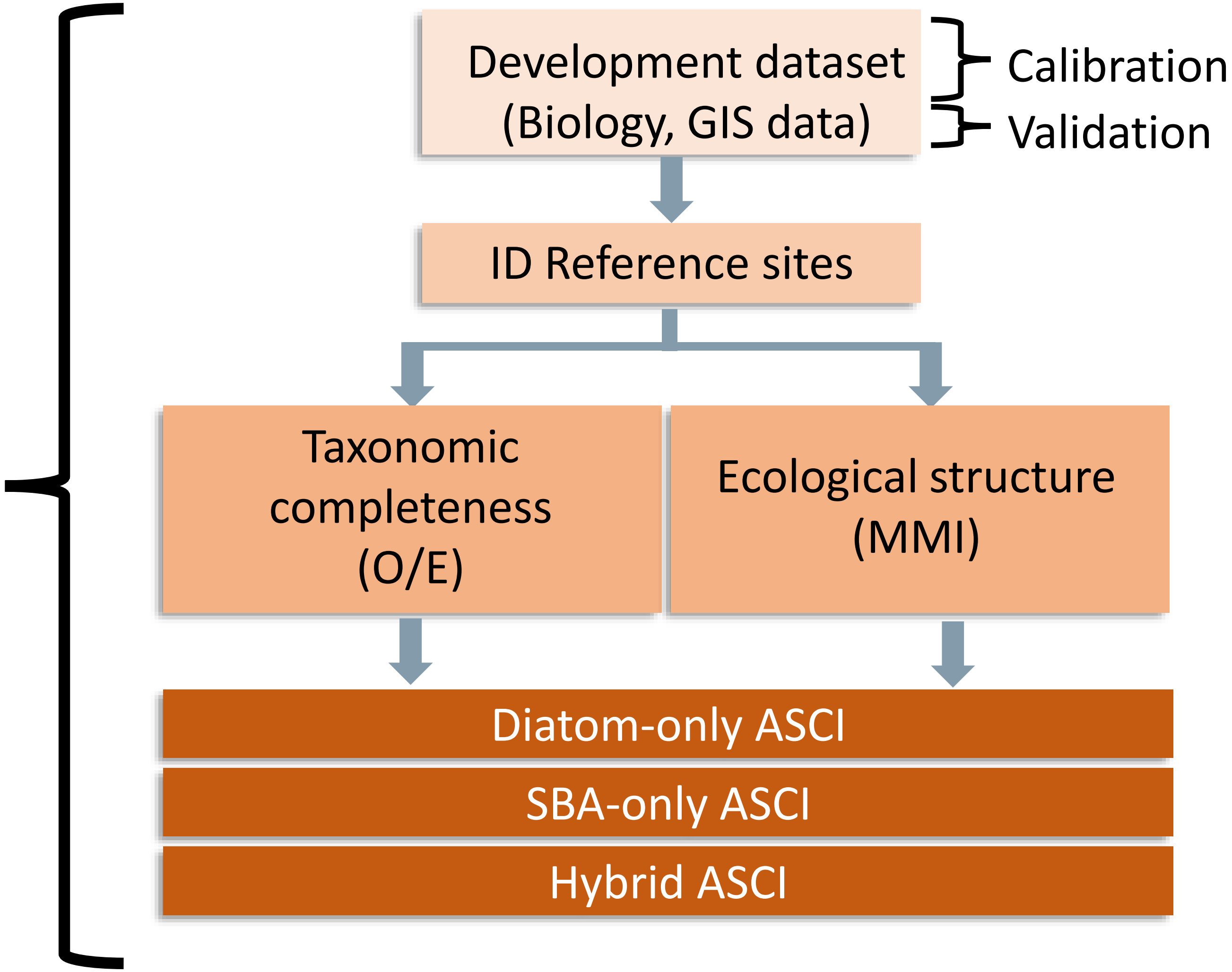
Algal Stream Condition Index (ASCI)

Susie Theroux

December 12, 2018

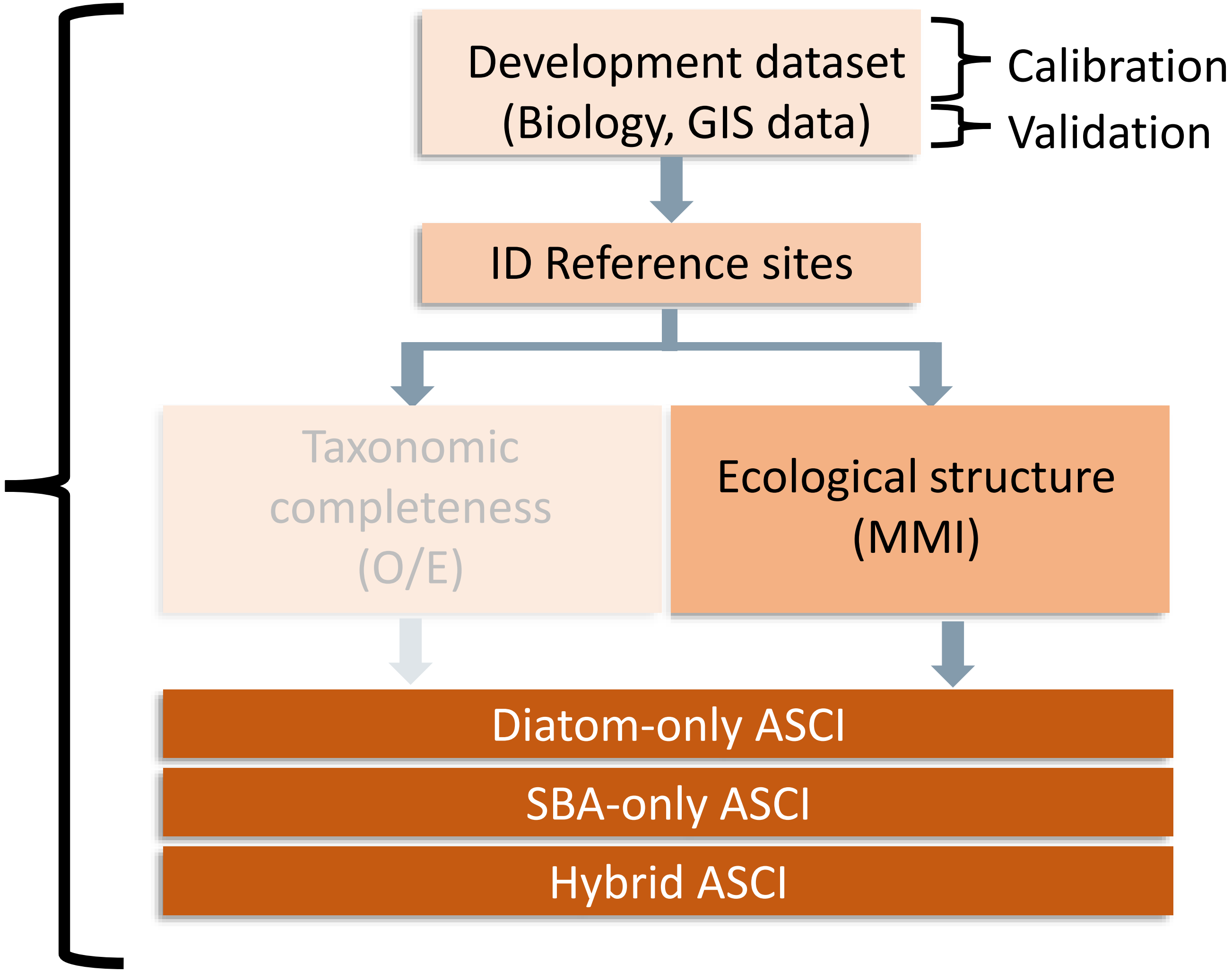
Once upon a time…

- **GOAL:**
  - Develop a statewide algal index
- **APPROACH:**
  - Model the ASCI after the CSCI
  - Develop an Observed to Expected (**O/E**) and a Multi-Metric Index (**MMI**) and a combined version
  - Develop for diatoms, soft-algae, and hybrid



Results

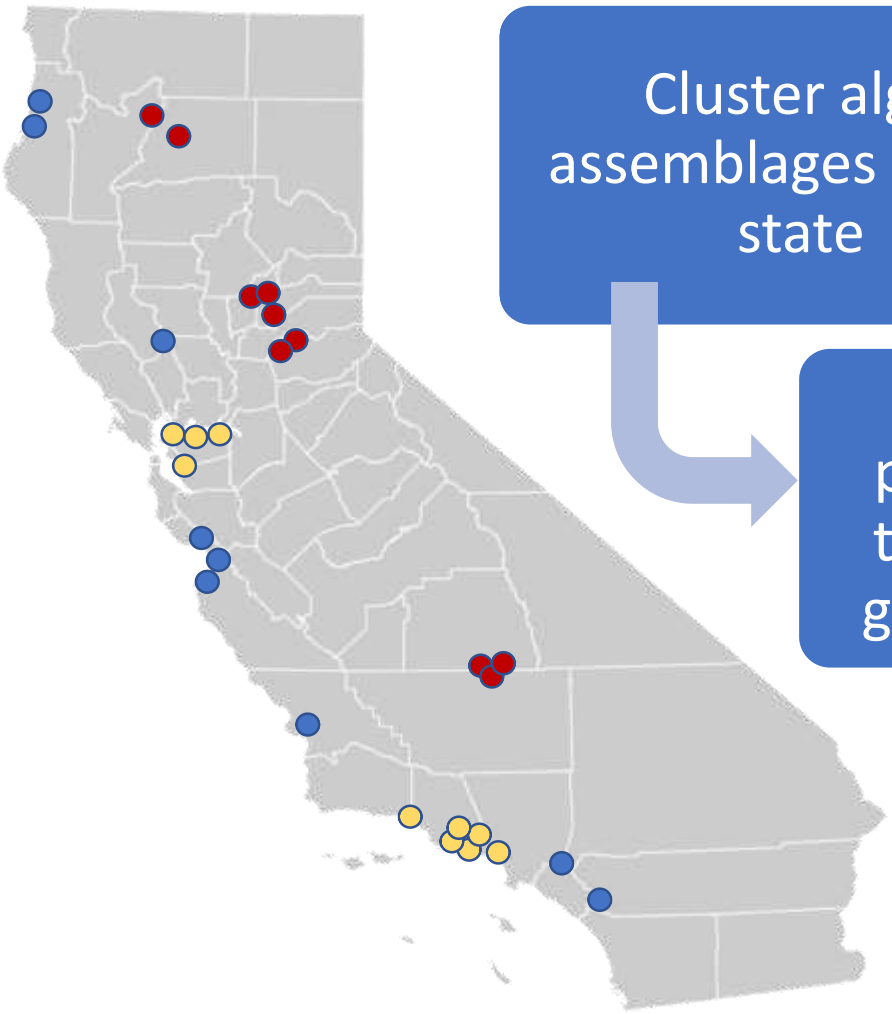
- **GOAL:**
  - Developed statewide algal indices!
- **DETAILS:**
  - O/E models had poor precision
  - Modeling did not improve MMI performance
  - MMIs for diatoms, soft-algae, and hybrid assemblages all had great performance
  - Genus-level diatom MMI had good, but not great, performance



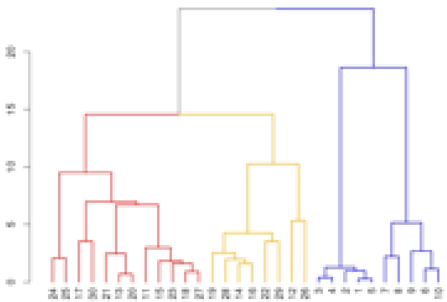
Final ASCI(s)

- MMI indices were high-performing 👍
- O/E indices had consistently poor performance for all three assemblages 👎
- Winning MMI indices did not include any predictive metrics, thus making them standard MMI indices (like the SoCal algae IBI) ¯_(ツ)_/¯
- New algal MMIs have much less regional bias scores than the previous algal IBI therefore making them excellent options for statewide application 👍👍

Refresher on O/E development



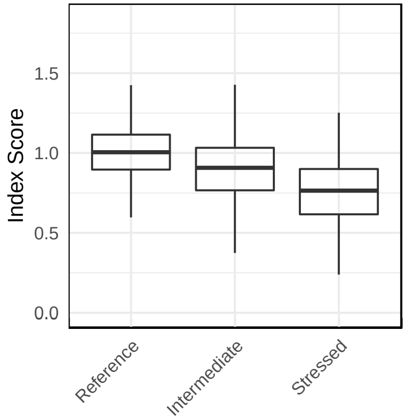
Cluster algal assemblages across state



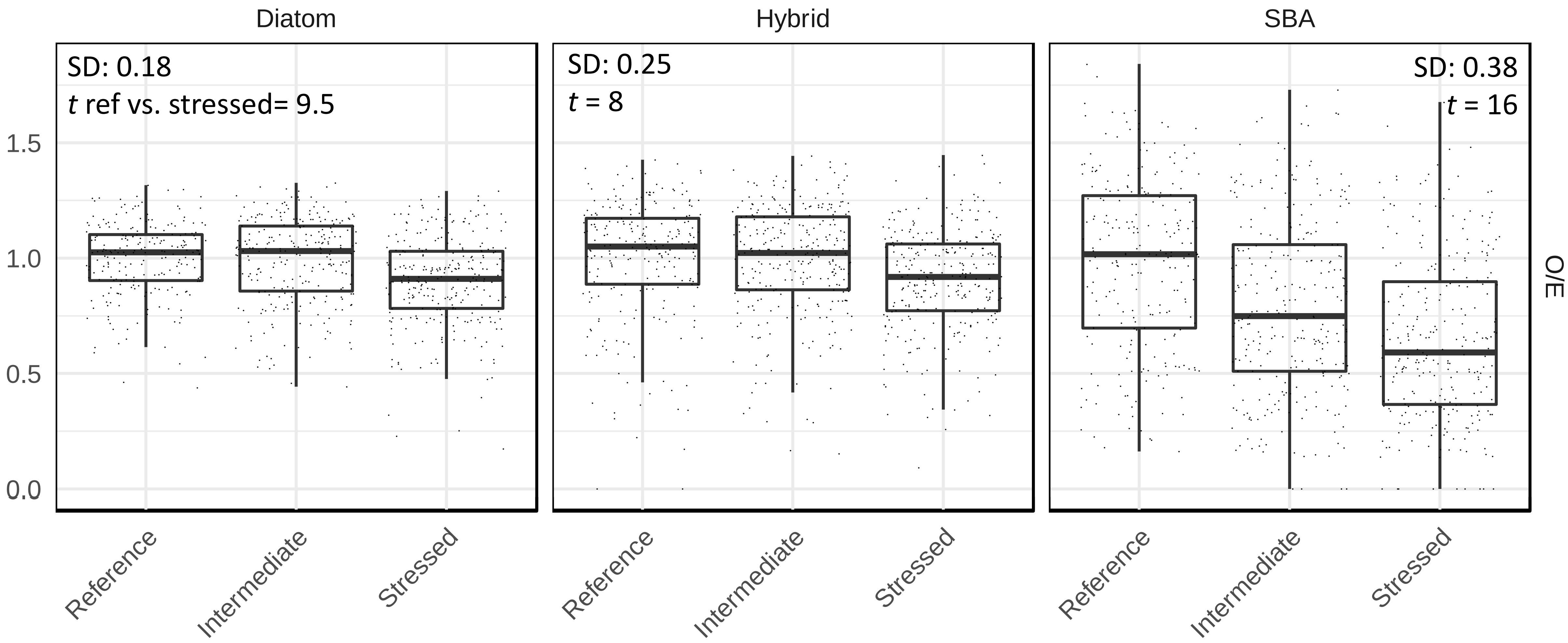
Build models to predict species at test site based on geographic setting

Location	Topography	Long-term climate	Soils	Minerology
Latitude	Watershed area*	Catchment precipitation*	Hydraulic conductance	MgO content
Longitude	Elevation range*	Local precipitation	Bulk density	CaO content
Elevation		Local temp	Erodibility	S content
			Permeability	N content
				P content

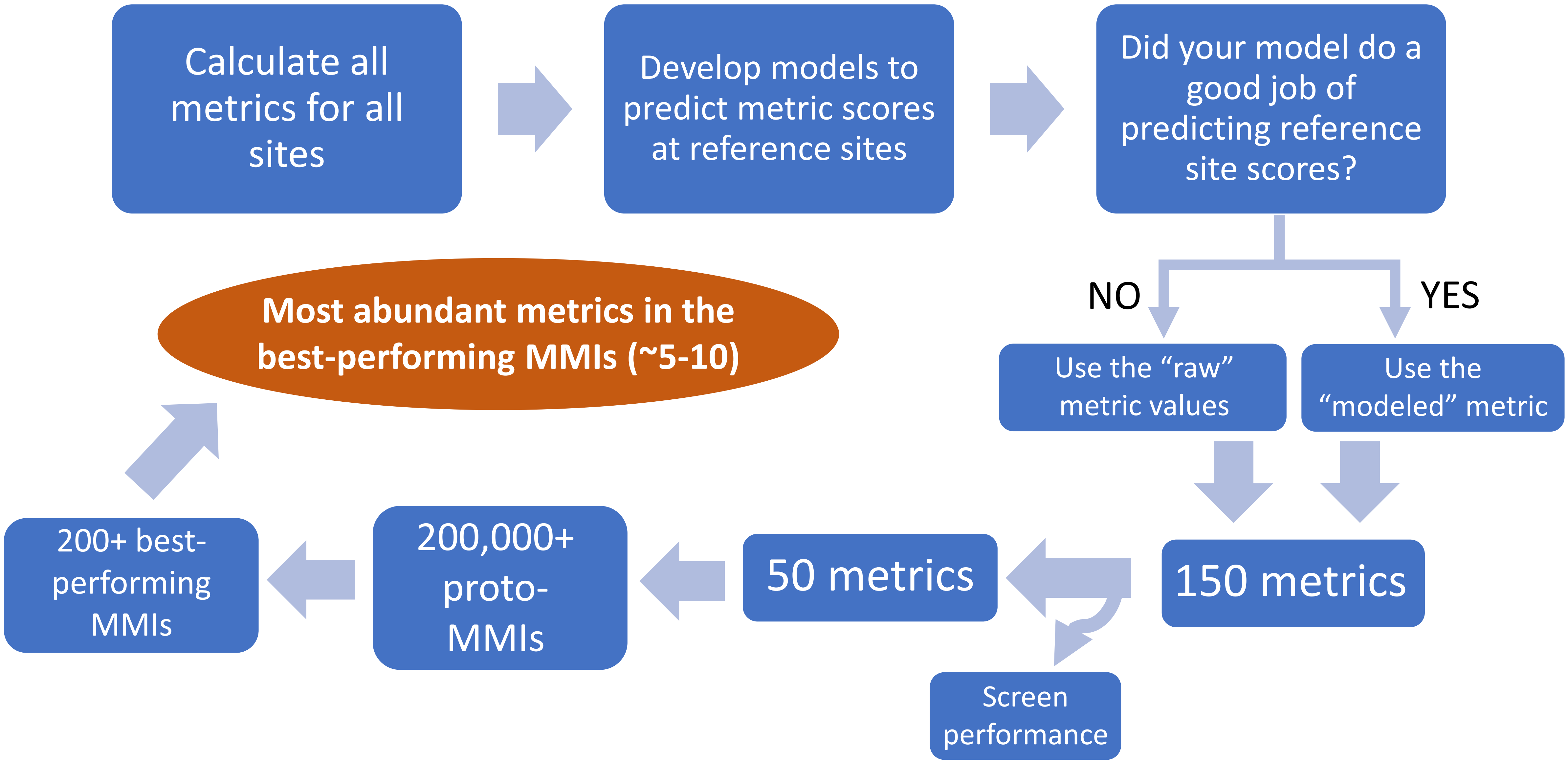
Score sites based on observed vs. expected taxa



O/E – okay responsiveness, poor precision



How we developed MMIs

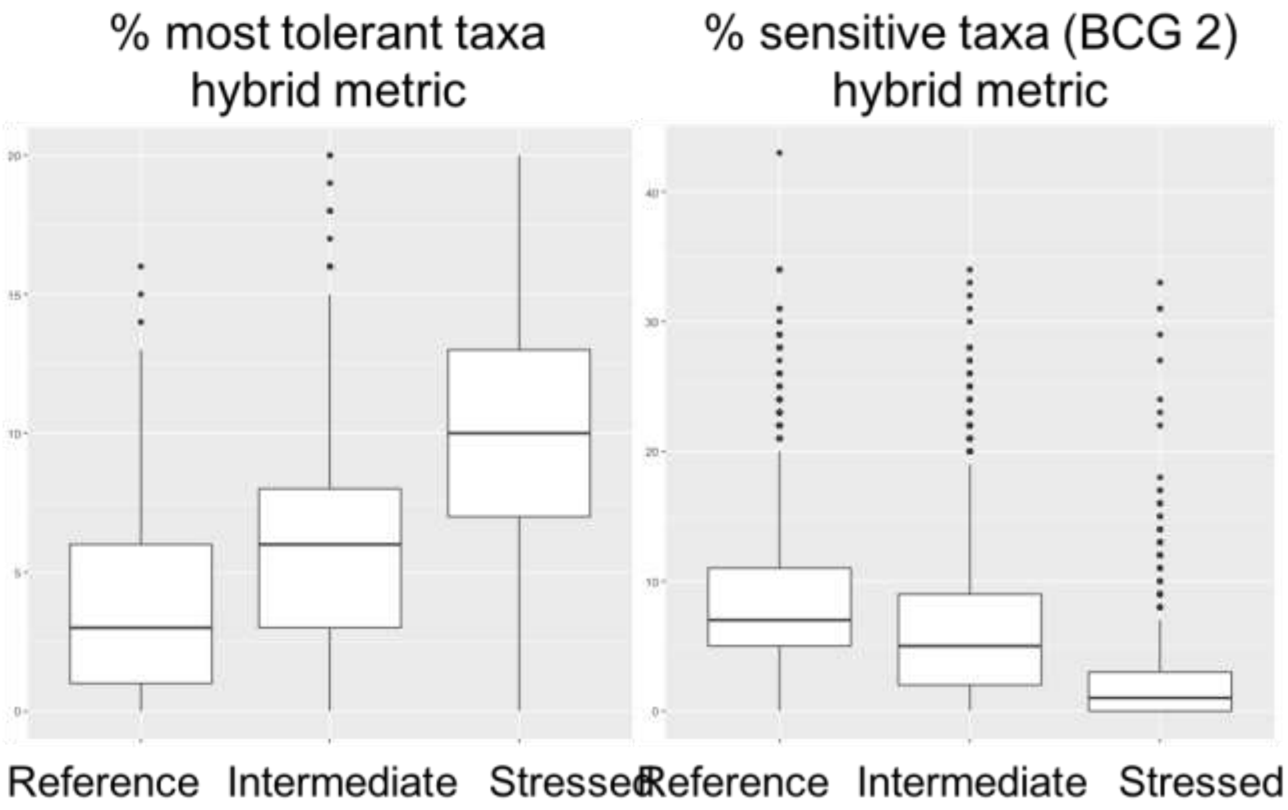


How we screened metrics

Description	Test	Threshold	Reference
Regional bias	ANOVA of metric values at reference sites by ecoregion (PSA)	*F* statistic < 3	Mazor et al., 2016
Sensitivity	t-test comparing reference/stressed site scores	*t* statistic > 10	Mazor et al., 2016
Frequency of Zero	Frequency of score = 0	< 33% of scores	Stoddard et al., 2008
Frequency of One	Frequency of score = 1	< 33% of scores	Stoddard et al., 2008
Range of Ref scores	Median score at reference sites	> 0	Stevenson and Zalack, 2013
Range of Stress scores	Median score at stressed sites	> 0	Stevenson and Zalack, 2013
Signal to Noise	Variance across all sites / variance at repeat site visits	> 1	Stoddard et al., 2008
Repeat visit variation	ANOVA on repeat samplings of station codes	*F* statistic < 3	Mazor et al., 2016

Examples of metrics

Class	Example metrics
Tolerance	BCG taxa, Tolerant/Intolerant taxa
Motility	Highly motile taxa
Dissolved oxygen	Requires 10% or 30% DO
Salinity	Brackish, freshwater taxa
Saprobility	AM/AMPS taxa
Indicator classes	High N; Low P; High Cu
Diversity	Simpson; Shannon
Taxonomic group	Amphora taxa; ZHR; CRUS taxa



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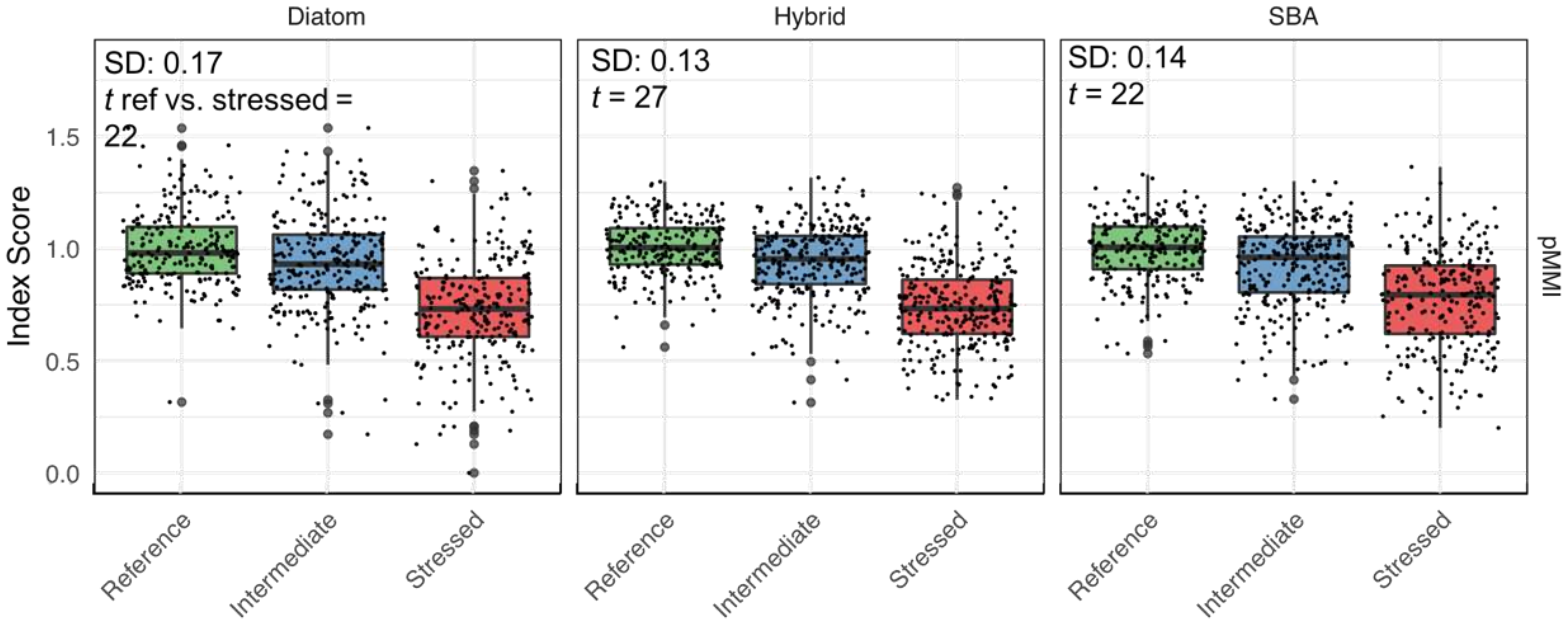
- Generally, trait attributes are assigned to algae at the species
  - Literature
  - Observations from field/lab studies
  - Indicator species analysis for California
  - Other diatom indices (e.g. French diatom index SPI)

MMI results – better precision and responsiveness than O/E

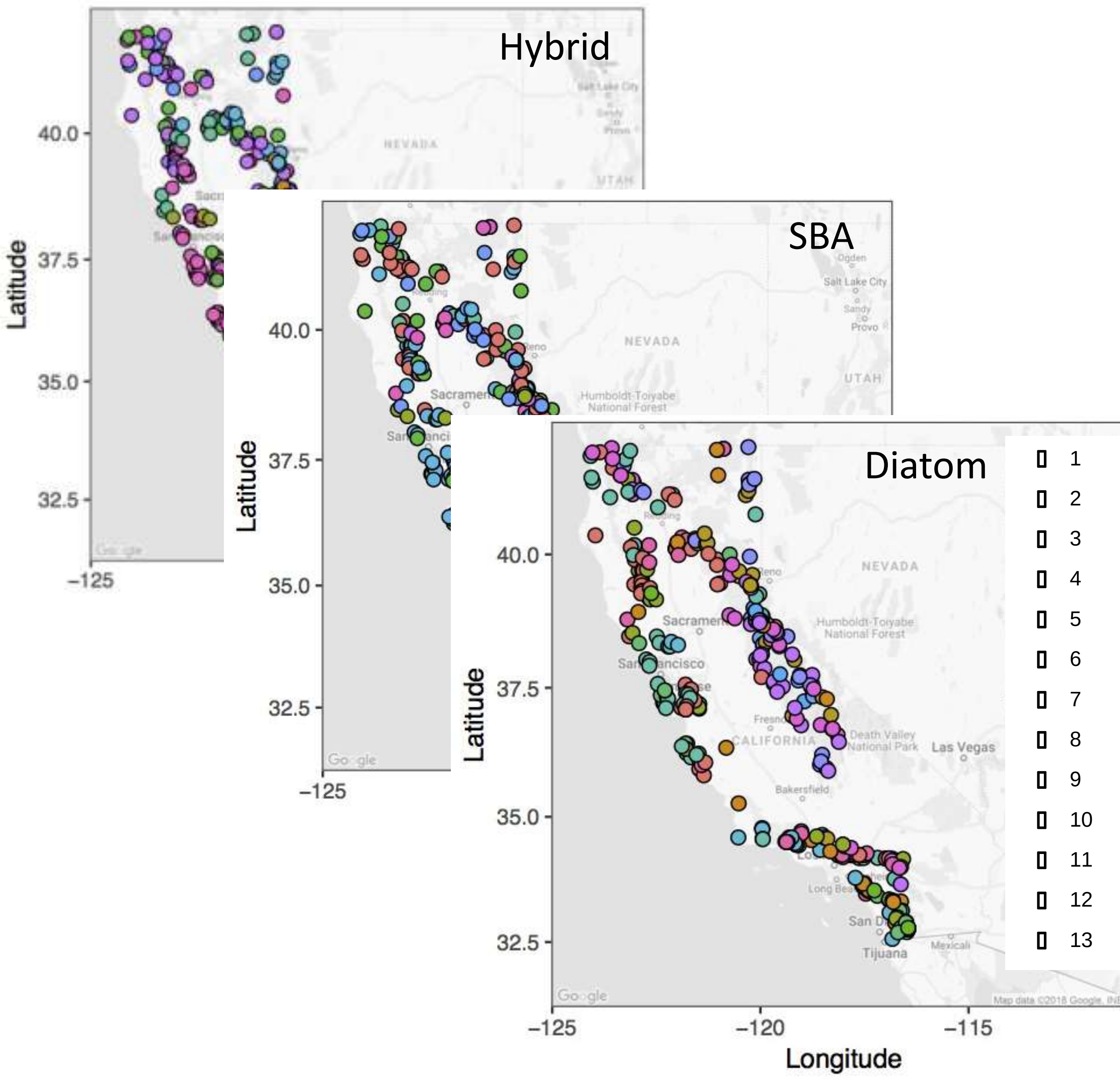


Metrics in each MMI

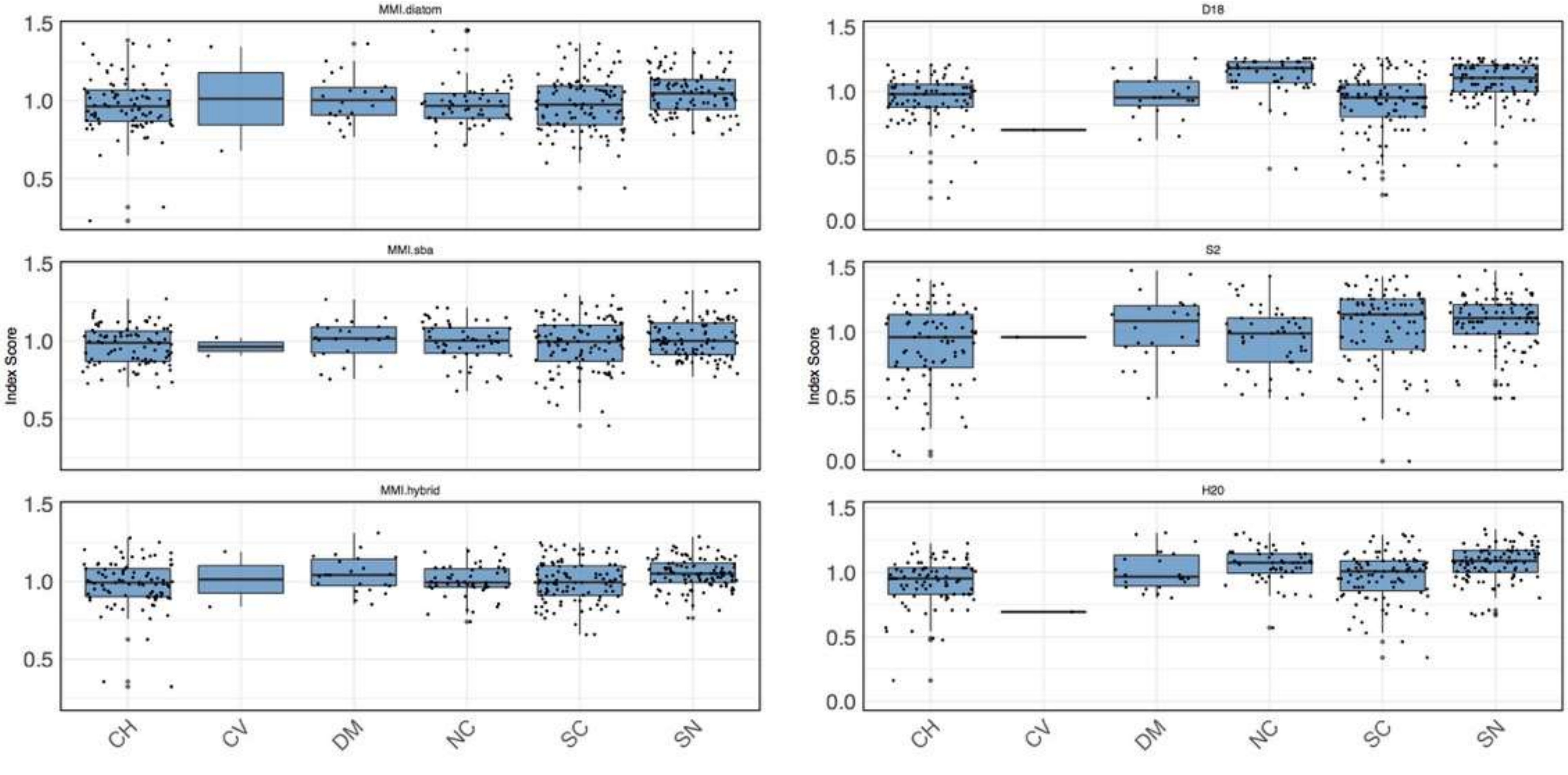
Description	Diatom	Soft-algae	Hybrid	Response to stress
Count species: BCG 3 taxa	x	x	x	Decrease
Count species: high copper indicators		x		Increase
Count species: high DOC indicators		x		Increase
Count species: low total phosphorous indicators		x		Decrease
Count species: of SPI 2 taxa				Decrease
Proportion individuals: most tolerant taxa		x		Increase
Proportion species: Cyclotella taxa	x		x	Increase
Proportion species: Green algae		x		Increase
Proportion species: high copper indicators			x	Increase
Proportion species: high DOC indicators			x	Increase
Proportion species: low total nitrogen indicators			x	Decrease
Proportion species: low total phosphorous indicators	x			Decrease
Proportion species: NHHONF taxa	x		x	
Proportion species: non-ref indicators		x		Increase
Proportion species: SPI 4+5 taxa				Increase
Proportion species: Suriella taxa	x		x	Increase
Proportion species: taxa requiring at least 10% oxygen	x		x	Increase

MMI results

- Why did modeling not improve MMI performance?
  - Modeling with geographic variables helped to decrease regional bias for many metrics
  - However, for some metrics, regional bias scores were still too high even after modeling
  - Minimal geographic clustering of algal communities, difficult to predict with geographic variables (same issue with O/E)
  - Algal diversity is high across the state, low at individual sites, potentially the result of highly fragmented algal communities

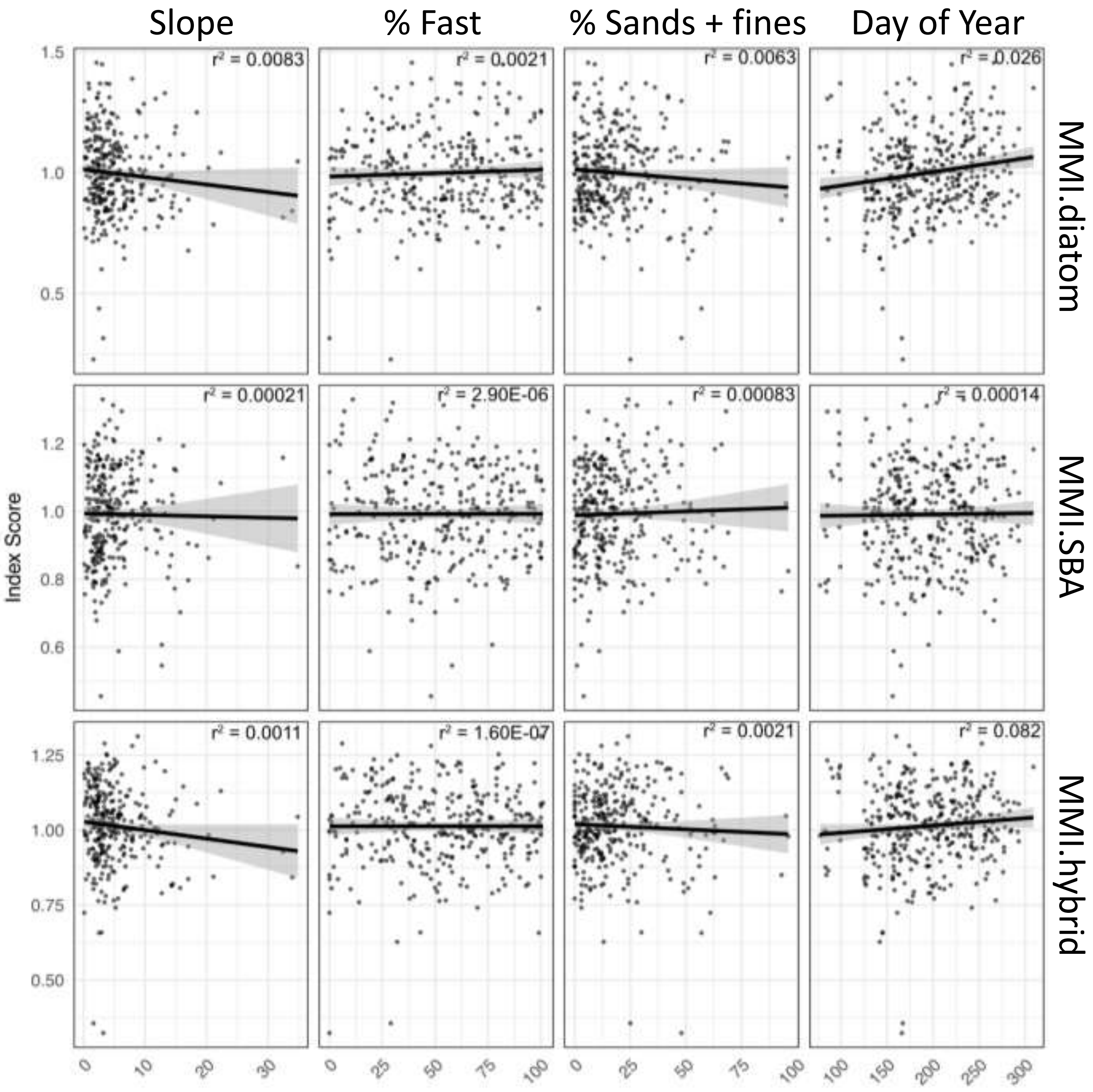


Low regional bias for MMI indices **…and much lower than SoCal IBI**

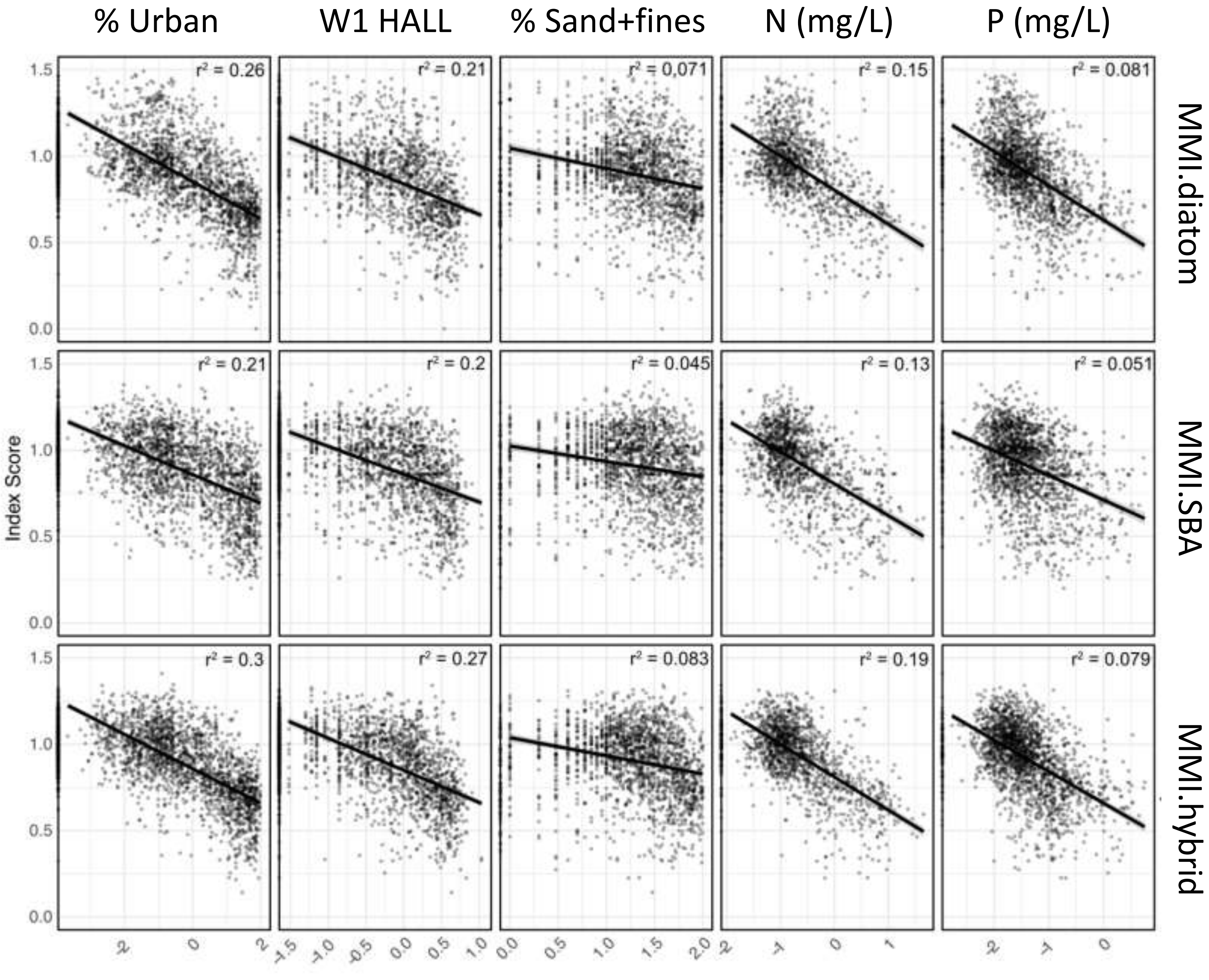


Response to environmental gradients at reference sites

- Low bias indicated by intercept near 1, slopes near 0

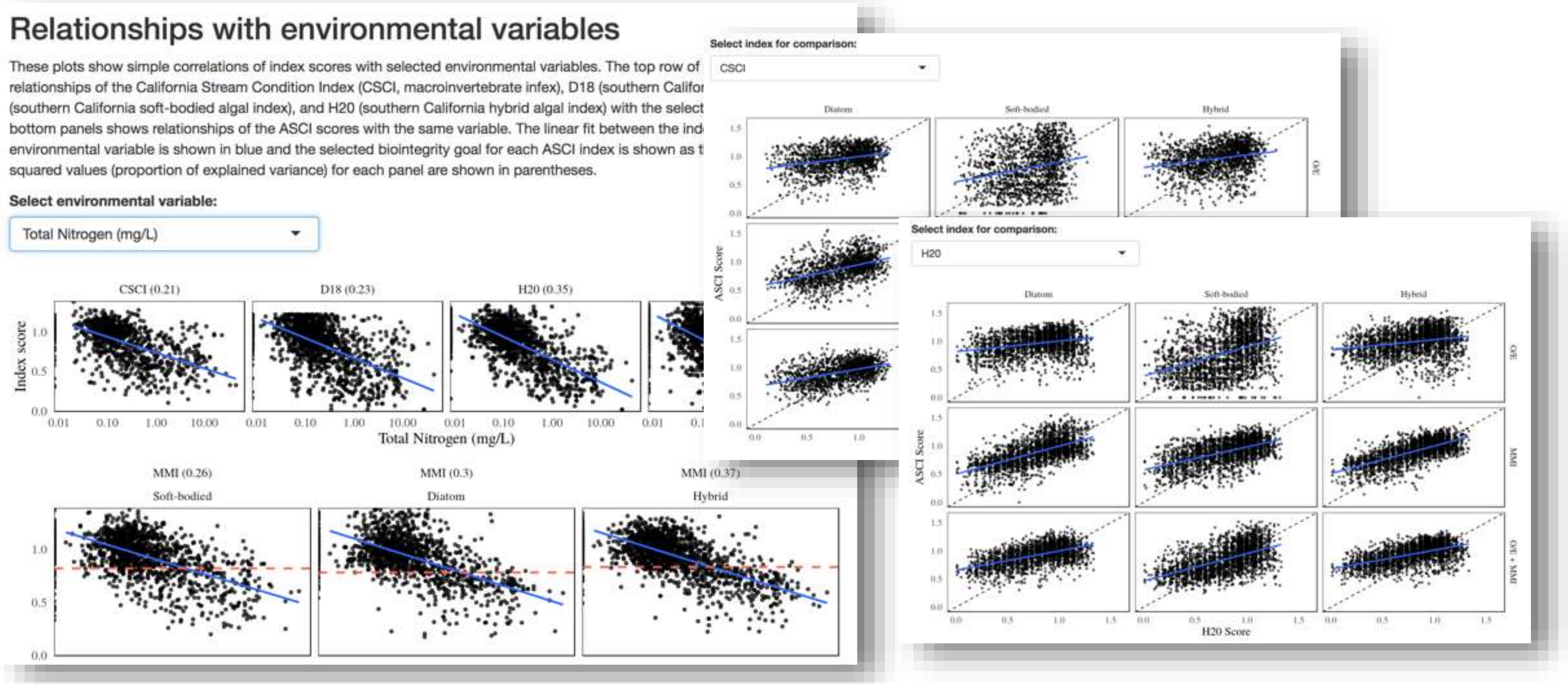


Response to stressor gradients



- Responsiveness indicated by negative slope

Explore ASCI performance



https://sites.google.com/view/asci/results/figures

Choosing the best-performing indices

				Accuracy			Precision		Responsiveness		Spearmans Correlation (Rho)		
				Mean score	F	Var	Among sites (SD)	Within sites (SD)	t	Var	TN	TP	SpCond
Index	Level	Assemblage	Type	Cal	Cal	Cal	Cal	Cal	Cal	Cal			
OE+MMI	species	diatoms	Predictive	1.00	0.34	0.13	0.14	0.07	18.68	0.50	-0.44	-0.37	-0.48
OE+MMI	species	hybrid	Predictive	1.00	2.60	0.05	0.17	0.09	17.70	0.35	-0.40	-0.36	-0.40
OE+MMI	species	sba	Predictive	1.00	1.74	0.07	0.24	0.13	20.56	0.39	-0.40	-0.43	-0.32
O/E	genus	diatoms	Predictive	1.01	0.49	-0.13	0.18	0.11	9.5	0.30	-0.305	-0.176	-0.314
O/E	genus	hybrid	Predictive	1.01	0.48	-0.18	0.25	0.16	8.0	0.20	-0.294	-0.202	-0.266
O/E	genus	sba	Predictive	1.01	0.66	-0.11	0.38	0.29	15.7	0.27	-0.316	-0.356	-0.227
MMI	species	diatoms	Null	1.00	3.31	0.16	0.17	0.09	22.30	0.52	-0.49	-0.49	-0.59
MMI	species	hybrid	Null	1.00	2.28	0.14	0.13	0.08	27.20	0.59	-0.55	-0.51	-0.55
MMI	species	sba	Null	1.00	1.34	-0.08	0.14	0.09	21.86	0.40	-0.45	-0.33	-0.41
pMMI	genus	diatoms	Pred	1.00	1.91	-0.17	0.17	0.13	22.65	0.32	-0.42	-0.41	-0.40

(p)MMIs with strongest performance

Conclusions

We have three ASCIs (specifically, MMIs for diatoms, SBA, and hybrid) for assessing biointegrity with an algal indicator in wadeable streams in California.

- Good responsiveness, low levels of regional bias make them the best options for statewide application
- O/E indices had poor performance, are not recommended
- The diatom genus-level pMMI had good performance, although not as strong as the species-level MMIs
- **Next steps: Submit manuscript, develop calculators, evaluate index performance in intermittent and channelized streams**

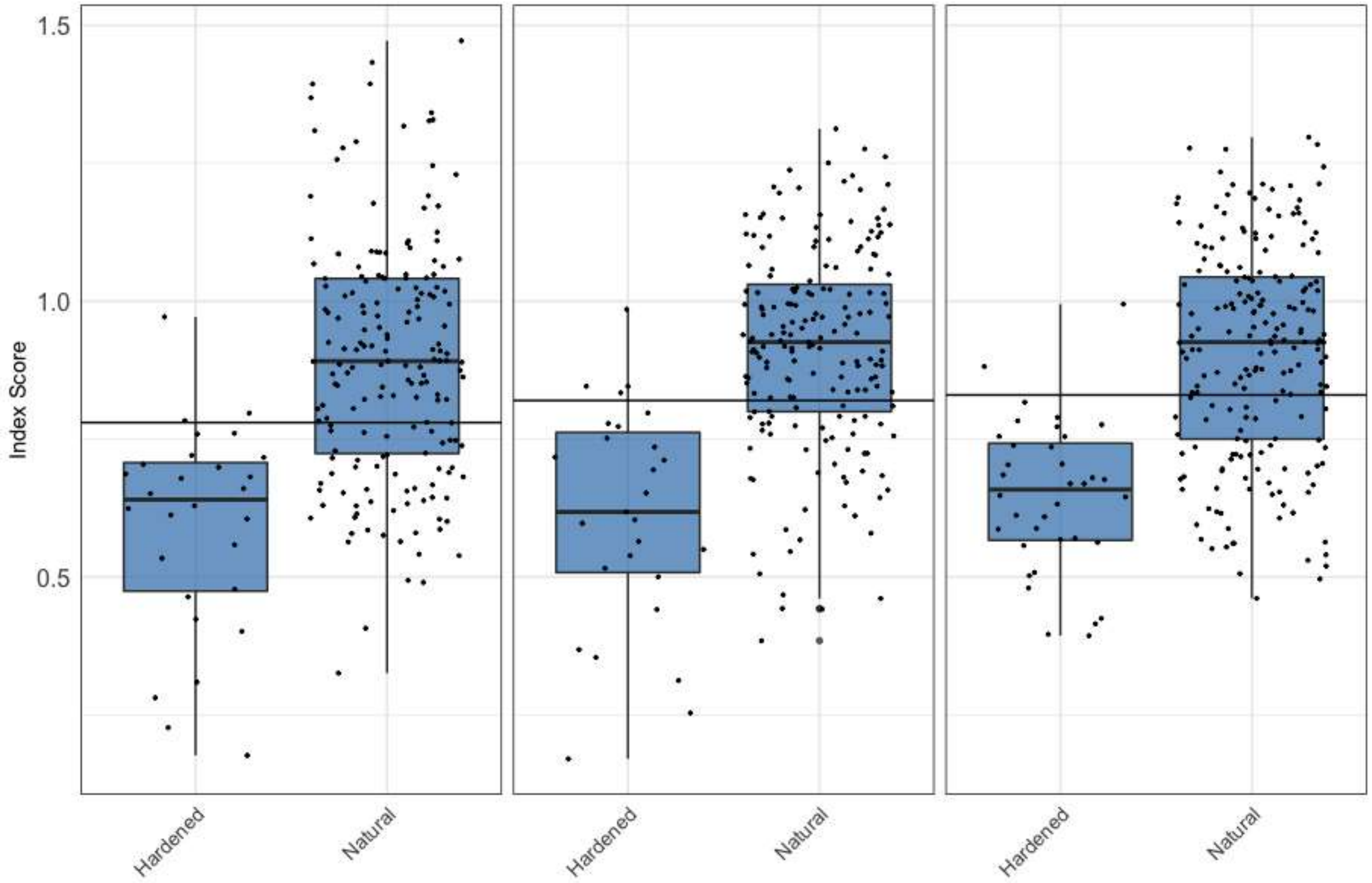
Waterboard Charge Questions

- Comment on the adequacy of the ASCIs to serve as a statewide bioassessment index applicable to most wadeable streams across CA, specifically with respect to data, statistical approaches, evaluation of performance, and soundness of findings.
- Among the 3 proposed ASCIs, which one do the SAP members think works best for determining water quality impacts to biointegrity? What about impacts due to biostimulatory substances and/or conditions? Why?
- Do the measures of performance (i.e., the accuracy, precision, responsiveness, and sensitivity) of the ASCIs indicate that they are adequate for use in most wadeable streams in CA?
- Are there specific stream-types where performance measures indicate that the indices should not be used to assess condition (or require special consideration)?
- Are there additional performance evaluations or refinements to the index that are essential and that can be done with available data?
- Are there any caveats or cautions that should be exercised when using the ASCIs to assess biological condition?
- Are there technical ways to address stakeholder concerns?

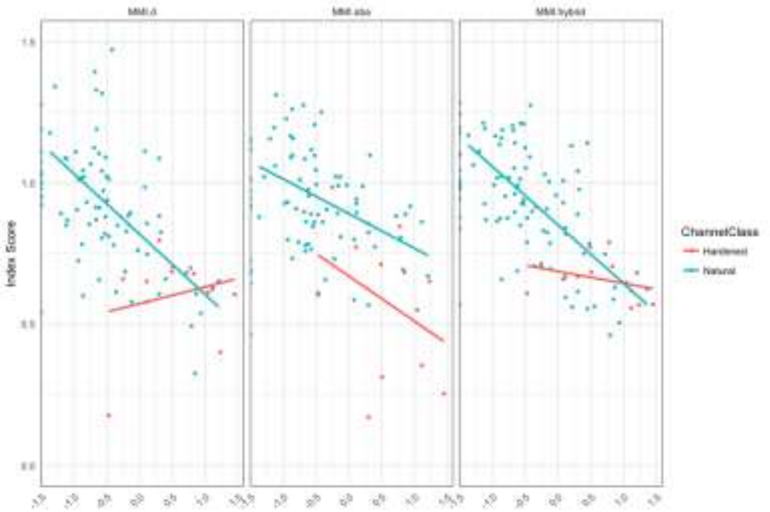
Bonus slides

Engineered streams

Diatom MMI | SBA MMI | Hybrid MMI



- Comparing index performance in natural versus engineered streams
- Some engineered streams are able to score above the 10th percentile of reference
- Do index scores respond to stress in engineered streams?

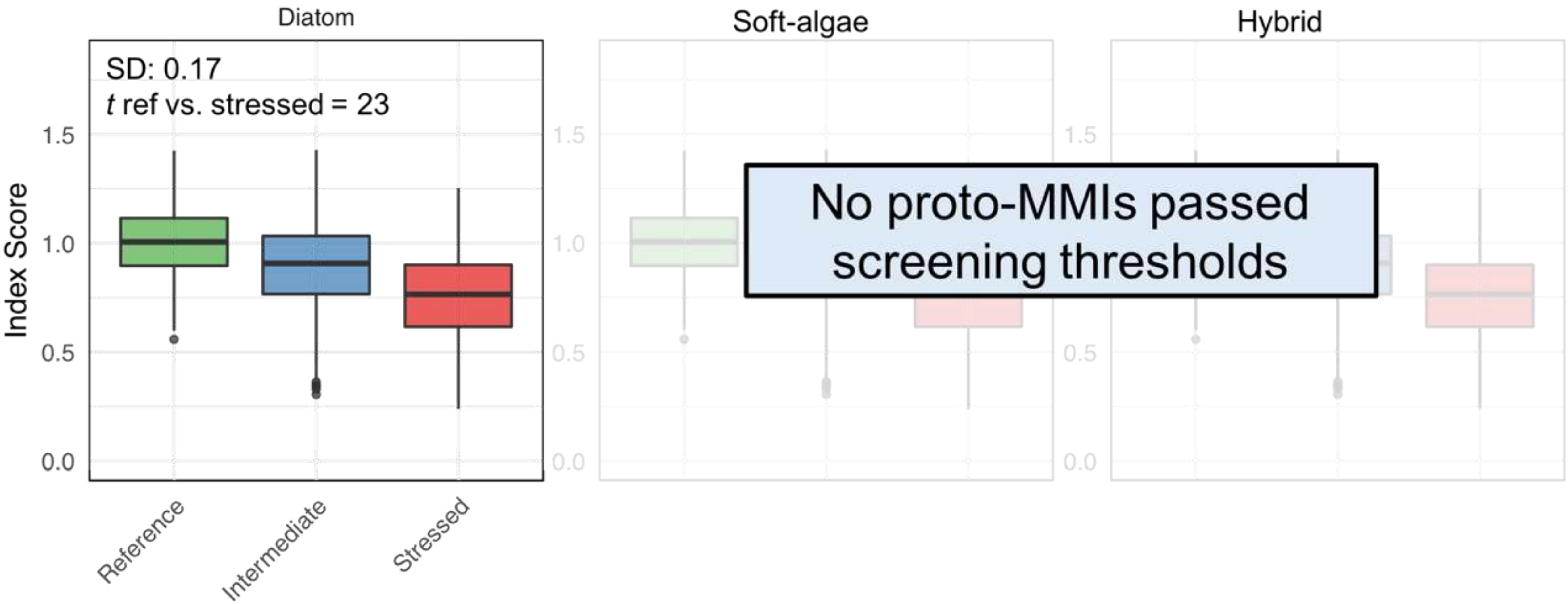


Intermittent streams

Diatom MMI SBA MMI Hybrid MMI

- Comparing index performance in for reference sites in intermittent streams
- Are intermittent streams able to score above the 10th percentile of reference?
- Do index scores respond to stress in intermittent streams?

Genus-level MMI



Genus-level MMI

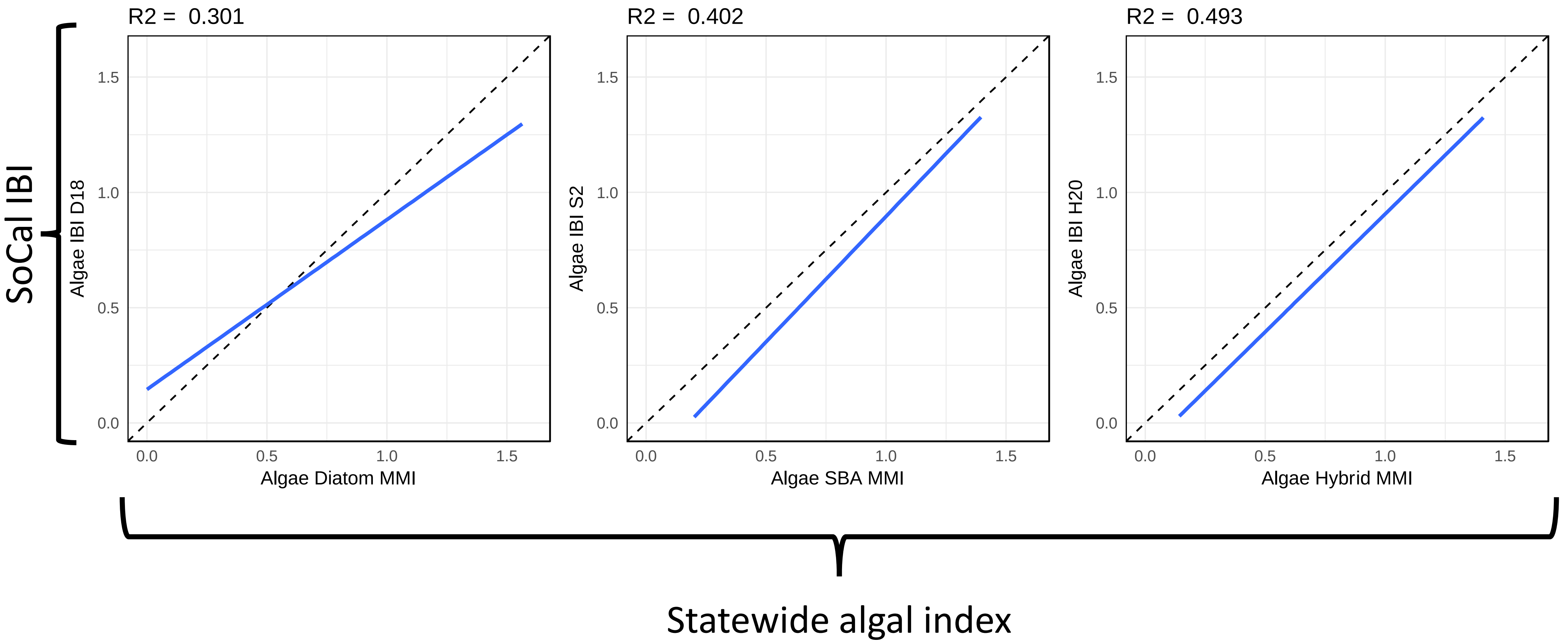
Description	Diatom	SBA	Hybrid	Diatom-genus	Response to stress
Count species: BCG 3 taxa	x	x	x		Increase
Count species: high copper indicators		x			Increase
Count species: high DOC indicators		x			Increase
Count species: low total phosphorous indicators		x			Decrease
Count species: of SPI 2 taxa				x	Decrease
Proportion individuals: most tolerant taxa		x			Increase
Proportion species: Cyclotella taxa	x		x	x	Increase
Proportion species: Green algae		x			Increase
Proportion species: high copper indicators			x		Increase
Proportion species: high DOC indicators			x		Increase
Proportion species: low total nitrogen indicators			x		Decrease
Proportion species: low total phosphorous indicators	x				Decrease
Proportion species: NHHONF taxa	x		x		
Proportion species: non-ref indicators		x			Increase
Proportion species: SPI 4+5 taxa				x*	Increase
Proportion species: Suriella taxa	x		x	x	Increase
Proportion species: taxa requiring at least 10% oxygen	x		x		Increase
Richness: NAHON taxa				x	Increase
Proportion species: Gomphonema taxa				x	Decrease
Proportion species: least tolerant taxa				x	Decrease

*denotes predictive metric

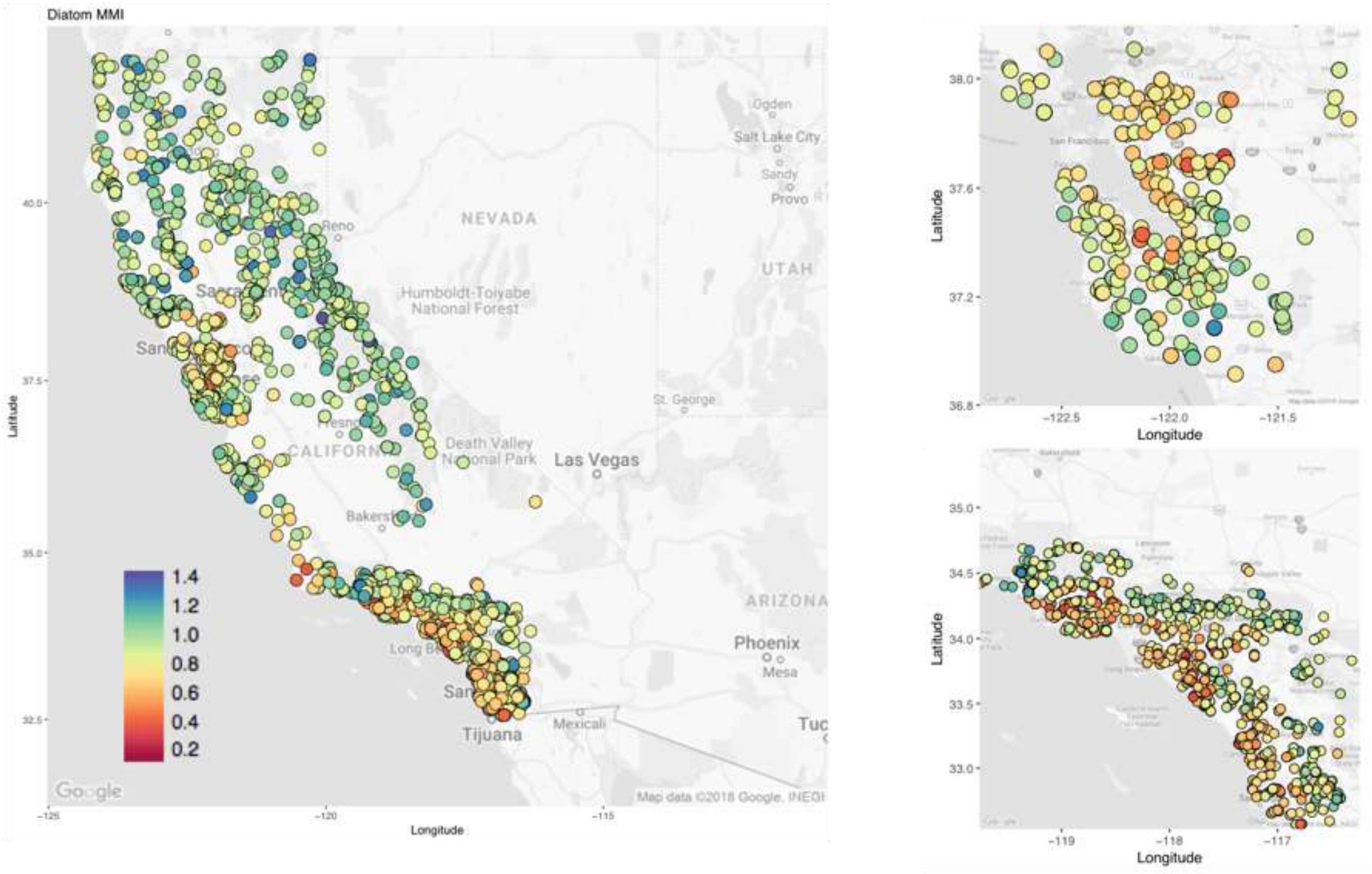
ASCI interactive website

Marcus Beck

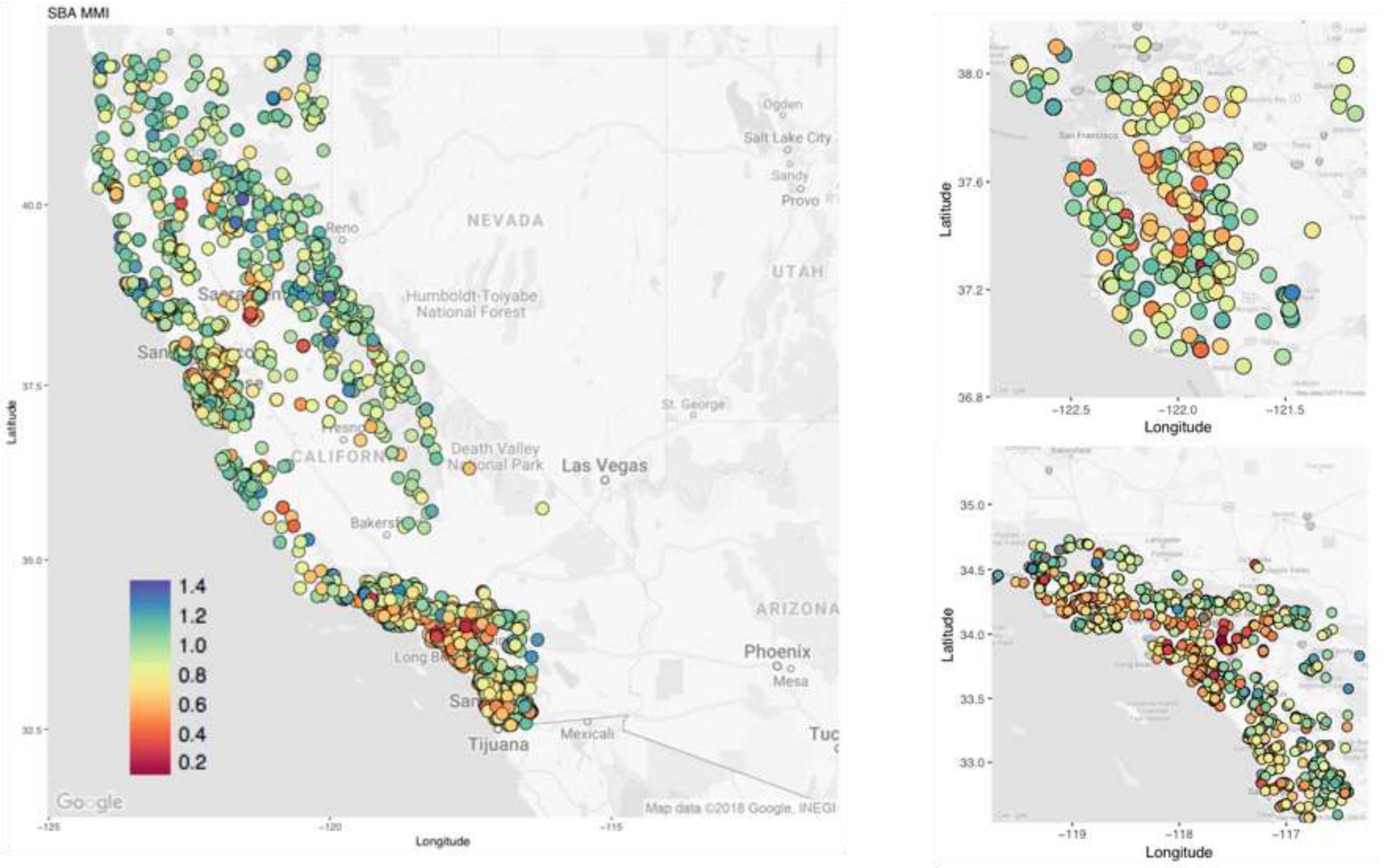
Algal MMIs vs. SoCal IBI



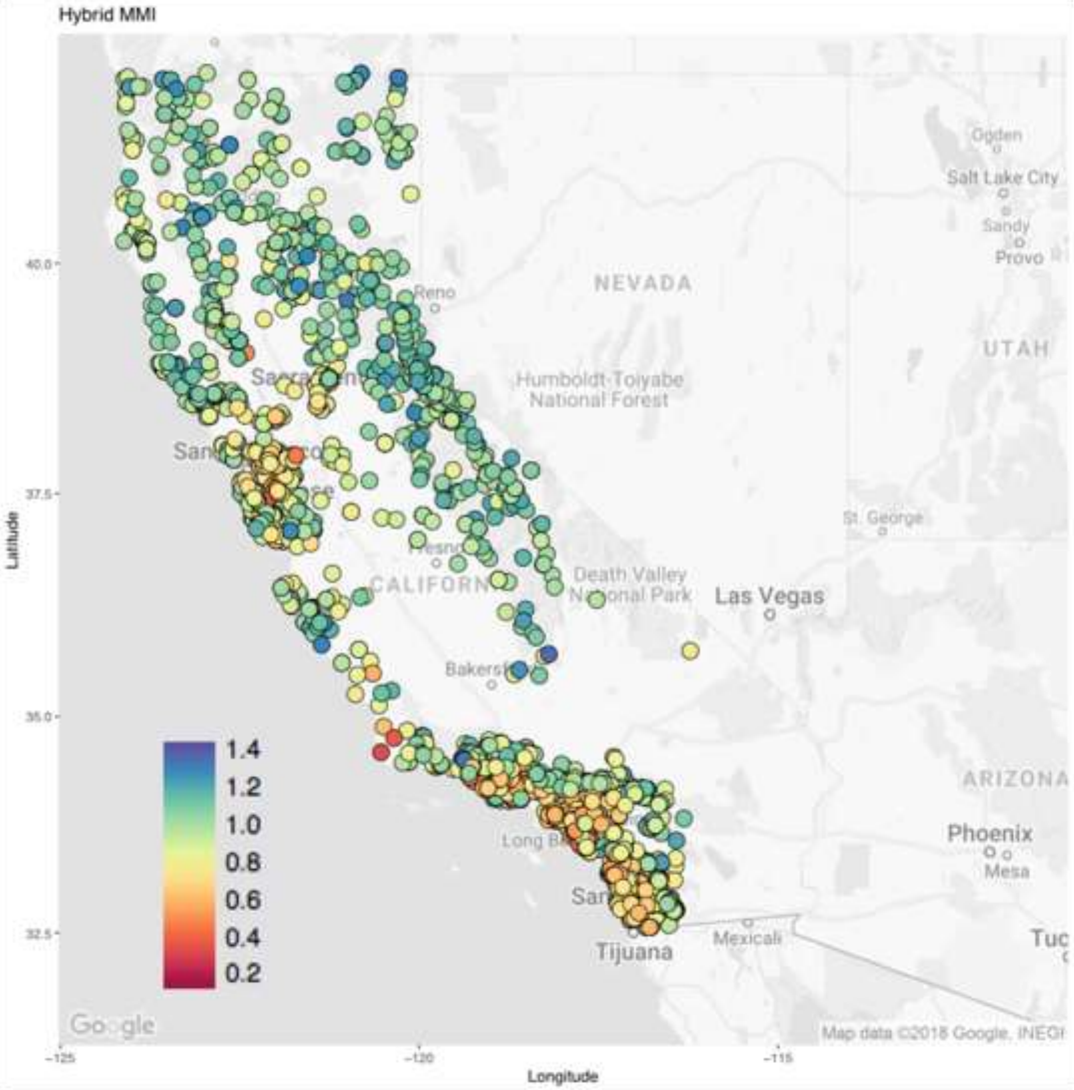
Diatom MMI scores



Soft-algae MMI scores



Hybrid MMI scores



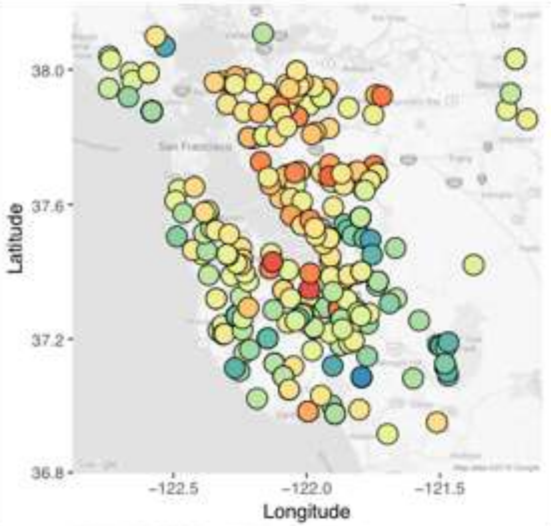


Table 1. Performance measures to evaluate the ASCI. pMMI = predictive multimetric index, and observed (O)/ expected (E) taxa index at calibration (Cal) sites. For accuracy tests, only reference sites were used. Accuracy: mean score (ref) = mean score of reference sites (* indicates value is mathematically fixed at 1); F = F-statistic for differences in scores at reference calibration sites among 5 PSA regions (Central Valley); Var = variance in index scores explained by natural gradients at reference sites. Precision: among sites = standard deviation of scores at reference sites; within sites = standard deviation of within-site residuals for reference calibration and validation sites with multiple samples. Responsiveness: t = t-statistic for difference between mean scores at reference and stressed sites, var = variance in index scores explained by human-activity gradients at all sites. Red scores indicate lower (worse) performance scores for each measure.

				Accuracy			Precision		Responsiveness		Spearmans Correlation (Rho)		
				Mean score	F	Var	Among sites (SD)	Within sites (SD)	t	Var	TN	TP	SpCond
Index	**Level**	**Spp**	**Type**	**Cal**	**Cal**	**Cal**	**Cal**	**Cal**	**Cal**	**Cal**			
O/E+MMI	genus/species	diatoms	Predictive	1.00	0.34	0.13	0.14	0.07	18.7	0.50	-0.44	-0.37	-0.48
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AlgaeField	AlgaeValue	AlgaeValueDescr
OxygenRequirements	DO_30	>30% DO saturation
OxygenRequirements	DO_50	>50% DO saturation
OxygenRequirements	DO_75	>75% DO saturation
OxygenRequirements	DO_10	about 10% DO saturation or less
OxygenRequirements	DO_100	nearly 100% DO Saturation
Saprobity	AMPS	alpha-meso/polysaprobous
Saprobity	AM	alpha-mesosaprobous
Saprobity	BM	beta-mesosaprobous
Saprobity	OS	oligosaprobous
Saprobity	PS	polysaprobous
TrophicState	E	Eutrophic
TrophicState	I	Indifferent
TrophicState	M	Mesotrophic
TrophicState	ME	Mesotrophic-Eutrophic
TrophicState	O	Oligotrophic
TrophicState	OM	Oligotrophic-Mesotrophic
TrophicState	PH	Polytrophic (Hypereutrophic)
NitrogenUptakeMetabolism	NAHON	N-autotrophic-high organic N
NitrogenUptakeMetabolism	NALON	N-autotrophic-low organic N
NitrogenUptakeMetabolism	NHHONF	N-heterotrophic-high organic N (facultative)
NitrogenUptakeMetabolism	NHHONO	N-heterotrophic-high organic N (obligate)