New Monitoring and Assessment Approaches for HABs in California

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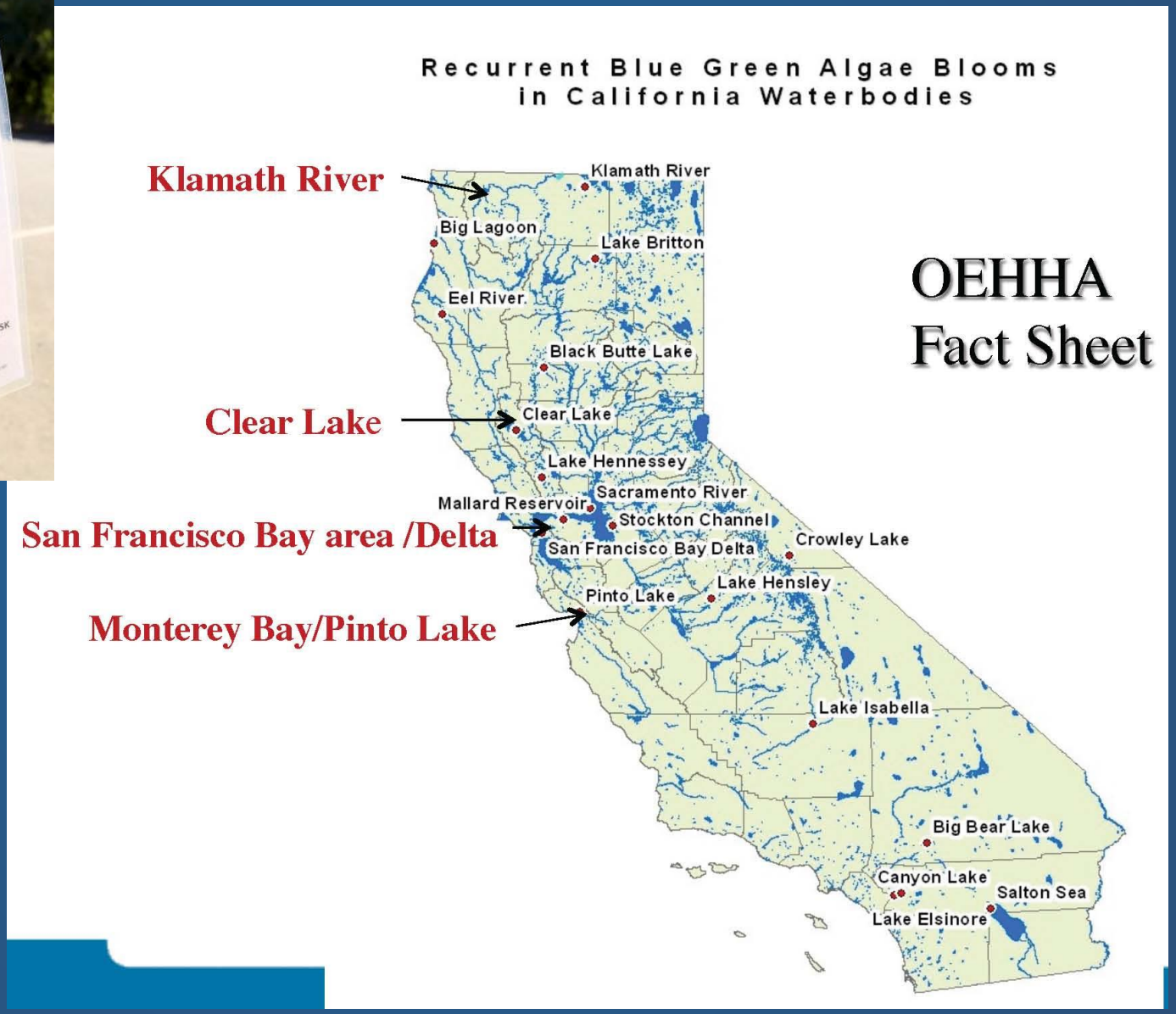
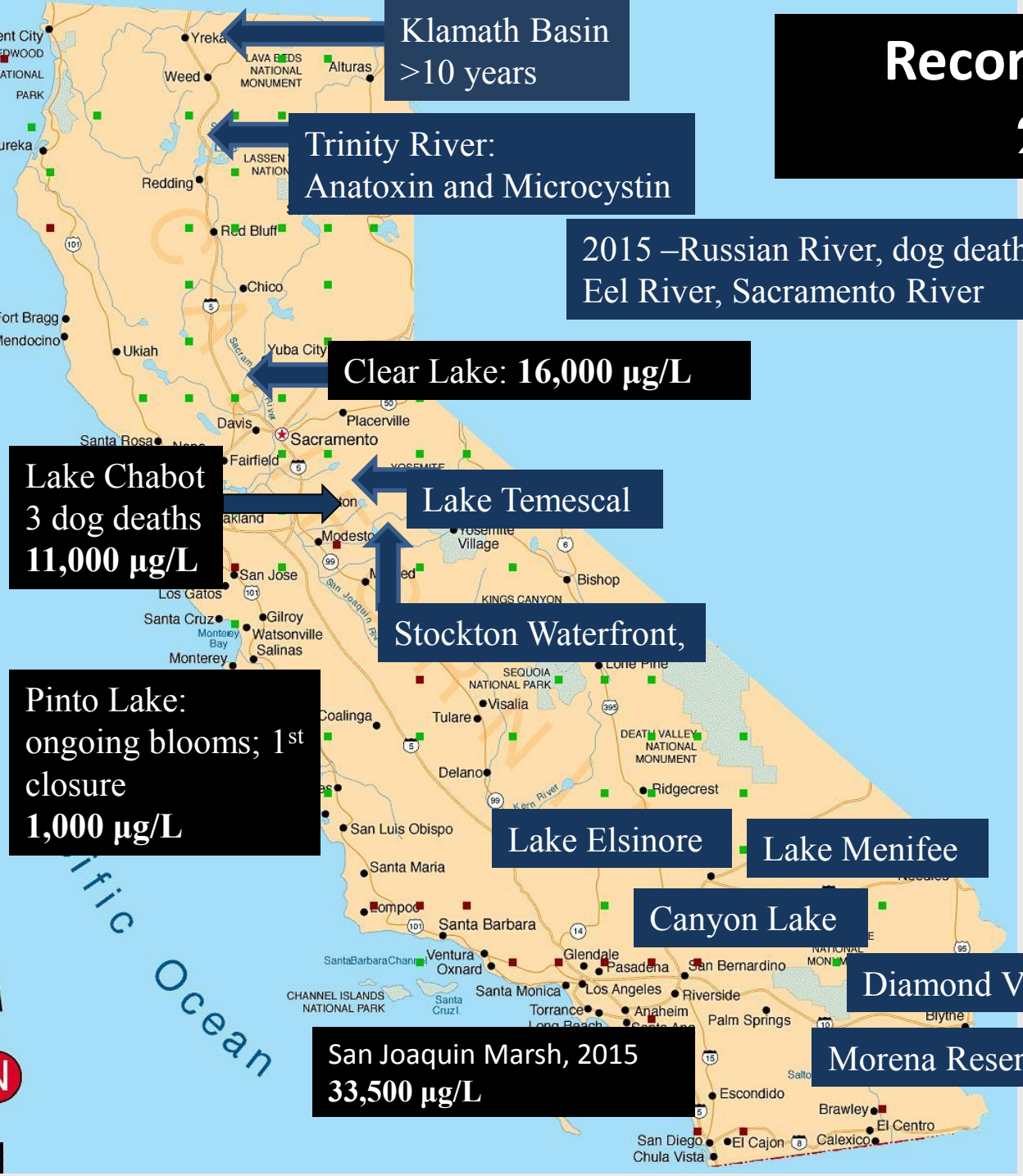
Historic Cyanotoxin Hotspots in California

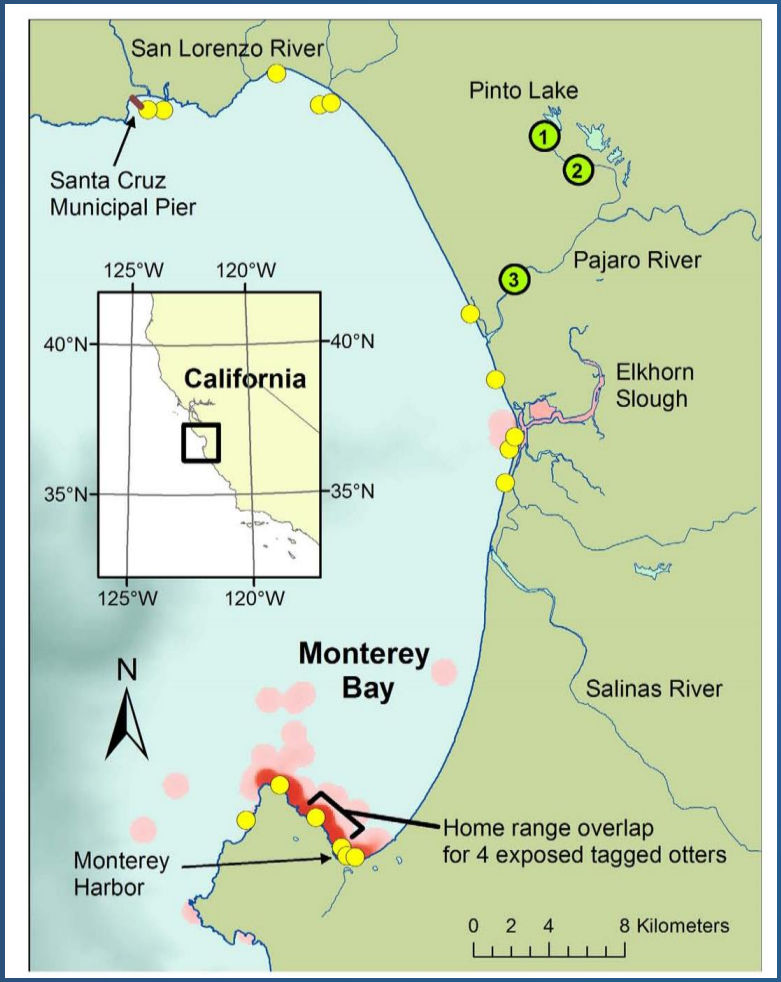


Record Breaking Years 2014 – 2015



- First time several lakes closed due to cyanotoxins
- Extremely high microcystin concentrations recorded
- Several dog deaths attributed to cyanotoxins
- Multiple toxins detected simultaneously
- Fish kills caused by *Pyrmnesium parvum*

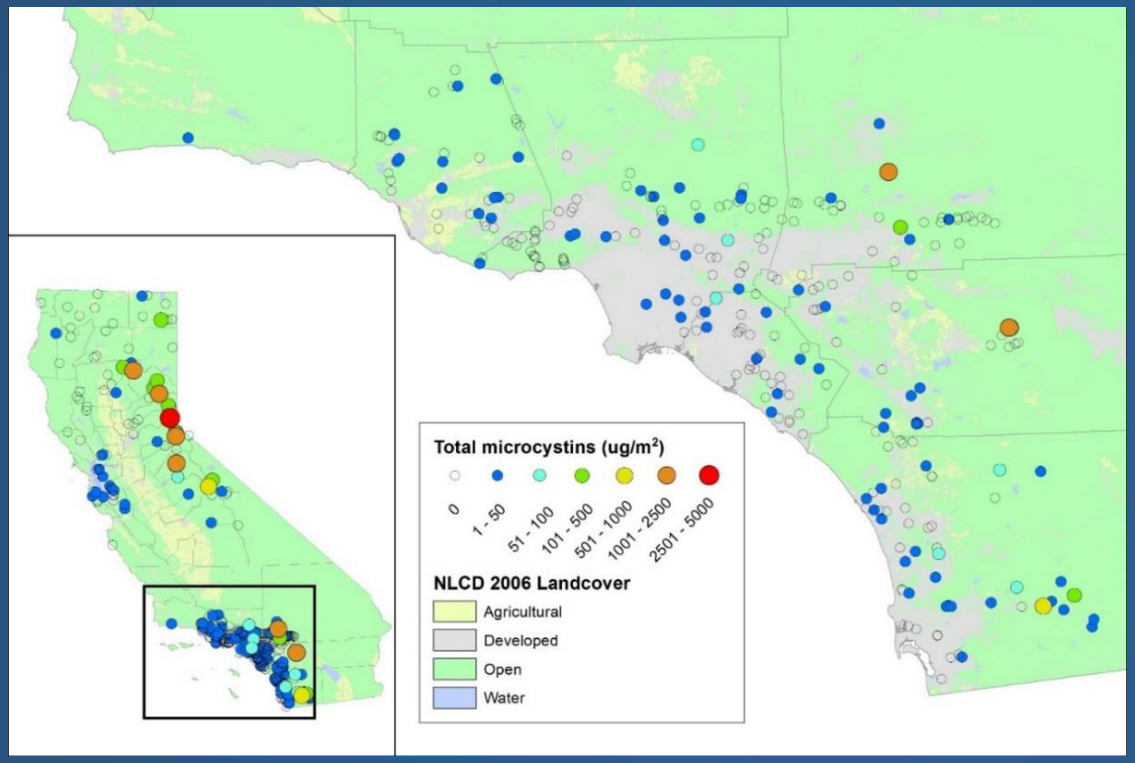
Far-Reaching Effects of Freshwater Toxins to Marine Waters

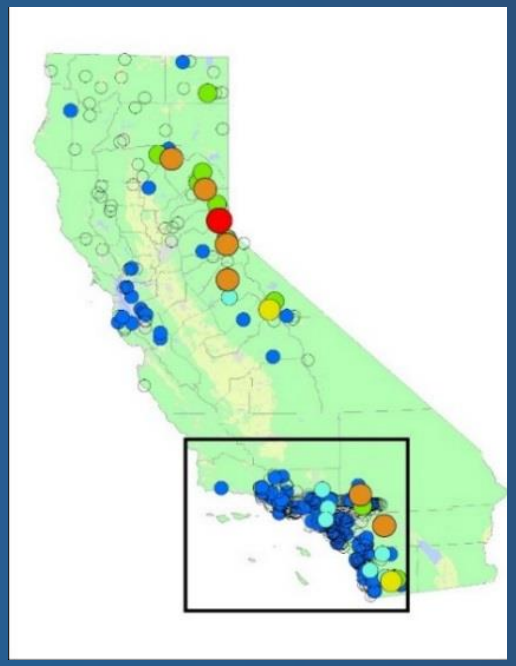


Mortality of sea otters due to microcystin intoxication

Miller *et al.*, 2010

Benthic Algae from Wadeable Streams a Potential Source of Toxin Loading to Downstream Waterbodies





Fetscher et al. 2015 Harmful Algae

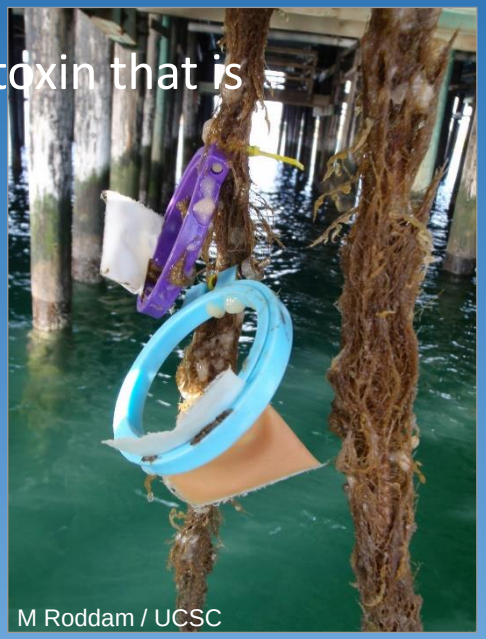
Microcystins detected at 33% of sites in California

Microcystins detected in 30-40% of sites in southeastern US stream study (water samples, not benthic algae) (Loftin et al., 2016)

Monitoring Tool:
Solid Phase Adsorption Toxin Tracking
SPATT

Passive sampler that is time-integrative

- Applicable in all waterbody types (marine, brackish, freshwater)
- Detects both freshwater and marine toxins
- Amenable to multiple toxin detection methods
- Low cost, simple and easy to deploy/recover
- *Disadvantage*: SPATT will not provide a concentration of toxin that is applicable to health advisory thresholds
  - ng/g units



MacKenzie, 2010, Lane et al., 2010, Kudela, 2011

Solid Phase Adsorption Toxin Tracking (SPATT)

- Has been used in many areas of the world for the monitoring of dissolved algal toxins
  - Anatoxins (Wood et al 2011)
  - Azaspiracids (Fu et al 2009)
  - Dinophysistoxins (Fu et al 2008, 2009, Pizarro et al 2013)
  - Domoic acid (Lane et al 2010)
  - Microcystins (Kudela 2011)
  - Okadaic acid (MacKenzie et al 2004, Fu et al 2008, 2009)
  - Pectenotoxins (MacKenzie et al 2004, Fu et al 2009)
  - Saxitoxin (Lane et al 2010)
  - Spirolide toxins (Fu et al 2009)
  - Yessotoxins (MacKenzie et al 2004, Fu et al 2009)

Why Use SPATT?
Persistence of Cyanotoxins

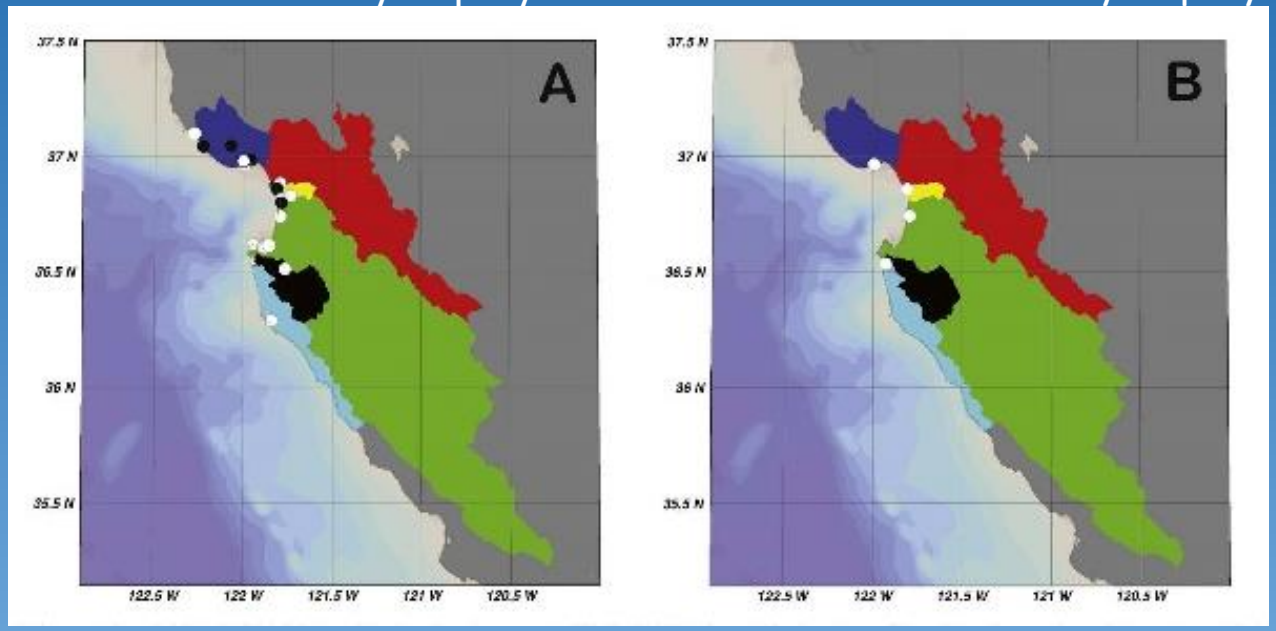
Do microcystins persistently flow into Monterey Bay from surrounding watersheds?

Answer: YES! Microcystins were persistently present over several years.

- Toxin peaks were in the spring and autumn seasons

2010-2011 Monthly deployments

2011-2013 Weekly deployments



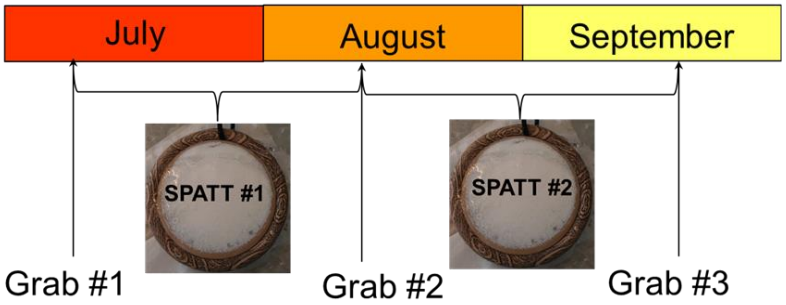
Microcystins detected

Microcystins not detected

Gibble and Kudela, 2014

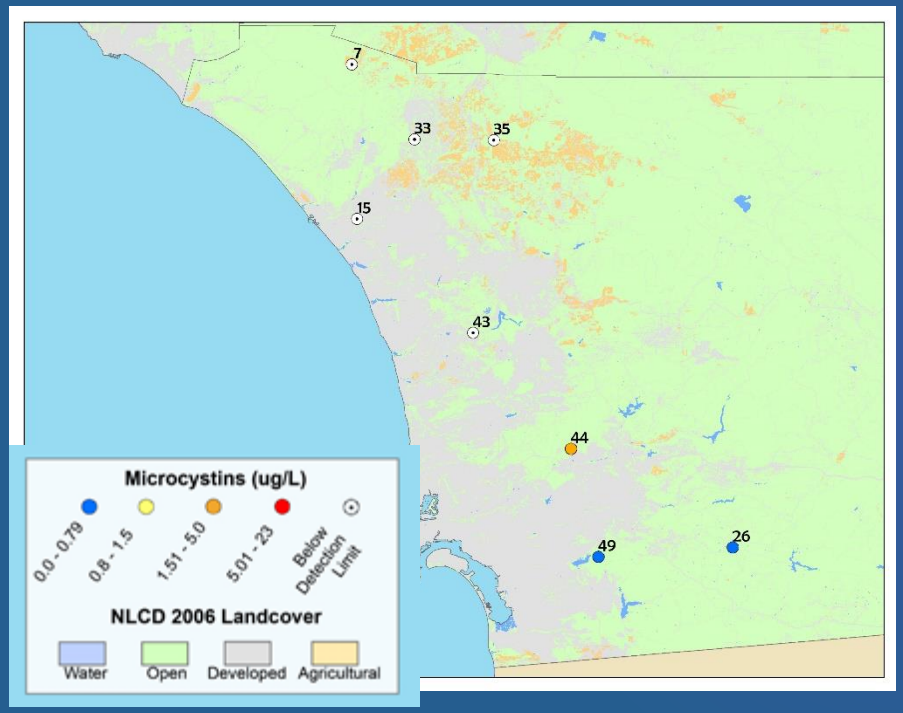
Why Use SPATT?
Determine Toxin *Prevalence*

- Condition assessments and screening studies
- Waterbodies with little to no HAB data
- Determine the prevalence of toxin across a region
  - Depressional wetlands assessment (probabilistic design)
  - Lakes, estuaries and reservoirs (targeted design)

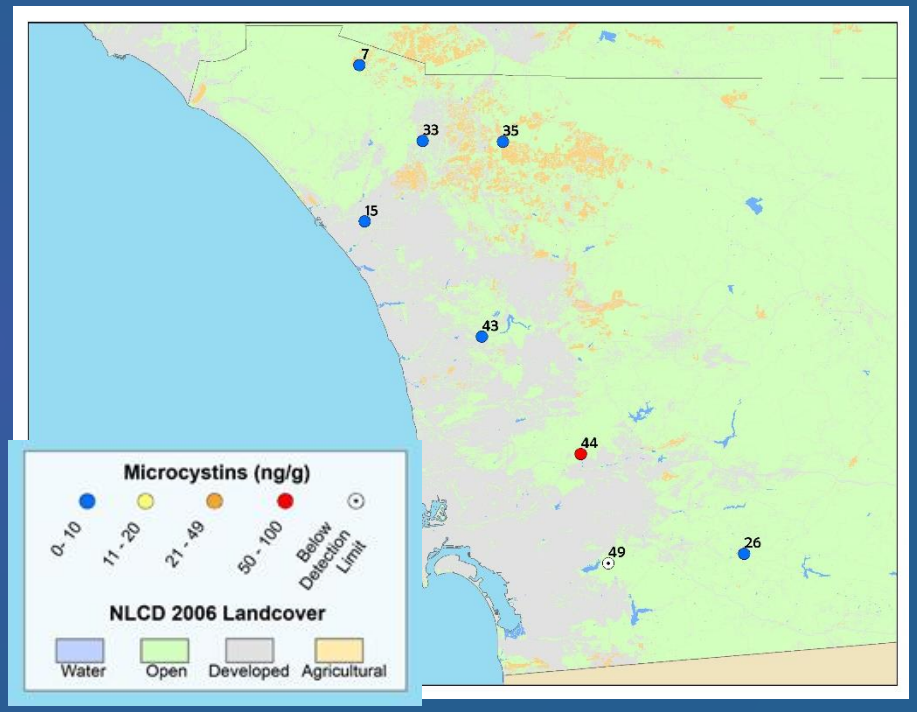


Microcystin Prevalence Underestimated From Grab Samples By ~50%

Grab Sample



SPATT Sample



% of Toxic Sites: Depressional Wetlands

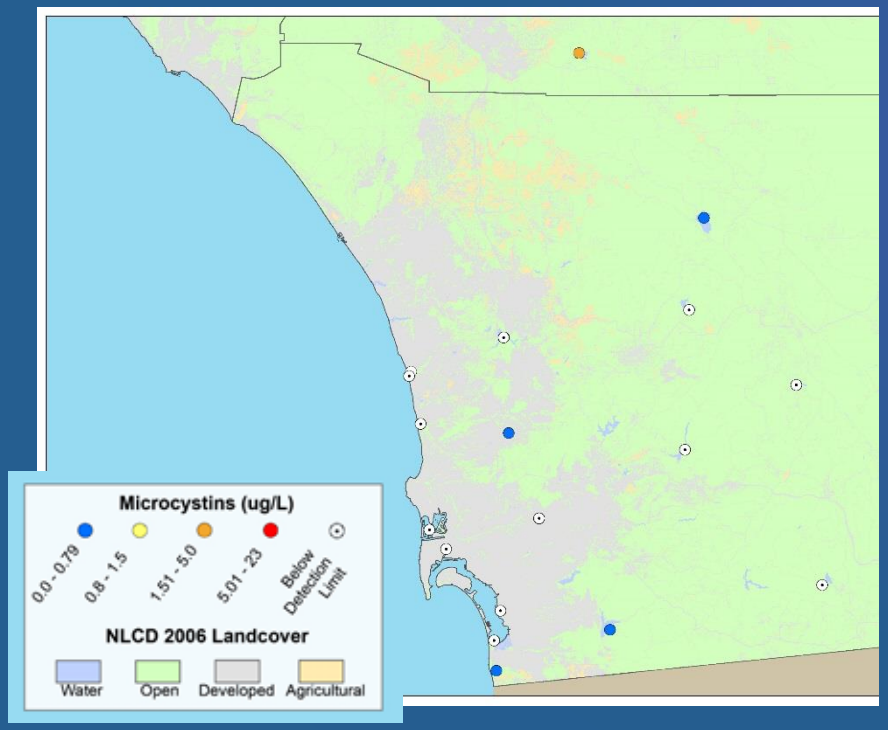
Grab Samples	**29%**
SPATT Samples	**83%**

Howard et al., in prep

Microcystins Detected at Every Site Sampled

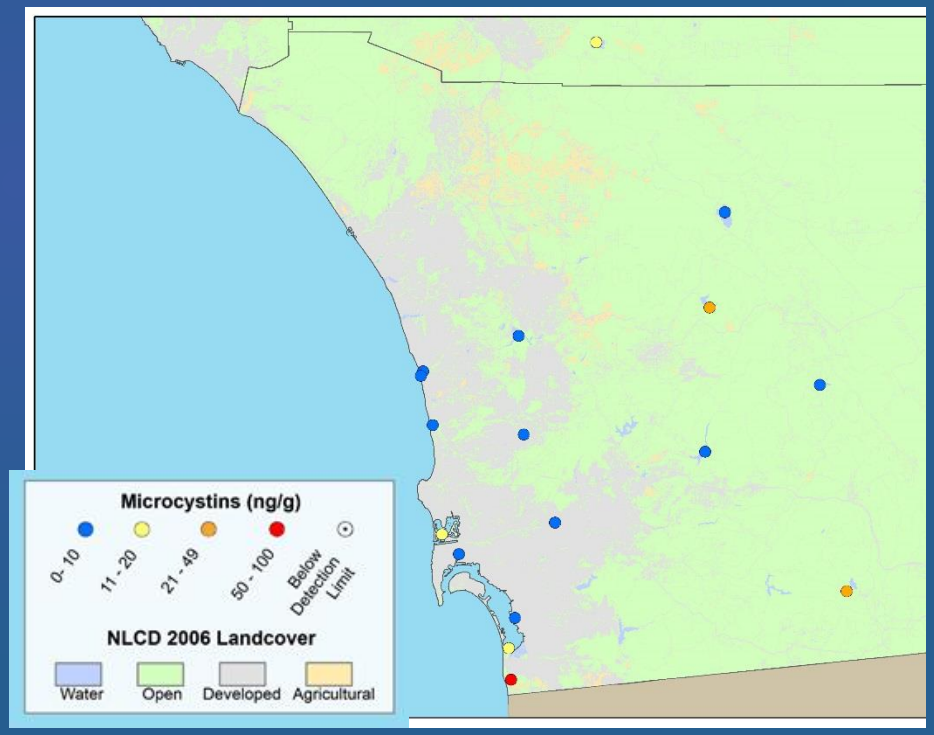
San Diego County: Lakes, Reservoirs, Estuaries and Coastal Lagoons

Grab Sample Results



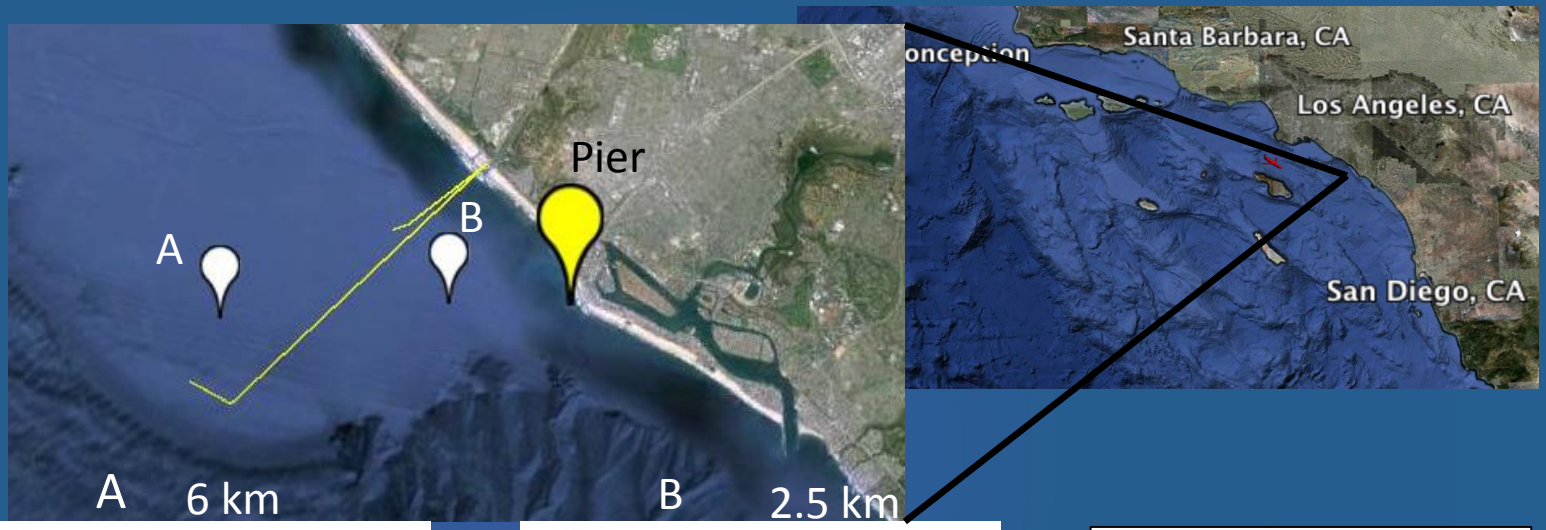
SPATT Sample Results:

All sites toxic



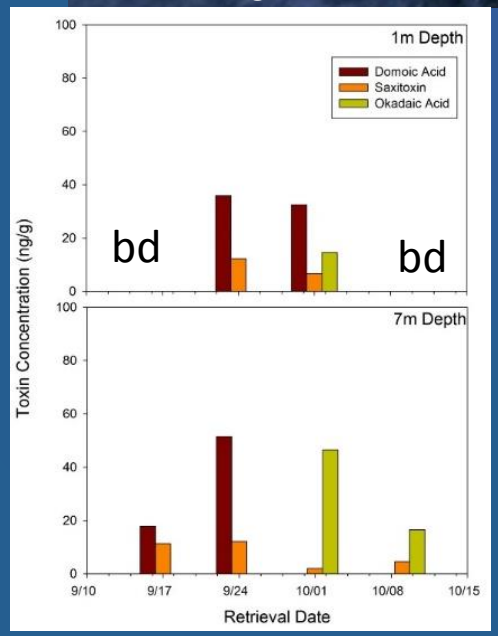
Howard et al., in prep

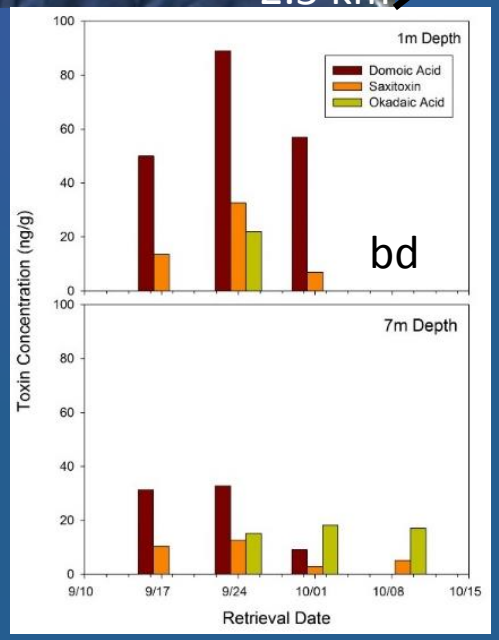
Why Use SPATT?
Deploy In Areas with Limited or No Sampling



1 meter depth

7 meter depth



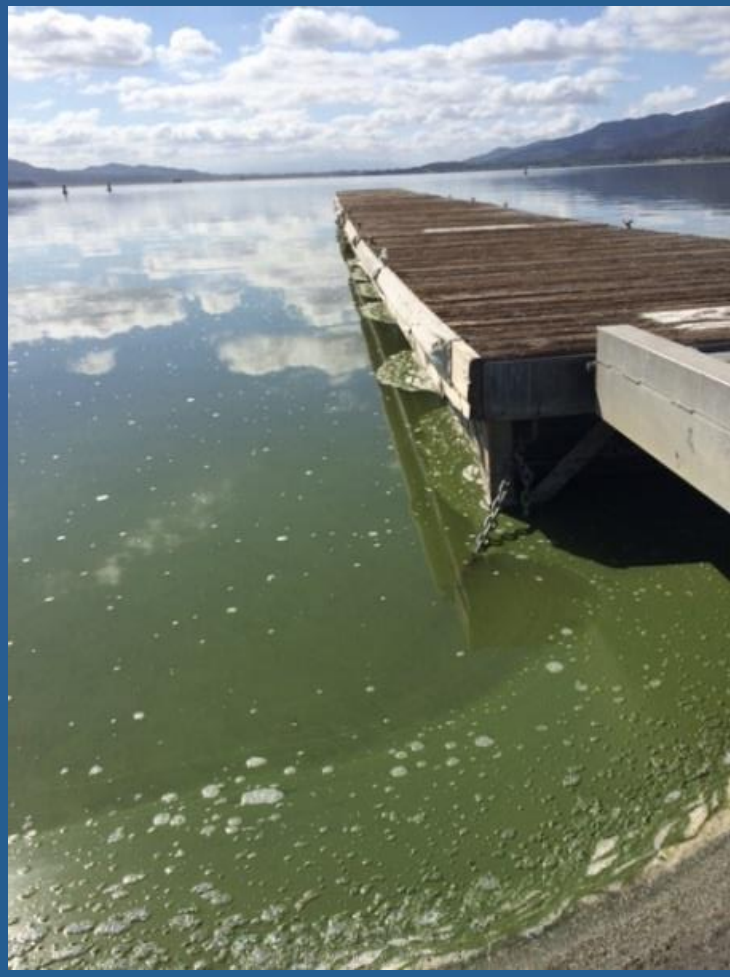


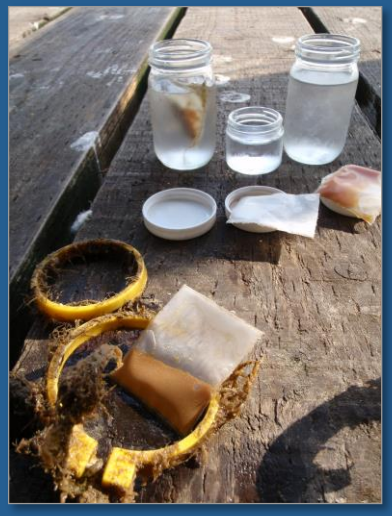
Pier:
DA below detection

Seubert et al., in prep

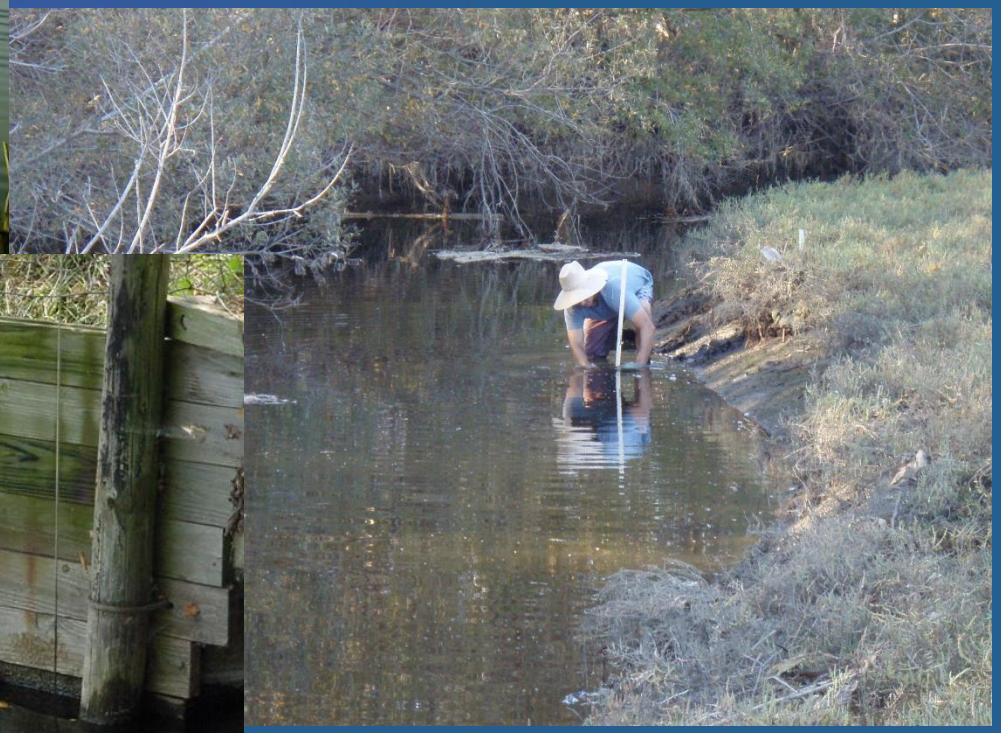
Many Ways To Deploy SPATT in Aquatic Environments

- Piers and floating docks
- Instruments deployed in the water
- PVC Tube in sediment
- Buoy and moorings
- Autonomous Underwater Vehicles
- Ship flow through system

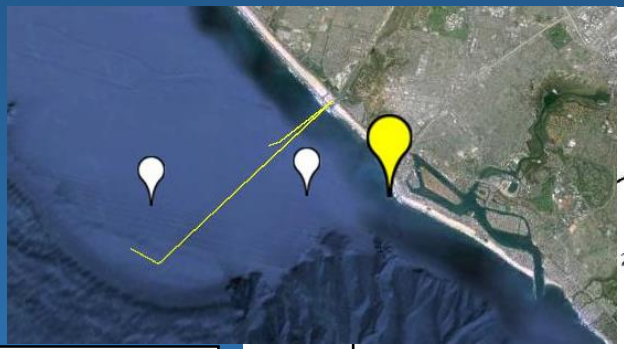




SPATT Deployment:
Pier, Dock, Instruments, PVC Tube

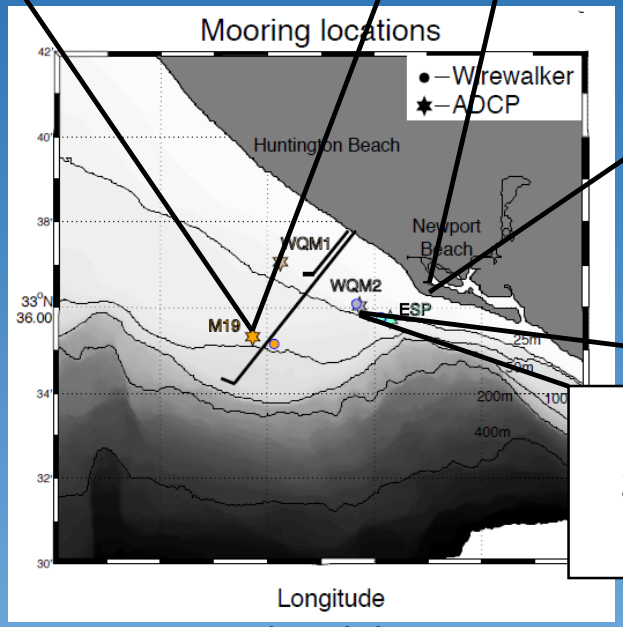


SPATT Deployment: Buoy and Mooring

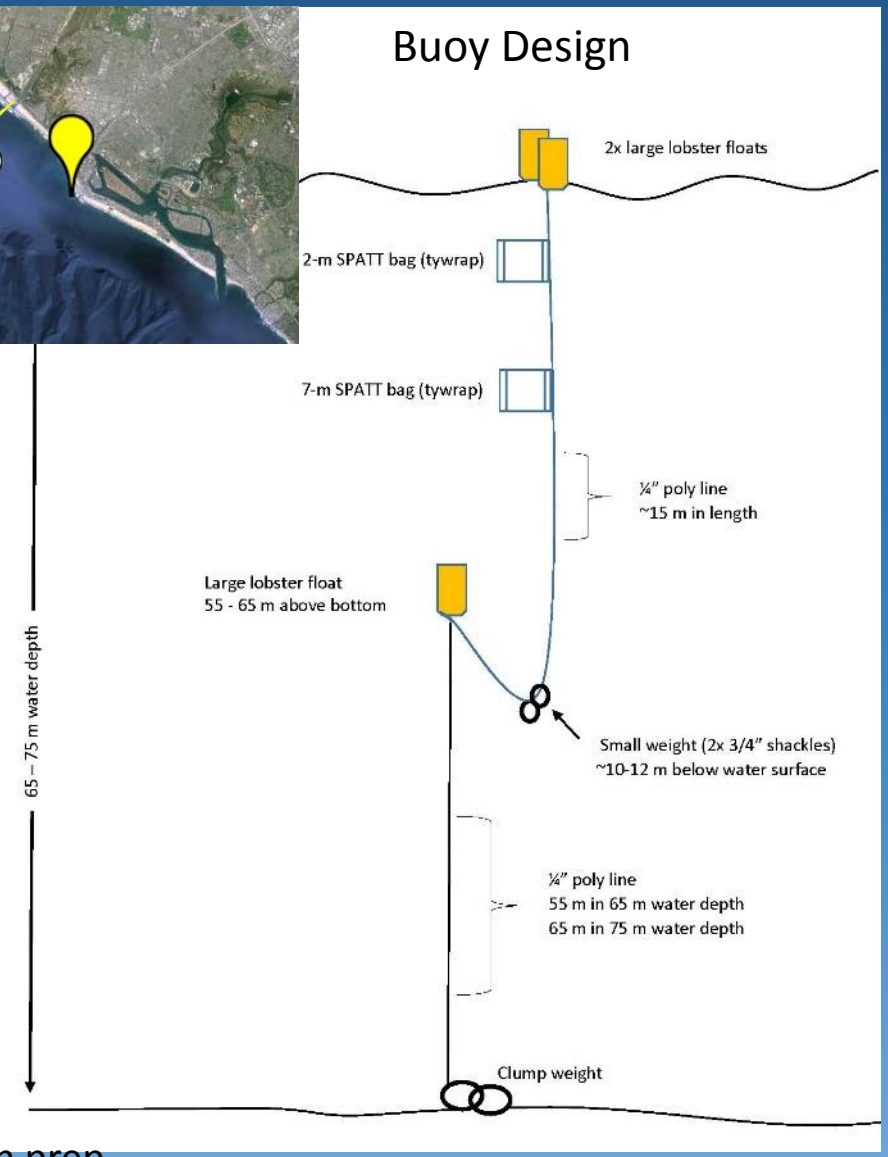


DA bd-89 ng/g
STX bd- 32 ng/g
OA bd-22 ng/g

Newport Pier
DA bd

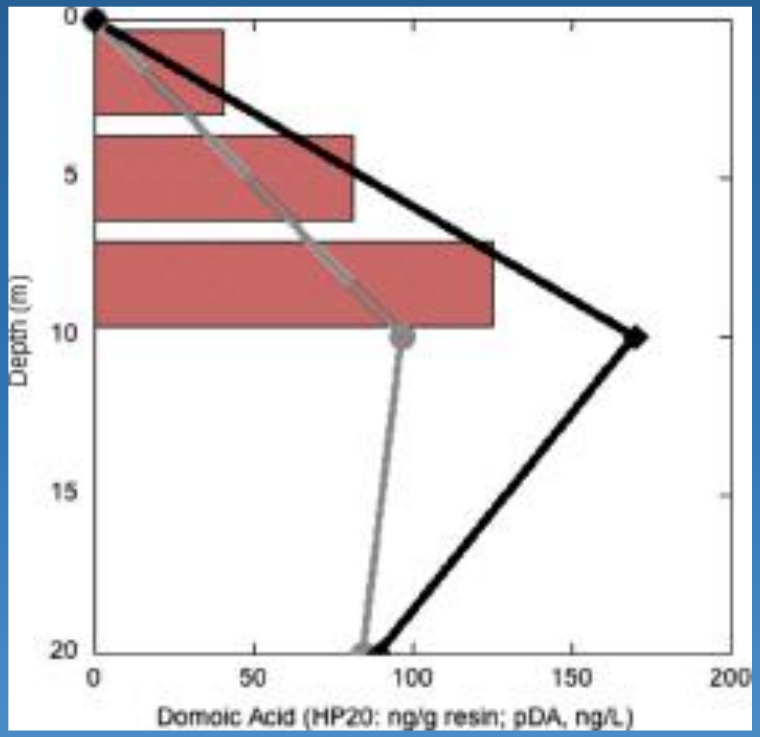


DA bd-51 ng/g
STX bd- 12 ng/g
OA bd-46 ng/g



Map: Lucas and Kudela 2015; Toxin data Seubert et al., in prep

SPATT Deployment: AUVs



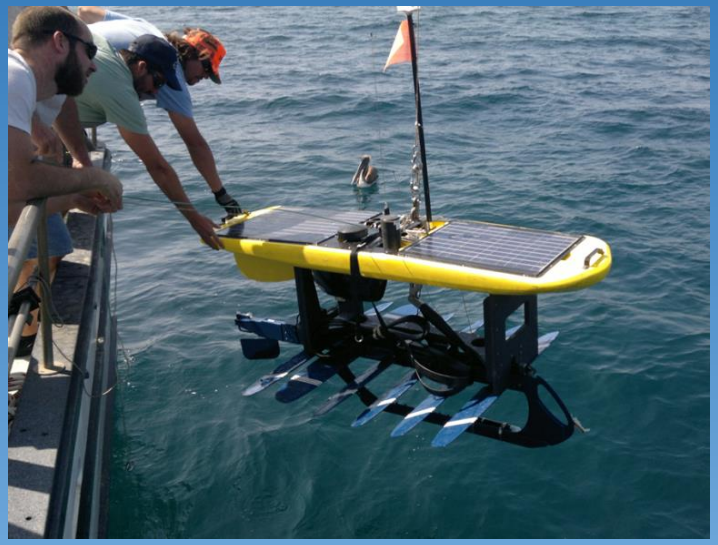
SPATT

Grab 25 Oct.

Grab 8 Nov.

Berdalet et al., 2014

Liquid Robotics G5 surface wave glider

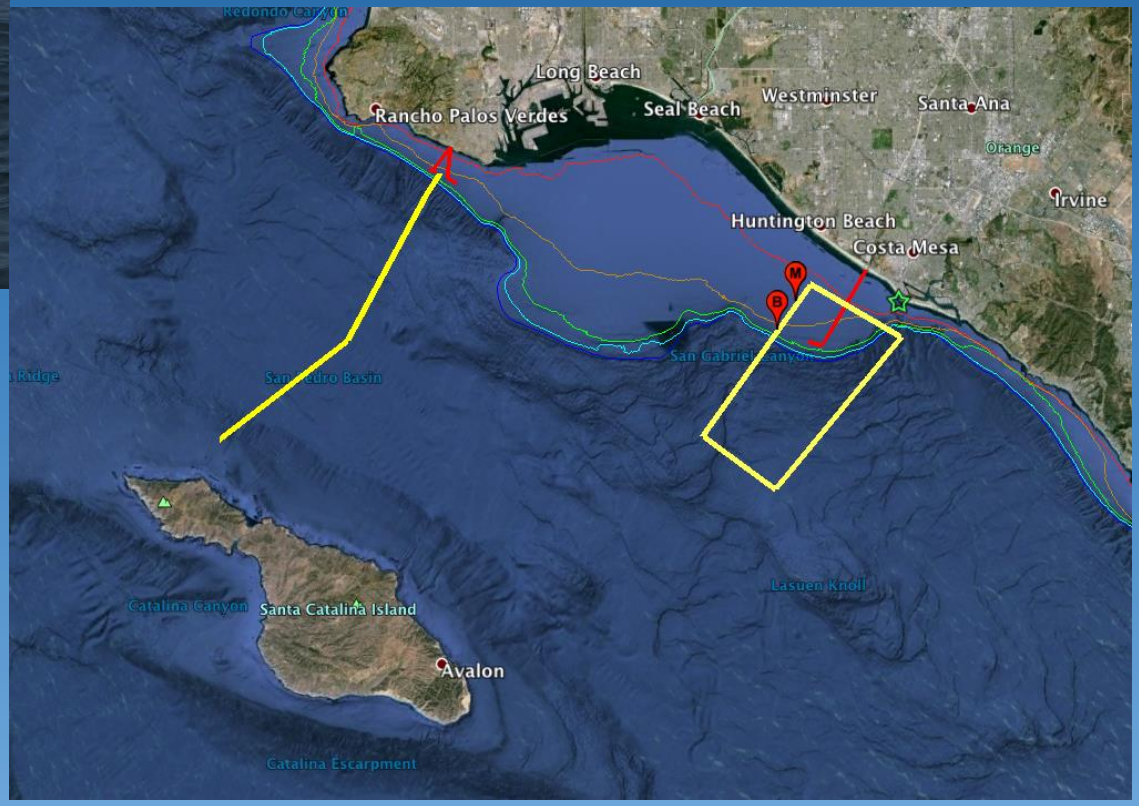


SPATT and Grab samples showed similar results: a persistent increase in DA

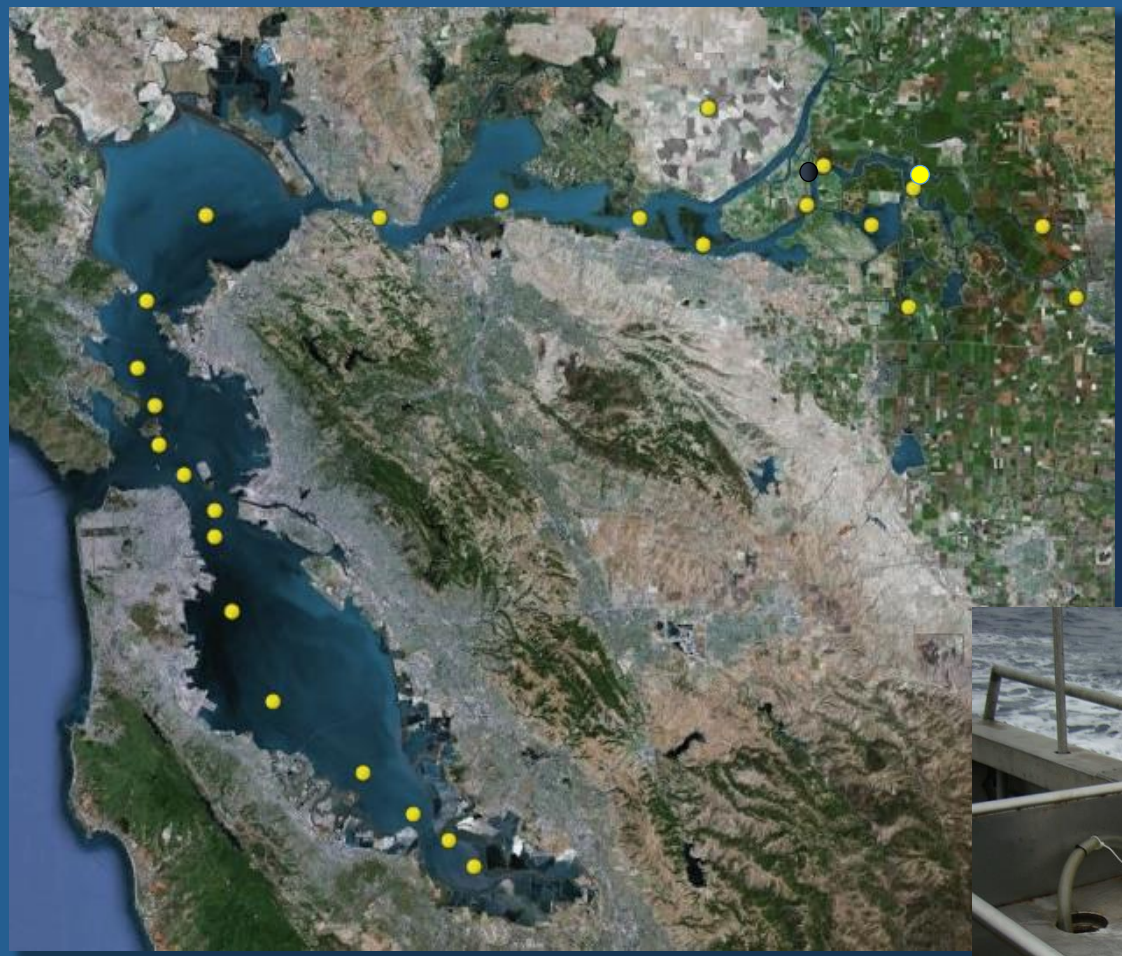
SPATT Deployment: AUVs

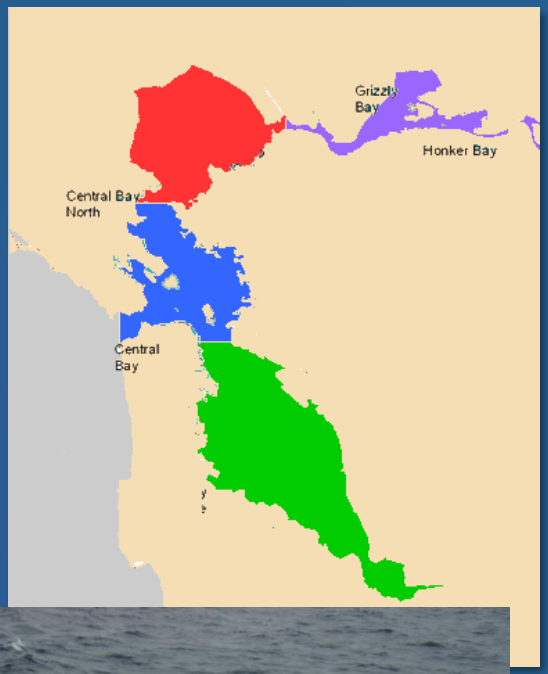
Teledyne Webb Slocum Gliders

SPATT detected domoic acid, saxitoxin; no okadaic acid detected



Ship Flow-Through System





Kudela Lab

Conclusions and Future Directions

- SPATT Advantages:
  - Low cost, easy to deploy tool
  - Applicable to marine, brackish and freshwater environments
  - Measures marine and freshwater toxins
  - Can be deployed in many different ways and in areas where there is limited sampling
  - More robust indicator of toxin prevalence compared to grab samples ('snapshots')
- Disadvantages:
  - Cannot be directly compared to health advisory thresholds

- MERHAB: Improve tools for monitoring multiple HAB toxins at the land-sea interface in CA
  - Develop SPATT for additional toxins and implement an integrated multi-toxin HAB strategy

Thank You!

NOAA (MERHAB NA05NO54781228 and ECOHAB NA11NOS4780053)

Orange County Sanitation District

CALIFORNIA Water Boards
STATE WATER RESOURCES CONTROL BOARD
REGIONAL WATER QUALITY CONTROL BOARDS

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

ORANGE COUNTY SANITATION DISTRICT
PROTECTING THE ENVIRONMENT

SCCWRP
Established 1969

SWAMP
Surface Water Ambient Monitoring Program

Sea Grant
University of Southern California

Sea Grant
California
COASTAL SCIENCE SERVING CALIFORNIA