Summary Minutes of the
U.S. Environmental Protection Agency (EPA)
Science Advisory Board (SAB) Ecological Processes and Effects Committee
Augmented for the Review of Nutrient Criteria Guidance
Meeting, September 9 – 11, 2009

Committee Members: See Committee Roster – Attachment A

Date and Time: Wednesday, September 9 (9:00 a.m. - 5:15 p.m.); Thursday, September 10 (8:15 a.m. – 5:00 p.m.); Friday, September 11 (8:30 a.m. – 12:00 noon) Eastern Daylight Time

Location: Marriott at Metro Center Hotel, 775 12th Street, N.W., Washington, D.C.

Purpose: The purpose of this meeting was to conduct a peer review of EPA's draft guidance document, *Empirical Approaches for Nutrient Criteria Derivation*

Attendees: Committee Chair: Dr. Judith Meyer

Committee Members: Dr. Richelle Allen-King
Dr. Fred Benfield
Dr. Victor Bierman
Dr. Elizabeth Boyer
Dr. Allen Burton
Dr. Peter Chapman
Dr. Loveday Conquest
Dr. Mark David
Dr. Wayne Landis
Dr. Douglas McLaughlin
Dr. Patrick Mulholland
Dr. James Oris
Dr. Amanda Rodewald
Dr. James Sanders
Dr. Andrew Sharpley
Mr. Timothy Thompson

EPA SAB Staff: Thomas Armitage, Designated Federal Officer
Vanessa Vu, Director, SAB Staff Office

EPA Staff: Janice Alers-Garcia
Robert Cantilli
Tiffany Crawford
Iffy Davis

Paula Diaz
Jim Keating
Jim Latimer
Edward Ohanian
Jacques Oliver
John Paul
Danielle Stephan
Dana Thomas
Lester Yuan
Danny Wiegand

Others Present: Fred Andes, Federal Water Quality Coalition
John Backus, Maryland Dept. Env.
Dominick DiToro, University of Delaware
Raymond Ferraro, Omni Environmental
Bob Fisher, R.J. Fisher & Associates
Mark Fournier, Telford Borough Authority
Thomas Gallagher, Hydroqual
Bill Hall, Hall and Associates
John Hall, Hall and Associates
John Hocheimer, Tetra Tech
Chris Hornback, NACWA
Carhane Johnson, Environmental Consultant
Robert Nemeroff, Warminster Municipal A Authority
Don Parrish, Farm Bureau
Jennifer Peters, CWN
Tom Purcell, API
Adam Retag, Maryland Dept. Env.
Linda Roeder, Bureau of National Affairs
Phil Rosenman, Hall and Associates
Nat Roy, CWN
Max Stoner, Glace Associates, Inc.
Mark Weand, Telford Borough Authority
George Wolfe, Lower Paxton Township
Greg Youngstrom, ORSANCO

Meeting Summary

The discussion followed the issues and timing as presented in the meeting agenda (Attachment B).

Convene Meeting

Dr. Thomas Armitage, Designated Federal Officer (DFO) for the SAB Ecological Processes and Effects Committee convened the meeting at 9:00 a.m. on September 9th, 2009. He stated that the EPA Science Advisory Board (SAB) was a chartered federal advisory committee. He reviewed Federal advisory Committee Act (FACA) requirements. He noted the Committee's compliance with ethics requirements. Dr. Armitage stated that as DFO, he would be present during Committee business and deliberations. He stated that summary minutes of the meeting would be prepared and certified by the Chair.

Welcoming Remarks

Dr. Vanessa Vu, Director of the EPA SAB Office, welcomed the Committee members and thanked them for providing advice to EPA on the draft guidance document, *Empirical Approaches for Nutrient Criteria Derivation* (the "Guidance").

Introduction of Members, Purpose of Meeting, and Review of the Agenda

Dr. Judith Meyer, Chair of the SAB Ecological Processes and Effects Committee (EPEC) provided introductory remarks. She asked members of the Committee and meeting attendees to introduce themselves. After the introductions, she thanked the Committee members for participating in the meeting, outlined the purpose of the meeting and reviewed the agenda (Attachment B). She stated that EPA had indicated that establishing numeric nutrient criteria was important in order to address the problem of excess nutrient pollution in the Nation's waters. She noted that EPA had previously published several guidance manuals and analytical approaches for nutrient criteria derivation and had now asked the Committee to review a new draft guidance document that focused on use of empirical approaches to describe stressor-response relationships for deriving numeric nutrient criteria. She stated that in the review, EPA was seeking advice from the SAB regarding the technical soundness of the guidance document. She stated that for this review, the SAB Staff Office had augmented the Ecological Processes and Effects Committee by inviting several additional experts to participate in the review.

Dr. Meyer then reviewed the Committee's seven charge questions (Attachment C). She noted that the charge questions focused on the technical soundness of proposed approaches for: 1) selecting stressor-response variables; 2) visualizing data; 3) assessing the cause-effect relationship in stressor-response linkages; 4) analyzing data; and 5) evaluating candidate stressor-response criteria. She stated that the committee had also been asked to comment on how EPA's draft guidance document could be made more useful to states for developing water quality standards.

Dr. Meyer stated that the Committee would develop a consensus advisory report providing advice in response to the charge questions and she outlined the process for developing the report. She noted that the Committee would hold a public teleconference to discuss the draft advisory report after it had been developed.

Dr. Meyer then reviewed the meeting agenda (Attachment B). She stated that the Committee would first hear presentations on EPA's draft guidance document and then hear public comments. She stated that, following public comments the Committee would discuss the responses to the charge questions and then break into writing groups to work on the responses to the questions. She further noted that, before adjourning on September 11th, the Committee would discuss the key points in the writing group responses. She stated that following the meeting, the writing groups would send their responses to the Designated Federal Officer who would incorporate them into a draft of the advisory report.

Remarks from EPA

Remarks from Drs. Edward Ohanian and Dana Thomas (EPA Office of Water)

Dr. Edward Ohanian, Director of EPA's Health and Ecological Criteria Division (HECD) in EPA's Office of Water, and Dr. Dana Thomas of HECD presented an overview of EPA activities to develop water quality criteria for nutrients. Dr. Ohanian stated that excess nutrient enrichment was a leading cause of impairment of the quality of the Nation's waters. He noted that states had been pursuing the use of empirically derived stressor-response relationships to develop water quality criteria for nutrients. He stated that the SAB's review of the EPA's draft guidance would help the Agency produce a high quality product.

Dr. Thomas' remarks are summarized in presentation slides provided in Attachment D. The Committee asked a number of clarifying questions to EPA staff (Drs. Thomas, Ohanian, and other EPA staff present at the meeting). Members asked questions about the progress that EPA had made in developing water quality criteria approaches other than the stressor-response approach. EPA staff described progress that had been made, and indicated that they intended to provide more guidance on mechanistic modeling.

Committee members asked EPA to further describe how the draft stressor-response guidance document would be used. EPA staff described how the Guidance could be used to develop water quality criteria for nutrients with available data. Staff stated that states could look at multiple lines of evidence to support criteria development. Committee members asked a number of questions about categories of industrial sources of nutrient enrichment and technologies to control nutrients. EPA staff responded to questions and indicated that the Guidance provided statistical tools that could be used to relate stressors and responses. Members asked questions about the intended scope of the statistical tools in the Guidance.

Committee members asked EPA staff a number of questions about barriers to progress in developing numeric nutrient criteria. EPA staff indicated that lack of data and in some cases technical expertise had been impediments to numeric nutrient criteria development. Members asked EPA staff to describe why numeric criteria (as opposed to narrative nutrient criteria) were important. EPA staff described importance of developing numeric nutrient targets.

Committee members asked questions about EPA's plans to develop mechanistic modeling guidance. EPA staff indicated that developing mechanistic modeling guidance would seem to be a logical next step. Staff noted that more experience with mechanistic modeling approaches would enable EPA to develop useful case study examples.

Committee members asked questions about: the spatial scale at which the Guidance would be applied, flexibility with regard to response variables used, and the linkage of response variables to designated uses. EPA Staff indicated that the Guidance could be applied within watersheds, but also stated that it was important to protect "downstream" waters (the Guidance did not address this issue). Staff noted that chlorophyll A and macroinvertebrate indices were two specific response variables described in the Guidance, but staff noted that the Guidance was flexible (i.e., when data on other variables were available they could be considered for use). EPA staff also stated that states were responsible for setting designated uses, and that the uses could be different from state-to-state. Staff noted that the response variable-designated use linkage was a complex issue.

Committee members asked EPA how states would select a particular method to be used for empirical derivation of nutrient criteria. EPA staff stated that in the Guidance, EPA wanted to provide a scientific foundation that could be a "starting point" for states wishing to use the stressor-response approach. Committee members asked whether states could use methods that were not described in the Guidance. EPA staff responded that states could choose to use other methods.

Remarks from Drs. Dana Thomas (EPA Office of Water), Lester Yuan (EPA Office of Research and Development), and John Paul (EPA Office of Research and Development)

Drs. Dana Thomas, Lester Yuan, and John Paul of EPA presented an overview of the Agency's draft guidance document, *Empirical Approaches for Nutrient Criteria Derivation*. They described the five-step process outlined in the Guidance for empirical derivation of numeric nutrient criteria. Committee members asked questions about the process and supporting analytical methods and tools described. Slides summarizing this presentation are provided in Attachment E.

Committee members noted that parts of the five-step process described in the Guidance had also been addressed in EPA's previous nutrient criteria guidance documents, and suggested that relevant parts of these previous guidance documents be highlighted in the empirical approaches guidance. Members discussed how data had been used to illustrate application of the statistical methods in the Guidance. Members asked EPA staff why Environmental Monitoring and Assessment Program (EMAP) data had been used to illustrate the methods in the Guidance. Members noted that some of the relationships that had been demonstrated using the EMAP data were not particularly strong. EPA staff responded that these data had been used because the dataset could provide illustrative examples for all of the methods.

Committee members discussed the importance of developing conceptual models to understand cause and effect relationships among stressors and response variables. A member stated that a weight of evidence approach should be used to consider multiple lines of evidence in developing criteria. EPA staff indicated that it might be useful to consider a process similar (but abbreviated) to the Causal Analysis/Diagnosis Decision Information System (CADDIS) that had been developed by the Office of Research and Development.

Committee members stated that in the Guidance, EPA had provided a number of "advanced" statistical methods but had not included other potentially useful statistical methods. A member asked how EPA had decided which methods to include in the Guidance. EPA staff responded that methods, such as structural equation modeling, that had been well described in the literature had been included in the Guidance. Committee members discussed problems associated with estimating trends from "wedge shaped" data plots illustrated in the guidance.

The Committee discussed the level of expertise that would be needed to apply methods presented in the Guidance. EPA staff stated that the document had been targeted to a "masters" level analyst with one or two semesters of training in statistics.

The Committee discussed the need for a "data synthesis" step to evaluate candidate criteria. In this regard, EPA staff indicated that the document did discuss approaches for thinking about data in time and space.

Following the EPA presentations and Committee discussion, the Chair called for a break. She stated that after the break the Committee would hear public comments.

Public Comments

The Chair reconvened the meeting and called for public comments. The speaker presentations and written public comments received are available in the meeting record file in the SAB Staff Office (SAB Staff Office Federal Advisory Committee Act Files) and on the SAB website at the following URLs:

http://yosemite.epa.gov/sab/sabproduct.nsf/MeetingCal/A436CC38C57967B58525759400609B09?OpenDocument

A list of persons who submitted written comments is provided in Attachment F.

Oral presentations were provided by the following individuals (their presentation slides are available on the SAB website at the URLs listed below each speaker and in the SAB Staff office Federal Advisory Committee Act files):

1. *John C. Hall, Hall & Associates*

Mr. Hall discussed EPA's approach to developing stream nutrient standards and how it would affect regulated entities. He discussed a number of observed problems in the approach.

http://yosemite.epa.gov/sab/sabproduct.nsf/AB3EA8BAA0DCFCC78525762B006AAD65/$File/John+C+Hall+Presentation+for+EPEC+Sept+9-11+2009+Meeting.pdf

2. Dominic DiToro, University of Delaware

Dr. Di Toro further discussed observed problems associated with approaches in EPA's draft guidance. He suggested that a more appropriate approach would be to evaluate solutions to nutrient over-enrichment on a site-specific basis.

http://yosemite.epa.gov/sab/sabproduct.nsf/565334415DD2F1B78525762B006E4C3C/$File/Dominic+Di+Toro+Presentation+for+EPEC+Sept+9-11+2209+Meeting.pdf

3. William T. Hall, Hall & Associates

Mr. Hall presented several case studies that illustrated observed problems associated with the empirical approach for deriving numeric nutrient criteria.

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4. Thomas Gallagher, Hydroqual, Inc.

Mr. Gallagher further discussed observed problems associated with using regression equations for empirical derivation of numeric nutrient criteria. He discussed the advantages of using mechanistic models for evaluating nutrient control alternatives.

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5. Fredric P. Andes, Barnes & Thornburg LLP

Mr. Andes discussed the impact of nutrient regulation on dischargers and pointed out a number of observed problems associated with EPA's proposed approaches for empirical derivation of numeric nutrient criteria.

6. Chris Hornback, National Association of Clean Water Agencies

Mr. Hornback discussed the importance of ensuring that relationships used to derive nutrient criteria were environmentally not just statistically significant.

(no presentation slides were provided)

7. Don Parrish, American Farm Bureau Federation

Mr. Parrish discussed the use of nutrients in agriculture.

(no presentation slides were provided)

8. Raymond A. Ferrara, Omni Environmental LLC

Dr. Ferrara discussed complexities in the relationships among eutrophication cause and response variables.

http://yosemite.epa.gov/sab/sabproduct.nsf/D6D99D6B053DAFC18525762B007099A6/$File/R+Ferrara+Presentation+for+EPEC+Nutrient+Criteria+Sept+7-11+2009+Meeting.pdf

9. Max Stoner – Goose Creek WWTP (Goose Creek TMDL)

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10. Mark Fournier – Telford Borough (Indian Creek TMDL)

http://yosemite.epa.gov/sab/sabproduct.nsf/E3AAC8343E1529008525762B0072E379/$File/M+Fornier+Presentation+for+EPEC+September+9-11+2009+Meeting.pdf

11. George Wolfe (Lower Paxton Township)

http://yosemite.epa.gov/sab/sabproduct.nsf/7E1E0A3D608F84A88525762B007469FD/$File/G+Wolfe+Presentation+for+EPEC+September+9-11+2009+Meeting.pdf

12. Bob Fischer (Harrisburg Home Builders) (Paxton Creek TMDL)

Messrs. Stoner, Fournier, Wolfe, and Fisher pointed out observed problems associated with nutrient Total Maximum Daily Loads that had been developed for a number of waterbodies.

Following each speaker's presentation the Committee asked clarifying questions. Following the public comments the Chair thanked the members of the public for their presentations and for responding to the Committee's questions.

Discussion of the Charge Questions

After public comment period the Chair called for discussion of the responses to Charge Questions 2 and 4 (Attachment C). These questions focused on: selecting stressor and response variables and assessing the strength of the cause-effect relationship.

Discussion of the response to Charge Question 2 – Selecting stressor and response variables

Members discussed the importance of considering nutrients and ancillary stressor variables (such as light, habitat, and hydrodynamics) in empirical derivation of nutrient criteria. Members noted that EPA's Guidance presented limited examples (only chlorophyll and macroinvertebrates) of response variables. Members discussed the importance of developing the conceptual model before deriving the criteria. A member stated that, depending upon the conceptual model, different variables should be selected. Members discussed the differences between lake and stream environments, several members noted that complex stream environments posed additional problems that should be considered.

Members noted that none of the examples in the Guidance involved dissolved oxygen (DO). Members suggested that examples should be presented in the Guidance to illustrate use of DO as a response variable. Members noted that the Guidance seemed to focus on a single stressor (total nitrogen or total phosphorus). Members noted that the recent literature had indicated that a dual nutrient control strategy involving both nitrogen and phosphorus was important. A member stated that it was important to consider loading rate. Members stated that considering load under low flow conditions was also important. Members pointed out that other variables such as temperature were also important. Members asked EPA whether the Guidance would limit the variables to be considered to total nitrogen or phosphorus. EPA staff responded that other variables could be considered.

A member stated that species richness, a response variable illustrated in the Guidance, was not necessarily a good example. She asked why EPA had chosen to use this as an example. EPA staff responded that data were available for this response variable.

Members noted that the Guidance did not discuss feedback or interaction between air and water criteria. A member stated that, in this regard, some integration was needed. Another member agreed that it was important to consider setting water quality criteria for nutrients in the context of other criteria. A member stated that without such consideration, solving one problem might create or ignore another.

Members discussed the flow diagram (Figure 1) in EPA's Guidance. A member stated that in Figure 1 it was not clear what endpoint EPA was trying to protect. Other members stated that Figure 1 did not address uncertainty. Members stated that when variables were combined into one number, such as an index of biotic integrity, the representation of uncertainty was lost. Other members stated that indices were useful and that that it was important to provide a multimetric understanding of uncertainty. A member stated that it

was important to avoid managing a system for a single use. She noted that multiple factors should be considered.

A member stated that the purpose of the Guidance should be protection of the system from nutrient enrichment. He stated that, in this regard it was important to conduct problem formulation. He stated that the conceptual diagram in Figure 10 of the Guidance needed improvement. He pointed out the need to deal with different systems (streams, lakes, and estuaries).

A member pointed out that in the flow diagram presented in Figure 1 of the Guidance there was no "jumping out" place to consider possible approaches other than the empirical stressor-response relationship. He stated that it was important to consider whether the stressor-response approach was appropriate, and noted that an example of this was provided in the draft guidance document developed by the Florida Department of Environmental Protection.

Members stated that in the problem formulation step, EPA should identify the pathways that lead to impairment of designated uses. A member noted that cause and effect and spatial relationships needed to be considered in the conceptual model. A member stated that the conceptual model should be used to understand what factors to consider in the process of deriving nutrient criteria. A member stated that stressor-response models needed to be ground truthed with real data, and that uncertainties needed to be identified. A member noted that, because there were many uncertainties, a data quality objectives (DQO) process would be useful for identifying "acceptable" levels of uncertainties.

Discussion of the response to Charge Question 4 – Methods for assessing the strength of the cause and effect relationship

Members discussed methods provided in the Guidance to assess the strength of the cause and effect relationship. Members stated that it was appropriate that the Guidance indicated that conceptual models and the existing literature be used to assess cause and effect. A member noted, however, that this kind of analysis was difficult and that considerable resources would be needed for states to do this. He noted that states could benefit from a compendium of resources. A member stated that principal components analysis could be used as a "front end" to multiple or single linear regression. He noted that longitundinal plots at fixed points in time would also be useful.

A member noted that the Guidance focused on looking at R^2 in the relationships. He stated that the guidance should acknowledge the importance of looking at slope. He indicated that, in this regard, log-log plots could be used to normalize the data.

A member stated that almost all of the examples in the Guidance were applications of regional data. She stated that it would be useful to provide state examples as well. Another member indicated that the Guidance should clearly state that, by themselves, the statistical correlations did not determine cause and effect. Another member stated in the text of the Guidance he had difficulty distinguishing differences between step two

(assessing the strength of the cause and effect relationship) and step three (analyzing data) in Figure 1. Another member stated that he did not see mechanistic modeling described in the guidance as a possible source of information. He noted that, in this regard, both quantitative and qualitative information would be useful.

A member stated that if the ultimate goal of the Guidance was to protect designated uses it was important to determine which relationships and measures would allow detection of impaired uses, and whether the strength of the relationships were strong enough to use them. She noted that a range of protective measures should be considered. EPA staff stated that in the water quality standards programs designated uses were defined and standards were developed to protect those uses. Member discussed the importance of linking the water quality criteria to protection of designated uses.

Discussion of the response to Charge Question 5 – Methods for analyzing the data

Members discussed the data analysis methods presented in the Guidance. Members noted that the methods presented in the Guidance were appropriate for characterization of relationships. However, members expressed concern that in the Guidance, it had not been demonstrated that the linear regression approaches would be useful for prediction. Members noted that through extensive data evaluation, it might be possible to remove variability associated with confounding variables, but this would be a challenge. Members noted that multiple linear regression could be more useful in this regard, but some methods were missing from the Guidance. A member noted that it might be useful to include a discussion of principal components analysis and discriminant function analysis in the Guidance. A member stated that the Guidance did not include much information about nonparametric linear regression. She also stated that methods were available to consider "non-detect" data. She stated that the Guidance should acknowledge these other methods. A member noted that the Guidance should provide information to assist users in defining a strong or weak relationship.

Other members stated that the guidance was a useful primer on statistical techniques for evaluating stressor-response relationships. Members noted that if data indicated that a threshold response did not exist, a nonparametric approach could be used. The Committee discussed the change point analysis method presented in the Guidance. Several members noted that a change point may or may not be statistically or biologically significant and that numerical thresholds needed to be carefully evaluated.

A member stated that the audience of the Guidance should be clearly defined and that adequate information and training should be provided to enable the audience to apply the methods presented.

A member questioned how principal components analysis could be applied in developing numeric nutrient criteria. Another member stated that EPA could start with a large number of independent stressors and use principal components analysis to eliminate some of the stressors. He stated that multiple regression could then be used to develop empirical models with less variability. Members discussed other statistical tools that

could be used for the analysis. A member noted that EPA should not use only one tool, but should consider how multiple tools could be used.

Members discussed the need for a statistical process that could be used to determine whether the stressor-response approach was appropriate for use in developing a nutrient criterion. A member stated that the data quality objectives process could be helpful in this regard because it could be used to help identify whether information was acceptable or unacceptable. A member stated that it was important to understand the differences between statistical and biological significance of relationships. A member stated that model averaging was a possible approach that could be used when the results from multiple analyses differed. A member stated that the Guidance should include information on "how to make a decision" (e.g., what is an acceptable R^2 value). Another member cautioned that it was easy to rely too much on an R^2 value; he stated that the slope should be considered.

The Committee further discussed the use of change point analysis and the need to consider the relationship of the change point to designated use.

Following the discussion of methods for analyzing the data, the Chair stated that the Committee would recess for the day. She noted that on the following day members would continue the discussion of the response to Charge Question 5 and then discuss responses to Charge Questions 6, 7, and 1. She noted that the Committee would then work in groups on the responses to the charge questions. She stated that the writing group assignments had been provided in the material sent to members before the meeting.

Thursday, September 10, 2009

The Chair convened the meeting at 8:15 a.m. and reviewed the plans for the day. She stated that the Committee would continue the discussion of the response to Charge Question 5. Before beginning that discussion Dr. Dana Thomas of EPA presented a brief overview of Clean Water Act provisions for water quality criteria and standards.
The Committee members asked several questions concerning the need for numeric water quality standards. A member stated that total maximum daily loads were being developed in the Chesapeake Bay using variables such as dissolved oxygen, water clarity and submerged aquatic vegetation, not numeric nitrogen and phosphorus endpoints. He asked whether numeric standards were needed if other endpoint were related to designated uses. EPA staff responded that some states wanted to use numeric nitrogen and phosphorus endpoints. The Committee then asked questions about how total maximum daily loads were developed and used. EPA staff responded to the questions.

The Chair then thanked EPA for clarifications concerning Clean Water Act requirements and called for continued discussion of methods for analyzing data.

Continued discussion of the response to Charge Question 5

The Committee continued to discuss the statistical methods in the Guidance. A member noted that some of the methods might be appropriate for use in lakes but not in streams. She stated that the Guidance could be improved by describing where the methods might work best. A member stated that the Guidance did not appear to address the impacts of nutrients on the detritus food web.

A member reiterated that statement that the Guidance should contain a discussion of the statistical strength needed in empirically derived stressor-response relationships. A member stated that the Guidance should also contain information indicating how the output of various statistical approaches could be combined. A member stated that in the Guidance, it might be useful to include an appendix of information showing how the entire process of criteria development would work. Simulated data sets could be included in such an appendix. Another member cautioned that the Committee should not ask EPA to develop a new textbook. She noted, however, that useful textbooks could be referenced in the Guidance and cited several examples.

A member suggested that mechanistic modeling would be useful in understanding nutrient effects and suggested that this be discussed in the Guidance.

Another member suggested that empirical models such as SPARROW (USGS Spatially Referenced Regression on Watershed Attributes) could be useful in considering site-specific factors. She noted that at sites where limited data were available, uncertainty could be large but the results of model application could be useful. Another member stated that the SPARROW model provided nutrient loading information but he did not think it could provide information related to designated uses. A member noted that SPARROW could be used to characterize a system and provide a sense of the anthropogenic impairment of a waterbody. She stated that both mechanistic models and empirical approaches were useful.

A member stated that there were other stressors in watersheds in addition to nutrients. He stated that these other stressors should be considered.

A member stated that the stressor-response approach should be used with other methods to develop water quality criteria. Another member stated that it was important to define the conditions under which the stressor-response approach could be used.

The Chair then thanked the Committee for the discussion of the Response to Charge Question 5 and called for discussion of Charge Question 3.

Discussion of Charge Question 3 – Methods to visualize available data

The Committee discussed the methods in the Guidance for visualizing available data. A member stated that it was difficult to separate this section of the Guidance from the other sections because there was considerable overlap. He recommended that explanatory data analysis be presented as a separate section of the document. He noted that there were many useful data visualization methods that had not been included in the Guidance, and

recommended that this be stated in the document. He supported using a weight of evidence approach. He recommended including a number of different examples to demonstrate visualization of the data. He stated that these examples should include both data rich and data poor systems. He noted that visualization and statistical methods should be used in "screening mode." He also questioned whether EPA had considered the use of field-based species sensitivity data for developing nutrient criteria

Another member stated that it would be useful to provide additional case studies illustrating cases where a simple approach did not provide useful information but a more complex multivariate approach proved to be useful.

Several members stated that the conditional probability approach should not be included in the data visualization section of the Guidance. A member stated that conditional probability should be viewed as an analytical method not a visualization technique. A member stated that the example maps in the data visualization section of the guidance should be improved. She noted that the maps did not clearly show patterns and that it would be helpful to show seasonal or monthly differences as part of exploratory analysis.

Another member commented that conditional probability was appropriate for visualizing data but he did not find that it described stressors and responses over a range of concentrations.

Another member noted that it was hard to draw a line between methods that were exploratory and those that were to be used for statistical analysis. A member stated that the Guidance could be enhanced by including more information from reference articles. Another member agreed, stating that it would be useful to include more case examples in the Guidance to show how methods should be used and illustrate their strengths and limitations. Another member noted that it was important to indicate which of the procedures in the Guidance had good predictive capability.

Following the discussion of charge question 3 the Chair called for a break. After the break the Committee discussed the response to Charge Question 6.

Discussion of Charge Question 6 – Evaluating estimated stressor-response relationships

Committee members discussed the need to consider uncertainty in estimated stressor-response relationships. Members noted that the approaches in the Guidance would be more useful if uncertainty information were provided. They stated that a framework for assessing uncertainty should be provided. A member suggested that confidence intervals could be provided. A member stated that a "rule of thumb" for uncertainty should be provided to indicate when a stressor-response relationship could "stand up." In addition, he stated that more guidance should be provided on how to use randomly or non-randomly selected datasets for validation of empirically derived stressor-response relationships. He stated that it was important to look at the question of how much data

should be held out for validation. He noted that it was important to evaluate predictive accuracy.

A member noted that the Guidance provided a collection of tools but the document did not provide enough discussion of how to select and use the tools. He also stated that it was important to consider possible confounding issues. Several members further discussed issues concerning validation of empirical stressor-response models.

Members stated that the Guidance should discuss differences between prospective and retrospective data collection. Members noted that the document should be more explicit in its description of the kinds of data needed. A member stated that data needs could be described in a table.

The Committee further discussed the need to address uncertainty in models. Members again stated that case examples would be useful to illustrate model development and how to handle uncertainty. Several members stated that the data quality objectives process should be used to set boundaries for Type I and Type II errors. A member stated than Type II error could be more important than Type I error in establishing criteria, and he stressed the importance of the data quality objectives process. A member noted that decisions concerning statistical power and uncertainty should be made "up front" before data were collected or used, and that calculating statistical power after data had been collected was not appropriate.

Discussion of Charge Question 7 – Methods for Evaluating Candidate Stressor-Response Criteria

Following the discussion of responses to Charge Question 6 the Committee discussed the section of the Guidance that provided methods for evaluating candidate stressor-response criteria. A member stated that this section of the Guidance was perhaps the most important part of the document because selection of criteria had environmental, social, and economic consequences. Members discussed the need to: 1) address or partition inherent critical uncertainties in the stressor-response approach, and 2) account for factors such as habitat condition that influenced biological responses to nutrient inputs. Members suggested that uncertainty could be reduced by obtaining data from well-designed monitoring programs.

A member stated that it was important that analysis tools used to derive criteria reflect cause-effect relationships. A member stated that a tiered weight of evidence assessment should be used to develop criteria.

Members further discussed the need to use appropriate data for developing stressor-response relationships. A member stated that when cross-sectional data were used to derive criteria, the range of values of the data should encompass the range of predicted values. Another member stated that determination of how EPA should deal with uncertainty was essentially a management question. Other members noted that

measuring uncertainty was a science issue. A member noted that it was important to clarify how the Guidance would be used.

The committee discussed whether net environmental benefit should be addressed in the Guidance. A member stated that it might be useful to include information in the document to indicate how criteria related to costs and benefits. Another member stated that this was a management issue that is a part of problem formulation, and was not in the realm of the science that the Committee had been charged to address. A member stated that other EPA guidance (e.g., the Superfund Remedial Investigation Feasibility Studies guidance) contained this kind of information

Committee members further discussed the need for uncertainty analysis. The Committee discussed a number of recommendations to reduce uncertainty.

The Committee discussed consideration of site-specific factors in developing nutrient criteria (e.g., shaded vs. unshaded streams). Some members noted that EPA's Guidance was not designed to be site-specific. Other members stated that the Guidance should indicate that site-specific factors should be considered. Members noted that states already considered site-specific factors in developing water quality criteria. A member noted that the techniques presented in the Guidance were appropriate but they could be used inappropriately if the guidance was not clear.

Members further discussed the approach presented in Section 5 of the Guidance to predict conditions that might result after implementing different nutrient criteria. A member suggested that the approach should be revisited and possibly replaced because it appeared to be highly sensitive to the way that individual data points located above a response threshold were distributed around the regression line. A member noted that the procedure to be used should take into account the uncertainty in the slope of the regression line.

Following the discussion of Charge Question 7 the committee recessed for lunch, and after lunch reconvened to discuss the response to Charge Question 1.

Discussion of Charge Question1 – Suggestions to improve the utility of EPA's draft guidance for deriving numeric nutrient criteria

Members noted that many of the points to be discussed in response to Charge Question 1 had also been discussed in responses to the other charge questions.

Committee members discussed a number of recommendations to improve the Guidance. These included:

- Addressing the goal of accelerating progress toward state adoption of nutrient criteria.
- Providing technical support for use of methods in the Guidance.
- Articulating how the guidance related to and complemented other EPA guidance.

- Providing caveats concerning use of the methods (i.e., advantages of various methods and cautions concerning potential problems and shortcomings)
- Addressing data quality objectives.
- Providing more information on how to use the methods in the document.
- Providing other sources of useful information about the statistical methods.
- Providing more information about alternative methodological approaches (i.e., a broader perspective).

Members further discussed incorporation of problem formulation and data quality objectives approaches into the criteria development process.

A member stated that the Guidance was well-written but it could be improved. A member suggested that the document might be more appropriately titled, Empirical Approaches for Stressor-Response Derivation. He noted that the document should provide a better discussion of when the stressor-response approach was appropriate. A member noted that acknowledging conditions where the stressor-response approach would be most appropriate (e.g., in an open canopy environment) would improve the document.

Members discussed the steps outlined in the Guidance for developing nutrient criteria. A member noted that the titles of the steps were too general and not reflective of the process. A member noted that the empirical approach was useful but it was necessary to stratify the data, and that this should be addressed in the Guidance. Members discussed ways to stratify the data (e.g., stream gradient, canopy, substrate). A member noted that the "classification" section of the Guidance could be improved.

Members further discussed the need to consider confounding variables. A member noted that, without data on covariance, the multiple linear regression approach was problematic.

The Committee discussed the need to address downstream effects of nutrient enrichment. Members noted that the Guidance did not address downstream effects.

Members noted that, unless the document more explicitly addressed how the tools should be used, the document could be confusing to resource managers. A member stated that more detail rather than less should be provided. A member stated that it might be useful to clarify the level of expertise that would be needed to use the Guidance.

Following the discussion of the response to Charge Question 7 the Chair stated the Committee would break into writing groups to work on developing the responses for the Committee's advisory report. She stated that on the following morning the Committee would reconvene to discuss key points and recommendation for the advisory report. She noted that the meeting would adjourn by noon the following day.

The meeting then recessed for the day and Committee members worked in writing groups.

Friday, September 11, 2009

The Chair convened the meeting at 8:30 a.m. and called for discussion of key points in the responses to the charge questions. Members discussed the key points summarized in Attachment G.

Following discussion of the key points in responses to the charge questions, the Chair called for discussion of points to be included in the letter to the Administrator. Members discussed the following points.

- Excessive nutrient enrichment is a major cause of water quality impairment and the Guidance provides a primer on some statistical methods that could be used to develop stressor-response relationships.
- Statistical associations do not prove cause and effect.
- More information is needed to explain the scope and intended use of the Guidance. (EPA should more clearly articulate how the Guidance fits in the Agency's decision making and regulatory processes and how it relates to other approaches).
- Additional information is needed in the Guidance on limitations of the statistical methods and approaches as well as the supporting analyses and data needed to use the methods.
- There is a need for more examples to illustrate use of the methods and a more specific and descriptive framework outlining steps in the criteria development process.
- The stressor-response approach should be used with other available methodologies in the context of a tiered approach where uncertainties in different approach are recognized and weight of evidence is used to establish the likelihood of causal relationships between nutrients and their effects for criteria derivation.
- The Guidance does not address the downstream impacts of excess nutrients.
- EPA should invest in providing technical support for users of the approaches in the Guidance.
- The Committee stands ready to provide additional advice as EPA continues to develop nutrient criteria guidance

Following the discussion of key points for the letter, the Chair reviewed the next steps and schedule for completion of the Committee's advisory report. She stated that the Committee writing groups would send charge question responses to the DFO who would work with the Chair to prepare a first draft of the advisory report. The draft report would then be sent to Committee members for review and comment. The DFO would then work with the Chair on a second draft which would be sent to the Committee for discussion on a public teleconference. Following the teleconference any additional changes needed would be incorporated into the report and a third draft would be sent to the Committee for review and concurrence. Following concurrence the report would be submitted to the chartered Science Advisory Board for final quality review.

The Chair then asked EPA staff for any final comments to the Committee. Drs. Edward Ohanian Dana Thomas of EPA's Office of Water thanked the Committee for reviewing the Guidance and indicated that they looked forward to seeing the Committee's advisory report. The Chair then thanked the members for their work and thanked EPA staff for presenting information and responding to the Committee's questions. She then adjourned the meeting.

Respectfully Submitted:

/Signed/

Dr. Thomas Armitage
Designated Federal Officer

Certified as True:

/Signed/

Dr. Judith L. Meyer, Chair
SAB Ecological Processes and Effects Committee

ATTACHMENTS

Attachment A: Committee Roster

Attachment B: Meeting Agenda

Attachment C: Charge to the Committee

Attachment D: EPA Presentation: Deriving Numeric Nutrient Water Quality Criteria (Edward Ohanian and Dana Thomas, EPA Office of Water)

Attachment E: EPA Presentation: Overview - Empirical Approaches for Nutrient Criteria Derivation (Lester Yuan and John Paul, EPA Office of Research and Development)

Attachment F: Written Public Comments

Attachment G: Summary of Key Points Discussed in Response to the Charge Questions

U.S. Environmental Protection Agency
Science Advisory Board
Ecological Processes and Effects Committee Augmented for Review of Nutrient Criteria Guidance

CHAIR

Dr. Judith L. Meyer, Distinguished Research Professor Emeritus, University of Georgia, Lopez Island, WA

MEMBERS

Dr. Richelle Allen-King, Professor and Chair, Department of Geology, University at Buffalo, Buffalo, NY

Dr. Ernest F Benfield, Professor of Ecology, Department of Biological Sciences, Virginia Tech, Blacksburg, VA

***Dr. Ingrid Burke**, Director, Haub School and Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, Laramie, WY

Dr. G. Allen Burton, Professor and Director, Cooperative Institute for Limnology and Ecosystems Research, School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI

Dr. Peter Chapman, Principal and Senior Environmental Scientist, Environmental Sciences Group, Golder Associates Ltd, Burnaby, BC, Canada

Dr. Loveday Conquest, Professor, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA

Dr. Wayne Landis, Professor and Director, Department of Environmental Toxicology, Institute of Environmental Toxicology, Huxley College of the Environment , Western Washington University, Bellingham, WA

Dr. James Oris, Professor, Department of Zoology, Miami University, Oxford, OH

***Dr. Charles Rabeni**, Research Professor, Department of Fisheries & Wildlife, University of Missouri, Columbia, MO

Dr. Amanda Rodewald, Associate Professor of Wildlife Ecology, School of Environment and Natural Resources, The Ohio State University, Columbus, OH

Dr. James Sanders, Director and Professor, Skidaway Institute of Oceanography, Savannah, GA

Mr. Timothy Thompson, Senior Environmental Scientist, Science and Engineering for the Environment, LLC, Seattle, WA

***Dr. Ivor van Heerden**, Director, Center for the Study of Public Health Impacts of Hurricanes, Louisiana State University, Baton Rouge, LA

CONSULTANTS

Dr. Victor Bierman, Senior Scientist, LimnoTech, Oak Ridge, NC

Dr. Elizabeth Boyer, Associate Professor, School of Forest Resources and Assistant Director, Pennsylvania State Institutes of Energy & the Environment, and Director, Pennsylvania Water Resources Research Center, Pennsylvania State University, University Park, PA

Dr. Mark David, Professor, Natural Resources & Environmental Sciences, University of Illinois, Urbana, IL

Dr. Douglas McLaughlin, Principal Research Scientist, National Council for Air and Stream Improvement, Inc., Western Michigan University, Kalamazoo, MI

Dr. Patrick J. Mulholland., Distinguished Research Staff Member, Carbon & Nutrient Biogeochemistry Group, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN

Dr. Andrew N. Sharpley, Research Soil Scientist, Department of Crop, Soil and Environmental Sciences, University of Arkansas, Fayetteville, AR

SCIENCE ADVISORY BOARD STAFF

Dr. Thomas Armitage, Designated Federal Officer, U.S. Environmental Protection Agency, Washington, DC

* Did not participate in this advisory activity.

U.S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD
Ecological Processes and Effects Committee Augmented for the Review of Nutrient Criteria Guidance
Public Meeting, September 9-11, 2009

Marriott at Metro Center Hotel
775 12th Street, N.W., Washington, D.C. 20005

AGENDA

Wednesday, September 9, 2009

9:00 - 9:10 a.m.	**Meeting Convened by the Designated Federal Officer** Dr. Thomas Armitage
	Welcoming Remarks Dr. Anthony Maciorowski, Deputy Director EPA Science Advisory Board Staff Office
9:10 - 9:20 a.m.	**Purpose of the Meeting and Review of Agenda** Dr. Judith Meyer, Chair
9:20 - 10:05 a.m.	**Overview of EPA Activities to Develop Water Quality Criteria for Nutrients -- Historical Perspective and Future Direction** Dr. Edward Ohanian, Director, Health and Ecological Criteria Division, EPA Office of Water
	Dr. Dana Thomas, EPA Office of Water
10:05 - 11:00 a.m.	**Review of Empirical Approaches for Nutrient Criteria Derivation Presented in EPA's Draft Guidance Document** Dr. Dana Thomas, EPA Office of Water
	Dr. Lester Yuan, EPA Office of Research and Development
	Dr. John Paul, EPA Office of Research and Development

11:00 - 11:15 a.m.	**BREAK**
11:15 a.m. - 12:00 noon	**Public Comments**
12:00 noon - 1:00 p.m.	**LUNCH**
1:00 - 3:00 p.m.	**Public Comments (Continued)**
3:00 - 3:15 p.m.	**BREAK**
3:15 - 4:30 p.m.	**Committee Discussion of Selecting Stressor and Response Variables, and Assessing the Strength of the Cause-Effect Relationship (response to charge questions 2 and 4)** Lead Discussants: Dr. Patrick Mulholland, Dr. Mark David, Dr. Fred Benfield, and Dr. Victor Bierman
4:30 - 5:45 p.m.	**Committee Discussion of Methods for Analyzing the Data (response to charge question 5)** Lead Discussants: Dr. Douglas McLaughlin, Dr. Loveday Conquest, Dr. Elizabeth Boyer, Dr. Richelle Allen-King, and Dr. Ivor van Heerden
5:45 p.m.	**Recess for Day**

Thursday, September 10, 2009

8:15 - 8:45 a.m.	**Committee Discussion of Methods for Analyzing the Data (response to charge question 5) Continued**
8:45 - 10:00 a.m.	**Committee Discussion of Methods to Visualize Available Data (response to charge question 3)** Lead Discussants: Dr. Victor Bierman, Dr. Allen Burton, Dr. James Oris, Dr. Patrick Mulholland, and Dr. Ivor van Heerden
10:00 - 10:15 a.m.	**BREAK**
10:15 - 11:15 a.m.	**Committee Discussion of Evaluating Estimated Stressor-Response Relationships (response to charge question 6)** Lead Discussants: Dr. Elizabeth Boyer, Dr. Loveday Conquest, Dr. James Oris, Dr. Douglas McLaughlin, and Dr. James Sanders

11:15 a.m. - 12:15 p.m.	**Committee Discussion of Methods for Evaluating Candidate Stressor-Response Criteria (response to charge question 7)** Lead Discussants: Dr. Andrew Sharpley, Dr. Wayne Landis, Dr. Peter Chapman, Mr. Timothy Thompson, and Dr. Fred Benfield
12:15 - 1:15 p.m.	**LUNCH**
1:15 - 2:30 p.m.	**Committee Discussion of Suggestions to Improve the Utility of EPA's Draft Guidance for Deriving Numeric Nutrient Criteria (response to charge question 1)** Lead Discussants: Dr. Amanda Rodewald, Mr. Timothy Thompson, Dr. James Sanders, Dr. Wayne Landis, and Dr. Ingrid Burke
2:30 - 5:00 p.m.	**Writing Session by Committee Subgroups**
5:00 p.m.	**Recess for the Day**

Friday, September 11, 2009

8:30 - 10:00 a.m.	**Discussion of Key Points in Response to the Charge Questions (1-7)** Dr. Judith Meyer and Committee
10:00 - 10:15 a.m.	**BREAK**
10:15 - 11:00 a.m.	**Discussion (continued)** Dr. Judith Meyer and Committee
11:00 - 11:50 a.m.	**Summary of Major Recommendations** Dr. Judith Meyer and Committee
11:50 a.m. - 12:00 noon	**Meeting Summary and Next Steps** Dr. Judith Meyer
12:00 noon	**Adjourn**

Attachment C – Committee Charge

Charge to the

Science Advisory Board (SAB)
ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE

For Review of Guidance on:

EMPIRICAL APPROACHES FOR NUTRIENT CRITERIA DERIVATION

Prepared by the
EPA Office of Water,
Office of Science and Technology

September 9th – 11th, 2009

Background

The U.S. Environmental Protection Agency (EPA), Office of Water, is charged with protecting aquatic life, wildlife and human health from adverse anthropogenic, water-mediated effects under the purview of the Clean Water Act (CWA). Under the CWA, States, authorized Tribes, and Territories (hereafter referred to collectively as "States")

are responsible for establishing water quality standards that include the designated uses, such as aquatic life protection and recreation, and water quality criteria that protect the designated uses. EPA's Office of Science and Technology (OST) is responsible for deriving national recommended water quality criteria that serve as guidance to States to assist them in establishing water quality standards.

The Nutrient Problem
Aquatic ecosystems require nutrients, such as nitrogen and phosphorus, to function naturally, but excess nutrients are harmful. Many of our nation's waters, including rivers, lakes, estuaries, and coastal marine waters, are affected by nitrogen and phosphorus pollution.

Excess nitrogen and phosphorus in waters can produce excess plant and algal growth. The excess primary production is then decomposed, a process that consumes oxygen and is, itself stimulated by nutrients as well. Low oxygen conditions (hypoxia and anoxia) result in insufficient oxygen to support aquatic life. The process is the basis for large "dead zones" found in many coastal areas.

The biannually published National Water Quality Inventory Report to Congress indicates that nutrients (nitrogen and phosphorus) are consistently a major source of water quality impairment in the Nation's waters. Since the first report published in 1992, nutrients have ranked in the top five causes of water quality impairment each time.

Sources of Nitrogen and Phosphorus Pollution
- Overusing fertilizer (both residential and agricultural usage)
- Storm runoff from cropland, Animal Feeding Operations and pastures
- Storm runoff from urban and suburban areas (e.g., parking lots, lawns, rooftops, roads)
- Discharge of nitrogen and phosphorus from wastewater treatment plants
- Overflow from septic systems
- Atmospheric deposition

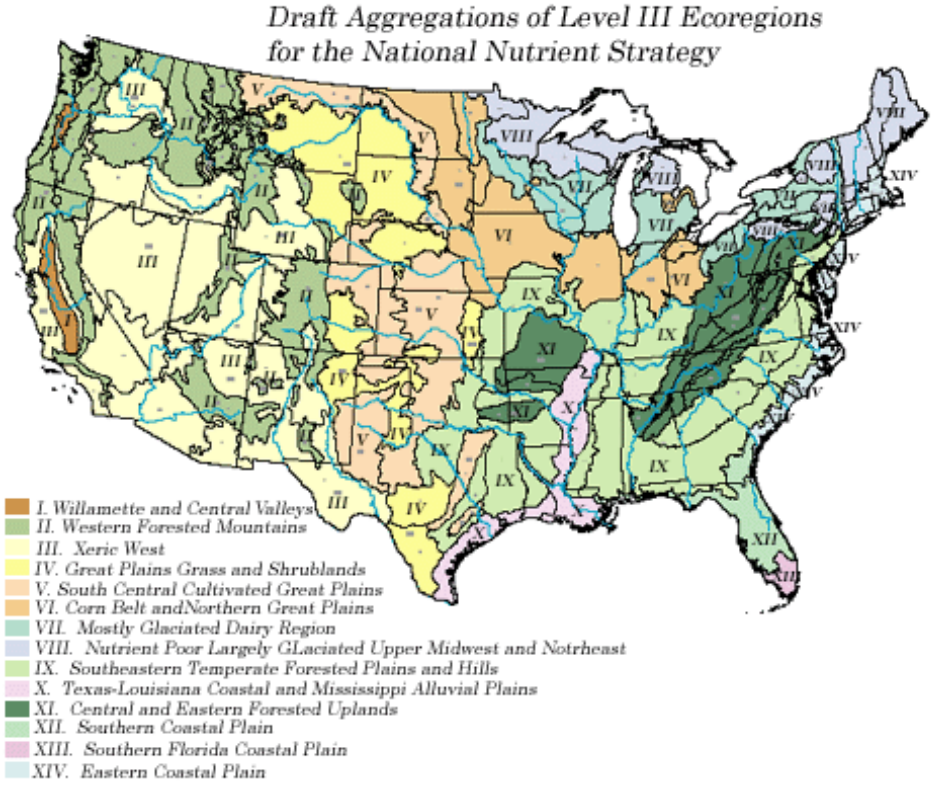
National Nutrient Strategy

EPA seeks to improve the progress of State adoption of numeric nutrient criteria into their WATER QUALITY STANDARDS by building on the scientific and technical foundation for deriving criteria to address nitrogen and phosphorus pollution.

In order to expand and update EPA nutrient related guidance, the Agency held a National Nutrient Assessment Workshop (see Proceedings of the National Nutrient Assessment Workshop: December 4-6, 1995, EPA 822-R-96-004). In response to this workgroup effort to address nutrient assessment and over-enrichment, EPA published a peer reviewed national nutrient strategy (The National Strategy for the Development of Regional Nutrient Criteria) (http://www.epa.gov/waterscience/criteria/nutrient/strategy/index.html#strategy) in June

1998 that set the roadmap to develop and publish numeric nutrient water quality criteria recommendations.

The June 1998 strategy described the approach to develop nutrient information and work with States to adopt nutrient criteria as part of their water quality standards. It presented over-enrichment assessment tools and recognized current capabilities for conducting these assessments at regional watershed and waterbody levels. The major focus of the strategy was the development of waterbody-type technical guidance and ecoregion-specific nutrient criteria. Once the waterbody-type guidance and nutrient criteria were established, EPA expected States to adopt numeric nutrient criteria into water quality standards.



At the time the 1998 strategy was written, the only national nutrient related criteria that existed were from EPA's 1976 publication entitled Quality Criteria for Water (also known as the Red Book) in which EPA presented ambient water quality criteria for nitrates and elemental phosphorus. The criterion for nitrate was 10 mg/L for the protection of domestic water supplies. The nitrate criterion was intended to protect human and animal health. The phosphorus criterion was 0.10 µg/L elemental phosphorus for the protection of marine and estuarine waters. This criterion was based on a conservative estimate to protect against the toxic effects of the bioconcentration of elemental phosphorus to estuarine and marine organisms, and not on the potential to cause eutrophication.

As stated in the 1998 strategy, EPA believed the development of waterbody-type guidance and regional nutrient criteria could only be successfully accomplished with the cooperation and contributions of EPA regional offices and States, with the assistance of other expert parties. EPA regions were asked to form regional nutrient teams to draw on the talents and knowledge of States, universities and other interested/concerned parties within each EPA Region. States were specifically asked to provide information on nutrient levels in their surface waters to help provide information essential for identifying reference conditions (minimally impacted waters) and developing regional nutrient criteria.

Nutrient Criteria Development Guidance

EPA published peer reviewed technical guidance for developing nutrient criteria for lakes and reservoirs in April 2000, rivers and streams in July 2000, estuaries and coastal marine waters in October 2001, and wetlands in June 2008. These technical guidance documents describe the techniques used to develop numeric nutrient criteria for use in State water quality standards. They provide background information on classifying waterbodies, selecting criteria variables, designing monitoring programs, analyzing nutrient and algal data, deriving regional criteria, and implementing management practices. These guidance documents describe a reference condition approach for deriving nutrient criteria from distributions of nutrient concentrations and biological responses in minimally disturbed reference waterbodies. Each document can be accessed from OST's website: http://www.epa.gov/waterscience/criteria/nutrient/guidance/index.html

Prior to the wetlands guidance manual, EPA published several methods modules (March 2002) to give States the "state-of-the-science" information that will help them develop biological assessment methods to evaluate both the overall ecological condition of wetlands and nutrient over- enrichment, see http://www.epa.gov/waterscience/criteria/nutrient/guidance/wetlands/#modules

Ecoregional Nutrient Criteria

Using the reference condition approach described in the EPA's previously published nutrient criteria guidance for lakes and reservoirs, rivers and streams, estuaries and coastal marine waters, and wetlands, the Agency has developed numeric nutrient criteria values for both causal (total phosphorus (TP) and total nitrogen (TN)) and response (chlorophyll *a*, and measures of water clarity, e.g., Secchi depth, turbidity) variables. These criteria were to be used to help identify problem areas, serve as the basis of development for State numeric nutrient criteria, and evaluate relative success in reducing anthropogenic eutrophication.

EPA published 26 peer-reviewed ecoregional criteria documents in 2001 and 2002 that cover most waterbodies in the U.S. (12 lakes & reservoirs, 13 rivers & streams, and 1 wetland). These documents have numeric nutrient criteria values published as

recommendations to States in setting water quality standards. These documents can be accessed at the following websites: http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/lakes/index.html, http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/rivers/index.html, and http://www.epa.gov/waterscience/criteria/nutrient/ecoregions/wetlands/wetlands_13.pdf. Each document has tables that present the recommended criteria for each of the aggregate nutrient ecoregions for the following parameters: TP, TN, chlorophyll *a*, and turbidity or Secchi depth. These criteria values were intended as starting points for States to develop their own State-specific criteria.

Why Numeric Nutrient Criteria are Important

Numeric nutrient water quality standards drive water quality assessments and watershed protection management. They support improved development of nutrient related Total Maximum Daily Loads (TMDLs) (i.e., the calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards). Perhaps most importantly, they will create environmental baselines that allow EPA and States to manage more effectively, measure progress, and support broader partnerships based on nutrient trading, Best Management Practices (BMPs), land stewardship, wetlands protection, voluntary collaboration, and urban stormwater runoff control strategies. The progress of States in setting numeric nutrient water quality standards is extremely important to help address nutrient pollution. Adopting numeric standards has a number of key advantages:

- easier and faster development of TMDLs;
- quantitative targets to support trading programs;
- easier to write protective NPDES permits(i.e., permits to regulate the discharge of pollutants under the Clean Water Act);
- increased effectiveness in evaluating success of nutrient runoff minimization programs; and
- measurable objective water quality baselines against which to measure environmental progress.

Current Status

Over the last eleven years, EPA has taken a number of steps to provide leadership and articulate its commitment of working in partnership with States to establish quantitative endpoints to minimize excess nutrient loadings in our nation's waters. As stated previously, EPA issued a National Strategy for the development of regional nutrient criteria in June 1998, and followed it with a November 2001 Policy Memo for the development and establishment of numeric nutrient criteria. (http://www.epa.gov/waterscience/criteria/nutrient/files/nutrientswqsmemo.pdf).

Progress has been made, and a number of States have already moved ahead to establish numeric criteria for priority waterbodies. Others are in the process of collecting data. Still others are in the earlier stages of planning and deciding which criteria derivation

approach will work best for them. In a more recent policy memo issued in 2007, which can be found at: http://www.epa.gov/waterscience/criteria/nutrient/files/policy20070525.pdf, EPA restated its commitment to support all efforts to adopt numeric nutrient criteria that are protective of designated uses.

How Will Information in the Empirical Approaches Document Be Used?

As stated in previously published guidance manuals, basic analytical approaches for nutrient criteria derivation include: (1) the reference condition approach, (2) stressor-response analysis, and (3) mechanistic modeling. EPA's draft guidance document, *Empirical Approaches for Nutrient Criteria Derivation* elaborates on the second of these three. The purpose of this guidance document is to provide information on the scientific foundation for using empirical approaches to describe stressor-response relationships for developing numeric nutrient criteria. This document supports and is consistent with existing nutrient criteria guidance (USEPA 2000a, 2000b, 2001, and 2008). The statistical and analytical approaches described in the document represent a scientifically defensible means of identifying patterns and relationships in field data. Examples illustrate how these approaches could be applied for purposes of deriving numeric nutrient criteria. Although the examples provided focus on streams and lakes, the information presented in the document should be applicable to any waterbody type. The document is intended for State, local and tribal government water resource managers and other interested stakeholders, with some scientific training.

EPA is seeking advice from the Science Advisory Board (SAB) Ecological Processes and Effects Committee regarding the technical soundness of these empirical approaches as the basis for future development of numeric nutrient water quality criteria.

Charge to SAB

Overall

1. What suggestions do you have that will improve the utility of the draft document, *Empirical Approaches for Nutrient Criteria Derivation,* for State water quality scientists and resource managers to derive numeric nutrient criteria based on stressor-response relationships?

Using an Empirical Stressor-Response Relationship to Set a Nutrient Criterion

2. Section 1 of the draft guidance document reviews how to select the variables that appropriately quantify the stressor (i.e., excess nutrients) and the response (e.g., chlorophyll *a*, dissolved oxygen, or a biological index). Please comment on whether the factors to consider described in section 1 of the draft document are

appropriate for selecting response variables that are sensitive to nutrients and related to measures of designated uses.

3. In addition, Section 1 outlines methods to visualize available data. Please comment on the effectiveness of the following approaches described in the document (listed below) to demonstrate the distribution of and relationships among variables.

    a) Basic data visualization techniques
    b) Maps
    c) Conditional probability
    d) Classifications

4. Section 2 of the draft guidance document describes methods for assessing the strength of the cause-effect relationship represented in the stressor-response linkage. Please comment on whether the draft guidance document adequately describes how conceptual models, existing literature, and empirical models can be used to assess how changes in nutrient concentration are likely to cause changes in the chosen response variable.

Analyzing Data

5. Section 3 of the draft guidance document outlines statistical methods to analyze the data to estimate stressor-response relationships. Please comment on the appropriateness of the methods outlined in the document (listed below) for describing stressor-response relationships associated with nutrient pollution. What approaches would you recommend that could effectively address indirect pathways of adverse effects? What recommendations do you have to address the effects of confounding variables and uncertainty in the estimated relationships?

    a) Simple linear regression
    b) Quantile regression
    c) Logistic regression
    d) Multiple linear regression
    e) Non-parametric changepoint analysis
    f) Discontinuous regression models

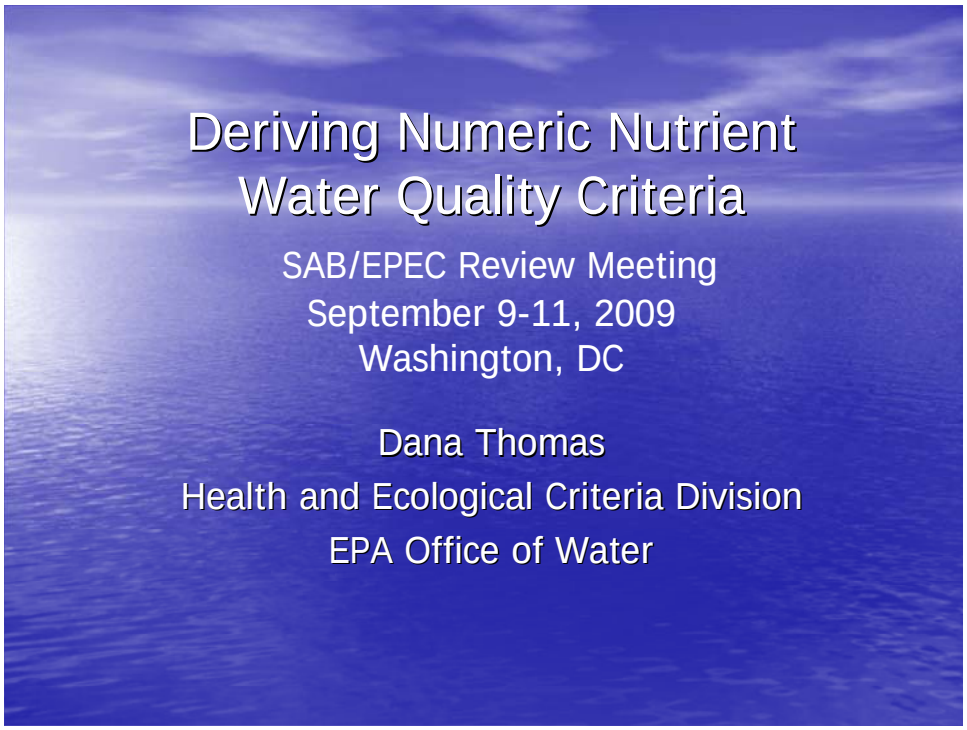
Evaluating Estimated Stressor-Response Relationships

6. Section 4 of the draft guidance document describes how to evaluate the predictive accuracy of estimated stressor-response relationships. Please comment on the appropriateness of approaches in Section 4 of the guidance document and factors to consider in evaluating and comparing different estimates of the stressor-response relationships and selecting those most appropriate for criteria derivation.

Evaluating Candidate Stressor-Response Criteria

7. Section 5 of the draft guidance document describes how to evaluate the candidate stressor-response criteria. An approach is outlined for predicting conditions that might result after implementing different nutrient criteria. Please comment on uncertainties that would remain if water quality criteria for nutrients were based solely on estimated stressor-response relationships and in what ways would other information/analysis help address and possibly reduce this uncertainty?

Attachment D – Presentation: Deriving Numeric Nutrient Water Quality Criteria (Edward Ohanian and Dana Thomas)



Scope and Impacts of Nutrient Pollution

- The amount of nutrients entering our waters has escalated over the last 50 years.
- Nutrients pose significant water quality and public health concerns across the U.S.
- As the U.S. population continues to increase, the rate and impact of nutrient pollution will also accelerate.

Water Quality Impairment

- Nationally, nutrient pollution is one of the top causes of water quality impairment.
- States continue to report over 14,000 nutrient related impairments.
  - Over 80,000 miles of rivers and streams
  - Over 2.5 million acres of lakes and reservoirs
  - 168 hypoxic zones in U.S. estuarine and coastal waters

Major Sources of Nutrient Pollution

- Urban Stormwater Runoff
- Municipal Wastewater Treatment
- Atmospheric Nitrogen Deposition
- Agricultural Livestock Activities
- Agricultural Row Crops

Examples of Recent Key Reports on Nutrient Pollution

- EPA SAB 2009: *Reactive Nitrogen in the United States: An analysis of Inputs, Flows, Consequences, and Management Options*
- EPA SAB 2007: *Hypoxia in the Northern Gulf of Mexico*
- NRC 2008: *Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities*
- NRC 2008: *Urban Stormwater Management in the United States*
- EPA 2008: *National Coastal Condition Report III*
- EPA 2006: *Wadeable Streams Assessment*
- NOAA 2007: *Effects of Nutrient Enrichment in the Nation's Estuaries: A Decade of Change*

Clean Water Act

- §101(a): objective is to restore and maintain the chemical, physical and biological integrity of the Nation's waters
  - National goal of "water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water"
- §303(c): provides for State adoption and EPA approval of water quality standards that include the designated use, **criteria**, and antidegradation provisions
- §304(a): requires EPA to develop and publish water quality criteria for pollutants accurately reflecting the latest scientific knowledge that serve as recommendations to the States

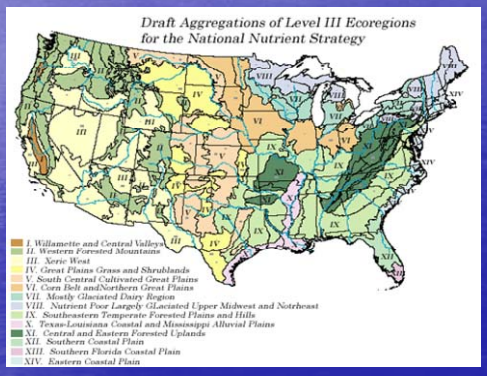
Why Numeric Nutrient Criteria are Important

- Water quality baselines against which to measure environmental progress
- Facilitate the writing of protective NPDES permits
- Easier and timely development of TMDLs
- Targets to support trading programs

National Nutrient Strategy

- The National Nutrient Strategy (June 1998) provided blueprint for developing nutrient information and collaborating with States to adopt numeric nutrient criteria into water quality standards.
- Strategic focus on
  - Development of waterbody type technical guidance manuals
  - Ecoregional numeric nutrient criteria recommendations
  - Regional Technical Assistance Groups (RTAGs)
  - Funding of nutrient criteria development efforts in States, Territories and Tribes

National Nutrient Ecoregions



Technical Guidance Manuals

- Waterbody specific technical guidance manuals recommended approaches for deriving numeric nutrient criteria including reference condition, stressor-response, and mechanistic modeling.
  - Lakes & Reservoirs (2000)
  - Rivers & Streams (2000)
  - Estuaries & Coastal Marine Waters (2001)
  - Wetlands (2008)

Ecoregional Nutrient Criteria

- Using the reference condition approach, EPA published numeric nutrient criteria recommendations for 4 parameters – TN, TP, chl *a*, and a measure of clarity
  - Lakes & Reservoirs (12 ecoregions)
  - Rivers & Streams (13 ecoregions)
  - Wetlands (1 ecoregion)

Current Status

- Progress has been made, but slower than expected.
- In 2008, EPA analyzed the status of State adoption of numeric nutrient criteria over the past 10 years.
  - 7 States have adopted numeric criteria for at least one parameter for at least one waterbody type.
  - 18 States have adopted numeric criteria for at least one parameter for selected waters.
  - 25 States have no numeric criteria.

EPA Office of Inspector General Evaluation Report

- In August 2009, the OIG published their review of EPA's nutrient criteria program
  - "EPA Needs to Accelerate Adoption of Numeric Nutrient Water Quality Standards"
- Key findings:
  - States have been slow to adopt numeric standards
  - EPA needs to ensure the protection of downstream waters
  - EPA needs to better monitor State progress and hold itself and the States accountable

Future Directions

- Continue to provide technical guidance and support that reflect the state of the science to facilitate criteria derivation and the standards adoption process
- Look for ways to accelerate the adoption of numeric nutrient water quality standards to meet CWA requirements

State Nutrient Criteria Plans

- 43 States have nutrient criteria development plans that have been reviewed and mutually agreed upon by EPA.
- Of these, the majority of States are interested in deriving numeric criteria using stressor-response relationships.

About the Empirical Approaches Document

- The purpose of this document is to provide current information on the scientific foundation for using empirical approaches to describe stressor-response relationships for deriving numeric nutrient criteria.
- This document acts as a supplement to the previously published guidance on nutrient criteria derivation.
- The document is intended for use by State water quality scientists and resource managers.

Prior Review of this Document

- EPA internal peer reviews from:
  - Scientific, Regional, and Management
- Informal external peer reviews from:
  - Academia and one State

Overall Charge to SAB

- What technical suggestions do you have that will improve the utility of the draft document for State water quality scientists and resource managers to derive numeric nutrient criteria based on stressor-response relationships?

Attachment E – Presentation: Overview - Empirical Approaches for Nutrient Criteria Derivation (Lester Yuan and John Paul)

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Overview: Empirical Approaches for Nutrient Criteria Derivation

Lester L. Yuan, John F. Paul, and Dana Thomas

Office of Research and Development
National Center for Environmental Assessment and National Health and Environmental Effects Research Laboratory

January 8, 2010

EPA United States Environmental Protection Agency

Purpose of the document

- Provide guidance on using known and accepted statistical methods to estimate stressor-response relationships from field data and on deriving nutrient criteria from these relationships to support the advancement of environmental protection and achieve water quality goals.

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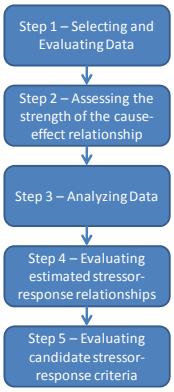
Five step framework for using stressor-response relationships to derive nutrient criteria

1. Select and evaluate data
2. Assess strength of cause-effect relationship
3. Analyze data
4. Evaluate estimated stressor-response relationships
5. Evaluate candidate stressor-response criteria



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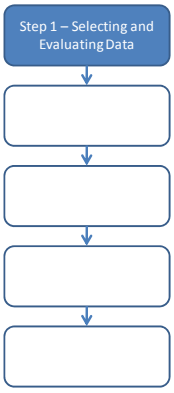
Step 1: Select and evaluate data



- Identify variables that quantify nutrient concentrations and a response variable that relates to a water quality goal.
  - Nutrient concentration variables: (e.g.,TN, TP)
  - Response variables:
    - Relate to water quality goal (e.g., aquatic life protection)
    - Causally relate to changes in nutrient concentrations
- Explore data set to understand relationships between nutrient variables, response variables, and possible confounding variables.

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Identify variables

- Example Dataset: Lakes from the Northeast United States, sampled by the Environmental Monitoring and Assessment Program
- Nutrient variable: total phosphorus (TP)
- Response variable: chlorophyll a (chl-a)
  - *Assume for illustrative purposes that chl-a = 15 µg/L is the threshold to support aquatic life protection in Northeast Lakes.*

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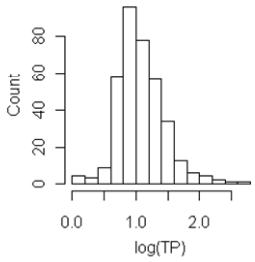
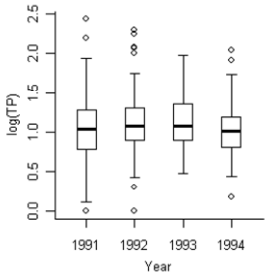
Examine data distributions

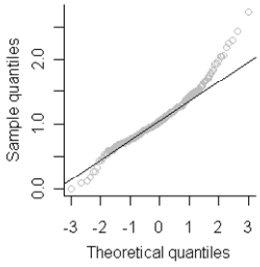
Histograms



Boxplots

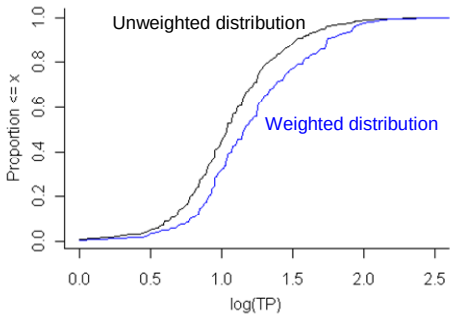


Q-Q plots



Cumulative distribution functions

- View distribution of data and allows for weighting of data from probability samples.



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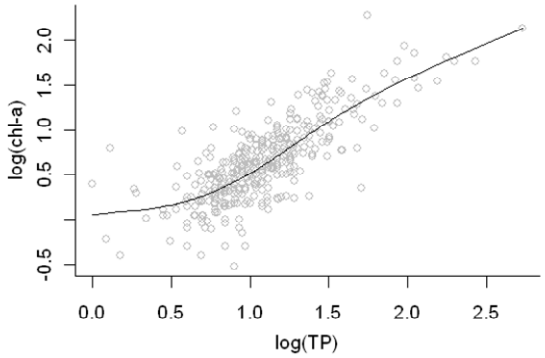
Fit nonparametric curves to data

- Helps visualize relationships between variables



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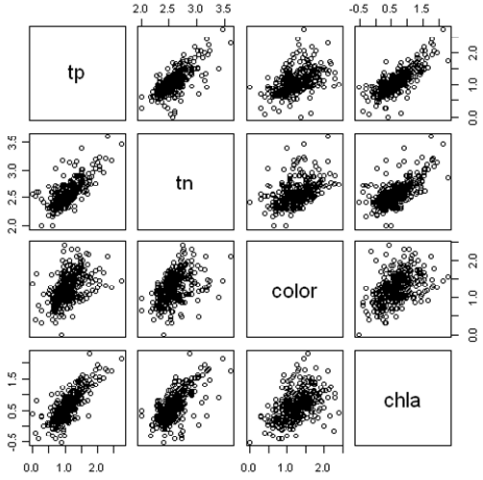
Examine covariance among several different variables



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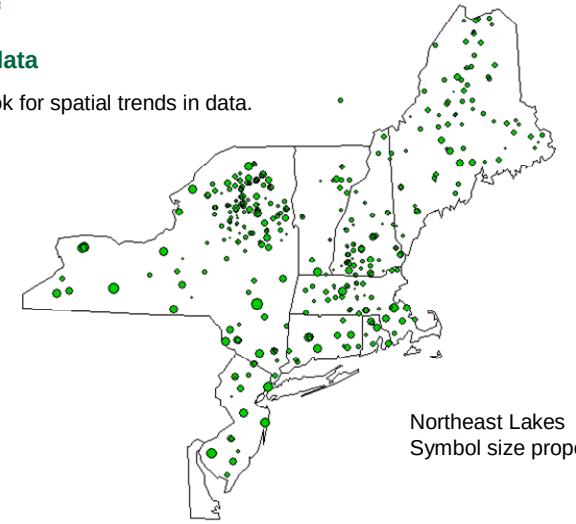
Map data

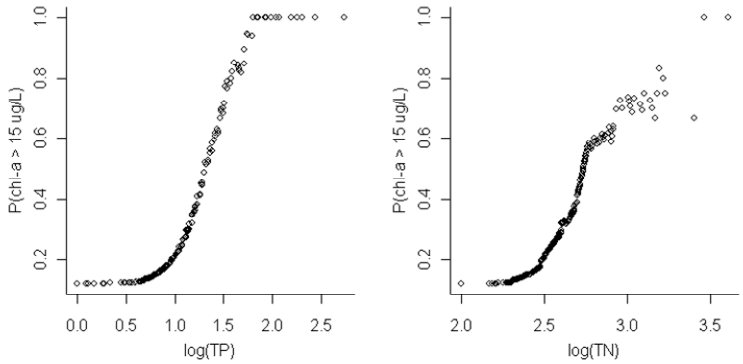
Look for spatial trends in data.



Northeast Lakes
Symbol size proportional to log(chl-a)

Conditional probability analysis (CPA)

CPA quantifies the probability of not supporting water quality goal, given different nutrient concentrations.



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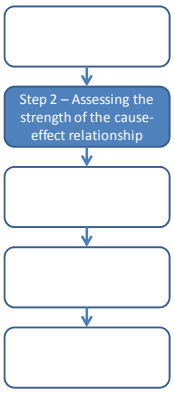
Step 2: Assess strength of the cause-effect relationship

- Conceptual model: Describe sequence of relationships by which nutrients affect response variable
- Existing literature: Document cause-effect relationships observed in other studies.
- Additional analyses:
  - Structural Equation Modeling
  - Propensity Score Analysis



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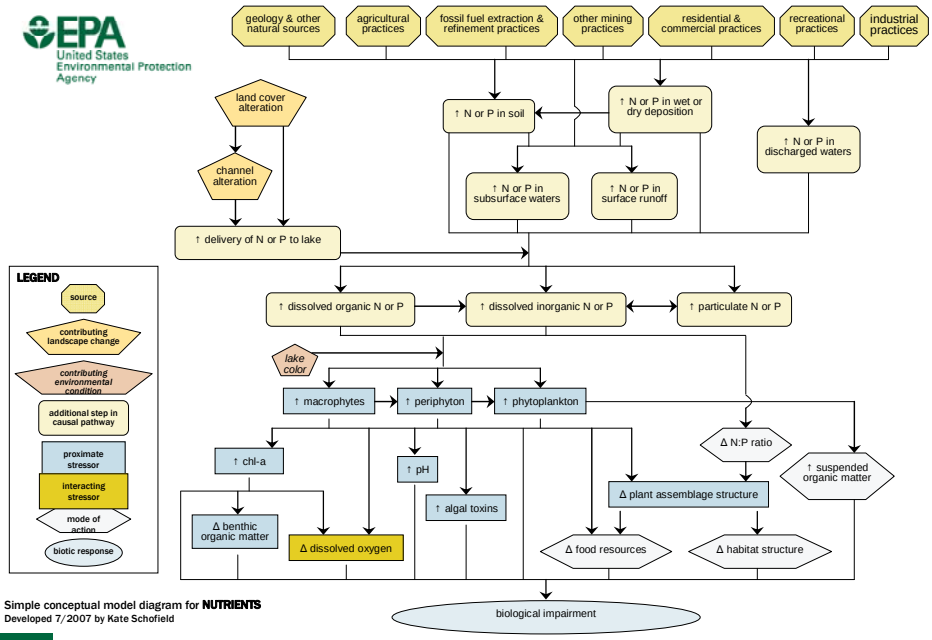

Simple conceptual model diagram for **NUTRIENTS**
Developed 7/2007 by Kate Schofield

Cause-effect relationships between TP and chl-a in literature

For example, increased total phosphorus increases chlorophyll a concentration

Supporting evidence includes:

- Whole lake fertilization experiments (Schindler 1974, 1977; Stockner and Shortreed, 1985; Carpenter et al. 1996)
- Consistent relationships estimated from observational data collected from many different locations.

Step 3: Analyze data

Two distinct approaches for informing criterion derivation from a stressor-response relationship.

1. Threshold is known for response variable

   Stressor-response relationship is used to "translate" response threshold to a protective nutrient concentration.

2. No threshold available for response variable

   Use characteristics of the stressor-response relationship to inform the derivation of a criterion.

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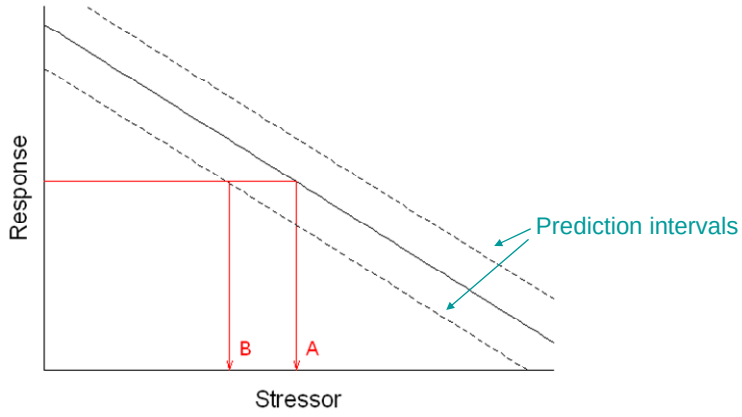
Step 3: Analyze data

Translate a known response threshold



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Translate a known response threshold:

Methods for estimating the stressor-response relationship

- Simple linear regression
- Quantile regression
- Logistic regression

- Multiple linear regression

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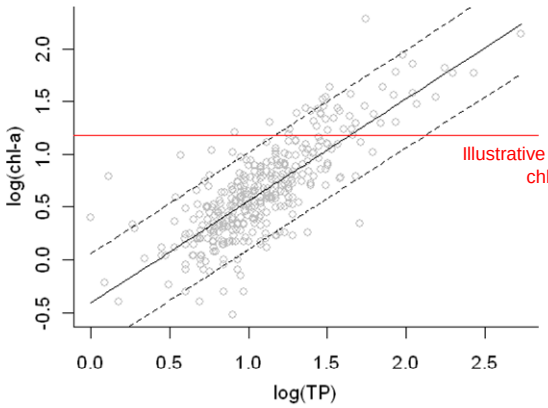
Simple linear regression



Illustrative response threshold:
chl-a = 15 µg/L

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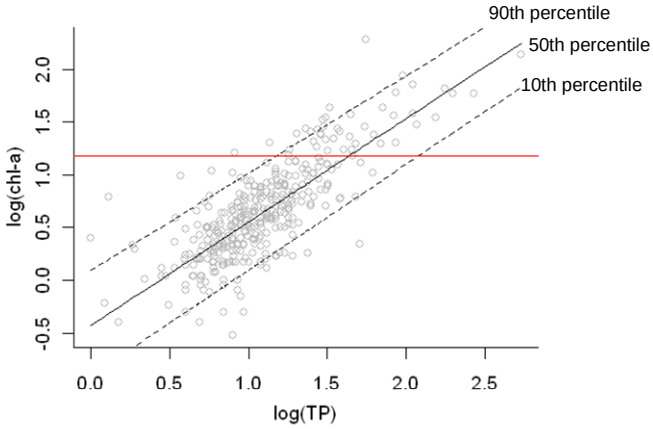
Quantile regression



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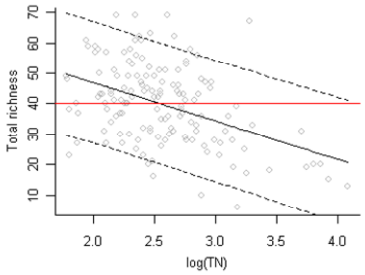
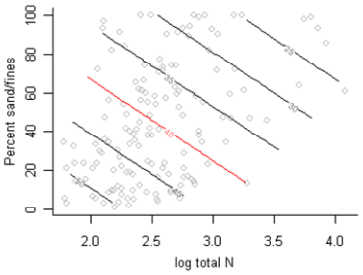
Multiple linear regression

Multiple linear regression models can be useful when nutrients are one of many factors influencing biota.

Many factors, in addition to nutrients, influence macroinvertebrate richness:



$R^2 = 0.19$



$R^2 = 0.32$

Data from EMAP-West

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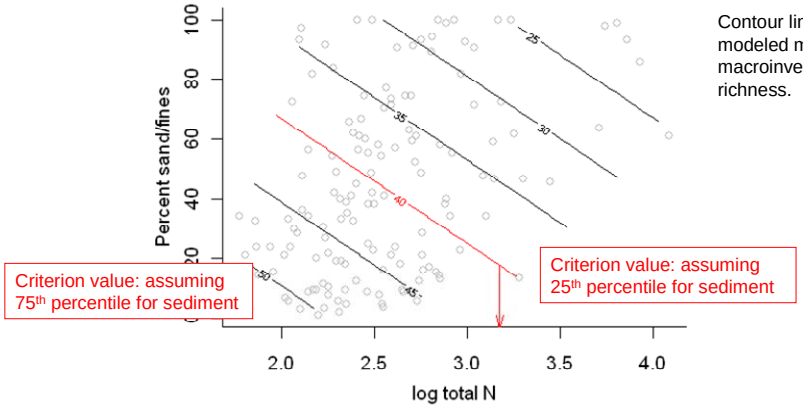
Use results from multiple linear regression to translate an existing response threshold



Contour lines indicate modeled mean macroinvertebrate richness.

Step 3: Analyze data

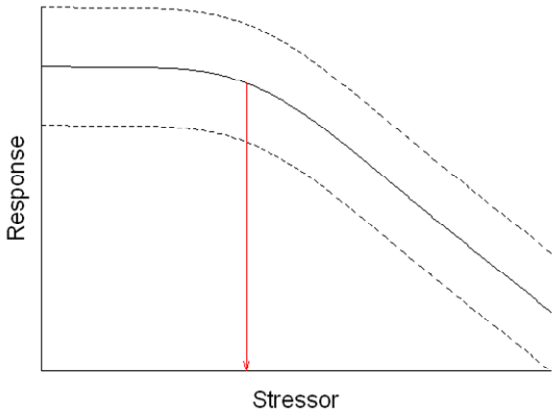
Two distinct approaches for informing criterion derivation from a stressor-response relationship.

1. Threshold is known for response variable
   Stressor-response relationship is used to "translate" response threshold to a protective nutrient concentration.

2. No threshold available for response variable
   Use characteristics of the stressor-response relationship to inform the derivation of a criterion.

Step 3: Analyze data

Use characteristics of the stressor-response relationship



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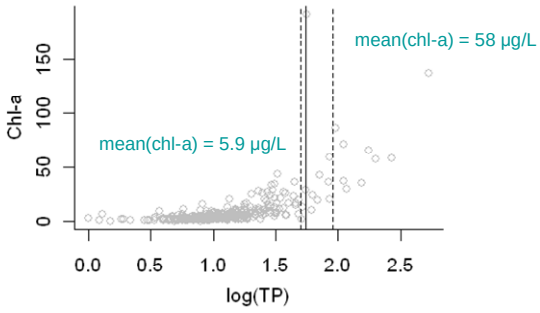
Methods for identifying characteristics of the stressor-response curve

- Nonparametric changepoint analysis
- Discontinuous regression models

Nonparametric changepoint analysis



Data from Northeast Lakes

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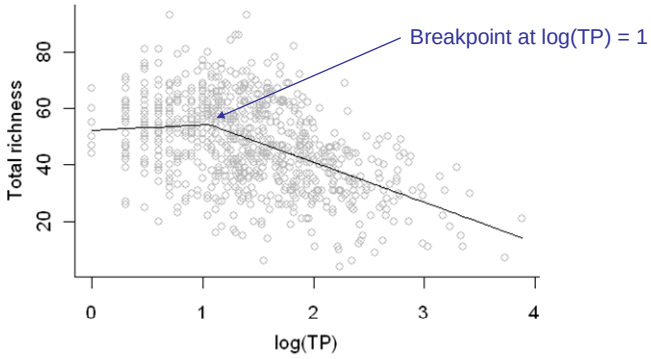
Discontinuous linear regression



Data from EMAP-West

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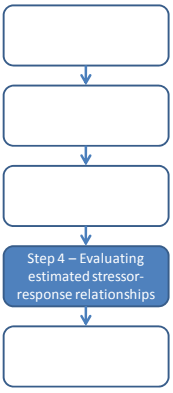
Step 4: Evaluate estimated stressor-response relationships

- Validation:
  - Apply models to independent data to quantify predictive accuracy.
- Assess uncertainty in model
  - Model assumptions (e.g., space-for-time substitution, regression model assumptions)
  - Model structure: included variables and functional form
- Select stressor-response model



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Evaluating models for Northeast Lakes

- Quantile regression and simple linear regression provide similar results.
  - *Regression assumptions are reasonably supported*
- Multiple regression model does not substantially increase explanatory power of the model.
  - *Simple linear regression provides representative model*.
- Select simple linear regression model of log(chl-a) vs. log(TP)

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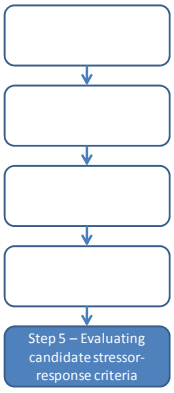
Step 5: Evaluate candidate stressor-response criteria

- Estimate the predicted effects of different candidate criteria to achieve water quality goals.



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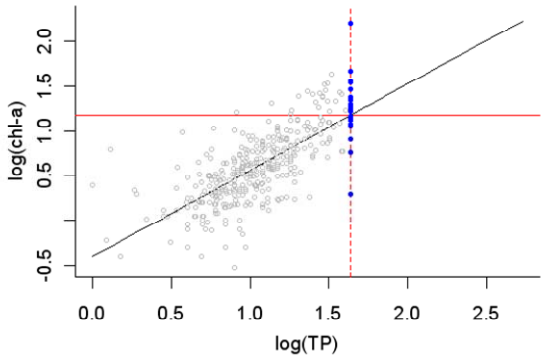
Predicting the effects of a criterion value on achieving water quality goals



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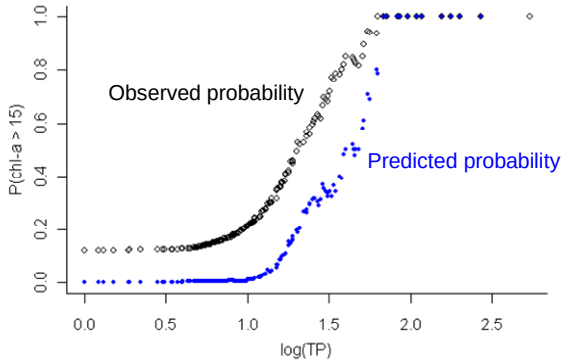
Assess effects of different candidate criteria

Compare *observed* probabilities of not achieving water quality goals with *predicted* probabilities, assuming that nutrient concentrations are reduced to a specified criterion value.



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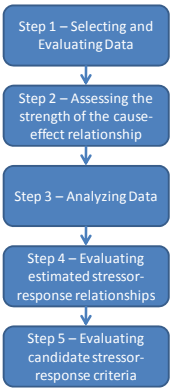
Conclusions

- Statistical methods presented within a five-step framework for deriving nutrient criteria.
- Resulting analyses provide information useful for decisions regarding final nutrient criteria.



Attachment F – Written Public Comments

Public comments were received from the following persons. The comments are available in the SAB Staff Office Federal Advisory Committee Act (FACA) file for this meeting and on the SAB website at the URLs listed after each speaker.

1. Frederic Andes, on behalf of the Federal Water Quality Coalition

http://yosemite.epa.gov/sab/sabproduct.nsf/C277F5A72A48E47585257629004326B6/$File/Comments+from+Fredric+P.+Andes.pdf

2. John W. Brosius, Pennsylvania Municipal Authorities Association

http://yosemite.epa.gov/sab/sabproduct.nsf/CA473E71E105987E8525761E0064D897/$File/Email+from+John+W.+Brosious+9-9-09+EPEC+Meeting.pdf

3. Steven C. Chapra, Tufts University School of Engineering

http://yosemite.epa.gov/sab/sabproduct.nsf/8DA1A51FF19978AA85257627006C517B/$File/Comments+from+Steven+C.+Chapra-09-07-09.pdf

4. Brian Dorn, Illinois Association of Wastewater Agencies

http://yosemite.epa.gov/sab/sabproduct.nsf/1809AC24B168637285257625004B9F2B/$File/Comments+from+Brian+Dorn+for+EPEC+Sept+9-11+2009+Meeting.pdf

5. Albert Ettinger, Kris Sigford, and JoAnn Burkholder, on behalf of the Mississippi River Collaborative

http://yosemite.epa.gov/sab/sabproduct.nsf/63D016600E21EEBC85257640007C2634/$File/Comments+from+Albert+Ettinger_Kris+Sigford_JoAnn+Burkholder+for+Sep+9-11+2009+EPEC+Mtg.pdf

6. Raymond A. Ferrara, Omni Environmental, LLC.

http://yosemite.epa.gov/sab/sabproduct.nsf/7D7FC4D45640C73B85257627006BF1C9/$File/Comments+from+Raymond+A.Ferrara.pdf

7. Manley Fuller, Florida Wildlife Federation, Inc.

http://yosemite.epa.gov/sab/sabproduct.nsf/FAC5AA0224319CDC852576290043757C/$File/Comments+from+Manley+Fuller.pdf

8. Ellen Gulbinski, Association of Environmental Authorities

http://yosemite.epa.gov/sab/sabproduct.nsf/EDB1002CC7D23A2B8525761E0064A9F0/$File/Letter+from+Ellen+Gubinsky+9-9-09+EPEC+Meeting.pdf

9. Response to Ellen Gulbinski from EPA Deputy Administrator Scott Fulton

http://yosemite.epa.gov/sab/sabproduct.nsf/C09DCF2710D5ADAE8525765500587688/$File/Ltr+from+EPA+Deputy+Administrator+S+Fulton+Sept+10+2009+to+E+Gulbinsky.pdf

10. John C. Hall, Hall & Associates

- Letter of August 17, 2009

  http://yosemite.epa.gov/sab/sabproduct.nsf/75988B6D1AB468F08525761E0064449A/$File/Letter+from+John+C.+Hall+9-9-09+EPEC+Meeting.pdf

- Response from Vanessa Vu Director of the EPA Science Advisory Board Staff Office to letter of August 17, 2009 from John C. Hall

  http://yosemite.epa.gov/sab/sabproduct.nsf/52ECCEBE65CB996E8525761E006521F3/$File/Response+to+John+C.+Hall+EPEC+9-9-09+Meeting.pdf

- Comments of September 3, 2009

  http://yosemite.epa.gov/sab/sabproduct.nsf/F2A2C6F29A6D26F9852576270067CE85/$File/Comments+from+John+C.+Hall.pdf

- Comments of October 16th 2009

  http://yosemite.epa.gov/sab/sabproduct.nsf/BA7518B522244FA18525765400767042/$File/Oct+16+2009+Comments+from+John+Hall+for+EPEC+Sept+9-11+2009+Meeting.pdf

11. William T. Hall, Hall & Associates

http://yosemite.epa.gov/sab/sabproduct.nsf/A954FE78E301177E852576540075237F/$File/Oct+7+2009+Comments+from+William+Hall+for+EPEC+Sept+9-11+2009+Meeting.pdf

12. Chris Hornback, National Association of Clean Water Agencies

http://yosemite.epa.gov/sab/sabproduct.nsf/3DA61521F720E54285257678003F6BE4/$File/Public+Comments+from+Chris+Hornback+September+9,+2009+EPEC+Mtg.pdf

13. Daryll Joyner, Florida Department of Environmental Protection

http://yosemite.epa.gov/sab/sabproduct.nsf/4B3F72138829D3B9852576270067A54A/$File/Comments+from+Daryll+Joyner.pdf

14. Nancy Keller, Colorado Wastewater Utility Council

http://yosemite.epa.gov/sab/sabproduct.nsf/A1EA4A018B4363F08525761E006478B1/$File/Letter+from+Nancy+Keller+9-9-09+EPEC+Meeting.pdf

15. G. Fred Lee and Anne Jones-Lee, G. Fred Lee & Associates

http://yosemite.epa.gov/sab/sabproduct.nsf/E94BA88C810797D585257625005645F7/$File/Comments+from+G+Fred+Lee+and+A+Jones-Lee+for+EPEC+Sept+9-11+2009+Mtg.pdf

16. Peter T. Slack, Pennsylvania Municipal Authorities Association

http://yosemite.epa.gov/sab/sabproduct.nsf/1A0DAE3A2BEC3967852576240040F940/$File/Comments+from+Peter+T.+Slack.pdf

17. Paul E. Stacey, Connecticut Department of Environmental Protection

http://yosemite.epa.gov/sab/sabproduct.nsf/78D34E2A7EBA944585257627006E69DF/$File/Comments+from+Paul+E.+Stacey.pdf

Attachment G – Summary of Key Points Discussed at the Meeting in Response to the Charge Questions

Summary of Key Points Discussed for Responses to the Charge Questions

Charge Question 1

- The steps that provide the framework for the document should be more specific and descriptive.
- Clearly articulate how the document fits within the decision-making and regulatory processes and how it relates to/complements Nutrient Criteria Technical Guidance Manuals and other EPA documents.
- Explain the linkages among designated uses, measured responses, stressors, measures of those stressors .
- Emphasize that the Guidance does not address downstream effects.
- Be sure that the document addresses the central problem driving its development.
- Consider alternative conceptual and methodological approaches
- Provide technical support and training for users of the document.
- Clearly express the caveats and limitations of the approaches.
- Consider addition of more technical guidance and examples that describe when to use different approaches.
- Address data requirements, including data acquisition and data quality.

Charge Question 2

- Coupling of response variables to designated uses should be clear and the rationale explained.
- Provide guidance on need for data on other stressor and constraint variables needed for applying multivariate techniques or for stratification/classification of univariate nutrient-response relationships.
- Address Co-limitation by both N and P.

- Consider inorganic forms of nutrients.

- Consider how nutrients control hetrotrophic microbes and decomposition of organic matter.

- Address temporal/spatial aspects of data needed to develop relevant stressor-response relationships.

Charge Question 3

- Exploratory data analysis, including visualization, should be conducted prior to inferential statistical analyses of potential stressors and responses.

- In addition to the methods described in the report, there should also be the recommendation of summary statistics, time series plots at fixed points in space, longitudinal plots at fixed points in time, bubble plots, Pearson correlation analyses, and maps that show temporal (monthly, seasonal, inter-annual) as well as spatial patterns.

- Provide guidance for identifying which statistical methods and visualization techniques should be used, with their associated strengths and limitations.

- Expand Section 1.6 to discuss data analysis and provide examples for different spatial classifications.

Charge Question 4

- This section really doesn't address the strength, but rather support for the stressor-response relationship that is to be explored statistically.

- Using conceptual models and existing literature is appropriate and required as a scientific basis to assess how changes in nutrient concentrations might affect response variables.

- Structural Equation Modeling (SEM), offered as an alternative model for exploring nutrient-ecosystem response, needs to be more fully explained with clear examples in order to be useful.

- Stratification of data using Propensity Scores (or other techniques) can be useful in analyzing stressor-response relationships and further explanation and examples would be helpful.

- Mechanistic models could be used to support the relationships found.

Charge Question 5

- The statistical methods described in the document are generally appropriate but require careful consideration of confounding variables.

- The document needs to be more detailed and sophisticated, not less. Statistical rigor is essential .

- Those charged with using stressor-response methodology are likely to require technical support.

- Make it clear that statistical associations do not prove cause and effect, but can be very useful in supporting a cause and effect argument.

- Provide guidance regarding how to interpret statistical significance with "low" R^2 values.

- Uncertainty should be identified and quantified.

Charge Question 6

- This section lacks the detail that is given in other sections.

- A clear framework for statistical model selection is needed.

- Model corroboration and uncertainty analysis should both be part of model evaluation and selection. These activities should be directed and informed by pre-established Data Quality Objectives.

- Use the stressor-response approach with other methodologies in a tiered weight of evidence approach .

Charge Question 7

- Explicitly detail critical levels of uncertainty inherent in the different steps and in the final product(s) and provide guidance on addressing uncertainty.

- A solid conceptual model is important to understanding uncertainty, calculating sensitivity, and for connecting the analysis to the criterion making process.