Causal Analysis and Probability Surveys: Examples

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11 April 2007

Acknowledgements

Steve Hedtke
Susan Cormier
Sue Norton
Glenn Suter
EMAP-Surface Waters
EMAP-Coastal

Presentation Outline

- What is causal analysis?
- Hill's elements of causality
- Stressor Identification Guidance
- Examples
- Take home message

What is causal analysis?

Identify what is causing an effect.

Difficult, if not impossible, to prove cause-effect for natural resources.

What most people consider “proof” is really convincing evidence (for them).

Easier to disprove cause-effect

Sir Bradford Hill's Elements of Causality

Hill, 1965, Proc Roy Soc Med, 58:285-300

1, Strength of Association

2, Consistency

3. Specificity of Association

4. Temporality

5. Biological Gradient

6. Plausibility

7. Coherence

8. Experiment

9. Analogy

Stressor Identification Guidance Document

EPA-822-B-00-025)

- Identify alternative candidate causes
- Logically eliminate what you can
- Diagnose when you can
- Use strength of evidence when you can

- Do not claim proof of causation
- Identify the most likely cause
- Use a consistent process
- Document the evidence and inferences

Criteria to Judge Evidence

- Time order SDI
  - Strength SDI
  - Consistency SDI– replication
  - Coherence SDI– agrees with fact & theory
  - Specificity SDI – occurrence of one with other

** Beware of publication bias **

Aquatic Examples

EMAP data

Eutrophication in Northeast Lakes

EMAP sampling of lakes in northeast in 1991-94

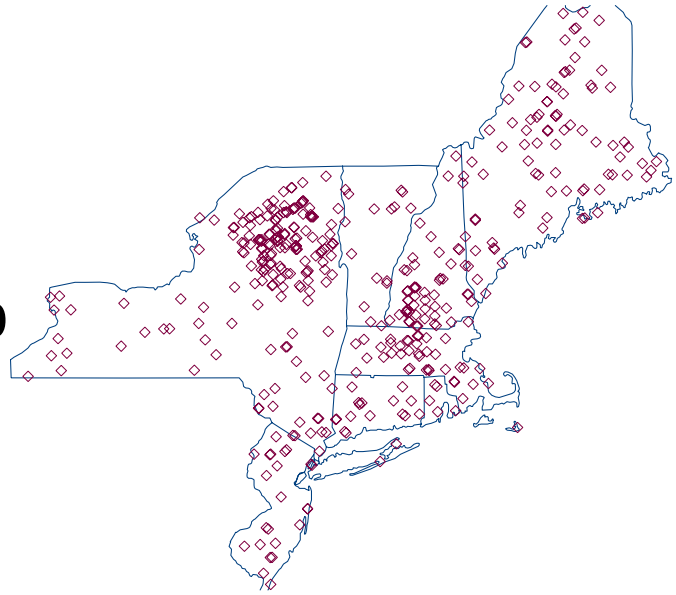
Response variable – chlorophyll a

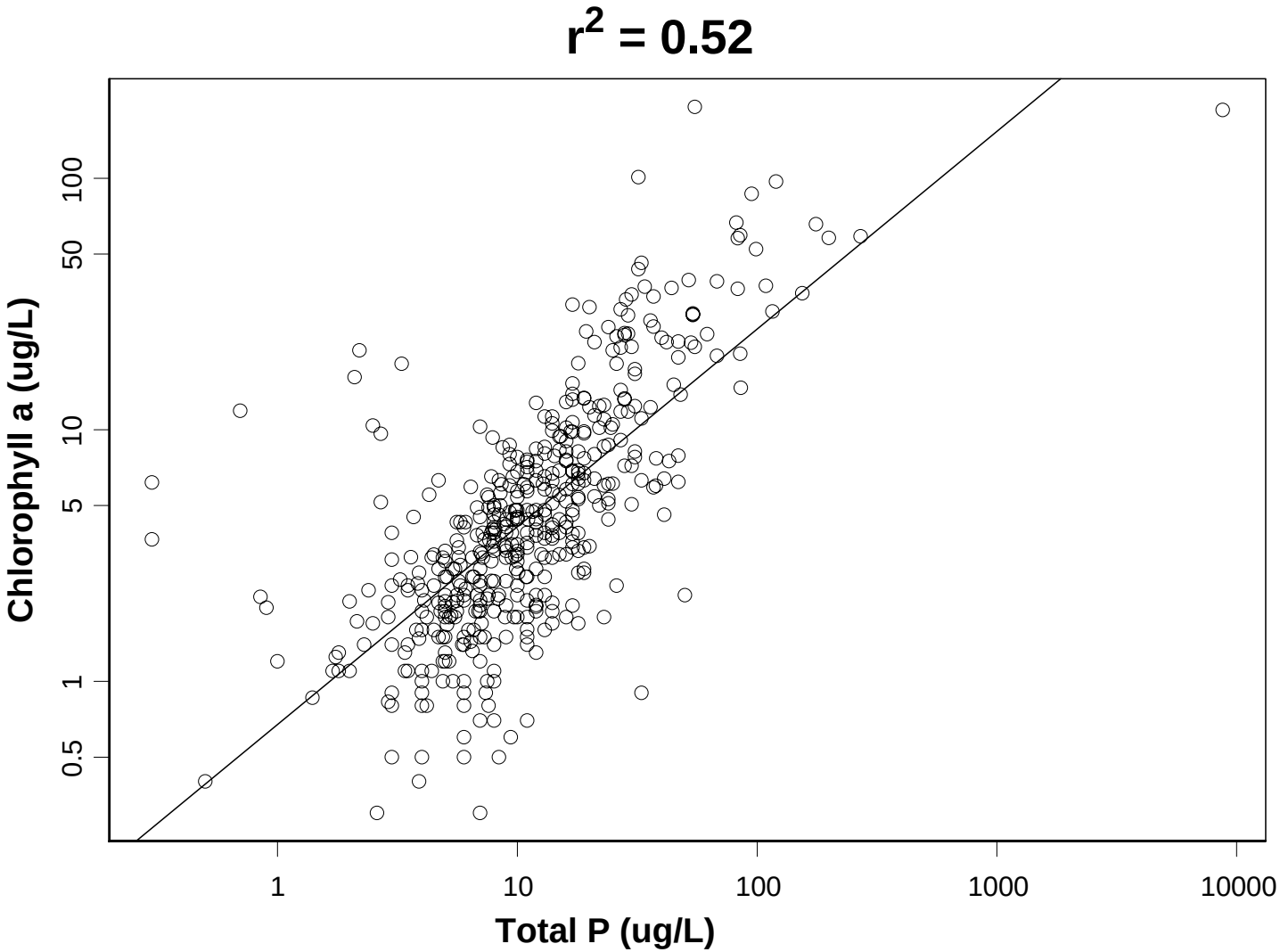
Define eutrophy as chla > 30 ug/L

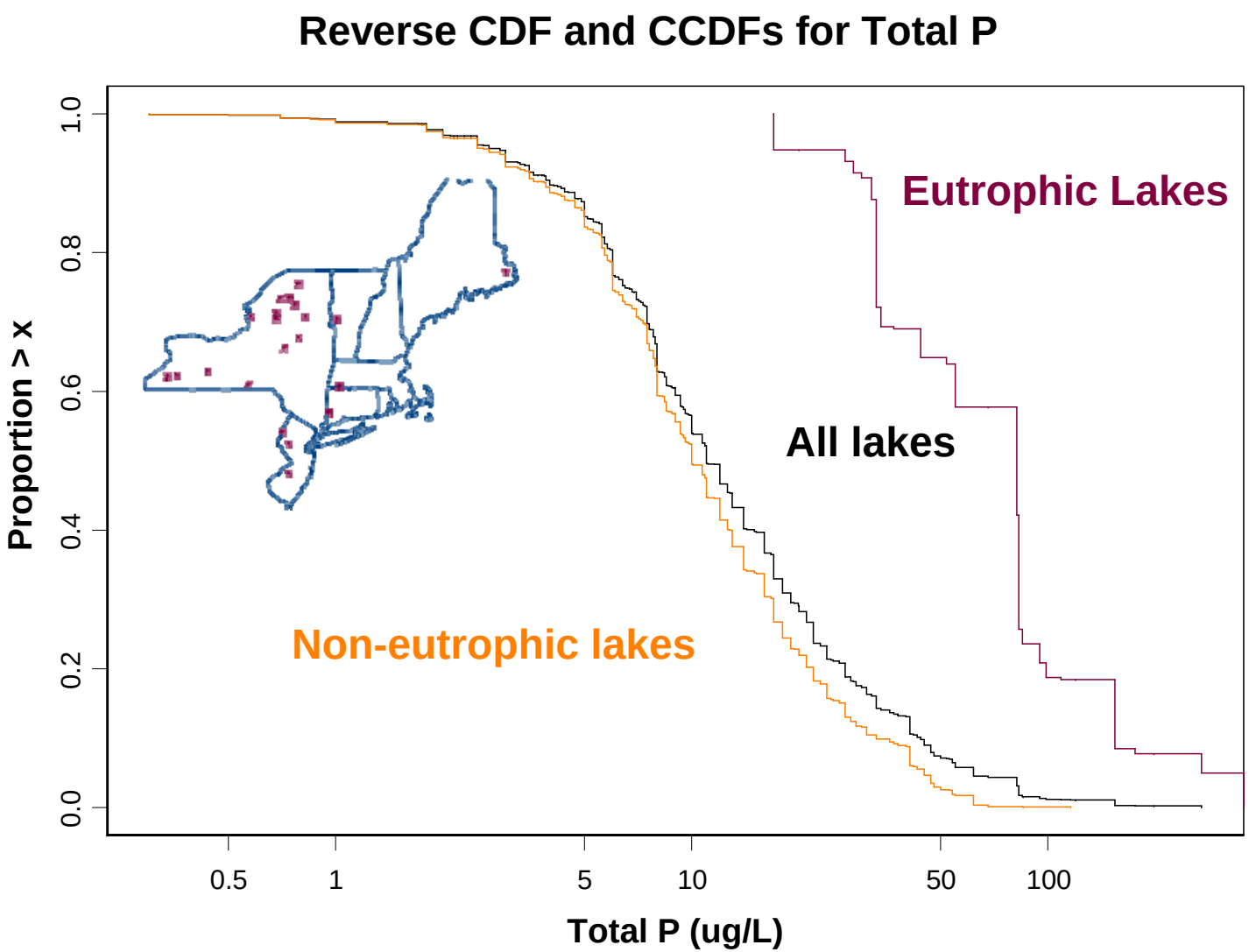
Threshold parameter – phosphorus

333 lakes sampled

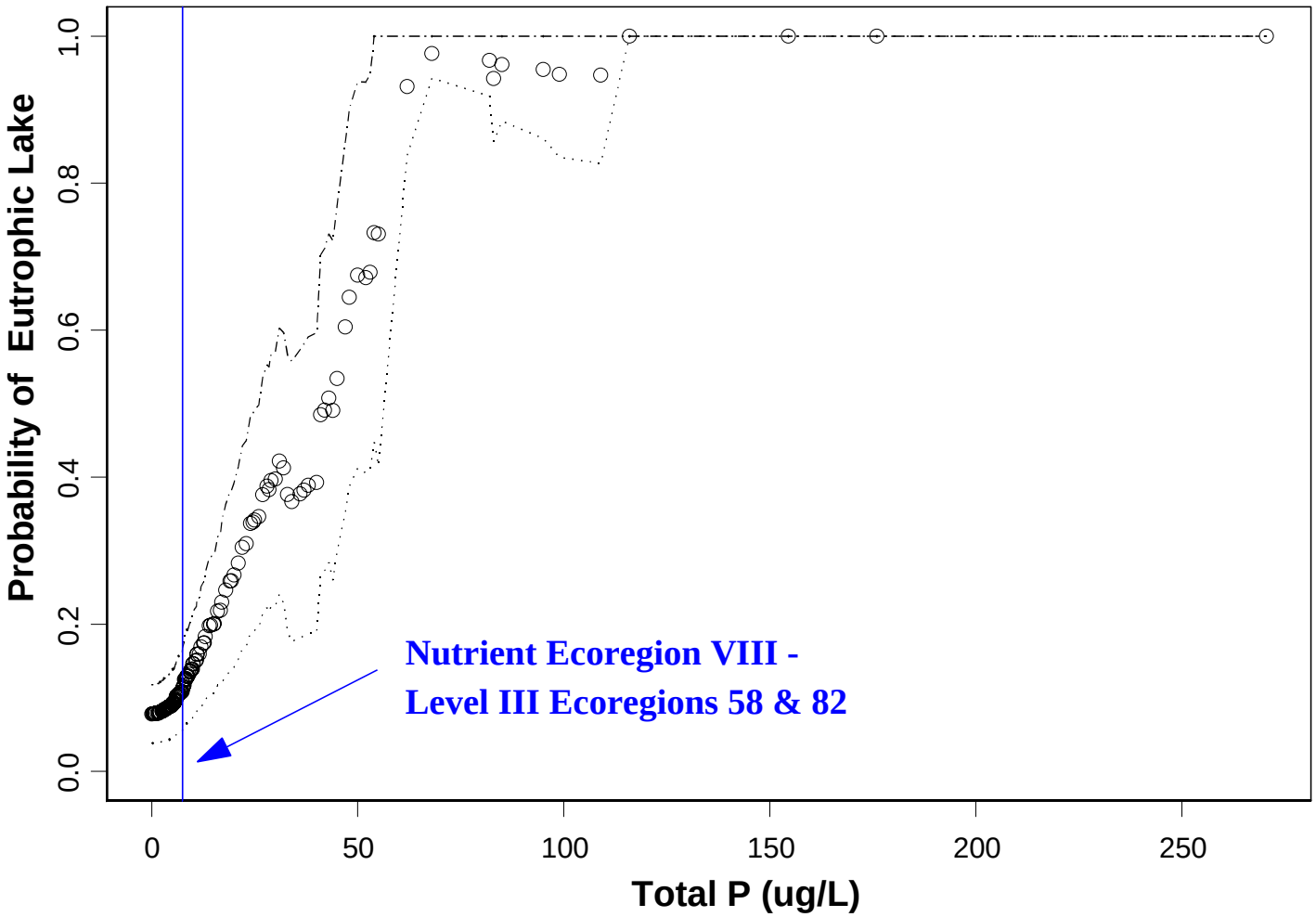
Data available at www.epa.gov/emap







Conditional Probability for Exceeding Total Phosphorus Level



Mid-Atlantic EMAP Streams

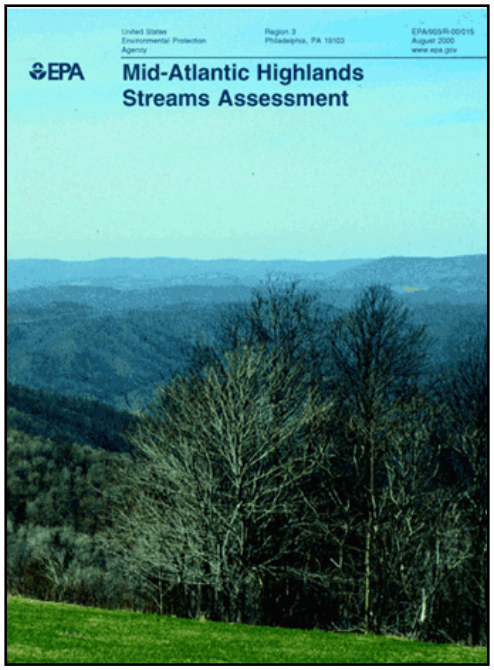
Status of biological resources – EMAP indicators

Sampling with EMAP probability design

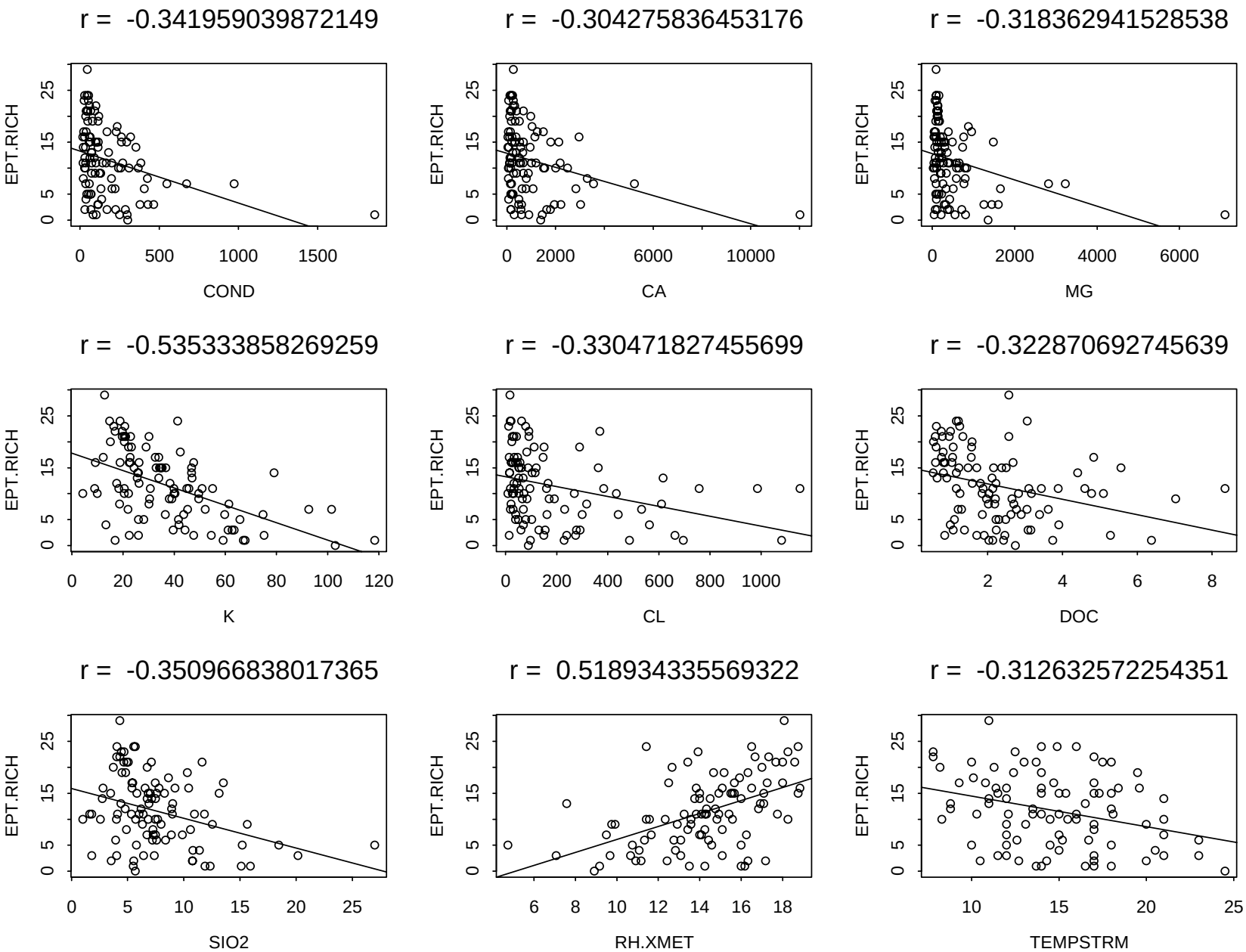
380 stream segments sampled in 1993-96

1st to 3rd order wadable streams

Data available at www.epa.gov/emap

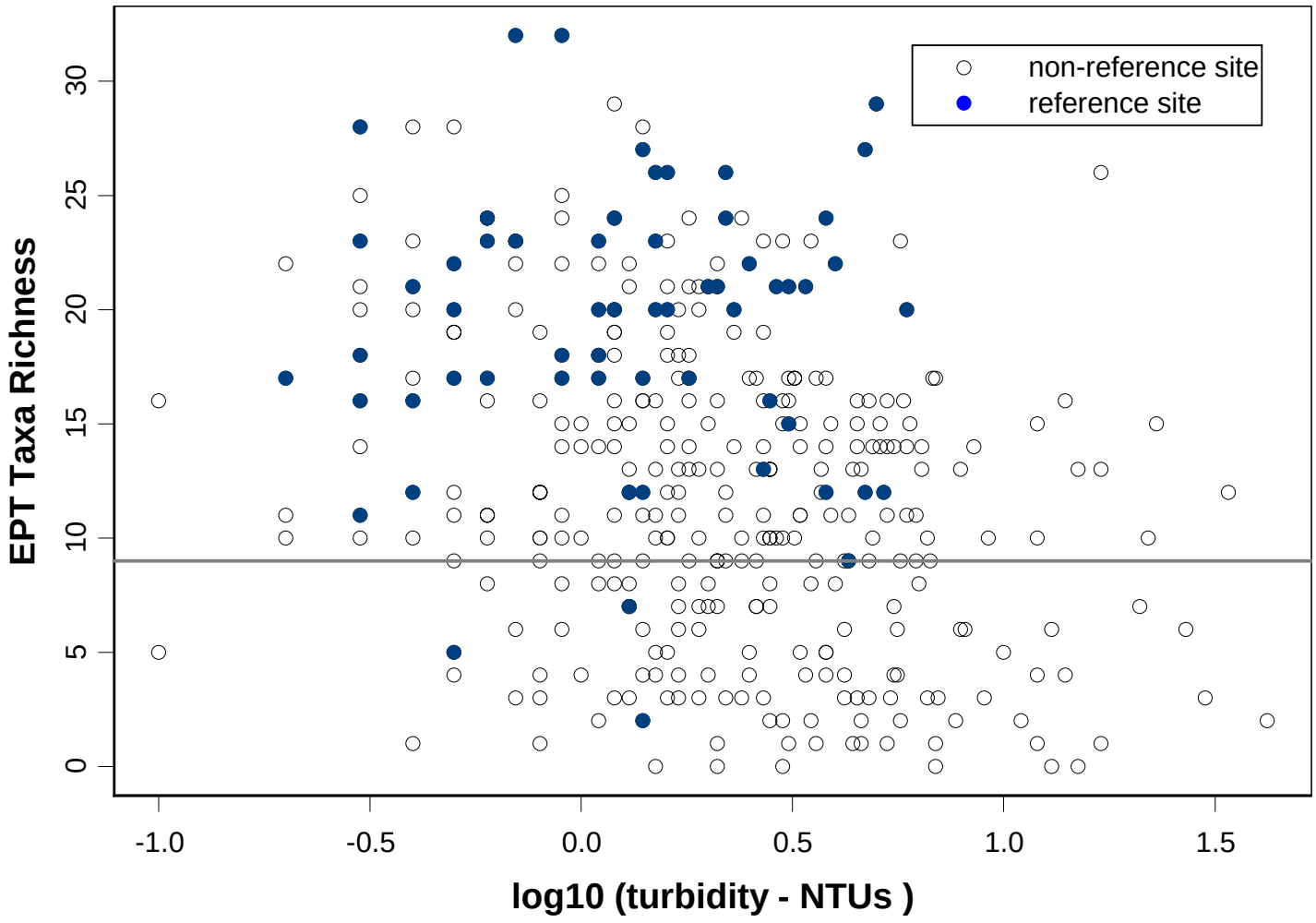


Scatter plots (EPT taxa richness vs. stressors) and correlation coefficients



How about log x-scale plots?

example-MAIA-013.sgr

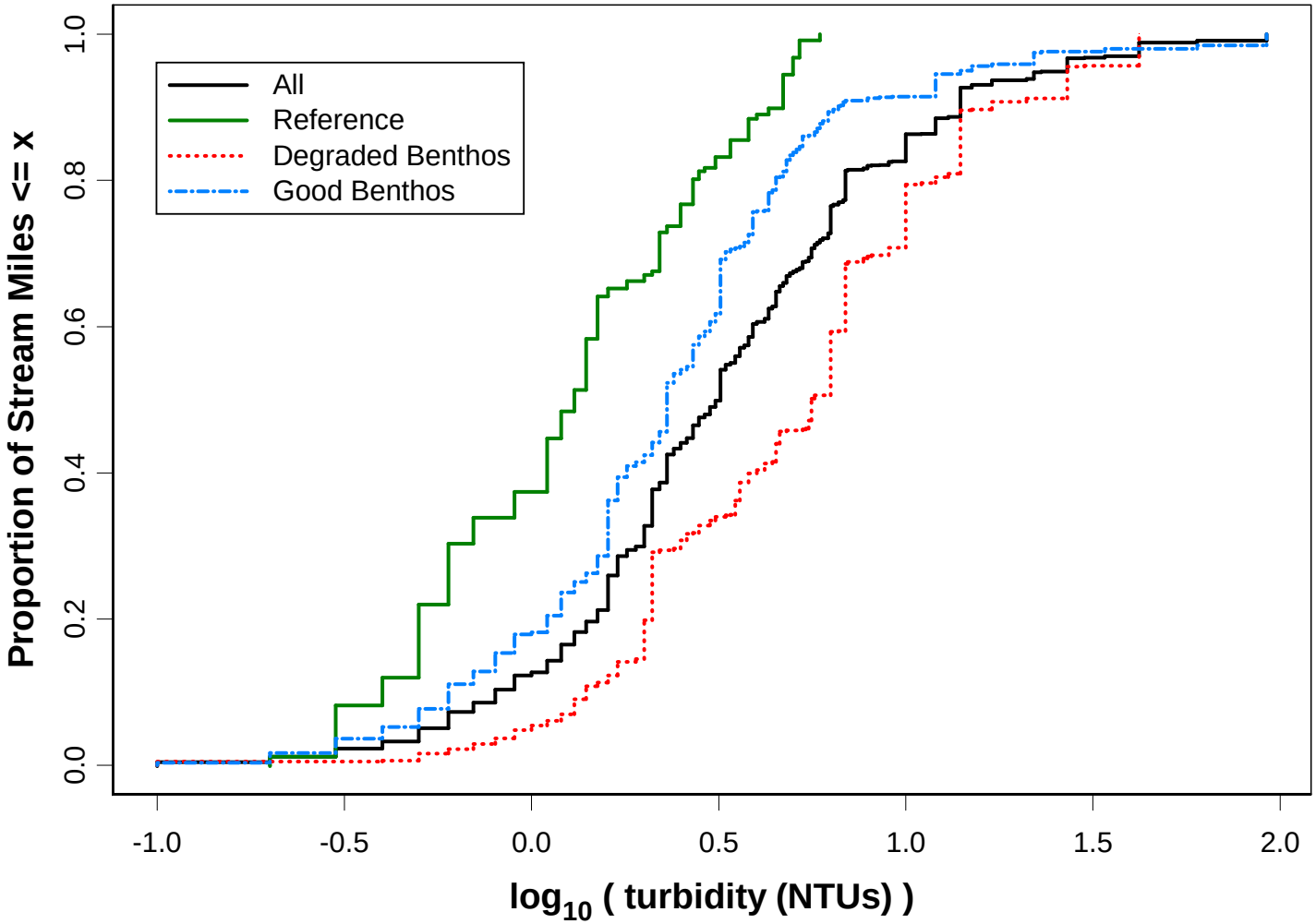


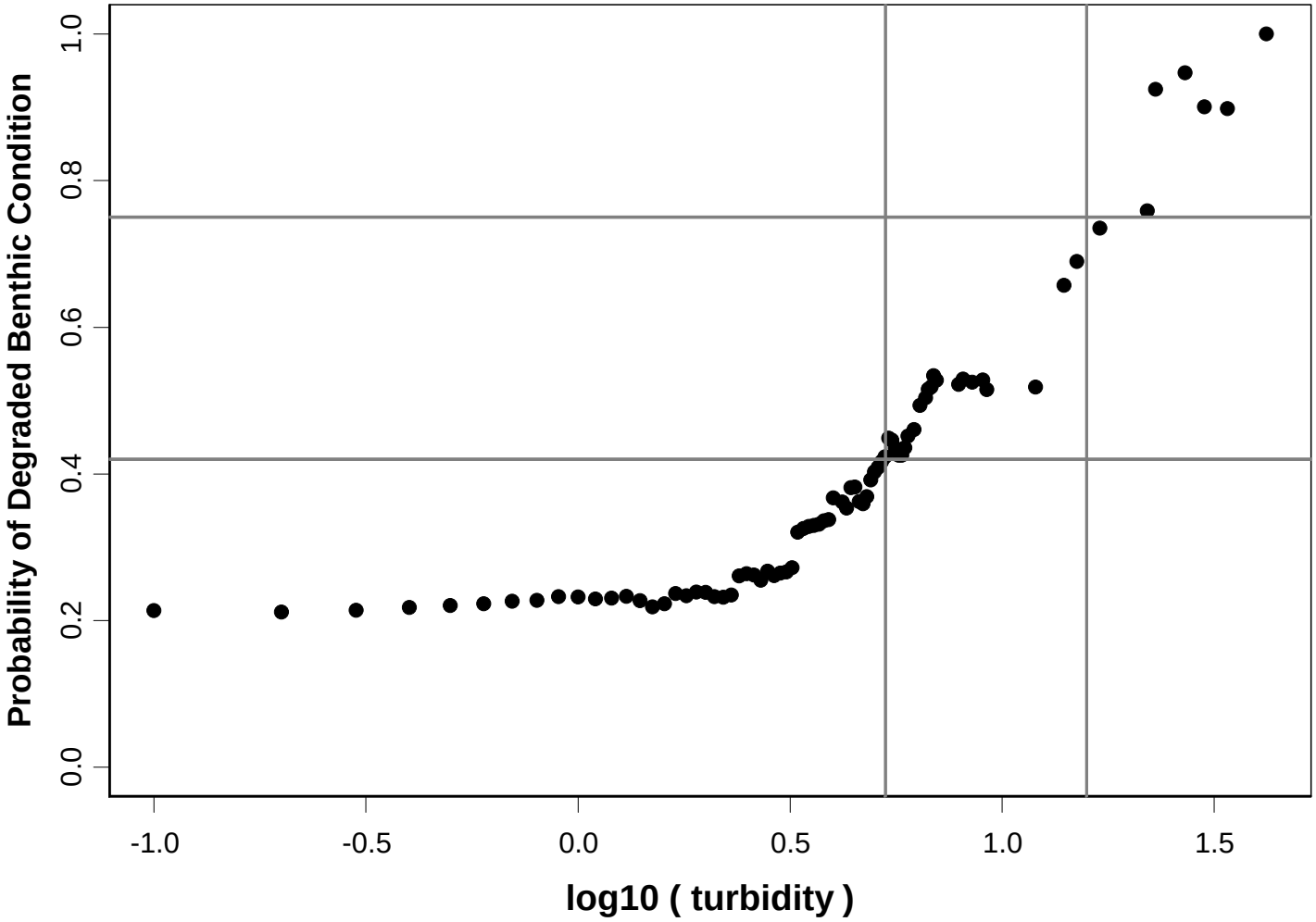
Distribution of Turbidity Values Per Stream Mile

1993-96 data

Cumulative Distribution Functions (CDFs)

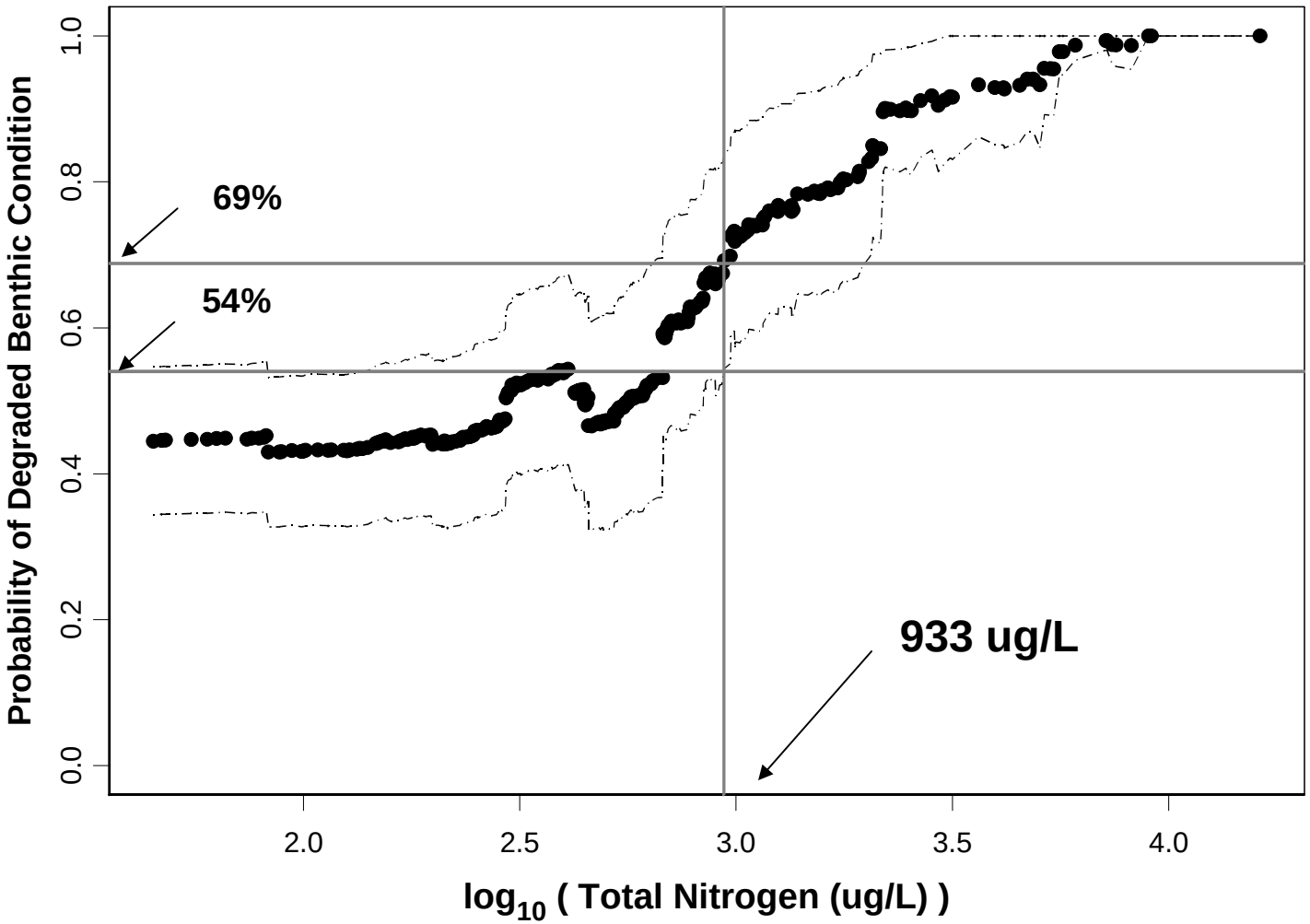
Conditional Cumulative Distribution Functions (CCDFs)





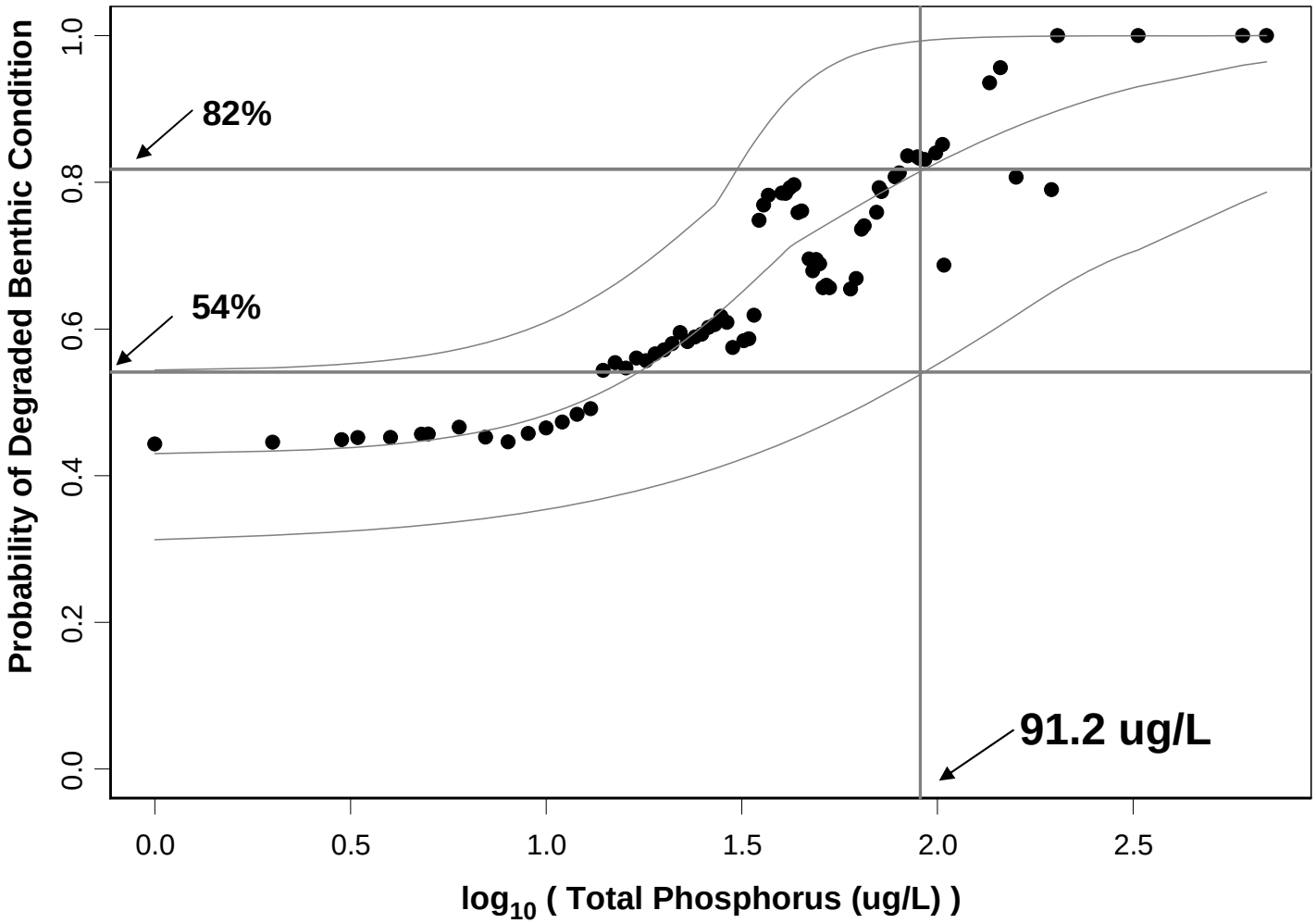
Conditional Probability Analysis for Total Nitrogen

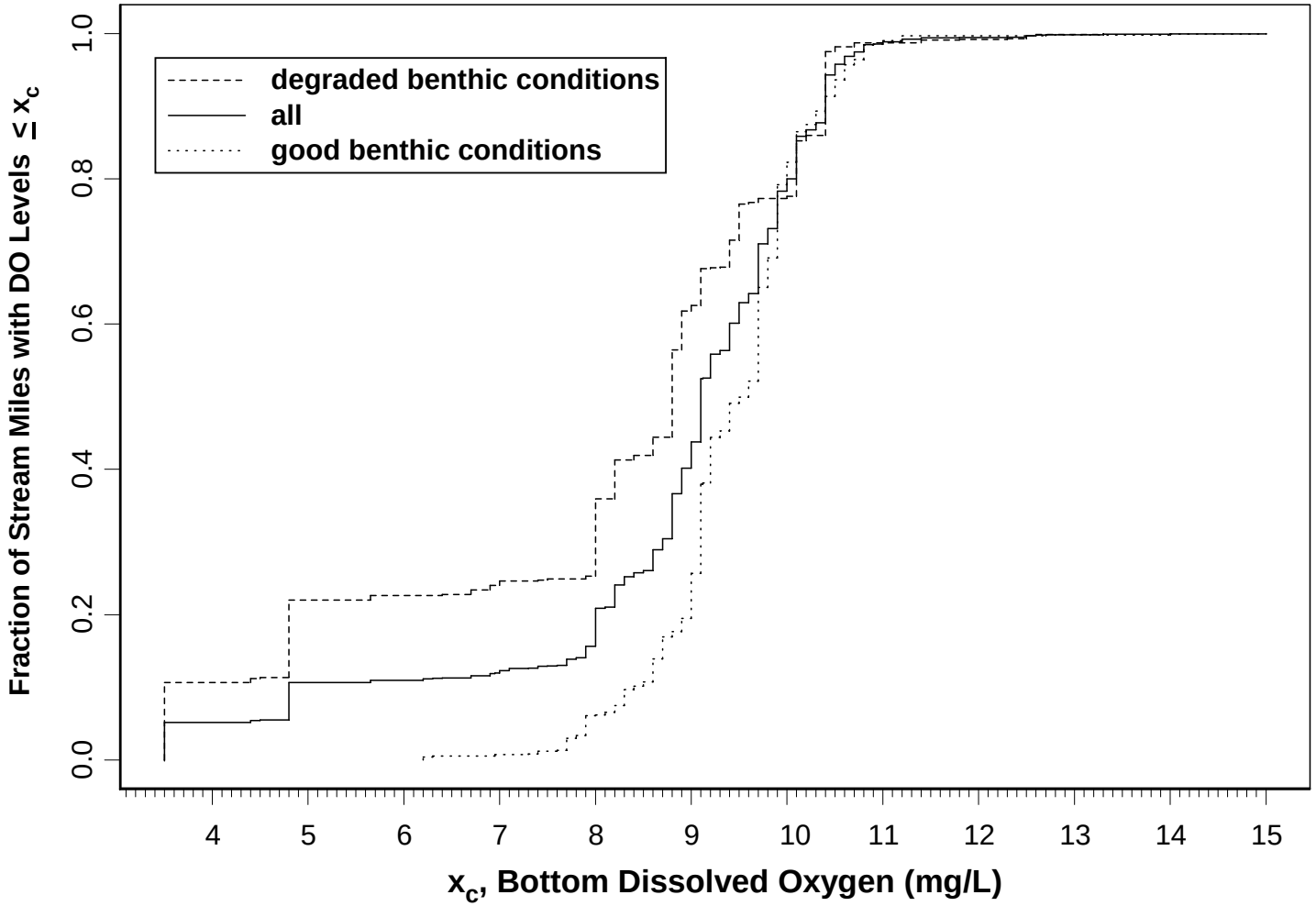
Degraded Benthic Condition for EPT Taxa < 9



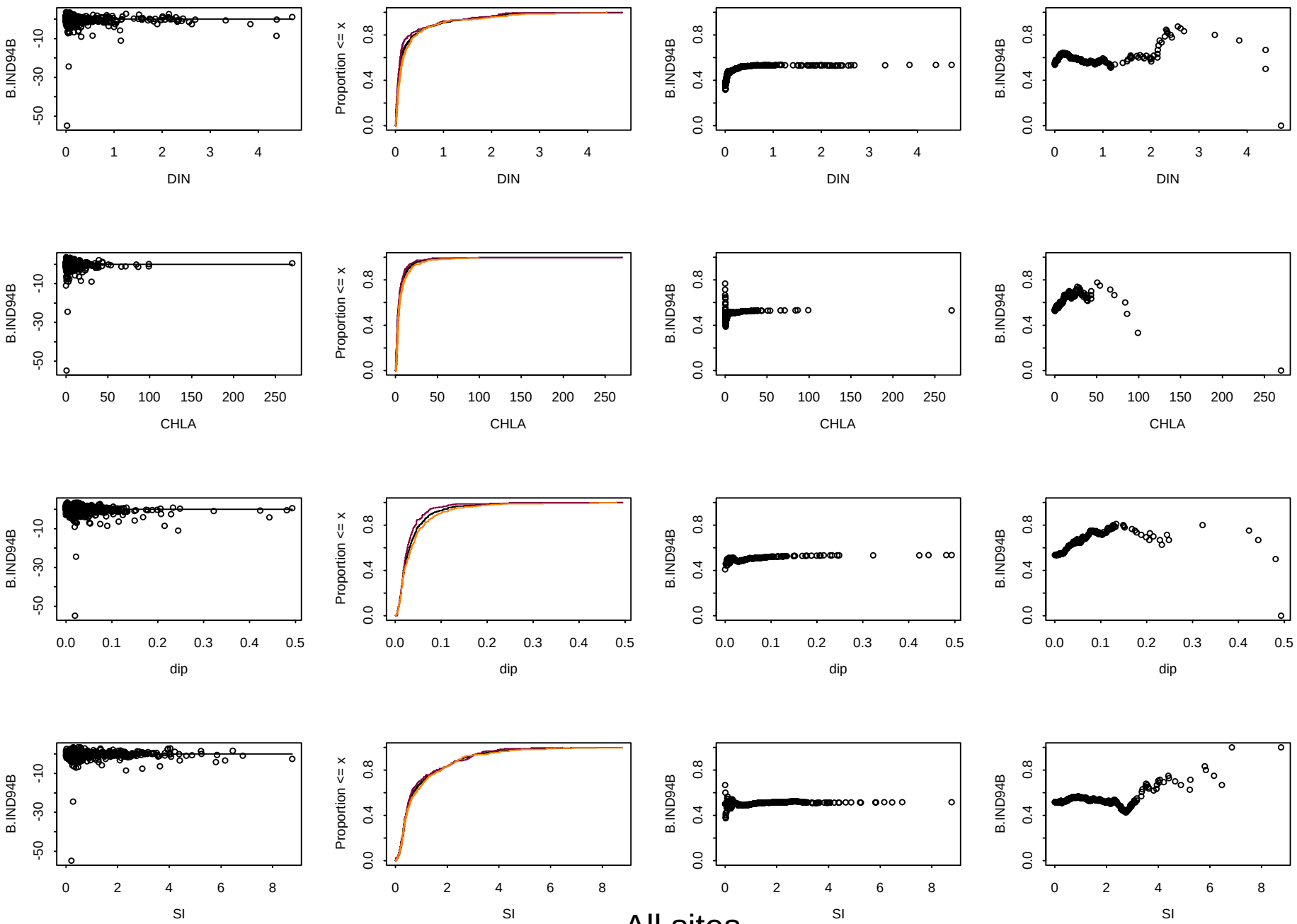
Conditional Probability Analysis for Total Phosphorus

Degraded Benthic Condition for EPT Taxa < 9

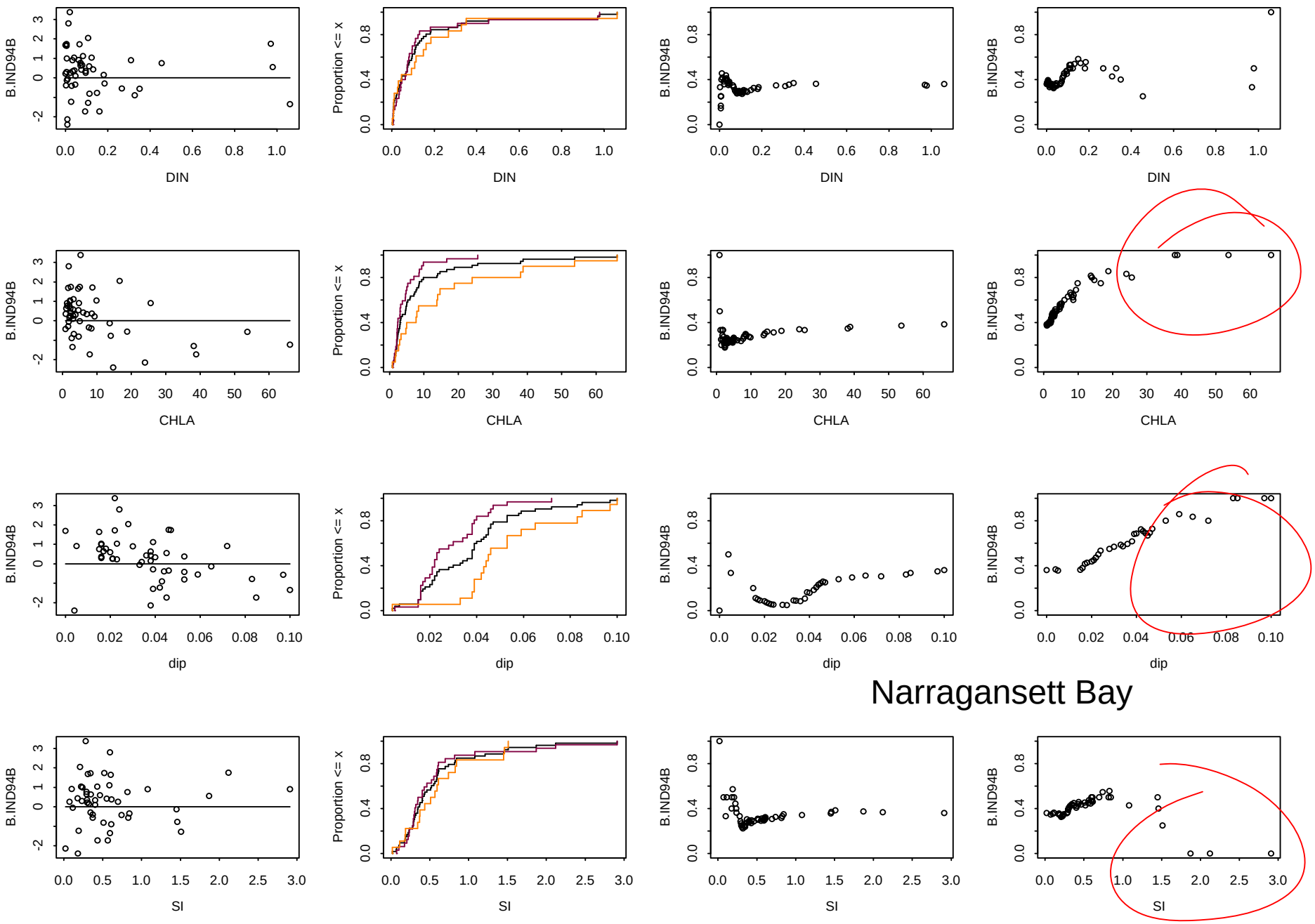




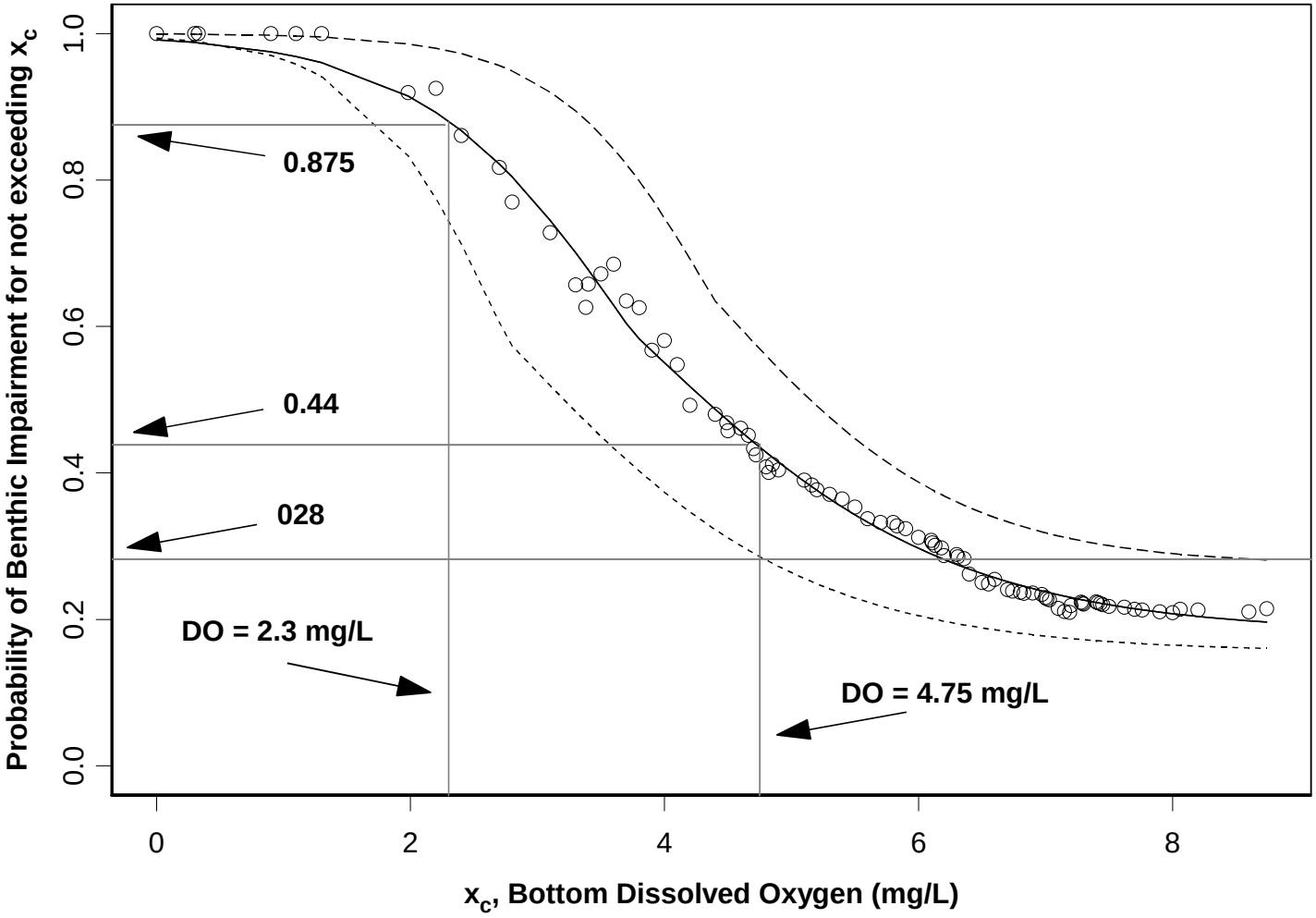
Estuarine example



All sites



Narragansett Bay



But……

What value do probability surveys add?

Instead of results being applicable only to sites of observations, now they can be extrapolated to entire statsitical population

Things to Remember

- Use a consistent process
- Identify possible candidate causes
- Document, document, document
- Stressor Identification Guidance
- WWW. EPA.GOV/CADDIS

Take Home Message

Probability surveys

- Unbiased estimates
- Candidate criteria thresholds
  - Paul & McDonald, 2005, JAWRA
  - SABS WQC Document EPA-822-R-06-001
- Quantitative probabilistic ERA
  - Poster
  - Paul & Munns in review.
- Diagnostics

Cost-effectiveness of probability survey as backbone of monitoring program