California Statewide Algae Plan: Past, Present, and Future

Susie Theroux
SCCWRP


2008
Reno
Nevada
Sacramento
Oakland
San Francisco
San Jose
Salinas
Fresno
California
Las Vegas
Bakersfield
Los Angeles
Riverside
San Diego
Mexicali
Puebla
San Luis Río Colorado
Tijuana

2008-2009
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Las Vegas
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Mexicali
Puebla
San Luis Río Colorado
Tijuana

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Riverside
San Diego
Mexicali
Puebla
San Luis Río Colorado
Tijuana


2008-2011
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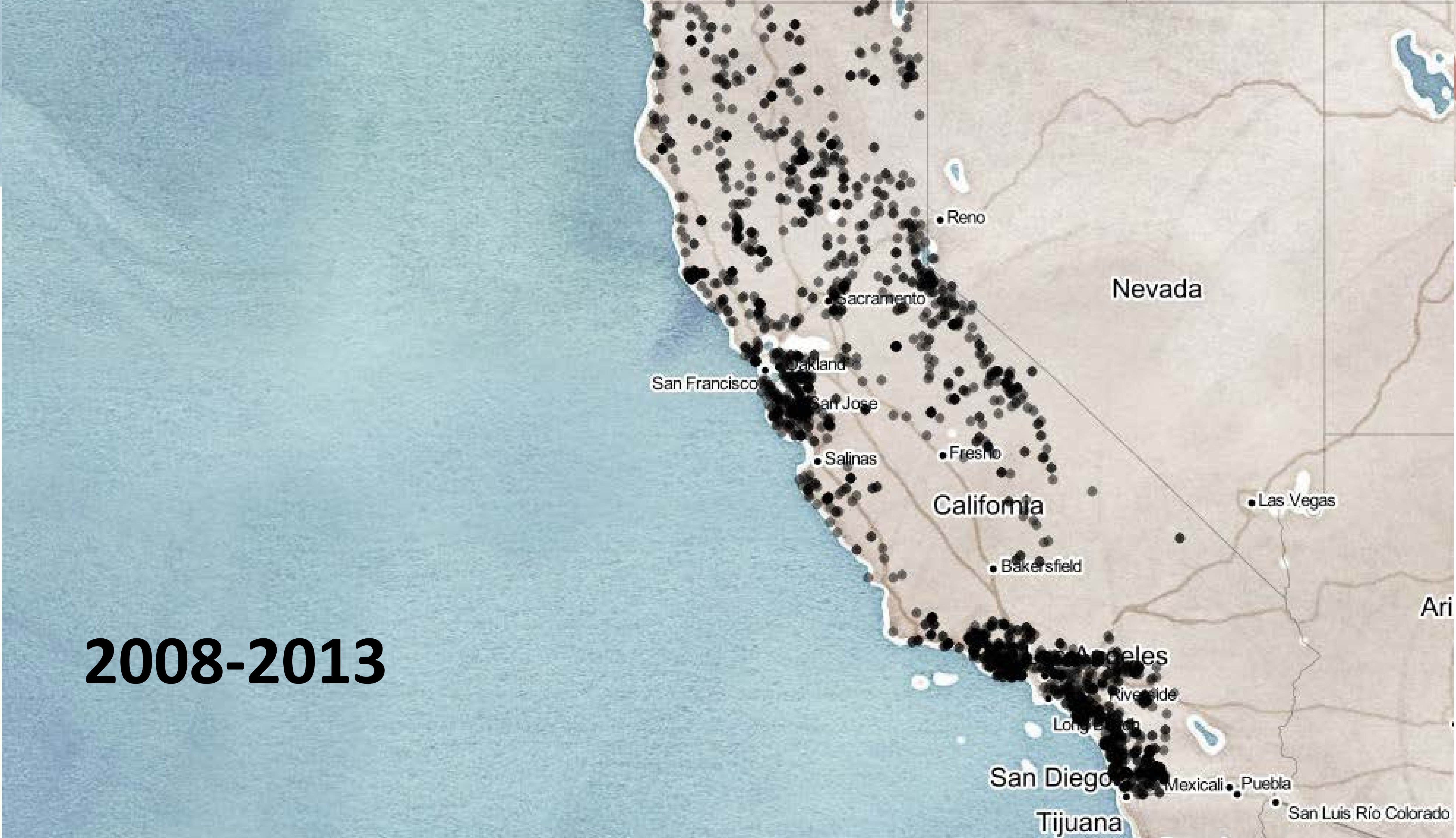
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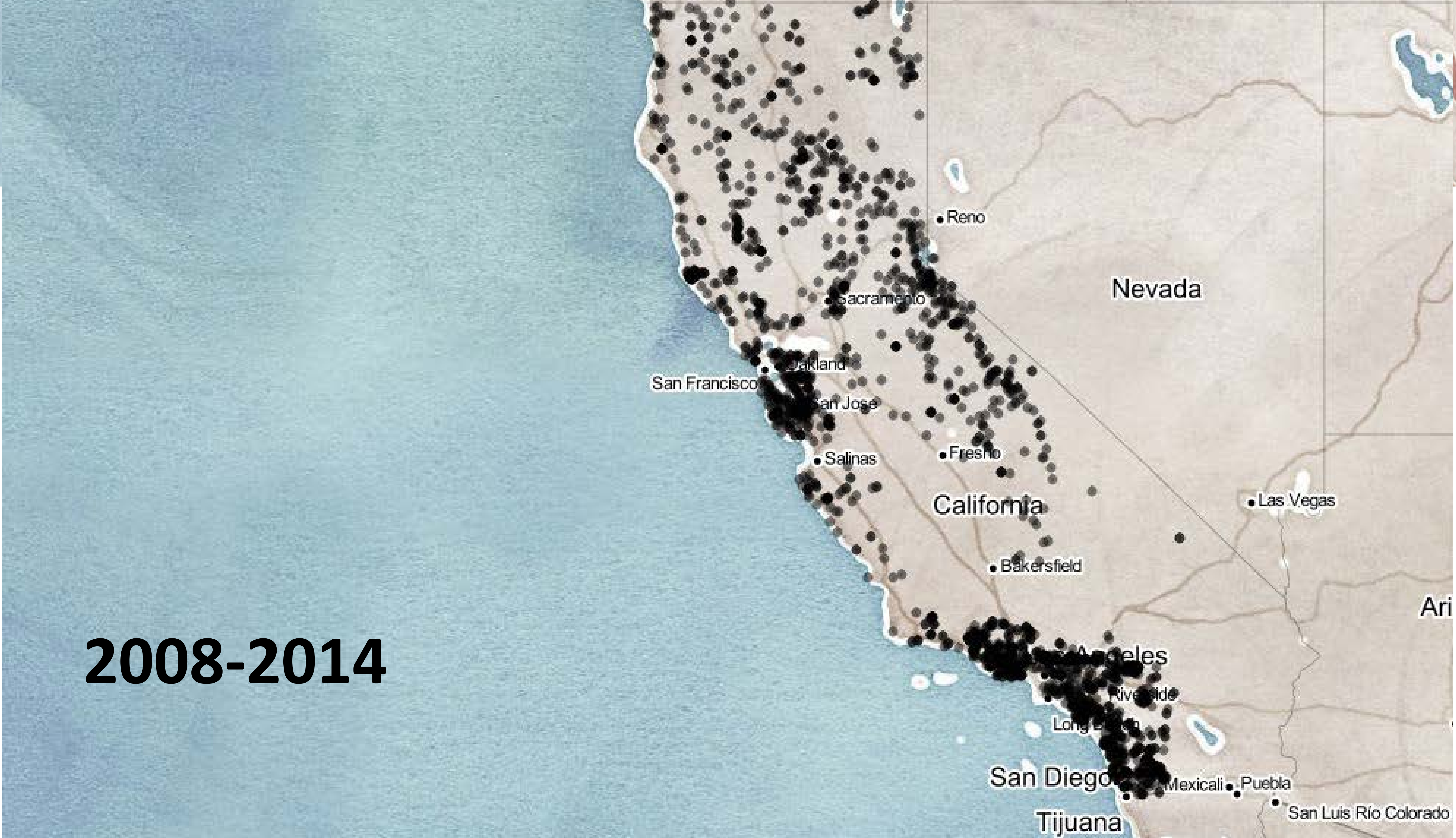
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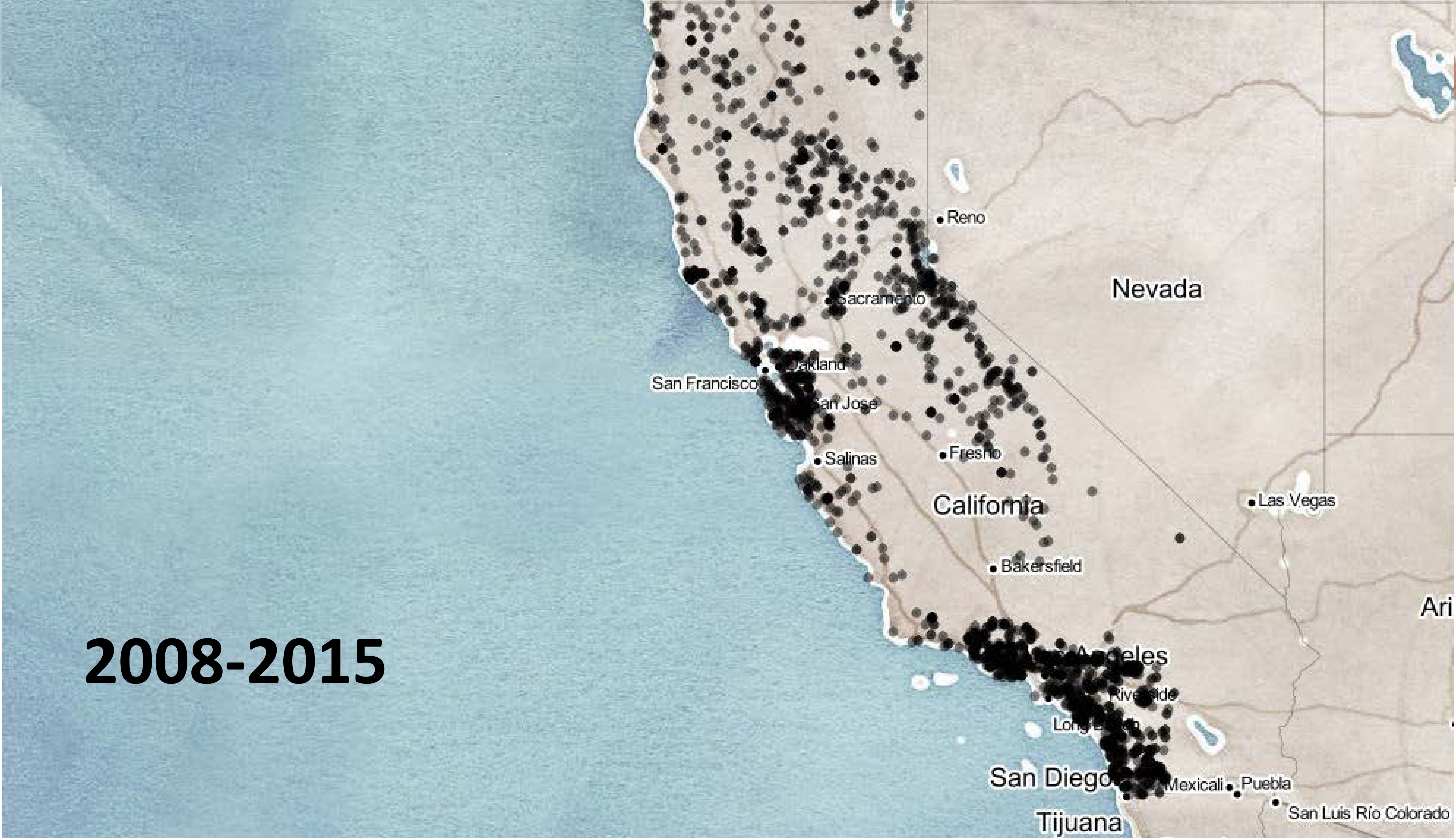
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Salinas
Fresno
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Las Vegas
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San Diego
Mexicali
Puebla
San Luis Río Colorado
Tijuana

Statewide Algae Plan

Past – Standard methods/tools

- Sampling and lab protocols
- S. California Algal IBI

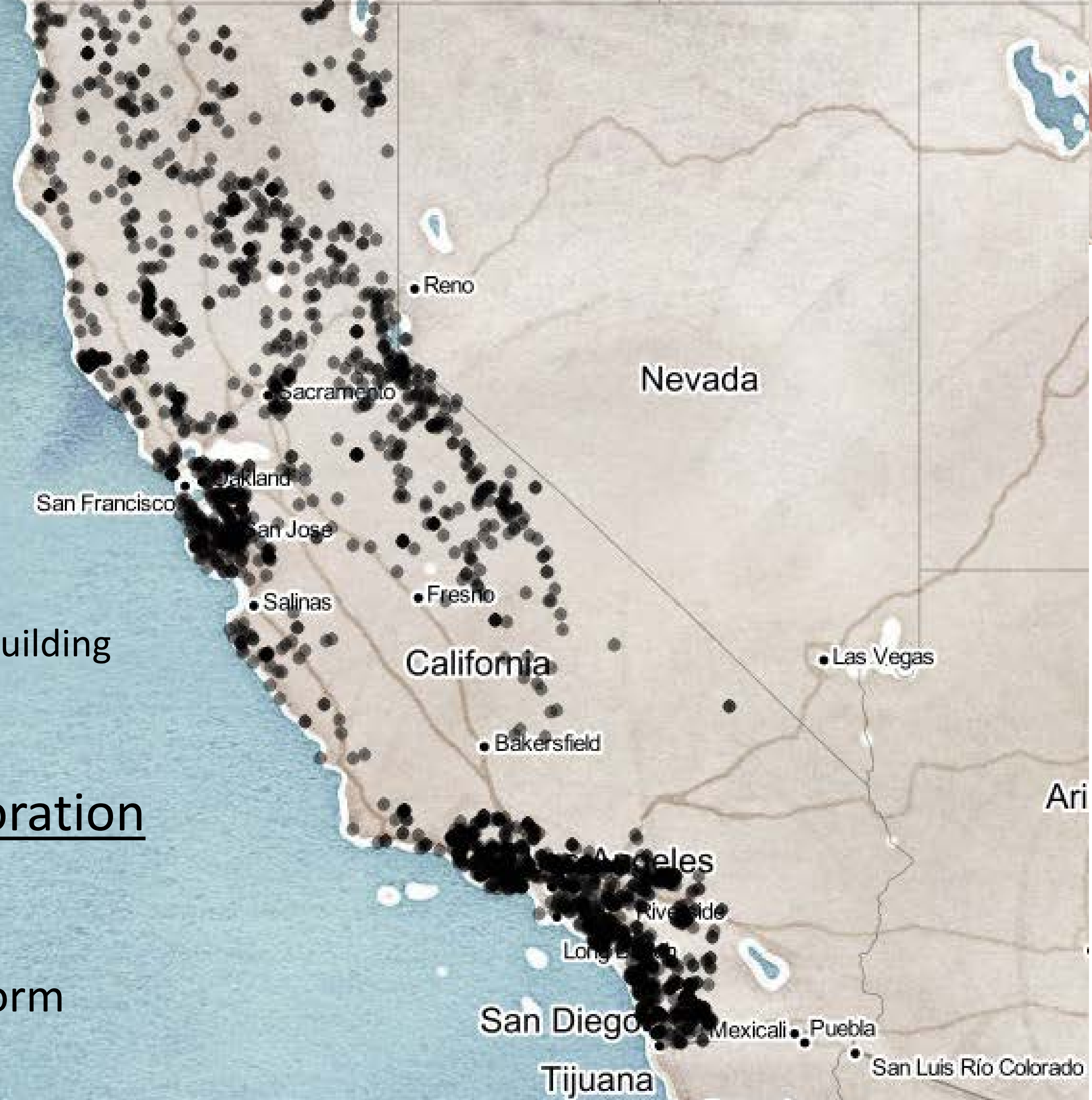
Present - Multiuse datasets

- Statewide Algal Index
- STE
- Molecular methods

} Capacity building

Future – Communication/collaboration

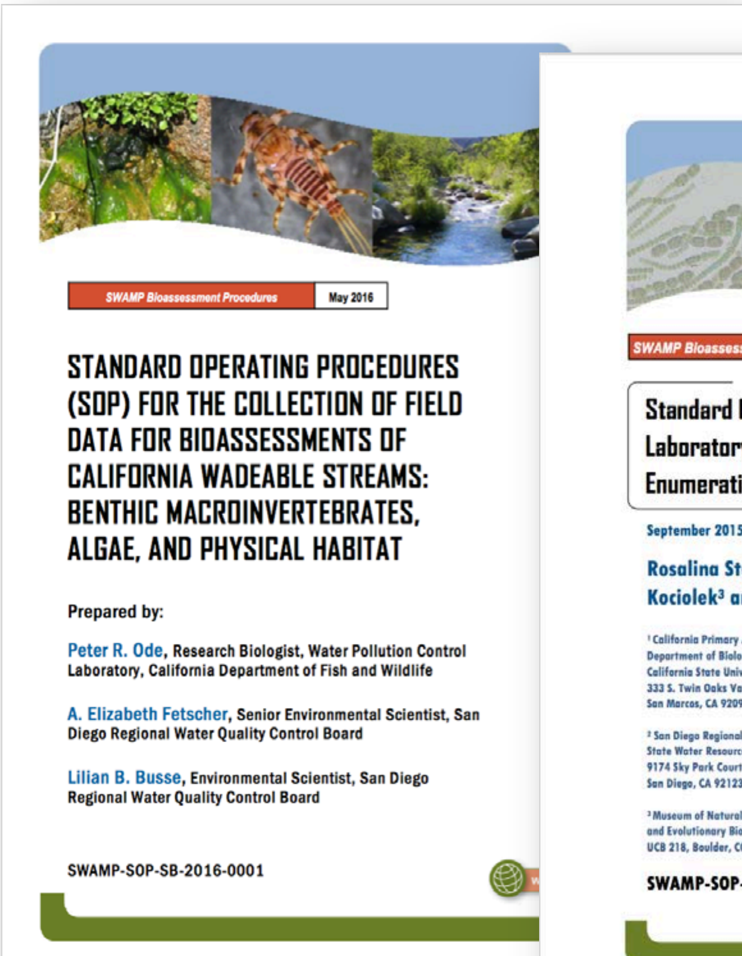
- Integrating tools into State infrastructure
- Using algal bioassessment to inform regulatory policy



Why algae?

- Provide a direct link to nutrient concentrations and imbalances
- Sensitive to changes in water chemistry
- Short life span, rapid growth rate and rapid response to stress
- High dispersal rates and high species numbers
- Toxic species

Algal bioassessment protocols



SWAMP Bioassessment Procedures May 2016

STANDARD OPERATING PROCEDURES (SOP) FOR THE COLLECTION OF FIELD DATA FOR BIOASSESSMENTS OF CALIFORNIA WADEABLE STREAMS: BENTHIC MACROINVERTEBRATES, ALGAE, AND PHYSICAL HABITAT

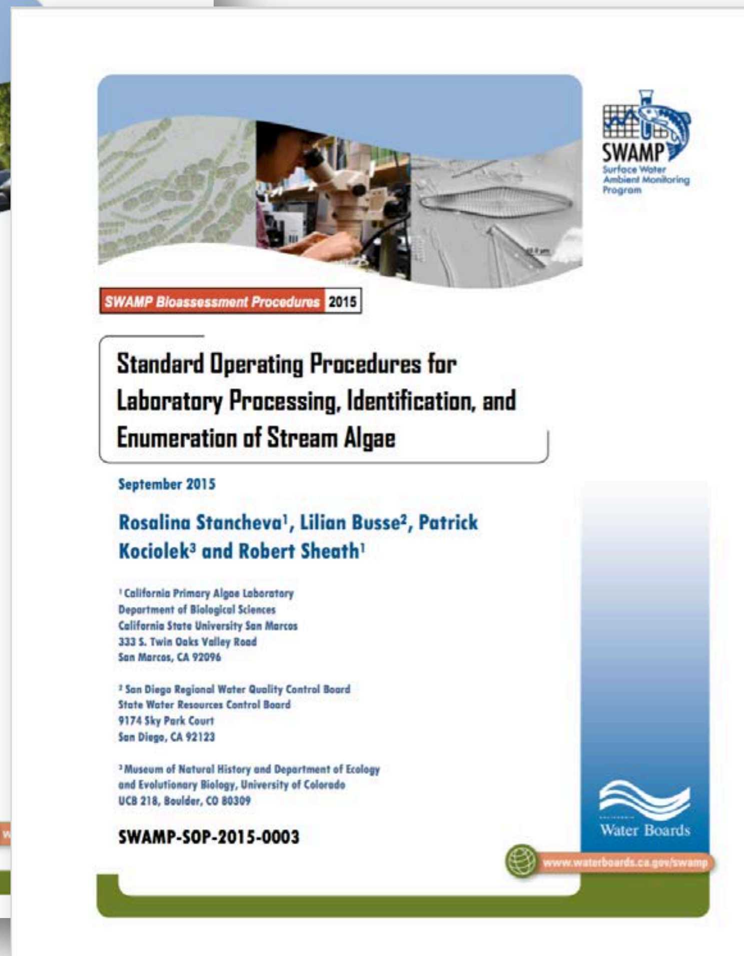
Prepared by:

Peter R. Ode, Research Biologist, Water Pollution Control Laboratory, California Department of Fish and Wildlife

A. Elizabeth Fetscher, Senior Environmental Scientist, San Diego Regional Water Quality Control Board

Lilian B. Busse, Environmental Scientist, San Diego Regional Water Quality Control Board

SWAMP-SOP-SB-2016-0001



SWAMP Surface Water Ambient Monitoring Program

SWAMP Bioassessment Procedures 2015

Standard Operating Procedures for Laboratory Processing, Identification, and Enumeration of Stream Algae

September 2015

Rosalina Stancheva[1], Lilian Busse[2], Patrick Kociolek[3] and Robert Sheath[1]

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San Marcos, CA 92096

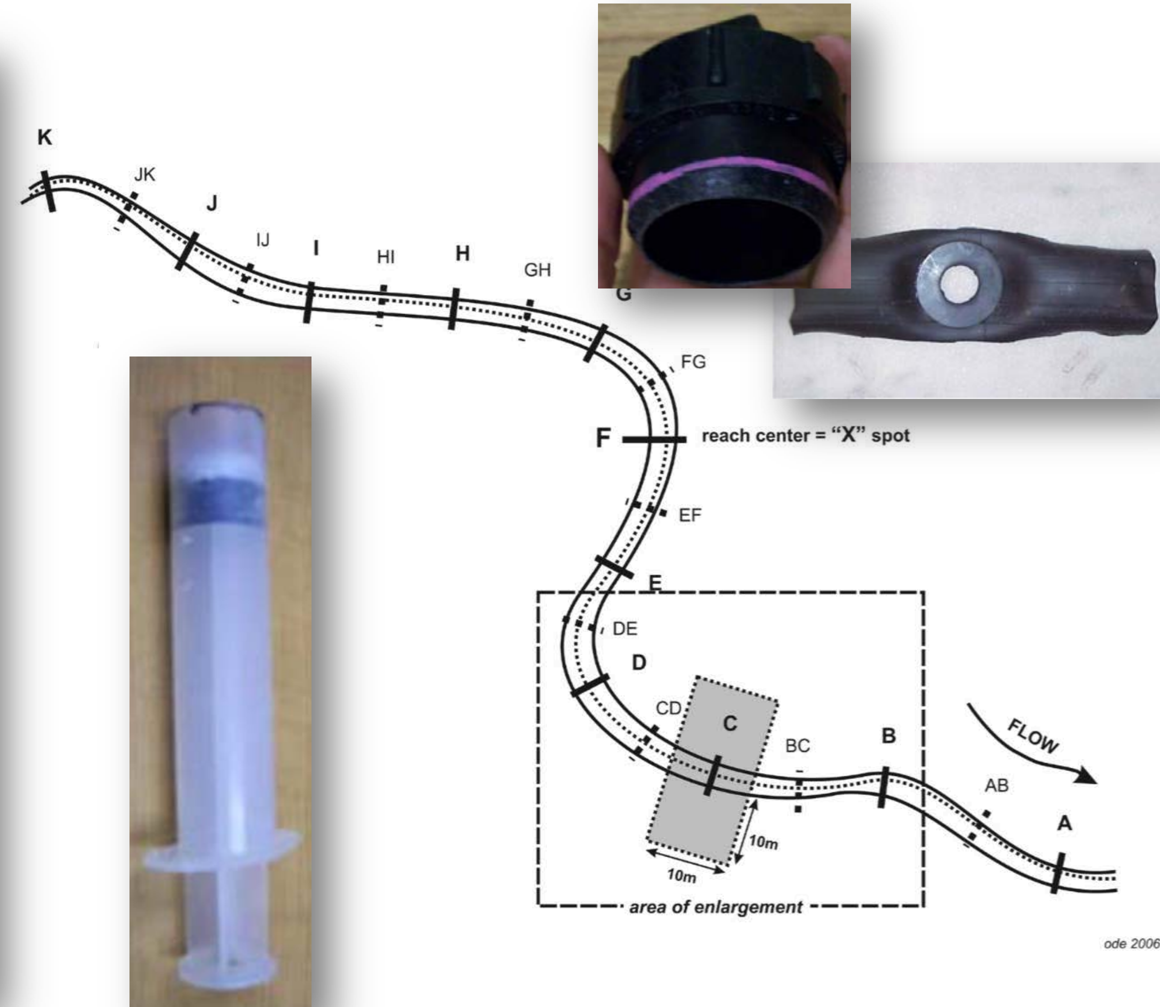
[2] San Diego Regional Water Quality Control Board
State Water Resources Control Board
9174 Sky Park Court
San Diego, CA 92123

[3] Museum of Natural History and Department of Ecology and Evolutionary Biology, University of Colorado
UCB 218, Boulder, CO 80309

SWAMP-SOP-2015-0003

Water Boards

www.waterboards.ca.gov/swamp

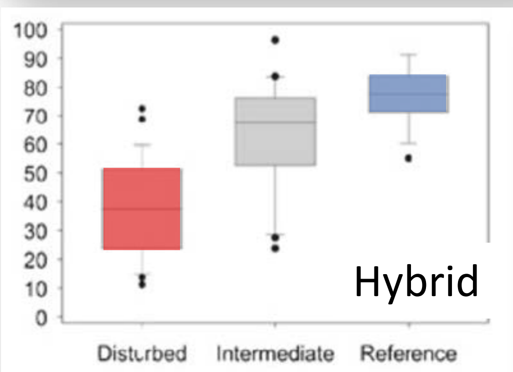


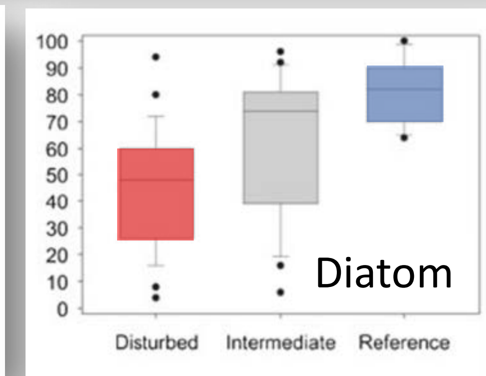
Algal Index of Biotic Integrity (IBI)

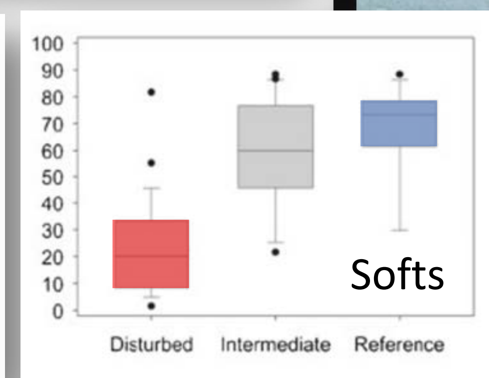
J Appl Phycol (2014) 26:433–450
DOI 10.1007/s10811-013-0088-2

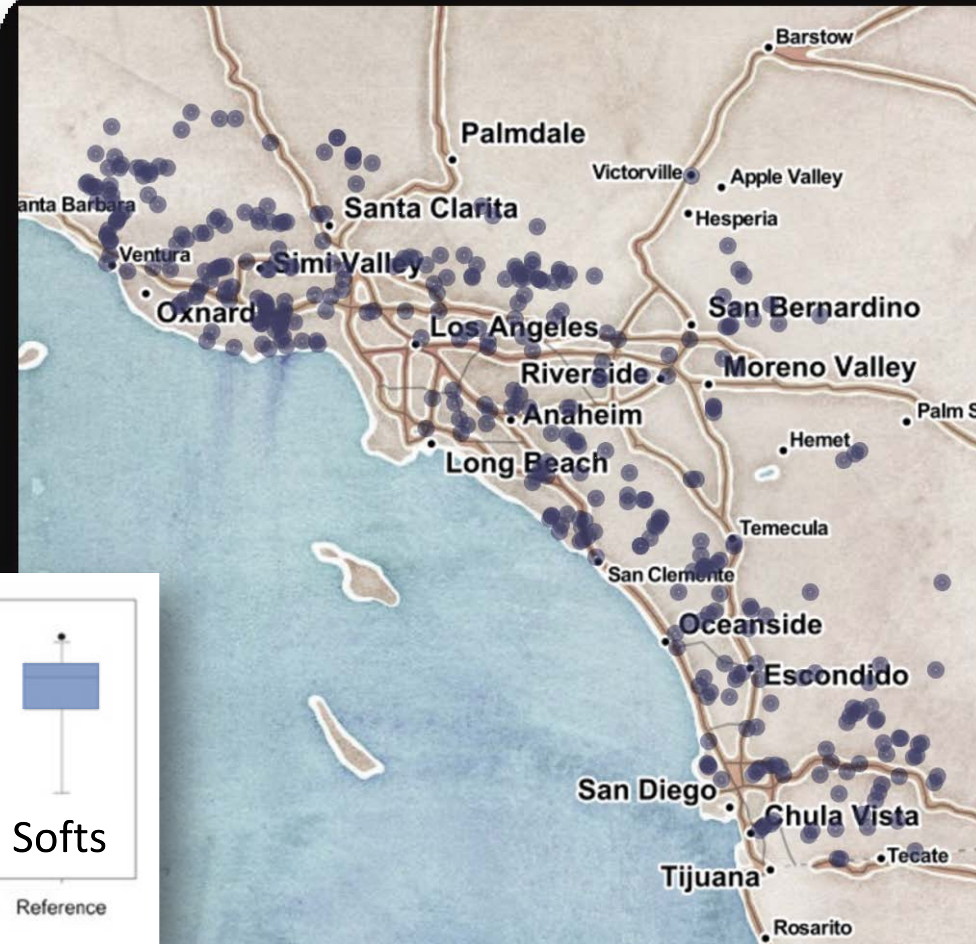
Development and comparison of stream indices of biotic integrity using diatoms vs. non-diatom algae vs. a combination

A. Elizabeth Fetscher · Rosalina Stancheva · J. Patrick Kociolek · Robert G. Sheath · Eric D. Stein · Raphael D. Mazor · Peter R. Ode · Lilian B. Busse

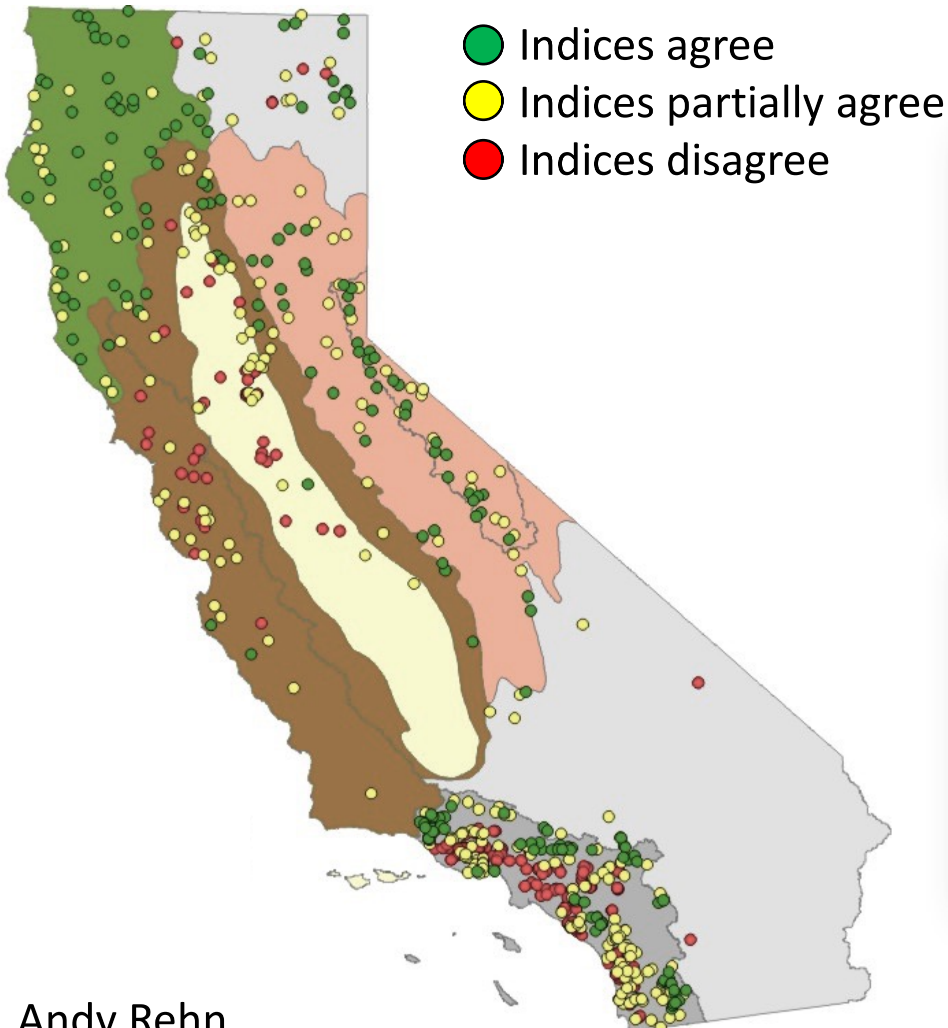








Two indices are better than one



Andy Rehn

- California Stream Condition Index (CSCI): benthic macroinvertebrate (bugs)
- Algal IBI (H20)
- $CRAM_{bio\text{-}phys}$ measures biotic structure and physical structure

- **CSCI was more sensitive to physical habitat conditions, whereas IBI was more sensitive to chemistry**

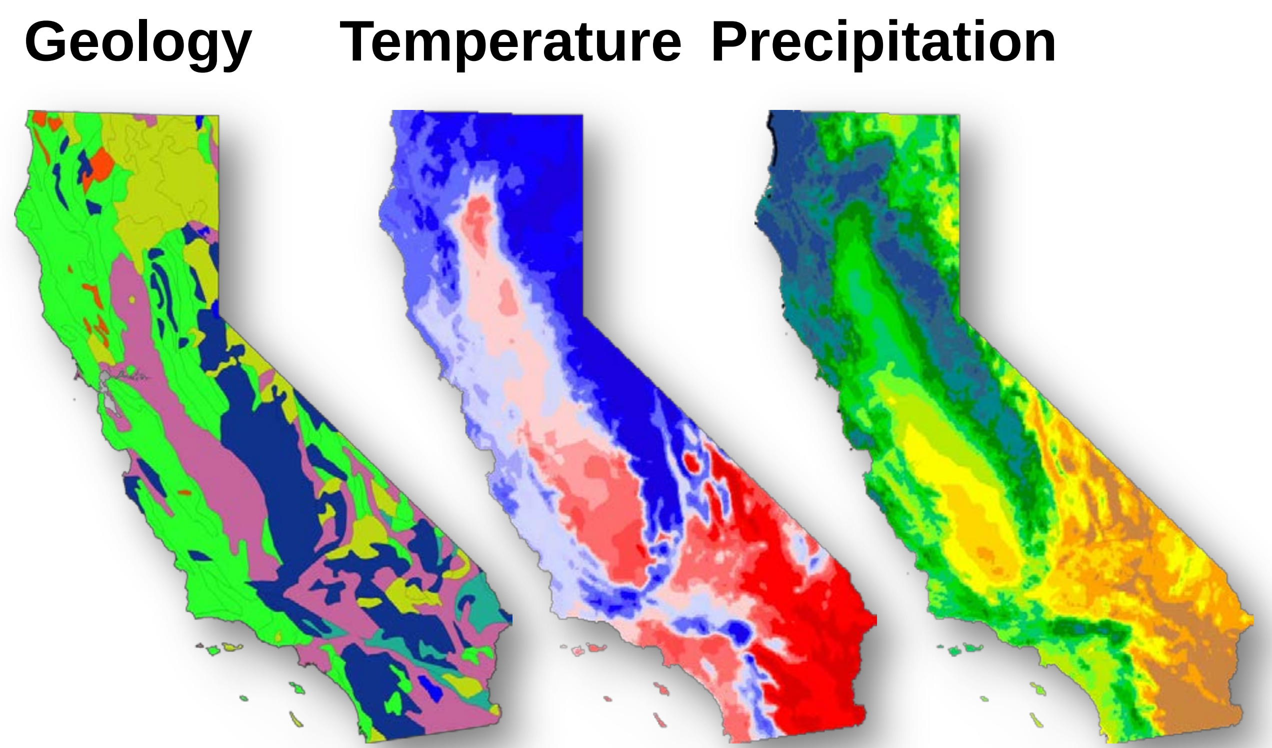
Current efforts: Statewide Algal Index

Problem: Algal IBI tuned for Southern California

Solution: Develop predictive statewide Algal Index

Dataset

- Stormwater Monitoring Coalition (SMC)
- Perennial Stream Assessment (PSA)
- Reference Condition Management Program (RCMP)
- Regional Monitoring Coalition(RMC)
- 2000 stations, 3800 taxa



Statewide Algal Index

Reference-based approach

- Site-specific expectations for each site based on taxa found at groups of similar reference sites

Observed/expected (O/E)

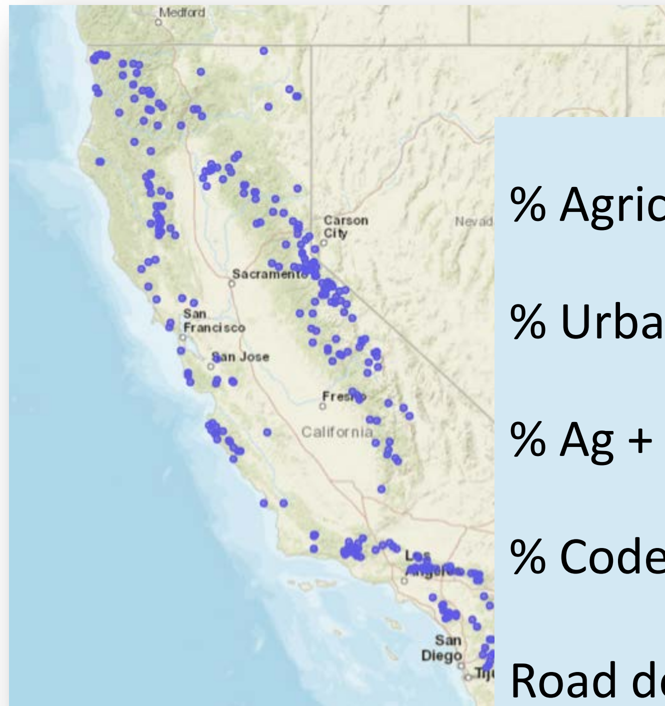
- Taxonomic completeness

Multi-Metric Index (MMI)

- Ecological structure
- Comprised of several metrics that represent community structure

- ETA Fall 2017

Reference



% Agriculture	Dam distance
% Urban	% Canals and pipelines
% Ag + % Urban	In-stream gravel mines
% Code 21	Producer mines
Road density	Specific conductance
Road crossings	W1_HALL

Mazor et al., 2016; Ode et al., 2016

Capacity building - STE

Problem: Taxonomy data not always comparable, variable levels of taxonomic resolution

Solution: Standard Taxonomic Effort (STE)

- Standard taxa list and level of taxonomic resolution
- Minimize time spent harmonizing algae taxonomy data from different labs

Amphora, German Benthic Diatom Intercalibration Exercise 2011

Capacity building - STE

- Build upon the SAFIT model for bugs
- ETA: June 2017

Class	STE 1	STE 2	Low Abd	Trait	Hard to ID
Prasinophyceae	Genus	Species	x		
Cyanophyceae	Species	Species		x	
Zygnematophyceae	Genus	Genus			x

Amphora, German Benthic Diatom Intercalibration Exercise 2011

Capacity building - Molecular methods

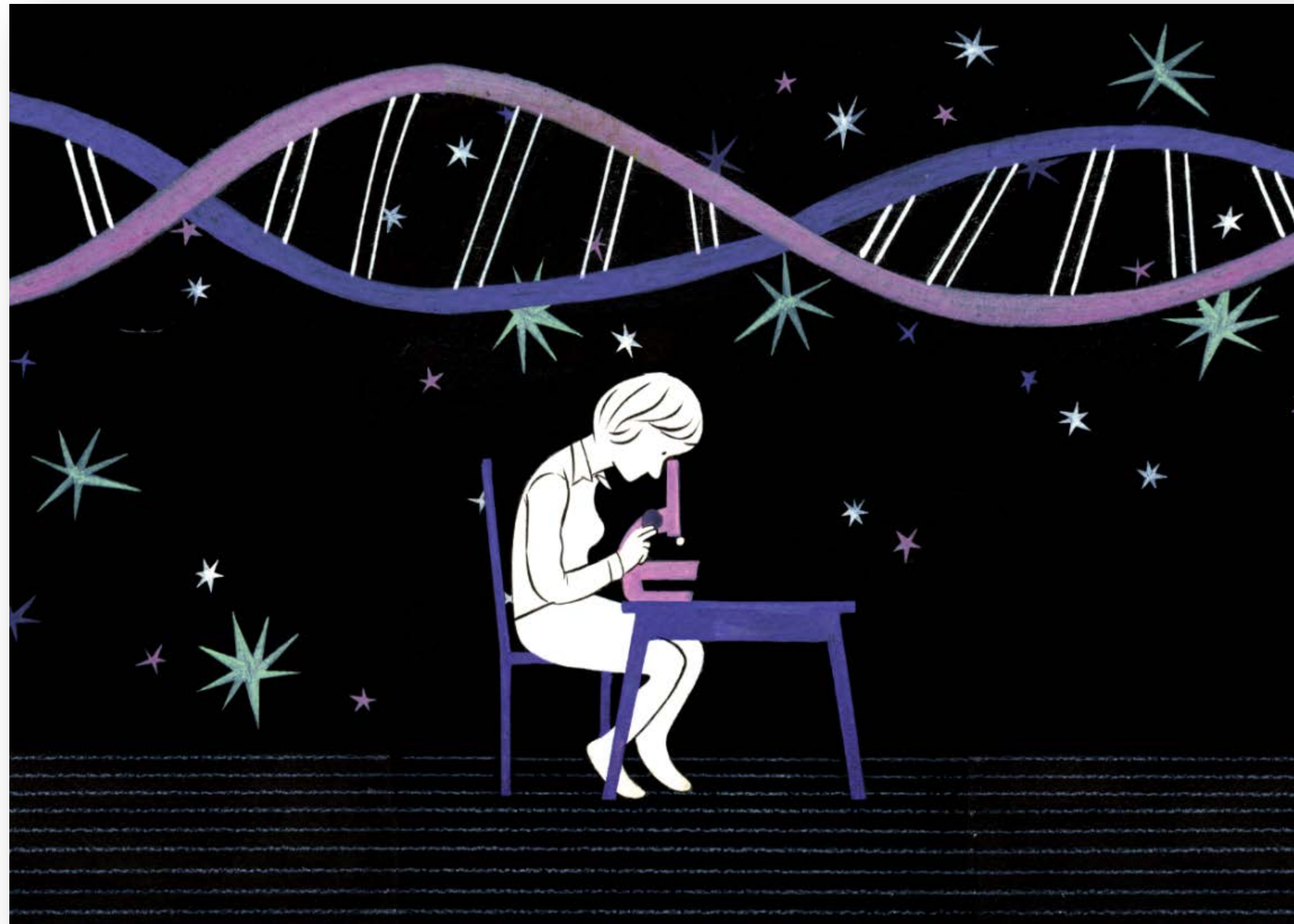
Problem: Limited number of labs capable of performing algae taxonomic analyses; results in backlog of taxonomy data and long wait times

HELIX, Daniel Locke

Capacity building - Molecular methods

Solution: Explore DNA-based approach to algae taxonomy

- Illuminate previously overlooked species
- Dozens of commercial and academic labs can perform analyses
- Inexpensive

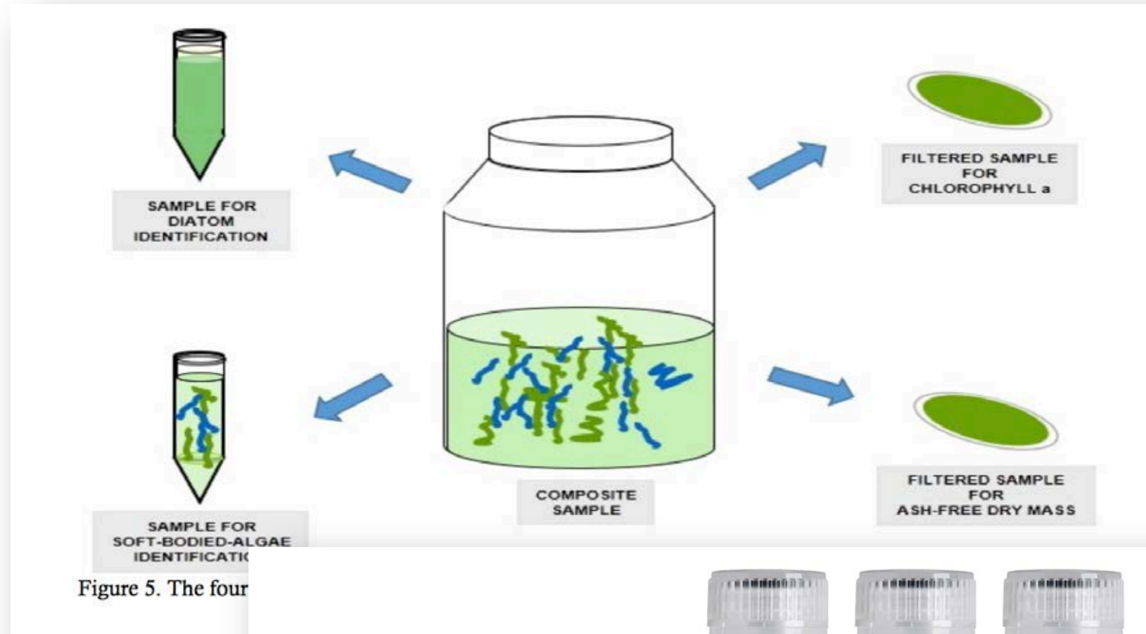


HELIX, Daniel Locke

Capacity building - Molecular methods

DNA barcode approach

- Easily integrated into current field sampling protocols
- Sample stable (frozen) for months to years
- Pilot studies: ~200 Paired DNA/morphology samples collected during 2016



Capacity building - Molecular methods

Key questions for pilot studies

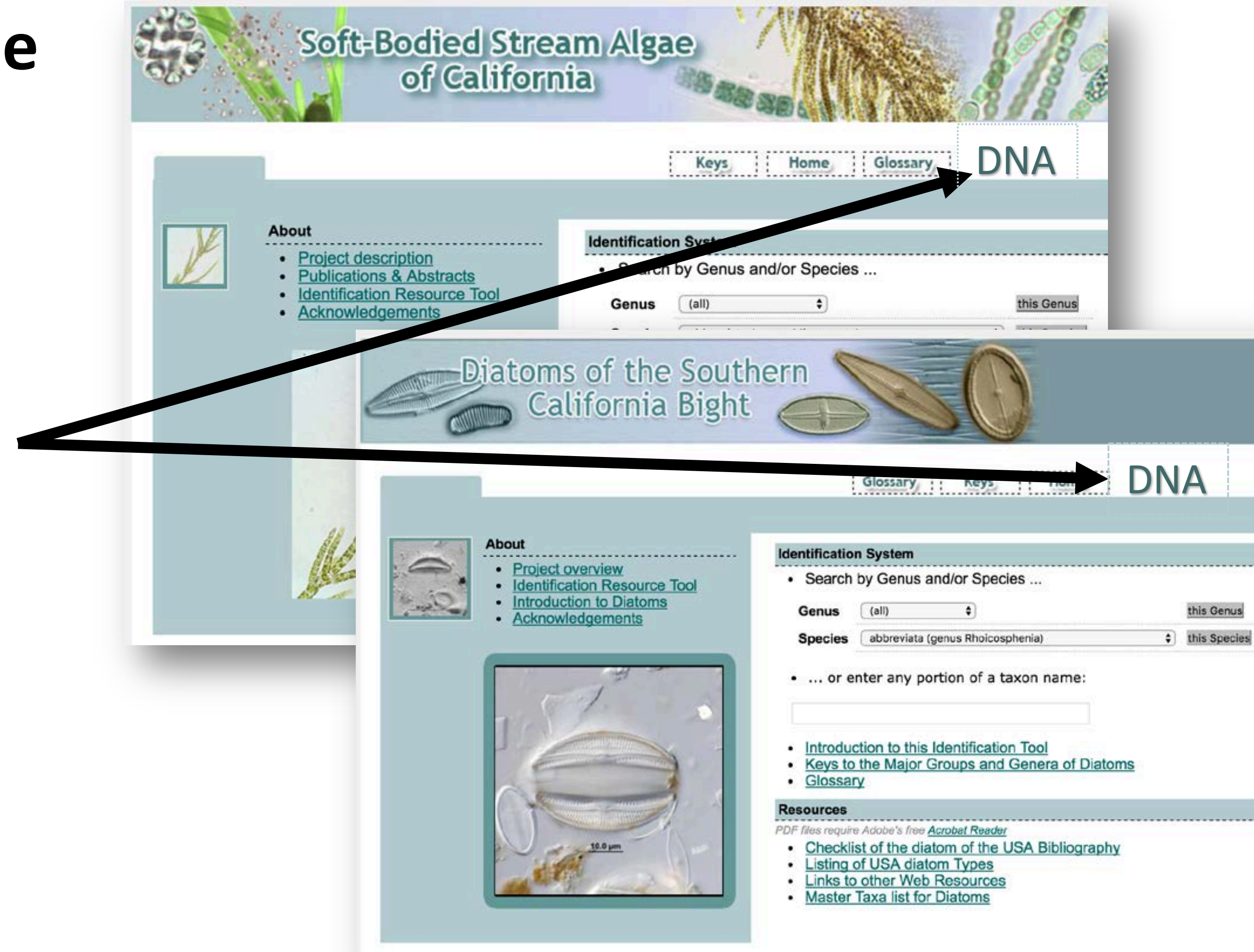
1. How do morphology-based and DNA-based algae taxonomy data compare?
2. What algal species are missing from DNA reference databases?
3. How well do algal indices perform with DNA data?

ETA: Early 2018

Future plans

Making algae tools accessible

- Incorporating Statewide Algal Index into online resources (SWAMP)
- Building California Algae DNA Reference Database
  - Isolating and sequencing priority taxa absent from existing DNA databases
- Guidance documents



http://dbmuseblade.colorado.edu/DiatomTwo/sbsac_site/

Future plans

Integration of algal toolkit

- Support State Water Board's combined nutrient and biointegrity policy
  - Set nutrient thresholds?
  - How to use as one of multiple lines of evidence? In concert with other indices?
  - How to use in water programs, e.g. ambient assessment and 303(d) listing, NPDES, etc. ?
  - Required technical elements for its implementation?

Thanks!

Contact: susannat@sccwrp.org

- Interested in algae DNA sampling? Have DNA samples to send to SCCWRP?
- Do you have algal bioassessment data not in SWAMP that could be useful in the statewide index development?

Acknowledgements

- SWAMP/SWRCB
- Regional Boards
- CSUSM
- SMC
- DFW

-Pete Ode, Andy Rehn
-Rafi Mazor
-Eric Stein, Martha Sutula
-Betty Fetscher

BONUS SLIDES

Capacity building - Molecular methods

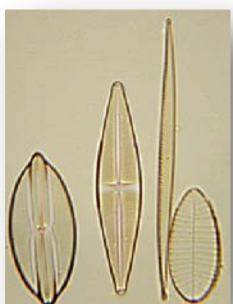
How will Algal Indices perform with DNA barcode data?

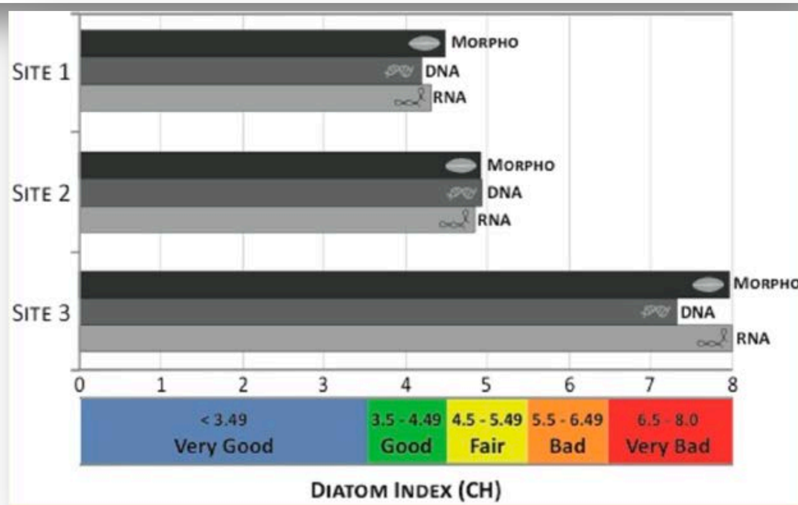
DOI: 10.1021/es506158m
Environ. Sci. Technol. 2015, 49, 7597−7605
pubs.acs.org/est

Environmental Monitoring: Inferring the Diatom Index from Next-Generation Sequencing Data

Joana Amorim Visco,† Laure Apothéloz-Perret-Gentil,† Arielle Cordonier,‡ Philippe Esling,†,§ Loïc Pillet,†,∥ and Jan Pawlowski*,†

Swiss Diatom Index (DI-CH)





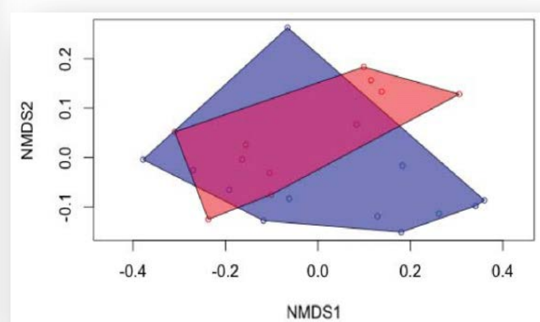
PLOS ONE | DOI:10.1371/journal.pone.0138432 October 21, 2015

RESEARCH ARTICLE

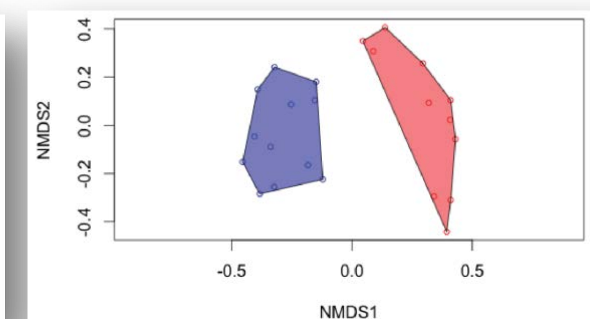
Large-Scale Biomonitoring of Remote and Threatened Ecosystems via High-Throughput Sequencing

Joel F. Gibson[1,2], Shadi Shokralla[1], Colin Curry[3], Donald J. Baird[3], Wendy A. Monk[4], Ian King[1], Mehrdad Hajibabaei[1]*

Morphology-based taxonomy

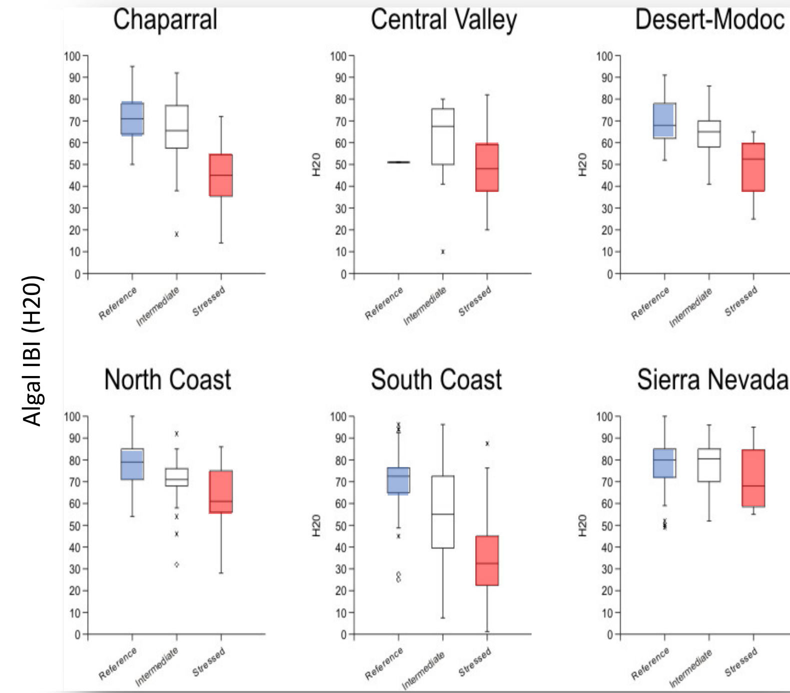


DNA – species level



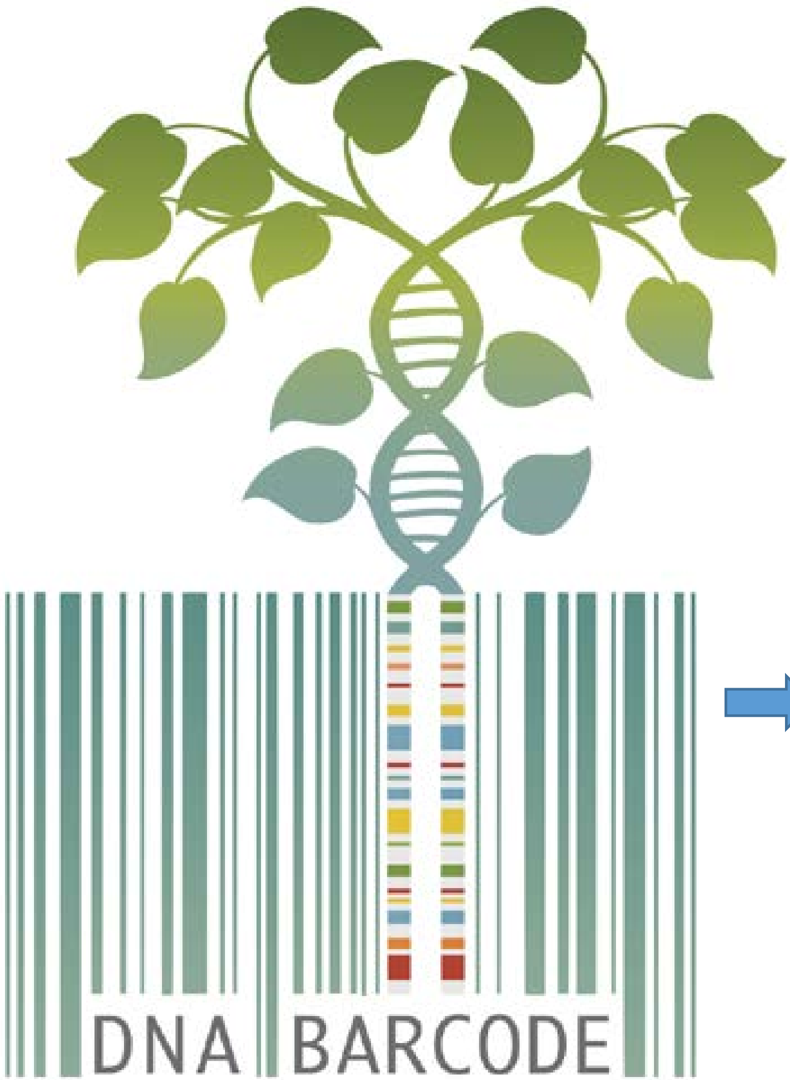
Reference screening

Variable	Scale	Threshold	Unit
% Agriculture	1 km, 5 km, WS	<3	%
% Urban	1 km, 5 km, WS	<3	%
% Ag + % Urban	1 km, 5 km, WS	<5	%
% Code 21	1 km and 5 km	<7	%
	WS	<10	%
Road density	1 km, 5 km, WS	<2	km/km^2
Road crossings	1 km	<5	crossings/ km^2
	5 km	<10	crossings/ km^2
	WS	<50	crossings/ km^2
Dam distance	WS	<10	km
% Canals and pipelines	WS	<10	%
Instream gravel mines	5 km	<0.1	mines/km
Producer mines	5 km	0	mines
Specific conductance	Site	99/1**	prediction interval
W1_HALL	Sample reach	<1.5	NA

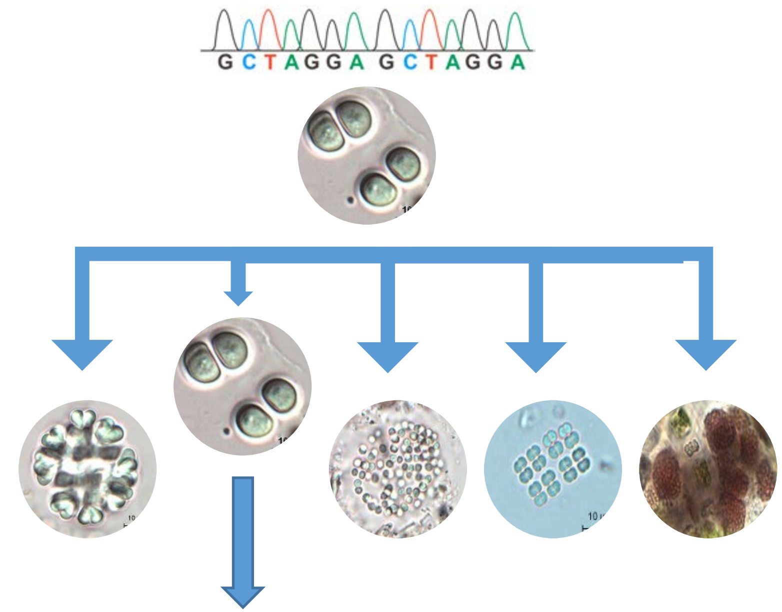


Andy Rehn

DNA barcoding – what is it?



- Sequence one or two DNA regions as a "fingerprint"
- Infer species of organisms by comparing to reference databases

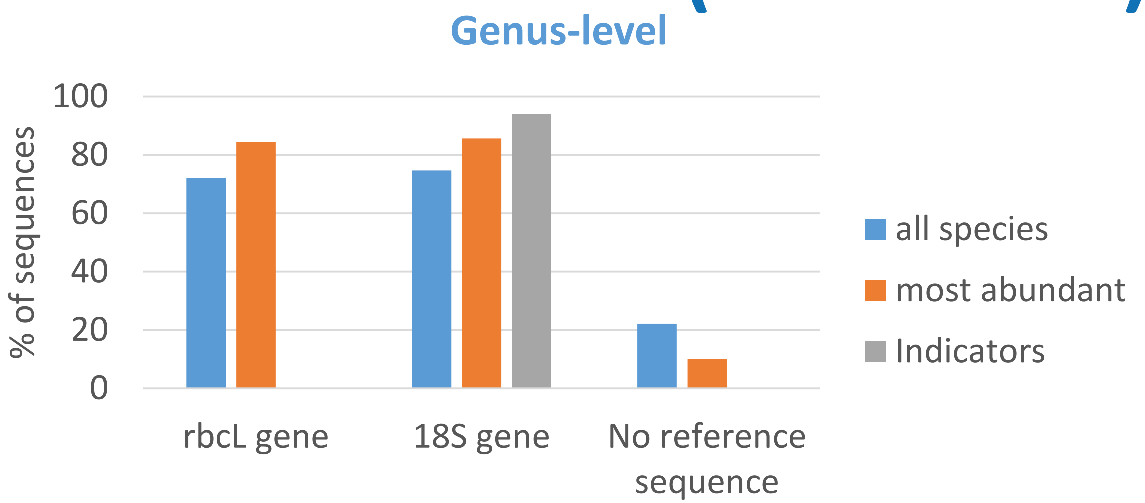


Limnococcus limneticus

Christina Ullman

DNA barcode reference database

SMC (2009-2013) Diatoms in Genbank



- 90% of most abundant taxa and 93% of indicator species have a sequence in Genbank database at *genus* level.

- 50% of most abundant taxa and 38% of indicator species have a sequence in Genbank database at *species* level.

Statewide Algal Index

Reference-based approach

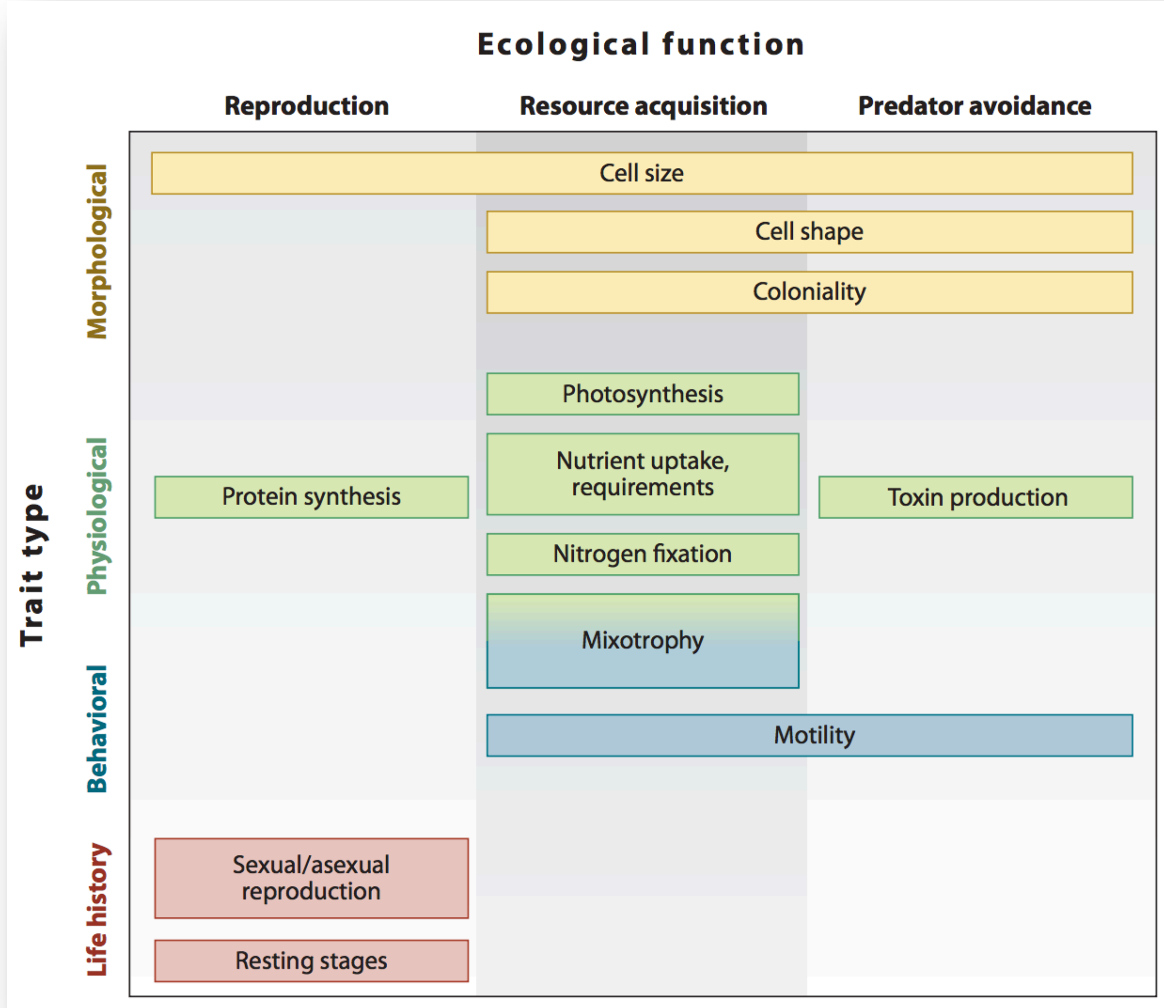
Site-specific expectations for each site based on taxa found at groups of similar reference sites

Candidate traits

1. sedimentation tolerant (incl. highly motile)
2. low-nitrogen indicators (incl. N fixers)
3. halobiontic
4. nitrogen heterotrophs
5. requiring > 50% saturation DO
6. organic-associated
7. copper-associated
8. low-phosphorus

Fetscher et al., 2014

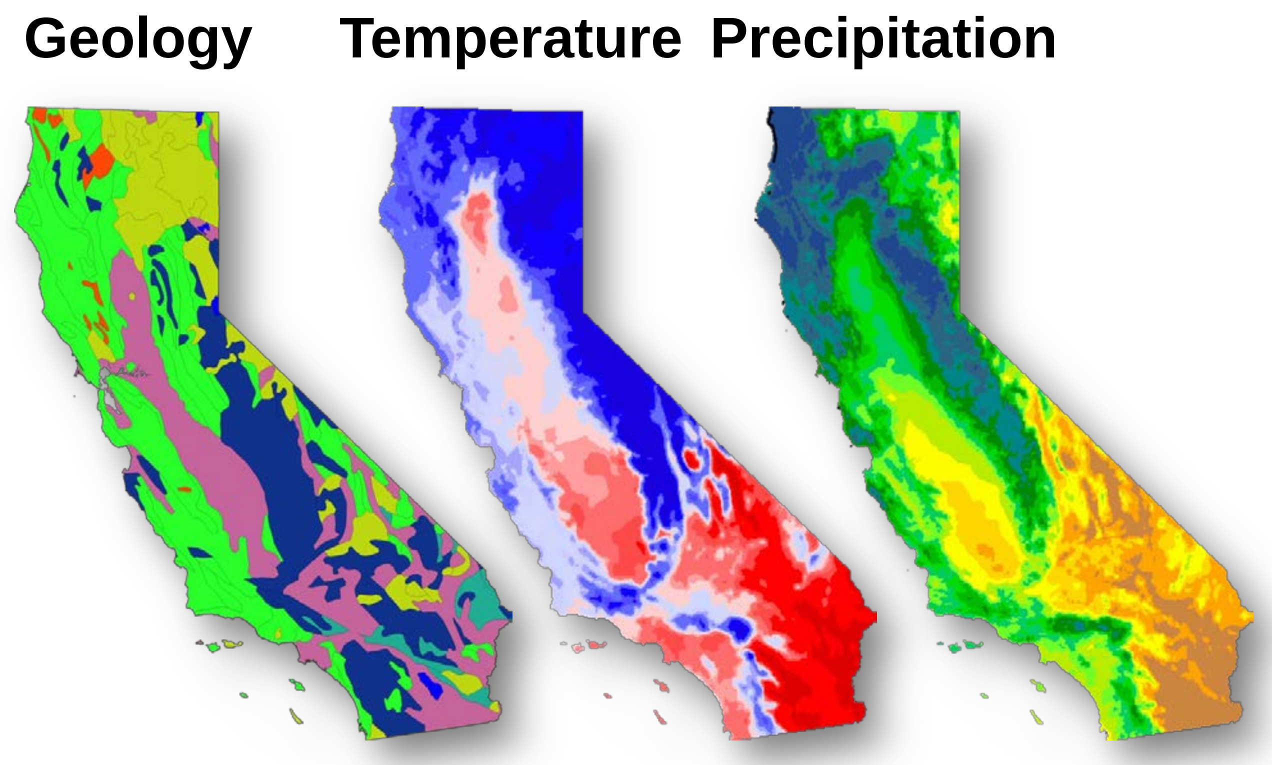
ETA: Fall 2017



Statewide Algae Plan – current efforts

- Development of a statewide scoring tool

- Capacity building
  - Development of standard taxonomic effort (STE) for algal species
  - Exploration of molecular methods



Doriano Solinas; Jian Feng/AP