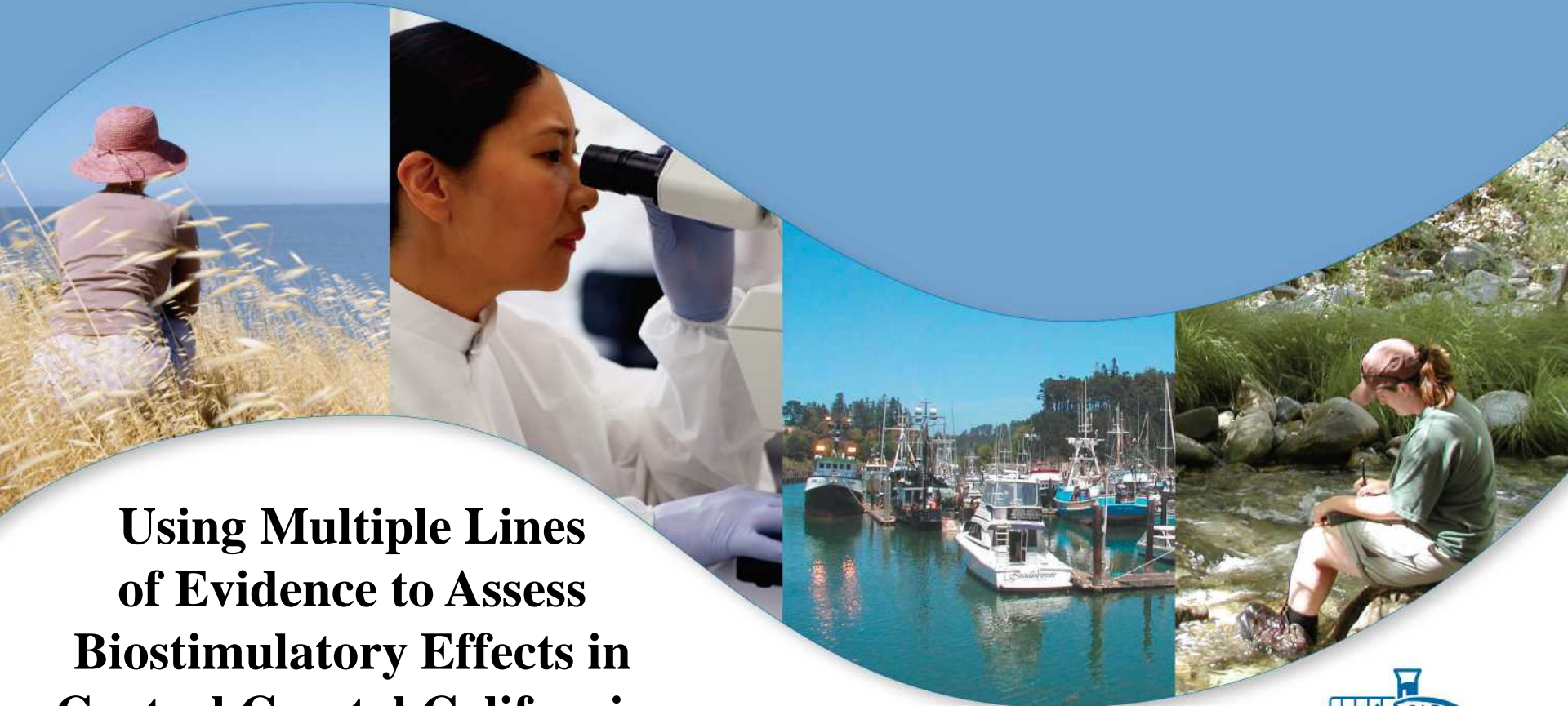California's Surface Water Ambient Monitoring Program
Central Coast Ambient Monitoring Program

Using Multiple Lines of Evidence to Assess Biostimulatory Effects in Central Coastal California Surface Waters

Karen Worcester, Staff Environmental Scientist

How does the Central Coast Water Board protect for nutrient pollution?

Municipal Supply Beneficial Use

- **10 mg/L Nitrate (as N)**

Aquatic Life and Other Beneficial Uses

- Un-ionized ammonia shall not exceed 0.025 mg/L

- Substances should not be present in quantities that are toxic to aquatic life

- Waters shall not contain bio-stimulatory substances in concentrations that adversely affect beneficial uses.

SWAMP
Surface Water
Ambient Monitoring
Program

Direct Toxicity

"The main toxic action of nitrate is due to the conversion of oxygen-carrying pigments to forms that are incapable of carrying oxygen."

"A maximum level of 2 mg/L NO3-N would be appropriate for protecting the most sensitive freshwater species"

From:

J. A. Camargo, A. Alonso and A. Salamanca, 2005. Nitrate toxicity to aquatic animals: a review with new data for freshwater invertebrates. Chemosphere. Volume 58(9): 1255-1267.

SWAMP
Surface Water
Ambient Monitoring
Program

Indirect Toxicity

Blue-green Algae (*Microcystis*) from Pinto Lake

Downstream Impacts

SWAMP
Surface Water
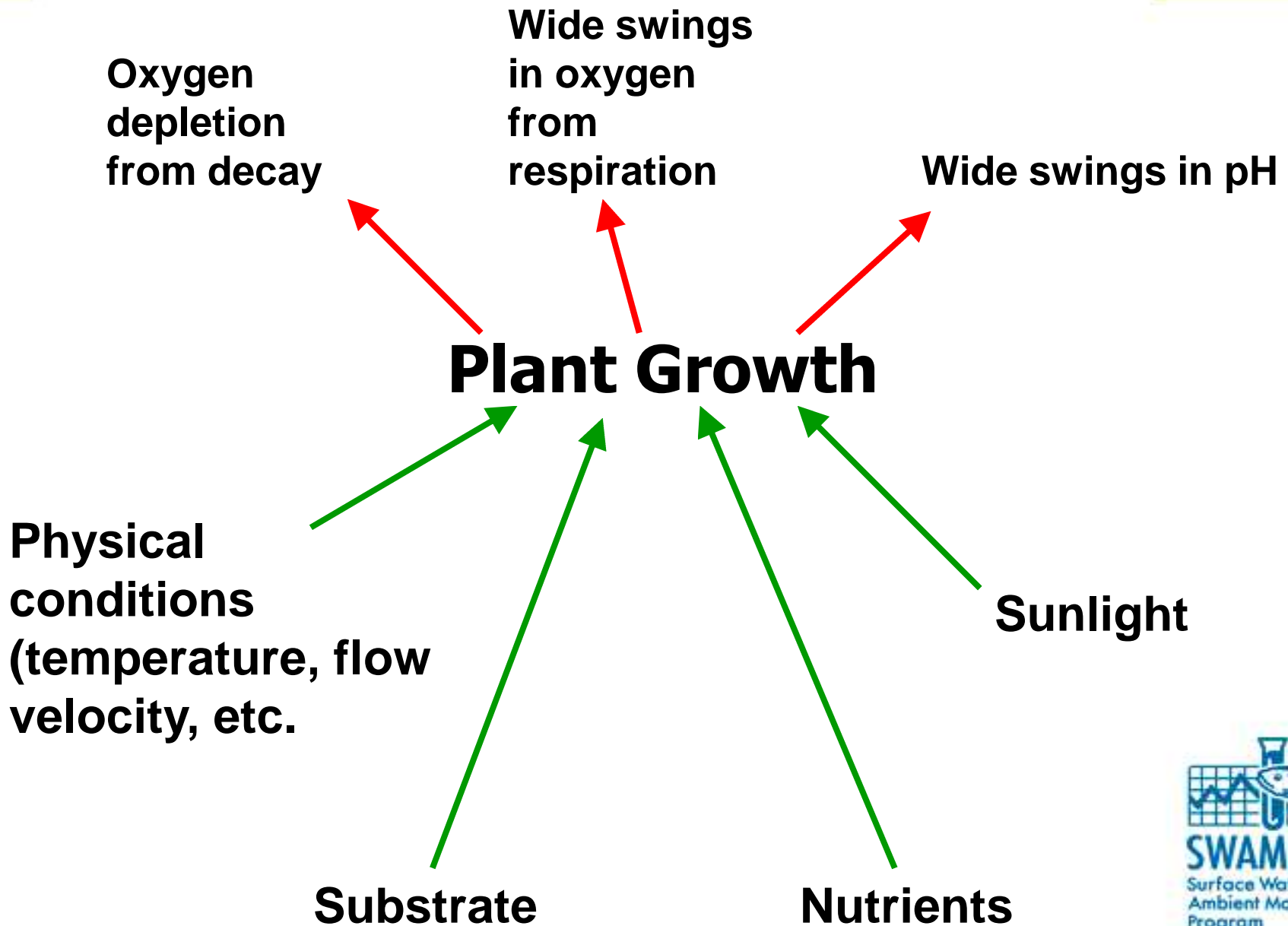Ambient Monitoring
Program

Fish Kills from O2 Depletion

Nuisance Algae

Various proposed nitrogen limits to protect aquatic life uses

U.S. EPA (2000)

- **25th percentile of all data**
  - ➢ 0.5 mg/L TN in western states

OR

- **75th percentile of reference streams**

Black, Moran and Frankforter, USGS (2010)

- **Nutrients and algal metrics**
  - ➢ 0.6 – 1.8 mg/L TN ecologically relevant threshold

California Nutrient Numeric Endpoint Technical Approach (2006)
Tetratech Inc., under contract with U.S. EPA Region IX

- **Identifies secondary indicators including benthic algal biomass (measured as chlorophyll a)**

- **Defines three risk categories for indicators**

  - **Presumably unimpaired**
  - **Potentially impaired**
  - **Likely impaired**

- **Includes a benthic biomass modeling tool to link indicators to nutrient concentrations**

SWAMP
Surface Water
Ambient Monitoring
Program

California Nutrient Numeric Endpoint Technical Approach (2006)

Tetratech Inc., under contract with U.S. EPA Region IX

- **Identifies secondary indicators including benthic algal biomass (measured as chlorophyll *a*)**

- **Defines three risk categories for indicators**

  - **Presumably unimpaired**
  - **Potentially impaired**
  - **Likely impaired**

  100 mg chl-*a*/m2

  150 mg chl-*a*/m2

- **Includes a benthic biomass modeling tool to link indicators to nutrient concentrations**

SWAMP
Surface Water
Ambient Monitoring
Program

For Central Coast Water Board:

We wanted to derive a nitrate threshold at which we could reasonably expect impairment for 303(d) listing purposes, and support that with measured and modeled indicators of bio-stimulatory effects

We started by examining CCAMP oxygen data

- **Routine monthly grab sampling**
- **105 sites with 24-hour dissolved oxygen probe data**

  - **59 sites <u>never</u> violated the warm water oxygen objective (5 mg/L)**
  - **32 sites <u>never</u> violated the cold water oxygen objective (7 mg/L)**
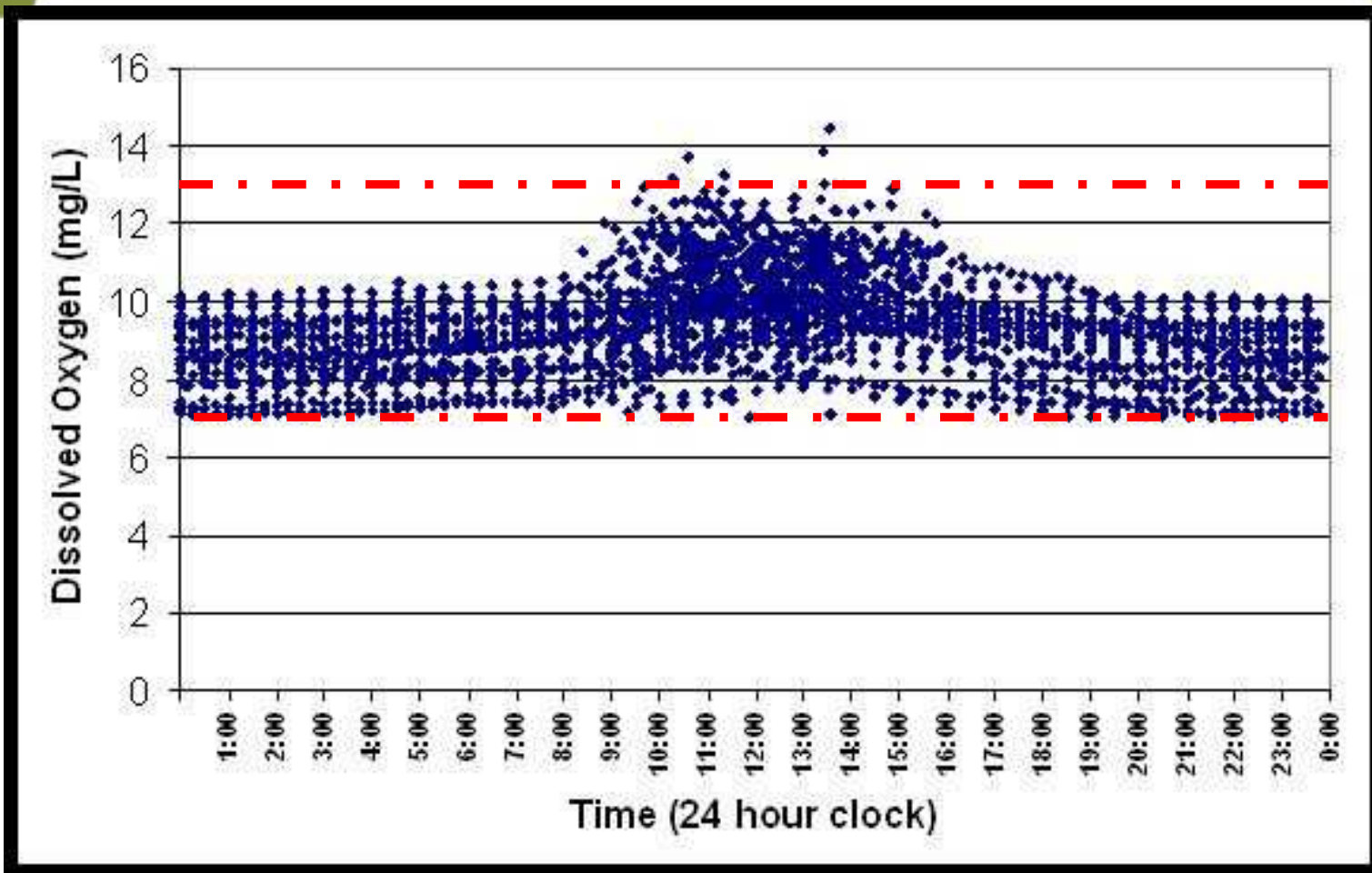
Nearly all samples remain under 13 mg/L at sites that never violate oxygen objectives

In addition, 94% of sites which exceed 13 mg/L as a maximum drop below 7 mg/L as a minimum.
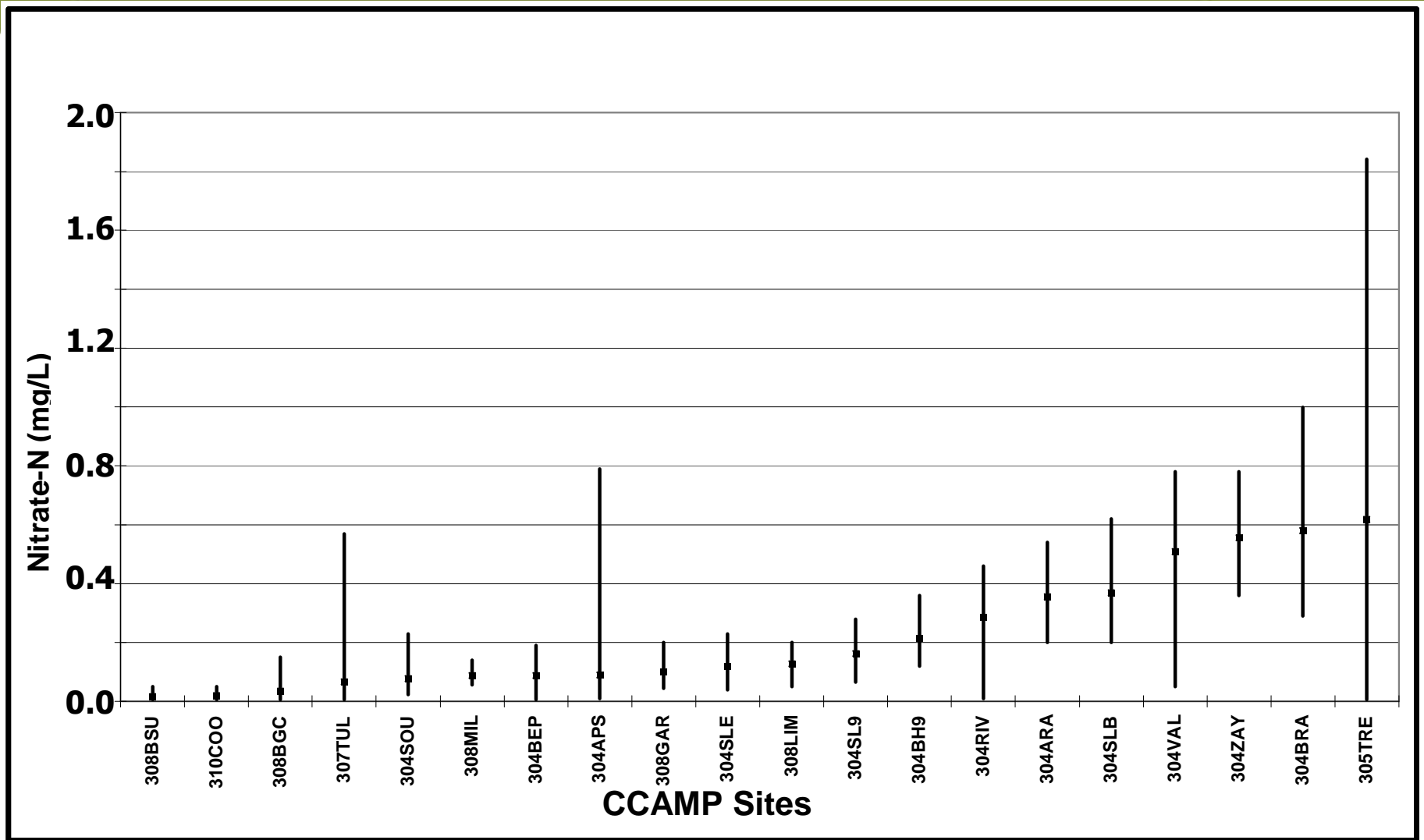
We decided we could use exceedance of 13 mg/L as an indicator of widely ranging oxygen concentrations and a likely indicator of oxygen sags.

We then created a pool of "reference" sites by eliminating sites with:

- Dissolved oxygen over 13 mg/L

- Water column chlorophyll *a* over 15 ug/L
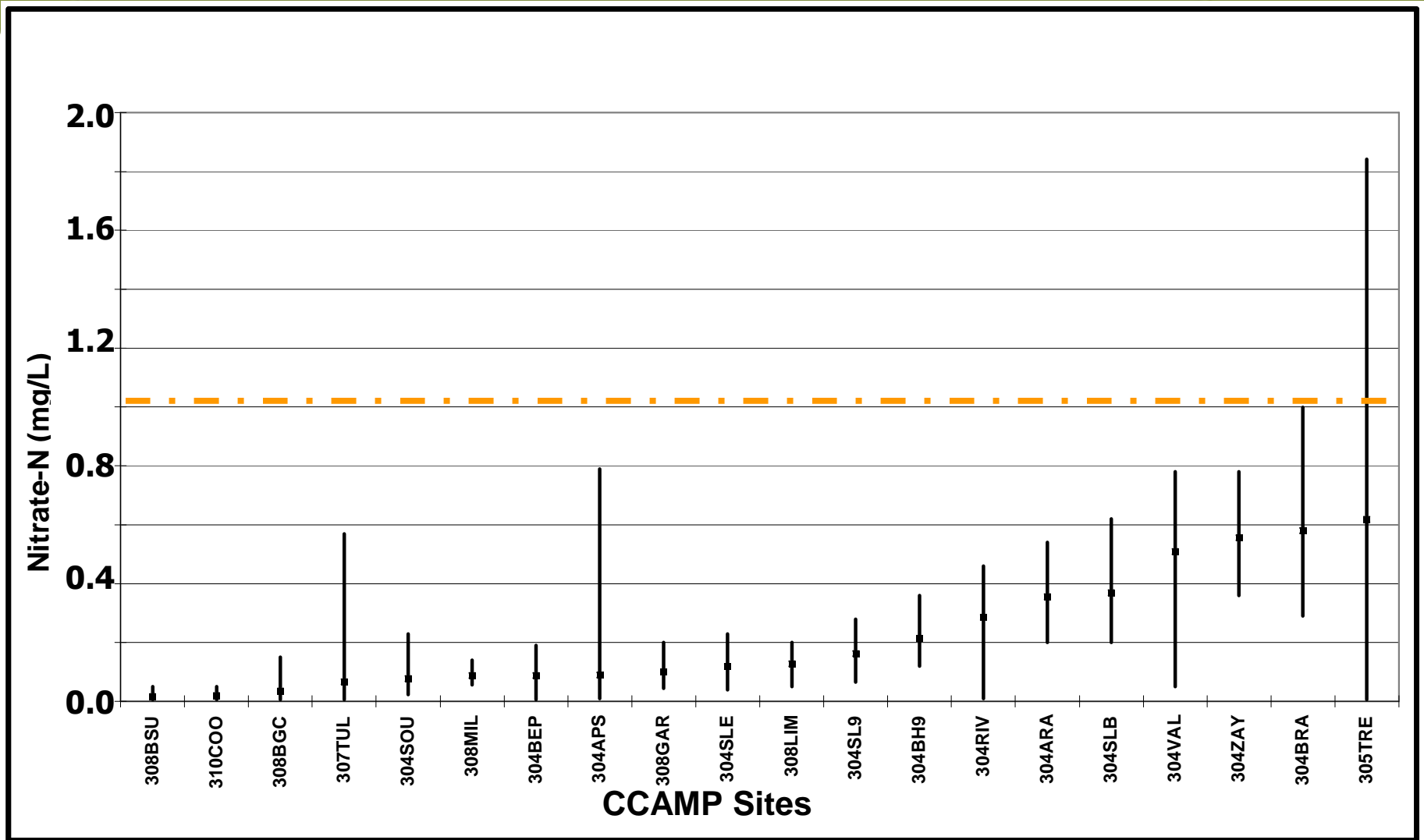
- Floating algal mat cover greater than 50%

Average and range of nitrate at cold water reference sites

We proposed a guideline concentration for Nitrate of 1 mg/L based on reference data evaluation
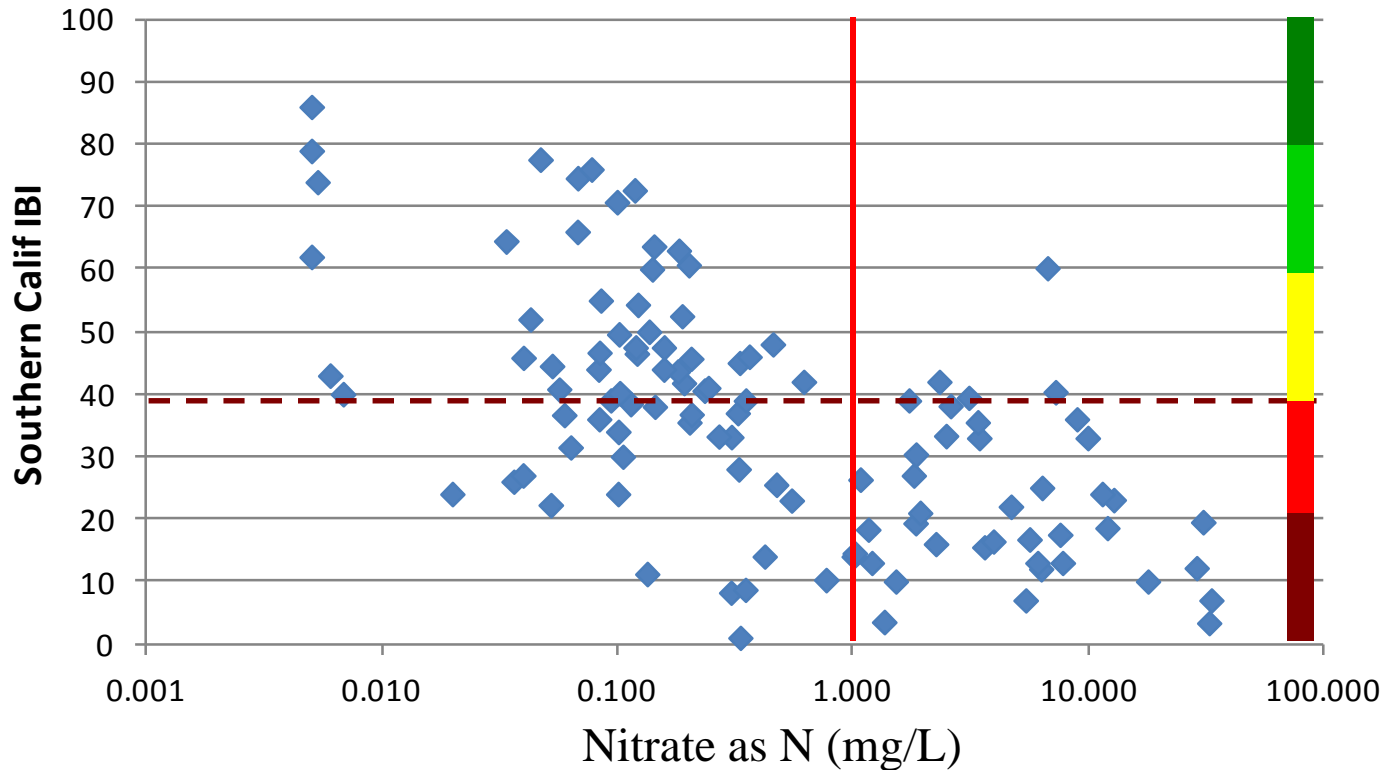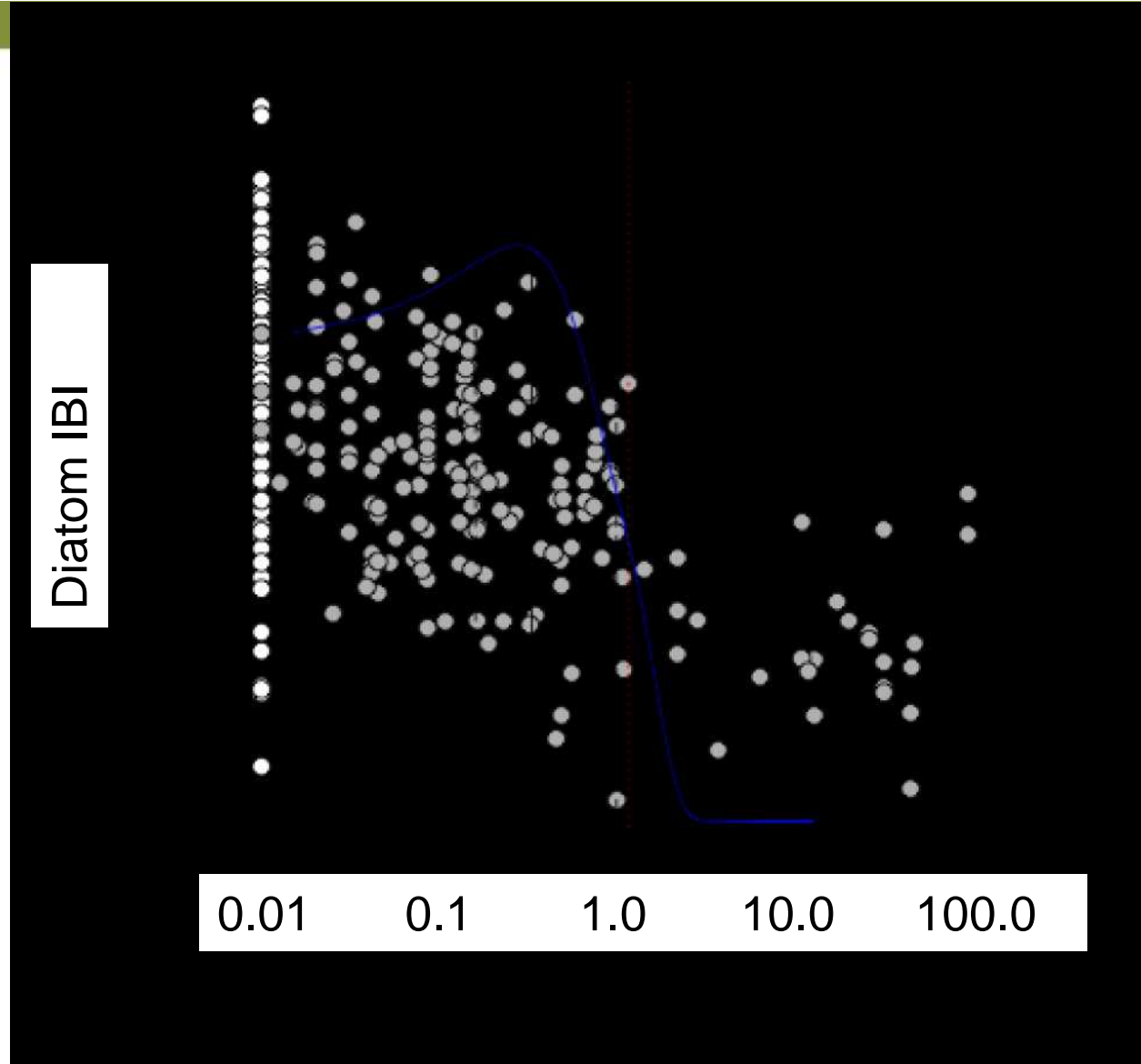
1 mg/L NO3-N is the 95th percentile of reference data

Invertebrate IBI and average nitrate concentration
(showing proposed guideline value of 1.0 mg/L)

Huertos, Krone-Davis,

Non-parametric change-point analysis evaluating
diatom IBI/nitrate relationship
(at 1.0 mg/L, 86% chance that threshold has been surpassed)

Tetratech NNE Benthic Biomass Tool

- **Inputs include nutrients, canopy closure, water temperature, latitude, flow velocity and depth**

- **Predicts biological responses (benthic algal biomass as chlorophyll *a*, benthic algae density, oxygen deficit)**

- **Compares algae predictions to thresholds of impairment**

SWAMP
Surface Water
Ambient Monitoring
Program

RESULTS

Less than or equal to Target		
Greater than Target		

Method	Max algal density, ave conditions (g/m^2 AFDW)	Benthic chlorophyll a estimate (mg/m^2)
Standard QUAL2K	49	123
Revised QUAL2K	41	104
Revised QUAL2K with accrual adj	29	73
Dodds '97, mean Chl a	13	32
Dodds '97, max Chl a	36	91
Dodds '02, mean Chl a	10	25
Dodds '02, max Chl a	33	82

Max algal contribution to DO deficit (mg/L)	1.29

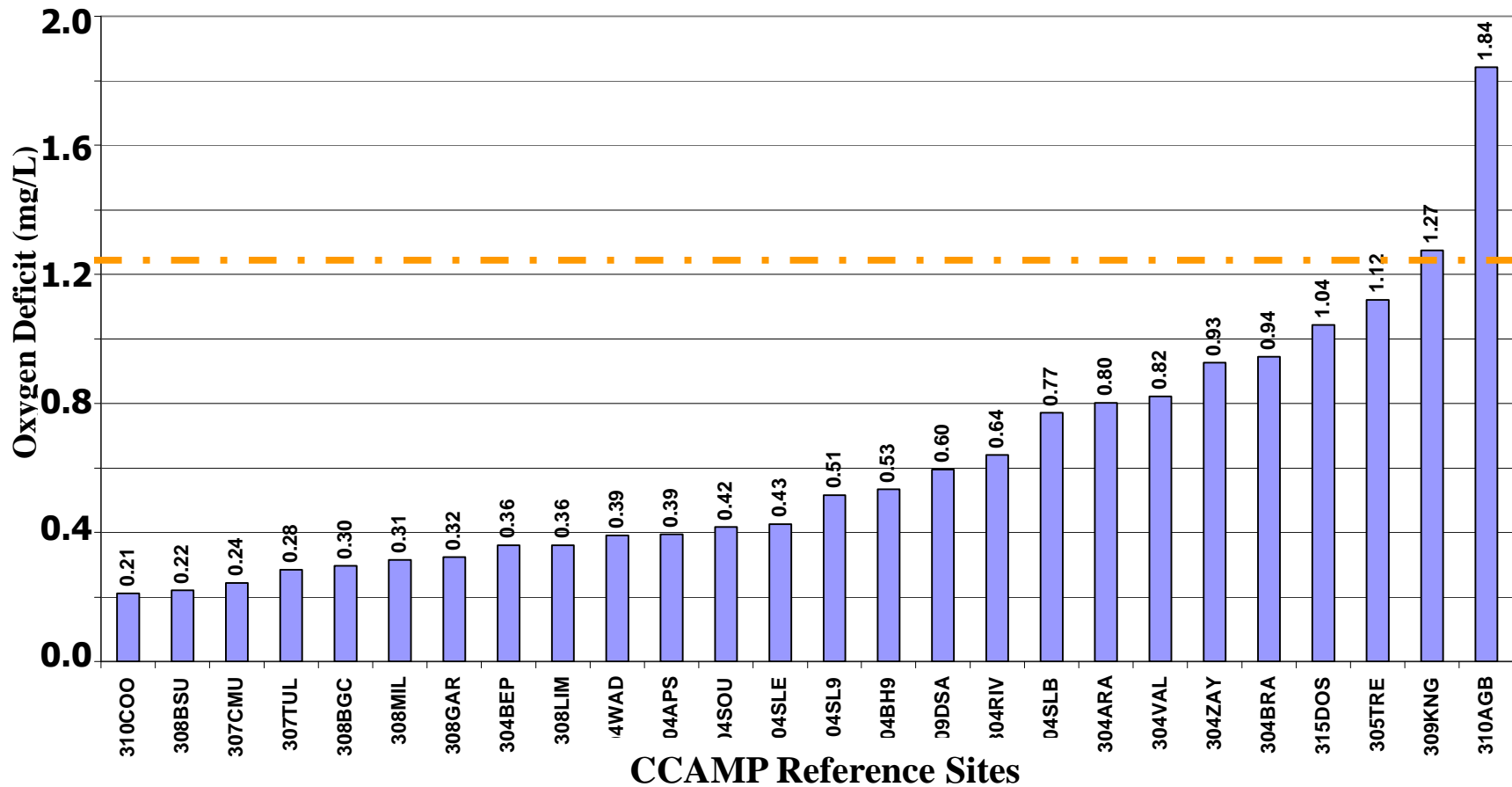**Output from the California Benthic Biomass Tool**

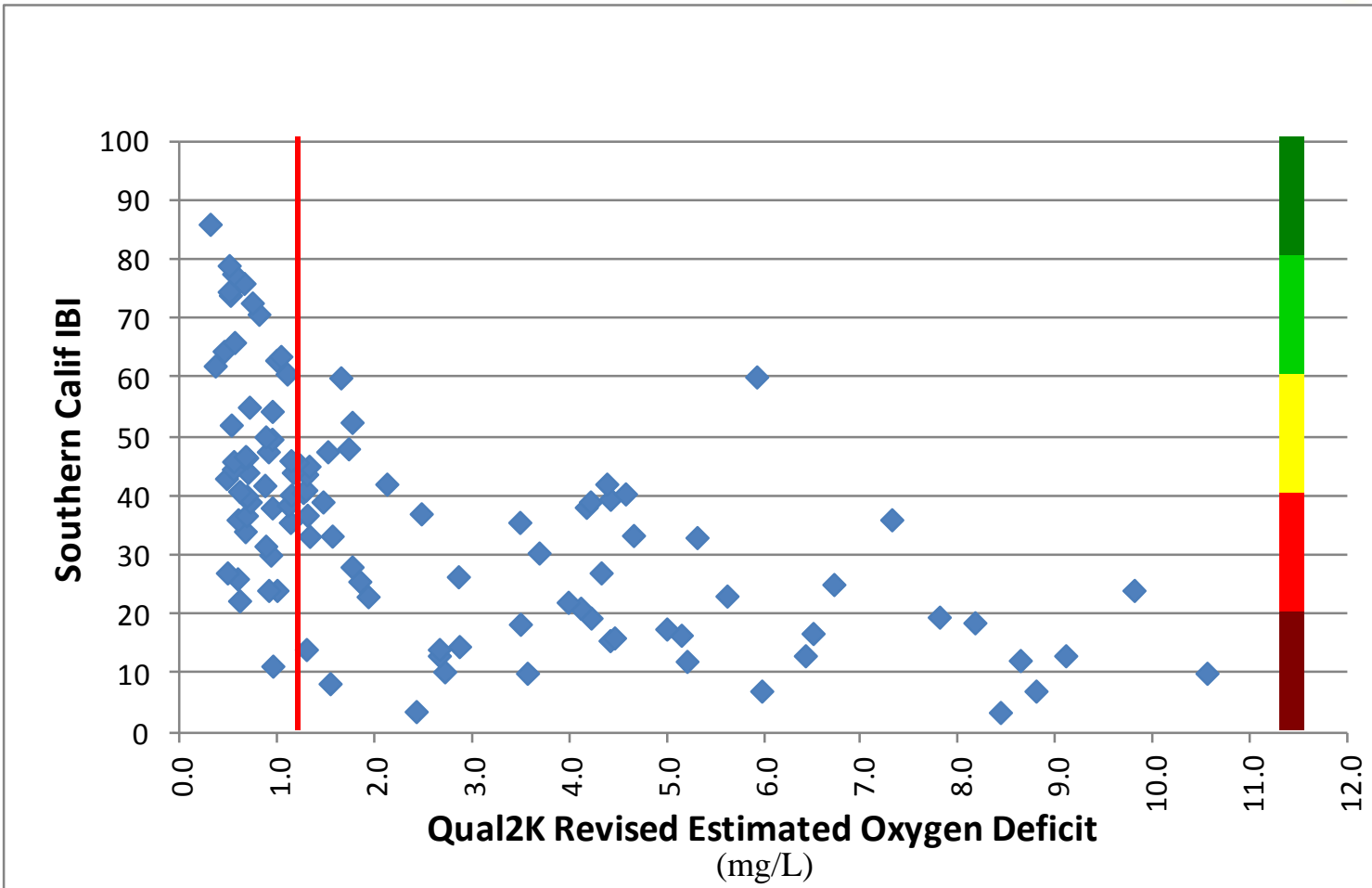**Predicted Oxygen Deficit vs. Average Nitrate Concentration**
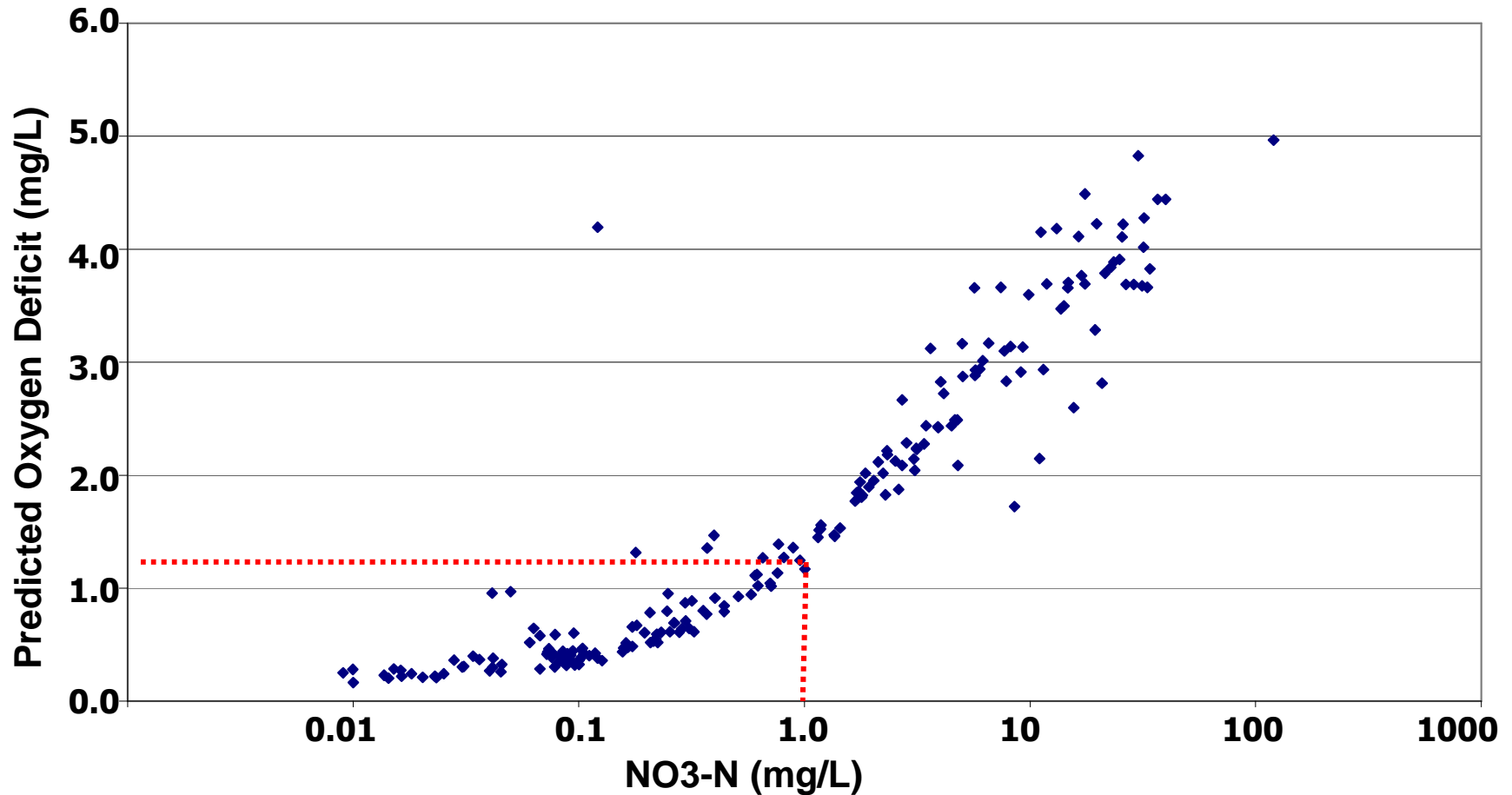
Oxygen deficit due to benthic algae is approximately 1.25 mg/L at 1 mg/L NO3-N

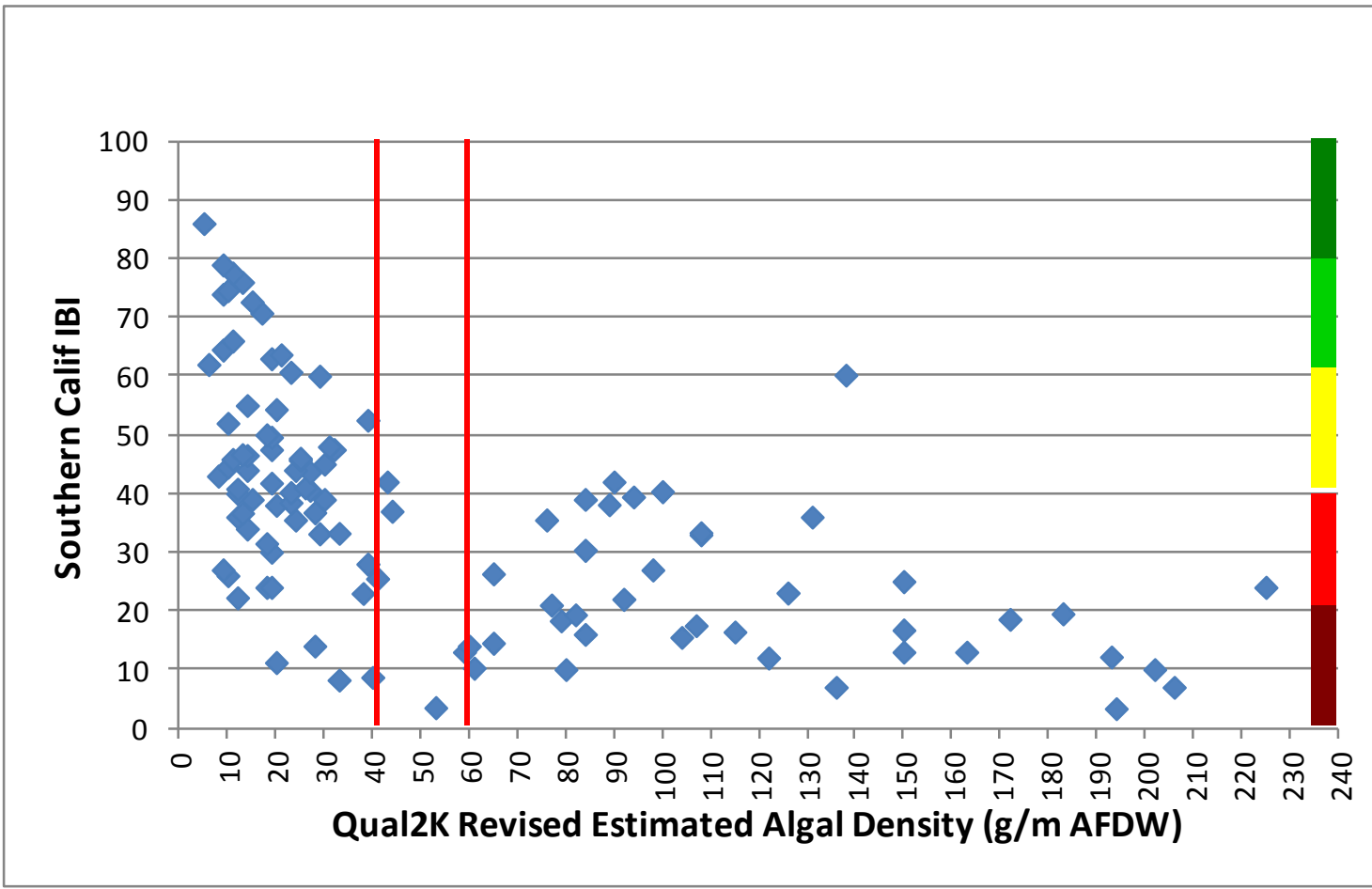# Predicted Oxygen Deficit (mg/L) at Reference Sites

An average oxygen deficit under 1.25 mg/L is typical at sites that show no evidence of biostimulation

Invertebrate IBI and predicted algal contribution to oxygen deficit

Invertebrate IBI and estimated algal density

(40 and 60 g/m² are thresholds for "potentially" and "likely" impaired)

Using this Information to List for Aquatic Life Impairment

- **Sites are screened for nitrate exceedance of 1 mg/L following CA Listing Policy**

- **Listing Decisions are further supported by:**

    - **Widely ranging oxygen concentrations (below standards or above 13 mg/L)**
    - **Predicted oxygen deficit over 1.25 mg/L**
    - **Predicted benthic algal biomass or chlorophyll *a* over NNE thresholds of concern**
    - **Water column chlorophyll *a* over 15 ug/L**
    - **Filamentous algal mat cover >50%**

SWAMP
Surface Water
Ambient Monitoring
Program

Findings

- **1.0 mg/L NO3-N can be used as a guideline value for impairment, supported by secondary indicators**

- **1.0 mg/L is the 95th percentile of a reference dataset**

- **Bioassessment data for both algae and invertebrates confirms that sites exceeding 1.0 mg/L NO3-N are typically in poor condition**

- **Lower NO3-N thresholds could be justified for protection of aquatic life resources**

SWAMP
Surface Water
Ambient Monitoring
Program

Questions?

Karen Worcester
Staff Environmental Scientist
Kworcester@waterboards.ca.gov
(805) 549-3333

www.ccamp.org