Observing System Requirements for the Harmful Algal Bloom Forecast System in the Gulf of Mexico

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Background

The Harmful Algal Bloom (HAB) Forecast System provides nowcasts and forecasts of *Karenia* HABs location and impact in the Gulf of Mexico. Currently analysis is performed separately for the eastern Gulf of Mexico and the western Gulf of Mexico. A bulletin is produced for managers in order to provide information that will aid in guiding sampling, monitoring, and response strategies. Forecasts of HAB impact are provided to the public. The bulletin for managers, sent by email, includes an analysis of field measurements, satellite imagery, and models. The Forecast System, while emphasizing *Karenia* "red tide", also will respond to other potential HAB events. The system became operational for the eastern Gulf of Mexico in September 2004. It started as a demonstration in September 1999 with provision of SeaWiFS satellite imagery interpreted against state-reported cell counts. Improvements were made, particularly in adding observations and models. A demonstration, pre-operational system began for Texas in September 2006. Analysts are on-call on all business days and monitor an email address (hab@noaa.gov).

The forecast information can be obtained from http://www.csc.noaa.gov/crs/habf/ . A technical report on the first operational year can be found at http://tidesandcurrents.noaa.gov/pub.html (Technical Report NOS CO-OPS 047).

Many of the data sets that are incorporated into the forecast system (as well as other data of interest to the Gulf of Mexico community) are available for other analysis through a Web-based GIS system called HABSOS http://www.ncddc.noaa.gov/habsos/Mapping/ .

Skill assessment and validation are a component of the Forecast System, as are bi-weekly "post-mortem" reviews of the forecasts. These, combined with user meetings, have identified requirements that would improve the forecasts. The description below identifies information used for the forecasts, and the observations that will mostly likely improve the forecasts. These requirements do not address other needs for HAB observations, such as understanding marine mammal mortalities or HAB initiation.

Requirements

The current system involves a combination of data and models, many of which are considered part of IOOS. These include satellite imagery processed to target blooms most likely to be Karenia HABs, meteorological observations—especially wind, cell counts, and transport models (for forecasts). As the blooms form subsurface, demonstration projects are under way to incorporate autonomous underwater vehicles (AUVs) to find the blooms offshore before reaching land. To capture patchiness of the

HABs, Brevebuster sensors have been deployed at two piers, and lifeguard observations of respiratory impacts are examined.

In order to forecast and nowcast HABs, the most critical lack of information is the location of the HABs. The current combination of satellite and cell counts can identify general areas of HABs, but cannot provide details at the coast at resolutions better than 10-30 km. This points to the need for anthropic-based sampling, gliders, and aircraft.

Mobile Systems *Highest Priority*

The lack of information on blooms and their inherent patchiness mandates a need for more data at high resolutions. Mobile in-water sampling would best address this.

Water Samples

The most significant problem for HAB forecasts is identifying the location of actual blooms. The data from satellite is insufficient for this purpose, particularly at the coast.

Current: State and research sampling programs. Florida semi-routine, Texas routine during an event. Alabama, Mississippi, Louisiana collection over shellfisheries (?) during potential events.

Need: More sampling. Need a replacement for microscopy for positive identification of "NONE" "MEDIUM" "HIGH" concentrations.
Both chlorophyll and HAB concentration are needed routinely

Anthropic-based systems

There is insufficient resolution to determine presence and impacts at the coast. The lifeguard network provides important respiratory information; it does not, however, identify the presence of a HAB in the absence of respiratory irritation (e.g. offshore winds). A detection approach that can draw on volunteers will provide additional HAB locations.

Current: Near-real time daily detection of respiratory irritation in two Florida counties (lifeguard network)

Need: Network with reports every few km along coasts with respiratory impact.
"Dipstick" detector for presence of high concentrations of HAB (see "Water samples" above)

Gliders

Karenia HABs appear to start offshore in subsurface waters. Most water sampling and all satellite imagery shows near surface blooms. The gliders offer both confirmation of the extent of surface blooms and identification of subsurface blooms.

Current: Three gliders based in eastern Gulf of Mexico. NOAA configured with brevebuster, oxygen, CTD, current estimates

Need: Multiple gliders with brevebuster, oxygen, backscatter, CTD, current estimate, chlorophyll. Six to ten gliders for deployment from summer to winter.

Research ships and ships of opportunity
Shipboard data will provide additional identification of offshore blooms, and provide monitoring of low concentrations.

Current: Cell counts sometimes made and reported in near-real time.

Need: Near-real-time availability of data. Data types of interest include Brevebuster, cell counts or "concentration", salinity, temperature, chlorophyll, backscatter, and profile data.

Fixed Systems

Fixed HAB Sampling
Continuous observations at coastal points will aid in identifying patchiness and significantly improve transport prediction. The Brevebuster provides indication of HAB presence, but may provide false negative in mixed blooms.

Current: Breve detectors (brevebuster, optical system) on some moorings
Brevebuster (NOAA NWLON, CMAN in Florida; stand alone, COMPS)
Optical detector (one research instrument in Texas)
Required: More coastal instruments for continuous detection, about every 20-30 km in areas normally impacted by HABs.

Fixed Physical Oceanographic Sampling
Currents without tides are needed to tune and evaluate model selection for transport forecasts, and to provide nowcasts. Temperature and salinity at surface and bottom at key locations will assure improved model accuracy.

Current: Currents, temperature, salinity
Required: Near-surface and near-bottom currents with tides removed at all locations.
Temperature and salinity as needed for model assimilation.
Current fields in areas of complex currents,
e.g. CODAR or extensive model validation around capes and estuaries.

Fixed: Meteorological
Wind data provides an excellent example of integration. NDBC provides transparency in access and format to the different data systems. Winds are necessary for identification of HABs and HAB conditions, and are used for predicting alongshore transport in Florida,

and intensification. Other met observations are relevant only in that they lead to better circulation forecasts from models.

Current: Standard met data at moored/fixed met stations available through NDBC (NDBC, TABS, COMPS)
Need: No additional need for winds
Additions to standard met data as needed for improved circulation models

Remote sensing Systems

Satellite:
Satellite remote sensing is used to identify water features that may be Karenia HABs and also to identify circulation patterns that may be relevant to understanding circulation (plumes, etc.) Satellite remote sensing data has good coverage, and imagery is readily available for use in HABs. Ocean color and temperature are available. CoastWatch is a key provider. NRL and USF are providers of near-real time experimental products. Concern exists for future, if VIIRS data proves to be insufficient.

Current: SeaWiFS (near-real time is available)
MODIS

Need: Continuity into the future
MERIS is planned by CoastWatch in 2008
Cross-satellite calibration

Aircraft:
The critical need is for higher spatial resolution while maintaining frequency, which points to aircraft. Consideration should be given to developing a low-cost aircraft capability for transects (or imagery). Improved spectral analysis would be possible only with aircraft, as the necessary number of spectral bands will not be available from satellite at a useful frequency.

Current: None

Need: Low-cost aircraft systems

Models
The most critical biological modeling component is for dissipation of the HABs. The user community and the public need to know when a "red tide" HAB will disappear. Currently there is no model that can be used to make any assessment of the duration of the HABs.

Initiation is of some concern, but considerable progress has been made for SW Florida. The start of HABs along the Texas coast and the Florida panhandle is not understood. As these are infrequent, they are more critical to address.

Circulation models

Current: Several models, operational include TGLO (both ROMS and POM), NGOM, NRL, USF-WFS, ROMS onshore-offshore.

Need: Ease of access to modeled currents for ensemble forecasts with guidance from the observed currents. Research models would be used as part of ensembles.

Biological models

Current: Heuristic model of appearance and intensification of *Karenia* HABs at the Florida coast. Uses vertical 2-D transport model and identification of fronts.

Need: Model for dissipation of HABs.
Model for initiation of HABs off Texas and Florida Panhandle
Improved initiation for Florida