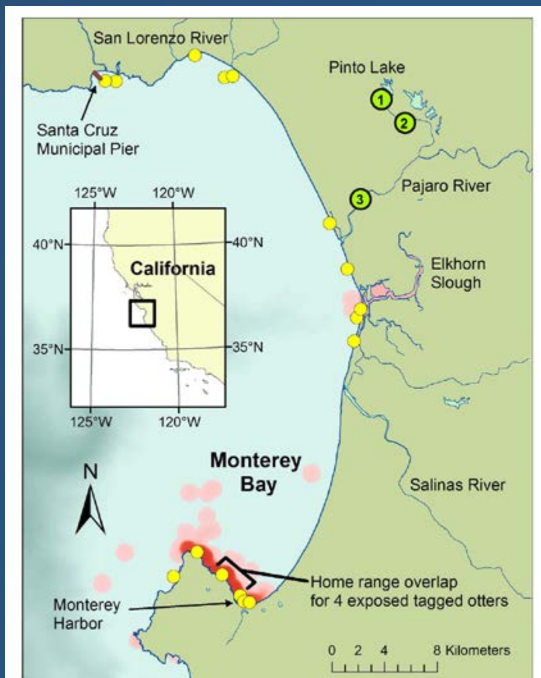
Monitoring Multiple HAB toxins at the Land-Sea Interface in Coastal California

Meredith Howard

Southern California Coastal Water Research Project

Far-Reaching Effects of Freshwater Toxins to Marine Waters



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Evidence for a Novel Marine Harmful Algal Bloom: Cyanotoxin (Microcystin) Transfer from Land to Sea Otters

Melissa A. Miller[1,2]*, Raphael M. Kudela[2], Abdu Mekebri[3], Dave Crane[3], Stori C. Oates[1], M. Timothy Tinker[4], Michelle Staedler[5], Woutrina A. Miller[6], Sharon Toy-Choutka[1], Clare Dominik[7], Dane Hardin[7], Gregg Langlois[8], Michael Murray[5], Kim Ward[9], David A. Jessup[1]

Detection of persistent microcystin toxins at the land–sea interface in Monterey Bay, California

CrossMark

Corinne M. Gibble *, Raphael M. Kudela
Ocean Sciences Department, 1156 High Street, University of California, Santa Cruz, CA 95064, USA

Microcystins are **persistent in the major watersheds** that flow into the ocean in Monterey Bay (Gibble and Kudela, 2014) *toxins*

Article

Microcystin Prevalence throughout Lentic Waterbodies in Coastal Southern California

Meredith D. A. Howard [1,*], Carey Nagoda [2], Raphael M. Kudela [3]
Avery Tatters [4], David A. Caron [4], Lilian Busse [5], Jeff Brown [1], Marth
and Eric D. Stein [1]

toxins

Article

Multiple Stressors at the Land-Sea Interface: Cyanotoxins at the Land-Sea Interface in the Southern California Bight

Avery O. Tatters [1,*], Meredith D.A. Howard [2], Carey Nagoda [3], Lilian Busse [4], Alyssa G. Gellene [1] and David A. Caron [1]

- Multiple cyanotoxins detected simultaneously in many systems (Tatters et al., 2017, Howard et al., 2017)
- Cyanobacteria dominate community composition in estuarine systems in Southern California (Tatters et al., 2017; Howard et al., 2017)

Freshwater Toxins Detected in Marine Shellfish

Blurred lines: Multiple freshwater and marine algal toxins at the land-sea interface of San Francisco Bay, California

Melissa B. Peacock[a, b, c], Corinne M. Gibble[b, d], David B. Senn[d], James E. Cloern[e], Raphael M. Kudela[b]

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ENVIRONMENT

San Francisco Bay Shellfish Are Loaded With Toxins, Study Finds

A man fishes at Baker Beach in San Francisco, with the Golden Gate Bridge in the ba

Evidence of freshwater algal toxins in marine shellfish: Implications for human and aquatic health

CrossMark

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MONITORING MULTIPLE HAB TOXINS AT THE LAND-SEA INTERFACE IN COASTAL CALIFORNIA

Meredith D.A. Howard[1], David Caron[2], Raphael Kudela[3], Keith Loftin[4], Avery Tatters[2], Kendra Hayashi[3], Jayme Smith[2], Ariel Donovan[4], Zachary Laughrey[4], Carey Nagoda[5], Betty Fetscher[5], Suzanne Fluharty[6], Richard Fadness[7] Jeff Crooks[8], Justin McCullough[8], Monica Almeida[8]

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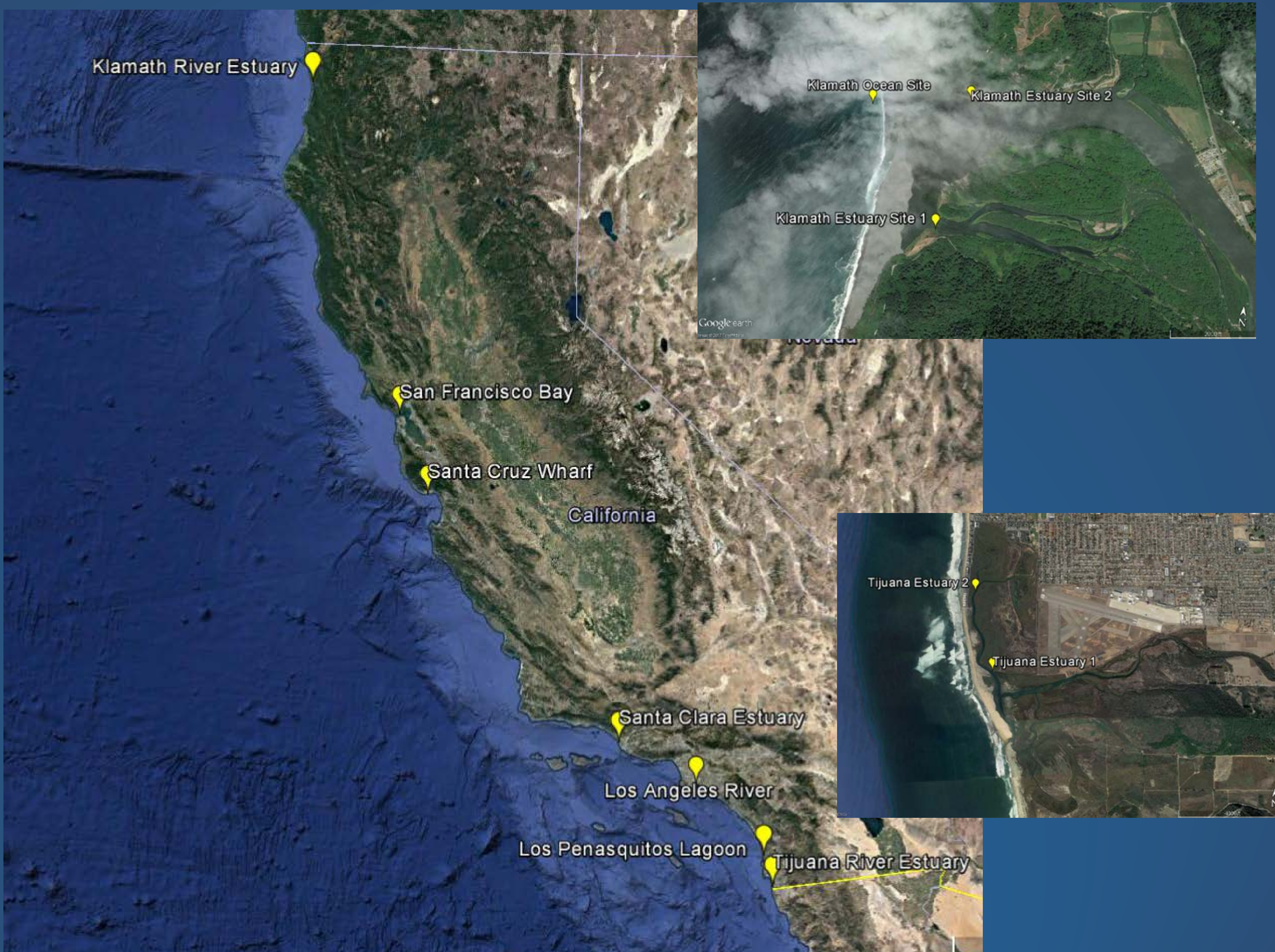
[6]Yurok Tribe, Klamath, CA

[7]North Coast Regional Water Quality Control Board, Santa Rosa, CA

[8]Tijuana River National Estuarine Research Reserve, Imperial Beach, CA


Klamath River Estuary
San Francisco Bay
Santa Cruz Wharf
California
Santa Clara Estuary
Los Angeles River
Los Penasquitos Lagoon
Tijuana River Estuary
Klamath Ocean Site
Klamath Estuary Site 2
Klamath Estuary Site 1
Google earth
Tijuana Estuary 2
Tijuana Estuary 1

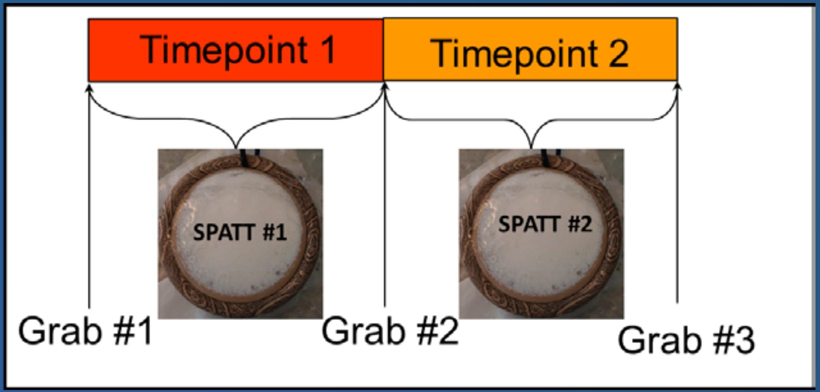
Challenges of Monitoring at the Land-Sea Interface

1. **Ephemeral pulses of toxin**
   – New monitoring tools and approaches

2. **Physical challenges: Adaptive approaches**

Solid Phase Adsorption Toxin Tracking

- Passive Sampler that is time-integrative
- Continuous toxin detection to capture ephemeral events
- Applicable in all waterbody types and for many different toxins
- Low cost, simple and easy to deploy/recover
- Not applicable to health advisory thresholds (ng/g)
- Only measures dissolved toxins not total toxins



Physical Challenges

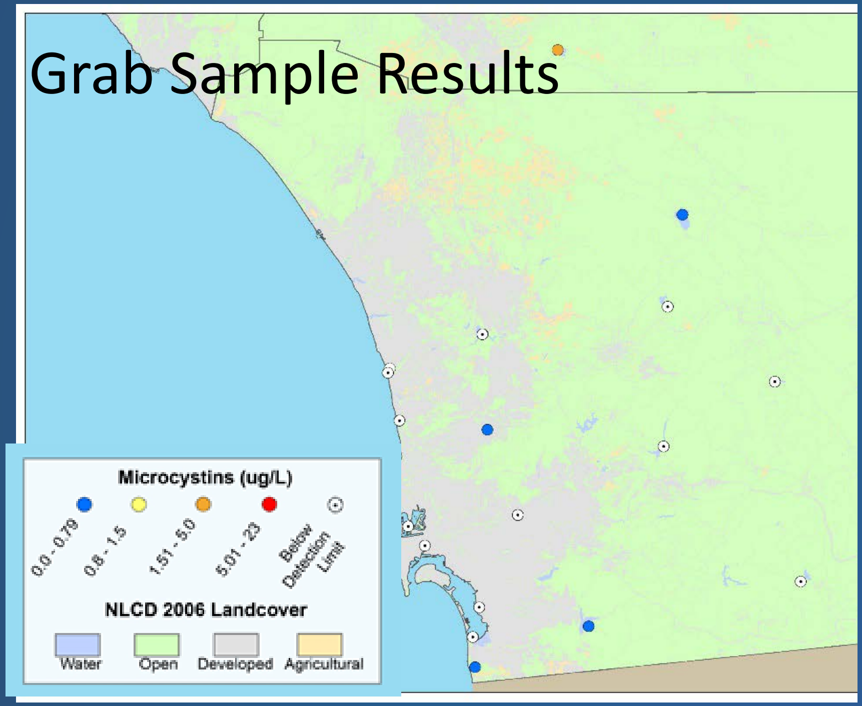
SPATT Housing

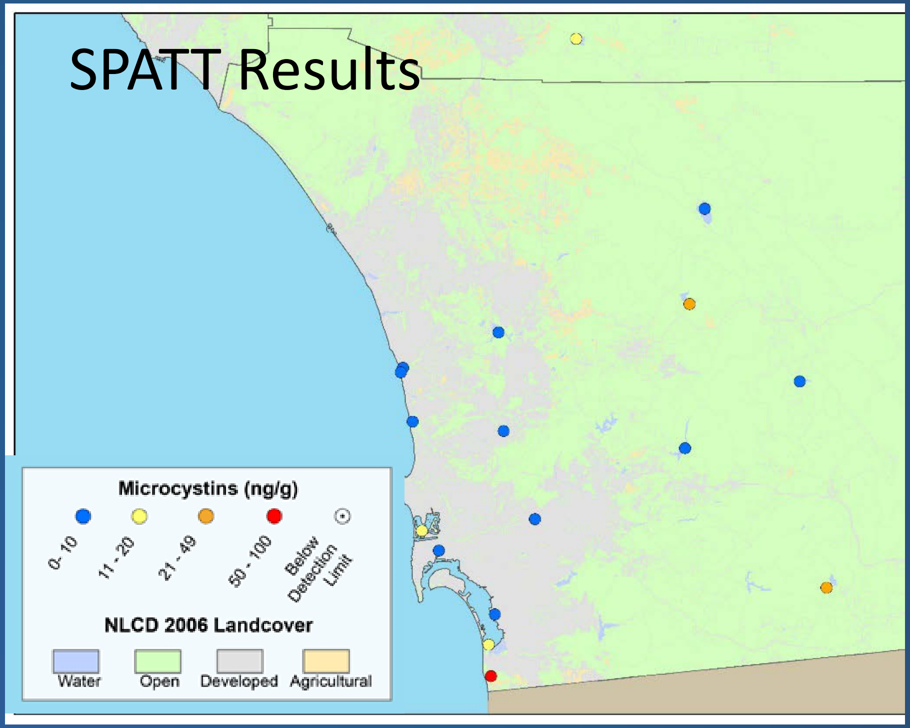
Picture: Keith Bouma-Gregson

Cyanotoxin Prevalence Underestimated From Grab Samples

% of Wetlands Sites Microcystins Detected

Grab Samples	29%
SPATT Samples	83%



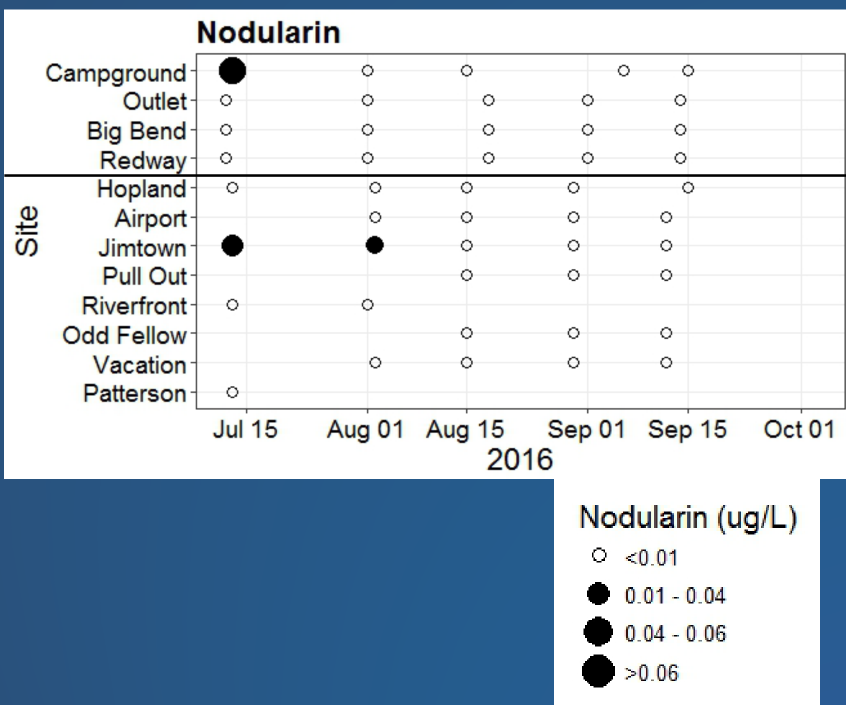


Howard et al., 2017; Kudela, 2017, Kudela 2011

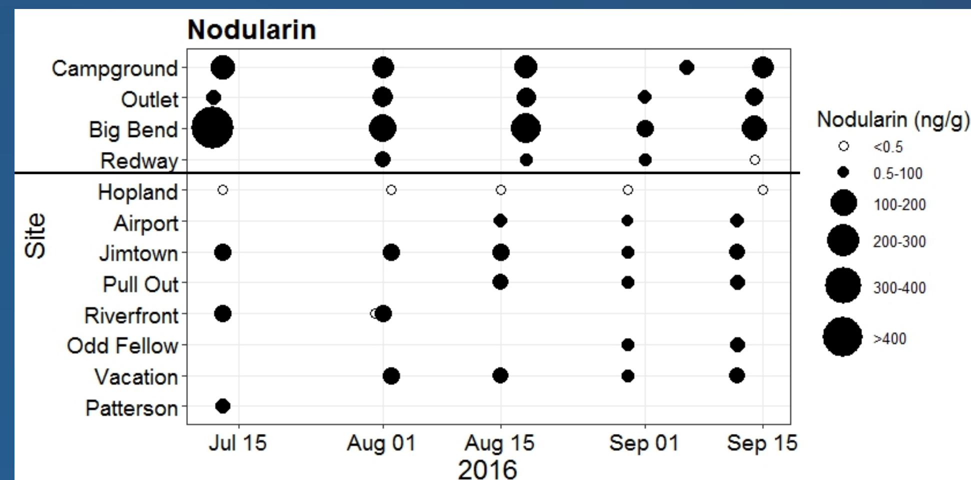
Each Sample Type Contributes a Different Piece of the Toxin Story

Nodularin

Grab Sample Results



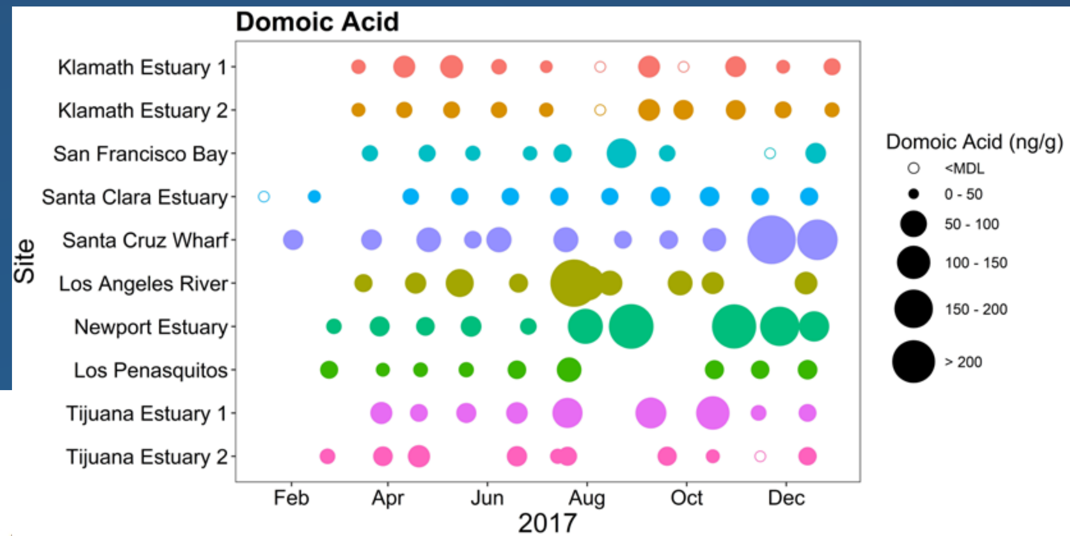
SPATT Results



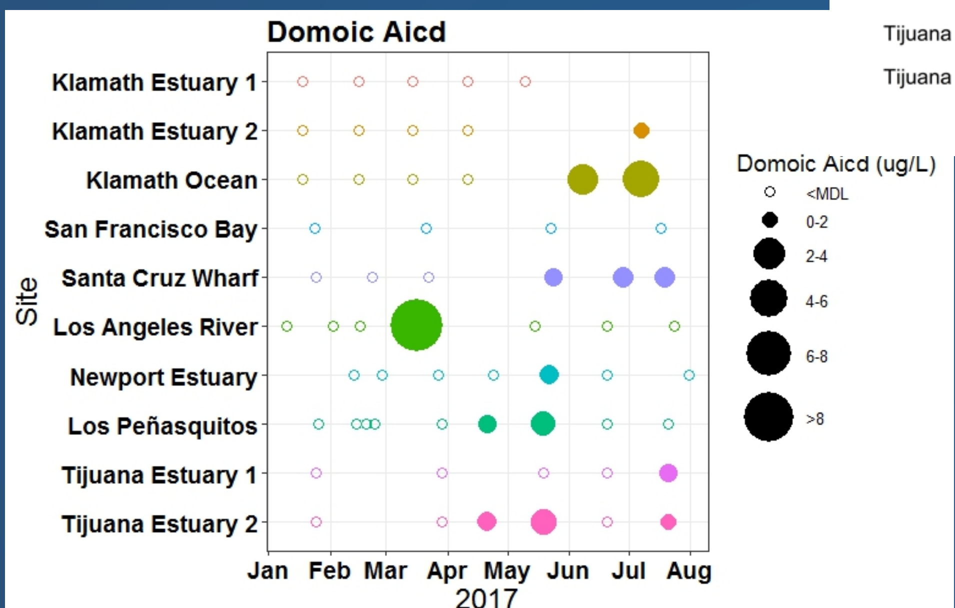
Sample Types	Nodularin
SPATT (ng g^{-1})	bd - 450
Water (µg L^{-1})	bd-0.06
Cyanobacterial Mats (µg L^{-1})	NA

Chronic Low Levels of Dissolved Domoic Acid Throughout California Estuaries

SPATT Results



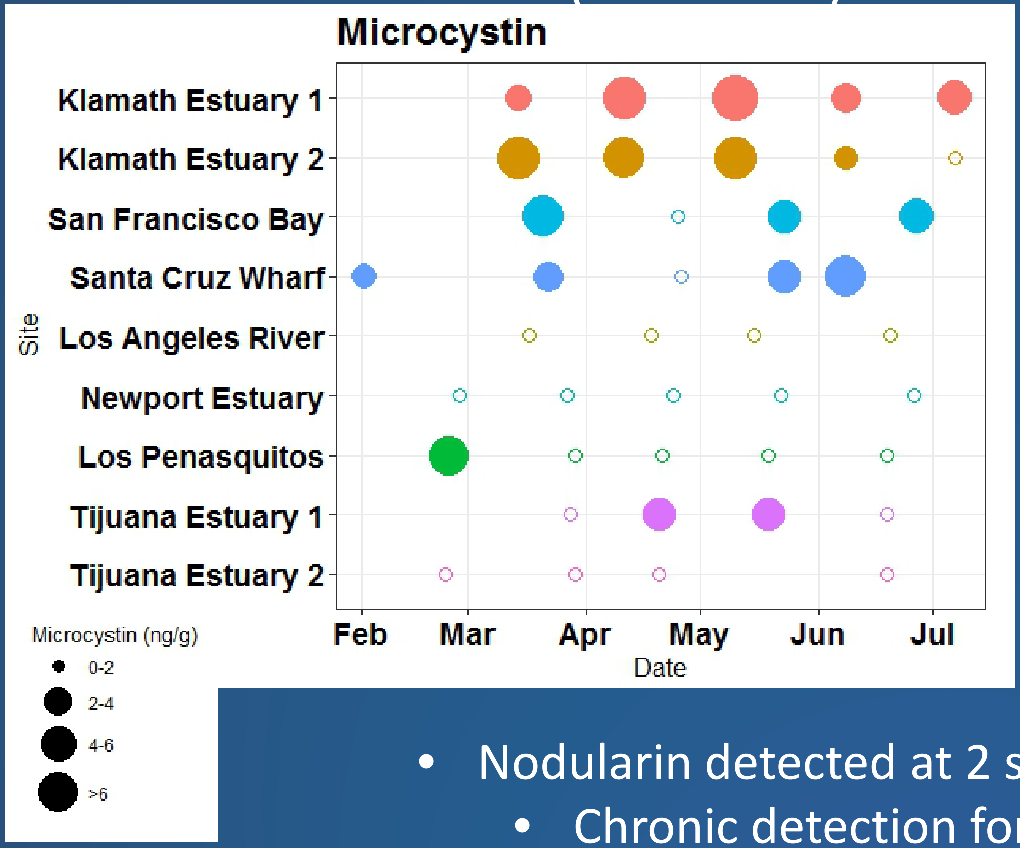
Whole Water Grab Results



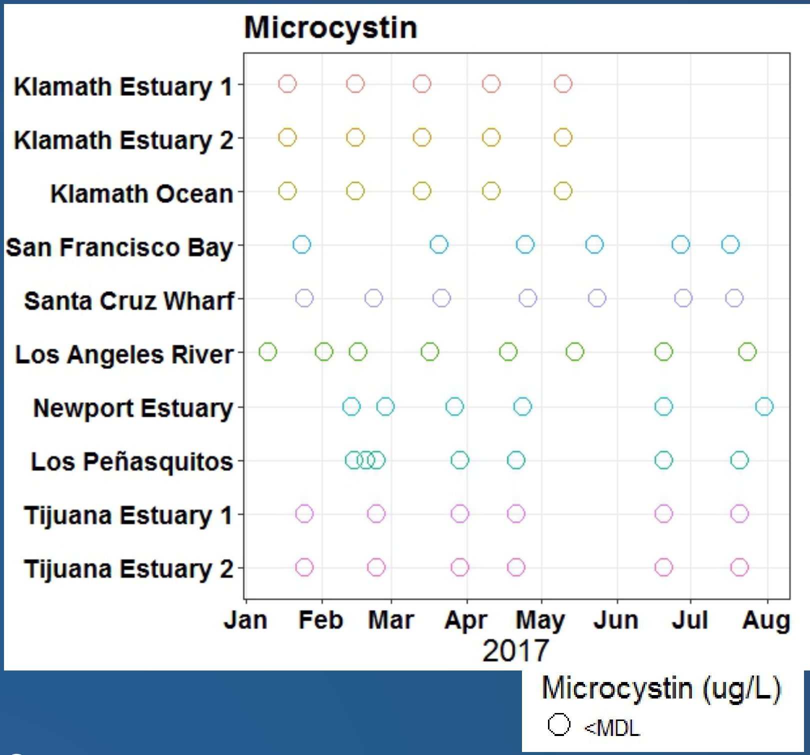
Howard, Kudela, Caron and Loftin, Unpublished Data

Microcystins Detected at Marine and Estuarine Coastal Sites

SPATT Results (dissolved)

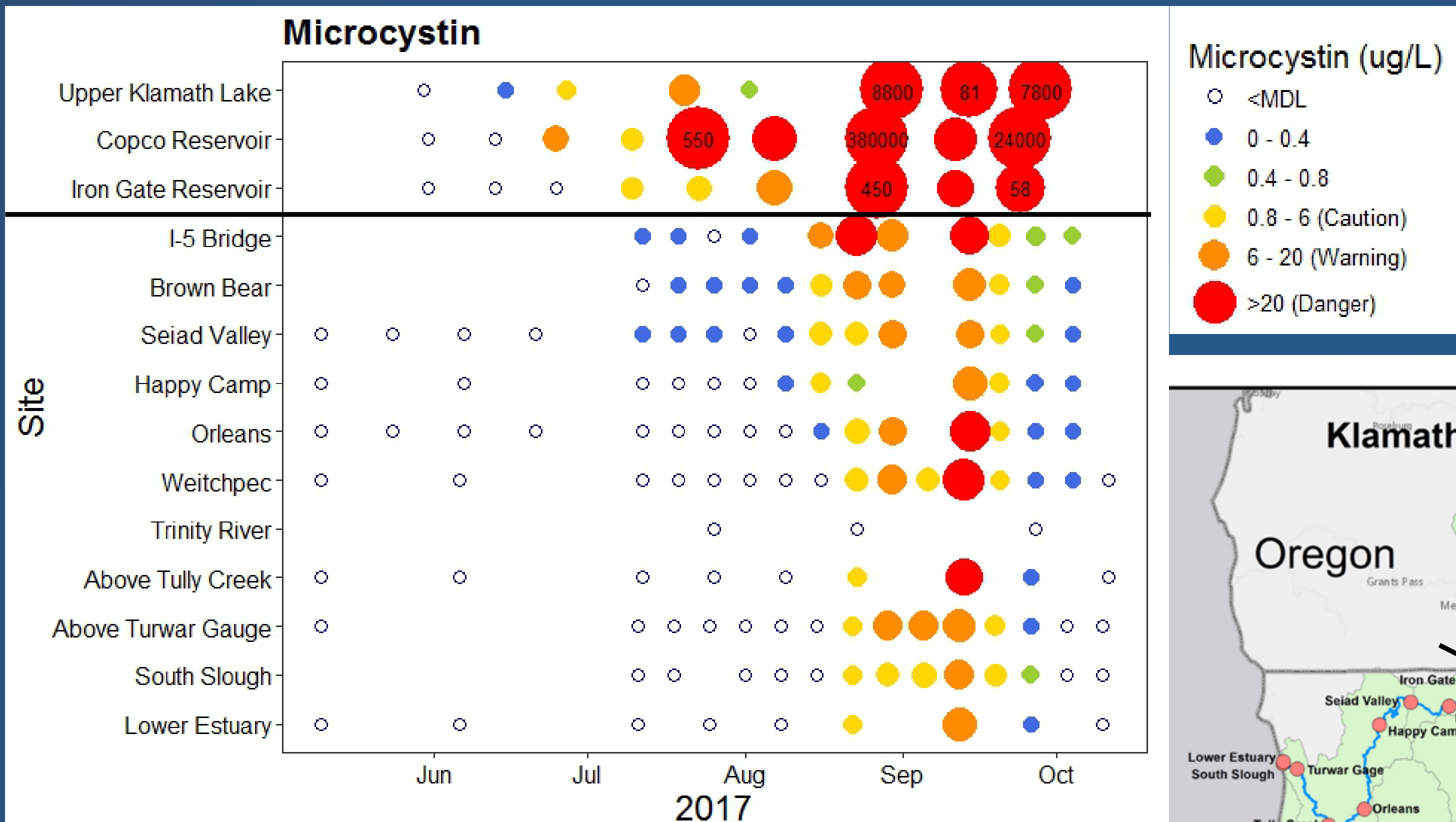


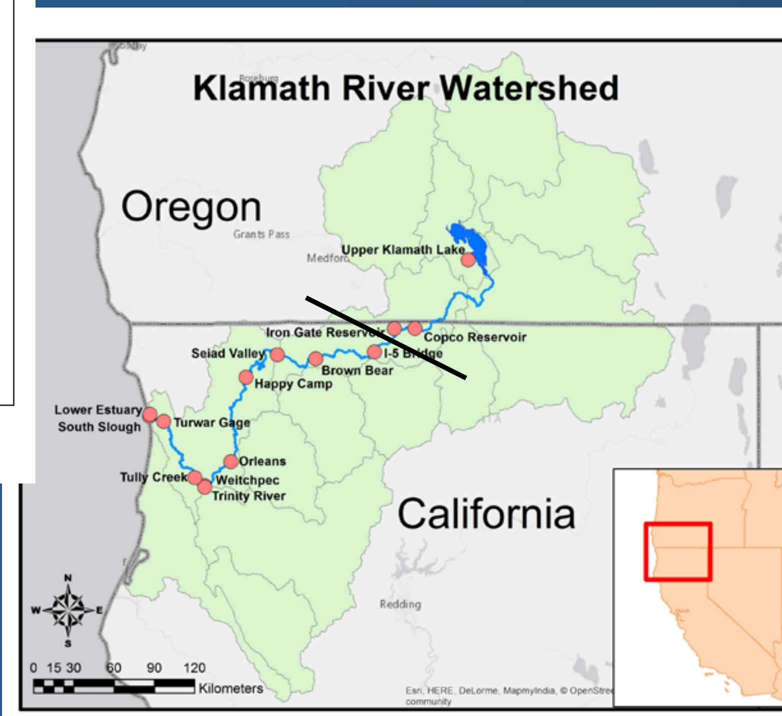
Whole Water Grab Results



- Nodularin detected at 2 sites
  - Chronic detection for 3 months at Los Penasquitos
- Anatoxin-a detected at 4 sites
- Cylindrospermopsin not detected

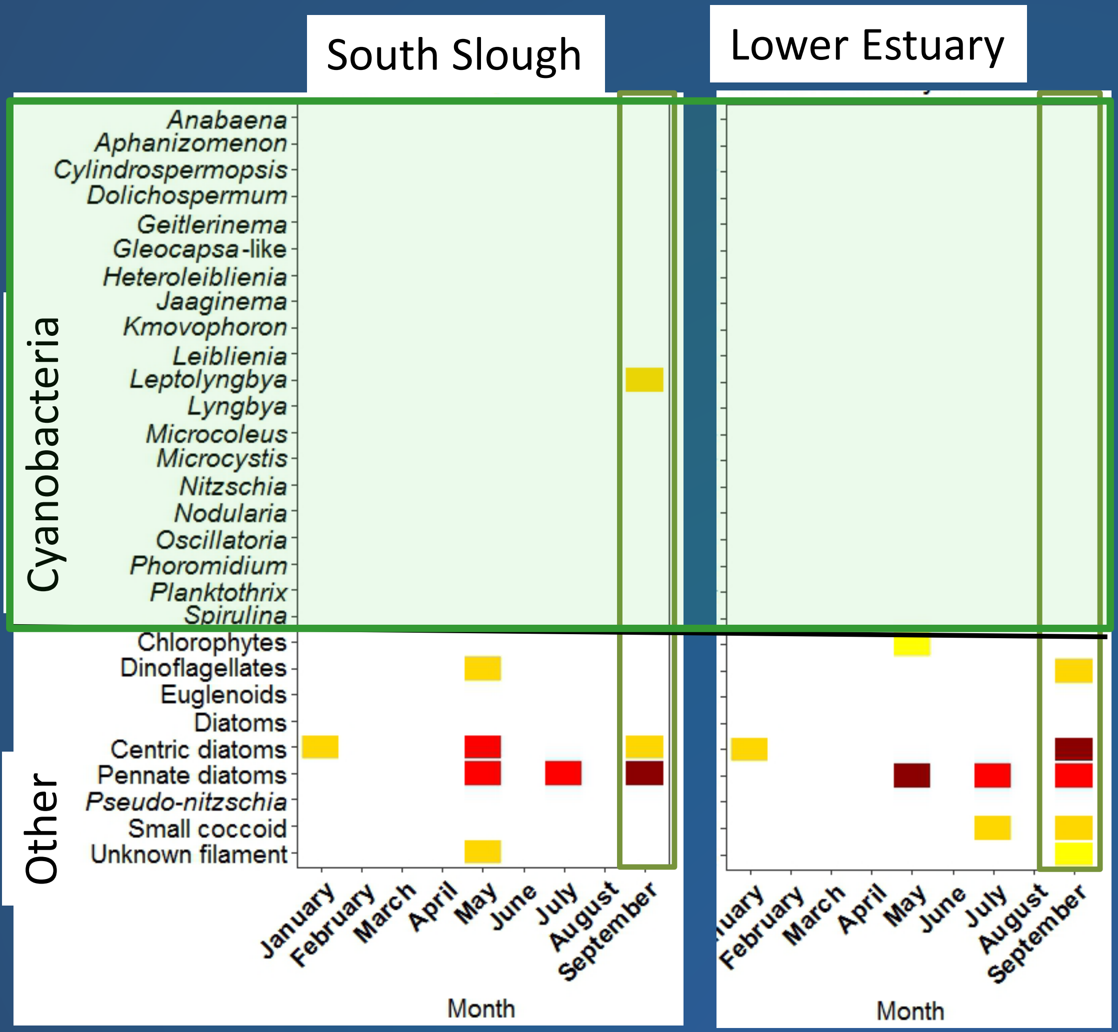
Microcystins Produced in Inland Reservoirs Transported Downstream

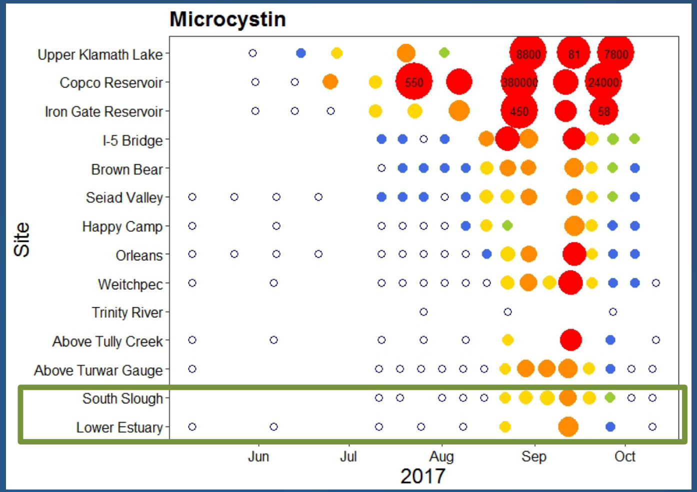




Microcystins detectable throughout river and estuary sites when maximum concentrations detected in reservoirs

Community Composition Results Indicate Toxin Originated Upstream





Lower Estuary

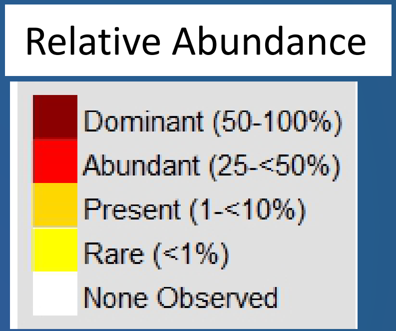
Anabaena circinalis nd - 10^2 cells/mL

M. Aeruginosa nd - 10^2 cells/mL

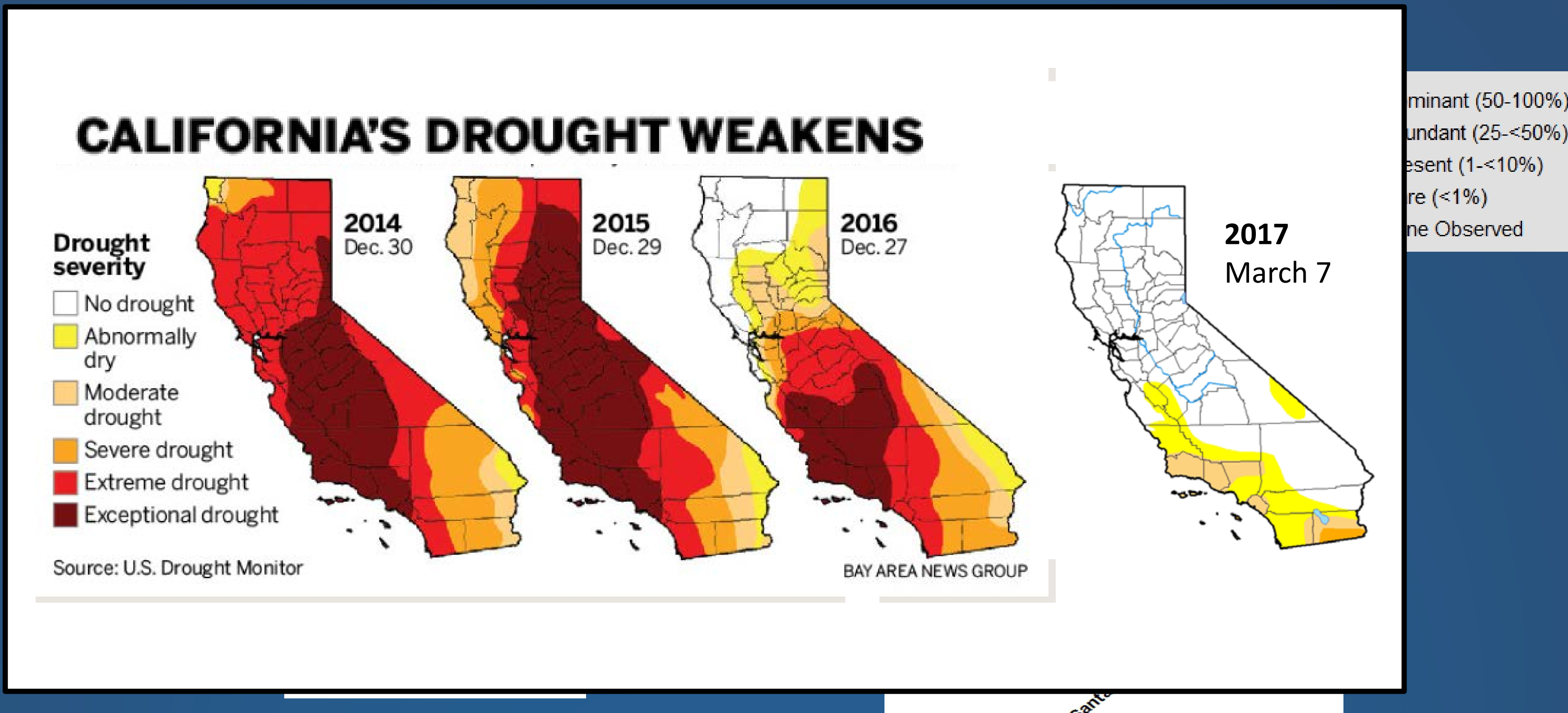
South Slough

Anabaena circinalis nd - 10^3 cells/mL

M. Aeruginosa nd - 10^4 cells/mL



Droughts, Storms and Community Composition



Tatters et al. 2017

- Relative abundance indicates 2017 was dominated by diatoms and dinoflagellates
  - Cyanobacteria frequently observed in 2015 and 2016
- Hydrology and weather impacts
  - 2015 and 2016 record drought years
  - 2017 record storms and precipitation

Russian and Eel Rivers Cyanotoxin Field Study

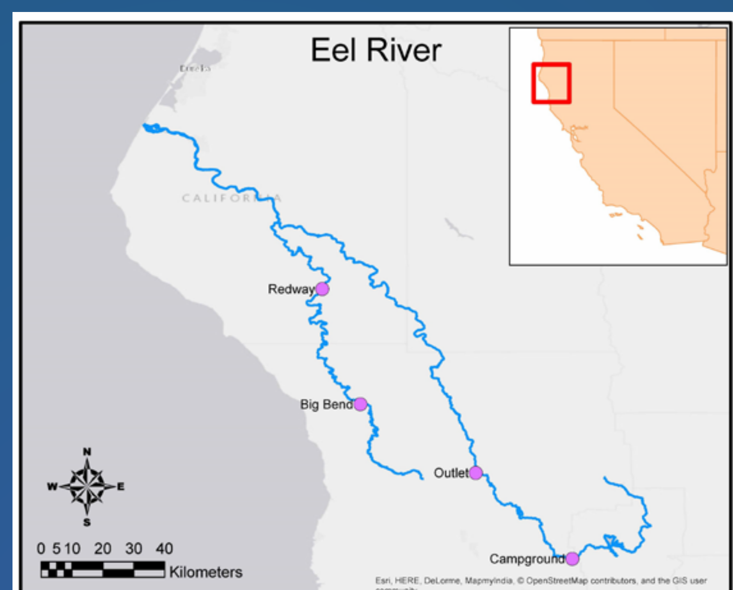
Monitoring Sites:

- July – Oct 2016, sampling 2X per month

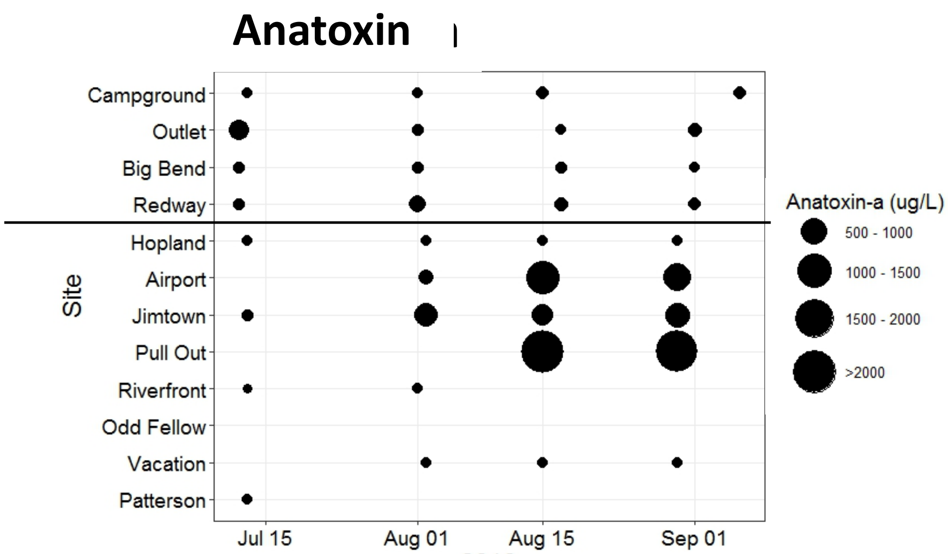
Cyanotoxins measured from 3 sample types:

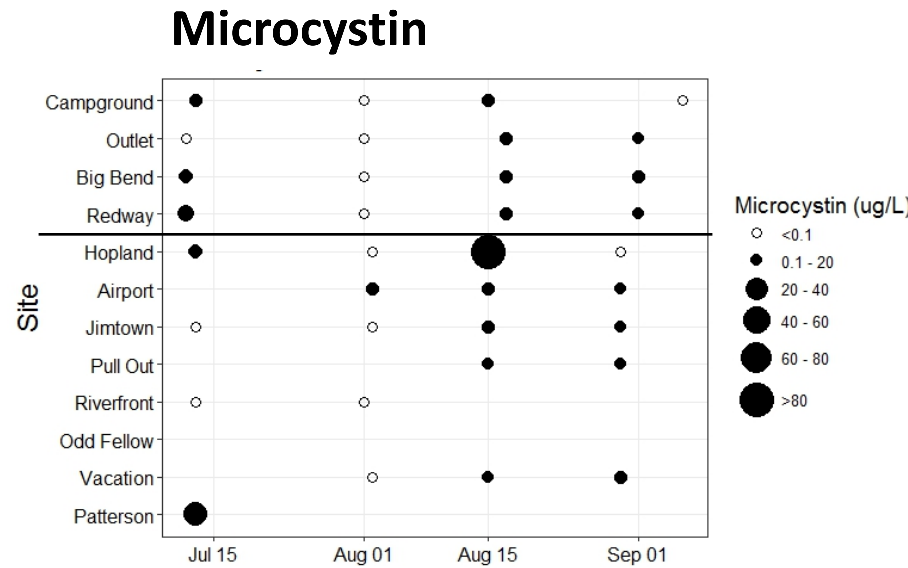
- Whole water (particulate and dissolved)
- SPATT passive samplers (dissolved)
- Cyanobacterial mats (particulate)

Cyanotoxins measured using LC-MS or ELISA (microcystins, anatoxin, nodularin, saxitoxin, cylindrospermopsin)



Buoyancy of Cyanobacterial Mats Increases Downstream Dispersal





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Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

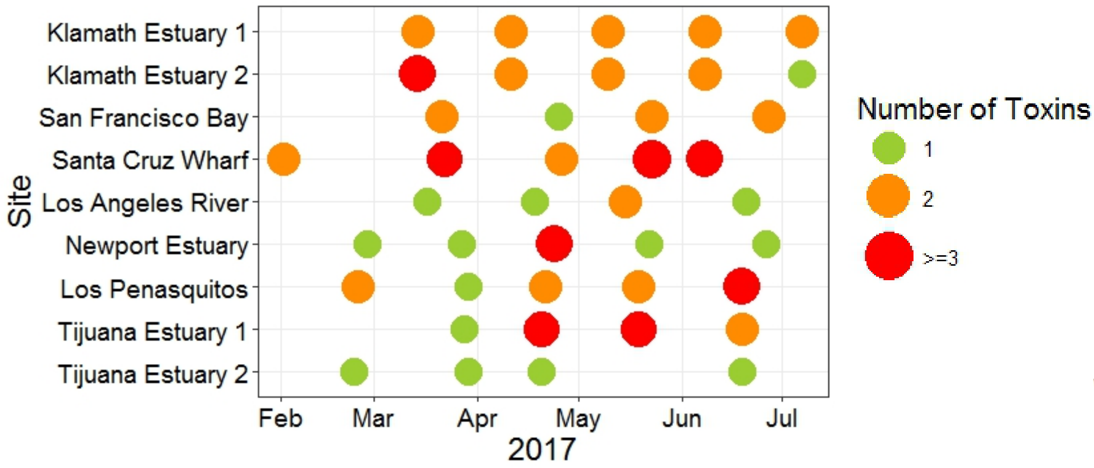
Rise and fall of toxic benthic freshwater cyanobacteria (*Anabaena* spp.) in the Eel river: Buoyancy and dispersal

Keith Bouma-Gregson[a,*], Mary E. Power[a], Myriam Bormans[b,c]

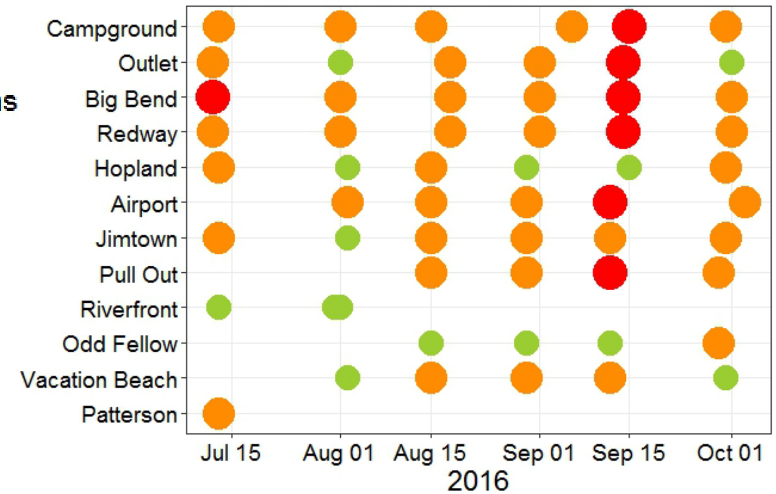
- Release of floating clumps from mats that are able to maintain buoyancy
- Buoyancy mechanism increases downstream dispersal distances

Synergistic Stressors at the Land-Sea Interface: Simultaneous Detection of Multiple Toxins

MERHAB Ocean and Estuarine Sites 2017



Russian and Eel Rivers - 2016



Similar results in San Francisco Bay, San Diego, Riverside Lakes (Howard et al., 2017, Peacock et al., 2018)

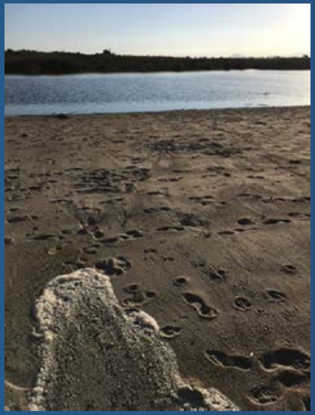
Recreational and drinking water health thresholds are based on single toxin exposure….

What are the consequences of exposure to multiple toxins for human, wildlife and ecological health?

Final Thoughts and Conclusions

- Chronic low concentrations of dissolved toxins detected throughout CA
  - SPATT results reveal chronic issue that may have health implications not currently addressed in routine monitoring programs
- Simultaneous detection of multiple toxins in most coastal monitoring sites in California
  - We hypothesize that mixtures of toxins can act as multiple physiological stressors with unknown consequences
- Monitoring programs should include both marine and freshwater toxins at the land-sea interface
  - SPATT combined with traditional monitoring provides comprehensive insight into toxin dynamics





Acknowledgements

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