New Monitoring and Assessment Approaches for HABs in California

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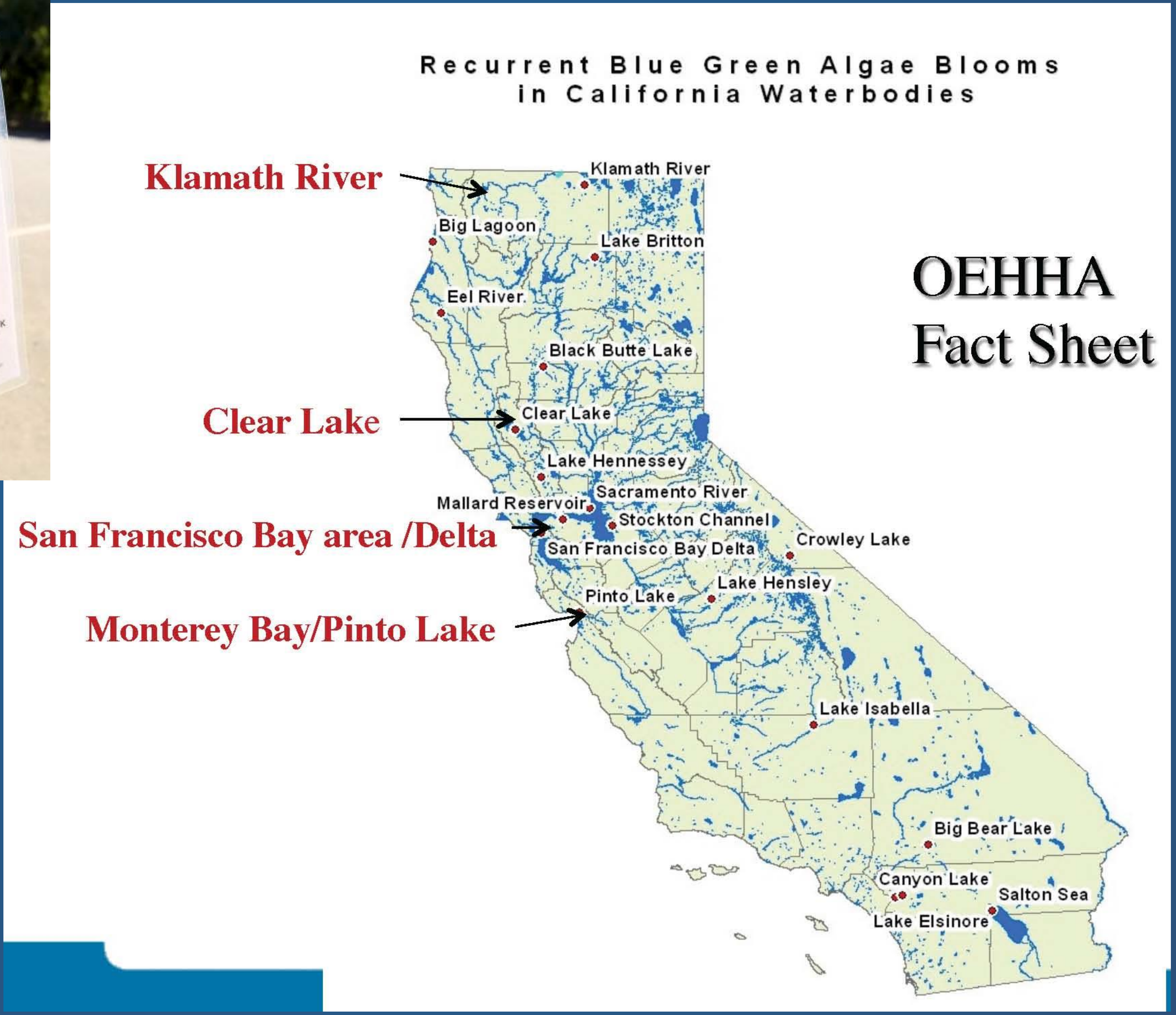
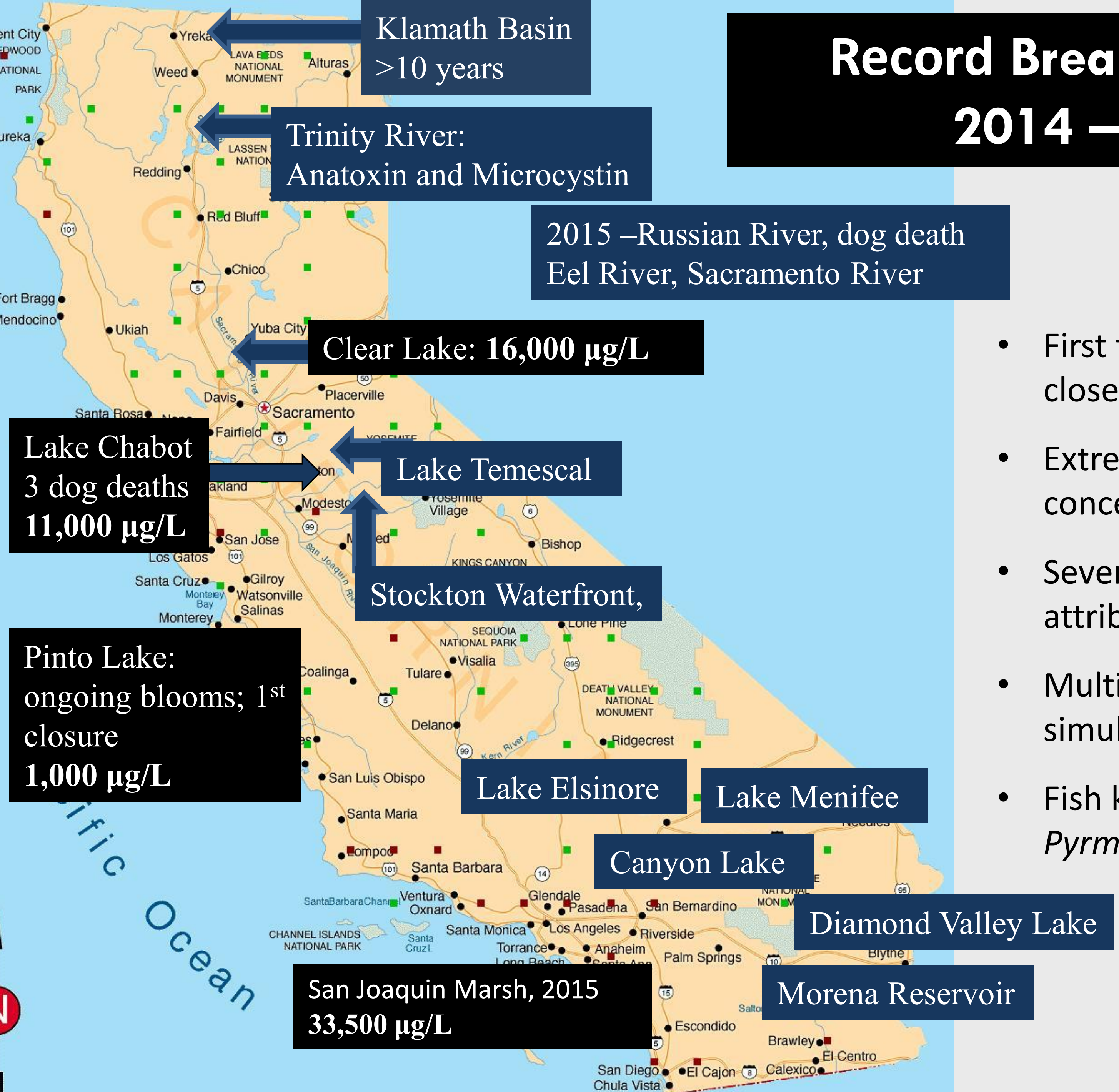
Historic Cyanotoxin Hotspots in California

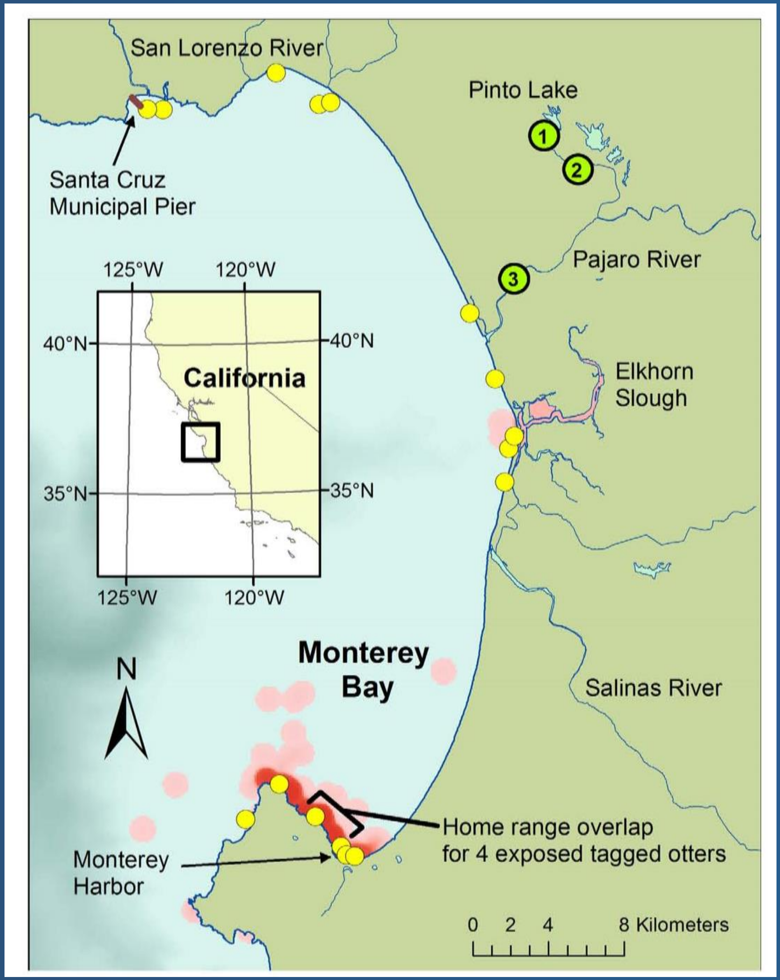


Record Breaking Years 2014 – 2015

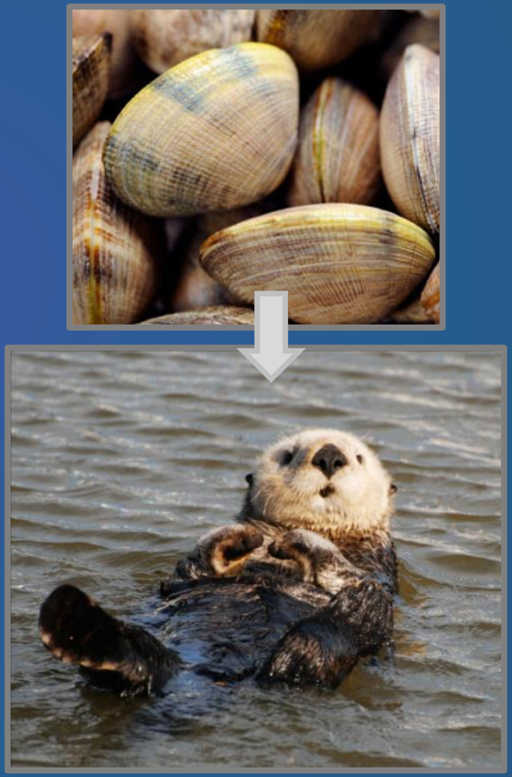


- First time several lakes closed due to cyanotoxins
- Extremely high microcystin concentrations recorded
- Several dog deaths attributed to cyanotoxins
- Multiple toxins detected simultaneously
- Fish kills caused by *Pyrmnesium parvum*

Far-Reaching Effects of Freshwater Toxins to Marine Waters

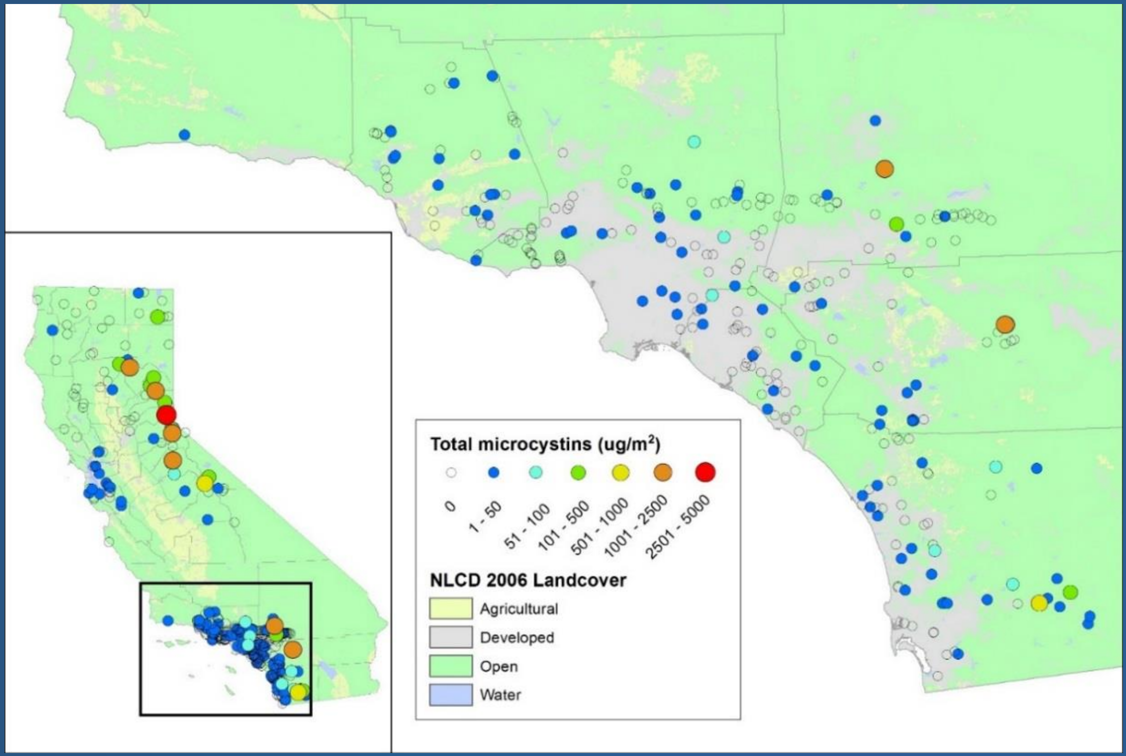


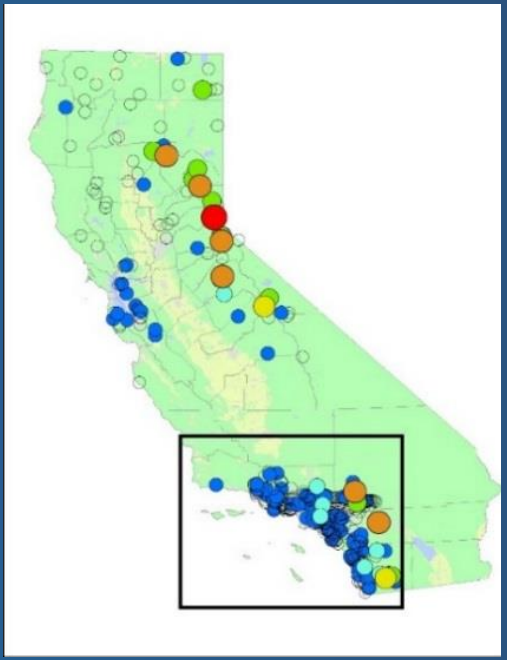
Mortality of sea otters due to microcystin intoxication



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)

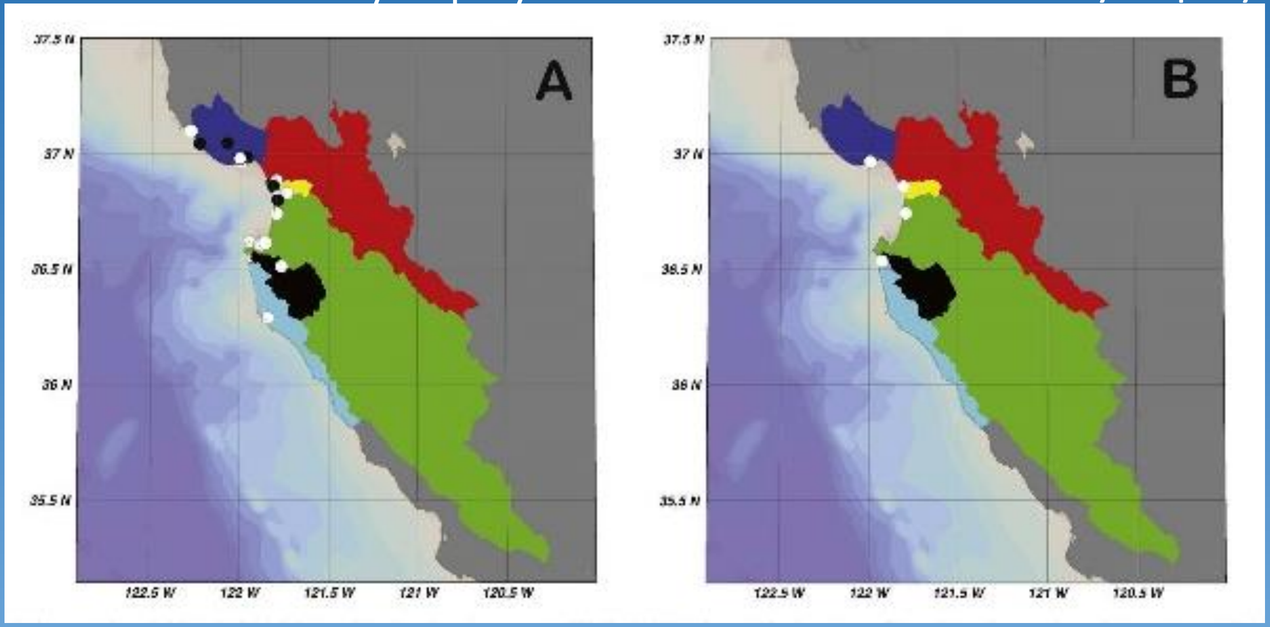
Why Use SPATT?
Persistence of Cyanotoxins

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



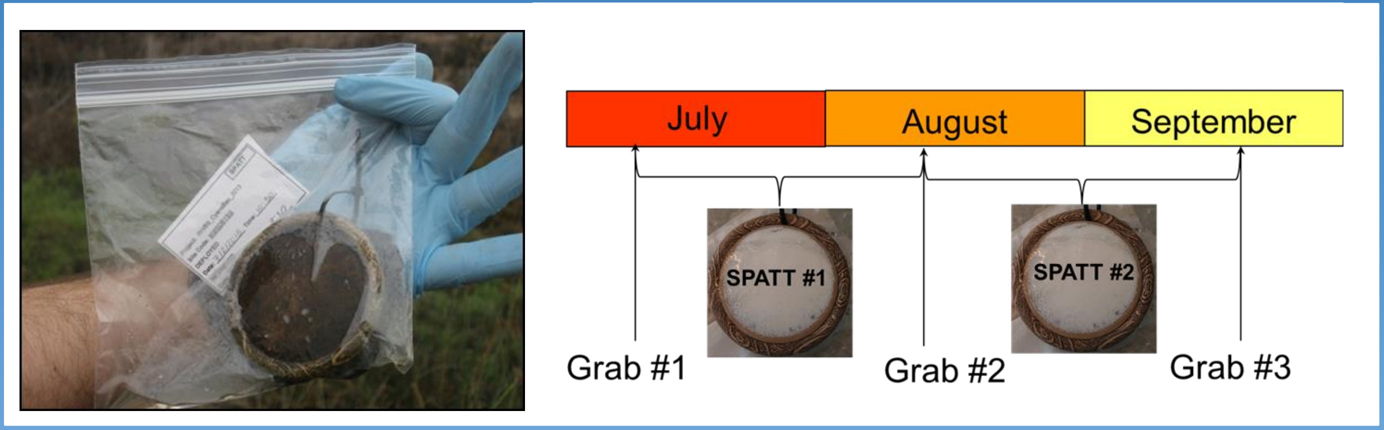
Microcystins detected

Microcystins not detected

Gibble and Kudela, 2014

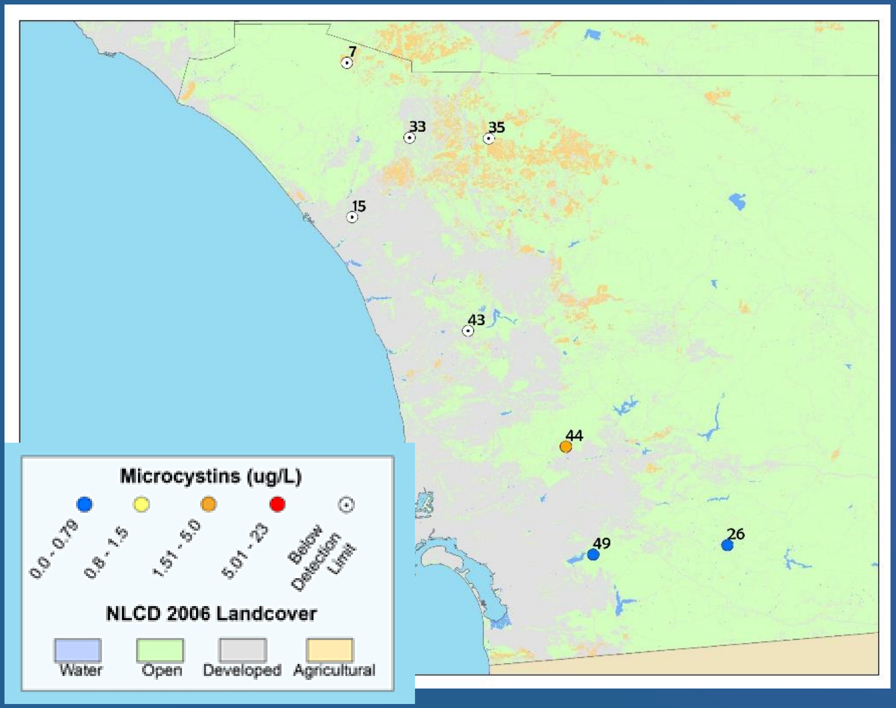
Why Use SPATT?
Determine Toxin *Prevalence*

- 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)

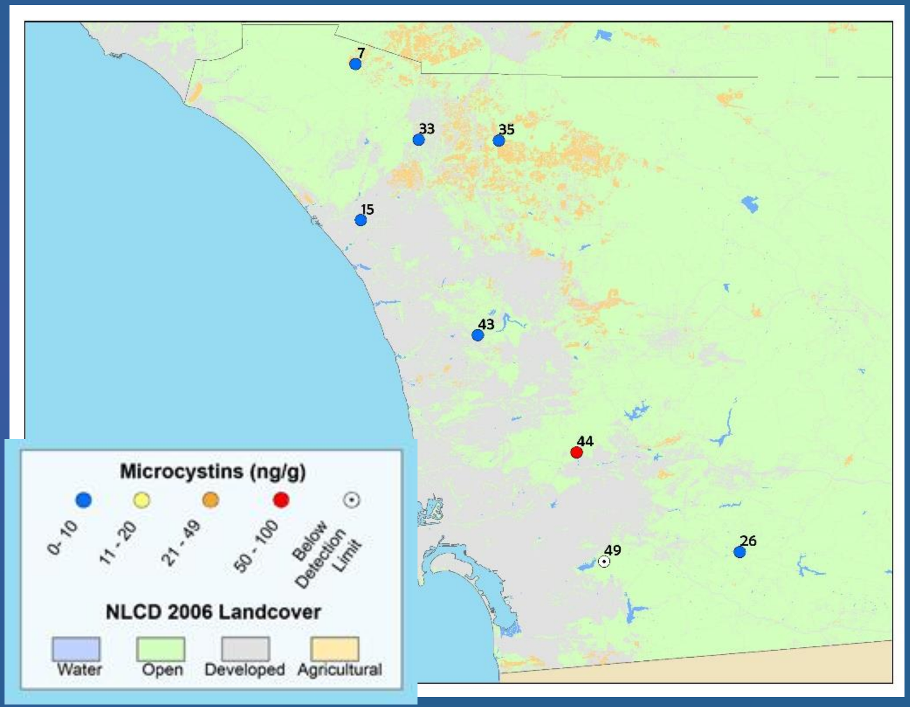


Microcystin Prevalence Underestimated From Grab Samples By ~50%

Grab Sample



SPATT Sample



% of Toxic Sites: Depressional Wetlands

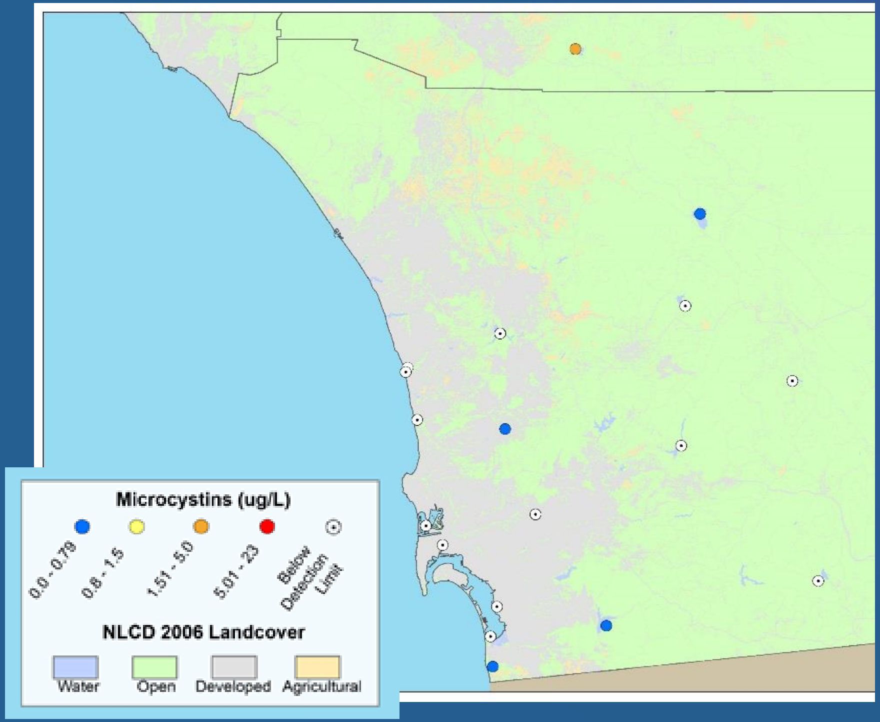
Grab Samples	**29%**
SPATT Samples	**83%**

Howard et al., in prep

Microcystins Detected at Every Site Sampled

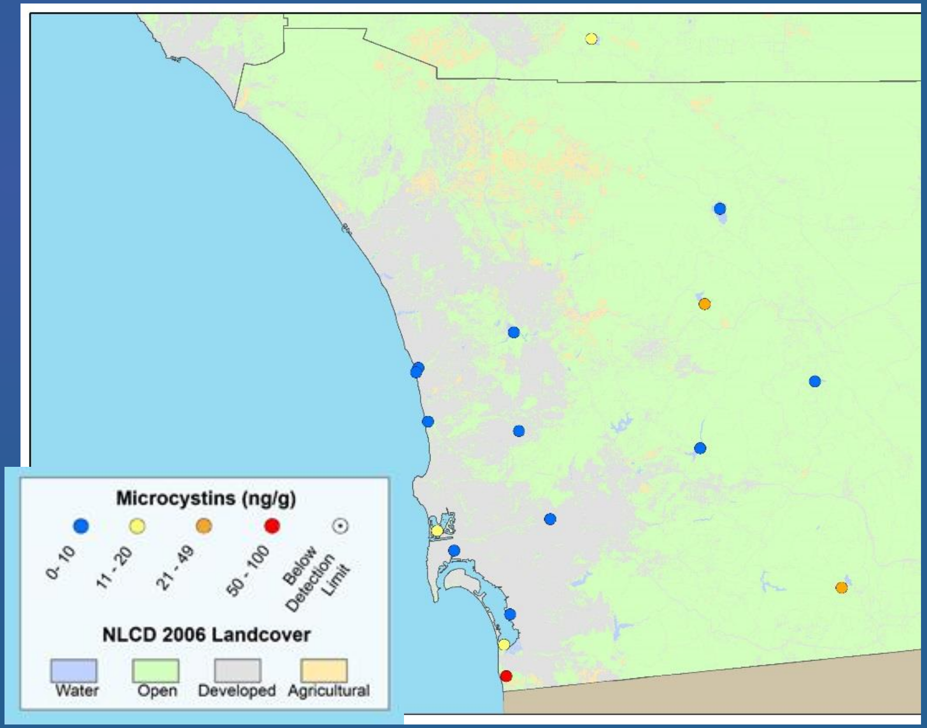
San Diego County: Lakes, Reservoirs, Estuaries and Coastal Lagoons

Grab Sample Results



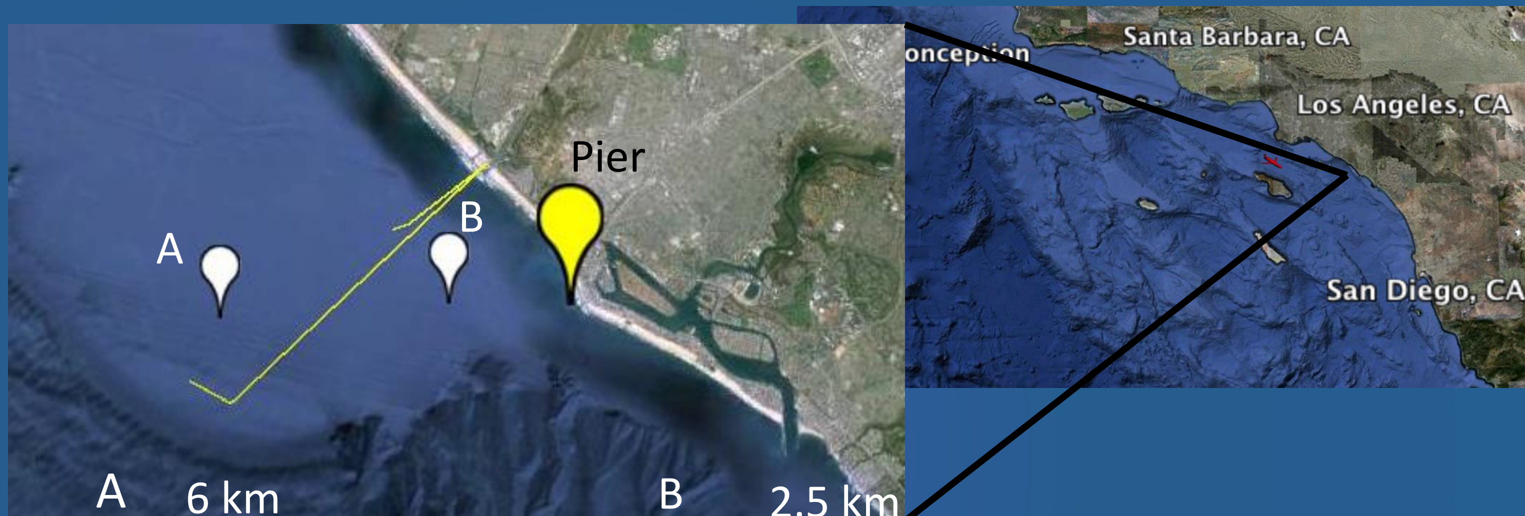
SPATT Sample Results:

All sites toxic



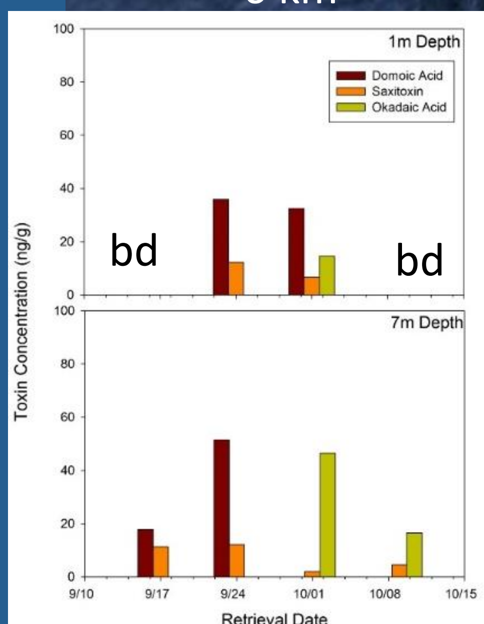
Howard et al., in prep

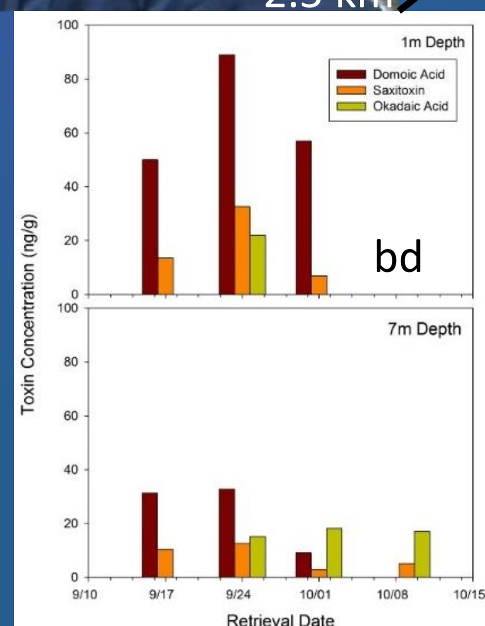
Why Use SPATT?
Deploy In Areas with Limited or No Sampling



1 meter depth

7 meter depth





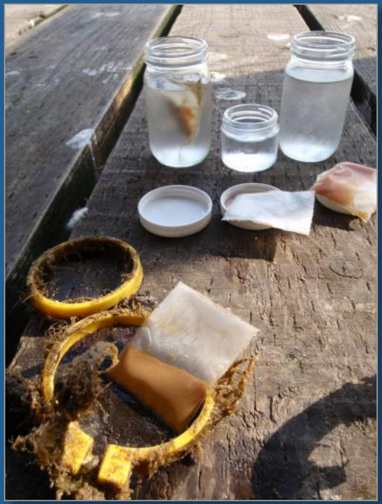
Pier:
DA below detection

Domoic Acid
Saxitoxin
Okadaic Acid

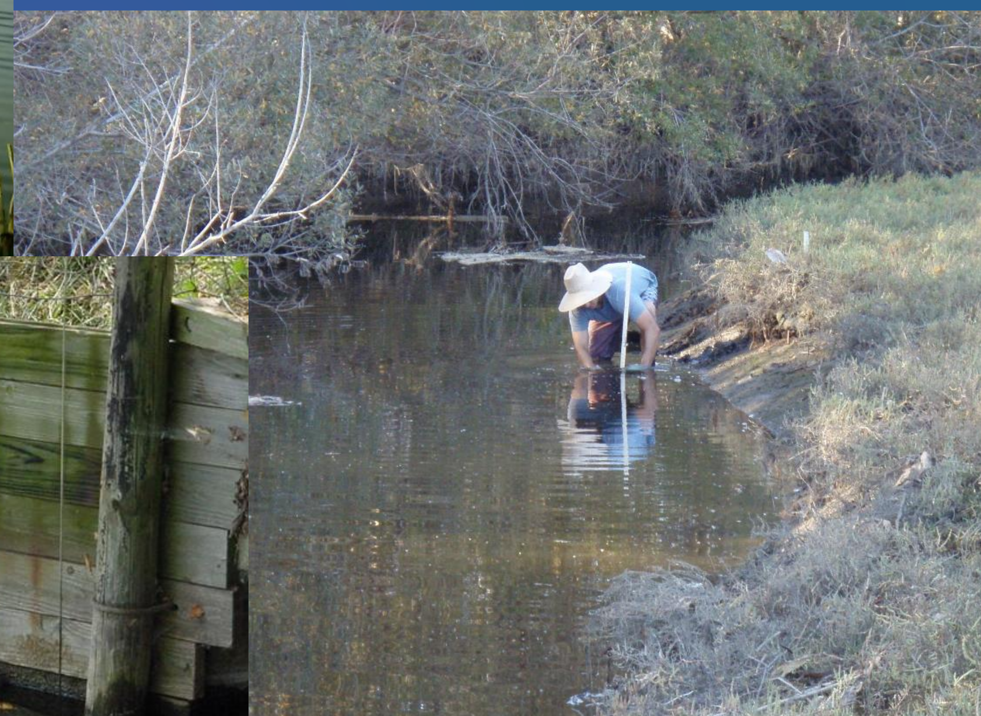
Seubert et al., in prep

Many Ways To Deploy SPATT in Aquatic Environments

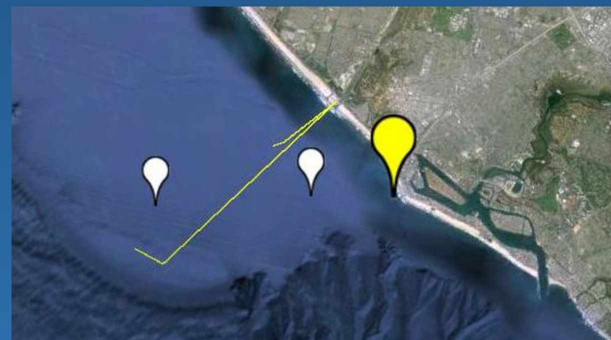
- Piers and floating docks
- Instruments deployed in the water
- PVC Tube in sediment
- Buoy and moorings
- Autonomous Underwater Vehicles
- Ship flow through system

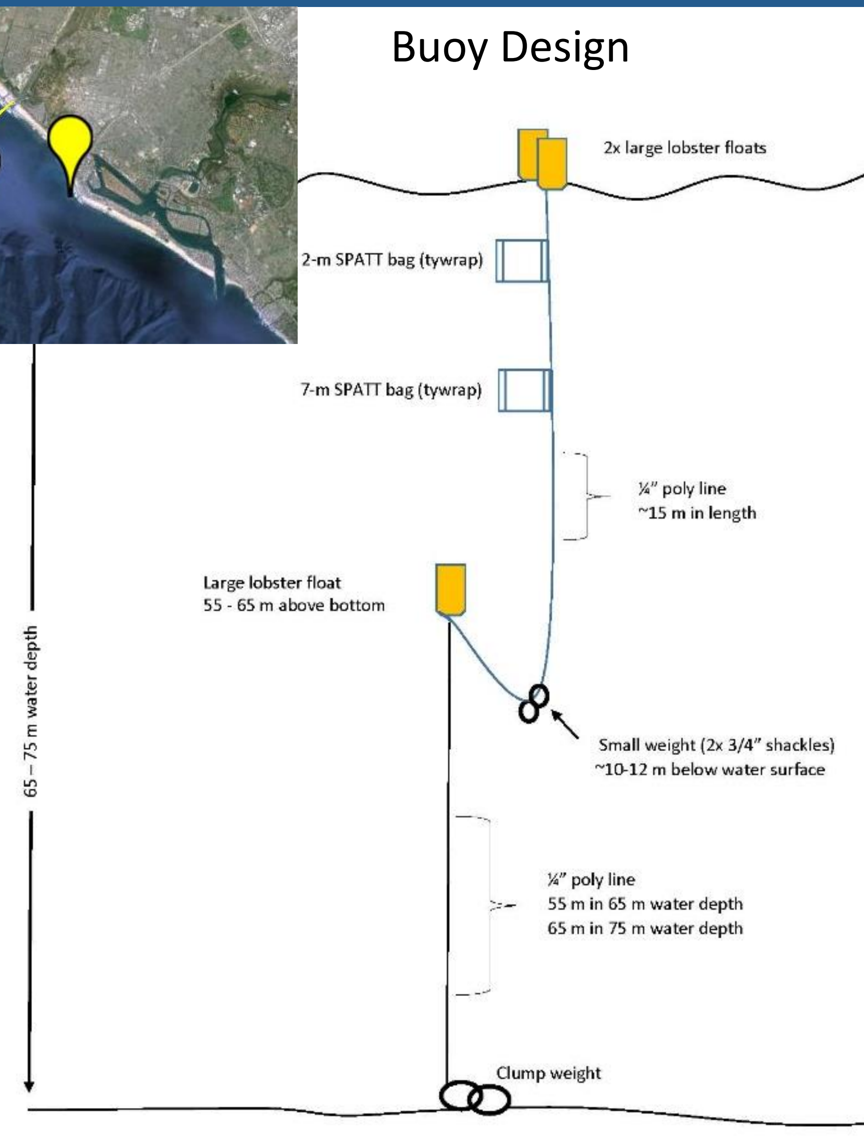


SPATT Deployment:
Pier, Dock, Instruments, PVC Tube



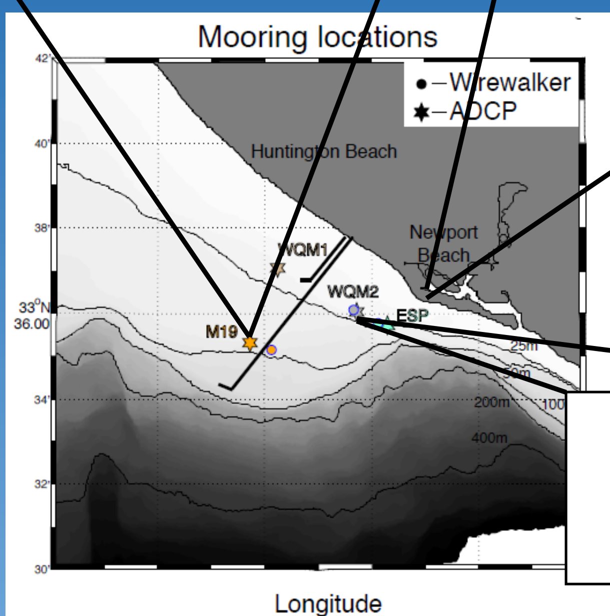
SPATT Deployment: Buoy and Mooring





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

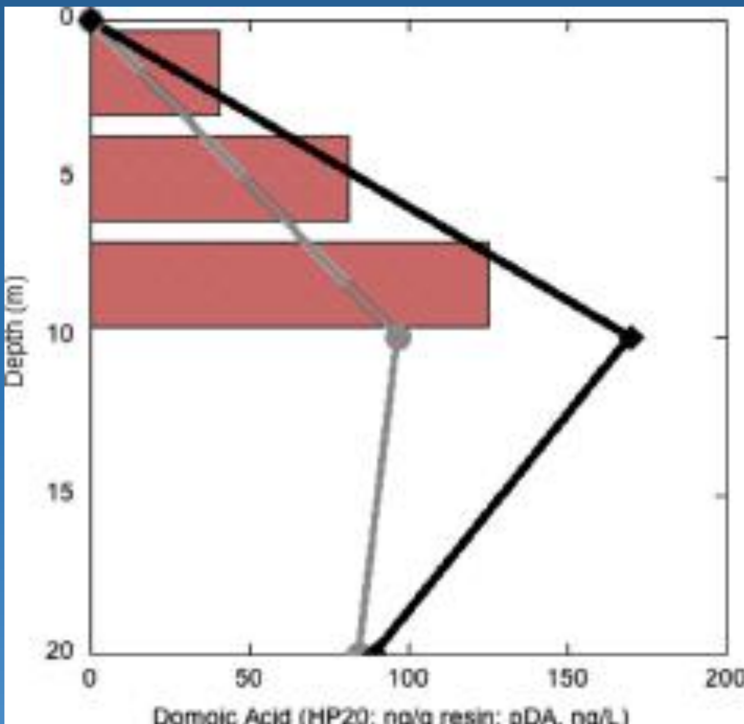
Newport Pier
DA bd



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.

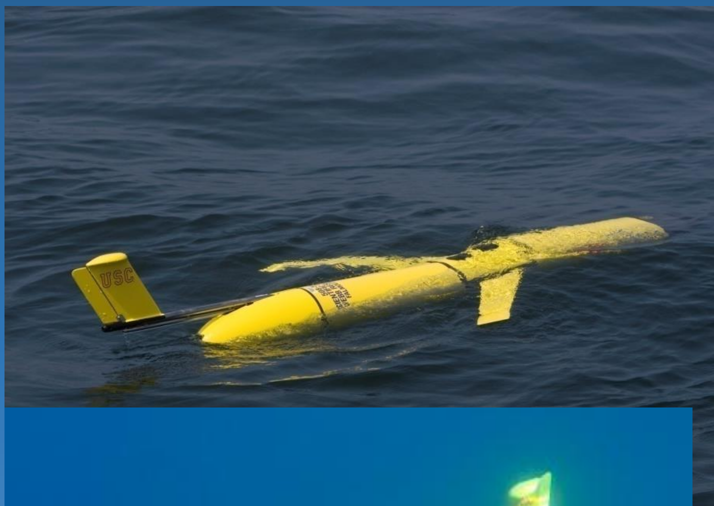
Berdalet et al., 2014

Liquid Robotics G5 surface wave glider

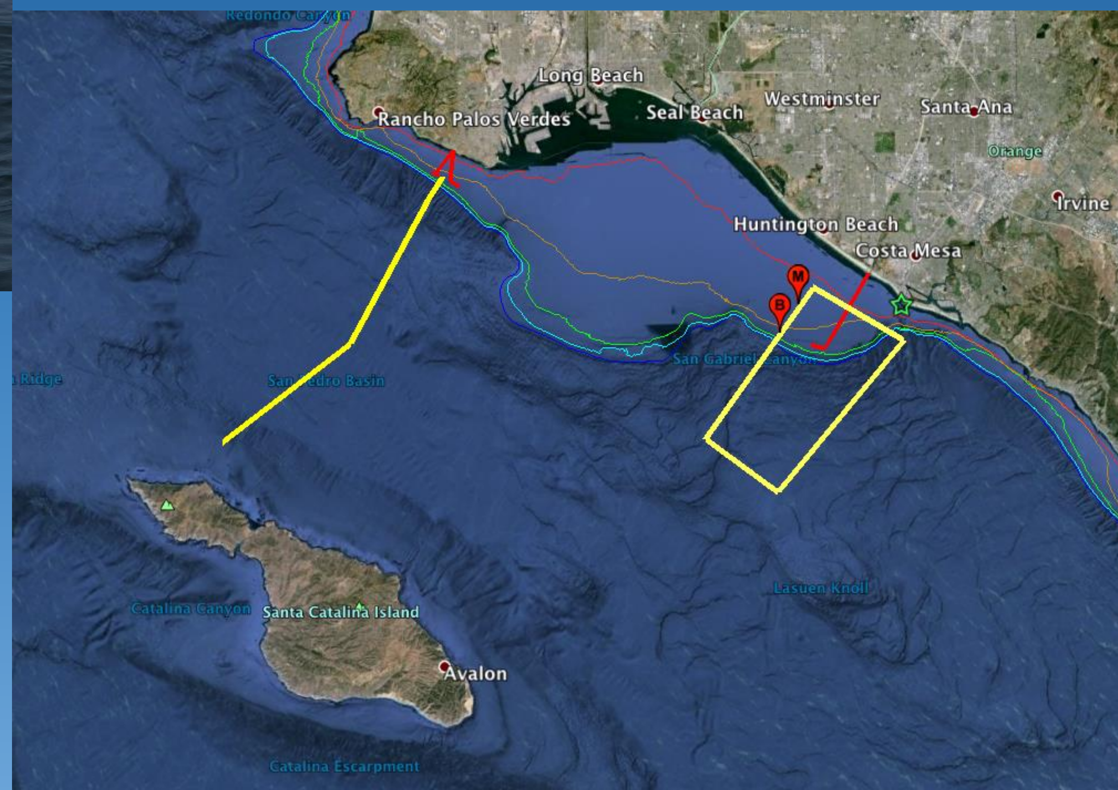
SPATT and Grab samples showed similar results: a persistent increase in DA

SPATT Deployment: AUVs

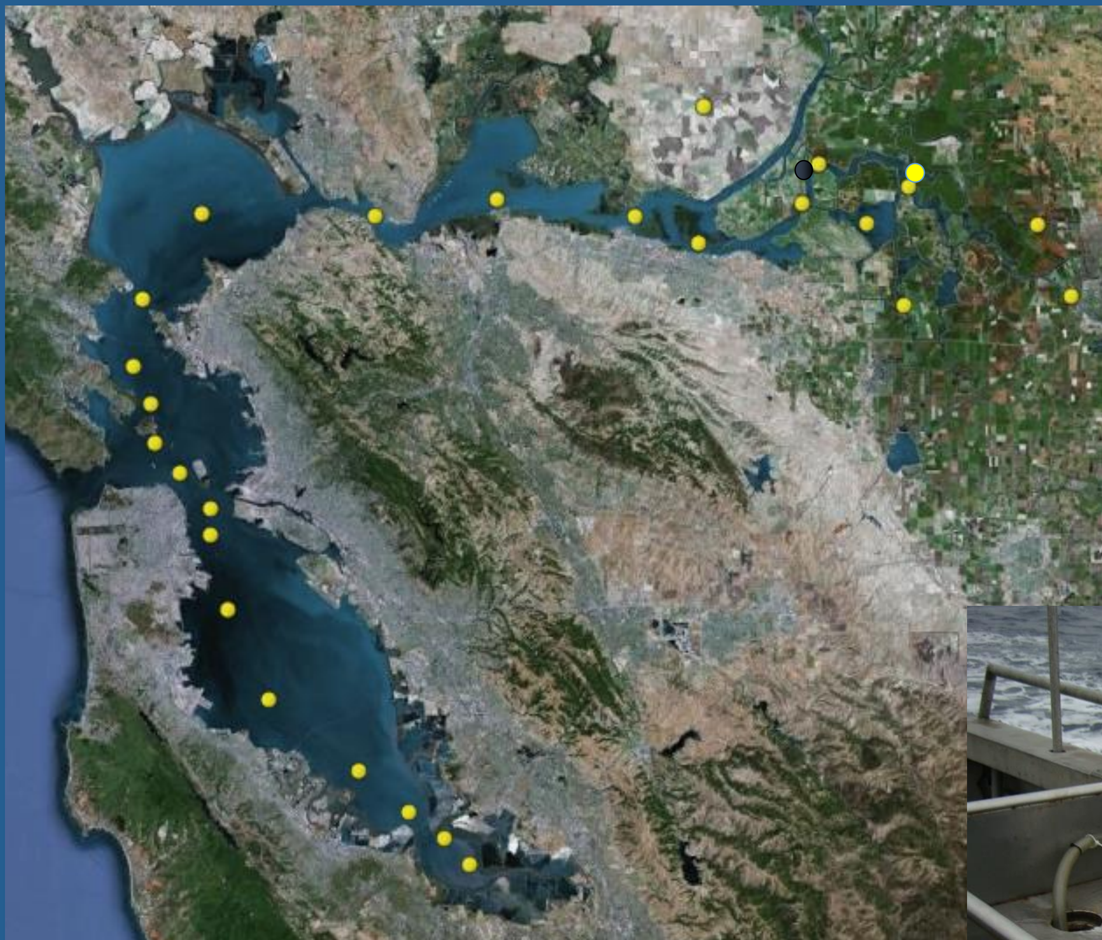
Teledyne Webb Slocum Gliders

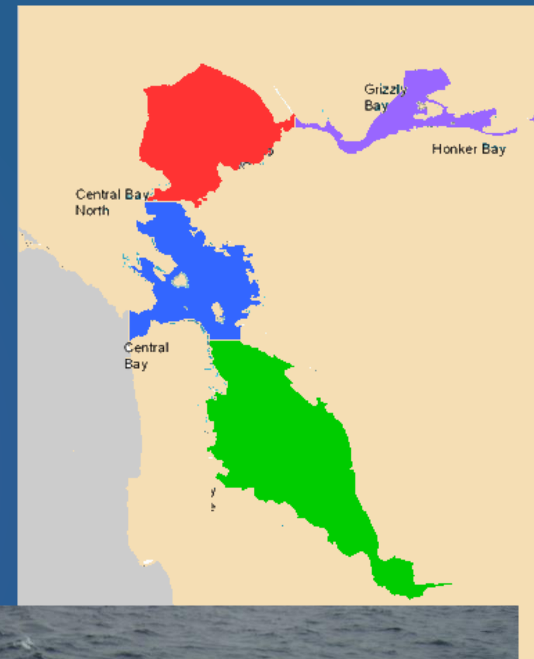


SPATT detected domoic acid, saxitoxin; no okadaic acid detected



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