Using Bioassessment to Develop TMDLs:

Malibu Creek & Lagoon TMDL

Sedimentation and Nutrients to Address Benthic Community Impairments

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TMDLs & Bioassesment, Oh My.

- Why this TMDL considers benthic macroinvertebrates?
- Why bioassessment was needed?
- What methods were used?
- How were results evaluated and used?
- Local considerations (e.g., geology)

CWA 303(d): TMDLs

"To restore and maintain the chemical, physical, and biological integrity of the Nation's waters"
-Clean Water Act

- A Total Maximum Daily Load (TMDL):

- Calculates a value of the maximum amount of a pollutant that a body of water can receive while still meeting water quality

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TMDL Required Elements

- Identify the critical water quality related **pollutant stressor(s)** impacting the beneficial uses;
- Identify appropriate water quality based numeric targets;
- Set wasteload and load allocations that will result in protection of the designated beneficial uses for Malibu Creek and Lagoon.

- Protect the waterbody's beneficial uses.

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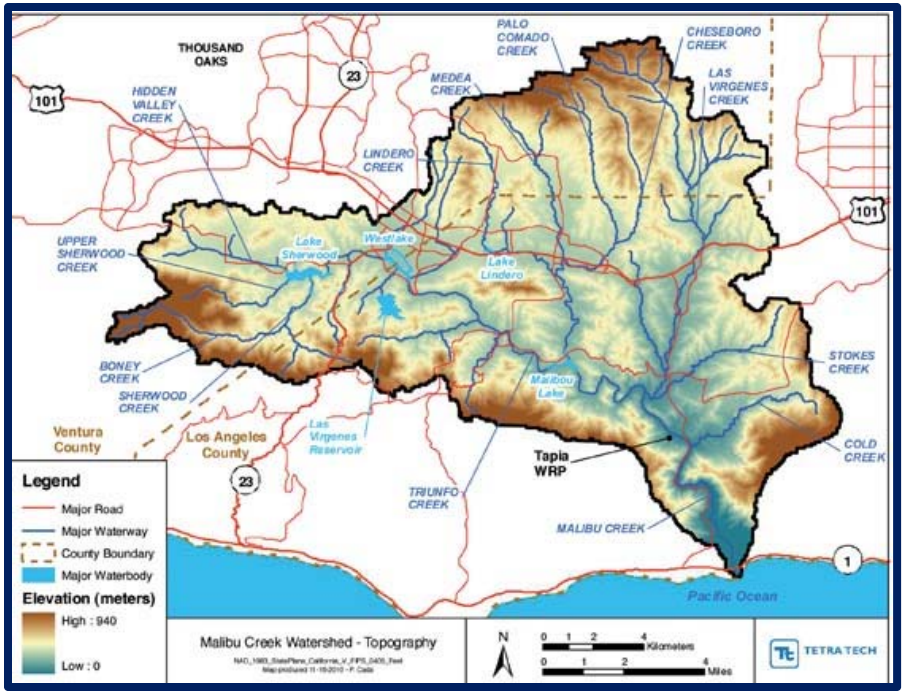
Why This TMDL?

- On State's Impaired Waterbody CWA Section 303(d) List for the following impairments:
  - **Negatively impacted benthic community**
  - Sedimentation

- EPA & State under court rule to complete this TMDL by July 2013.

Malibu Creek Watershed



Beneficial Uses in Malibu

- Recreation
- Aesthetic
- **Aquatic Life**
- **Freshwater Habitat**
- **Wildlife Habitat**
- **Spawning, Reproduction**
- **Rare, Threatened, Endangered Habitat**
- **Estuarine, Marine Habitat**
- Navigation
- Municipal

Protection of 23 Beneficial uses in Malibu Creek & Lagoon

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Assessment Approach

- Question:
  - Are benthic macroinvertebrate assemblages adversely affected?
  - What are the stressors and causes impacting benthic community?
  - Must conduct stressor identification and causal assessment to identify the connection between biological response and pollutant sources

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Data Analysis

- Reviewed all available biological, chemical, physical data (1998-2011);
- Water quality (won't cover)
- Identify reference or achievable best condition associated with the applicable water quality objectives.
- Identify the primary pollutant stressors to be addressed by TMDL.

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Benthic Macroinvertebrate Sampling Sites

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Biological Data

- Data collected by Heal the Bay Stream Team, Las Virgenes Municipal Water District, Los Angeles County, USEPA and Los Angeles County Flood Control District. (>44 sites with Biological data)
- Computed multiple bioscoring methods: So. CA Index of Biotic Integrity & CA Stream Condition Index (O/E and pMMI). The two methods showed comparable results.
- Observed difference between impacted & generally undisturbed sites.
- Natural & un-impacted conditions are based on those currently observed in the Watershed – achievable biological conditions.

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Bioscoring Tools

- Southern California Index of Biotic Integrity
  - Issues, concerns
- California Stream Condition Index
  - Observed/Expected Ratio (RIVPACS)
  - Probability-based multi-metric Index (pMMI)

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SO. CA Index of Biotic Integrity

- A multi-metric index designed to evaluate functional measures of ecological health. Seven metrics (e.g., EPT richness, predator richness, % intolerant individuals, % non-insecta taxa, etc.) most applicable to Southern California characteristics. (Ode et al. 2005)

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CA Stream Condition Index

- State Board's a new, statewide bioassessment scoring tool;
- Combines:
  - O/E Ratio (based on BMI assemblage), where impairment is indicated by the difference between expected and observed assemblages.
  - pMMI method (based on ecological structure of metrics), is a muti-metrics (i.e., IBI) approach but accounts for site-specific variability using predictive modeling.
- Based on 473 reference calibration sites across state, including extreme stressed conditions (e.g., Monterey/Modelo Formation)

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Reference/Comparator Sites

- Considerations
  - Large range of sites
  - Multiple factors: elevation, micro-climate characteristics, gradient, geology
  - Baseline, pre-human related data not available
  - Some traditional reference sites exists (disagreements)

- Criteria: Identify the biological potential consistent with landscape, climate, geology
  - Combination of reference sites and minimally-disturbed areas
  - Included sites with minimum of 5 BMI samples to account for temporal variability, comparable coastal geology, gradient, & landscape.

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Biological Analysis

- Bioscores at the reference/comparator and downstream sites
- Bioscores and other stressors

Results

- 96% of the SC-IBI results are rated as poor or very poor on the SC-IBI scale (<39). All data sources showed similar results.

- Distinct difference between comparator/reference sites and those downstream of impacted sites.

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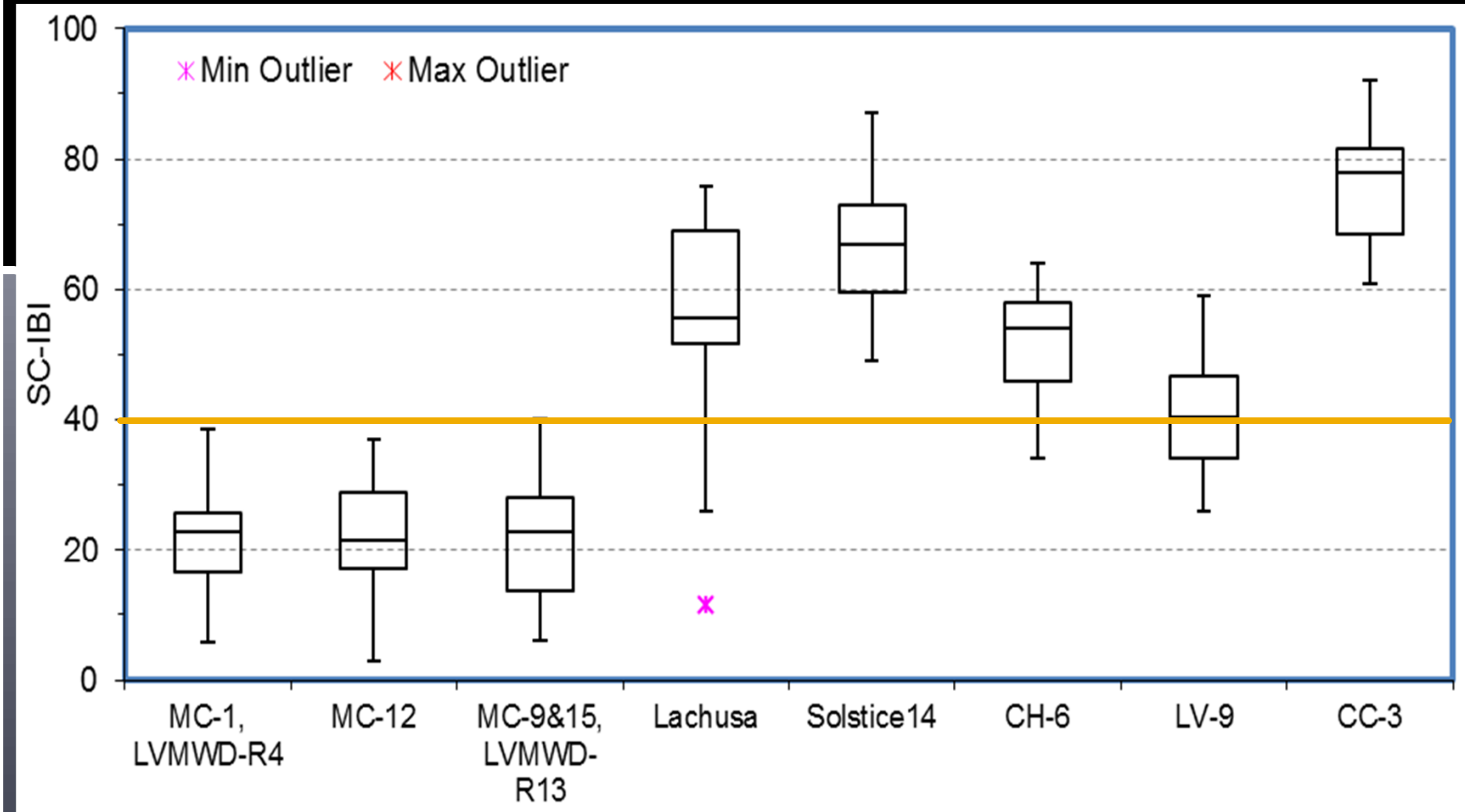
Downstream & Reference SC-IBI

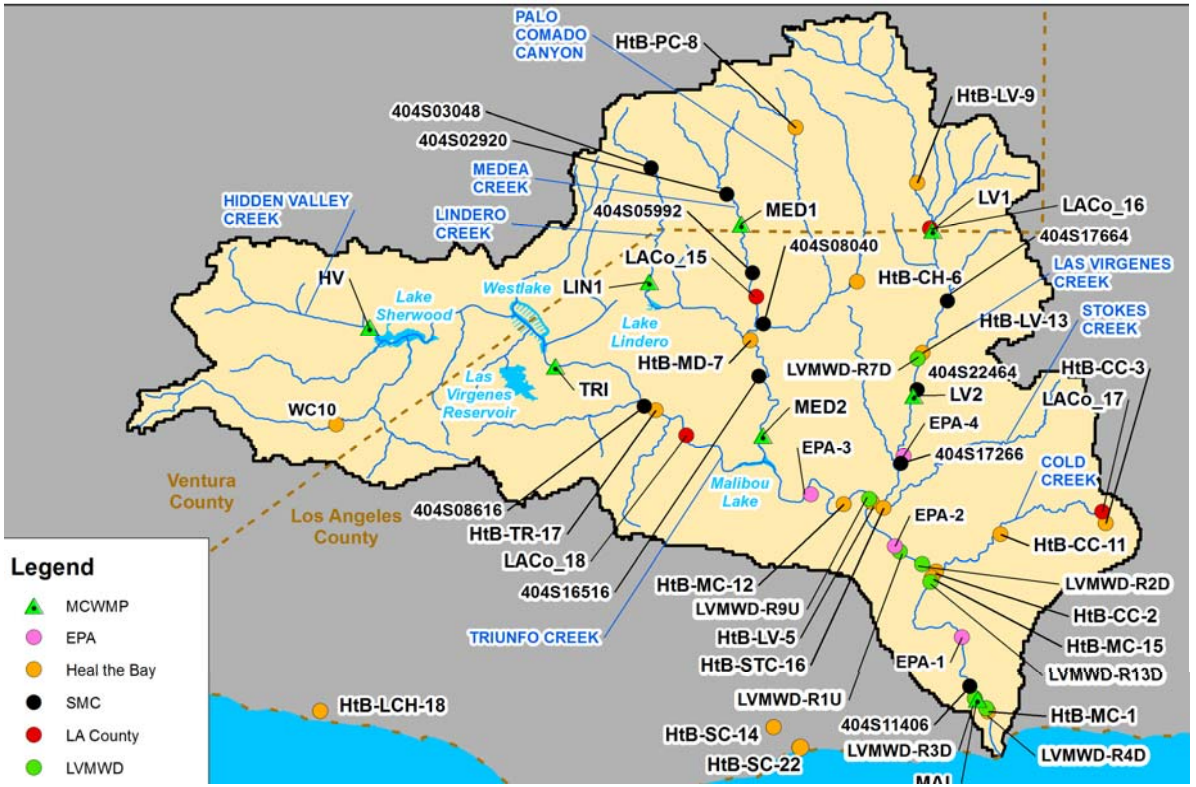


MC Sites: Malibu Creek Sites
Lachusa, Solstice, CH6, LV9, CC3: Reference/comparator Sites

CSCI Results

- USEPA implemented and tested the CSCI models.
- CSCI Science Team conducted bioscore estimates independently.
- CSCI Science Team showed same results.

BMI Sampling Sites & Data Source



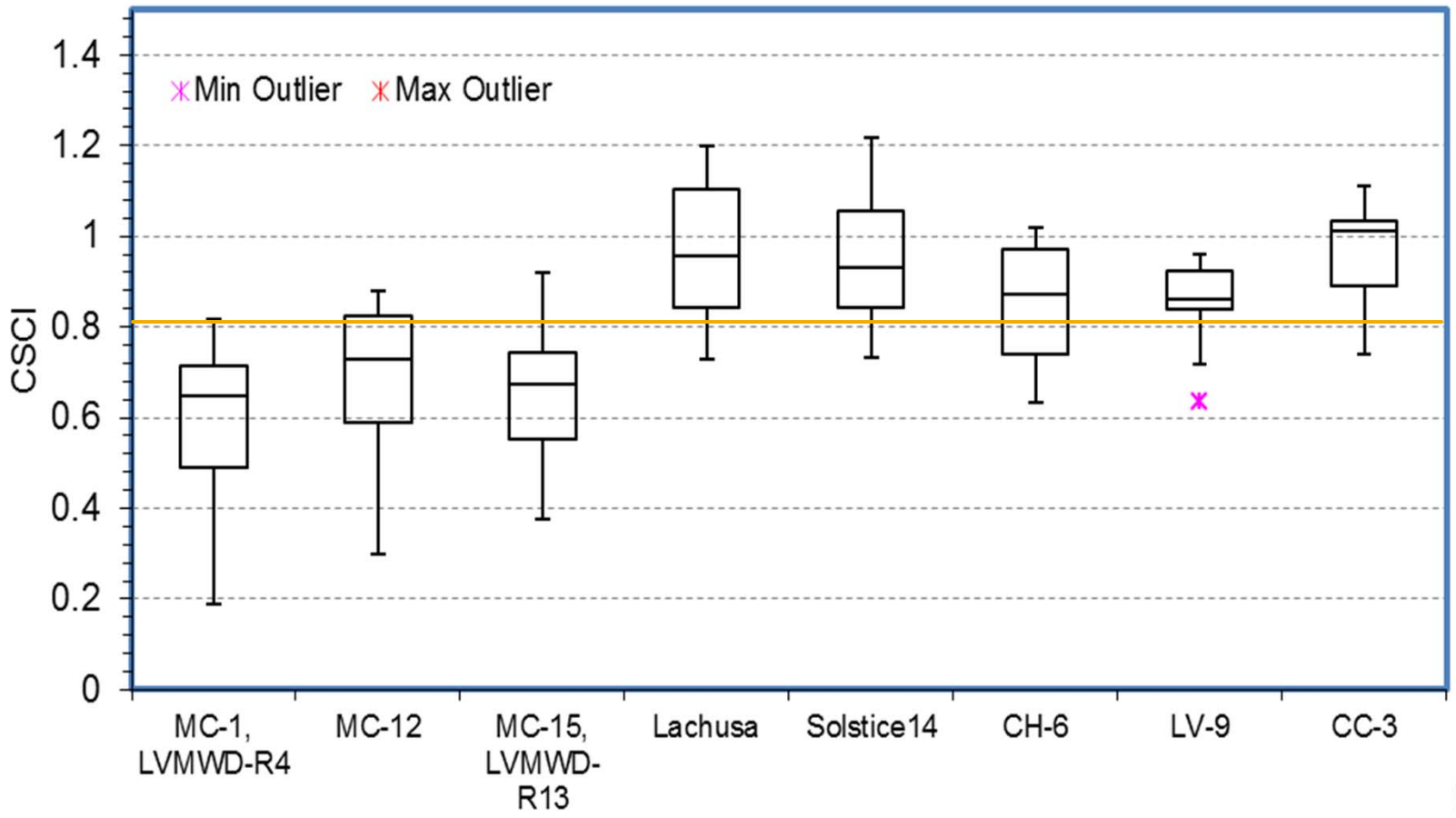
CA Stream Condition Index Scores

At all sites collecting benthic community data in Watershed; Pink denotes above threshold

Stream Name	Site	CSCI																	
		2000 (early)	2000 (late)	2001 (early)	2001 (late)	2002 (early)	2002 (late)	2003 (early)	2003 (late)	2004	2005 (early)	2005 (late)	2006	2007	2008	2009	2010	2011
Cold Creek (cont.)	LACo_17							0.80		0.91	0.84		0.91	1.00	0.83			
	HtB-CC-3	1.04	1.03	1.11	1.01	1.11	1.00	1.04	1.01		0.74		0.96		0.80	0.90 1.03	0.85	0.88
Stokes Creek	HtB-STC-16					0.94							0.83					
Las Virgenes Creek	HtB-LV-5	0.82	0.70	0.75	0.86	0.94	0.77	0.82	0.81		0.70 0.67		0.58 0.69			0.63	0.43	
	404S17266															0.65		
	EPA-4																	0.79
	LV2										0.73	0.36						
	404S22464															0.48		
	LVWMD-R7D												0.57	0.57	0.36	0.49	0.43	0.53
	HtB-LV-13			0.67		0.65	0.74	0.63	0.73		0.62		0.61			0.48	0.55	
	404S17664															0.52		
	SMC01640															0.38		
	LV1										0.85	0.80						
	LACo_16										0.85		0.44	0.50	0.31			
	HtB-LV-9			0.96	0.95	0.93	0.87	0.89			0.85		0.84			0.72	0.63	0.84
Cheseboro Creek	HtB-CH-6			1.02	0.93	1.02		0.87			0.75		0.73				0.63	
Palo Comado Canyon	404S08040															0.45		
	HtB-PC-8			1.04							0.86							
Medea Creek	MED2										0.43	0.39						
	HtB-MDC-21												0.37					
	404S16516															0.51		

Downstream & Reference CSCI

- **MC Sites: Malibu Creek Sites**
- **Lachusa, Solstice, CH6, LV9, CC3: Reference/comparator Sites**



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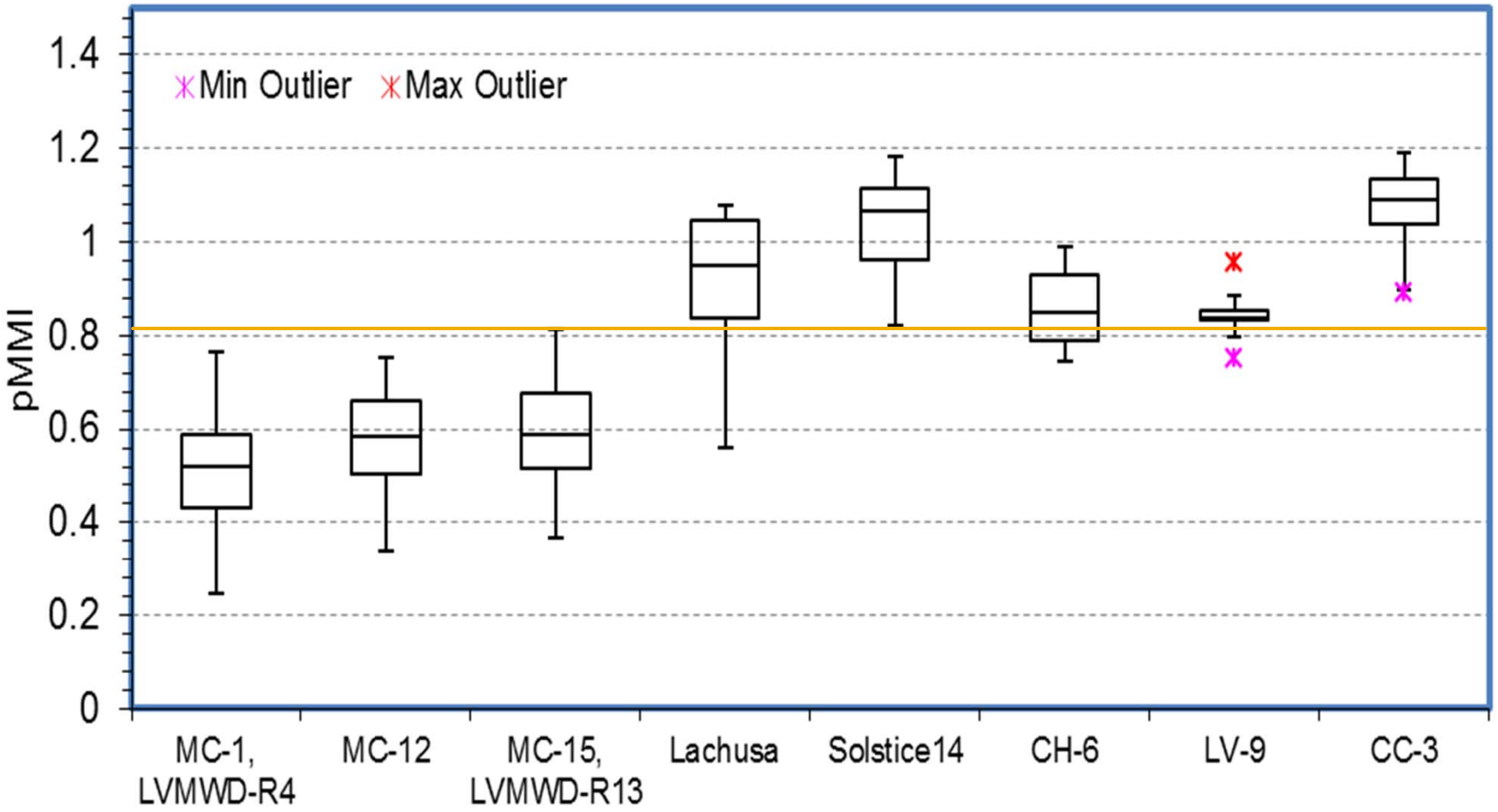
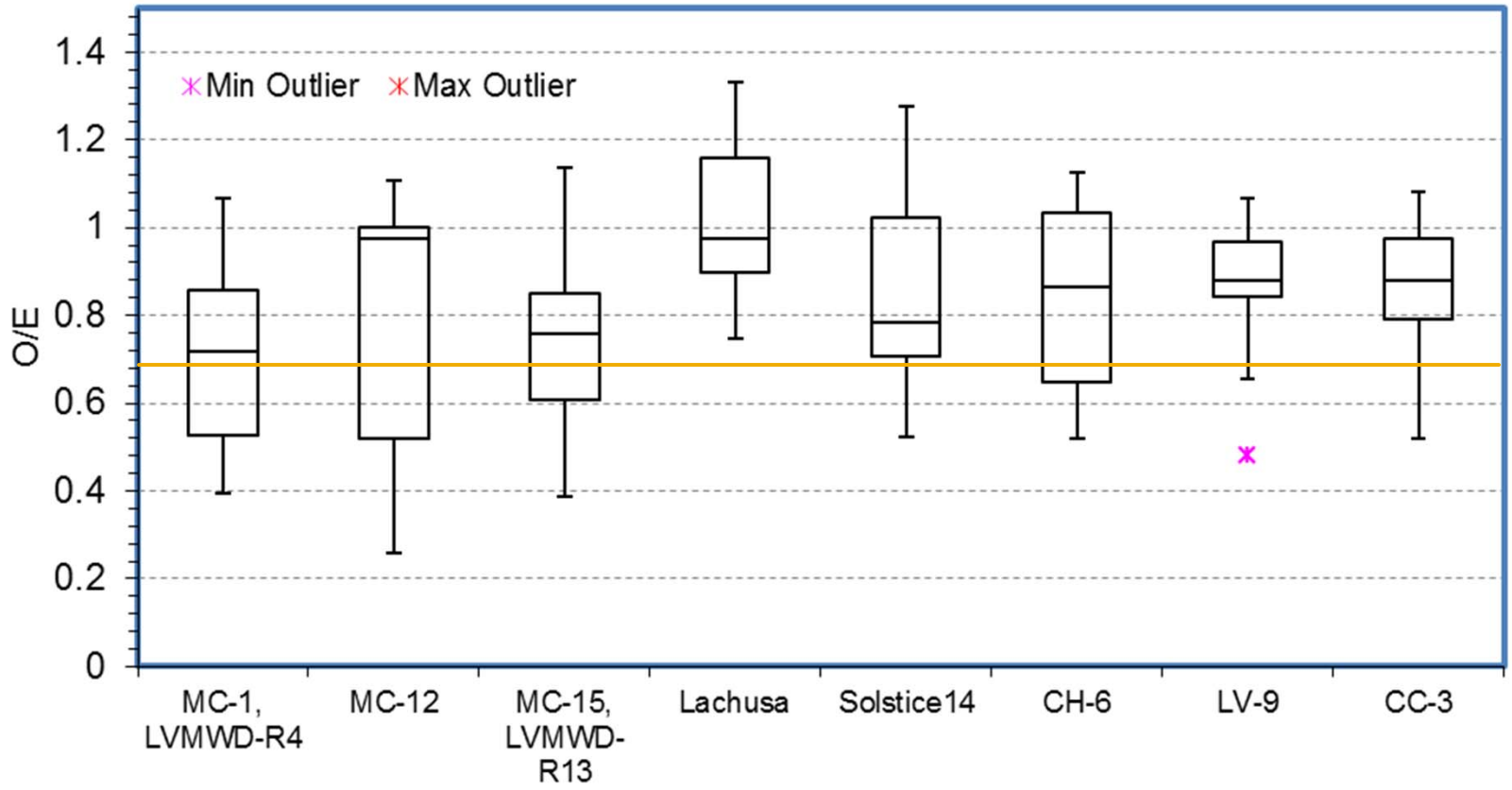
Downstream & Reference pMMI



Downstream & Reference O/E



MC Sites: Malibu Creek Sites

Lachusa, Solstice, CH6, LV9, CC3: Reference/comparator Sites

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Umm…Why?

- CSCI is an average of two endpoints providing different sensitivities in different settings. This is particularly critical when evaluating across the statewide region.
- Site-specific characteristics are embedded in the averaging of the scores.
- Good news: CSCI framework is set up so that one can evaluate the different indices: pMMI and O/E.
- O/E: sensitive to species loss and able to reflect impact of species loss to benthic community
- pMMI: sensitivity to community function; reflect better benthic species' function.

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O/E & pMMI for Malibu

- For Malibu, O/E generally indicates better stream condition than the pMMI (overestimates stream condition).
- O/E model does not include geology variables.
- O/E model is less robust when expected taxa is low (i.e., few expected taxa result in less sensitivity to local characteristics)
- pMMI includes geology variables as predictors (soil erodibility, soil permeability, conductivity, % CaO, MgO, N, P), and appear to reflect better the local watershed characteristics.

- **Statewide vs. Local Condition**

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Applicability to Malibu

- Accurately predict expected taxonomic composition & metrics for unique characteristics (e.g., geology).
- Calibrated our data by comparing predictor values in Monterey Formation areas in Malibu Creek Watershed and adjacent reference watershed.
- Maximum observed pMMI, O/E and CSCI scores similar, suggesting high-quality sites in Monterey/Modelo Formation are appropriately comparable to those of the reference watershed used in the CSCI model.

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Bioscore Trends for Malibu

- Similar trends observed for SC-IBI, CSCI and pMMI
- O/E show different temporal trend. For instance, showing higher watershed scores until 2005, and main stem sites are similar to comparator/reference sites with the best conditions, irregardless of the geology.
- O/E scores don't differentiate between reference and impaired sites in Malibu Creek Watershed.
- Multiple Lines of Evidence

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Stressors & Causes

What is (or are) causing the observed biological condition?

Stressor ID / Causal Assessment

- List Candidate Causes
  - Identify all stressor sources
- Analyze Evidence
  - Measurements of causes and responses in the Watershed
  - Measurements of similar causes/response nearby
  - Measurements from laboratory studies
  - Site measurements & intermediate steps in the causal process
- Characterize Causes
  - Eliminate Alternatives
  - Diagnostic Analysis
  - Strength of Evidence Analysis
  - Identification of Probable Cause

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Stressors & Causes

Based on (1) Weight of Evidence Approach; (2) Evaluation of all available Data and Relationships

- Sedimentation
- Nutrient enrichment
- Reduced DO
- Toxicity
- Altered hydrology
- Channel alteration
- Fire regime
- Point source discharge
- Urban runoff
- Agricultural runoff
- Naturally elevated levels of phosphate, sulfate, TDS
- Invasive species (New Zealand mudsnails)

TMDL includes data review of all the causes & sources.

Example of Causal Assessment

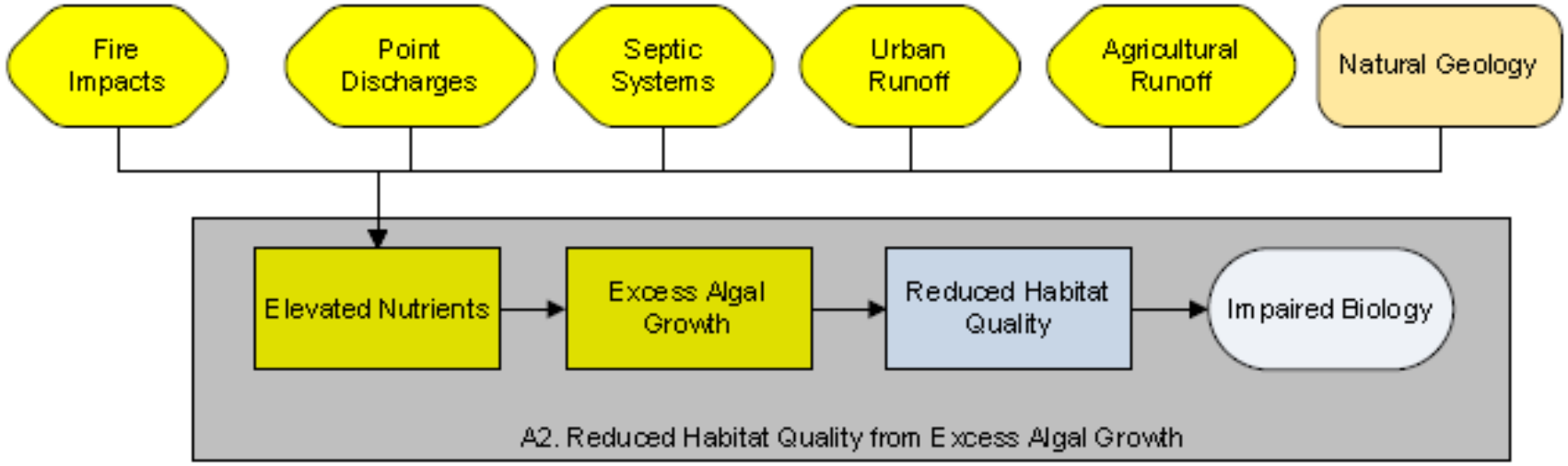

Figure 9-3. Illustrated Linkage between Elevated Nutrients and Impaired Biology as a Result of Excess Algal Growth and Reduced Habitat Quality

A2. Reduced Habitat Quality from Excess Algal Growth: Sources of excess algal growth include excess nutrients resulting from fire impacts, septic systems, point source discharges, non-point sources attributable to urban runoff, agricultural runoff, and natural geology. The following discussion presents the evidence for linkage between excess nutrients, excess algal growth, and reduced habitat quality for benthic macroinvertebrates (Figure 9-3).

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Evaluating Bioscore & Conductivity

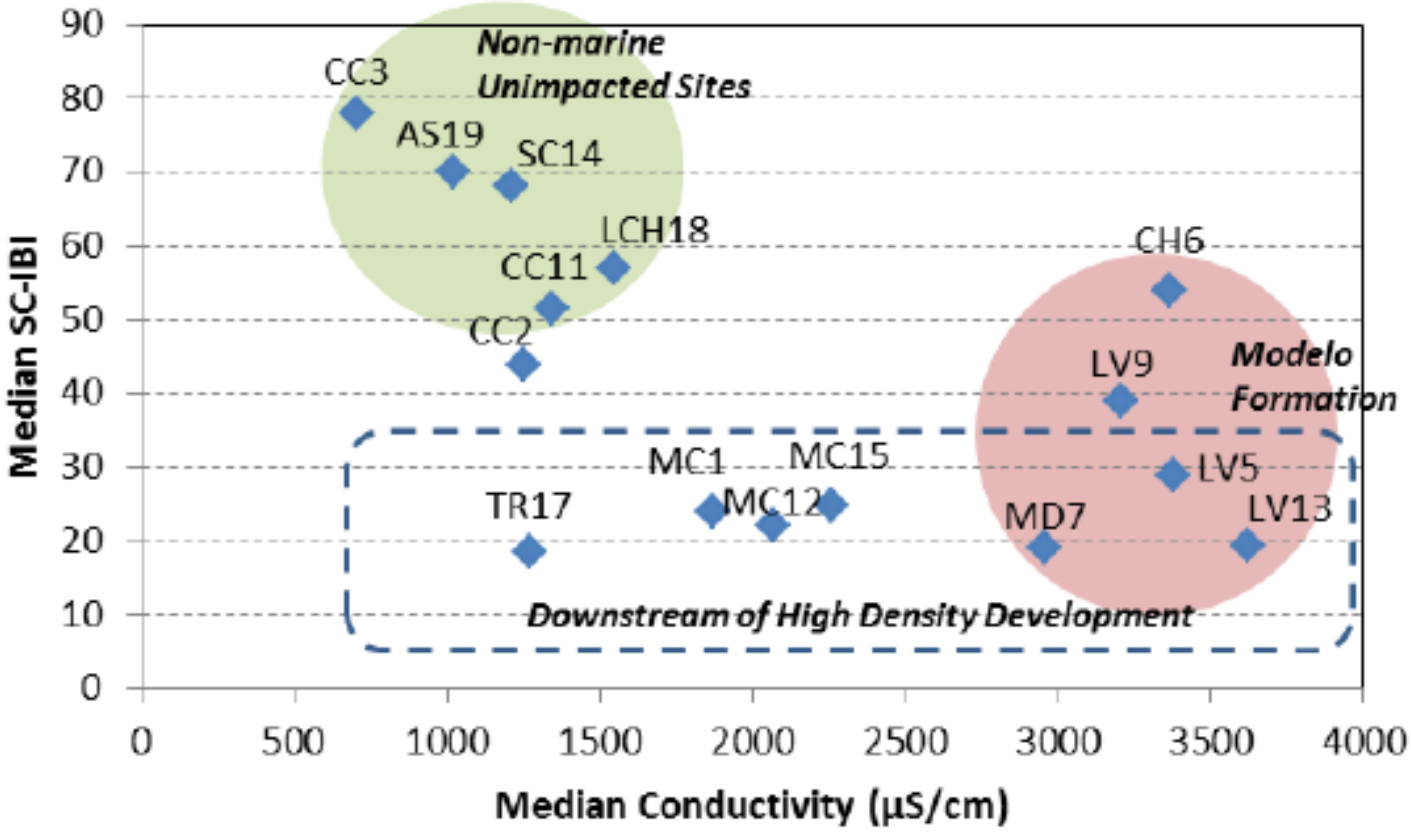
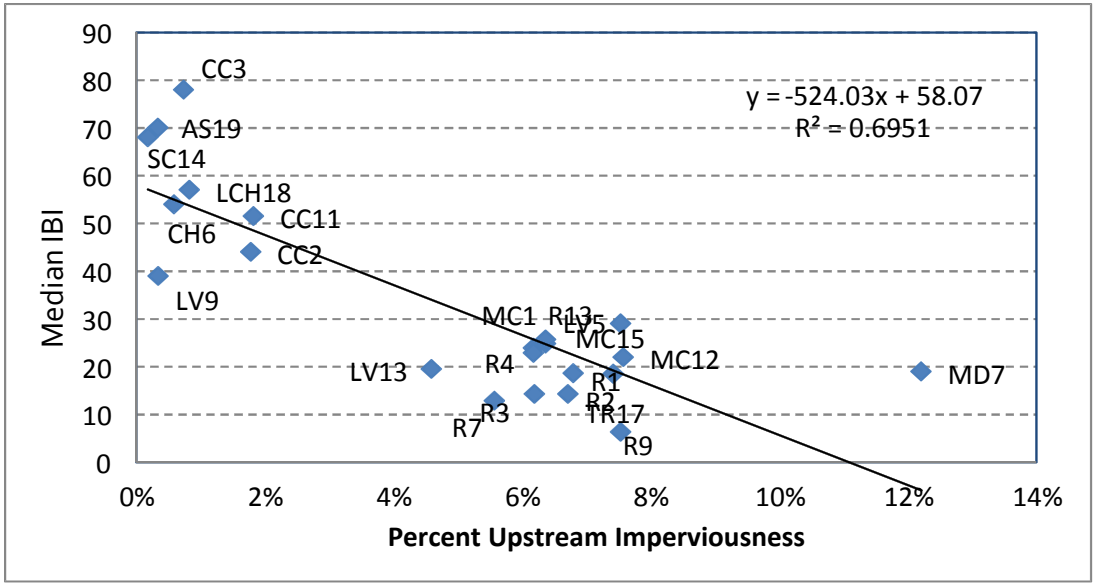


Figure 8-10. Correlation of Median SC-IBI Scores with Upstream High Density Development

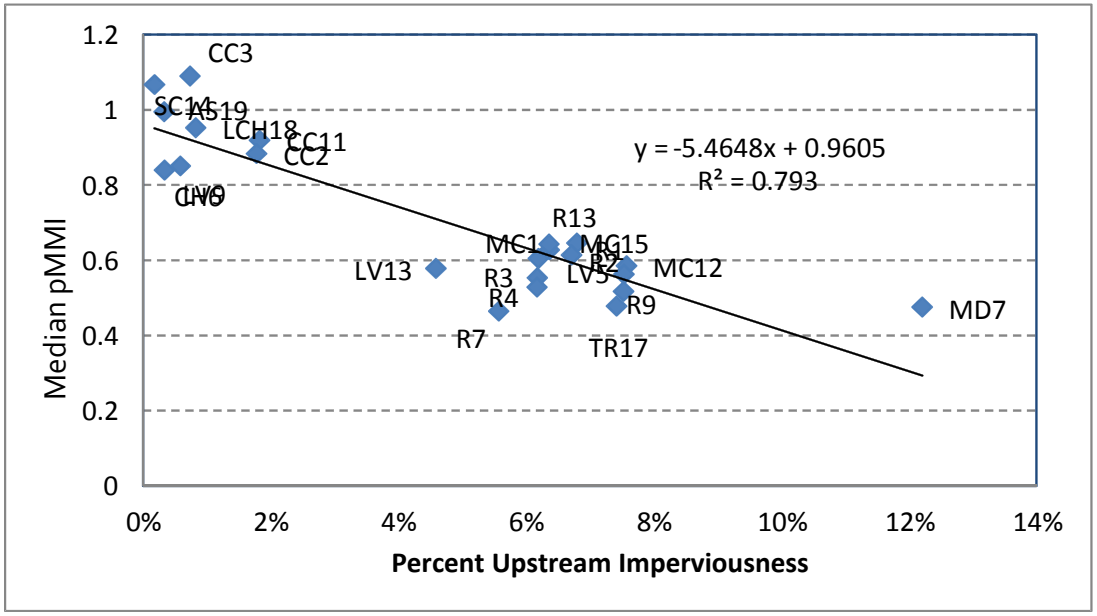
Note: Sites with at least 5 observations, 2000 – 2010. Median shown for MC-1 combines LVMWD-R4D samples; median shown for MC-15 combines LVMWD-R13D samples.

Upstream Imperviousness

Median SC-IBI
$R^2 = 0.70$

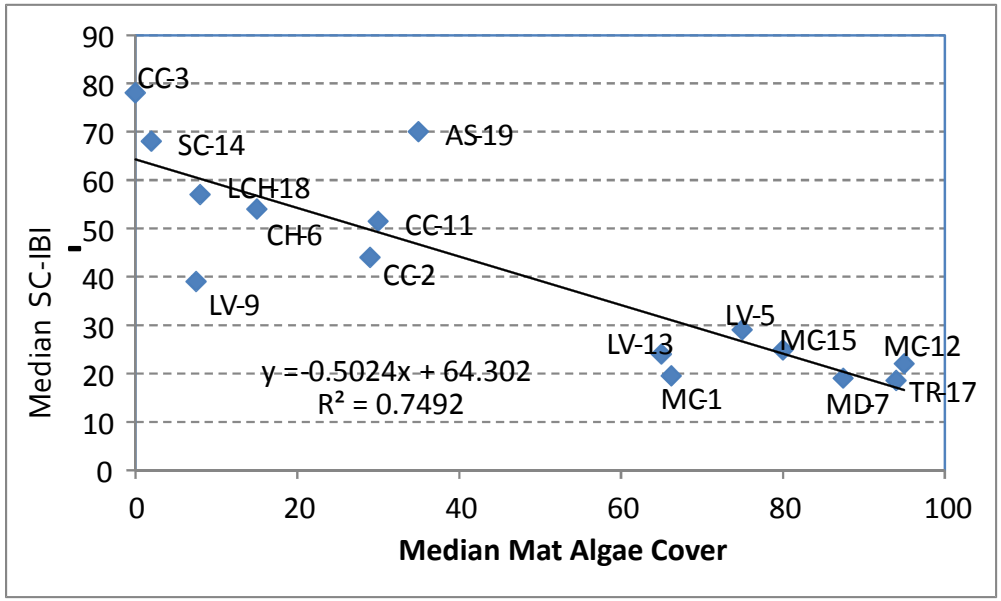


Median pMMI
$R^2 = 0.79$



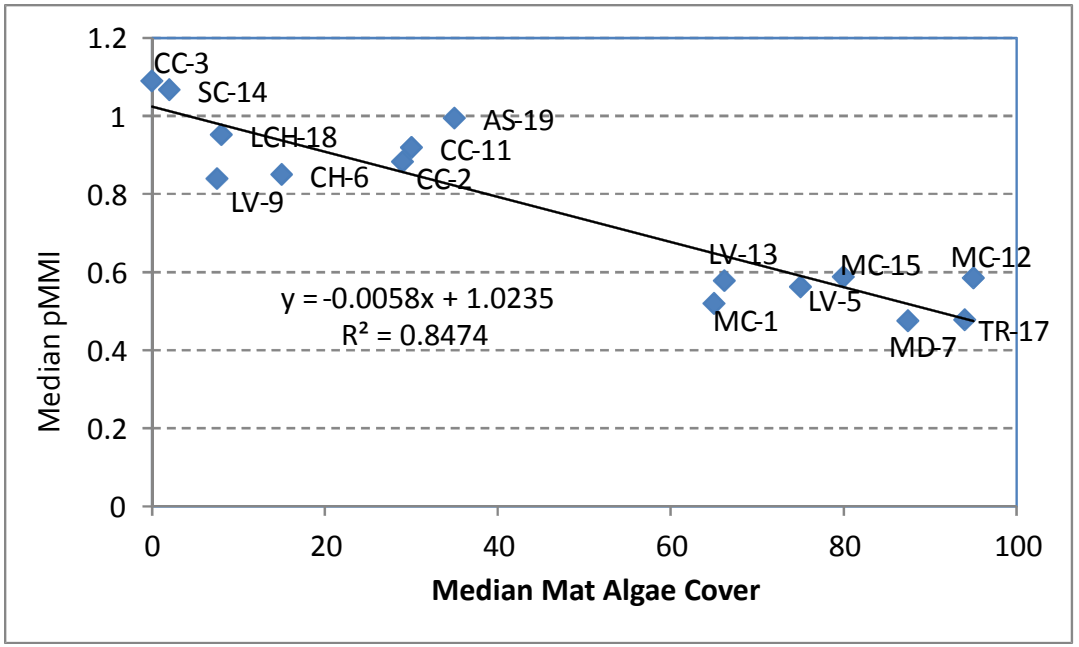
*Median O/E, $R^2 = 0.23$

Median Mat Algae Cover



Median SC-IBI
$R^2 = 0.75$

Median pMMI
$R^2 = 0.85$



*Median O/E, $R^2 = 0.23$

Monterey Bay/Modelo Formation

- Geologic soil found naturally in parts of Malibu Creek Watershed.
- Evaluated water quality and benthic community data at sites located within and outside of Monterey/Modelo Formation areas

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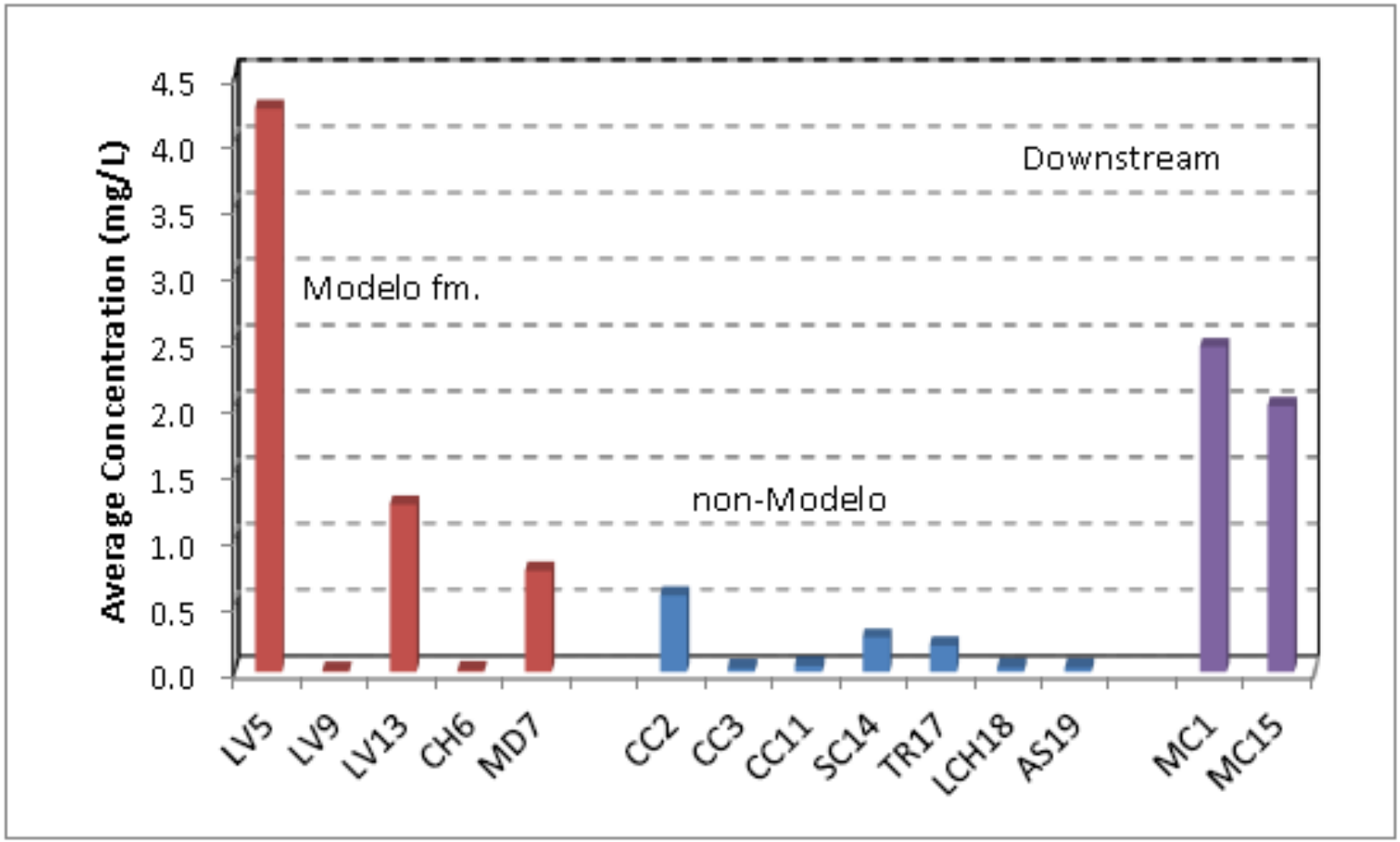
Average NO_3/NO_2 Levels



LV-9 & LV-6 sited in Monterey/Modelo Formation & upstream of development

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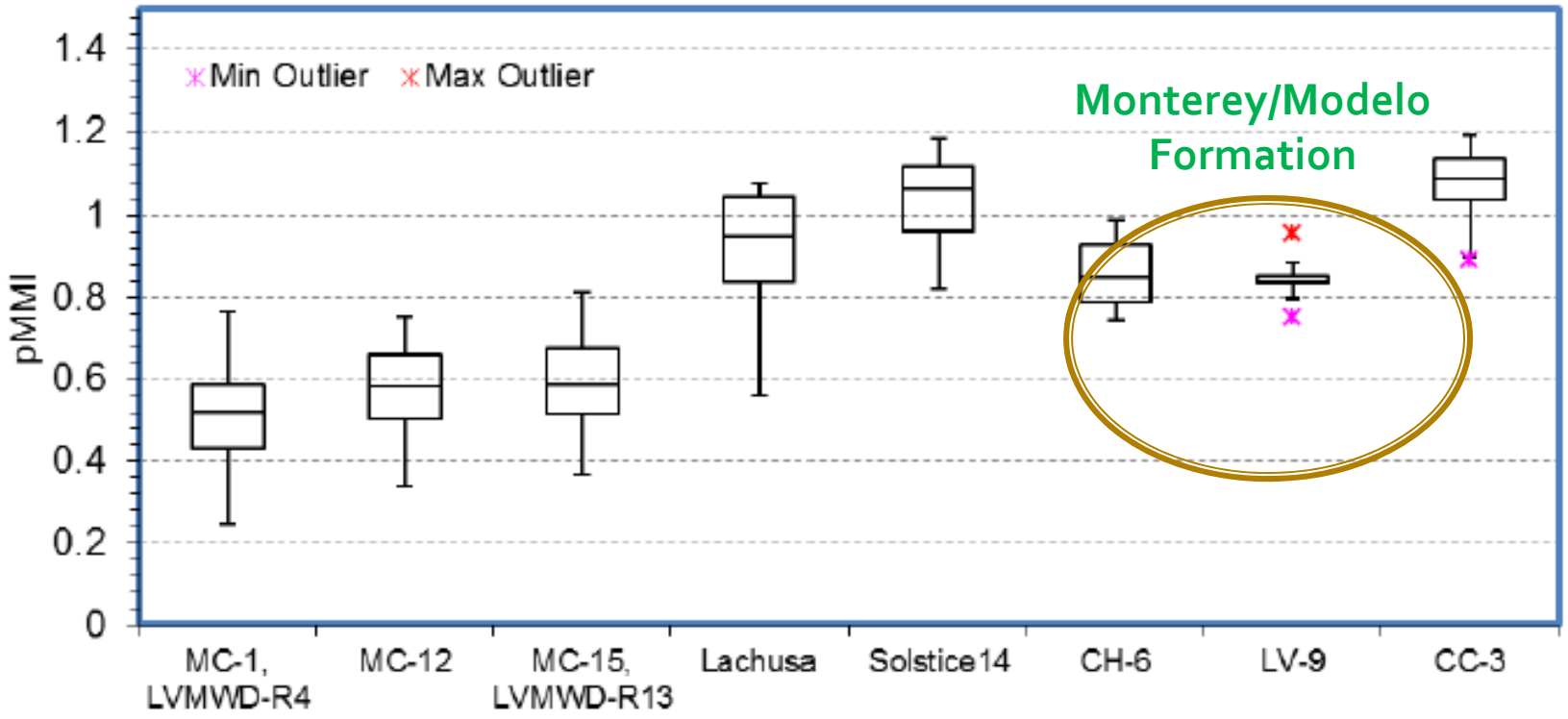
Multi-Metric Bioscores at Impacted & Reference Sites

pMMI considers geology



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Stressors & Causes

- Sedimentation
- TN, TP
- Reduced DO
- Toxicity
- Altered hydrology
- Channel alteration
- Fire regime
- Point source discharge
- Urban runoff
- Agricultural runoff
- Naturally elevated levels of phosphate, sulfate, TDS
- Invasive species (New Zealand mudsnails)

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Biological Threshold Action Levels

- These biological threshold action levels are set to address the observed long-term impaired biological condition.
- Benthic Algal Coverage:
  - ≤ 30% filamentous algae
  - ≤ 60% bottom algae (not new, existing numeric targets)
- CSCI Biological Threshold: 5^{th}-10^{th} percentile probability based threshold based on model reference distribution

- **<u>These are NOT WLAs</u>**; serve to inform monitoring programs & assist with improving performance.
- Exceedences of these action levels will only <u>trigger in-stream monitoring</u> and relevant activities to reduce nutrient pollutant loads.

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In-Stream Nutrient Targets

- Based on existing data from reference/un-impacted sites in Malibu Creek Watershed.
- Set TN and TP concentration limits for summer and winter period in-stream total allowable capacity.
- Set WLAs and LAs for the TMDL based on TN and TP.

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Conclusions & Recommendations

- TMDL sets specific pollutant limits for Nitrogen & Phosphorus based on observed reference condition;
- Set biological thresholds;
- Further evaluation of other stressors
- Watershed Approach to solving problem
- Adaptive Management:
  - Stepwise reduction approach to set TMDLs and associated allocations for interim and final allocations to be phased over time.

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THANK YOU!

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