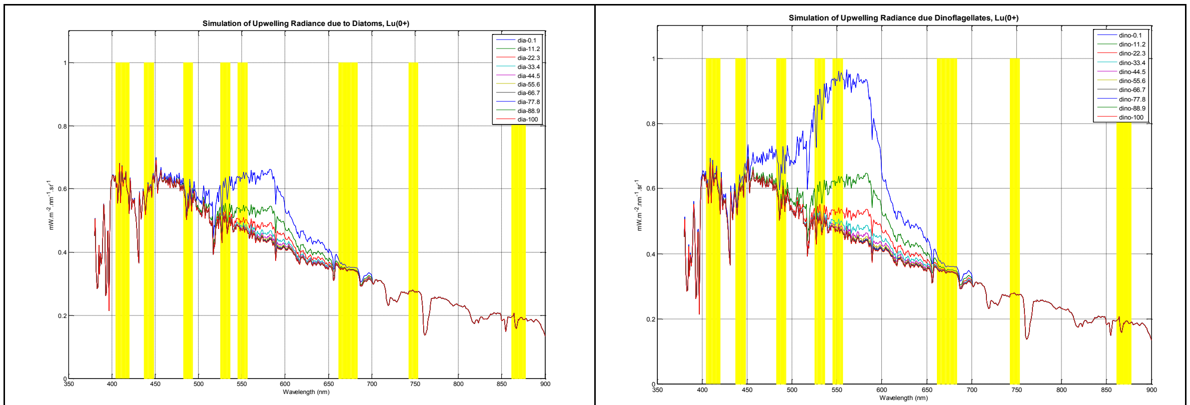

Figure 3 Optical discrimination of blooms of diatoms and dinoflagellates

References

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