# Harmful Algal Blooms Observation and Prediction System for the West Florida Shelf

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## Introduction

Harmful algal blooms (HAB, red tides) begin the same way each summer on the West Florida Shelf (WFS). The evolution of these episodes, while depending on biological interactions, is also dependent on ocean circulation. The continental shelves and adjacent oceans of the Florida peninsula play a key role in the frequent occurrence of HABs in the eastern Gulf of Mexico (GOM) with downstream implications for the eastern United States seaboard (Walsh et al., 2008). The Center for Prediction of Red Tides (CPR) at the University of South Florida, College of Marine Science (USF-CMS), a joint venture between the USF-CMS and the Florida Wildlife Commission Fish and Wildlife Research Institute (FWC FWRI), has coordinated a program for coastal ocean observing and modeling efforts focused on the development of a regional coupled physical-biogeochemical model capable of predicting HABs. Here we provide a description of the framework for prediction of the icthyotoxic dinoflagellate, Karenia brevis. Description of the model is presented with application to the 2006 and 2007 red tides.

**Hypothesis (Figure 1):**

a. Iron-laden Saharan dust fertilizes; (Fig.1a)

b. Stocks of $N_2$ fixing Trichodesmium which;(Fig. 1b)

c. Transfer nutrients to HAB blooms of Karenia brevis; (Fig. 1c)

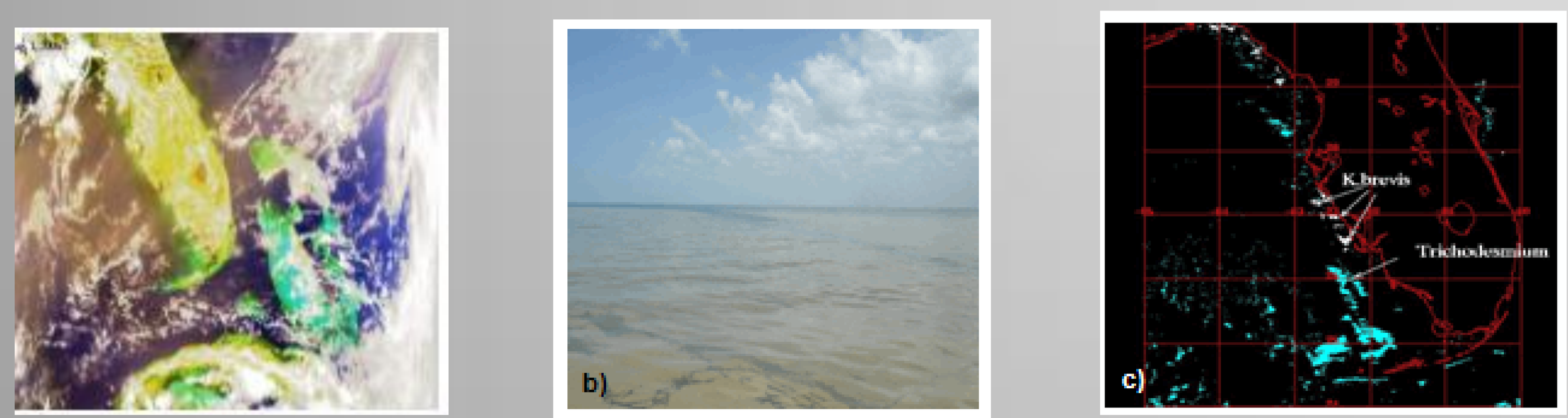


Figure 1. a) Saharan dust on 1 August 2006 in relation to b) in situ and c) satellite observations of Trichodesmium and K. brevis over the same region on 8-9 August 2006.

## Integrated physical, biogeochemical model:

The circulation model (Weisberg et al., 2008) is a regional application of the ROMS (Song and Haidvogel, 1994), nested in the HYCOM (Chassignet et al., 2003). The biological model assumes various exponential growth rates of the phytoplankton community, reflecting variable nutrient limitation of diatoms, flagellates, *Trichodesmium*, and *K. brevis* constrained by daily satellite estimates of surface biomass of light-adapted *K. brevis* (Walsh et al., 2002; Fig.2a). Surface velocity and temperate (°C) on 12/8/04 for the WFS ROMS model nested in the North Atlantic HYCOM. The WFS regional model is inside of the dashed line; the HYCOM is outside. Nesting provides for smooth transition between model as seen in the behavior of the Loop Current and its eddies. The coastal ocean is linked to the estuaries using the Finite Volume Coastal Ocean Model (FVCOM) (Chen et al., 2003). The biogeochemical model (HABSIM) incorporates 27 state variables over four submodels to evaluate the role of each potential nutrient source for support of red tide blooms on the WFS. HABSIM is imbedded inside ROMS (Fig.2b).

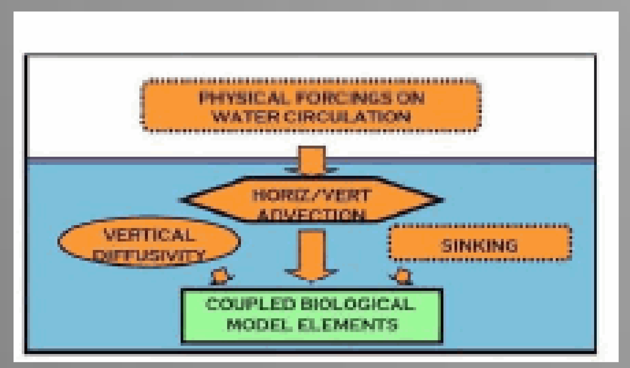


Figure. 2a

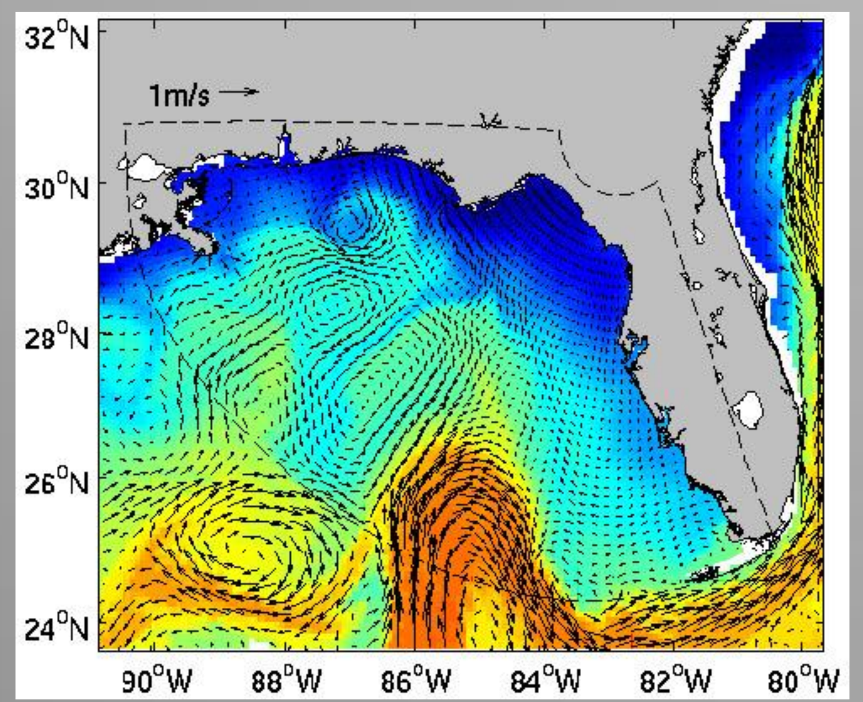


Figure. 2b

## Example of model outputs:

Following the demise of the 2005 red tide using the observed trajectory of satellite-tracked surface drifters (Fig. 3) and the decantation of the 2007 red tides using the simulated surface drifters released during September-October 2007 (Fig. 4) showed offshore advection to the Loop Current, and thence to US east coast points farther north via the Gulf Stream (Figs. 4a, b, Fig. 5b, Fig. 6b). These model drifters represented trajectories of the entrained red tides during 2007. In contrast, the near shore 2006 red tides remained mostly on the WFS (Figs. 4c, d), with only a few water parcels, and thus minimal red tides (Fig. 5a, Fig. 6a), transported eastwards to the Miami environs. In Fig. 7, satellite imagery showed Trichodesmium and K. brevis populations on 23 October 2007 and the simulated surface red tide locations after export.

Red tide went to east coast in 2007; it stayed on the west coast in 2006

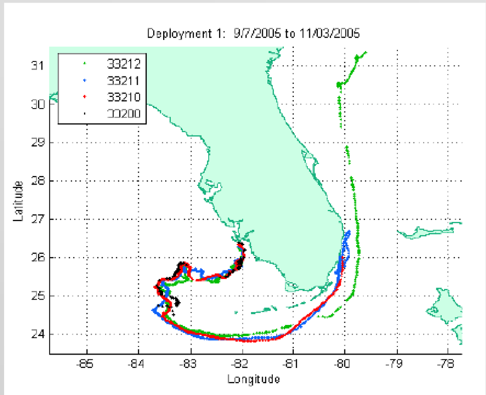

Figure. 3

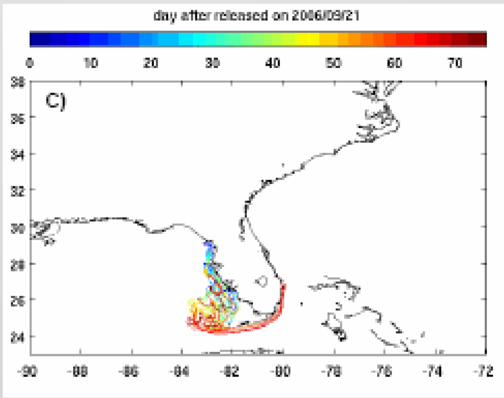


Figure. 4c

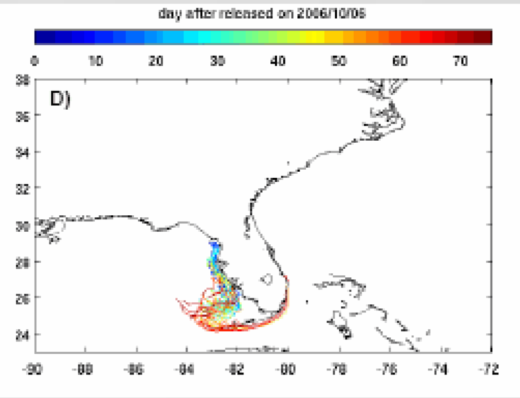


Figure. 4d

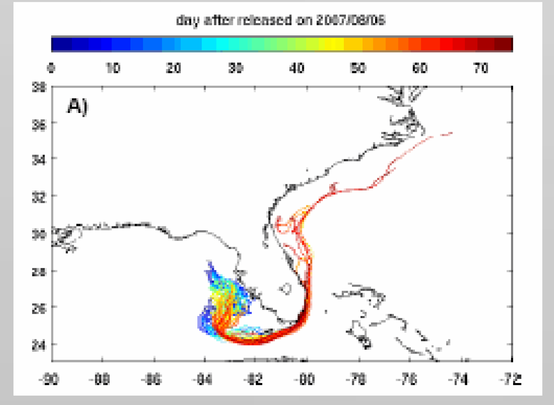


Figure. 4a

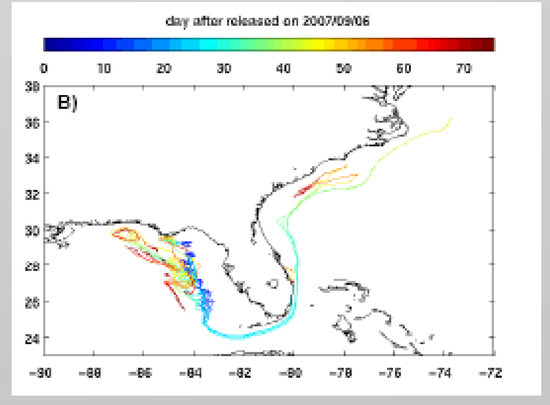


Figure. 4b

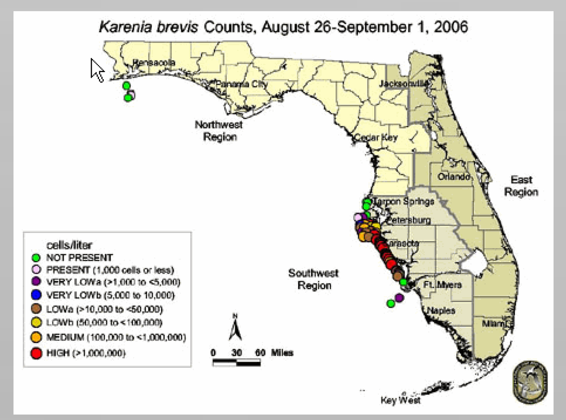


Figure. 5a

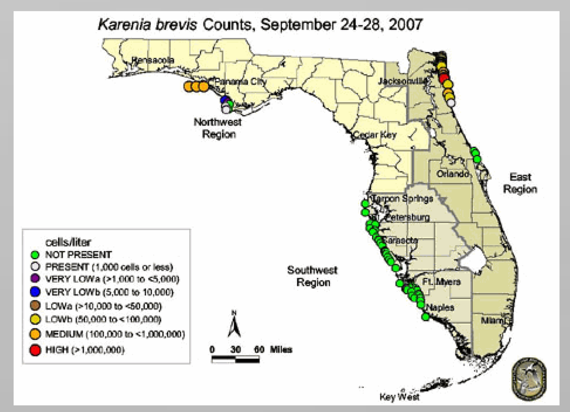


Figure. 5b

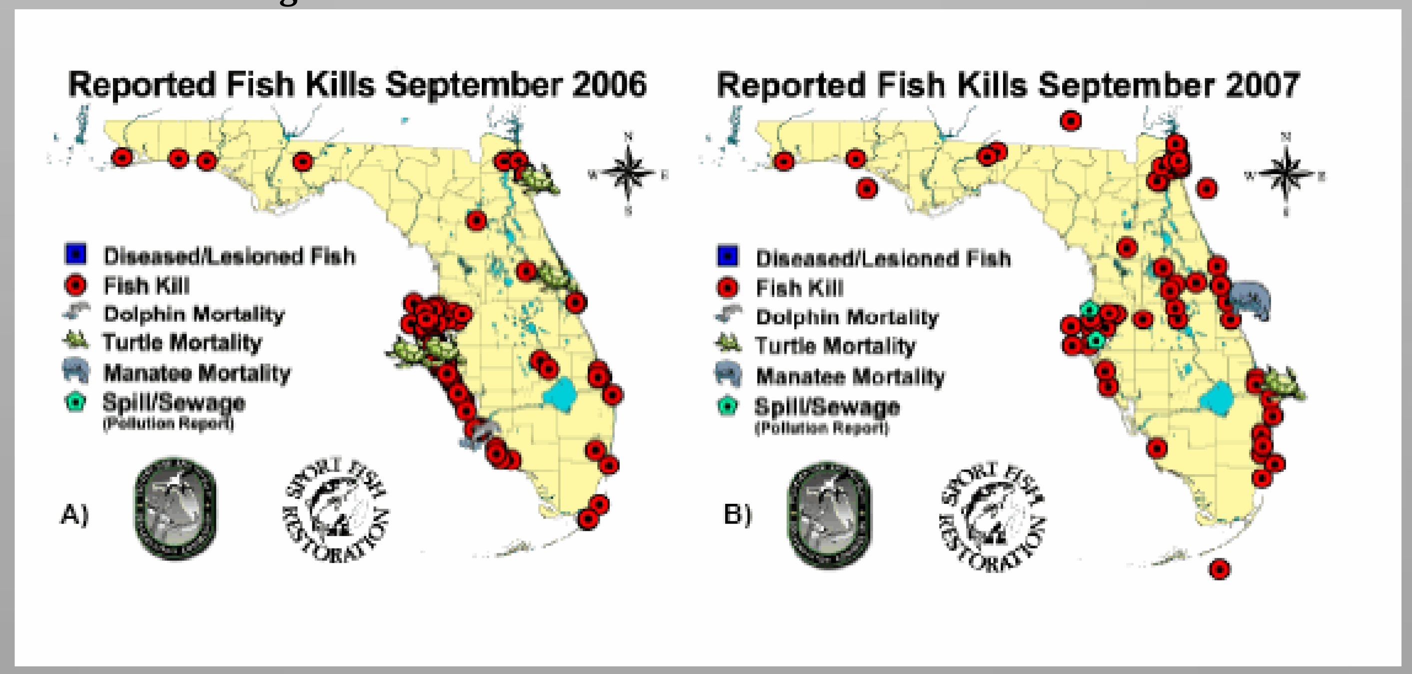


Figure. 6

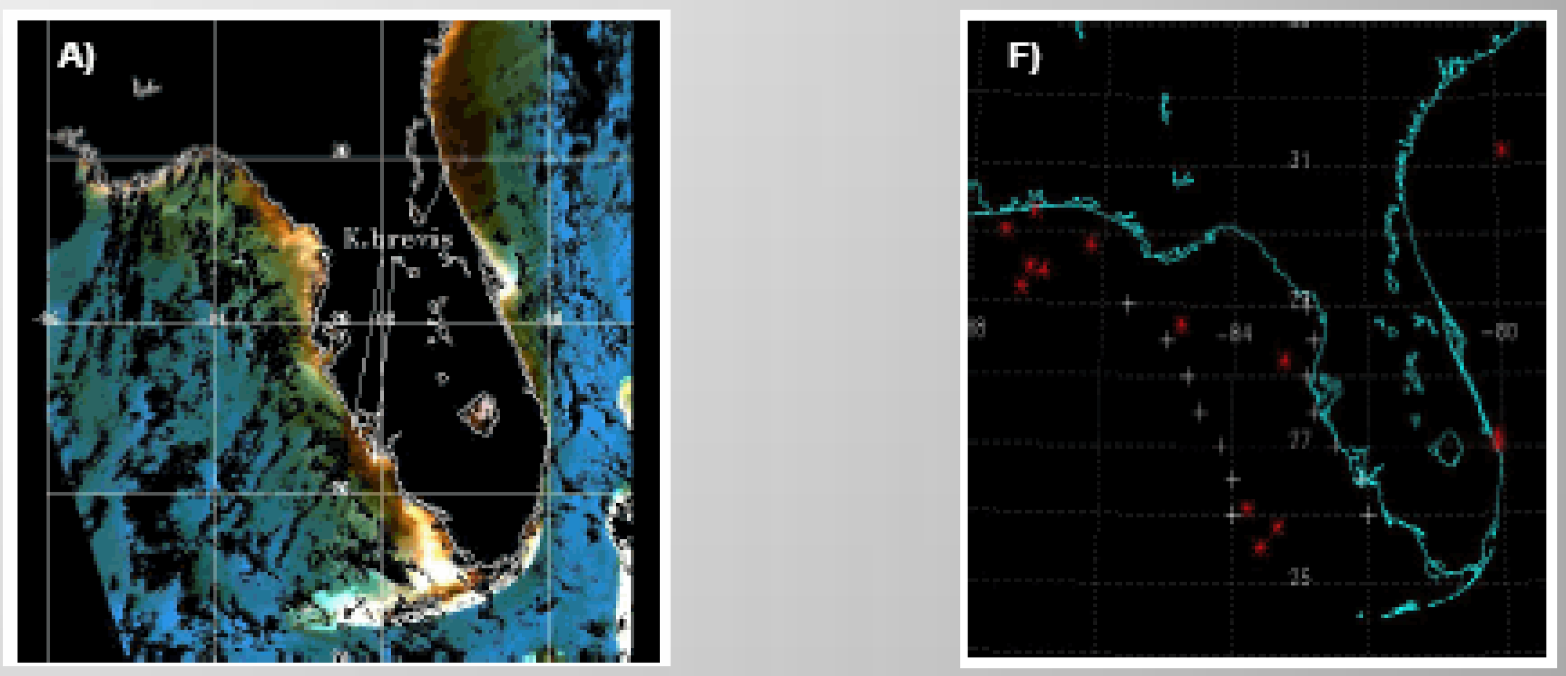


Figure 7. Satellite imagery on 23 Oct. 2007 of a) optical signatures of Tricodesmium (pale blue color) and Karenia (reddish-black color), b) the simulated surface red tides on that day, when the red symbols denote stocks of 34 ug chl per liter. The white crosses indicate launch sites if the surface drifters and entrained initial red tides on 6 Sep. 2007.

## Works in progress:

The model is designed to explain phytoplankton competition relative to deep-sea, estuarine, ground water, decomposing diazotrophs, benthic remineralization, zooplankton excretion, and rotting fish sources of nutrient. Clearly, the model needs to be complete enough to include all the above relevant processes. Therefore, further combination with observations and data assimilation can maximize the ability to optimize the prediction the red tides. Currently, we are working on embedding the model with The Data Assimilation Research Testbed (DART) (Anderson, 2001), developed by the National Center for Atmospheric Research (NCAR) to create an EAKF-enabled ROMS for assimilating HAB data. DART allows comparison of several assimilation algorithms, and requires multiple instances of model runs to generate an ensemble of states. DART applies a forward operator appropriate for each type of observation to each of the (prior) states to generate the expected observations. Comparing these estimates to the observations ultimately results in increments, which are then used to create new (posterior) model states. Finally, these new model states are run in multiple instances until the next set of observations are available. For a more extensive overview of how DART works, see http://www.image.ucar.edu/DAReS/DART.

## Acknowledgement

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