California's Surface Water Ambient Monitoring Program (SWAMP)
Cyanotoxins in California and the SWAMP Freshwater HABs Program

Karen Taberski
SF Bay RWQCB
NOAA Satellite Workshop
May 4th, 2015

California Water Boards

SWAMP Surface Water Ambient Monitoring Program

Recurrent Blue Green Algae Blooms in California Waterbodies

Klamath River

Clear Lake

San Francisco Bay area /Delta

Monterey Bay/Pinto Lake

OEHHA
Fact Sheet

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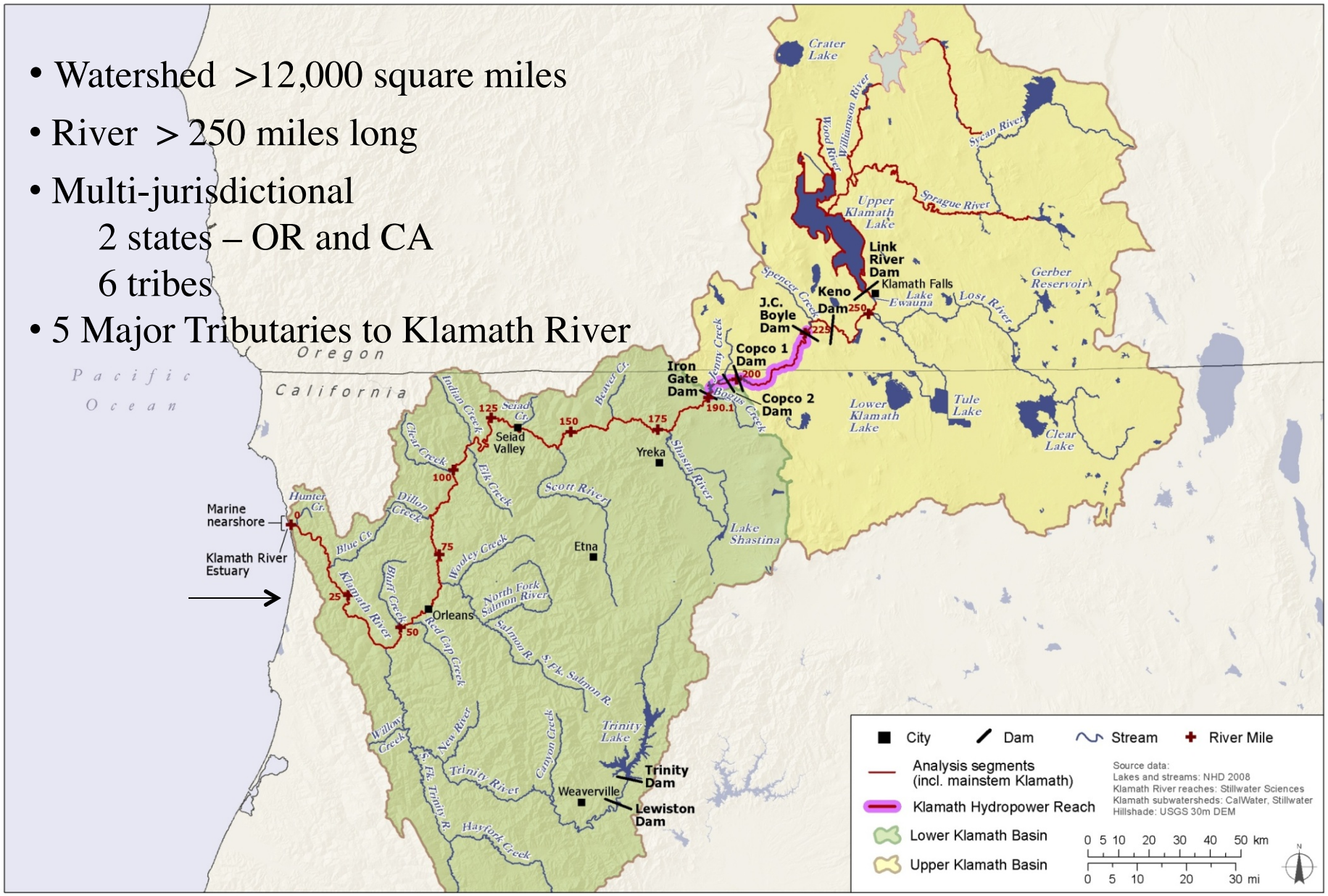
Klamath River Basin

- Watershed >12,000 square miles
- River > 250 miles long
- Multi-jurisdictional
  - 2 states – OR and CA
  - 6 tribes
- 5 Major Tributaries to Klamath River



River wide blooms

In 2007 and 2012 - 2014 cyanobacteria blooms extend from reservoirs to mouth of Klamath River (200 miles)

Source: Thomas B Dunklin Gallery

These photos were all taken on August 26, 2007.

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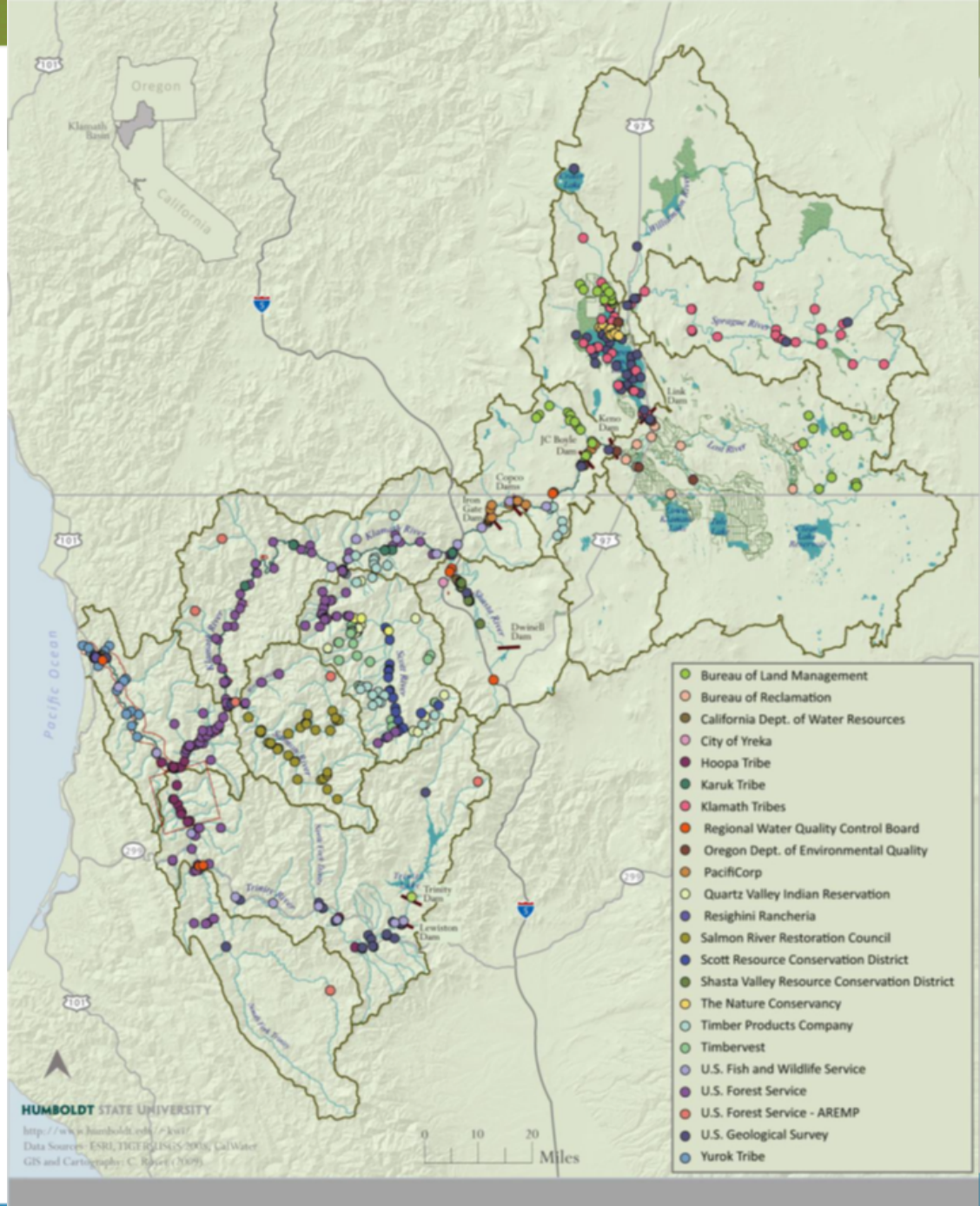
Cultural uses on Klamath Environmental Justice Issue

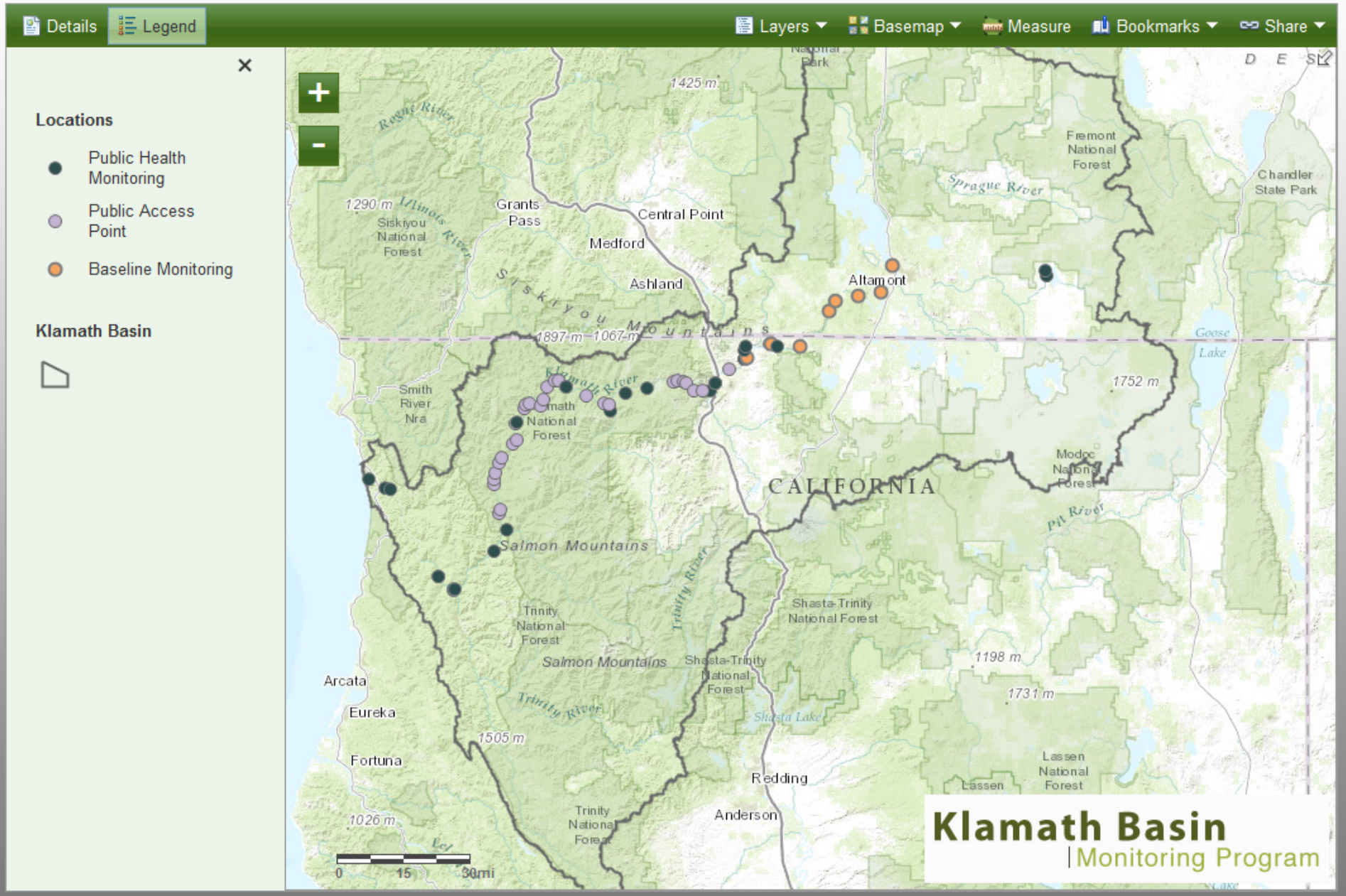
Klamath Basin Monitoring Program

- Monitoring coordination
- Common analytical methods and sampling protocols
- Data management
- Membership organization
- Watershed stewardship assessment reports
- Web Information Portal (Blue-green Algae Tracker)
- www.kbmp.net

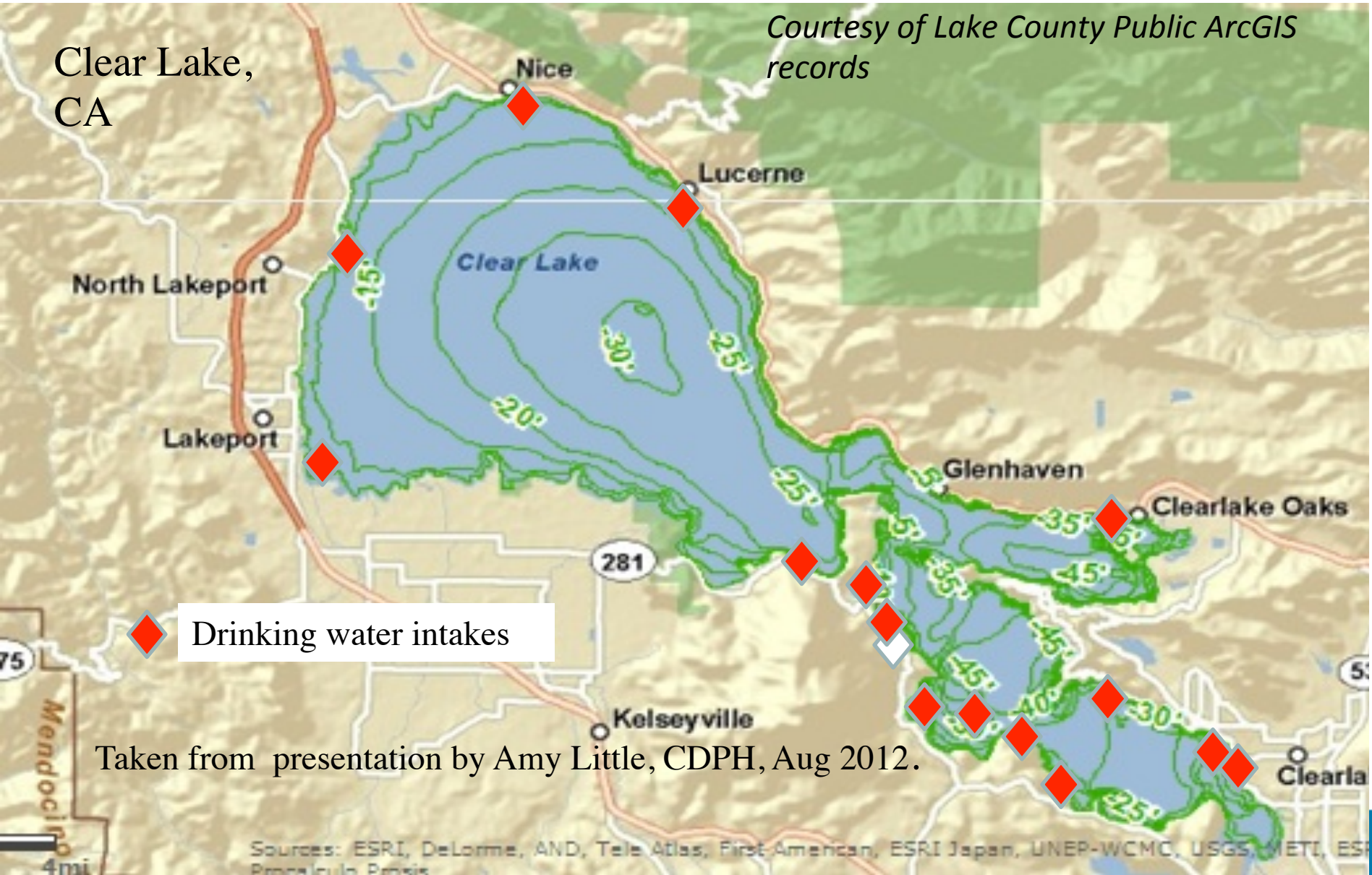


Klamath Basin Water Quality Monitoring Plan: 2009 Monitoring Locations by Organization

Blue-Green Algae Tracker



Clear Lake – Protecting drinking water



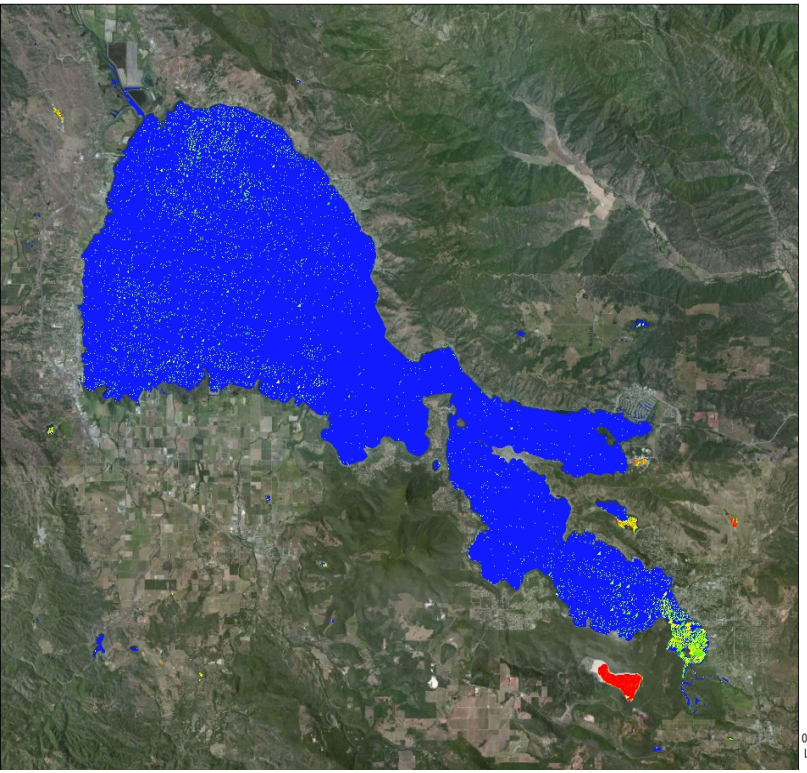
Taken from presentation by Amy Little, CDPH, Aug 2012.

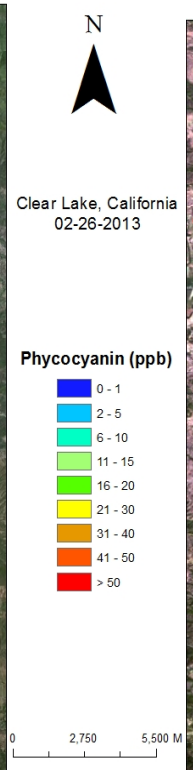
Beneficial Use Affected - Drinkable

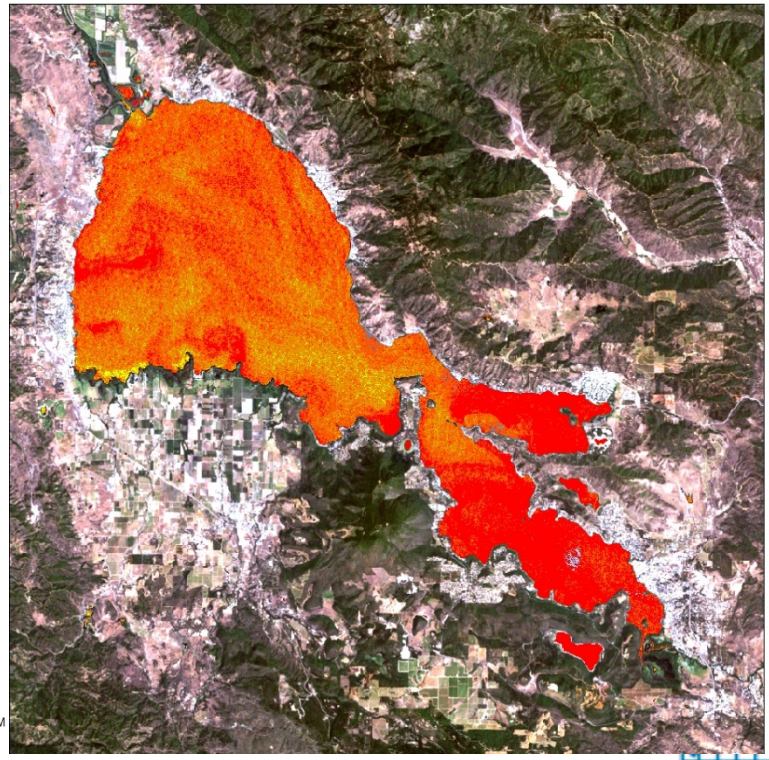
Eastern Oaks Arm, Clear Lake

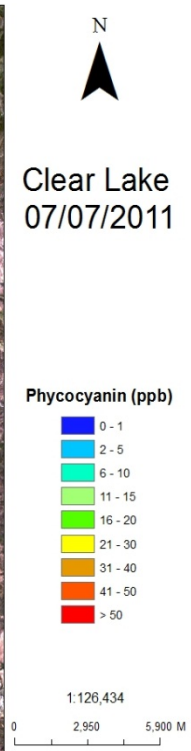
Aerial Image from Google maps; fly in photo from 8/12 presentation by Amy Little, CDPH

Clear Lake – Blue Water Satellite
Protecting drinking water supplies









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San Francisco Bay
(USGS Polaris Cruises)

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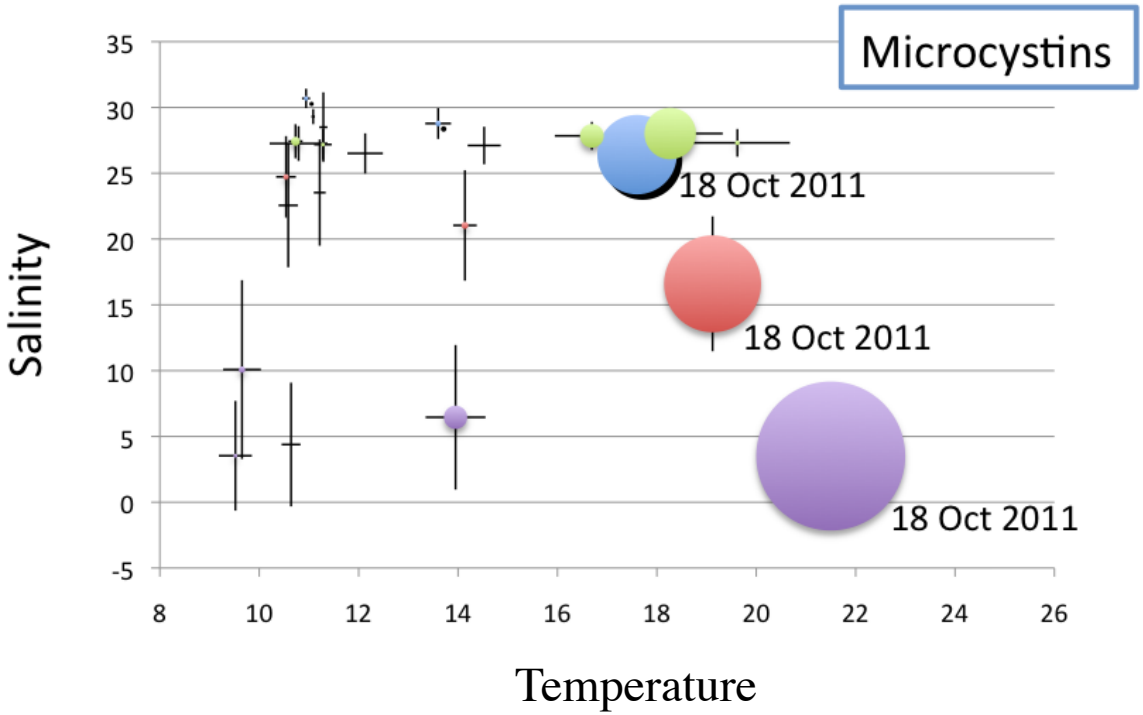
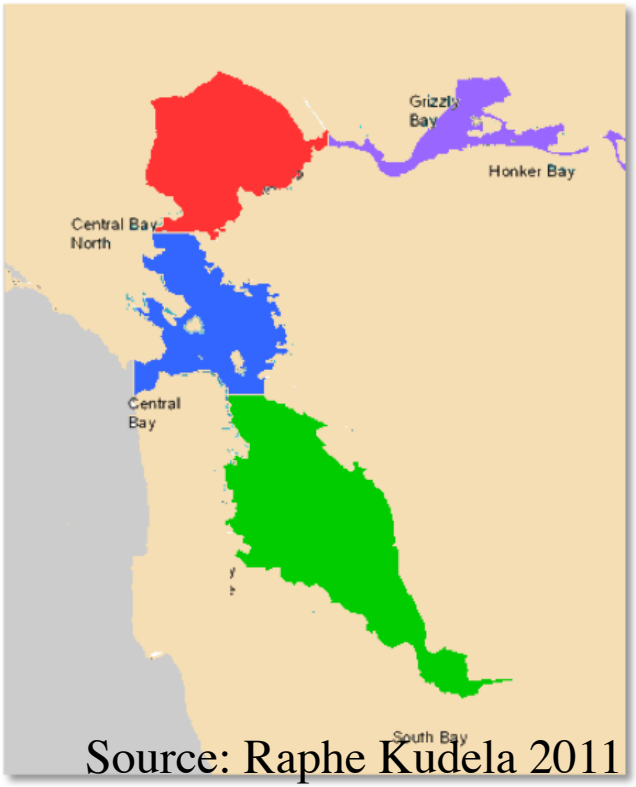
SPATT concentrations plotted in Temperature-Salinity space





Source: Raphe Kudela 2011

Bubble size = toxin concentration; color corresponds to Bay regions

ars represent 1 SD for Salinity and Temperature


CARQUINEZ STRAIT SHORELINE
LONE TREE POINT
BAY POINT WETLANDS
BROWNS ISLAND
MARTINEZ SHORELINE
SAN PABLO BAY SHORELINE
BIG BREAK
ANTIOCH SHORELINE
POINT PINOLE
CROCKETT HILLS
WATERBIRD
SOBRANTE RIDGE
BLACK DIAMOND MINES
CONTRA LOMA
WILDCAT CANYON
KENNEDY GROVE
BRIONES
DELTA ACCESS
MILLER/ KNOX
POINT ISABEL
CASTLE ROCK
CONTRA COSTA COUNTY
CLAYTON RANCH
TILDEN
DIABLO FOOTHILLS
BROOKS ISLAND
ROUND VALLEY
CLAREMONT CANYON
SIBLEY
EASTSHORE STATE PARK
LAS TRAMPAS
HUCKLEBERRY
TEMESCAL
SYCAMORE VALLEY
VASCO CAVES
REDWOOD
MIDDLE HARBOR
MORGAN TERRITORY
ANTHONY CHABOT
CROWN BEACH
LEONA OPEN SPACE
BISHOP RANCH
BRUSHY PEAK
LAKE CHABOT
MLK JR. SHORELINE
CULL CANYON
DUBLIN HILLS
TASSAJARA CREEK
PALOMARES RIDGE
OYSTER BAY
DON CASTRO
SHADOW CLIFFS
ALAMEDA COUNTY
GARIN
HAYWARD SHORELINE
PLEASANTON RIDGE
DRY CREEK PIONEER
DEL VALLE
COYOTE HILLS
VARGAS PLATEAU
QUARRY LAKES
ARDENWOOD
SUNOL
MISSION PEAK
OHLONE WILDERNESS
CAMP OHLONE
East Bay
Regional Park District

Monterey Bay/Pinto Lake

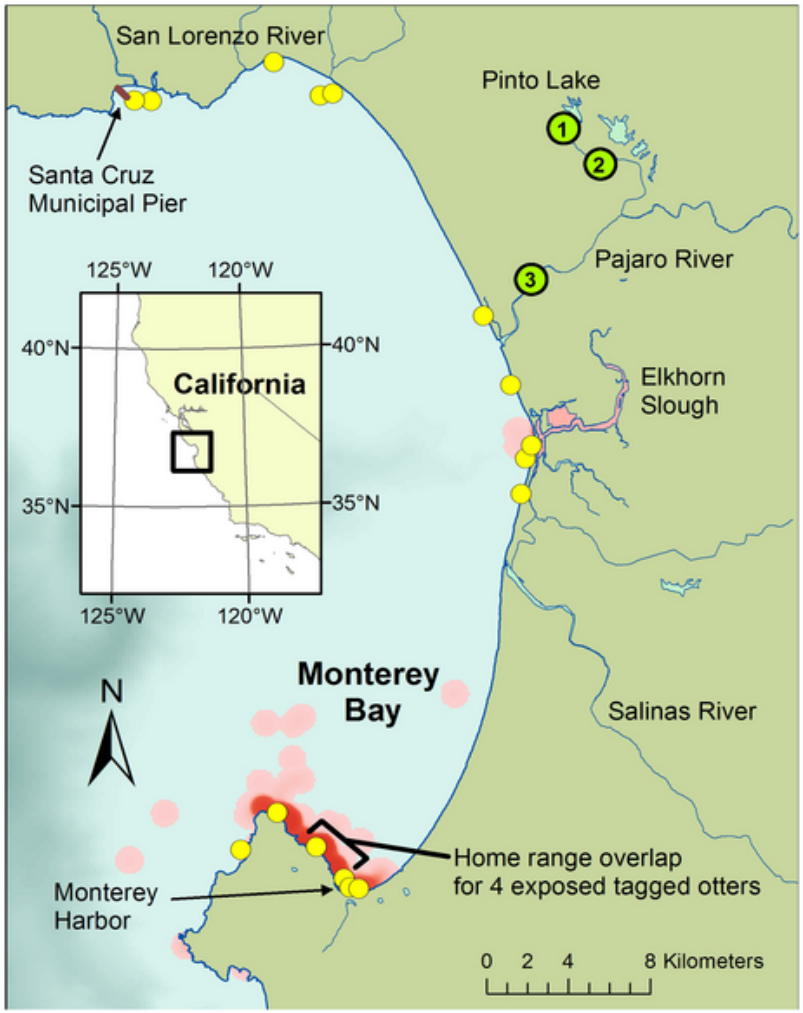


Figure 4. Map of Monterey Bay showing distribution of sea otters dying due to microcystin intoxication (yellow circles).

Miller MA, Kudela RM, Mekebri A, Crane D, et al. (2010) Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters. PLoS ONE 5(9): e12576. doi:10.1371/journal.pone.0012576
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0012576

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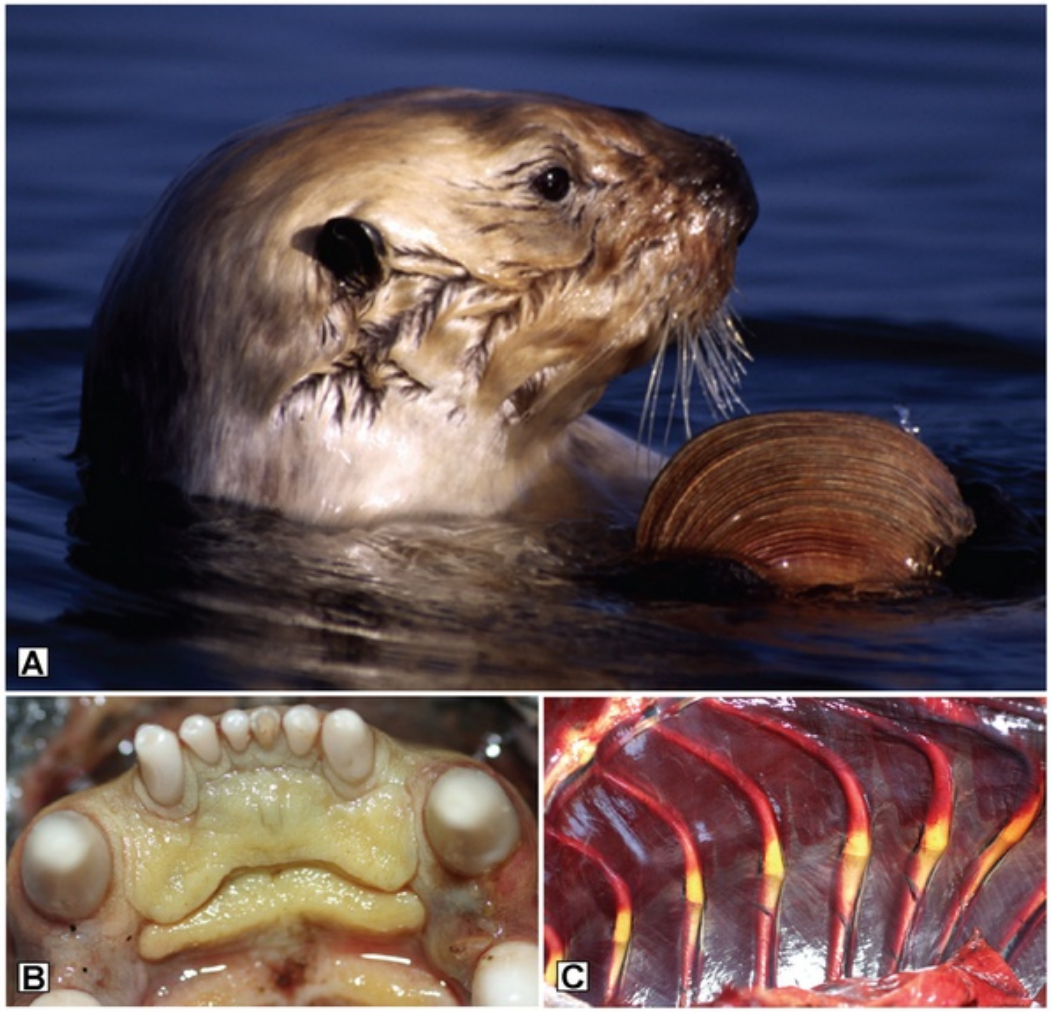
PLOS ONE

Figure 5. Microcystin detection in sea otter tissues was linked to bivalve consumption, liver damage and icterus.



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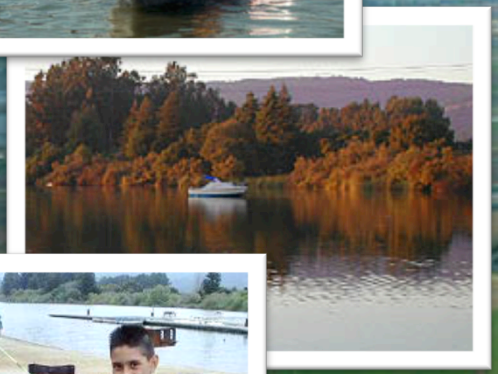
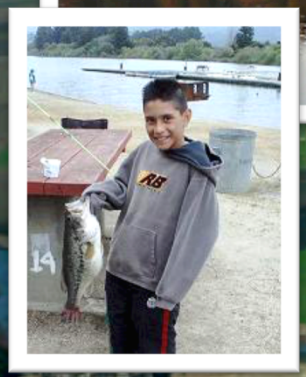
Investigation lead up the Pajaro River mouth to Pinto Lake





- Launch Ramp
- Picnic Areas
- Boat rentals
- Fishing

~8.5 km

X- Sick sea otter

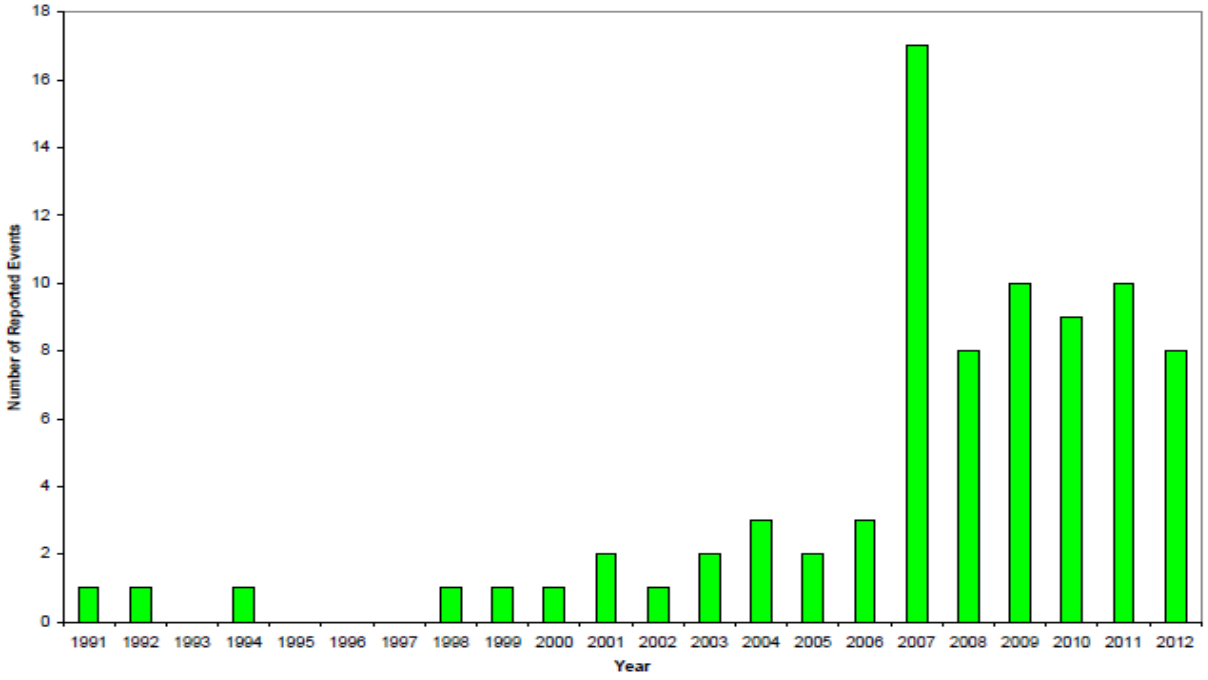
Monterey Bay

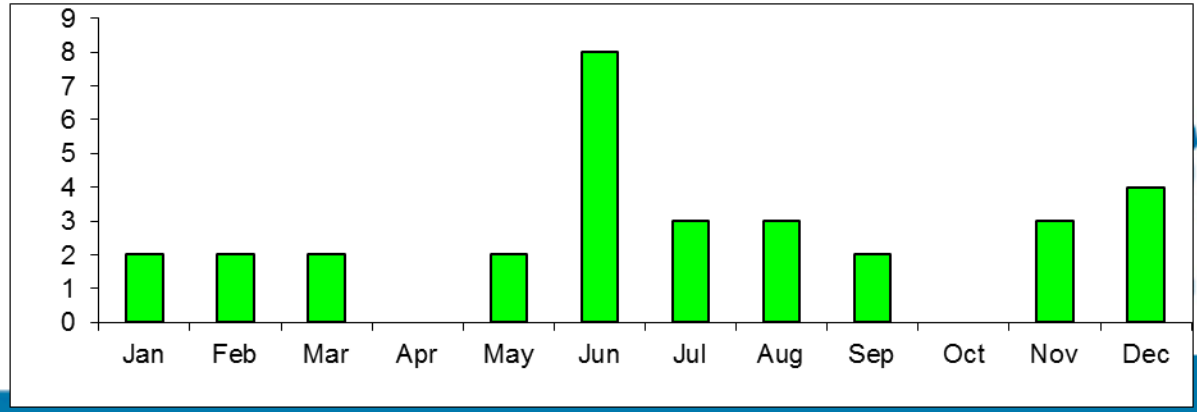
Cyanotoxin cases seem to be increasing through time in CA & can be present any time of the year
By 2013 31 sea otter deaths

Sea otters→ dogs, cattle, horses, fish, birds, goats

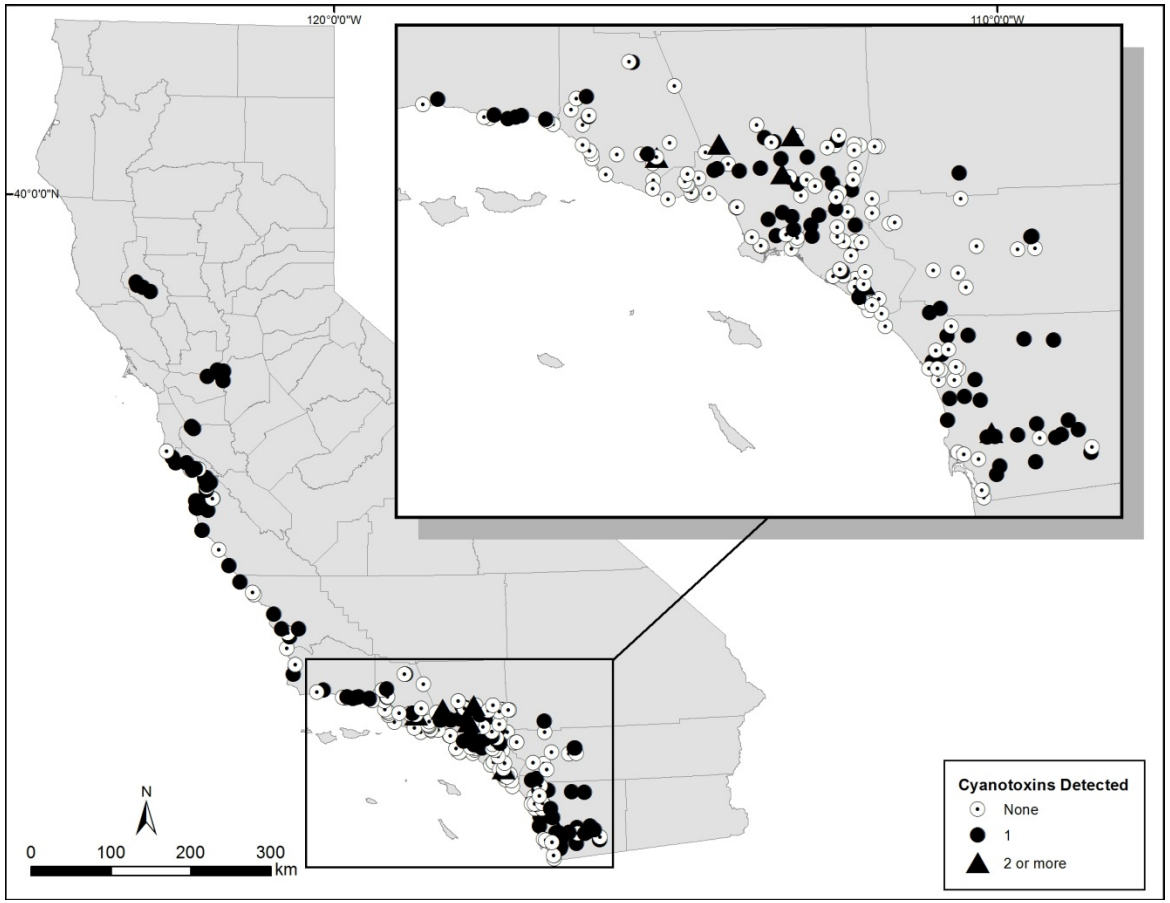
Sea otters→

Source: Melissa Miller DVM





Microcystins Detected in California 2010-2012 (SCCWRP)



Microcystin detected at >50% of sites where surveyed

Data collected from many organizations:

- UC Santa Cruz
- SCCWRP
- USGS
- Coastal Confluences
- Regional Water Board 9
- CalFED
- Stormwater Monitoring Coalition

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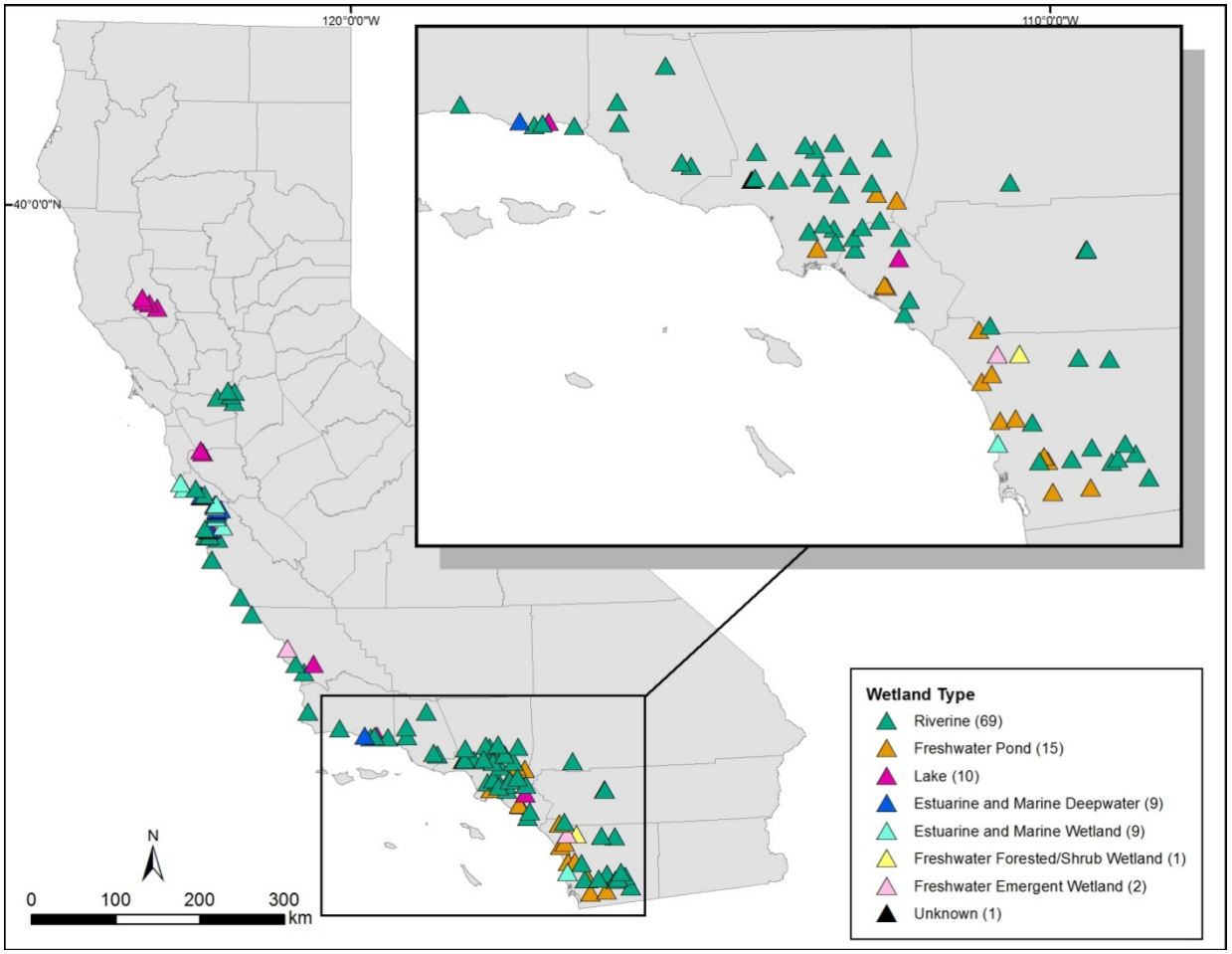
Microcystins Detected In a Variety of Waterbodies



- Wetlands
- Lagoons
- Lakes
- Ponds
- Streams and rivers
- Estuaries
- Marine seawater (Santa Cruz Wharf)

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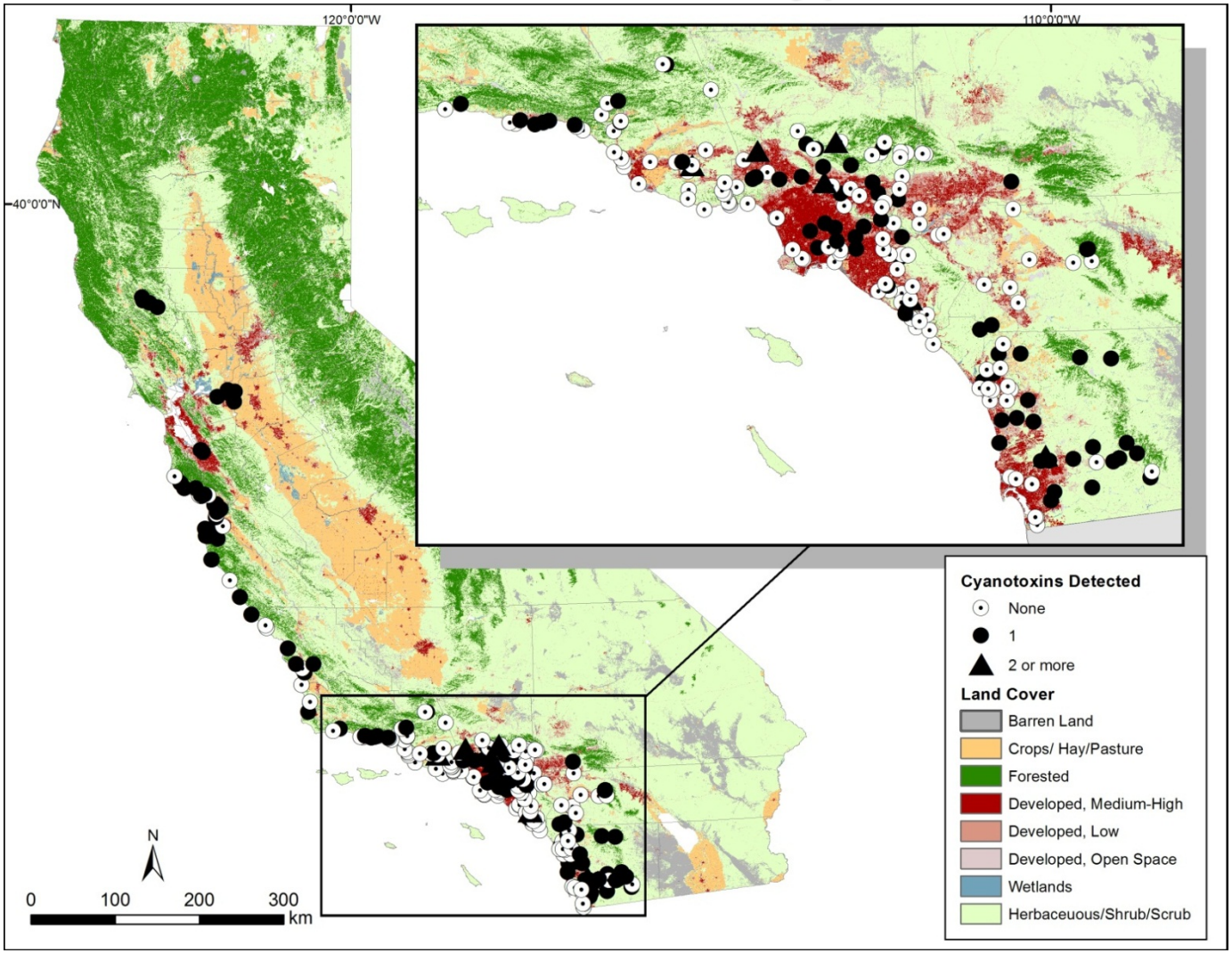
Microcystins Detected Across a Wide Array of Land Use Types



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SWAMP Cyanotoxin Projects 2012-2014

- 2-Day Cyanotoxin Workshop – November 2012
- SCCWRP compile additional cyanotoxin data
- NOAA projects
  - 2013/14 conduct satellite ground truthing with data
  - 2014/15 training, list of water bodies, time series
- Cyanotoxins added to regional and statewide SWAMP monitoring programs
- Freshwater HABs Monitoring, Assessment and Reporting Strategy (Due August 2015)
  - Contracted to Meredith Howard (SCCWRP)

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Draft Freshwater HABs Monitoring, Assessment and Reporting Strategy

Goal: Develop a coordinated and widely supported statewide strategy for monitoring, assessment and reporting to inform management decisions for freshwater HABs

Objectives:

- Design a scientifically sound statewide program
- Identify scientific framework and resources
- Provide a strategic roadmap of technical resources, infrastructure and funding

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Elements Required To Support Strategy

- **Quality assurance and development of SOPs**
  - Field collection
  - Toxin methods
  - Health and safety recommendations
- **Training program**
  - Water quality and public health issues of freshwater HABs for managers
  - Field sampling protocols
  - Taxonomy identification
  - Potential management actions
- **Guidance documentation**
  - Toxin thresholds to ensure public health and safety (OEHHA document)
  - Voluntary guidance on posting, closures etc. (CCHAB document)
- **Data management and visualization**
  - Centralized website
  - Bloom tracker
  - Reporting
  - Database management and storage

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SWAMP Freshwater HAB Program 2015 -2017 Projects

- Guidance document for field and lab work (Dave Crane & Mine Berg)
- Laboratory resources (Ca. Water Pollution Control Lab – Ca. F&W Dept.)
- Satellite imagery processing and near real-time notifications (SFEI)
- Development of databases and website (SFEI)
- Newsletter/bulletin (SFEI)
- Status and trends summary report (SFEI)
- Trainings – (NOAA and Training Academy)

Guidance document

- Field section (Mine Berg - AMS)
  - Compilation or development of SOPs for sampling for cyanotoxins in lakes/reservoirs, rivers, estuaries, marine waters and freshwater wetlands
  - Health and safety recommendations/plan
- Laboratory section (Dave Crane – WPCL)
  - Compile SOPs for ELISA and LC MSMS analysis of cyanotoxins from five major labs in Ca.
  - Development of a performance based QA system for cyanotoxins
  - Development of a decision tree framework for analyzing cyanobacteria and cyanotoxins for event-response sampling
- Draft due Jan. 1, 2016, final due June 1st, 2016

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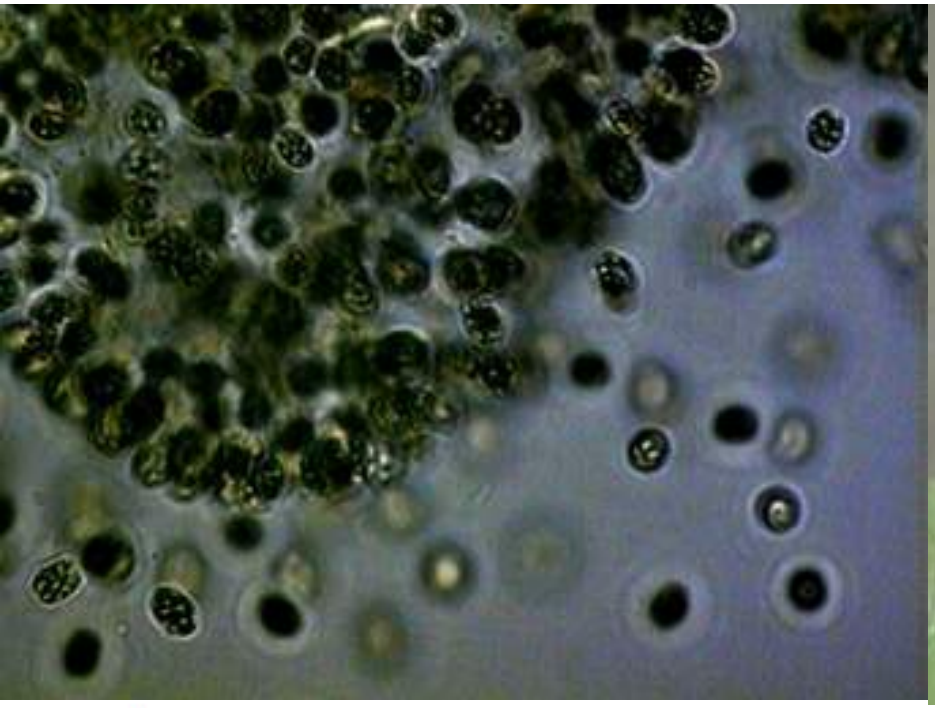
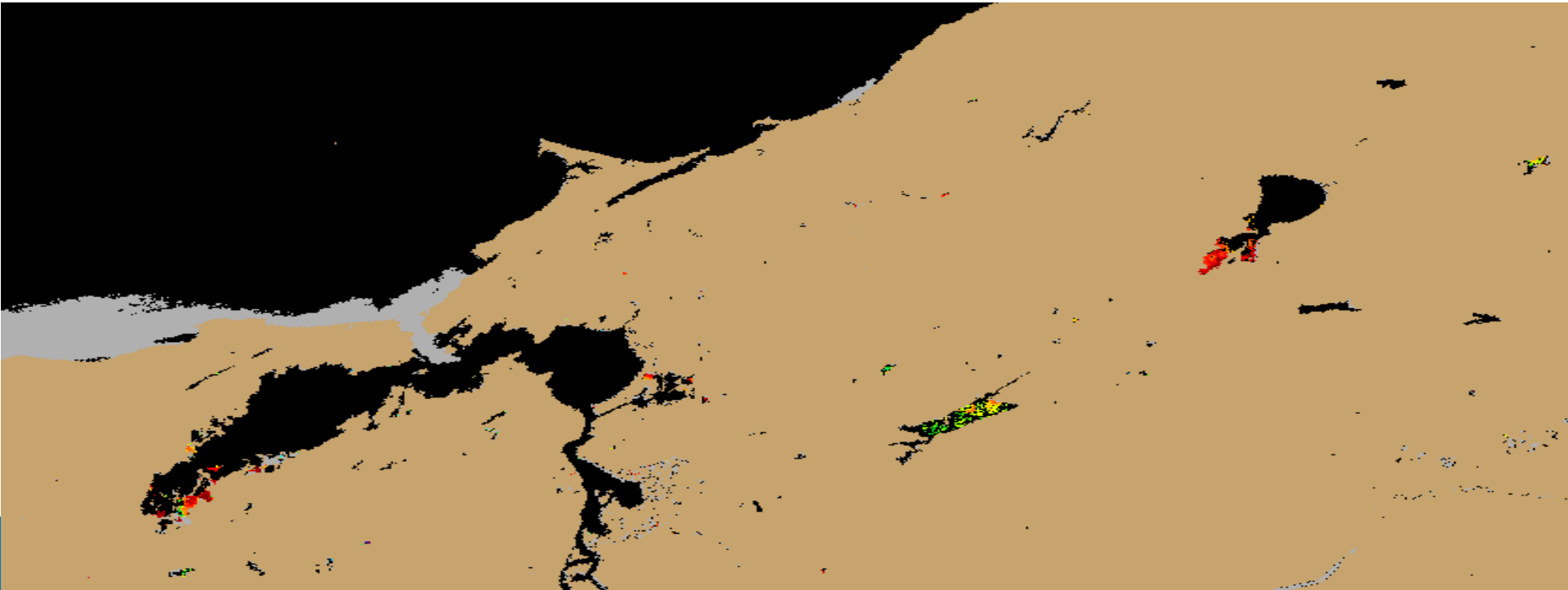
Laboratory resources

- Cyanotoxin analysis for event based sampling for agencies, individuals and responsible parties (Ca. Water Pollution Control Lab)



Satellite imagery and notification (SFEI)

- Retrieve and process imagery created by satellite
- Notify contacts when imagery indicates a bloom in near real time
- Respond to requests for follow up information



Newsletter/bulletin (SFEI)

- Biweekly (during bloom season) newsletter/bulletin (monthly in winter) which includes:
  - Inland HAB status report
  - Processed satellite imagery for the state with chl a and phycocyanin indices
  - Bloom and toxicity updates
  - Reports of human or animal illnesses or deaths

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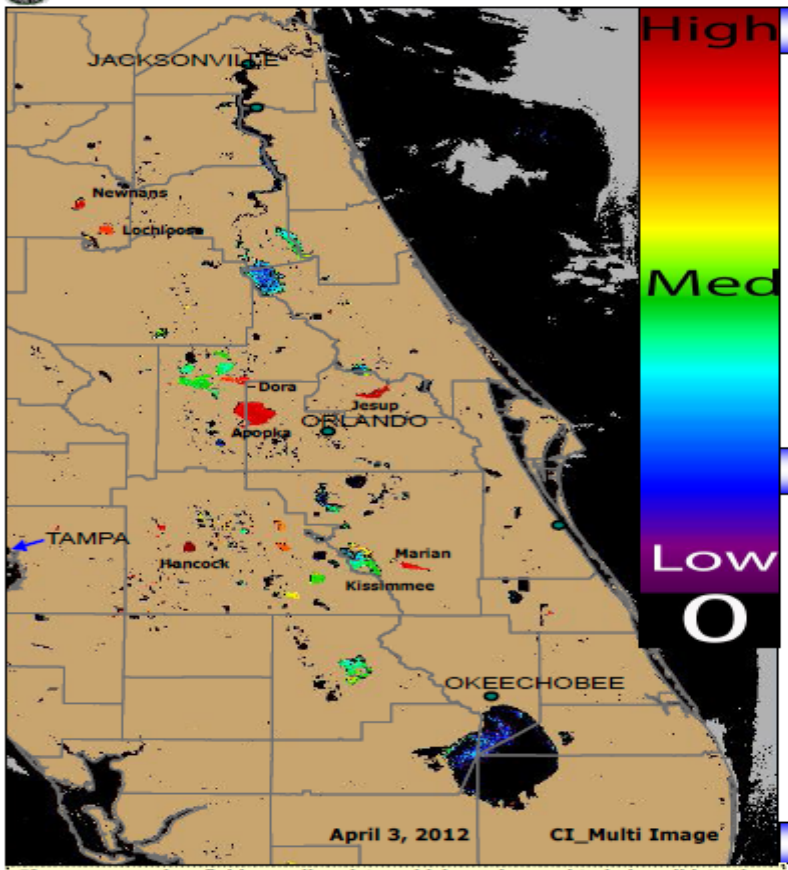
Satellite Health Bulletins: Florida

Experimental Cyanobacteria Health Bulletin: April 3, 2012

To report an illness related to a marine toxin or algal bloom please contact the Florida Poison Information Center-Miami Aquatic Toxins Hotline at 1-888-232-8635.

For questions about the report: contact Becky Lazensky, FL-DOH, at 352-955-1900. Images/data were obtained from Florida Water Management Districts, The National Oceanic and Atmospheric Administration (NOAA), NOAA National Climatic Data Centers and National Weather Centers. Support to produce this report was received through a NOAA/NASA Agreement (Number: NNH08ZDA001N)



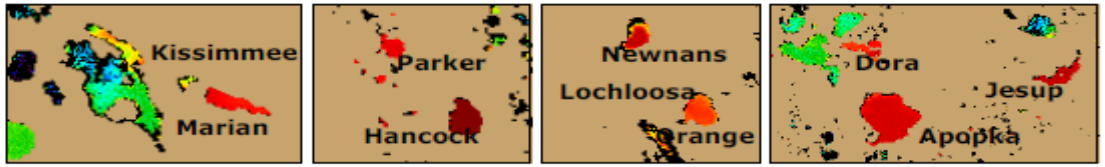
If your agency has field sampling data, which can be used to help validate the MERIS imagery, Contact Becky Lazensky at: 352-955-1900

MERIS Satellite Images display a cyanobacteria index generated with a Medium Resolution Imaging Spectrometer satellite provided by the European Space Agency & NOAA.

- Very low likelihood of a bloom
- May indicate clouds or missing data
- Low estimated cyanobacteria concentrations
- Medium estimated cyanobacteria concentrations
- Probable bloom or higher est. cyano. concentrations

Cyanobacteria HABs Conditions Report: April 3

- Lakes Kissimmee and Marian (Osceola County) displayed medium and high estimated cyanobacteria concentrations
- Lakes Parker and Hancock (Polk County) displayed high estimated cyanobacteria concentrations
- Newnans, Lochloosa, & Orange Lakes (Alachua & Marion Counties) and Jesup, Dora, and Apopka Lakes (Seminole, Lake, and Orange Counties) displayed high estimated cyanobacteria concentrations



ENVISAT SATELLITE IS DOWN-Impacts on MERIS Images

On April 8th, communications between the European Space Agency (ESA) and the Envisat satellite were lost. The Envisat satellite platform carries the MERIS sensor which captures the images featured in this bulletin. This will impede the production of MERIS satellite imagery until repairs are made or a new satellite is launched. The last MERIS image we have is the April 3rd image. NOAA may provide alternative MODIS imagery until communications are re-established. We will keep everyone updated on the progress. For more information visit: http://www.nature.com/news/workhorse-climate-satellite-goes-silent-

Envisat (Photo courtesy of European Space Agency)

Algal Bloom on the Caloosahatchee River-Update: April 13th

Olga, FL: An ongoing cyanobacteria bloom was reported in the Caloosahatchee River. Samples collected on April 2nd were positive for Planktothrix and Anabaena/Aphanizomenon dominant species. (Green Water Laboratories). These species of algae are potential toxin producers. Toxin testing is being conducted by Green Water Laboratories. The South Florida Water Management District plans to send down pulses of freshwater from Lake Okeechobee to 'flush' out the river and increase flows to the Caloosahatchee. The Lee County Health Department has issued a health advisory for the river.

Databases & website (SFEI)

- Databases
  - Cyanotoxins and cyanobacteria species information using CEDEN templates
  - Web base form for entry of bloom information
- Website
  - "My Water Quality" portal (CCHAB workgroup of Ca. WQMC)
  - Report and access:
    - Satellite images w/ indices,
    - Lab data,
    - Bloom information,
    - Incident reports of illnesses or deaths in humans and animals,
    - Newsletter/bulletin

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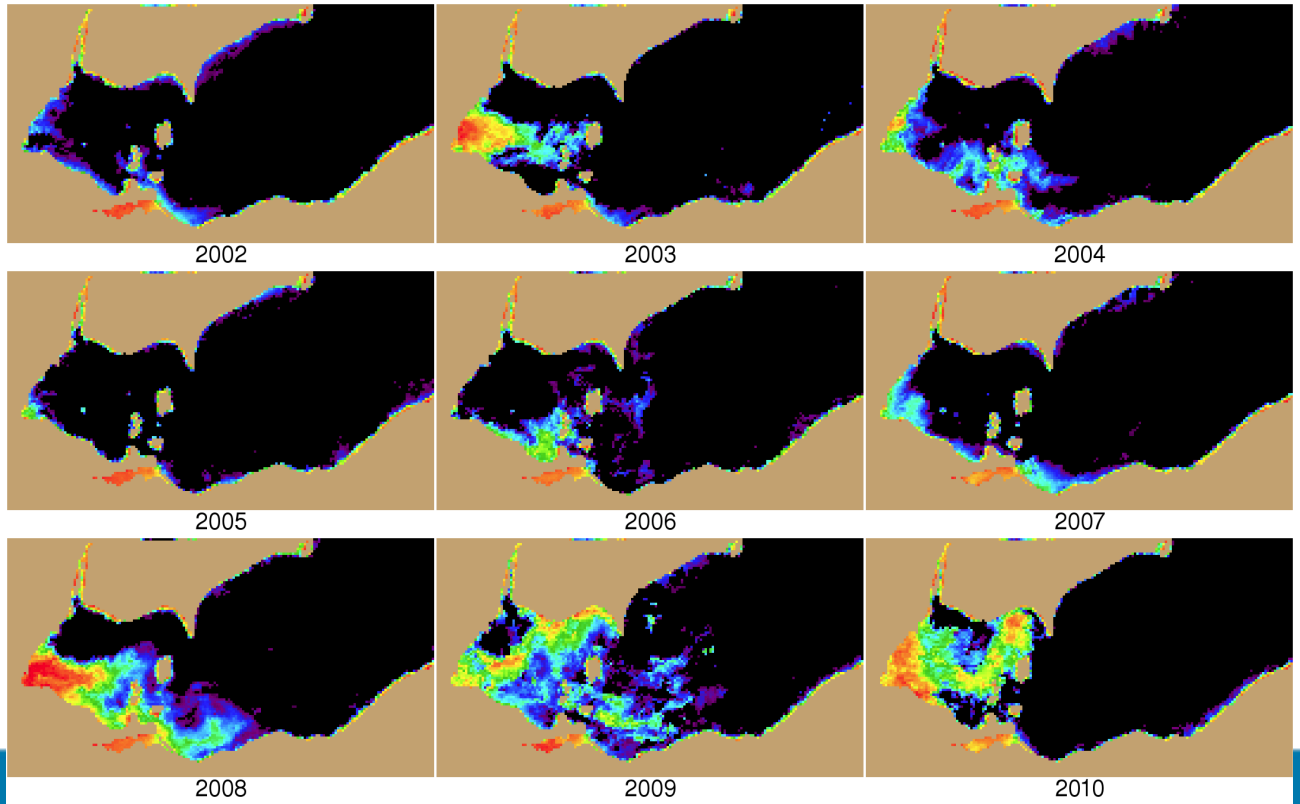
Status and trends report (SFEI)

- Status and trends summary report of cyanoHABs in Ca. using historic satellite imagery and lab data
  - Draft March 1, 2016
  - Final June 1, 2016



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Trainings

- NOAA training May 5 & 6, 2015
  - Overview of cyanoHABs and SWAMP program
  - Downloading & GIS analysis of satellite imagery
- State Water Board Training Academy and SWAMP
  - July 2015 -1 day in four locations - Dr. Wayne Carmichael
    - Background with reference materials
    - Field sampling protocols
    - Health and safety
    - Taxonomy training in laboratory with microscopes
    - Overview of management options
  - Spring 2016 – 2- day in same 4 locations will add:
    - SWAMP CyanoHAB program and guidance documents
    - Field and laboratory analysis for cyanotoxins
    - Tiered approach to sampling and analysis
    - Use of website and database
    - How to report blooms

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The End


WARNING
UNHEALTHY ALGAL BLOOM
IN LAKE WATER: MAY
CAUSE SICKNESS!
PLEASE STAY OUT
OF WATER, AVOID
WATER CONTACT.
THANK YOU FOR YOUR COOPERATION!
CITY OF WATSONVILLE

Joint EPA/NOAA/USGS grant from NASA

- "Cyanobacteria Assessment Network (CyAN) for freshwater systems: an early warning indicator for toxic and nuisance blooms using ocean color satellites"
- The Plan is to start in FY 2015 and end in FY 2020.
- Proposal $4 million

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Joint EPA/NOAA/USGS grant from NASA

- The Project proposes to use remote sensing technologies (satellites) that can monitor cyanobacteria, chlorophyll-a, and turbidity across the continental US, to:
  - develop a standard approach for identification of algal blooms in large surface waters using satellite imaging;
  - develop a dissemination information system (e.g., mobile app) to provide information about conditions in a satellite-tracked waterbody;
  - document impacts to health, economic, and environmental conditions due to cyanobacteria blooms;
  - integrate efforts of federal agencies to mainstream satellite capabilities into water quality management decisions
  - provide early notification and monitoring of blooms for large water bodies in the continental US.
- Satellites - Landsat, Sentinel (-2 and -3) , VIIRS, PACE, MODIS.
- By being proactive Ca. could be an early implementer and Beta tester, if not must wait until 2020

November 2011 Cyanotoxin Workshop - Recommendations

- **Develop a strategy** - Develop a long-term vision and a strategic plan for statewide coordination for addressing cyanotoxins. (contract to develop cyanotoxin monitoring strategy document)
- **Develop and prioritize** multi-agency **management priorities**. (cyanotoxin monitoring strategy document, CCHAB)
- **Synthesize** existing **information** and **identify data gaps**. (NNE contract)
- **Develop standardized protocols** for sampling and analytical methods. (guidance documents)
- **Develop communication tools** for sharing, accessing, and communicating data and information related to CyanoHABs, such as a web portal. Provide opportunities for exchanging information, such as additional workshops. (newsletter, website, trainings)
- **Identify the best use of SWAMP BOG** monitoring and assessment **resources** and additional **partnerships** and funding to support the long-term effort. BOG monitoring funds could be applied as seed funding to do initial groundwork. (Partnerships with NOAA, EPA,)

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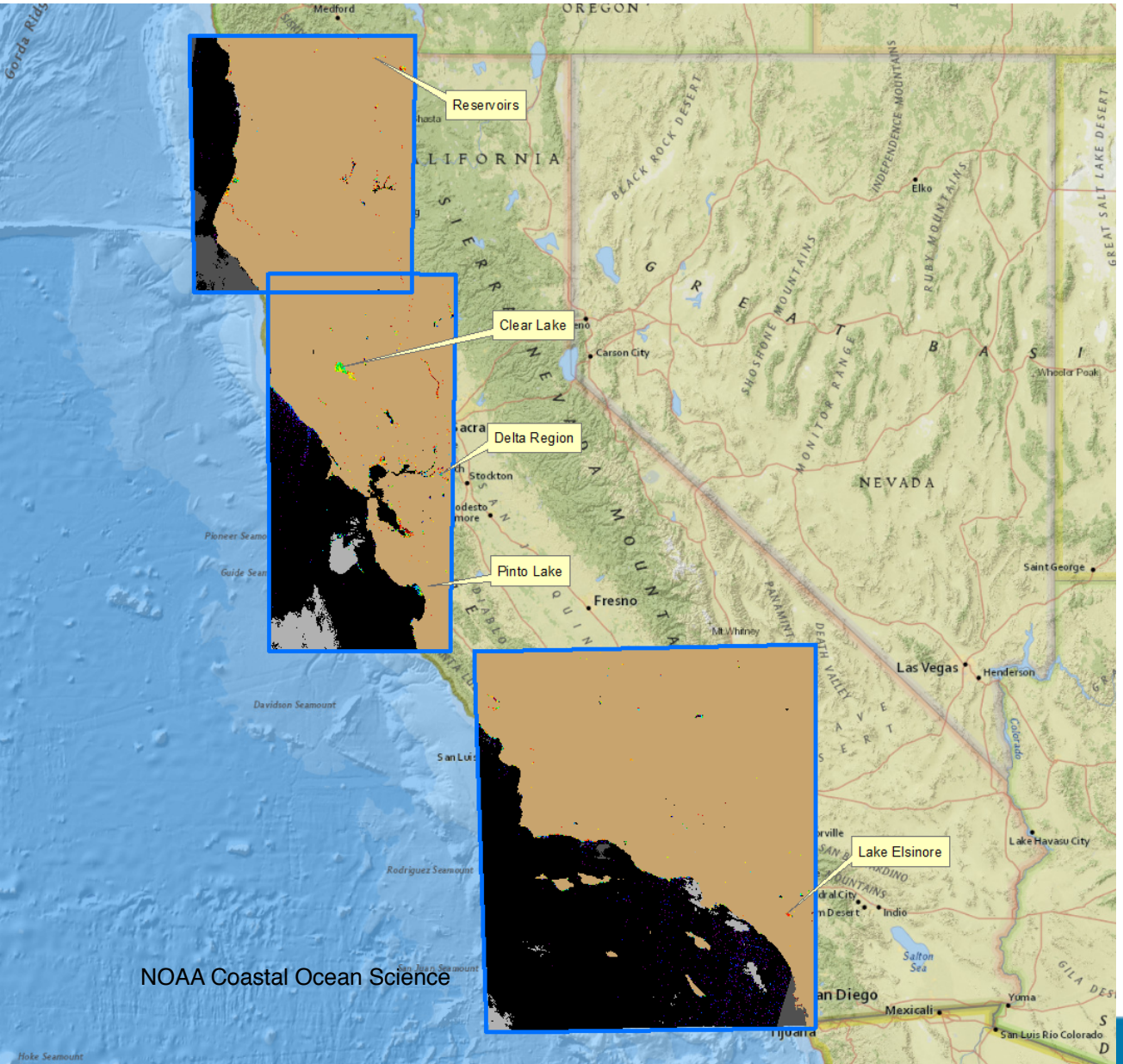
1st NOAA Project - California Lakes

MERIS satellite evaluation of Lakes for HABs



Rick Stumpf

Shelly Tomlinson

Travis Briggs

Tim Wynne

Danielle Dupuy

NOAA Centers for Coastal Ocean Science

For California Water Board (SWAMP BOG)

SWAMP Surface Water Ambient Monitoring Program

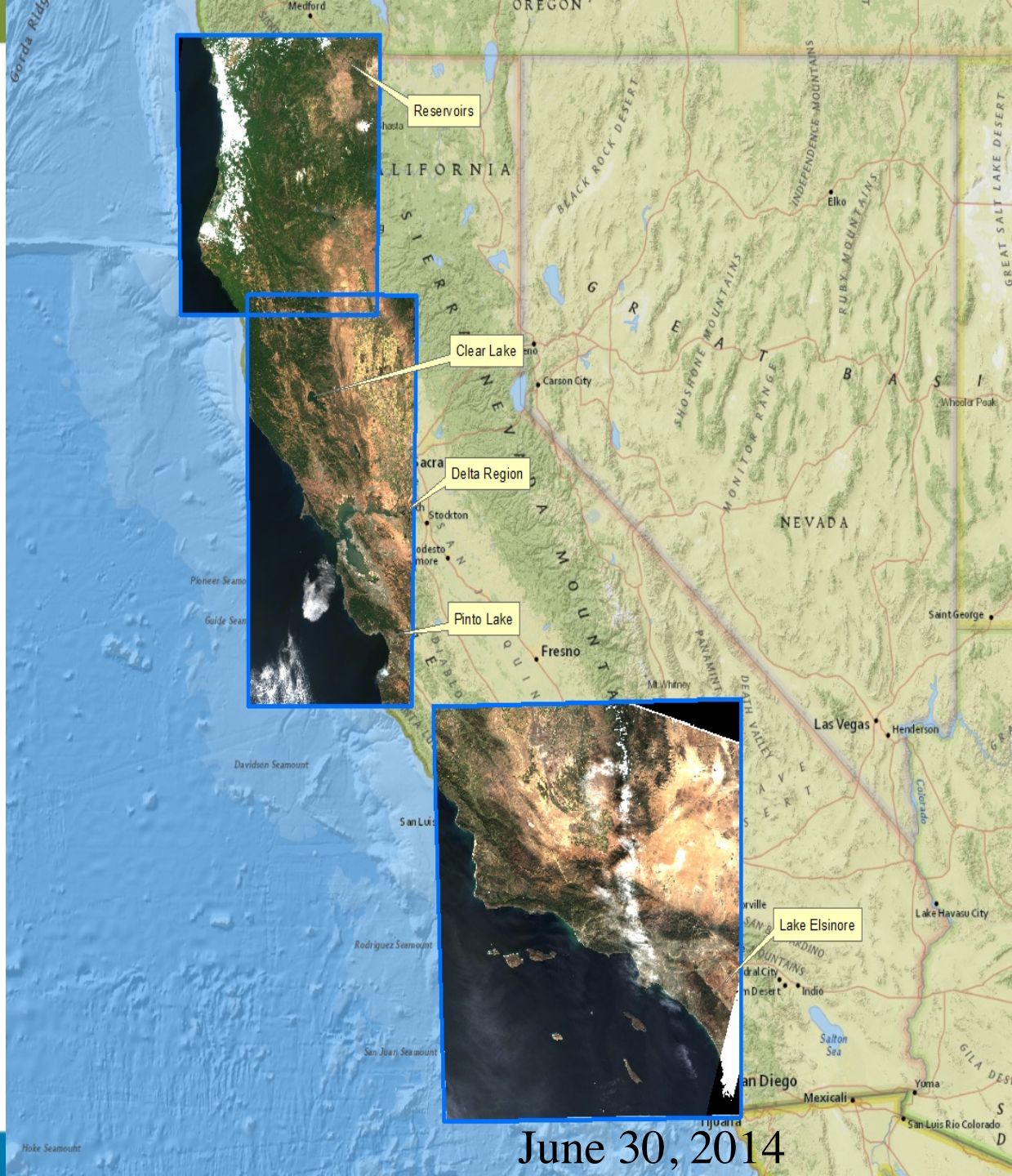
June 30, 2014

Question: Can standard MERIS products identify when lakes have HABs?

Examine whether MERIS is potentially useful in a set of example water bodies which have had reported blooms (2009-2011)

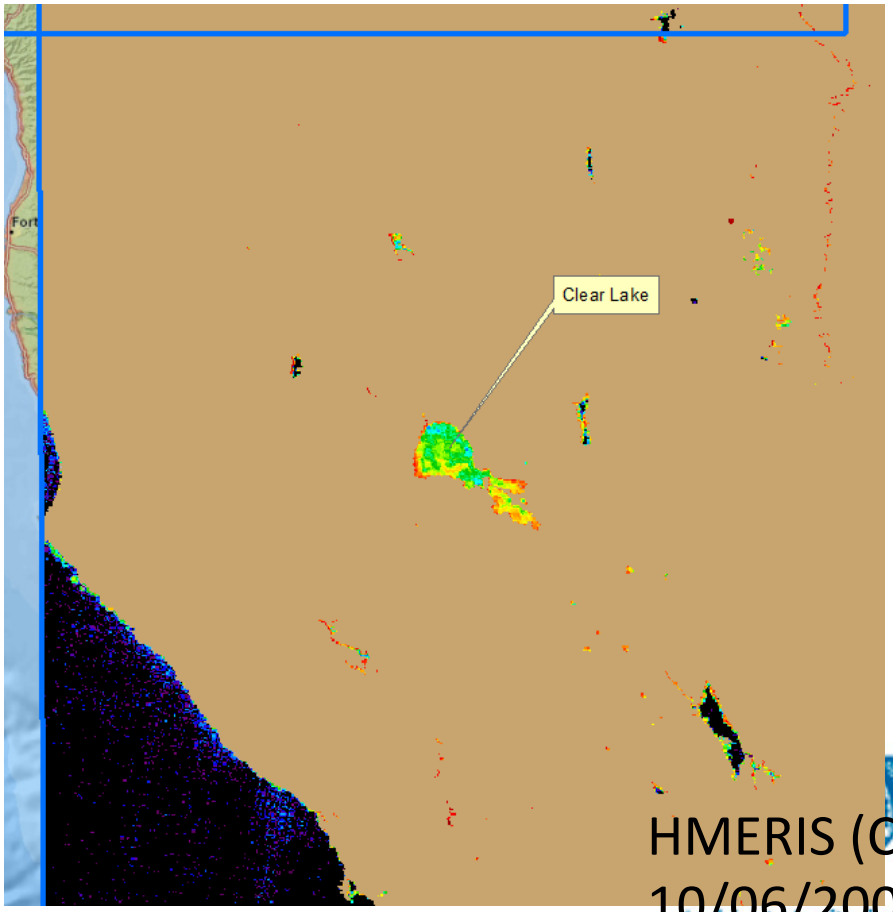
NOAA Coastal Ocean Science

MERIS 300 m resolution



Clear Lake

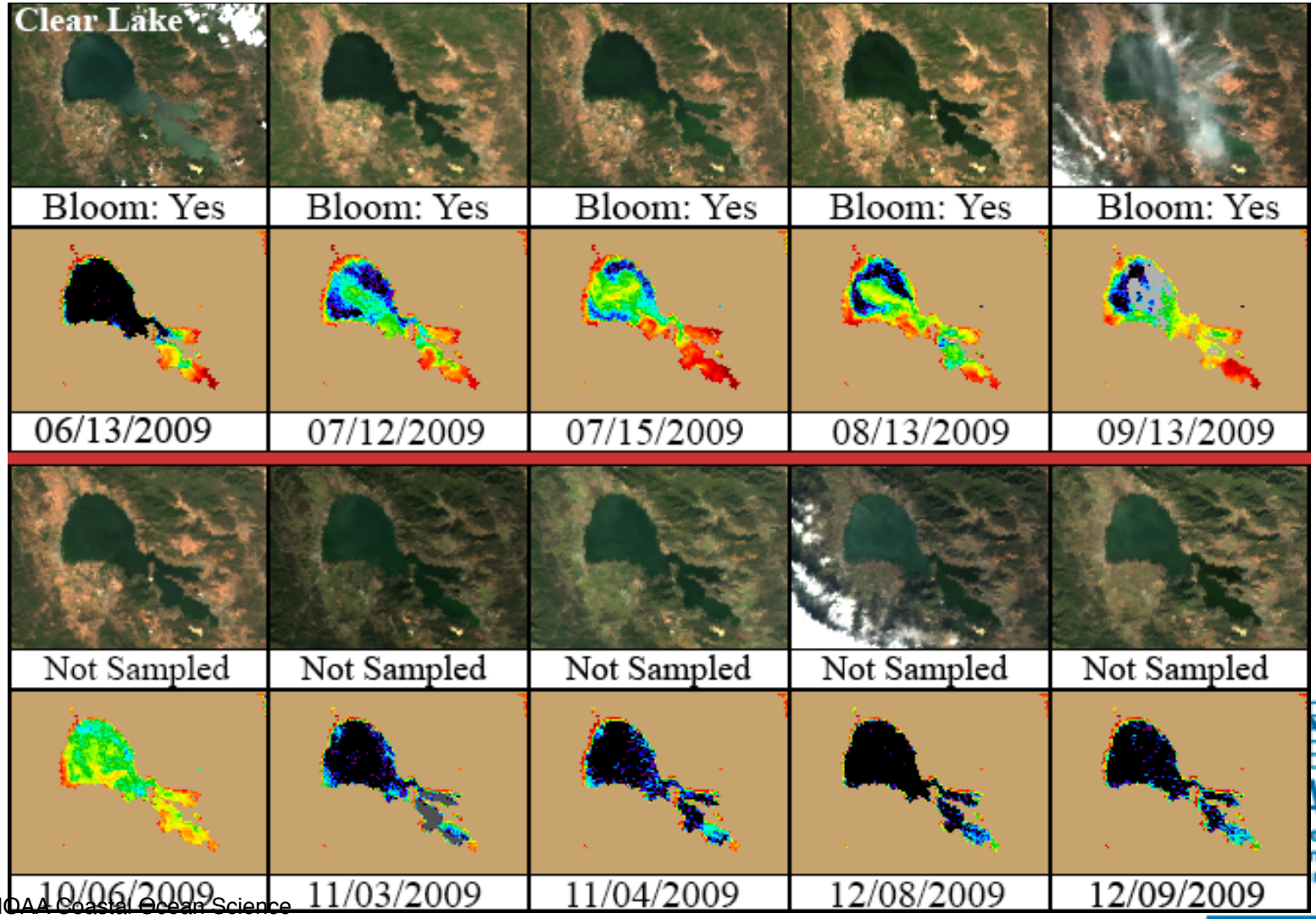
(Adequate size; data available for most of 2009, 2010, and 2011)



HMERIS (CI)
10/06/2009

Clear Lake

(Imagery flags a bloom when field data confirms a bloom; bloom disappears during winter, although not confirmed by in situ data).



Summary

- MERIS can find high-chlorophyll cyanobacteria blooms in California lakes.
- Time series assessment: good coverage from 2009-April 2012; thinner coverage from 2002 to 2009.
- The smallest lakes cannot be resolved in individual MERIS scenes.
- Chlorophyll of > 10-20 ug/L (WHO threshold) detectable. (algorithm under study may achieve 3-10 ug/L)
- Use of multiple sensors: 1) ID blooms w/chl a, 2) determine if phycocyanin, 3) determine biomass w/chl a.

Future

- OLCI/Sentinel-3 continues MERIS coverage after launch in 2015.
- Potential for higher-resolution, less-frequent, chlorophyll with Sentinel-2 after 2015 and another launch in 2017..

SWAMP Surface Water Ambient Monitoring Program