U.S. EPA - Office of Water - Office of Science and Technology

Guiding Principles for Developing and Implementing a Numeric Nutrient Criterion That Integrates Causal and Response Parameters ("Bioconfirmation")

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U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology

Guiding Principles for Developing and Implementing a Numeric Nutrient Criterion That Integrates Causal and Response Parameters ("Bioconfirmation")

Speaker
Mario Sengco
Standards and Health Protection Division

September 19, 2013

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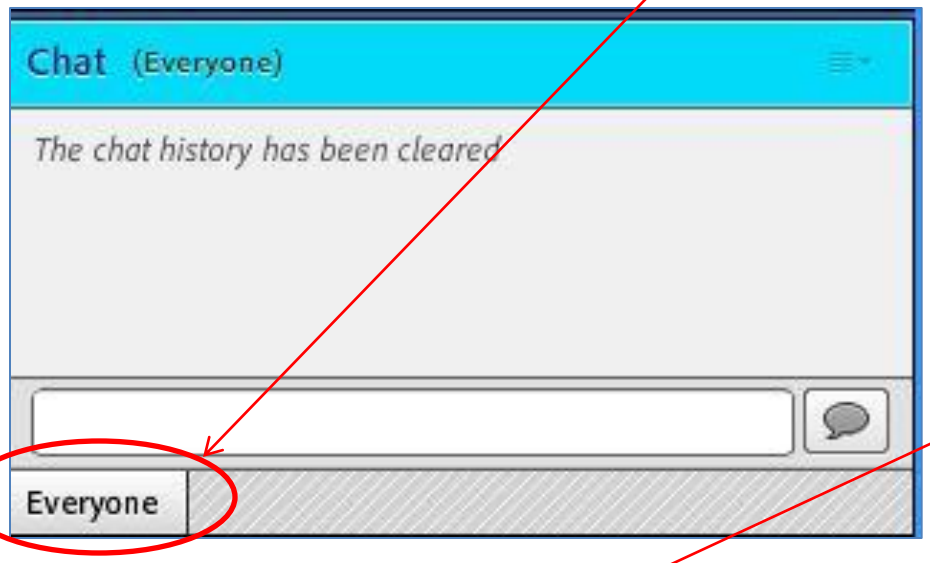

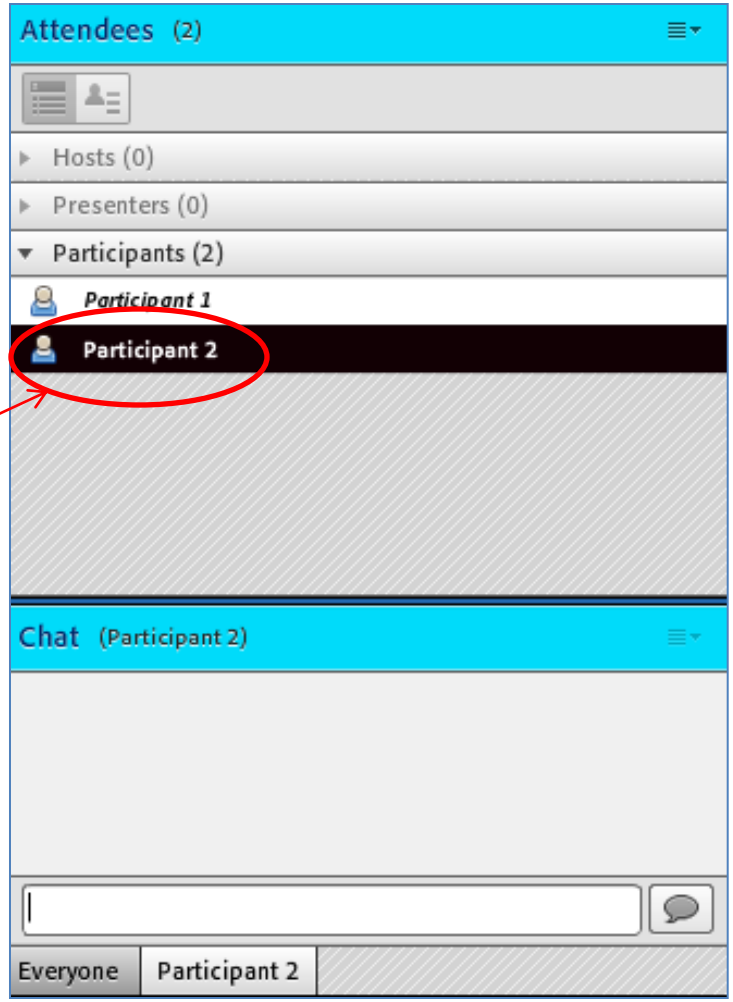

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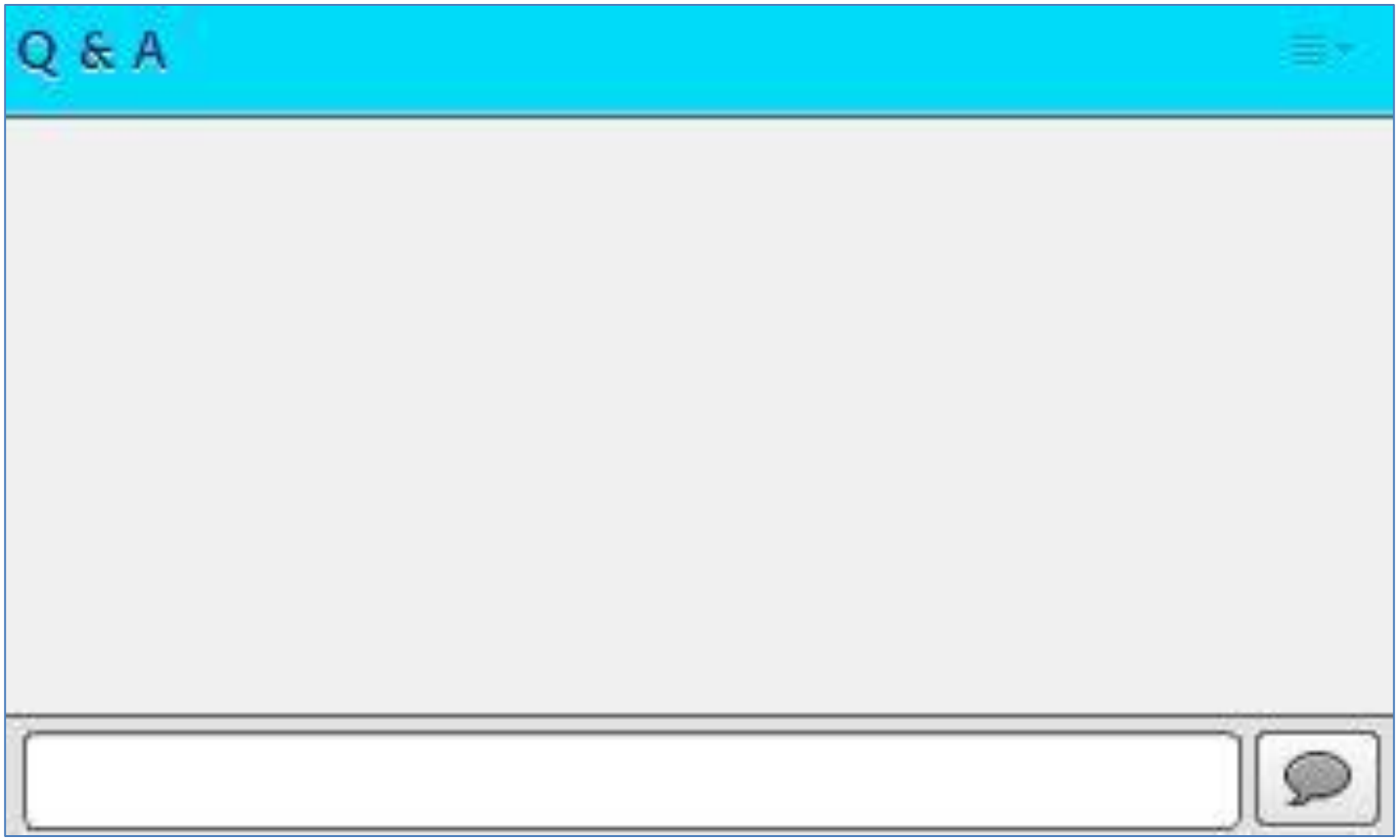


Purpose of Webinar

Clarify an optional approach for developing numeric nutrient criteria (NNC) that integrates causal (nitrogen and phosphorus) and response parameters into one water quality standard (WQS)

Present "guiding principles" regarding this approach

Why Did EPA Develop These Guiding Principles?

Provide a consistent framework for states and tribes currently pursuing or considering this approach for developing and implementing nutrient criteria

Presentation Outline

- **Background**
  - **Nutrients**
  - **Nutrient Pollution**
  - **Criteria Development**
- **Why Bioconfirmation?**
- **Guiding Principles**
  - **Examples in Maine and Florida**

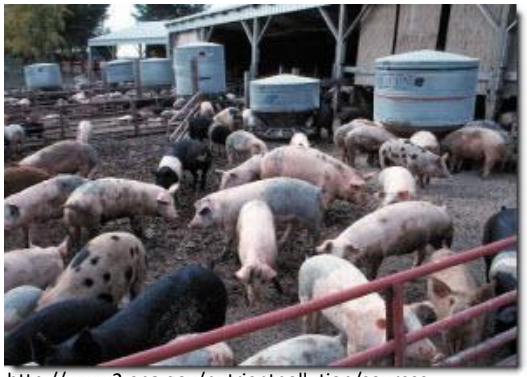
Nutrients

Nutrients, like nitrogen (N) and phosphorus (P), are essential for plant growth, which then supports consumers and provides habitat.

http://www.mikkelgrabowski.com/images/big/agriculture_pesticides_fertilizer_produce_poison.jpg

http://www.fishingclub.com/Portals/0/RU%20food_chain1e.jpg

In addition to natural sources, nutrients come from human sources:



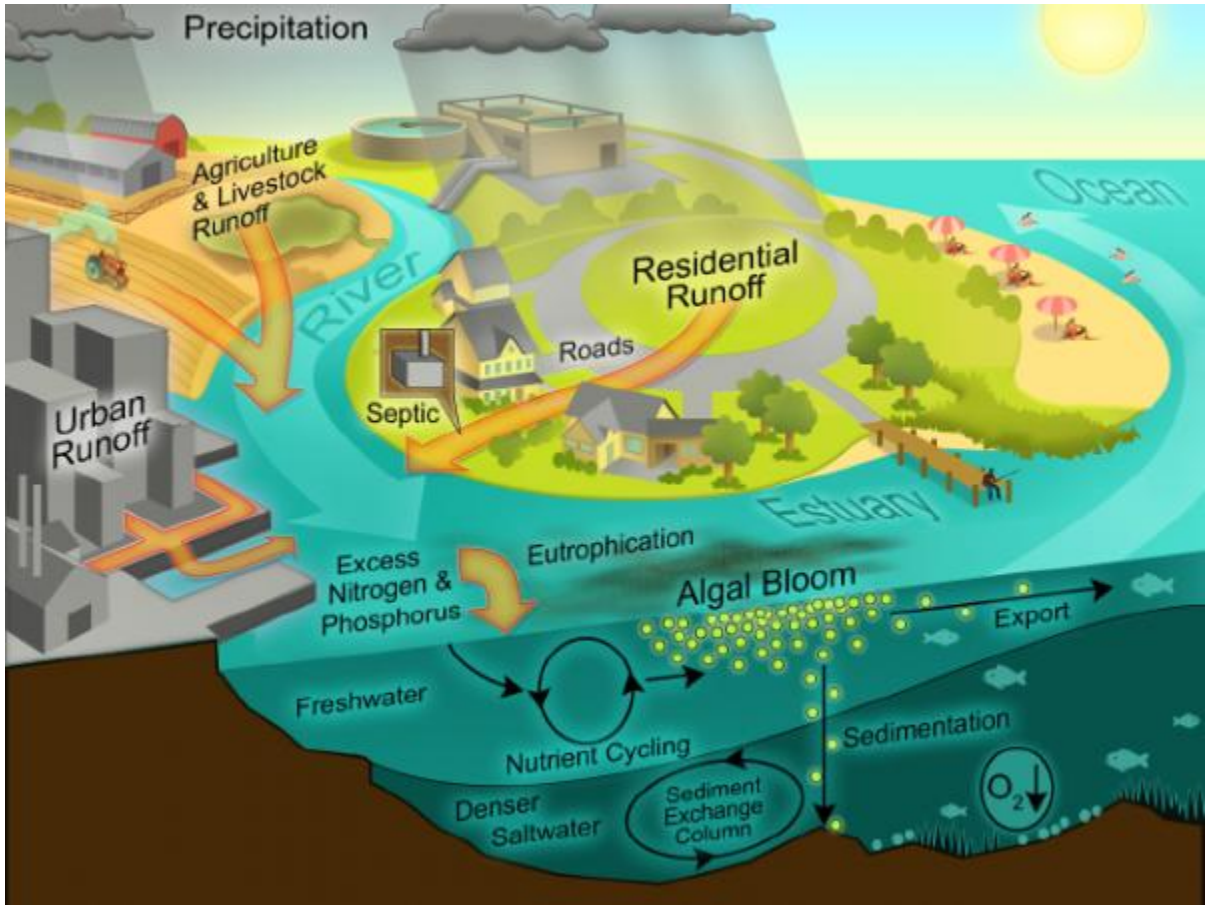
http://www2.epa.gov/nutrientpollution/sources-and-solutions

Agriculture
Stormwater discharge
Wastewater discharge
Fossil fuel combustion

http://www2.epa.gov/nutrientpollution/sources-and-solutions

Nutrient Pollution

Nutrient pollution can lead to significant impacts on public health, aquatic ecosystems, and the economy.



http://www.wri.org/files/wri/paerlFig7.png

http://2.bp.blogspot.com/-3Jk7bRfu0no/Ti4i3omp0VI/AAAAAAAAC-Q/C_9jpxSLZaw/s1600/green-algae-bloom-china-lake-children.jpg

http://www.waterencyclopedia.com/images/wsci_01_img0017.jpg

For details, see http://www2.epa.gov/nutrientpollution

Nutrient Criteria

40 CFR 131.3(b) – "*Criteria* are elements of State water quality standards expressed as constituent concentrations, levels or narrative statements, representing a quality of water that supports a particular *use*."

Nutrient criteria:

- **Causal parameters – nitrogen (N), phosphorus (P)**
- **Response parameters – chlorophyll *a*, turbidity**

Forms of nutrient criteria:

Numeric

- **Causal: TN = 0.56 mg/L; TP = 33 μg/L**
- **Response: chl *a* = 2.4 μg/L; Secchi depth = 1 m**

Narrative

- **Causal: Concentration to support balanced flora and fauna**
- **Response: Free from floating or nuisance algae**

EPA Recommends Adoption of Numeric Nutrient Criteria

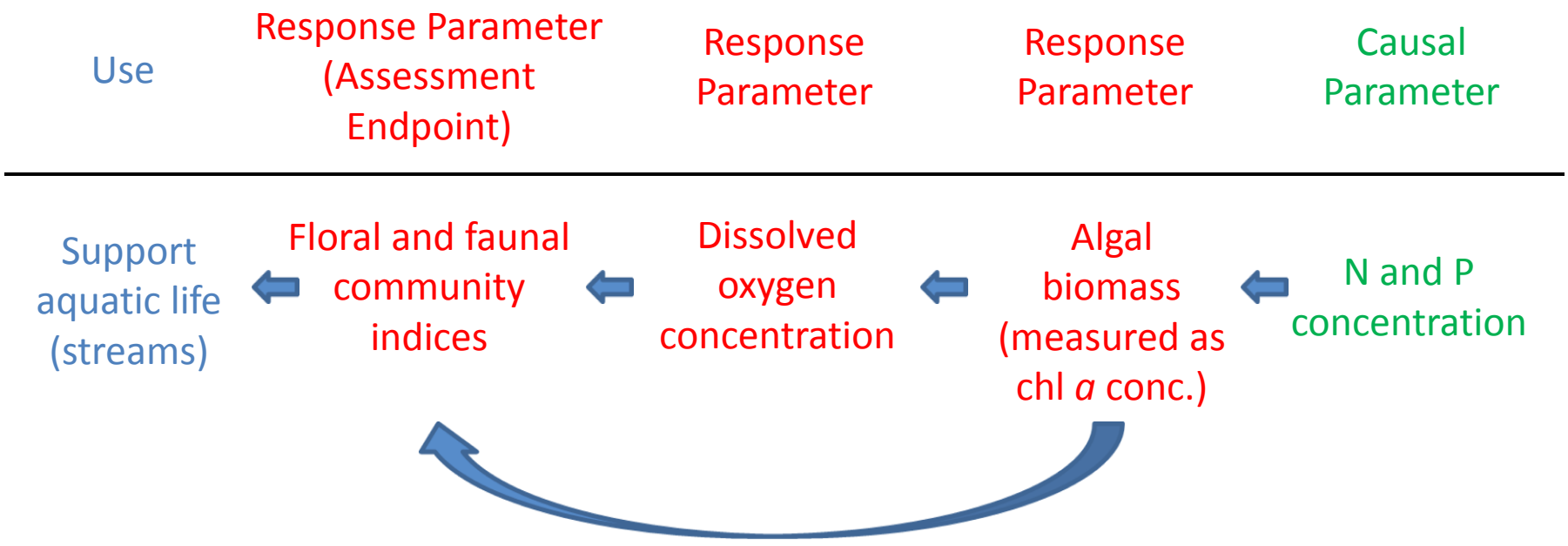
Numeric nutrient criteria will allow for more efficient and effective implementation of state WQS programs by:

- Facilitating state water quality assessments;
- Ensure protection of state waters by identifying nutrient problems *before* ecosystem responses are observed;
- Facilitating and expediting NPDES permit writing and development of TMDL loads for N and P.

EPA also highly recommends adoption of numeric causal criteria, for both nitrogen and phosphorus

Development of Numeric Nutrient Criteria

40 CFR 131.11 (a)(1) – States must adopt those water quality criteria that protect the *designated use*. Such criteria must be based on *sound scientific rationale* and must contain sufficient parameters or constituents to protect the designated use.



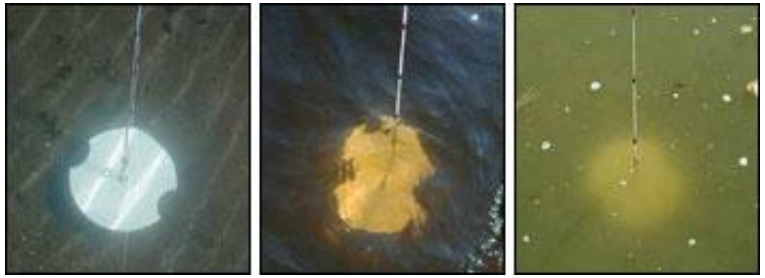
Note: Nutrients generally affect designated uses of water bodies through cascading effects

Challenges When Developing Nutrient Criteria

The linkages between nutrient inputs and environmental impacts are well-supported by the scientific literature, however, the ecosystem response to nutrient pollution can be variable due to the presence of confounding factors at a particular site.

Confounding factors include:

- **Light**
- **Water column stratification vs. flow**
- **Grazing pressure**
- **Competition and pathogens**



http://earthobservatory.nasa.gov/Features/WaterQuality/Images/secchi_comparison.jpg

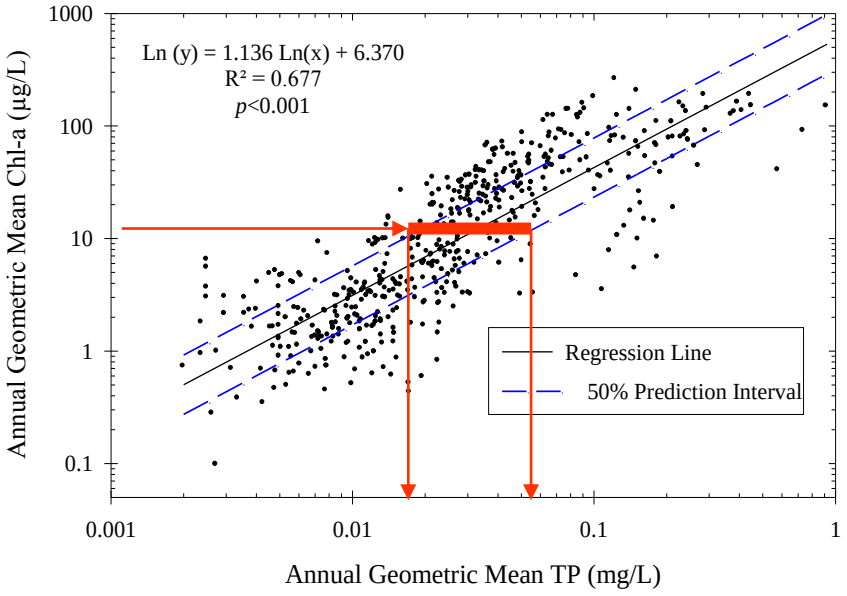
These factors may inhibit a response at a particular site, but the effects of nutrient pollution may be observed where and when these factors subside.

http://limnology.wisc.edu/blog/wp-content/uploads/2012/04/daphnia.jpg

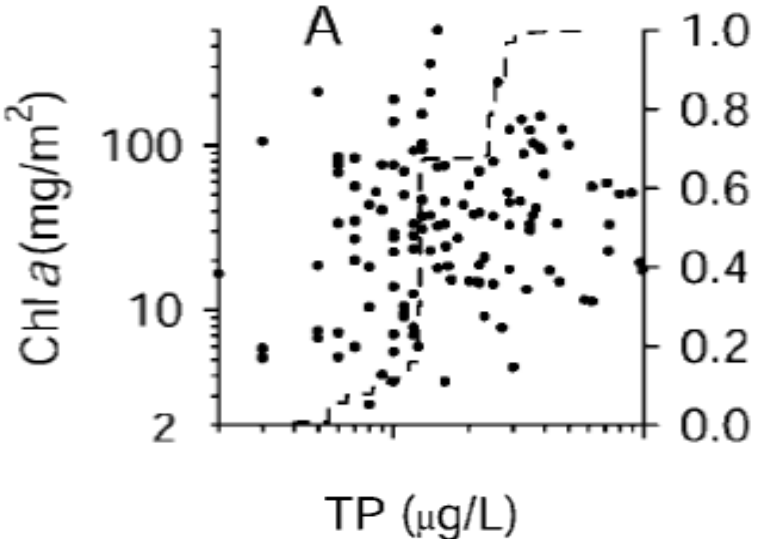
http://www.afcd.gov.hk/english/conservation/con_mar/con_mar_cor/con_mar_cor_hkcaml/images/bivalve5_1.jpg

Challenges When Developing Nutrient Criteria

Lake



Stream



•Stevenson et al. 2008

Why Bioconfirmation?

Bioconfirmation seeks to address possible challenges in developing numeric N and P criteria in light of multiple factors (e.g., light, flow) that can influence ecological responses (e.g., algal biomass), and uncertainty around predicting N and P concentrations that adversely affect aquatic life.

Remember:

Bioconfirmation is an optional approach for developing numeric nutrient criteria.

Statutory, Regulatory and Policy Issues

There are concerns about relying only or heavily on response variables:

- Nutrients may accumulate in the near-field and downstream, and the effects can also manifest away from the source;
- Waiting for a harmful response to occur before taking action is not protective; nutrient criteria should be protective.
- Cost: additional monitoring is expensive.

Bioconfirmation raises statutory, regulatory, and policy issues:

- Clean Water Act Section 303(d)(1)(a) requires listing if any WQS is not met.

Early Engagement with States

In October 2011, EPA's Office of Science and Technology held a workshop in Washington, D.C., with state co-regulators to discuss approaches currently in use or being contemplated by states that integrate both chemical and biological/ecological assessment parameters in a way that:

- Meets states' assessment and listing goals;
- Is preventive of the effects of nutrient pollution;
- Is protective of downstream water quality standards;
- Is scientifically defensible.

Current Science

In April 2013, EPA convened an expert workshop to explore the science underlying a bioconfirmation approach for streams.

The goals were to gather scientific insight to identify:

- Nutrient pollution indicators that are both sensitive to nutrient stress and predictive of impacts to higher trophic levels
- Approaches that protect designated uses

Current Science

Preliminary findings:

1. Indicators (i.e., response parameters or assessment endpoints) that are most sensitive to nutrient pollution and most predictive of impacts to higher trophic levels were TN/TP concentrations, measures of primary production and algal assemblage, and to a lesser extent, measures of ecosystem function (e.g., dissolved oxygen and pH).
2. Numeric nutrient criteria expressed as a decisional framework (i.e., bioconfirmation) could be defended scientifically where uncertainty or disagreement among nutrients and response variables exist.
3. Independent applicability was encouraged: any expression of adverse response being sufficient to indicate impairment

Current Science

Preliminary findings (continued):

4. Nitrogen and phosphorus concentrations should trigger impairment independently at levels above thresholds known to impact designated uses.
5. One approach would be to establish an upper nutrient concentration, above which designated uses are impaired, and a lower nutrient concentration, below which designated uses are attained, and a "grey zone" between these values, within which a bioconfirmation approach consisting of response variables could be applied.

EPA continues to evaluate and synthesize the input and discussions from this workshop.

Guiding Principles (GP)

Areas Covered include:

I. Applicability
II. Criterion Science and Expression
    A. Protectiveness
    B. Sound Scientific Rationale
    C. Expression of the Criterion
III. Implementation
    A. Section 303(d) Assessment and Listing
    B. Permitting

Guiding Principles – I. Applicability

1. GPs apply only for nutrients.
2. GPs apply when states/tribes wish to rely on response parameters to indicate that a designated use is protected, even though N and/or P are above an adopted threshold.
3. States/tribes should have a biological assessment program that confidently measures biological responses and other nutrient-related response parameters, through a robust monitoring program to account for spatial and temporal variability to document the effects of nutrient pollution.

   (a) Identify shifts in multiple biological assemblages (e.g., periphyton, benthic macroinvertebrates, fish) along a gradient of anthropogenic stress that can be tied to designated uses; and
   (b) Quantify the relationship between nitrogen and phosphorus concentrations and measures of biological assemblage response.

Guiding Principles – II. Criterion Science and Expression
A. Protectiveness

1. Per 40 CFR 131.11(a), a criterion must protect the designated use of the water.

   - States should clearly identify the use(s) they are seeking to protect.
   - Where a criterion is intended to protect multiple designated uses, states must ensure that it protects the most sensitive one.

2. Numeric values for all parameters must be set at levels that protect uses (i.e., before adverse conditions that will require restoration).

3. Per 40 CFR 131.10(b), states must ensure that WQS provide for the attainment and maintenance of the WQS of downstream waters.

Guiding Principles – II. Criterion Science and Expression
B. Sound Scientific Rationale

1. Supporting documentation should identify all applicable nutrient pathways, addressing all potential direct and indirect effects. Documentation should also describe which pathways are and are not accounted for and why.

2. Select biological response parameters that are consistent with the EPA's definition of assessment endpoints in the *Ecological Risk Assessment Guidelines.*

   - Assessment endpoints should be relevant to management goals (e.g., protect and maintain aquatic life) and should be sensitive to the stressor of interest (e.g., increased nitrogen and phosphorus concentrations).
   - Appropriate biological response parameters will directly link nutrient concentrations to the protection of designated uses.

Guiding Principles – II. Criterion Science and Expression
B. Sound Scientific Rationale

Indicators that are most indicative of nutrient pollution in streams:

- Intensively measured total phosphorus and total nitrogen,
- Measures of primary productivity (e.g., benthic chlorophyll *a*, percent cover of macrophytes)
- Measures of the algal assemblage (e.g., algal assemblage indices)
- Measures of ecosystem function (e.g., continuously monitored pH and dissolved oxygen).

Reliance on higher trophic level indicators designed to measure general biological condition (fish or invertebrates) may not be adequately sensitive or diagnostic of nutrient pollution.

Therefore, these general higher trophic level indicators may be used in a suite of response variables but should not be the predominant or sole indicator of nutrient pollution.

Guiding Principles – II. Criterion Science and Expression B. Sound Scientific Rationale

The EPA recommends the use of one or multiple of these ideal response indicators when deriving a combined criterion. This criterion should demonstrate the sensitivity of the response indicator(s) to increased nutrient concentrations and quantify how these nutrient-response linkages will achieve the goal of protecting and maintaining aquatic communities.

Appropriate type and quantity of response parameters may vary by state, ecosystem, and waterbody type.

3. It is important to have sufficient data to allow the development of quantitative relationships (e.g., via regression models).

   Sufficient data can also inform the selection of reference sites for deriving a criterion using the reference condition approach and calibration of mechanistic models.

Guiding Principles – II. Criterion Science and Expression
B. Sound Scientific Rationale

4. States should clearly and thoroughly document in their WQS (or supporting documentation)—for public review and submission to the EPA—how the criterion was developed and the technical aspects of their biological assessment protocols (including the assessment endpoints). This will ensure reproducibility, transparency, and defensibility. (See 40 CFR 131.6(b), 131.20(b)).

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

1. In order to ensure that states evaluate causal and response components as one standard when determining whether a segment is meeting any applicable WQS for purposes of CWA §303(d)(1)(A) and 40 CFR 130.7, causal and response parameters must be combined into one criterion.
2. All causal and response parameters should be expressed numerically.
3. Duration and frequency components for all parameters should be included in the criterion in the state's WQS.

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

4. The criterion should be expressed in a way that clearly establishes the water quality goal that applies for permitting, assessment/listing, and total maximum daily load (TMDL) decisions.

   The criterion should not include provisions or conditions (e.g., minimum sample size) that restrict its use for any CWA implementing program including permitting, assessment/listing, or TMDL activities.

If a state identifies a scientifically defensible range of numeric values for the response parameters above which impairment of designated uses is known and below which designated uses are protected, the state should transparently identify and include as part of the criterion the decision framework it will use when waterbody conditions are within that range.

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

5. The criterion should be constructed in a way that integrates causal parameters and a suite of response parameters; clearly states the desired ambient condition of, or level of protection for, the waterbody; and allows for a transparent and reproducible assessment/listing decision.

Guiding Principles – II. Criterion Science and Expression
C. Expression of the Criterion

The criterion should make the following situations clear:

Criterion	Condition of Waterbody
All casual and response parameters are met	Waterbody meeting designated use
One or more causal parameter(s) exceeded, but *all* response parameters are met	Waterbody meeting designated use
A causal parameter is exceeded and *any* response parameter is exceeded	Waterbody not meeting designated use
A causal parameter is exceeded and data *unavailable* for any applicable response parameter	Waterbody not meeting designated use
A causal parameter is met, but any applicable response parameter is exceeded	Waterbody not meeting designated use *(further investigation needed to determine if nutrient pollution is cause)*

Note: 2013 EPA Science Panel considered a potential "range" approach where a waterbody would be deemed impaired above an upper N/P threshold, even if one or more response parameter is exceeded. Conversely, the waterbody would be deemed clearly in attainment below a lower N/P threshold, and the bioconfirmation framework above would be used in between the two thresholds.

Guiding Principles – III. Implementation
A. Section 303(d) Assessment and Listing

1. The CWA Section 303(d) assessment methodology should be consistent with the criterion.
2. CWA Section 303(d) requirement that states identify water quality-limited segments still requiring TMDLs where pollution controls are not stringent enough to implement any WQS still applies.
3. If a causal parameter is significantly exceeded but no response parameters are exceeded, then the state should pursue additional studies to determine whether site-specific criteria are appropriate.
4. States should have a process for monitoring response parameters downstream when assessing upstream conditions.

Guiding Principles – III. Implementation
B. Permitting

1. States should develop NPDES permitting implementation procedures to ensure a consistent application of the criterion.
2. NPDES permits must contain limits for any pollutants or pollutant parameters that are or may be discharged at levels that will cause, have reasonable potential to cause, or contribute to an excursion above any WQS. (40 CFR 122.44(d)(1)).

   - Such limits must be sufficiently stringent to achieve all applicable WQSs.
   - Under this approach, where reasonable potential exists, permit writers must include limits in permits to achieve the WQS and, in doing so, should develop water quality-based effluent limits based on the numeric nutrient causal parameters.

Maine

- **Proposal includes TP criteria and the following response parameters :**
  - **Percent algal cover**
  - **Water column chlorophyll a concentration**
  - **Secchi disk depth (for lakes only)**
  - **Presence/absence of bacteria and fungi**
  - **pH**
  - **Dissolved oxygen concentration**
  - **Aquatic life**
- **EPA worked closely with ME to clarify and strengthen its draft nutrient WQS.**
- **EPA Letter to Maine DEP, December 22, 2011**
- **ME legislature has yet to adopt the criteria**

Florida

- **FL adopted and EPA approved numeric TN and TP thresholds along with numeric response parameter (for streams) within a decision framework:**
  - **Chlorophyll *a;***
  - **Periphyton coverage (measured via Rapid Periphyton Survey);**
  - **Nuisance macrophyte growth (measured via Linear Vegetation Survey);**
  - **Algal taxa dominance;**
  - **Stream Condition Index to measure flora and fauna**

- **FL provided additional technical details on how each parameter would be sampled and analyzed, and the quantitative targets to be used for each response parameter**
  - ***Implementation of Florida's Numeric Nutrient Standards* (March 2013).**
  - **Incorporated by reference and approved by EPA on June 27, 2013.**

Thank you

Polling Question - Geographic Location

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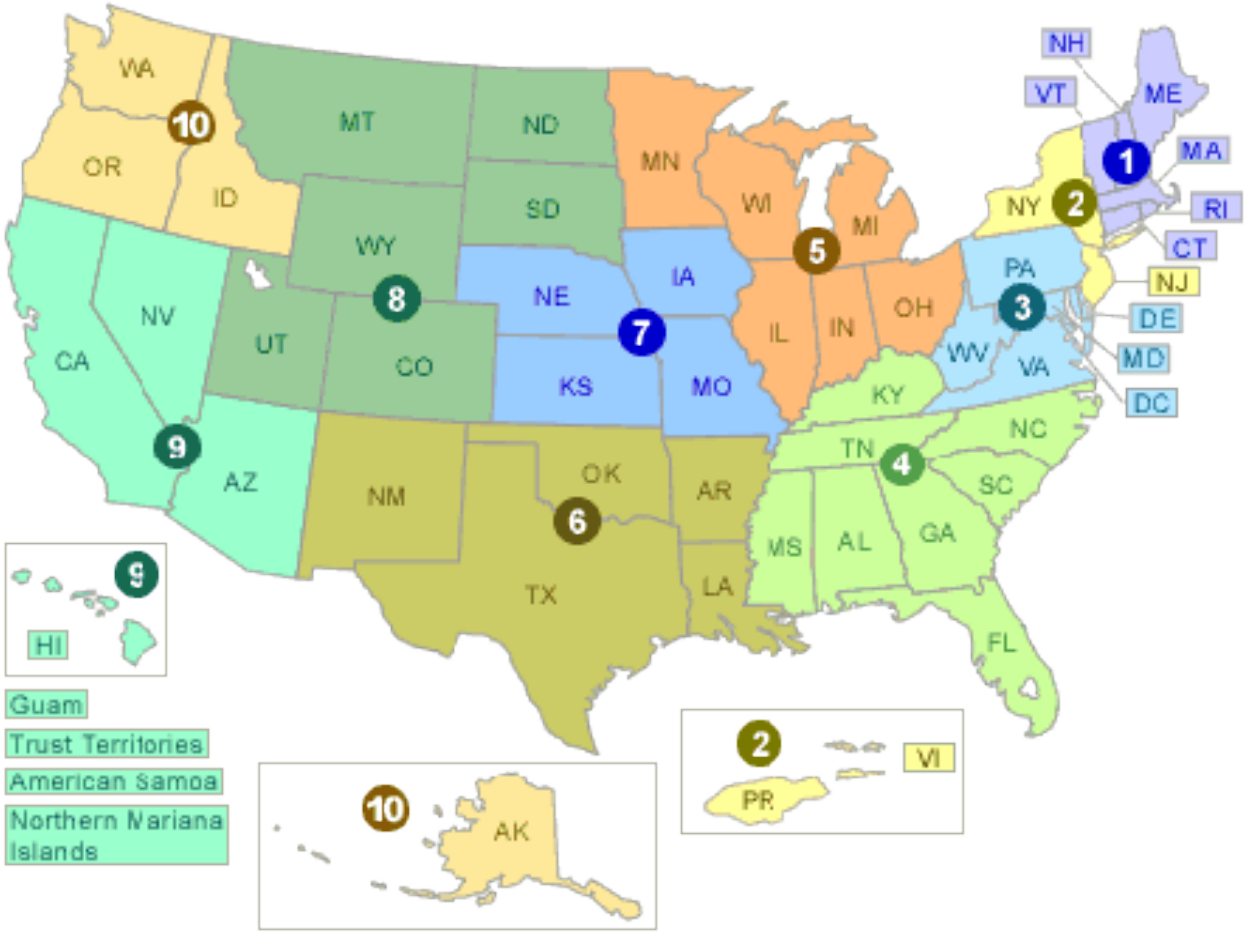

More Information

Questions and comments after the webinar:
sengco.mario@epa.gov
Use "Bioconfirmation" in the subject line.

Obtaining copies of this presentation, guiding principles and additional resources:

"Toolkit of Resources to Provide States with Flexibility in Adopting and Implementing Numeric Nutrient Criteria"
Available online at:
http://www2.epa.gov/nutrient-policy-data/toolkit-resources-provide-states-flexibility-adopting-and-implementing-numeric