HAB Bulletin Guide – An Overview

Blooms of toxic dinoflagellate *Karenia brevis* are commonly known as red tides or harmful algal blooms. These blooms are responsible for serious public health problems and shellfish harvesting closures in the Gulf of Mexico every year. The National Oceanic and Atmospheric Administration (NOAA) provides the Harmful Algal Bloom (HAB) Bulletin to help coastal resource managers decide where to focus their sampling efforts and prepare for these blooms.

The HAB Bulletin uses satellite imagery, field observations, autonomous underwater vehicles (AUV), and buoy data to provide information on the location, extent, and potential for development or movement of *Karenia brevis* blooms in the Gulf of Mexico. The information is sent twice a week via e-mail to registered users with natural resource management responsibilities. One week after the bulletin has been issued, it is posted to the CoastWatch Harmful Algal Bloom Bulletin Web site for public access.

Each bulletin includes satellite image interpretation, analysis of past and forecasted wind data from NOAA's National Weather Service and National Data Buoy Center, *Karenia brevis* cell concentration data from the state of Florida, water optical properties from Mote Marine Lab and observations of respiratory irritation reported by lifeguards.

The bulletin's developers welcome your feedback to improve the bulletin and the HAB forecasting system. Send your comments via e-mail to *hab@noaa.gov*.

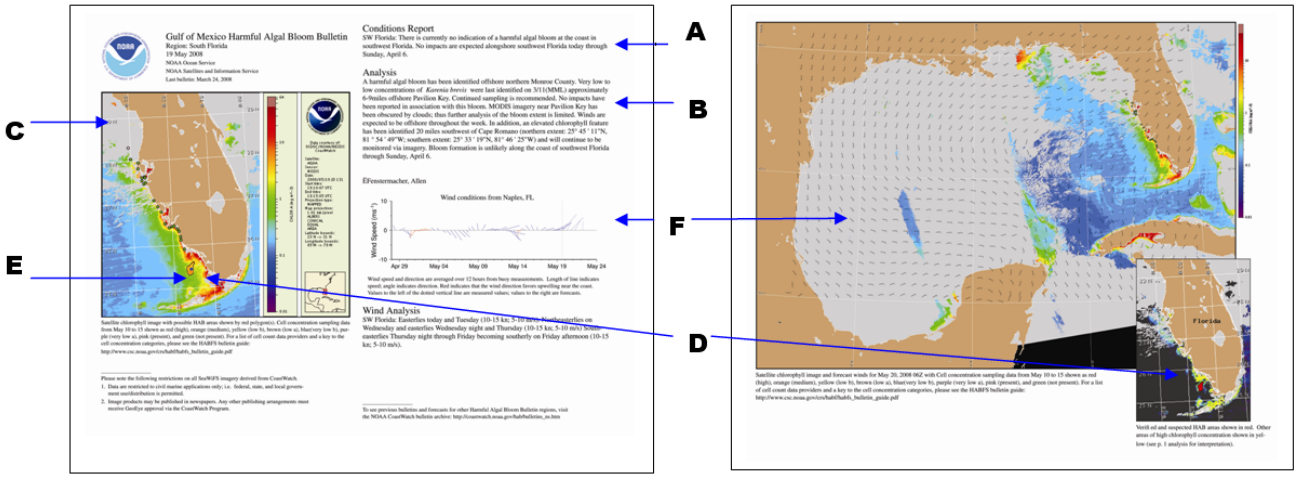
Understanding and Interpreting the Bulletin

The different sections of the bulletin are labeled and explained in the text below.

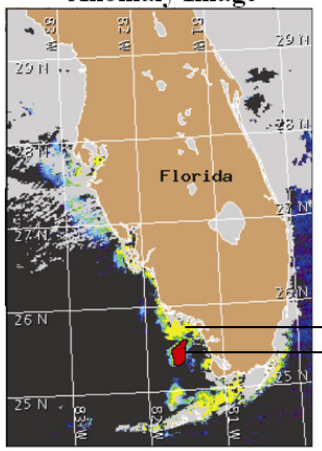
(A) *Conditions report*
The conditions report contains general information on bloom location and expected coastal impacts based on bloom concentration and prevailing winds (Kirkpatrick and others, 2004). This information was developed with state and local agencies, tourist boards, and citizen groups to provide accurate information to a non-technical audience. The report is released to the public on the *HAB Forecasting System Web site,* along with additional information about cell concentration categories and potential impacts, and a "frequently asked questions" section.

(B) *Analysis*
The analysis includes a synthesis of the supporting data such as chlorophyll concentrations, including anomalous chlorophyll concentrations, optical data from BreveBusters, respiratory irritation observations, and wind speed and direction, to help managers decide where to take their next samples and how to prepare for these blooms. The analysis also identifies existing HABs and their predicted location, as well as any reported impacts on humans, marine mammals, and fish.

(C) *Ocean color imagery*
Daily ocean color imagery from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the Moderate Resolution Imaging Spectroradiometer (MODIS) is processed to chlorophyll by NOAA CoastWatch. This chlorophyll imagery is provided in the HAB Bulletin. A detailed image of the region of interest is shown on the front, and an image of the entire Gulf of Mexico is shown on the back of the bulletin. Chlorophyll concentration units are reported in milligrams per

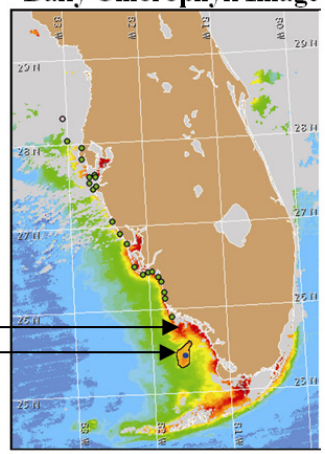


Anomaly Image



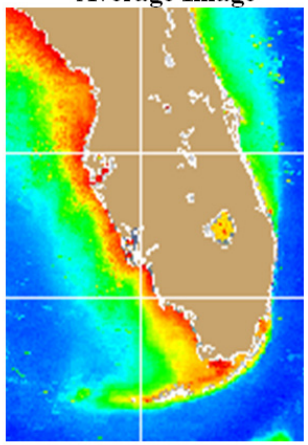
Example of a chlorophyll anomaly image (back page of bulletin). The red colored areas represent regions that have experienced a rapid increase in chlorophyll and have been confirmed as containing *K. brevis.*

Daily Chlorophyll Image



Example of a daily chlorophyll image with marked sampling sites (front side of bulletin). The red polygons are chlorophygll anomaly areas that have ben verified as containing *K. brevis* blooms.

Average Image



This image is the average chlorophyll concentration for 60 days prior to the image on the left. This image is not provided on the bulletin but is used to calculate the daily chlorophyll anomaly.

The top arrow indicates a region of high chlorophyll associated with a non-harmful bloom (colored yellow in the anomaly image).

The bottom arrow indicates an anomaly area (left image) that has been verified as a *K. brevis* bloom (middle image), shown as a red polygon.

Cloudy areas are shown in gray. Cell count data may fall outside of an anomaly polygon in areas of cloud coverage.

cubic meter (mg/m^3). The legend shows the chlorophyll concentration that corresponds to the coloration on the satellite image (ranging between 0.01 and 50 mg/m^3). Red and orange areas on the satellite image indicate high chlorophyll concentrations, and blue and purple areas indicate very low chlorophyll concentrations.

While *Karenia* blooms can cause high concentrations of chlorophyll, many non-harmful algae routinely produce high concentrations, so chlorophyll is not a reliable indicator of the presence of a red tide. For that reason, polygons of confirmed or probable *Karenia* blooms are overlain on the chlorophyll image. These are derived from the anomaly images (see next section) and are selected by the analysts. The polygon outlines the area most likely to contain the *K. brevis* bloom; however, the extent of a harmful bloom can go beyond the polygon, and in some cases, part of the enclosed area may include a bloom of a harmless species.

(D) *Chlorophyll anomaly*

The chlorophyll anomalies show areas where the daily chlorophyll concentration is significantly higher than the average for a particular region. Imagery from the previous 60 days is used to calculate a running mean for comparison to the current daily image (Stumpf and others, 2003). A *Karenia brevis* bloom grows fairly rapidly during the fall and often occurs solely, without the presence of other algae species (monospecific); an anomaly of 1 mg/m^3 can indicate a *K. brevis* bloom.

Anomalies can also indicate blooms of non-harmful species. The anomaly image represents areas that have undergone a fairly rapid change in chlorophyll, usually due to high growth, aggregation, or resuspension. The anomaly for the day is included as an inset on the back page and is colored black if there is no change, green if there is no significant change, yellow if significant change is detected, and red for a verified bloom. Clouds and pixels with missing data (such as areas outside the satellite swath) appear gray. If monitoring programs (such as the Mote Marine Lab, Florida Fish and Wildlife Research Institute, or others) verify an anomaly area as containing *Karenia* species, then the area is “flagged” as a red tide and will appear as a polygon on the front page chlorophyll image. An area is not identified as a red tide unless field samples taken by the state confirm that harmful algae are present.

(E) *Position and concentration of the present bloom*

Cell concentration field data are provided by the Florida Fish and Wildife Conservation Commission Fish and Wildlife Research Institute, Mote Marine Laboratory, the Alabama Department of Public Health, the Texas Parks and Wildlife Department, and the Texas Department of Health. Cell concentration are provided as they become available and are plotted on the chlorophyll image on the front page of the bulletin. Cell concentration sampling data are provided as they become available. There is often a several-day delay between the date of sampling and the date the information becomes available because of the need to verify algal species using microscopy. Cell concentrations are classified according to the Florida Fish and WIldlife Research Institute scheme as shown in table 1 (below).

Table 1
Cell Concentrations and Associated Cell Count Values (in cells per liter)

	Not Present	
Present	1,000 cells or less	
Very low a	>1,000 to < 5,000	
Very low b	5,000 to 10,000	
Low a	>10,000 to <50,000	
Low b	50,000 to <100,000	
Medium	100,000 to <1,000,000	
High	≥ 1,000,000	

(F) *Wind data*

Measured and forecasted wind speed and direction for the area of interest are used to estimate movement of blooms. A windplot diagram shows wind speed (reported in meters per second) and direction averaged over 12 hours from measurements made at station buoys. These measurements are reported to the NOAA National Data Buoy

Center (NDBC). Measured values for the past three weeks are shown to the left of the dotted vertical line, which represents the present time, and forecasted values for the next five days are to the right of the dotted vertical line. The length of the vector represents wind speed, and the angle indicates the direction. For each vector, the tail is the end that starts at the "0" reference line; the arrow at the head of the vector indicates the direction the wind is blowing. Red indicates that the wind direction favors upwelling near the coast, which can be an indicator of bloom initiation.

A 24-hour forecast of wind direction and speed as predicted by the National Weather Service's Environmental Modeling Center is plotted over the image of the Gulf of Mexico on the last page of the bulletin. The forecast is from the North American Mesoscale (NAM) computer model. In this diagram, wind speed and direction are depicted as barbs, which point in the direction the wind originates from (see figure to the right). The barb pennant symbol represents the wind speed.

Supplementary Information

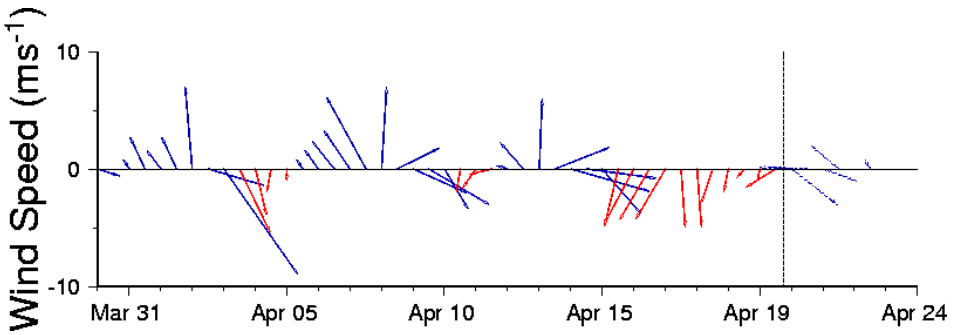
Additional data are used in the development of HAB nowcasts and forecasts but are not presented graphically in the bulletins. Optical sensors (called BreveBusters) deployed on autonomous underwater vehicles (AUV) and moored on piers are used to help detect and track the movement of subsurface *K. brevis* blooms. The BreveBuster identifies *K. brevis* blooms by their absorbance signal and provides a Similarity Index (SI) value, which represents the fraction of *K. brevis* biomass in the phytoplankton community.

At various beaches within the state of Florida, lifeguards observe respiratory irritation and the amount of dead fish twice daily and report the information with personal data assistants (PDAs). This information is used to assess potential public health impacts. Both the BreveBuster and lifeguard data sets are available to the NOAA HAB analysts for the development of bulletins and the public Conditions Report.

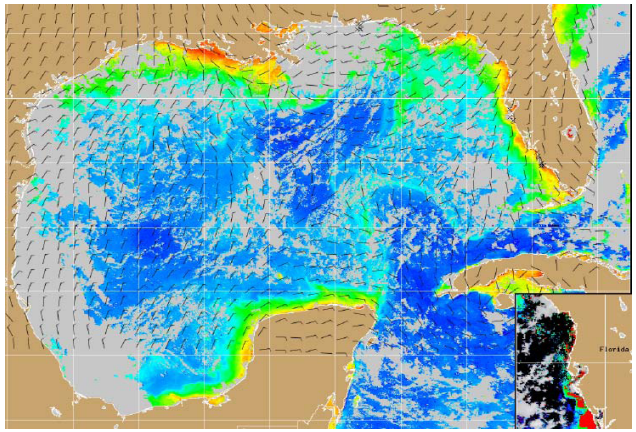
Citations

Kirkpatrick, B., L.E. Fleming, D. Squicciarini, L.C. Backer, R. Clark, W. Abraham, J. Benson, Y.S. Cheng, D. Johnson, R. Pierce, J. Zaias, G.D. Bossart, and D.G. Baden. 2004. "Literature Review of Florida Red Tide: Implications for Human Health Effects." *Harmful Algae*. Volume 3. Pages 99 to 115.

Stumpf, R.P., M.E. Culver, P.A. Tester, M. Tomlinson, G.J. Kirkpatrick, B.A. Pederson, E. Truby, V. Ransibrahmanukul, and M. Soracco. 2003. "Monitoring Karenia brevis Blooms in the Gulf of Mexico Using Satellite Ocean Color Imagery and Other Data." *Harmful Algae*. Volume 2. Pages 147 to 160.

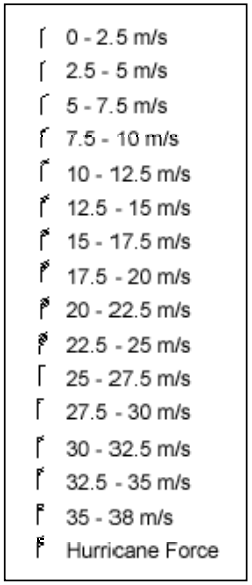


Example Windplot Diagram. Upwelling-favorable winds are marked in red.



Example Forecasted Wind Speed and Direction for the Gulf of Mexico

This barb indicates 5 to 7.5 meters per second (or 11.2 to 16.8 miles/hr) winds from the northeast



Barb Pennant Symbol and Corresponding Wind Speed