Science and Applications of Sentinel Missions: Harmful Algal Blooms

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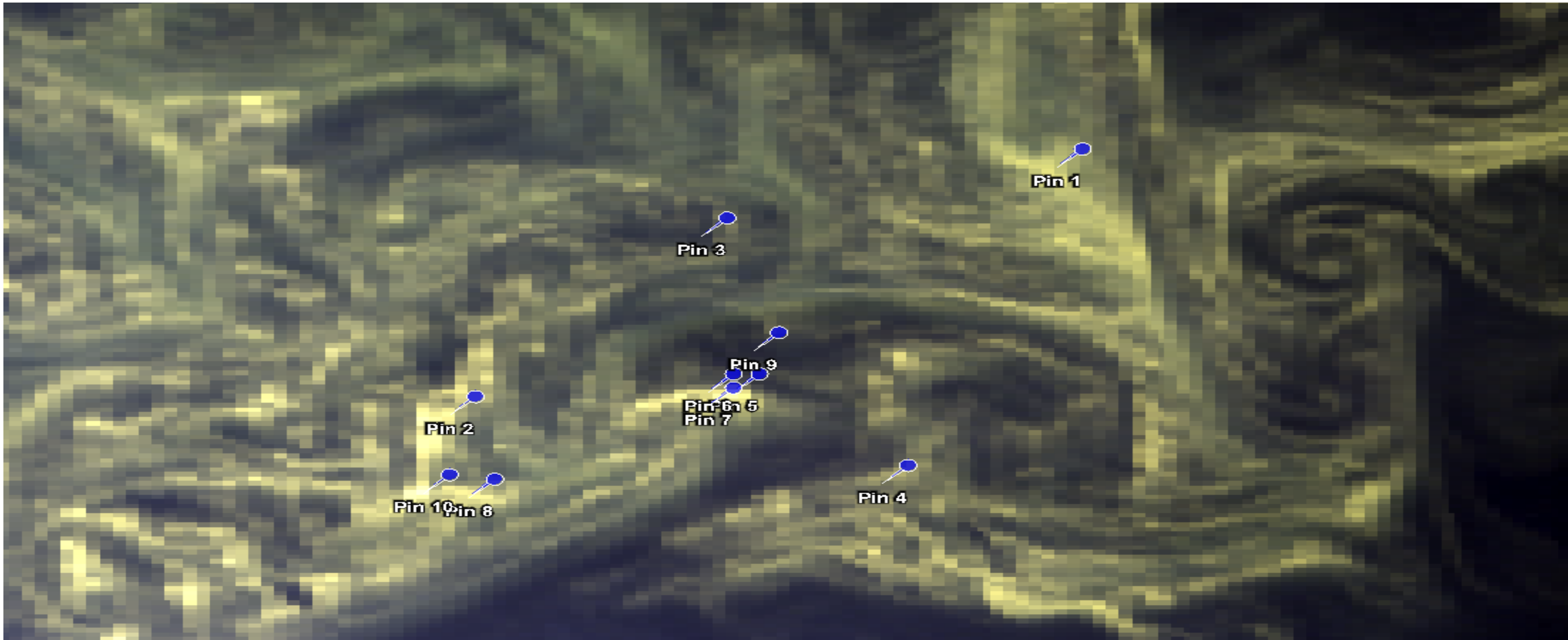
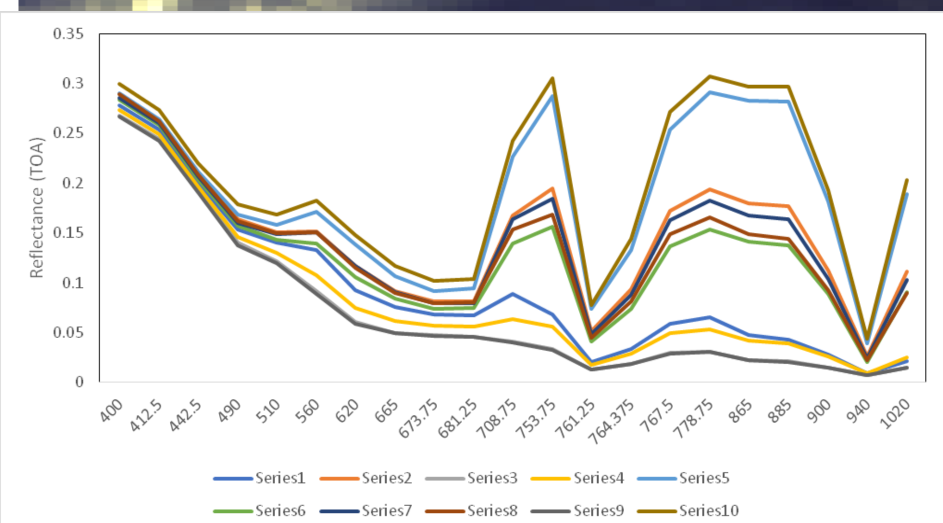
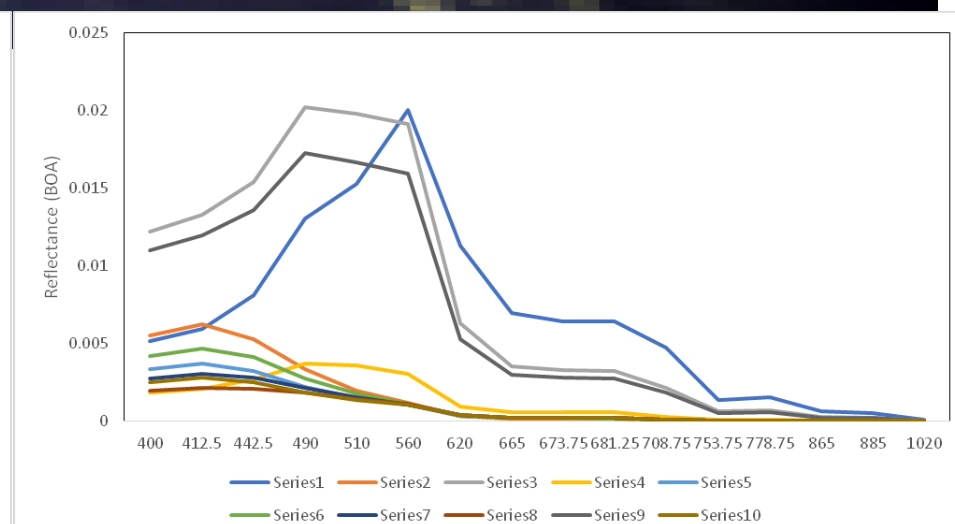
University of Southern California

POC: Kutser

OLCI atmospheric correction

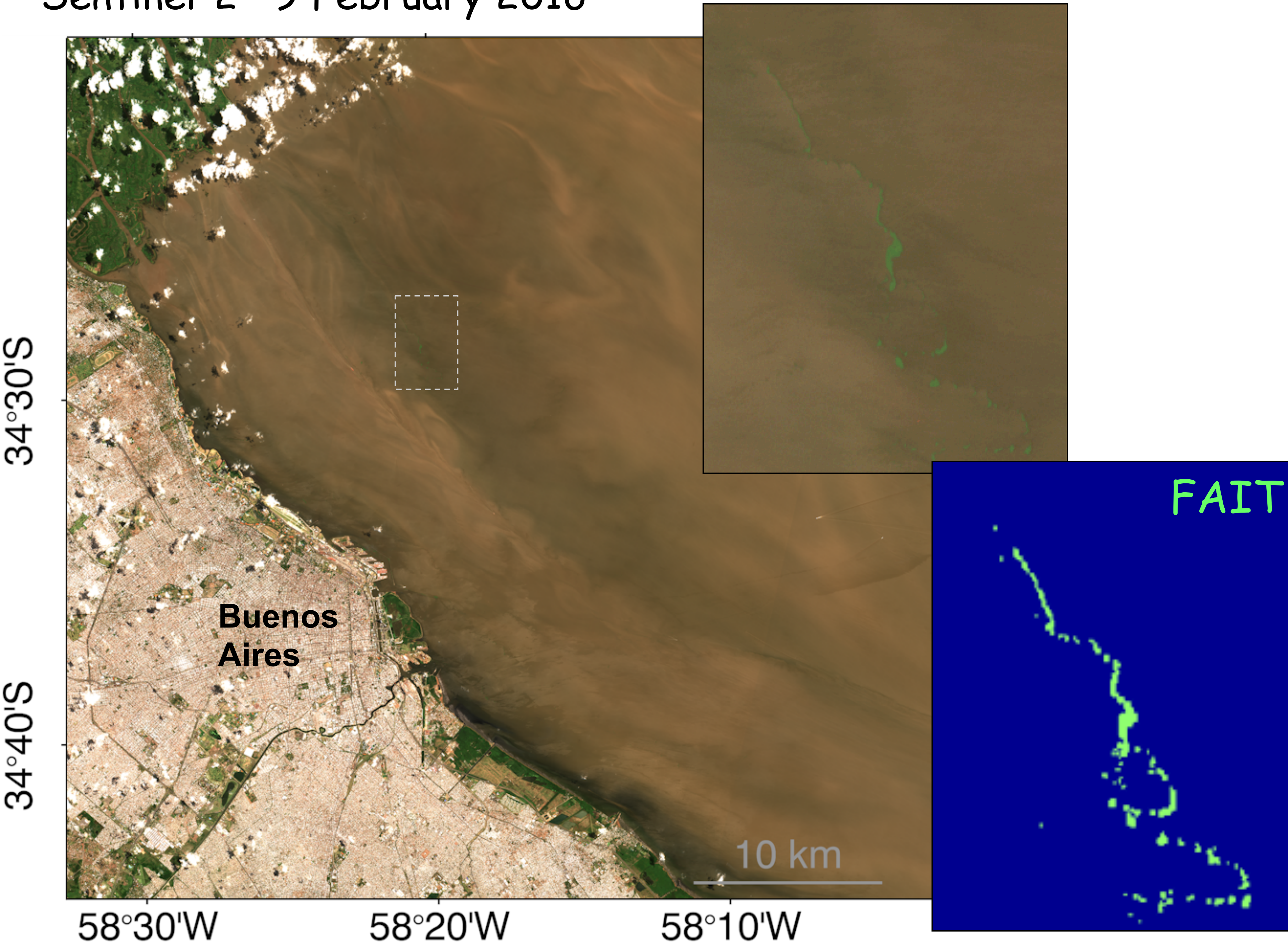






Sentinel-2 9 February 2016

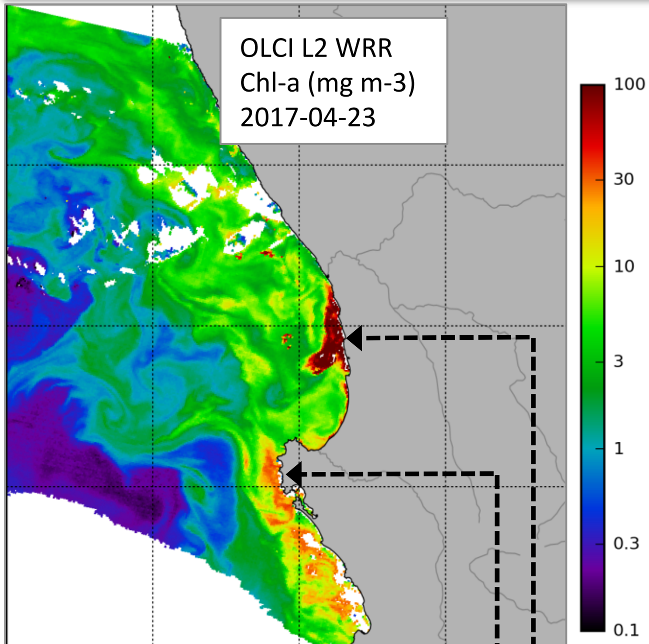
POC: Dogliotti



POC: Smith & Bernard

Performance of OLCI in high biomass waters in St Helena Bay, southern Benguela

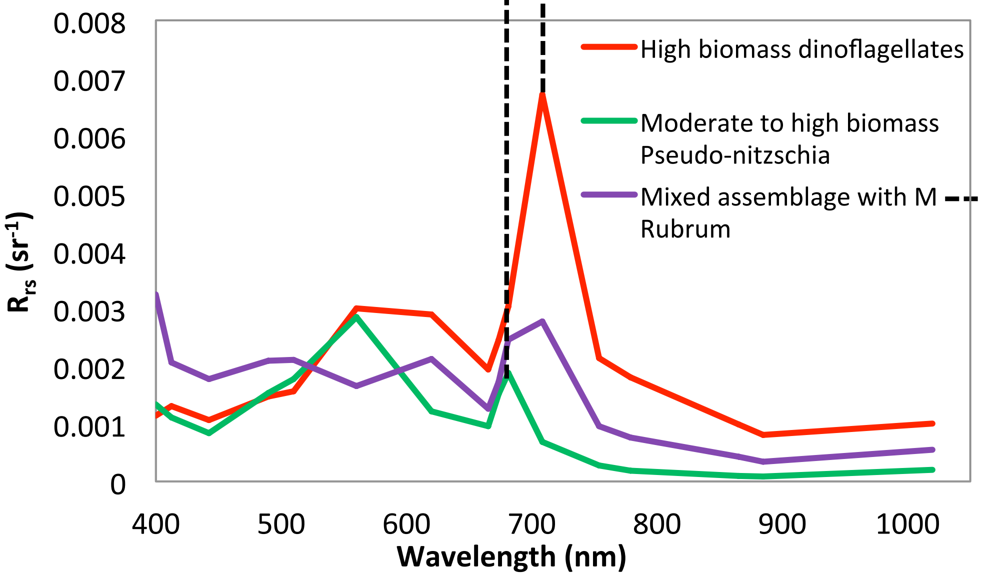
Marié Smith & Stewart Bernard, CSIR

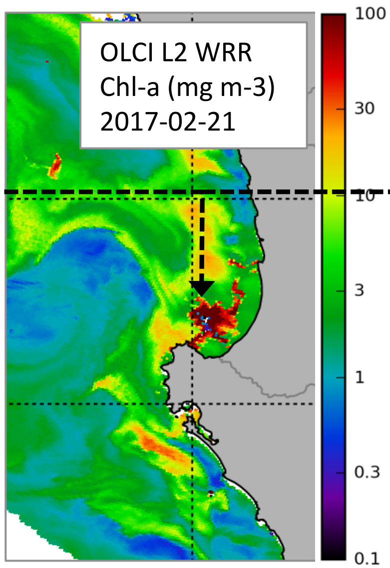


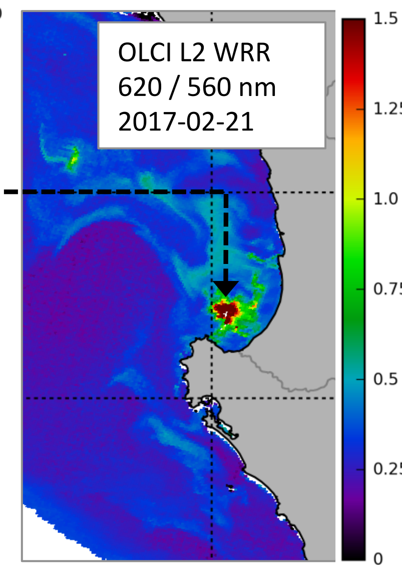
The Benguela system has been affected by numerous high biomass bloom events during the 2016/2017 austral summer. Bloom populations have been highly variable, with a range of toxic and non-toxic dinoflagellates, the toxic diatom *Pseudo-nitzschia* and the ciliate *Mesodinium rubrum* dominating in different locations and times. Sentinel 3, with highly optimised spectral band locations – particularly at red wavelengths - offers the ability to spectrally differentiate between high biomass bloom types.

The ability to identify both dinoflagellate and *Pseudo-nitzschia* dominated blooms using the relative height of the 681 and 709 nm reflectance peaks was confirmed on several occasions with validation data.

The presence of *Mesodinium rubrum* was reported in the St Helena Bay area during February 2017. A unique spectral feature due to phycoerythrin absorption allows detection with a 620/560 nm reflectance ratio.

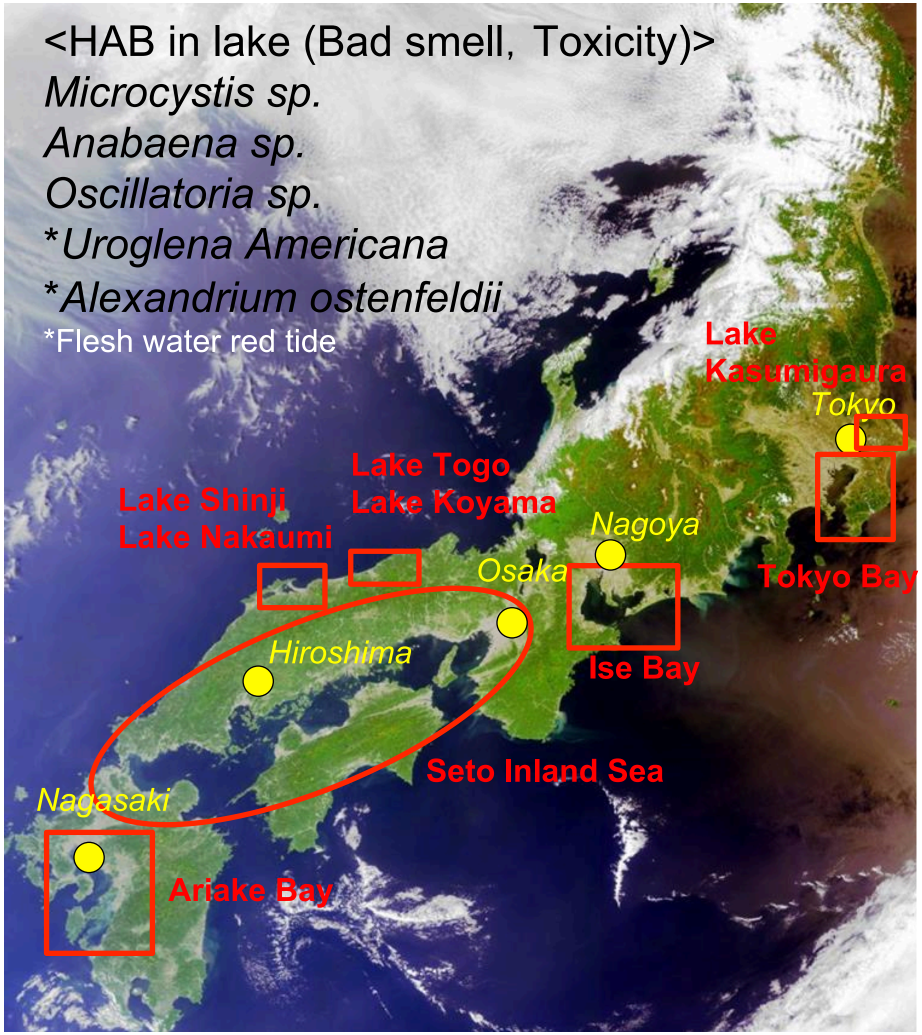






Typical HAB in Japanese coast

Graduate School of Eng.
Hiroshima University



First image around Japan observed by Sentinel-3 OLCI on May 12, 2016

<HAB in bay area>

Raphidophytes to kill fish

A. *Chattonella antiqua* (most serious)
B. *Chattonella marina*
C. *Chattonella ovata*
D. *Heterosigma akashiwo*

Dinoflagellate to kill fish and shellfish

E. *Cochlodinium polykrikoides*
F. *Karenia mikimotoi*

Dinoflagellates to kill bivalves

G. *Heterocapsa circularisquama*

Dinoflagellate bearing diarrhetic shellfish poison

H. *Dinophysis fortii*
I. *Dinophysis acuminata*

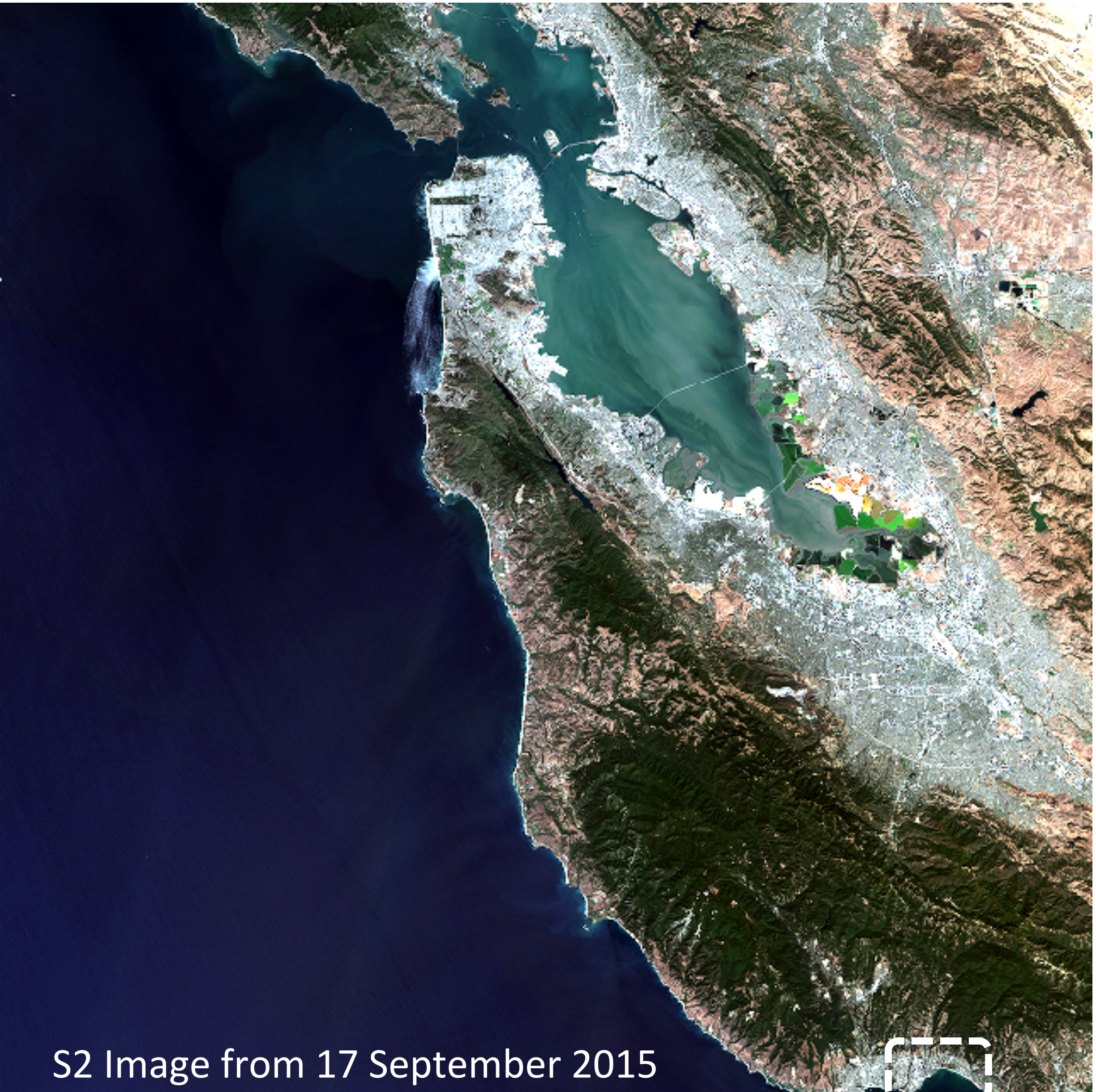
Dinoflagellate causing paralytic shellfish poison

J. *Alexandrium catenella*
K. *Gymnodinium catenatum*

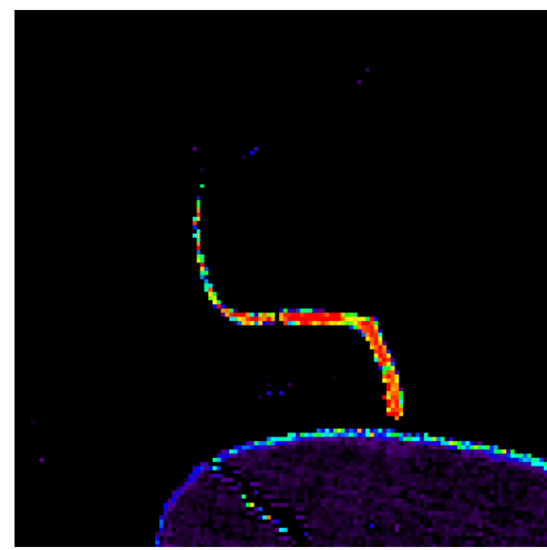
(Imai et al., Bull. Jpn. Soc. Fish. Oceanogr., 77:39-45, 2013)

POC: Kudela

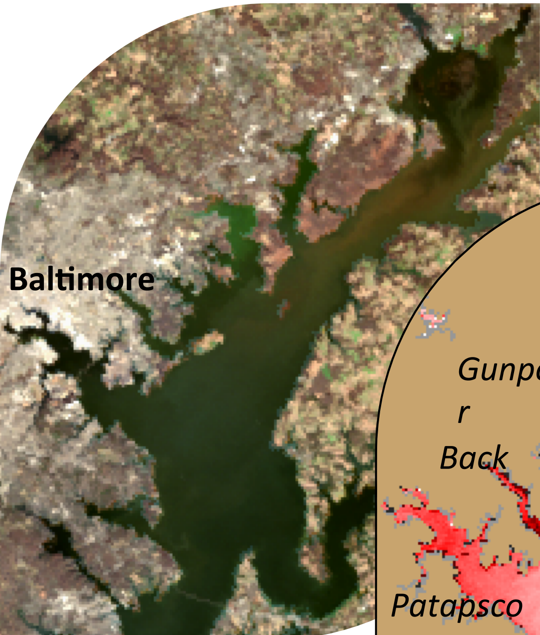
Next-Generation Sensors



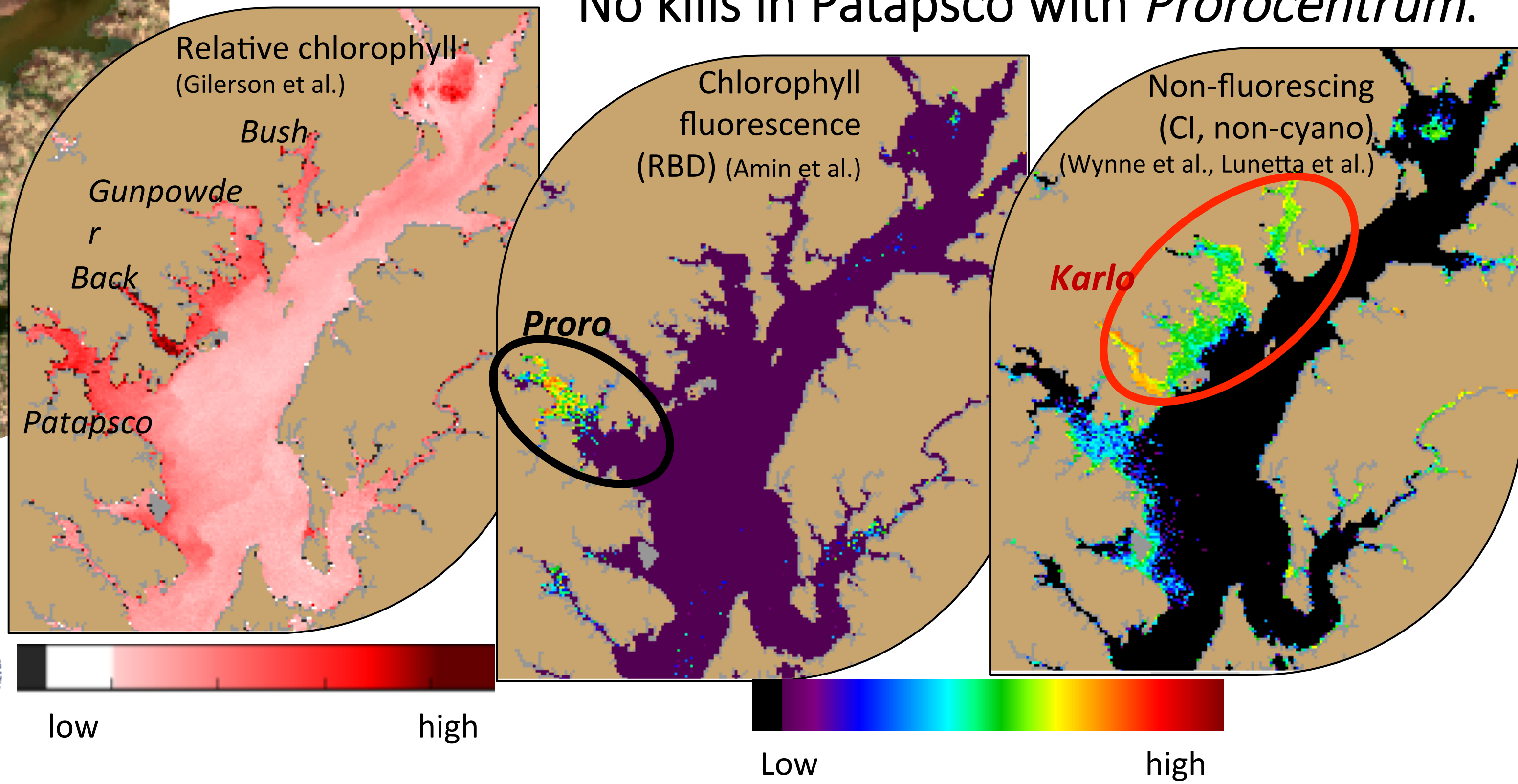
S2 Image from 17 September 2015



Chesapeake Bay Blooms. Fish kills in tributaries, Dec 20, 2016. *Karlodinium* present (fish killing). No kills in Patapsco with *Prorocentrum*.



OLCI "true color"



R. Stumpf
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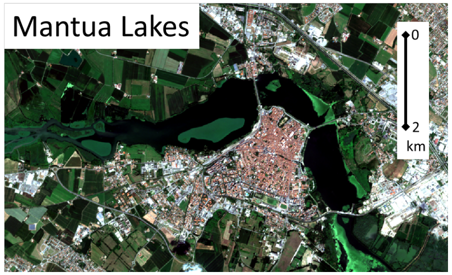
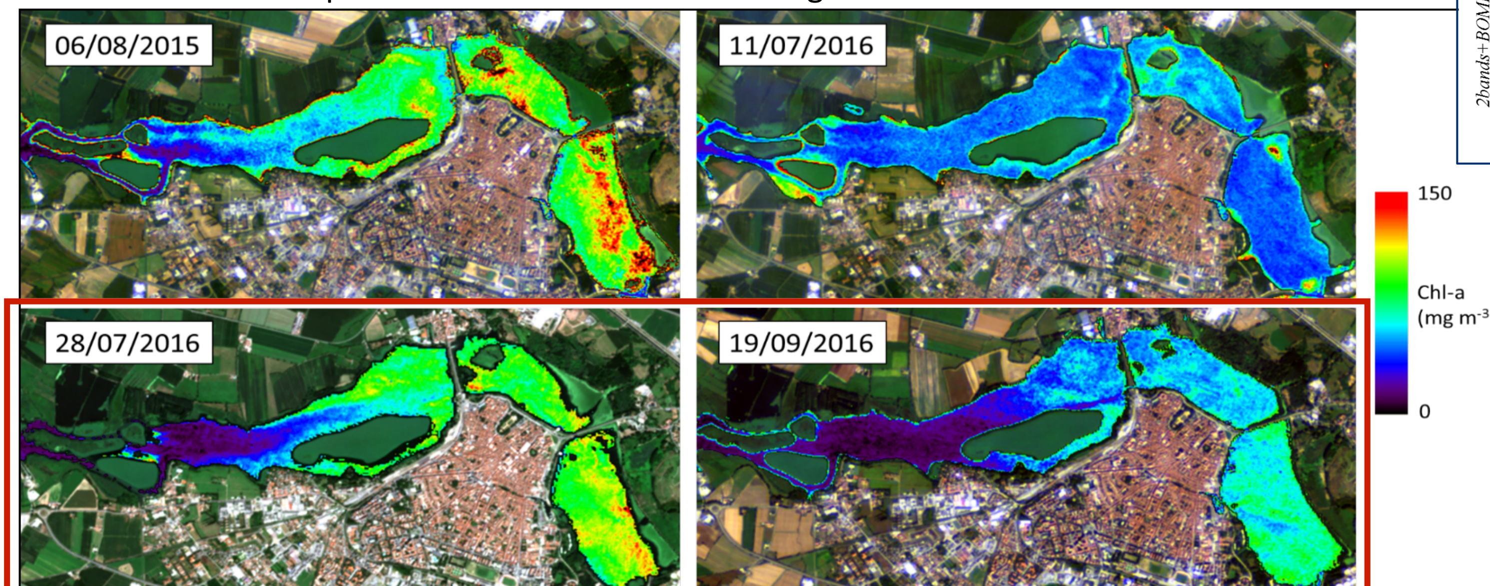
Maryland DNR

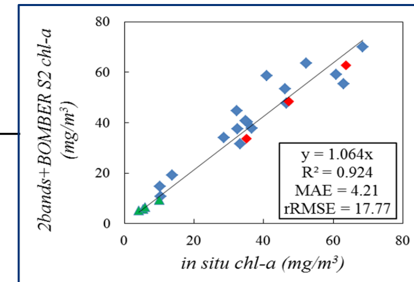
Sentinel-2 MSI for mapping phytoplankton in turbid extremely productive inland waters with recurrent cyanobacterial bloom



The Mantua Lakes (northern Italy, Po river valley) are three shallow basins characterized by nutrient-enriched and turbid waters and dominated by phytoplankton primary producers with recurrent blooms of potentially toxic cyanobacteria (e.g. *Pseudoanabaena* sp. and *Geitlerinema* sp.)

S2 maps the chl-a concentrations during the 2016 summer season





Product validation for three dates

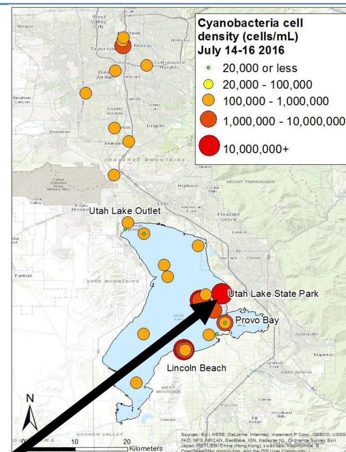
For the images in the box a distribution of phytoplankton groups was also produced (next slide)

POC: Peters

July 14 2016, Lindon Marina, Lake Utah

Toxic algae bloom closes Utah lake, sickens more than 100 people

July 14, 2016: This photo shows discolored water caused by an algae bloom near the Lindon Marina in Utah Lake in Lindon, Utah. (Rick Egan/The Salt Lake Tribune via AP,)



Sentinel 1 image of 21 July 2016 showing some wave dampening

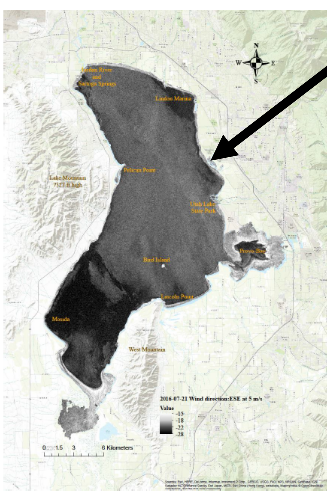


Figure 13 Wind direction ranging between East and South, Lake Utah image from 21 July 2016 at 13:34 UTC time

Sentinel 2 Chl-a map of 22 July 2016 showing relatively high concentrations

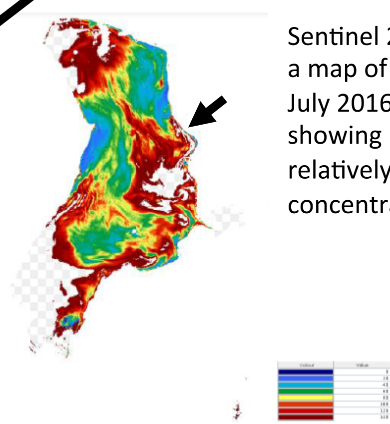


Figure 15 Chlorophyll classified optical image from 22 July, 2016 at 18:21 UTC time. (the blanck values are higher than 500 µgl⁻¹ and the white shows the presence of clouds) Image: Annelies Hommersom, Water Insight

Cyanobacteria monitoring by synergistic use of S1 and S2 (and S3):

Challenges are:

1) understand difference in physical observations and patterns (optical vs radar)

2) to find simultaneous overpasses (should improve with S3 for large lakes)

3) in radar: separate effects of wind, surface scums and recreation

4)in radar: for smaller lakes speckle removal is still a problem

DETECTING ALGAE IN LAKES

using Sentinel-1 C-band SAR images

by

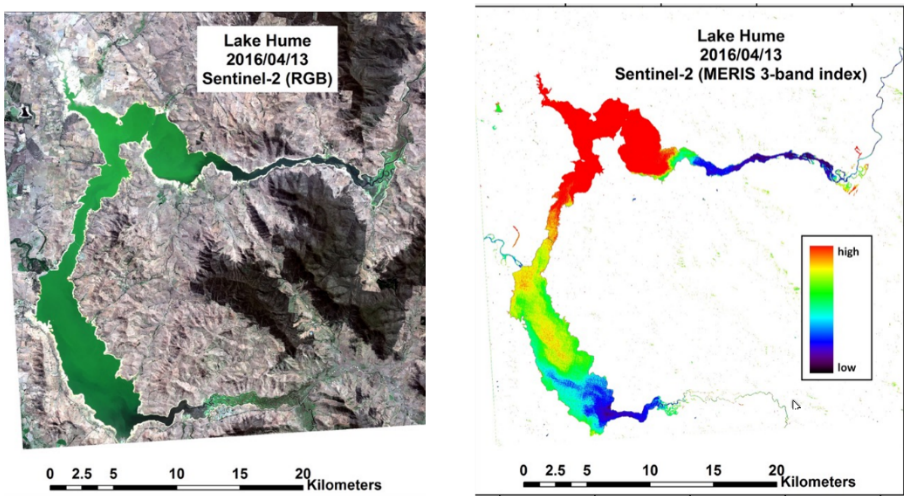
Geetika Rathee

WAGENINGEN UNIVERSITY & RESEARCH

Water Insight

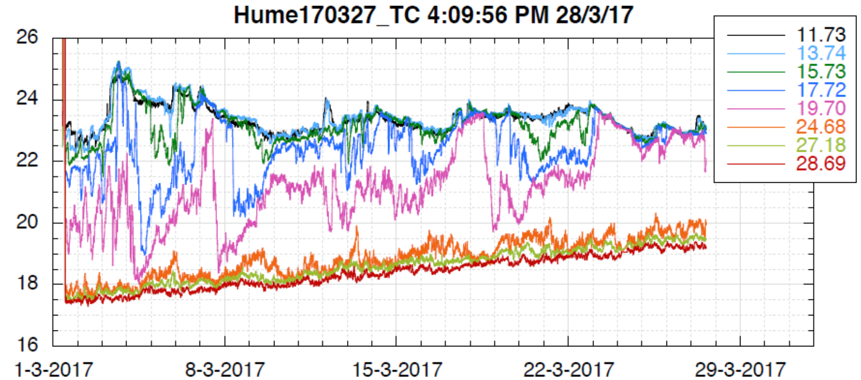
EOMORES

Satellite data + in-situ monitoring

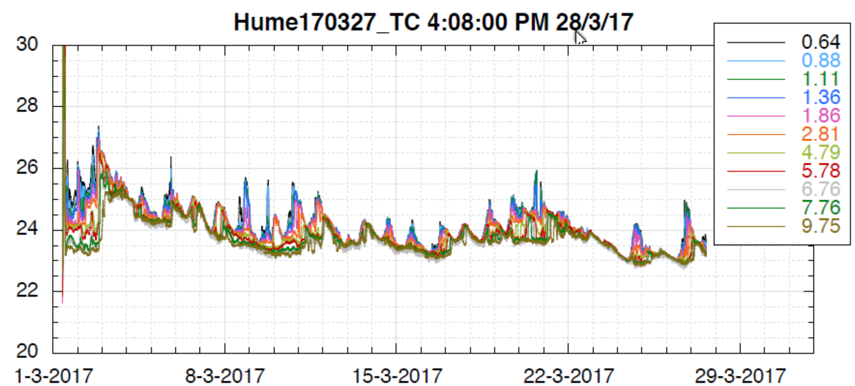


'True' colour

3 band chlorophyll index



Temperature (°C) at different depths



+ 3D modelling (Delft3D)

➔

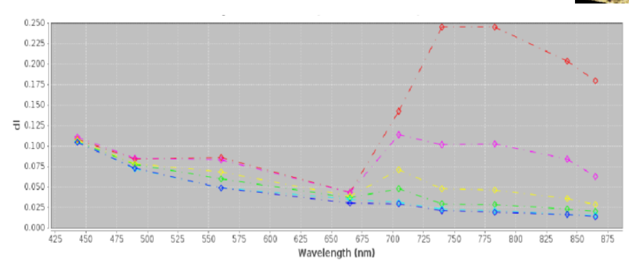
scenario forecast of cyanobacteria blooms in Lake Hume, Australia for risk minimisation

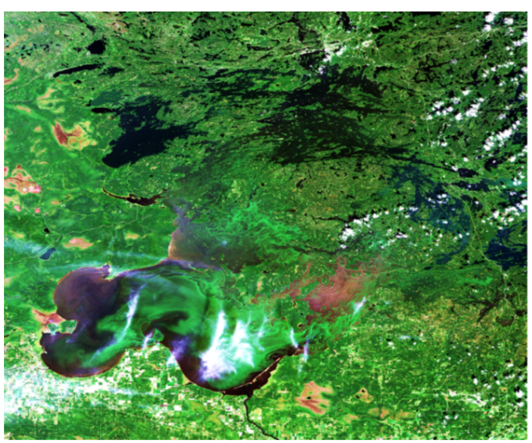
Malthus, T.J., Botha, E., and Anstee, J. (2016) Early warning system for harmful algal blooms:
Report on Workpackage 2 - Rapid Bloom Identification: Satellite sensing. CSIRO Land and Water, Australia.

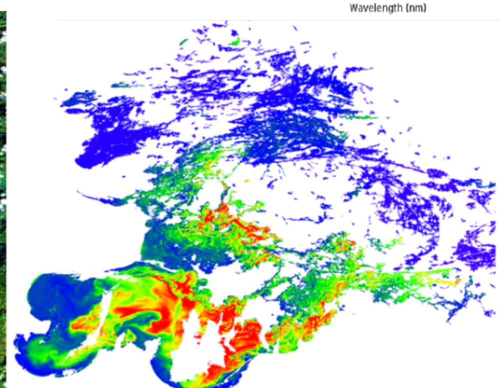
Algal bloom monitoring of Canadian inland waters

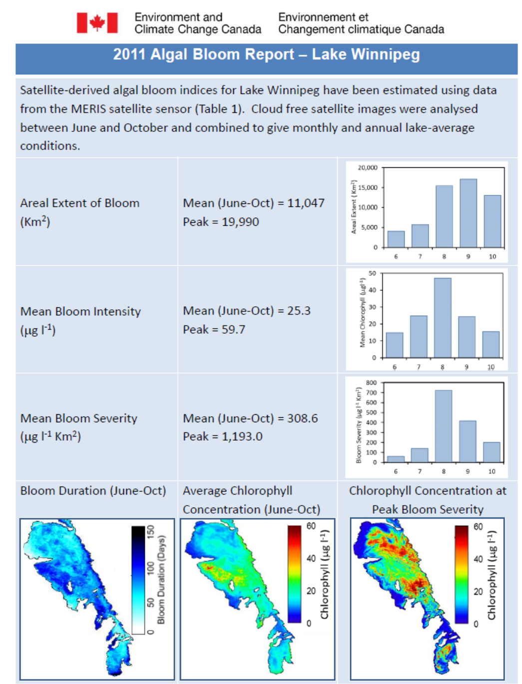
- Bloom monitoring of Canadian lakes transitioning from MERIS/MODIS to S-3 OLCI and S-2 MSI.
- Operational reporting on quantitative bloom indices; intensity, areal extent, duration and overall severity.
- Measuring lake responses to nutrient management practices, land-use change, climate change, and invasive species.

S-2 MSI true colour image and L1 MCI-derived Chlorophyll from an intense cyanobacteria bloom on Lake of the Woods, August 27 2016








Environment and Climate Change Canada | Environnement et Changement climatique Canada

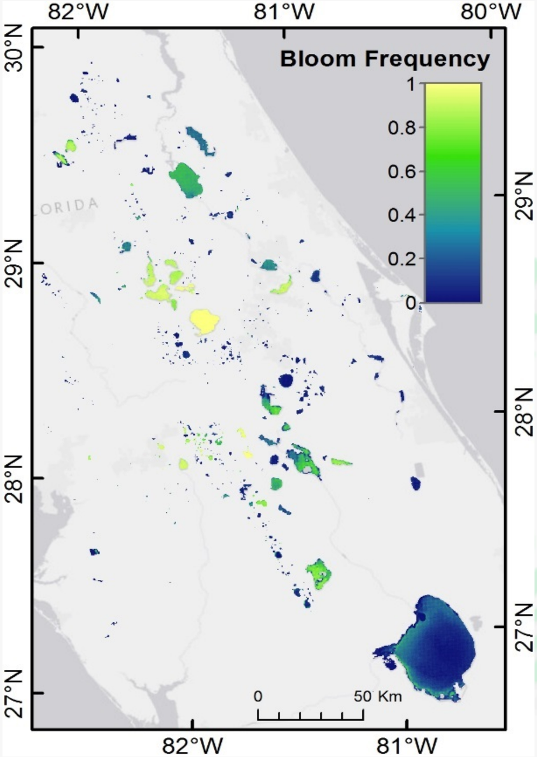
2011 Algal Bloom Report – Lake Winnipeg

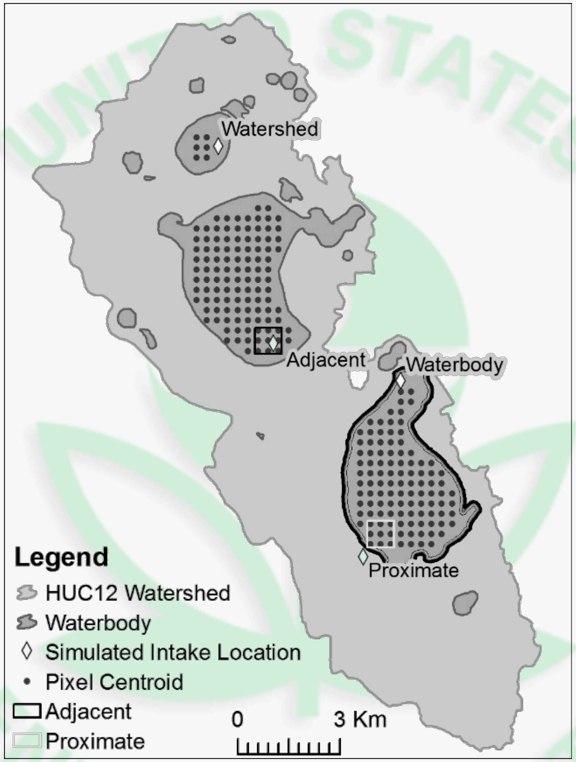
Satellite-derived algal bloom indices for Lake Winnipeg have been estimated using data from the MERIS satellite sensor (Table 1). Cloud free satellite images were analysed between June and October and combined to give monthly and annual lake-average conditions.

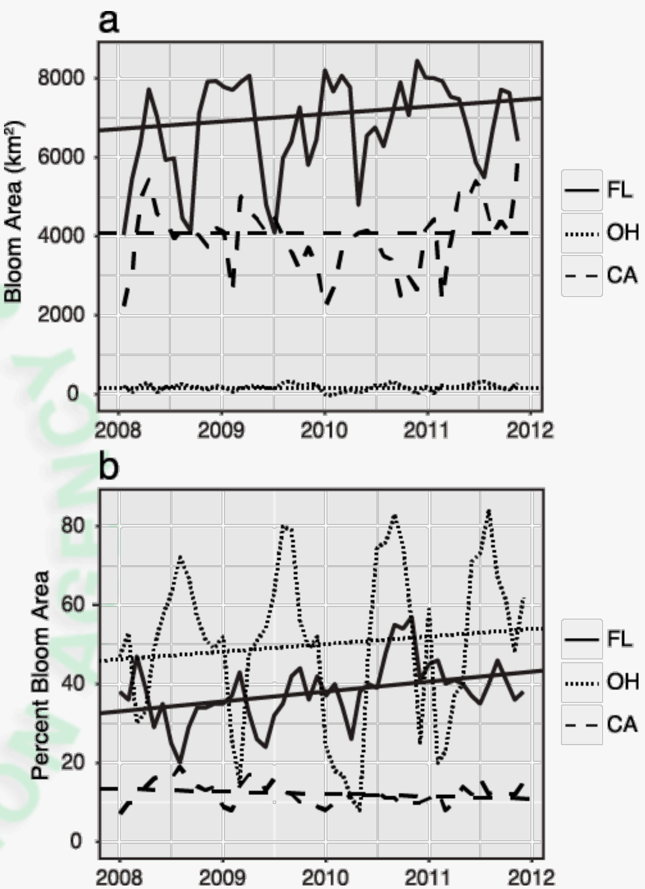
Areal Extent of Bloom (Km^2)	Mean (June-Oct) = 11,047 Peak = 19,990	
Mean Bloom Intensity (µg l^{-1})	Mean (June-Oct) = 25.3 Peak = 59.7	
Mean Bloom Severity (µg l^{-1} Km^2)	Mean (June-Oct) = 308.6 Peak = 1,193.0	
Bloom Duration (June-Oct)	Average Chlorophyll Concentration (June-Oct)	Chlorophyll Concentration at Peak Bloom Severity

Environment and Climate Change Canada

Frequency & Extent







Sources: Clark et al. (*In Press*). Satellite monitoring of cyanobacterial harmful algal bloom frequency in recreational and drinking source waters. Ecological Indicators.

Urquhart et al. (*In Revision*). A method for monitoring cyanobacterial harmful algal bloom spatial extent using satellite remote sensing data. Harmful Algae.

Points of Contact

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