Development of Sediment Quality Guidelines Based on Benthic Macrofauna Response

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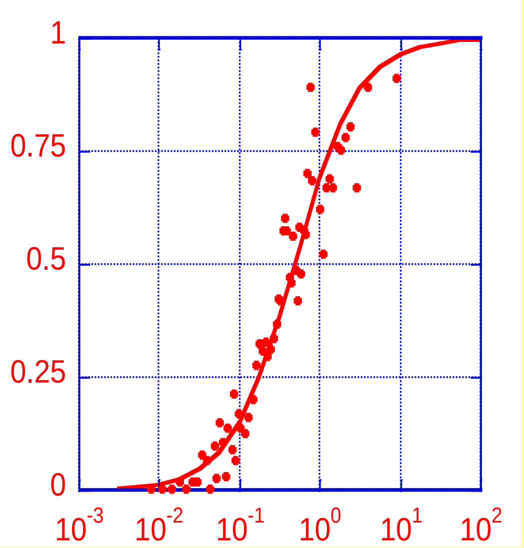
Background

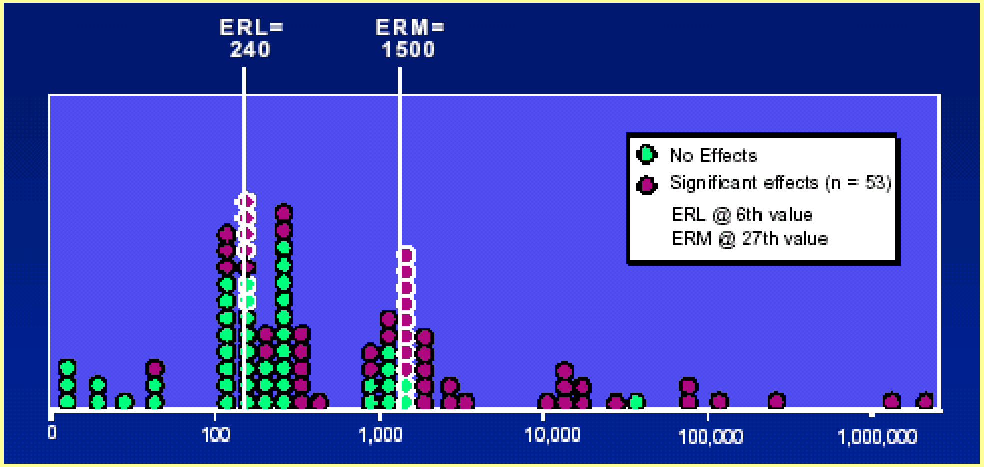
- **California is developing a sediment quality assessment framework focused on protection of the benthic macrofaunal community**
  - Regulatory incorporation of sediment quality triad
  - Specific tools for implementation statewide
- **Toolbox of indicators for chemistry, toxicity, and benthic community disturbance under development**
- **Sediment Quality Guidelines (SQGs) will be used to interpret chemistry measurements**

Sediment Quality Guidelines

- **Most SQGs are based on empirical relationships between individual chemical contaminants and toxicity**
  - Probability of toxicity (logistic regression)
  - Effects range median (ERM)



- **Approaches that integrate multiple chemicals perform best**
  - Maximum probability (Pmax)
  - Mean SQG quotient (mERMq)



Toxicity vs. Benthos

- **Want to protect benthos, but most SQGs based on toxicity data**
- **Are SQGs based on toxicity accurate predictors of benthic impact?**
- **Benthos may have a differential response to individual chemicals and/or chemical mixtures**
  - Laboratory vs. field
  - Single animal vs. population
  - Short-term vs. long-term exposure

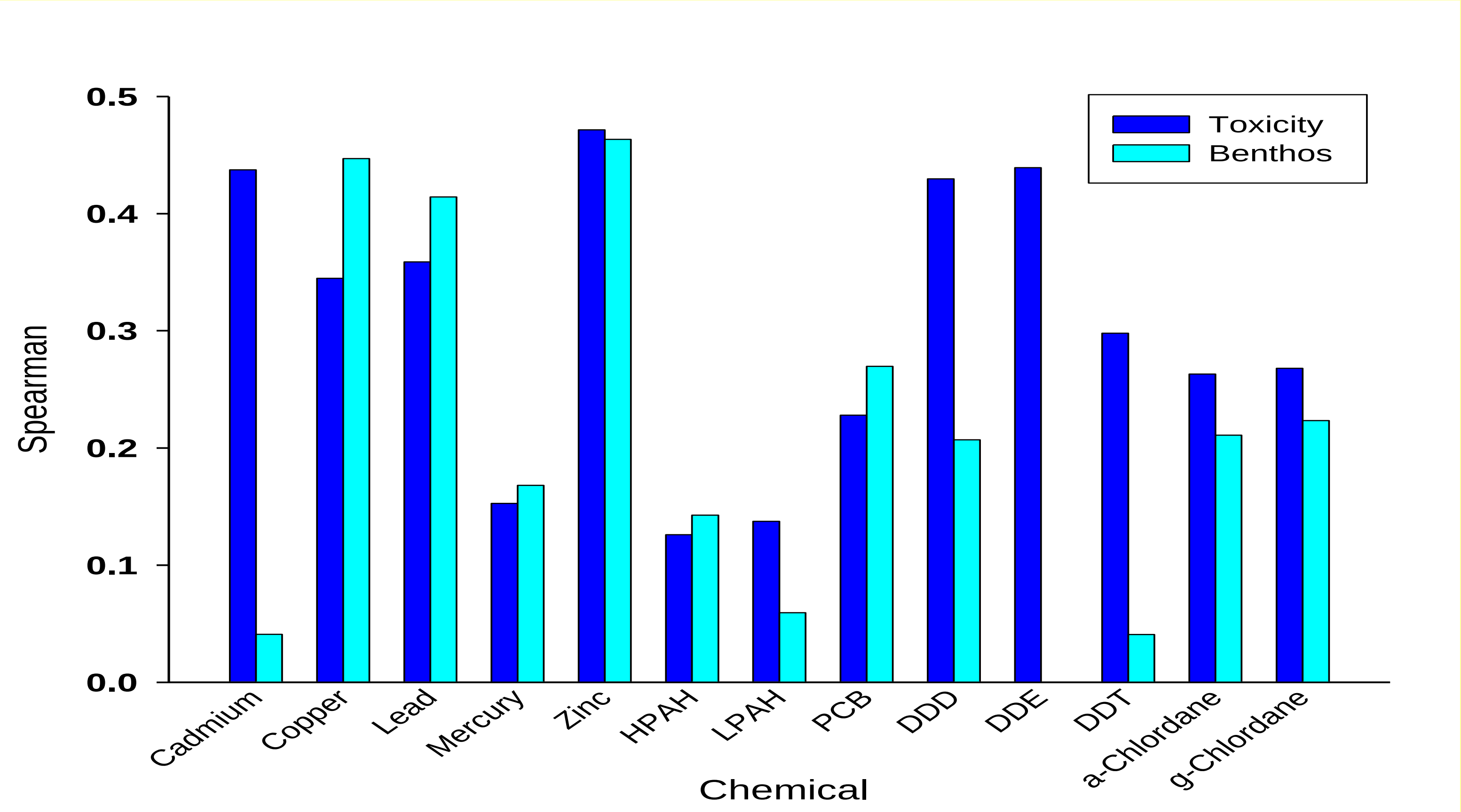
Research Questions

- **How do chemical relationships between toxicity and benthos compare?**
- **Can the predictive ability of SQGs be improved by developing a benthos-specific SQG?**

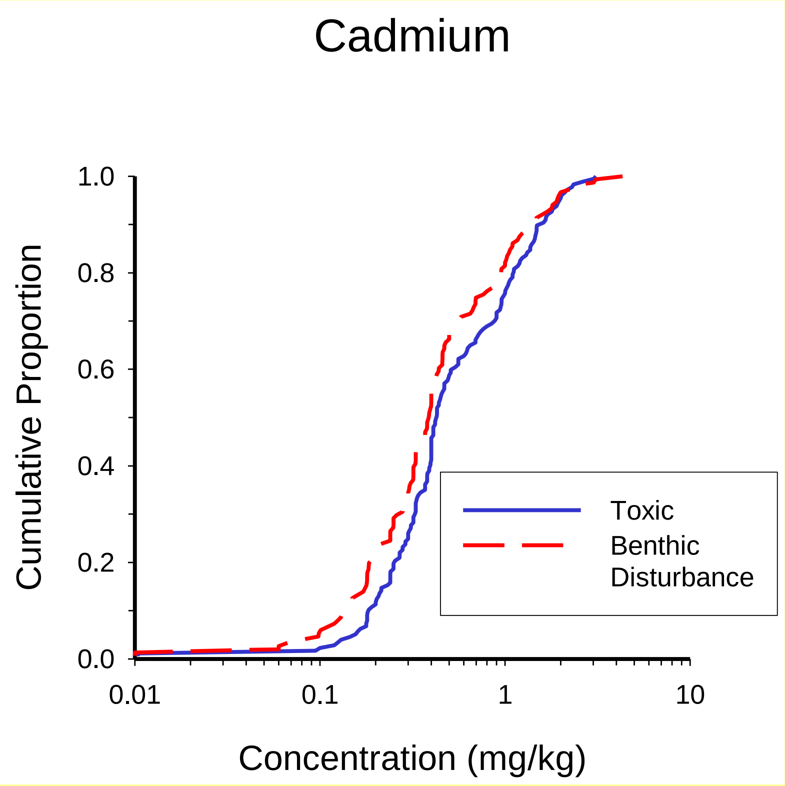
Comparison of Chemical Relationships

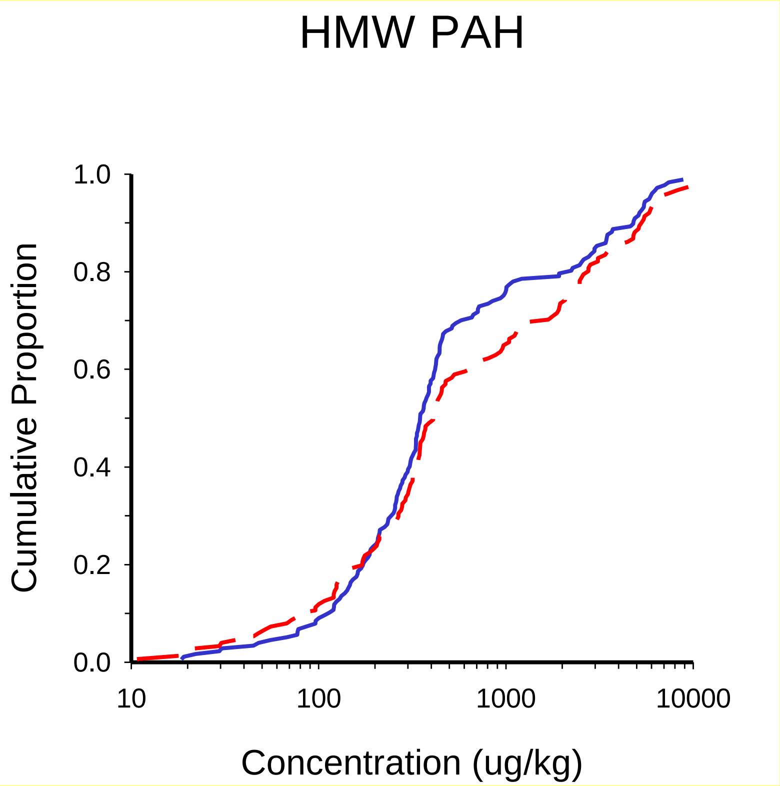
- **Matched chemistry, toxicity, and benthos data**
  - Southern California embayments (N=441)
  - <u>Toxicity: </u>10 day amphipod survival
  - <u>Benthos:</u> Abundance across multiple benthic organisms
- **Correlations between individual chemicals and toxicity/benthos**
- **Cumulative distribution functions of affected samples**

Spearman's Correlation



Chemical Response Ranges





Apparent response thresholds for toxicity and benthos disturbance were similar for all chemicals

Measuring SQG Agreement with Toxicity and Benthos

- **Four levels of biological response**
  - Reference, low, moderate, high
- **Two measures of response**
  - Toxicity (amphipod mortality)
  - Benthos (benthic community disturbance)
- **SQG thresholds for predicting biological response were selected by statistical optimization**

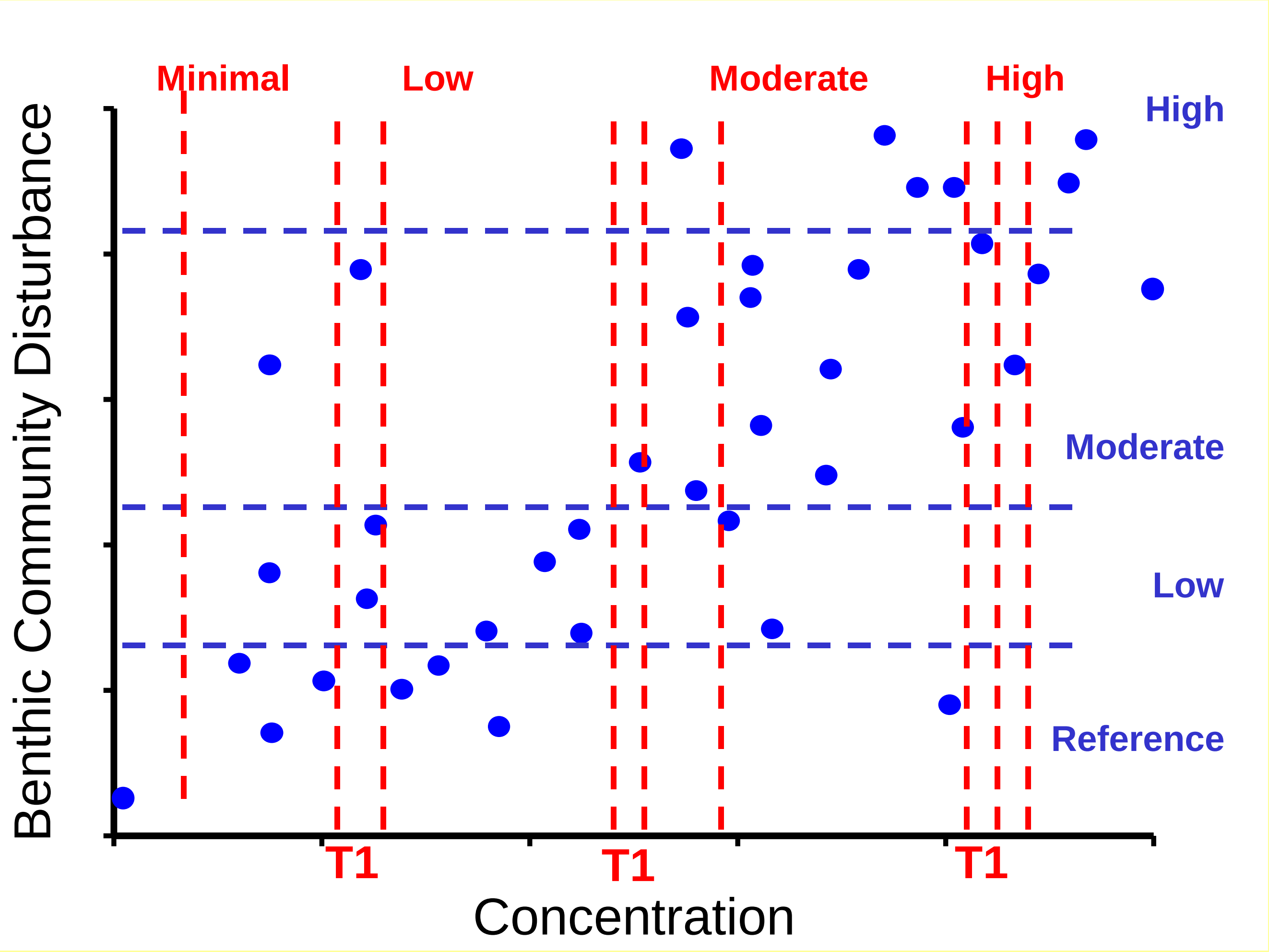
Predictive Ability Comparison

- **Compared agreement predicting biological response using tox-based SQGs and a new benthos-based SQG**
- **Toxicity-based SQGs**
  - **ERM:** mean ERMq across all chemicals
  - **Logistic Regression:** maximum probability of toxicity (Pmax)
- **Benthos-based SQG**
  - **Chemical Score Index (CSI):** mean score (mCSI)

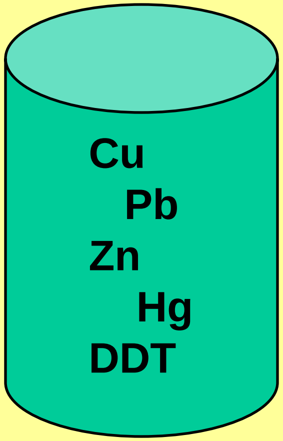
Chemical Score Index

- **Reflects association between chemicals and magnitude of response (BRI) of California benthos**
- **Two types of data are combined**
  - Set of <u>predicted benthic response categories</u> based on individual chemical concentrations
  - Set of <u>weighting factors</u> for each of the chemicals based on strength of association.

Chemical Response Categories



Calculating mCSI



Data

Chem	Conc
[Cu]	22
[Pb]	29
[Zn]	250
[Hg]	0.44
[DDT]	90.02

Apply thresholds

T1 T2 T3

Min	Low	Mod	High
X			
	X		
		X	
	X		
			X

Predicted Category
1
2
3
2
4

Multiply by Weights

Chemical Score
0.70
1.5
2.7
1.9
3.8

Average across all chemicals

$\overline{X}$

mCSI

Agreement with Respect to Toxicity (n=146)

SQG	Agreement
mERMq	38%
Pmax	40%

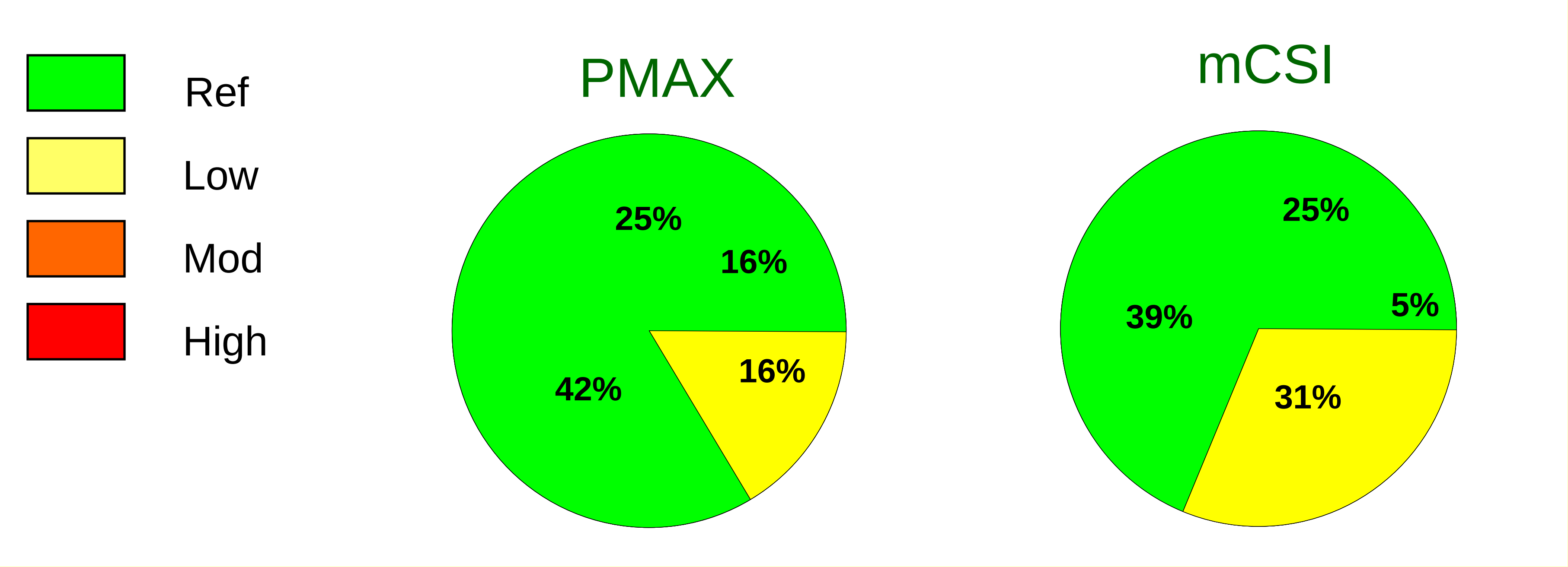
No statistically significant differences

Agreement with Respect to Benthic Response (n=146)

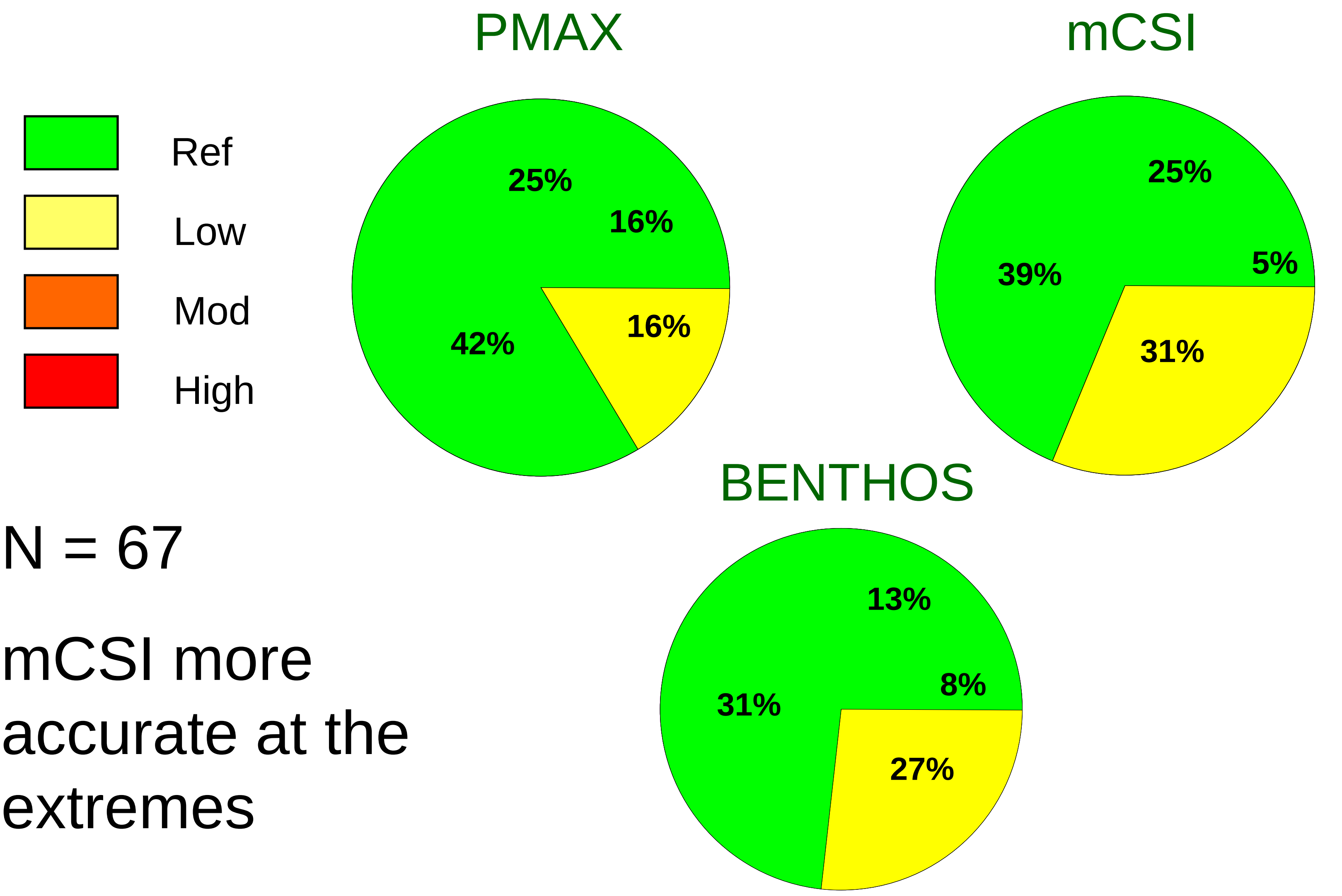
SQG	Agreement
mERMq	**43%**
Pmax	**31%**
mCSI	**52%***

* Statistically different from other SQGs

Application to San Pedro Bay
n=67



Application to San Pedro Bay



N = 67

mCSI more accurate at the extremes

Summary

- **Benthos and toxicity test responses appear to have differential associations with chemistry**
- **Toxicity-based SQGs are useful for predicting benthos**
- **Benthos-based SQGs show improvement in predicting response of benthos, particularly at the extremes**
- **Merit to using both types of SQGs in sediment quality assessments**