Developing Consistent and Improved Approaches to Water Quality Compliance Assessments

Stephen B. Weisberg

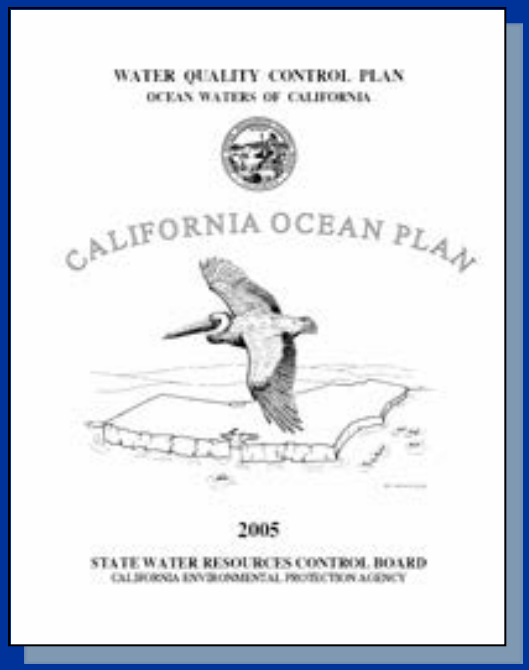
Presentation to SCCWRP Commission

June 7, 2013

BACKGROUND

- **Ocean dischargers are required to demonstrate compliance with California water quality standards**

- **For the water column, these standards are expressed as deviations from "natural" water quality**
  - Dissolved oxygen shall not at any time be depressed more than 10% from that which occurs naturally
  - pH shall not be changed at any time more than 0.2 units from that which occurs naturally
  - Natural light shall not be significantly reduced at any point outside the initial dilution zone



THE PROBLEM

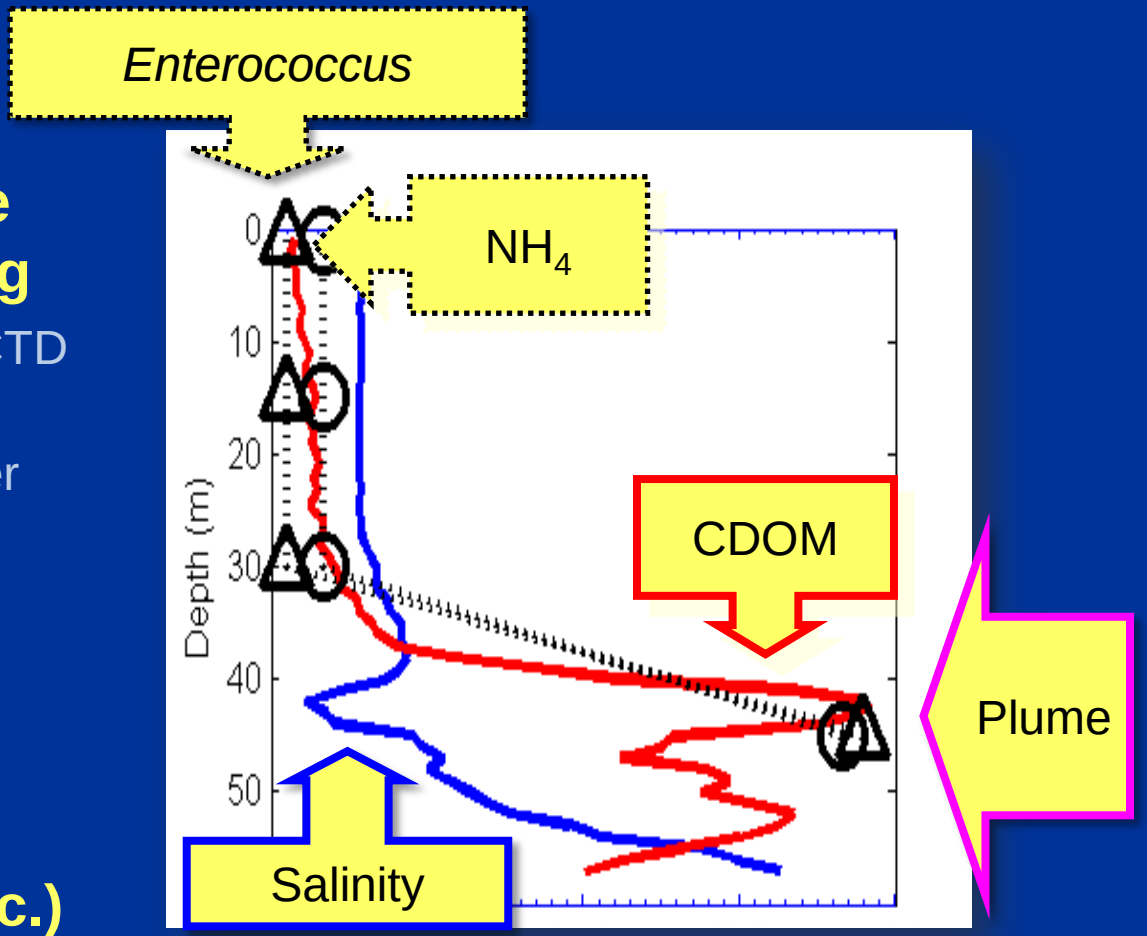
- **The Ocean Plan does not define “natural”**
- **Southern California POTWs differ in how they make that assessment**
  - Measurement they use to identify where the plume is located
  - How they select reference sites
  - Analytical approaches by which they compare plume and reference sites
  - How they differentiate an out-of-range value from compliance failure
- **The State Water Board and the POTW dischargers both asked SCCWRP to help draft a standardized assessment protocol**

THREE-PART PRESENTATION

- Develop an approach for determining plume location
- Develop an assessment algorithm for determining when a plume sample is out of range for dissolved oxygen, water clarity, and pH
- Examine whether gliders are an appropriate alternative for collecting the underlying data

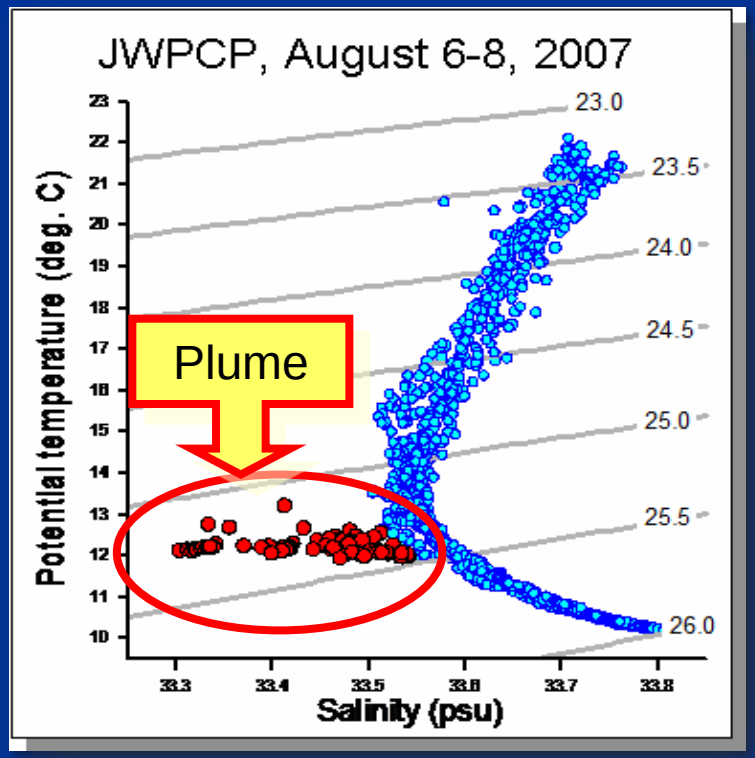
ALTERNATIVES TO BOTTLE SAMPLING

- **Discrete (bottle) samples of NH_4 and bacteria are expensive and logistically limiting**
  - Sampled at a subset of CTD sites
  - Sample depth at 10-meter intervals
- **CTD (conductivity, temperature, depth + pH, dissolved oxygen, chlorophyll, CDOM, etc.) provides continuous profiles**
  - Also provides instantaneous measurements



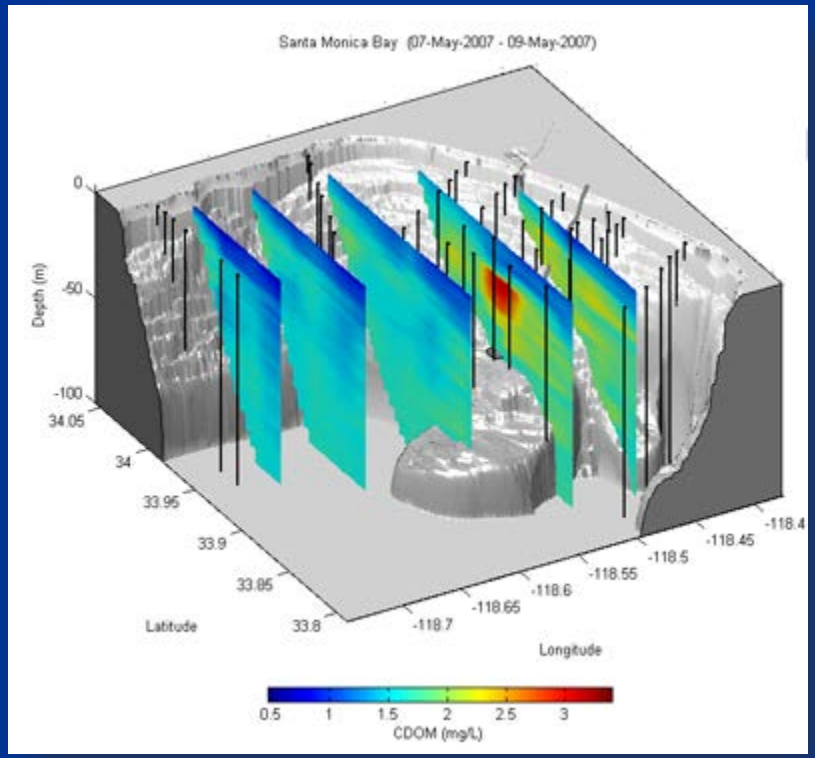
INVESTIGATED TWO COMPLIMENTARY APPROACHES

Density/Salinity Method



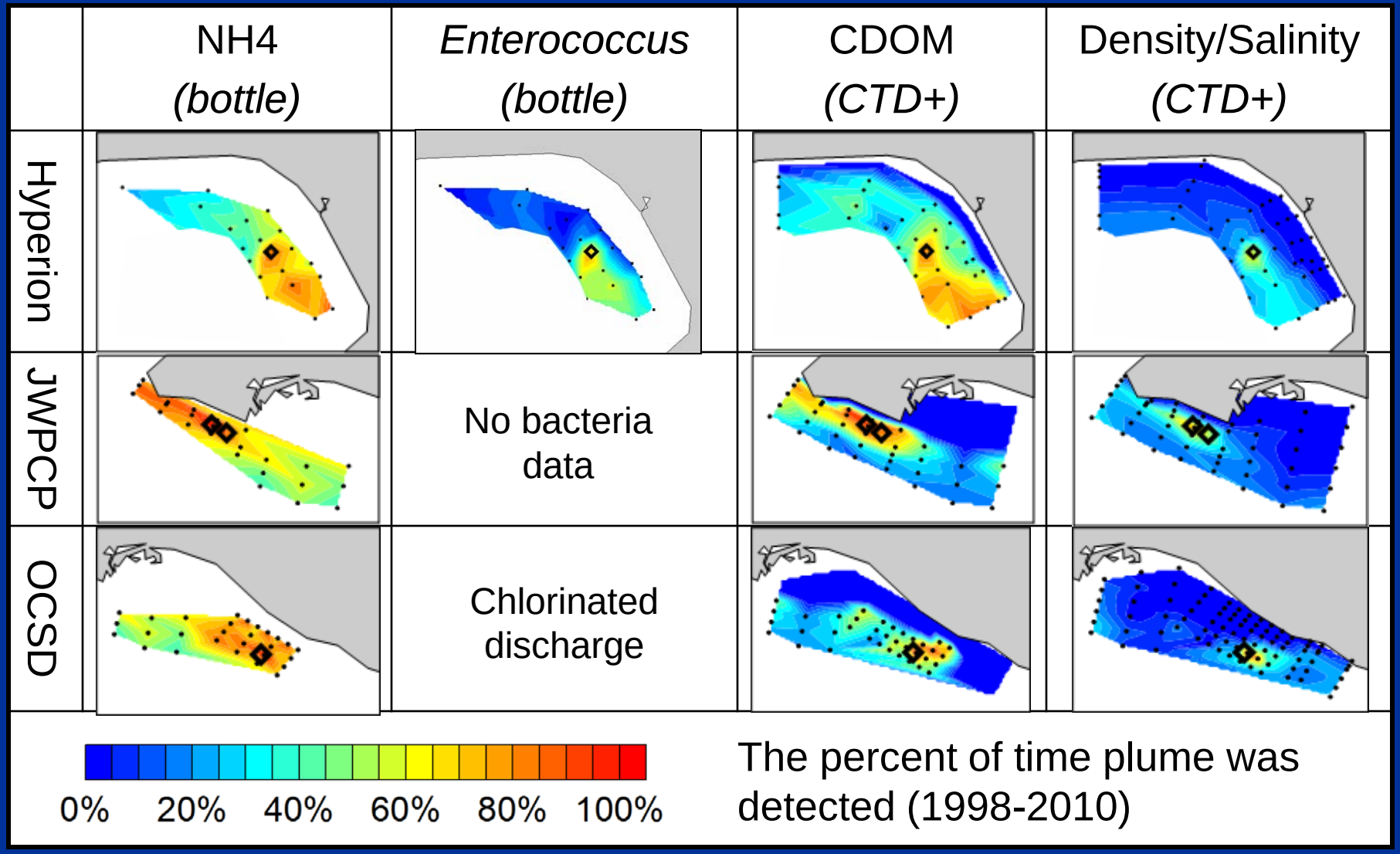
Effluent water is different in temperature, salinity, and density

CDOM Method



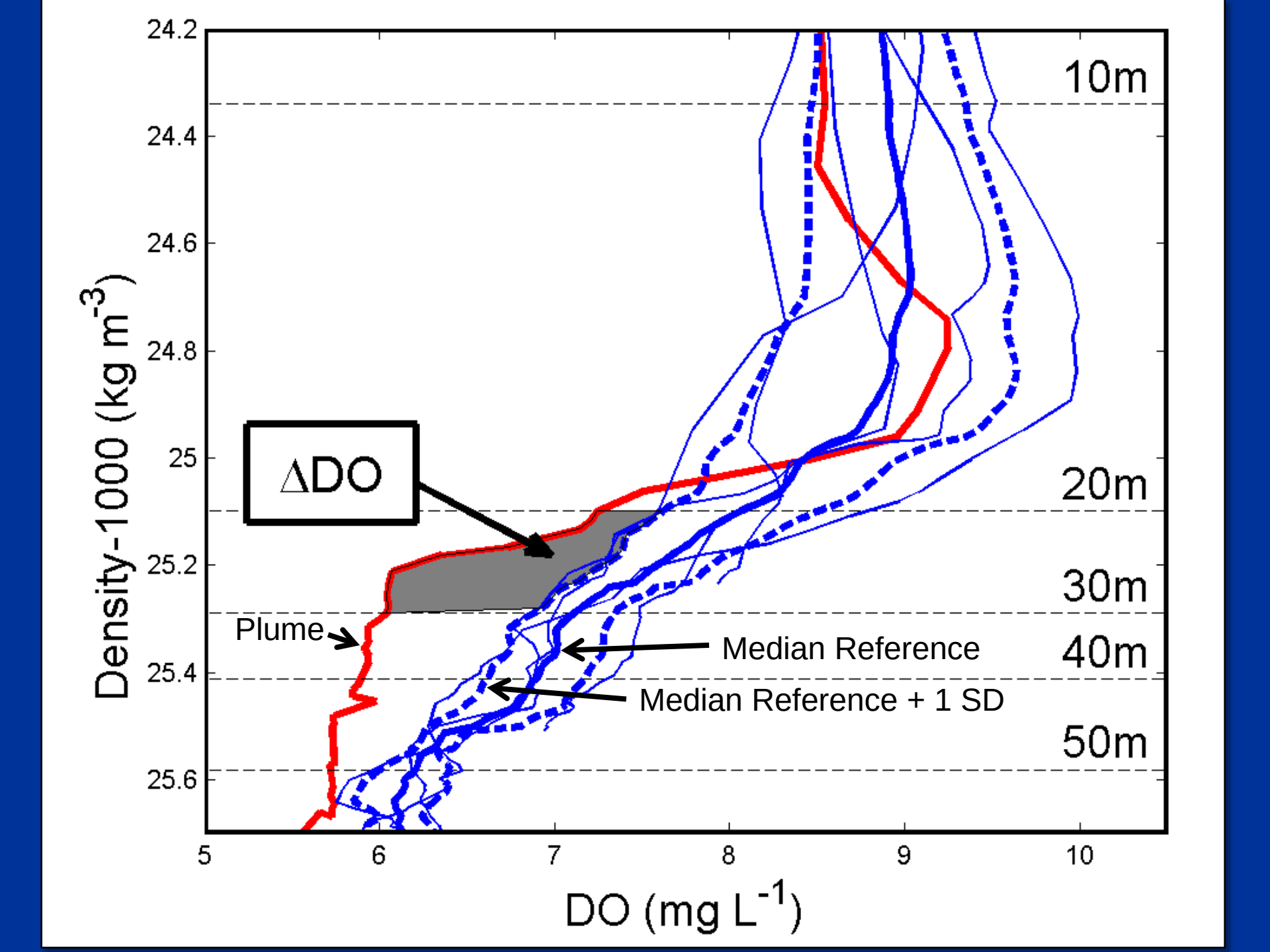
Effluent water contains high concentration of Colored Dissolved Organic Matter (CDOM)

Plumes detected by density and CDOM are reasonable alternatives to NH_4 and bacteria.



CHOICES FOR CONSTRUCTING A COMPLIANCE ASSESSMENT ALGORITHM

- **How many reference sites?**
- **How are reference sites selected?**
  - Fixed sites (upcurrent, based on plume direction)
  - Day-specific sites - based on the actual plume extension
    - Which plume definition?
- **Depth vs. density**
- **Vertical integration: How large are the depth/density layers that are being compared?**
- **What to compare from the reference sites?**
  - Mean or some property of the distribution

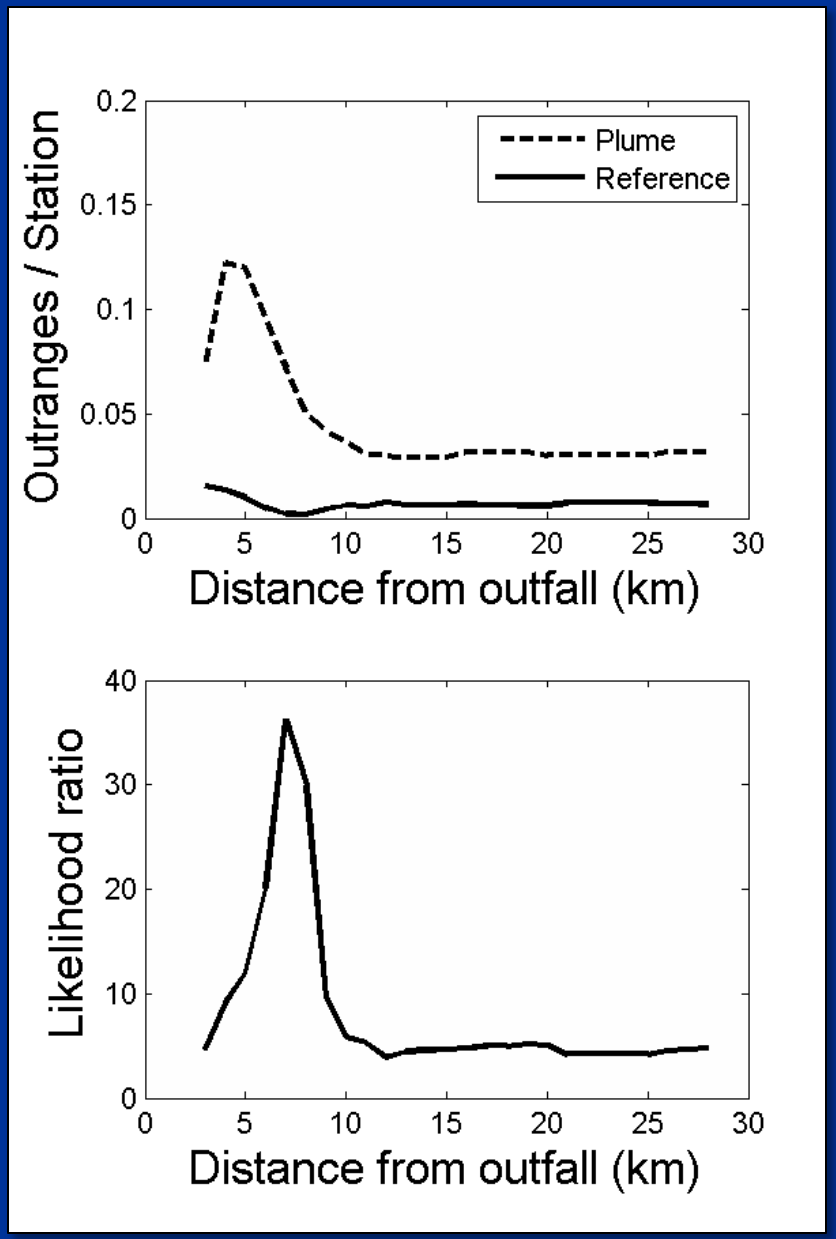

24.2
24.4
24.6
24.8
25
25.2
25.4
25.6
Density-1000 (kg m-3)
5
6
7
8
9
10
DO (mg L-1)
10m
20m
30m
40m
50m
ΔDO
Plume
Median Reference
Median Reference + 1 SD

A BALANCE

- **Goal is to balance two types of errors:**
  - **False alert:** Such as confusing natural variability with plume effect
  - **Missed alert:** Such as having reference sites to close to the outfall

- **Goal is to maximize sensitivity (1 – β) while minimizing false positive rate (α)**
  - "Likelihood ratio" = (1 – β) / α
  - Sensitivity — Estimate by comparing plume stations to reference stations
  - False positives — Estimate by comparing reference to reference

OPTIMAL REFERENCE ZONE SIZE



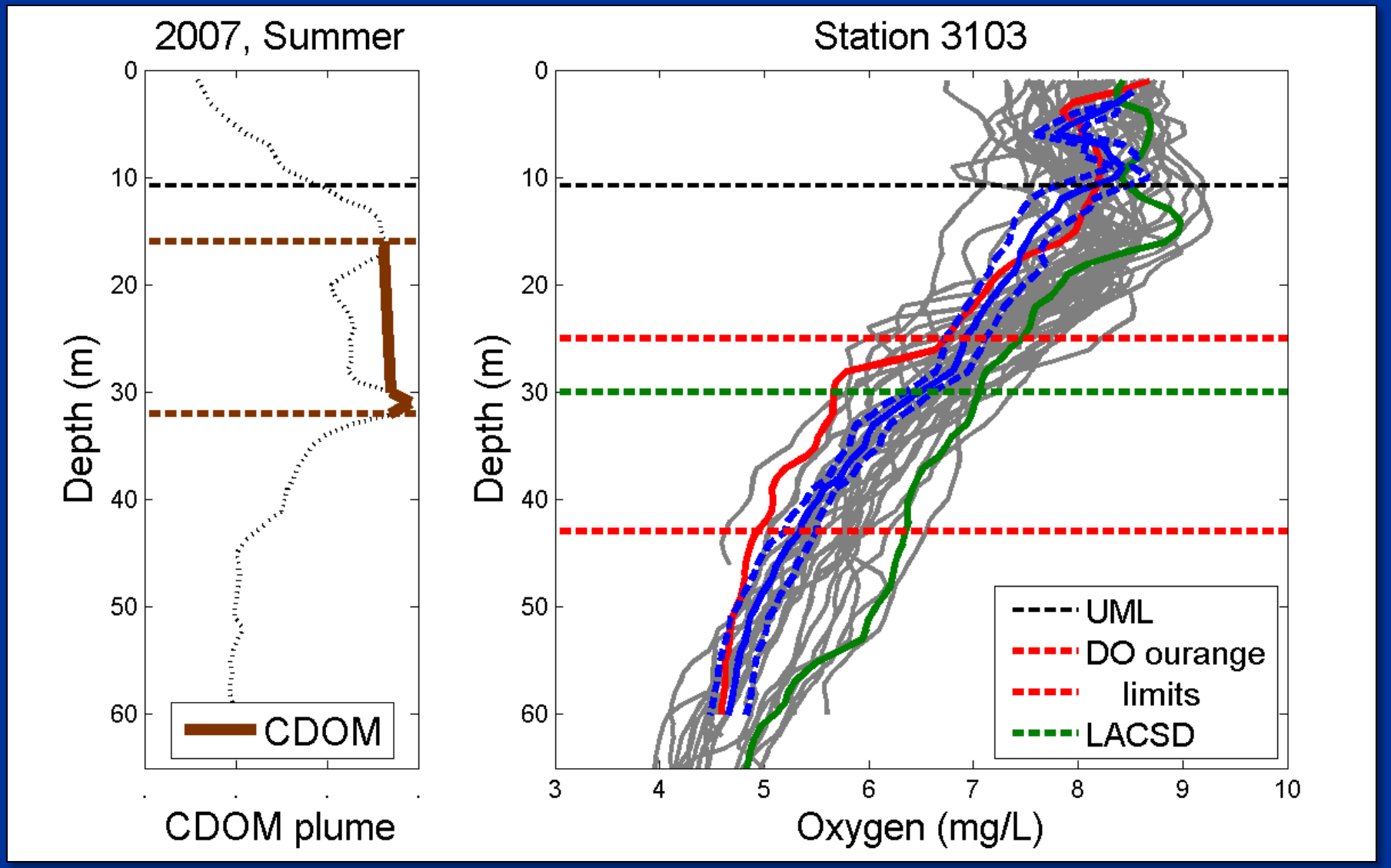
WE HAVE ANSWERS TO OUR QUESTIONS

- **How many reference sites?**
  - All non-plume stations within 7 km of the outfall
- **How are reference sites selected?**
  - Day-specific sites based on “old” plume definition
- **Depth vs. density**
  - Density
- **Vertical integration: How large are the depth/density layers that are being compared?**
  - 18-m layers
- **What to compare from the reference sites?**
  - Mean minus 1.3 standard deviations

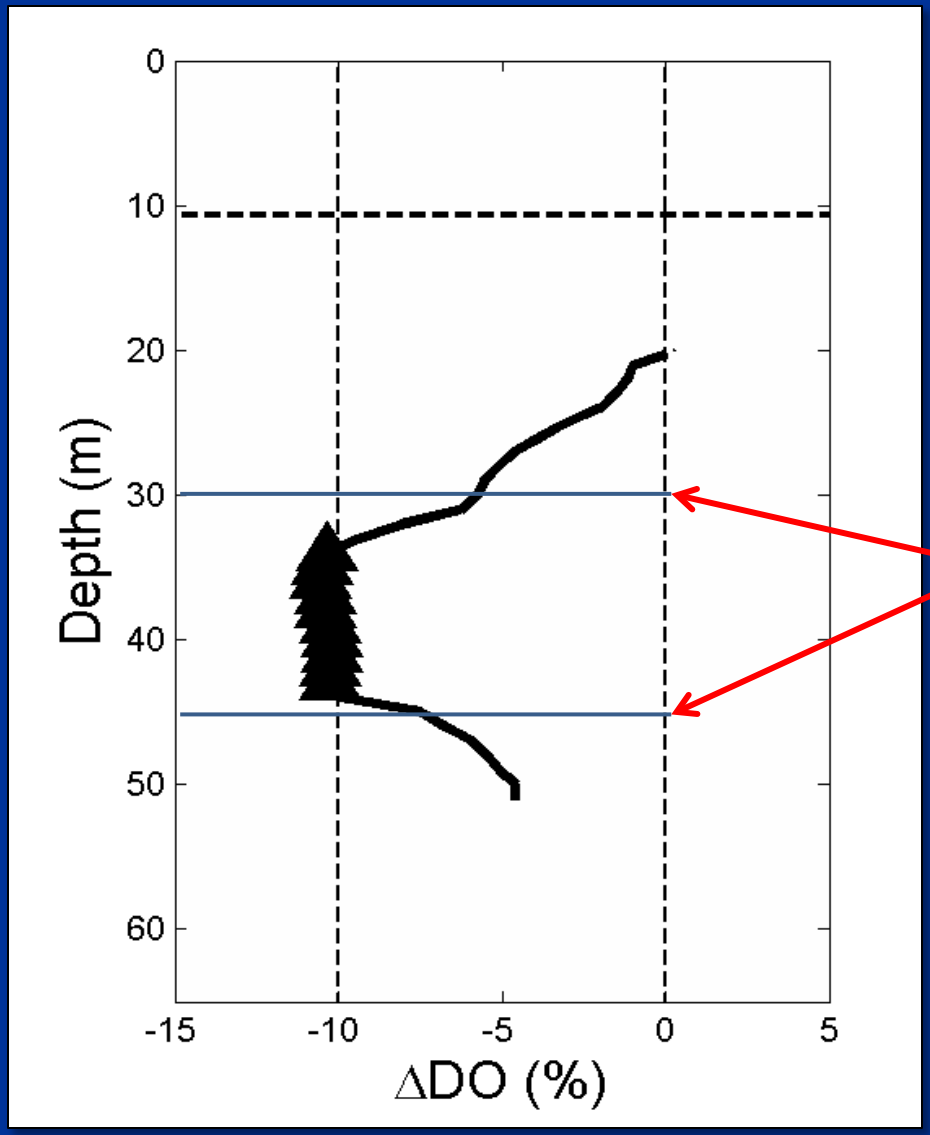
LAUGH TEST

- **How did the number of sites identified by algorithm compare with that identified in agency reports?**
- **LACSD: 13 outranges between 2004 and 2010**
  - SCCWRP algorithm: 15 outranges
- **On first glance, this is great**
  - On closer look, not all of these stations were held in common
- **Biggest differences were due to reference site selection and depth layer**

REFERENCE STATION SELECTION



DEPTH LAYER SELECTION



NEXT STEPS

- **Develop a relationship between outranges and water quality violations**
  - They are not identical
- **Expand algorithm to other parameters**
  - pH
  - Water clarity
  - Nutrient effects

DEVELOPING A RELATIONSHIP BETWEEN OUTRANGES AND WATER QUALITY VIOLATIONS

- **Data certainty**
  - Instrument error?
  - Truly a plume site?
- **How many outranges constitute a compliance problem?**
  - We do get some reference site outranges
- **Are the outranges due to other factors?**
  - Surface runoff
  - Upwelling
  - Chimney effect

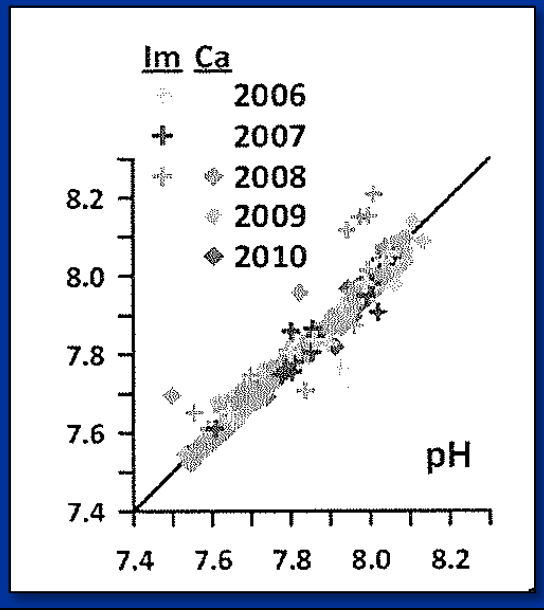
OTHER WATER QUALITY PARAMETERS PRESENT INTERESTING NUANCES

- **Ocean Plan standard for dissolved oxygen is “not more than 10%”**
- **pH is “not more than 0.2 units”**
  - Switch from percentage to absolute value
- **Water clarity is “not significantly reduced”**
  - A statistical test

ARE pH MEASUREMENTS ACCURATE?

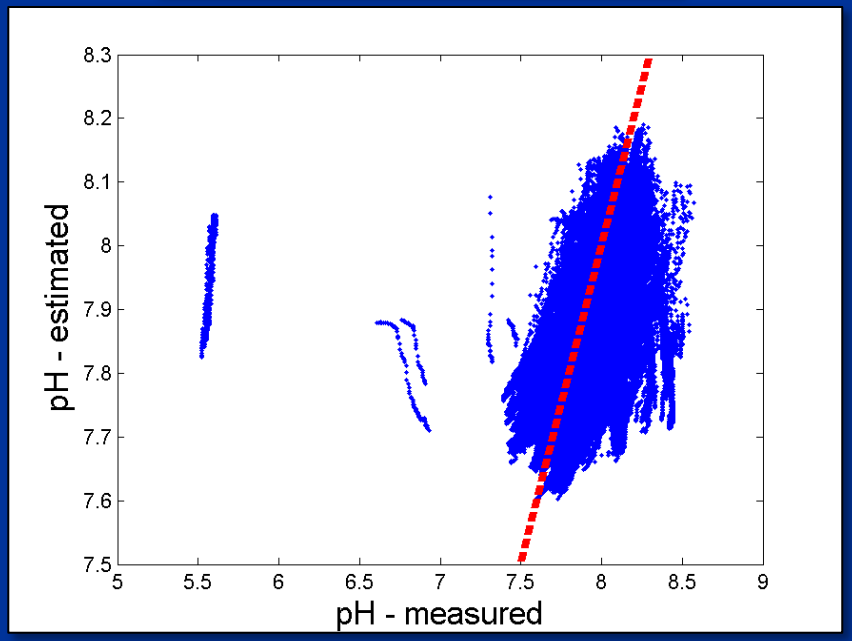
- **CalCOFI data has a good correlation between pH and DO for CalCOFI data**

  $R^2 = 0.980$

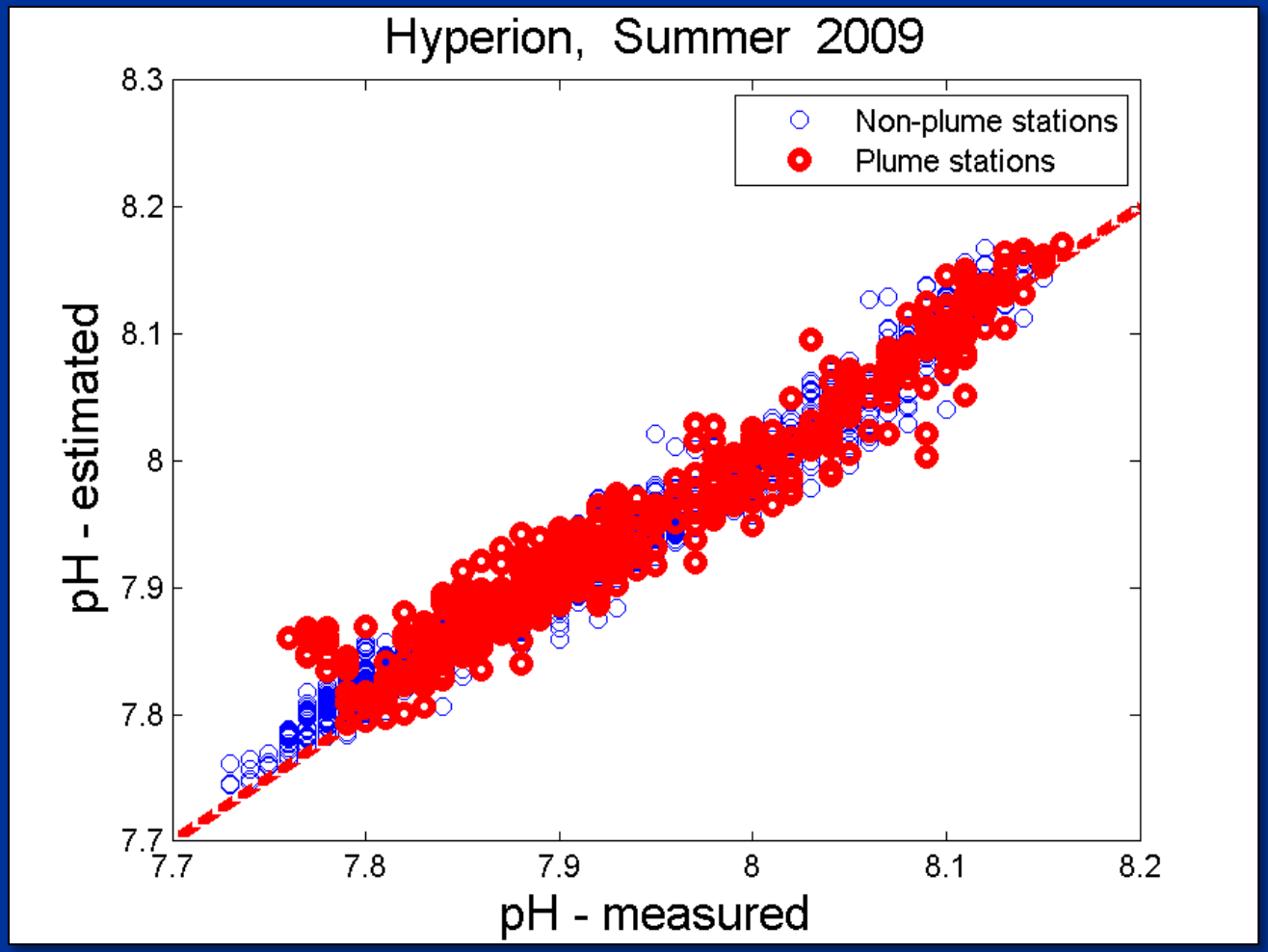


- **Much poorer relationship for POTW data**

  $R^2 = 0.249$



THE RELATIONSHIP WORKED FOR SOME STATIONS

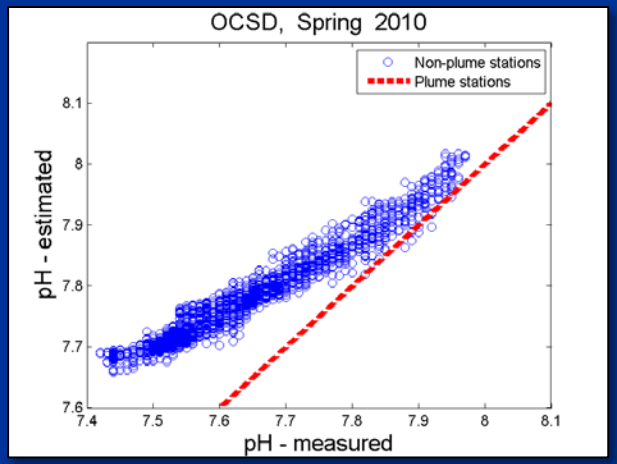


Example:

Hyperion
Summer 2009
$R^2 = 0.963$
RMSE = 0.0188

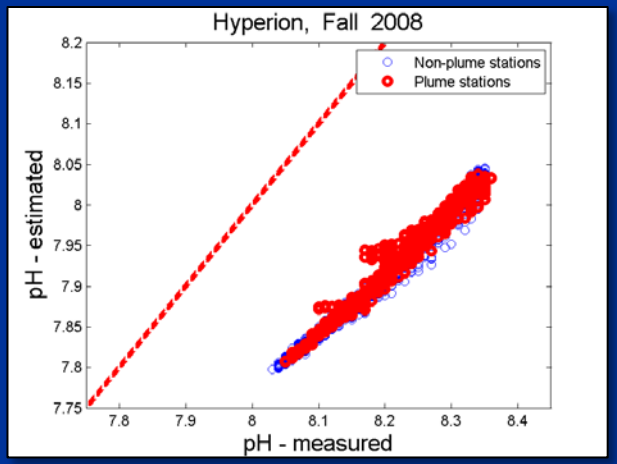
CORRELATED, BUT NOT A GOOD RELATIONSHIP

Above the 1:1 line



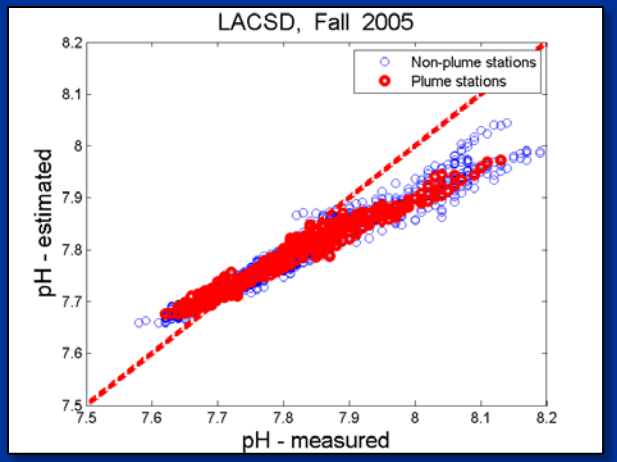
OCSD
Spring 2010
R^2 = 0.953
RMSE = 0.0170

Below the 1:1 line



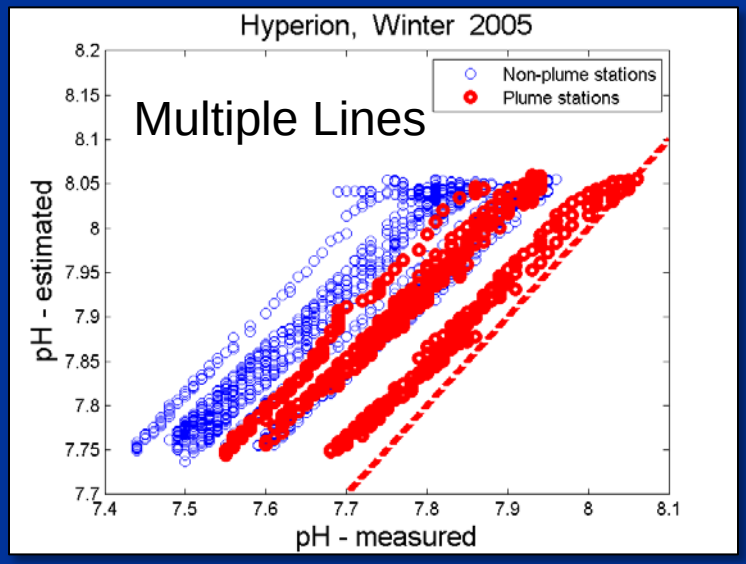
Hyperion
Fall 2008
R^2 = 0.978
RMSE = 0.0097

Across the 1:1 line

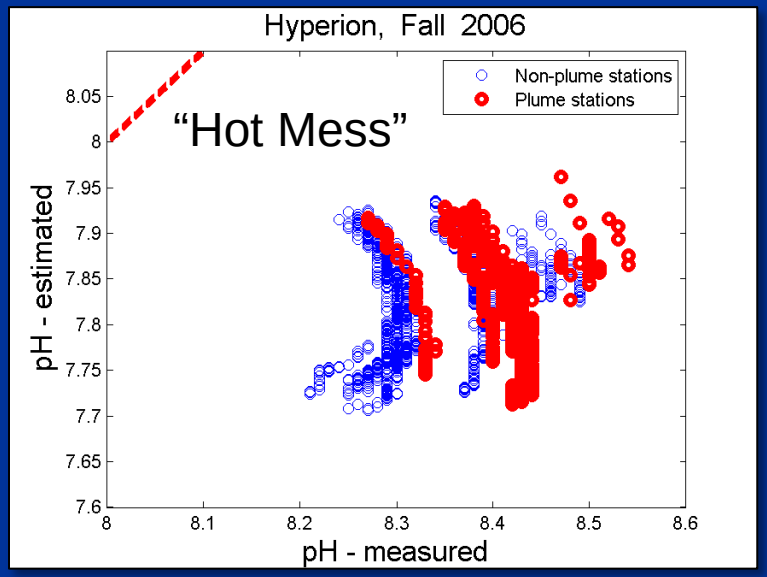


LACSD
Fall 2005
R^2 = 0.966
RMSE = 0.0142

WHAT????

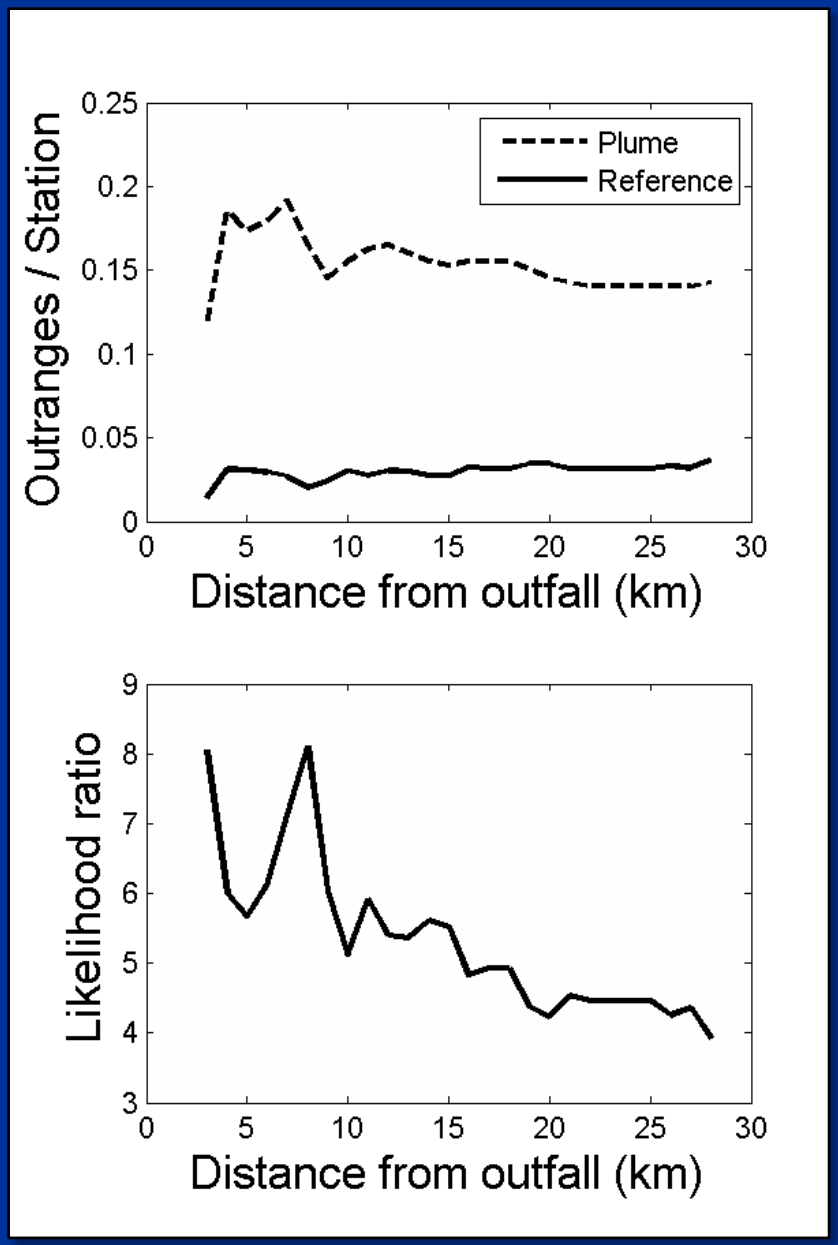


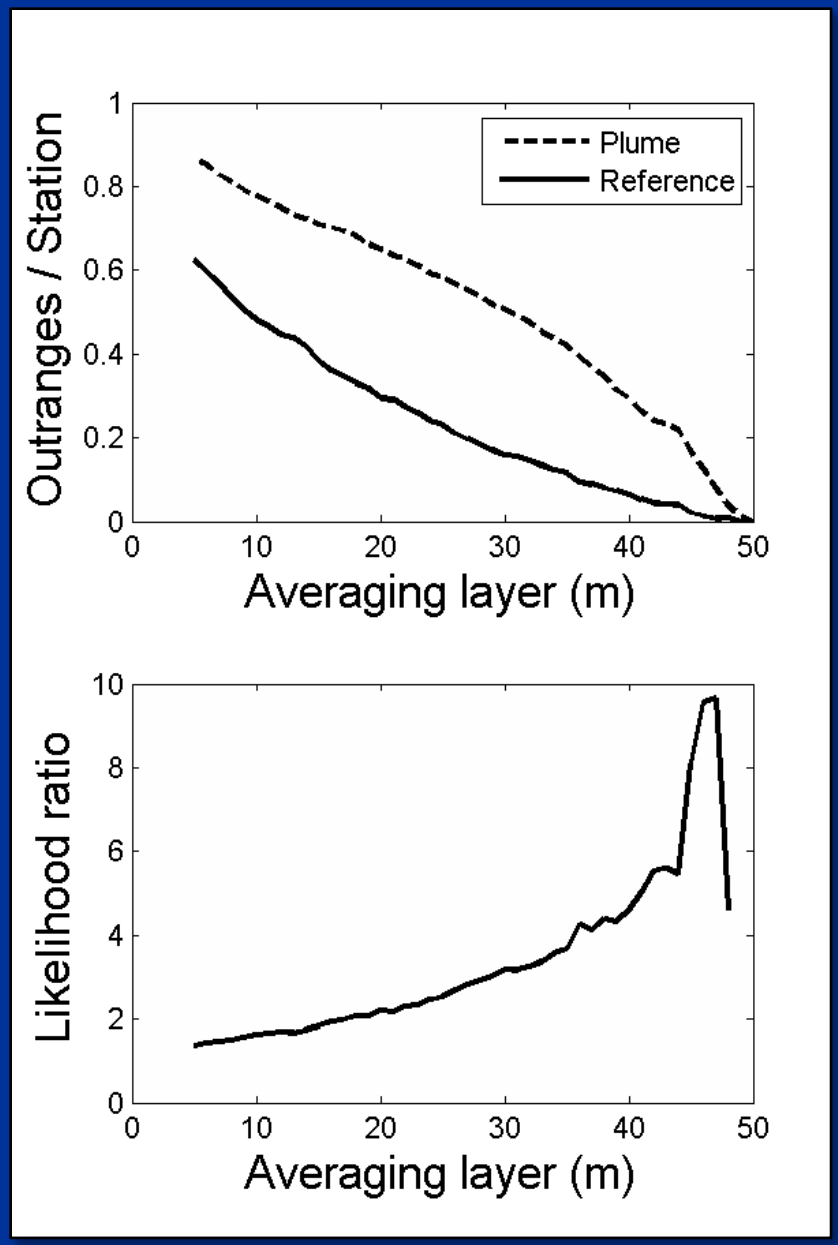
Hyperion
Winter 2005
$R^2 = 0.709$
RMSE = 0.0543



Hyperion
Fall 2006
$R^2 = 0.002$
RMSE = 0.0575

TRANSMISSOMETRY





OCEAN PLAN NUTRIENT STANDARD

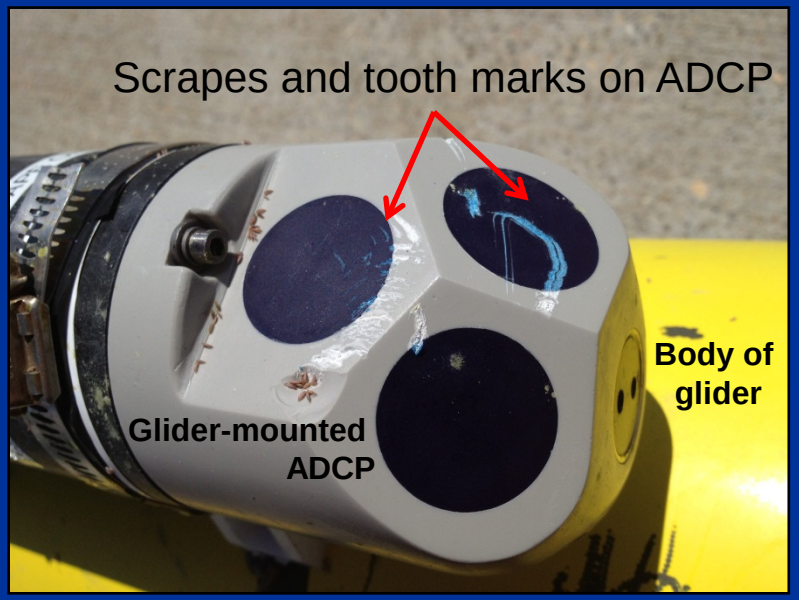
- **“Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota.”**
- **What is meant by “objectionable growth” and “degradation”?**
  - Does it include the acidification and hypoxia issues we have alerted you to?
- **What is the appropriate reference condition?**
  - Nutrient effects take weeks to play out, making it difficult to assess by spatial comparison
- **This is the next phase for the Water Quality Compliance Committee**

ARE GLIDERS AN ALTERNATIVE?

- **Five years ago, we did a side-by-side comparison of CTDs and gliders at SOCWA**
  - CTDs did not find the plume, gliders did
- **Commission response: Great idea, but we are not ready**
  - They don't measure ammonia, which is how we define plume location
  - Requires 24-hour tending, which is challenging for our operation
  - Too much opportunity for instrument failure
- **We have been working to address these concerns**

YOU WERE RIGHT ABOUT THEM BEING RESEARCH TOOLS

- **Operational snafus**
  - Ballast pump leak caused ours to get caught in the surf - $30K repair bill
  - USC glider hit by a boat
  - Santa Cruz glider sunk
  - UCSB glider bit by a shark



- **24-hour operation is a pain**
  - Frequent emails
  - Need for course corrections
  - Need battery replacement after 26 days

- **The manufacturer is less than fully supportive**

WHERE DO WE GO FROM HERE?

- **We are in good shape for a dissolved oxygen algorithm**
- **The pH data are problematic**
  - They don’t allow you to address whether Ocean Plan standards are being met
  - There are no commercially available alternative profiling instruments
  - We are using Bight ’13 to test some new equipment
- **Transmissometry is the biggest concern**
  - The problem is in the regulatory language
  - Consider an Ocean Plan amendment!
- **Nutrients is our next step**