HAB applications: short term

Management:

Monitoring and Response

Closing shellfisheries. Do not recall shellfish

Protecting fisheries (pulling mussels, clay-treatment in Korea)

Health advisories (respiratory for Karenia, swimming for cyanobacteria)

Public water supplies in freshwater
HAB applications: long term

Management:

Seasonal planning

Nutrient reduction strategies

Climate change risks

Understanding bloom ecology and dynamics
Need to get it right for manager, Tourism crisis

Baltic, 2005, cyanobacteria, commonly estimated from satellite.

This bloom missed west Öland beaches, Tourism crisis, source E. Graneli
Korea, protecting fish and mussel farms by clay dispersal

Serc.si.edu
Florida, improved detection. HAB initiation and intensification with upwelling

New bloom after upwelling more likely to be HAB)
NOAA work to date:
Lake Erie weekly Bulletin (forecast, now in 4th year)

**Conditions:** A massive *Microcystis* bloom persists throughout most of Lake Erie's Western Basin.

**Analysis:** As indicated in satellite imagery from Saturday (9/3/2011), an enormous *Microcystis* bloom was present in western Lake Erie. The southern extent of the bloom was remotely observed along the coast of Ohio from Maumee Bay to Catawba Island. The northern extent of the bloom was observed to be consistent along the Michigan coast from Northern Maumee Bay to the mouth of the Detroit River. The eastern-most portion of the bloom was observed past Point Pelee and to the northeast up to Rondeau Provincial Park.

At the mouth of the Detroit River, a five day nowcast shows a southward suppression of the western-most portions of the bloom. However, the bloom is likely to still persist in much of the Western Basin. The nowcast also suggest the bloom has spread to the east of Sandusky and into the Cleveland area. (Note: Due to a lack of clear imagery the bloom has not been remotely observed in the Cleveland area.) A three day forecast also suggests that the bloom will persist to the north of Cleveland through the weekend. Water temperatures remain above 20 degrees Celsius and are forecast to decrease into the weekend; however, conditions remain favorable for bloom growth.

**Figure 1:** MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from September 03, where colored pixels denote the likelihoods. The last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown at white squares (very light), circles (high), diamonds (medium), triangles (low), + (very low) and X (not present).

**Figure 2:** Nowcast position of *Microcystis* spp. bloom for September 08 using GLASS modeled currents to move the bloom from the September 05 image.
Potomac estuary 2011 *Microcystis* bloom

Improved CI  Loss of MERIS

[Images of maps showing Microcystis bloom over time from July 17 to August 23, 2011.]

Support State and local govt to reduce monitoring. Transferred algorithm from Lake Erie to Potomac estuary.

Jul 27, 2011
Courtesy of Dr. Chris Jones
George Mason Univ.
Bluegreen algae prognosis 2006

Risk of bluegreen algae blooms:
- low
- moderate
- considerable
- high

FIMR
SYKE

Bluegreen algae situation in July 2006

MODIS
1-31 July 2006
Average

mg/mL

Fleming-Lehtinen et al.
Chesapeake Bay Bloom Detection

Blooms, Cyanos in freshwater

Relative Sediment

19Nov2011
Monitoring for blooms, 2011 Cl Time Series subset
Satellite Detection of Increased Cyanobacteria Blooms in the Baltic Sea: Natural Fluctuation or Ecosystem Change?

Using data from the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA series of satellites, an increase in the area covered by cyanobacteria blooms in the Baltic Sea was detected. The time series of satellite data covers a period of 12 years from 1982 to 1993. The total area covered by surface-floating cyanobacteria (blue-green algae) has increased in the 1990s, reaching over 62,000 km² in 1992. From 1992, visible accumulations appeared for the first time in the Gulf of Riga and reappeared, in the western Gulf of Finland, after being absent from 1984. Conspicuous surface blooms were also present in the early 1980s, coincident with a period of sunny and calm summers. However, when the influence of variable sunshine duration is taken into account, the increase in 1991–1993 is still distinct, indicating significant changes in the Baltic environment. The causal factors for the increased cyanobacteria blooms are still not clear.
Figure 6. July–August average monthly sunshine duration and daily surface irradiance over the Baltic Sea in 1982–1993. Sunshine duration (bar plot, left scale) is the average of measurements at two stations (Ölande Södra Udde and Visby) by the Swedish Meteorological and Hydrological Institute with pyrheliometers (time > 120 W m$^{-2}$). Average daily surface irradiance (1983–1989, line plot, right scale) has been compiled from data produced by the International Satellite Cloud Climatology Program (10) and is an average for the Baltic Proper area.

Figure 7. Dynamics of the total area of cyanobacterial accumulations corrected for the monthly average (July–August) sunshine duration.
13-year gap (1985-1997) gap has AVHRR data

2 periods of OC data (1979-1984) and 1998-present with 13 year gap

After 2006, 13% increase in FCA from period 1 to period 2 (not sig). Kahru 2007
Lake Erie inter-annual variation
Analysis of bloom size. Comparison with phosphorus load (and discharge) for a forecast (Stumpf et al, in press)

Maumee River total phosphorus (m.tons)

Lake Erie Cyanobacteria Bloom Index and forecast for 2012
Combining satellite data sets help. K. mikimotoi starts at pycnocline, appears at the coast in upwelled cold water (Raine et al., 2001)
Korea HAB linkage to 25-26 °C line

Suh et al., 2004
Comparing data to impacts (e.g., low oxygen with HABs)

Kahru et al., 2004
### Some HABs detected or monitored with remote sensing

<table>
<thead>
<tr>
<th>HAB Species</th>
<th>Region</th>
<th>Sensing Type</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pseudo-nitzschia</em></td>
<td>Upwelling regions</td>
<td>SST, chlorophyll</td>
<td>ASP, variable</td>
</tr>
<tr>
<td><em>Karenia brevis</em></td>
<td>Gulf of Mexico</td>
<td>Test models with user input</td>
<td>NSP, respiratory, fish toxin</td>
</tr>
<tr>
<td><em>Karenia mikimotoi</em></td>
<td>Coastal ocean (Hong Kong, Ireland, New Zealand)</td>
<td>SST chlorophyll</td>
<td>NSP</td>
</tr>
<tr>
<td><em>Gymnodinium catenatum</em></td>
<td>Estuaries, coastal ocean, upwelling</td>
<td>SST chlorophyll</td>
<td>PSP</td>
</tr>
<tr>
<td><em>Alexandrium spp.</em></td>
<td>Coastal ocean (Gulf of Maine, Gulf of Alaska)</td>
<td>SST</td>
<td>PSP</td>
</tr>
<tr>
<td><em>Gonyaulax</em></td>
<td>Upwelling regions</td>
<td>Chlorophyll, possible UV absorption</td>
<td>Fish toxin</td>
</tr>
<tr>
<td><em>Cochlodinium</em></td>
<td>Coastal ocean (British Columbia, Korea)</td>
<td>SST, chlorophyll</td>
<td>Shellfish toxin</td>
</tr>
<tr>
<td><em>Nodularia</em></td>
<td>Enclosed Brackish</td>
<td>Color</td>
<td>Hepatotoxin</td>
</tr>
</tbody>
</table>

### Other major HABs not clearly monitored with remote sensing

<table>
<thead>
<tr>
<th>HAB Species</th>
<th>Region</th>
<th>Sensing Type</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dinophysis</em></td>
<td>Ireland, Portugal, Norway</td>
<td>SST</td>
<td>Shellfish toxin</td>
</tr>
</tbody>
</table>
In the EU, improved modeling to support forecasts

**Applied Simulations and Integrated Modelling for the Understanding of Toxic and Harmful Algal Blooms**
Figure 4. 250 m MODIS data processed with optimized atmospheric correction showing SST, CHL, FLH, and red tide probability (relative index) for 19 November 2008. Note the cyclonic eddy in the Gulf of Oman, associated with higher probability of red tide at the NE edge. Kudela et al., in press.
Tough Applications

Dead marine mammals
Dead birds
Unexpected fish kills
New bloom for the region.

Foam from ocean algae bloom killing thousands of birds
www.oregonlive.com; 22-Oct-2009; photo: P.
CHILTON/Coastal Observation and Seabird Survey Team.
Akashiwo sanguinea bloom

MODIS FLH
01-Nov-2009

NOAA
CoastWatch
Response strategy

• What is the bloom?
• Where?
• Has anything changed?
• Is it different than other years?
• What needs to be answered, how much, where?
Harmful Algal Blooms (HABs)

Richard P. Stumpf
NOAA, National Ocean Service

HAB occurrences worldwide

Image from whoi.edu/redtide