Use of Satellite to Identify and Quantify Cyanobacteria and “Red Tide”

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Florida's toxic algae problem and your health: 'Red tide' and 'green slime'

By Michael Nedelman, CNN

Updated 2:00 PM ET, Sat August 18, 2018
Cyanos: widespread problem
Lake Okeechobee algae bloom threatens to worsen water woes

Algal blooms reach toxic levels on the St. Johns
Be smart and respect toxic algae in lakes
Florida Water Symposium, Feb 2020

(CNN) — When Marcy Cornell's toddler son "couldn't breathe" on the first day of their recent Florida vacation, she took him straight to the emergency room.

"Before they even asked me anything else ... they said, 'Did you go to the beach today?' " she recalled.

Doctors said her son had upper airway inflammation

Karenia brevis “red tide”

The New York Times

A Red Tide on Florida’s Gulf Coast Has Been a Huge Hit to Tourism

Though an algae bloom on the coast is improving, locals and business owners say it may be too little, too late.
where are the blooms?

Historical satellite/sensor
Envisat-1 MERIS
  May 2002- Apr 2012
  3 days/week, 300-m pixel

New satellites (replacement)
Sentinel-3a/3b European Union
  Copernicus Program  2016 – into future

Nearly daily
300 m pixel (small stadium size)
Spectral Bands
Much more sensitive than our eye.

spectra from *Microcystis*

MERIS/OLCI bands

Chlorophyll, sediment, tannins, iron
Phycoerythrin
Chl-a scattering

In-situ cyanobacteria cell count

Satellite validation

\[ y = 0.98(x) - 0.12 \]
\[ R^2 = 0.95 \]
N = 349

Chl \( \sigma \) (\( \mu \text{L}^{-1} \))

Reflectance
Apply algorithm, examples from MERIS

10Jul2008

09Jul2010

St Johns River Bloom in 2010

Lake Dora

Lake Apopka Worse in 2008

True Color MERIS Image
(300mx300m)
Lake Okeechobee, 2018, areal coverage

<table>
<thead>
<tr>
<th>Date</th>
<th>Coverage</th>
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<tbody>
<tr>
<td>June 12</td>
<td>3%</td>
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<tr>
<td>June 20</td>
<td>42%</td>
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<tr>
<td>June 24</td>
<td>78%</td>
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<tr>
<td>June 28</td>
<td>90%</td>
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35 km

Cyanobacterial Density

- Absent
- $10^4$ cells/mL
- $10^5$ cells/mL
- $10^6$ cells/mL
We can examine the annual magnitude (seasonal average)

Seasonal Bloom Magnitude in Lake Okeechobee, FL
Different lakes: Bloom magnitude from satellite

Bloom magnitude

2011

Lake George (7.24)
Right Arm Lochloosa (3.5)
Thonotosassa Lake (0.49)
Apopka Lake (17.9)
Hancock Lake (4.18)
Lake Okeechobee (9.01)
West Lake (1.18)
Cuthbert Lake (0.6)

Area-normalized magnitude

2011

Hancock Lake (0.24)
Apopka Lake (0.14)
Cuthbert Lake (0.17)
Right Arm Lochloosa (0.16)
Thonotosassa Lake (0.16)
Lake George (0.04)
West Lake (0.15)
Lake Okeechobee (0.006)

Nature Scientific Reports, Mishra, Stumpf et al. 2019
Assess and rank lakes and relative trends

Median Area-normalized Magnitude (annual for 2003-2011)

Sen's Slope (Ranks yr⁻¹)

Area-normalized Magnitude Rank (annual for 2003-2011)

Kendall's τ
Karenia brevis “red tide”

UPDATE

A Red Tide on Florida’s Gulf Coast Has Been a Huge Hit to Tourism

Though an algae bloom on the coast is improving, locals and business owners say it may be too little, too late.
We use chlorophyll-a fluorescence as primary indicator of bloom.

Excludes cyanobacteria

Not specific to *Karenia brevis*.

But summer/fall blooms in Gulf are usually *Karenia*.

http://go.usa.gov/xd5nu
Karenia “red tide” bloom comparison July and Sep 2018

Karenia brevis (cells/liter)
- not present/background (0-1,000)
- very low (>1,000-10,000)
- low (>10,000-100,000)
- medium (>100,000-1,000,000)
- high (>1,000,000)

Karenia brevis
- 07/19/2018

Karenia brevis
- 09/20/2018
Karenia brevis “red tide” satellite bloom comparison July and Sep 2018

Image date: 2018-07-17

Image date: 2018-09-17

Products derived from Copernicus Sentinel-3 data
Karenia brevis “Red tide” Oct 2019

Red Band Difference (RBD) showing relative fluorescence from high (red) to low (violet). A median filter was applied to remove opalescence. Winds from NOAA.

https://go.usa.gov/xd5nu
Nearly daily updates available

http://go.usa.gov/xd5nu

Harmful Algal Bloom Monitoring System

Harmful algal blooms (HABs), sometimes known as "red tide", occur when certain kinds of algae grow very quickly, forming patches, or "blooms", in the water. These blooms can emit powerful toxins which endanger human and animal health. Reported in every coastal state, HABs have caused an estimated $1 billion in losses over the last several decades to coastal economies that rely on recreation, tourism, and seafood harvesting. Blooms can lead to odors that require more costly treatment for public water supplies. NCCOS conducts and funds research that helps communities protect the public and combat blooms in cost-