Use of Biological Assessment in State Water Programs: Focus on Nutrients

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Association of Clean Water Administrators

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ACKNOWLEDGEMENTS:

This report was assembled by the Association of Clean Water Administrators (ACWA) National Office, coordinated by Environmental Program Manager Sara Vinson. We would like to extend our appreciation to the state and interstate officials who took the time to complete ACWA's questionnaire. The Association acknowledges Paul E. Davis (retired, Tennessee Department of Environmental Conservation (TDEC)) for his time and effort analyzing the questionnaire responses and developing the report Executive Summary and Overview.

PURPOSE:

In October 2011, seventeen states participated in a workshop with the U.S. Environmental Protection Agency's Office of Water (EPA) to discuss the use of biological assessment, with respect to nutrients, in state water programs. In preparation for the meeting, participating states offered responses to a series of questions developed by ACWA to provide a baseline assessment of each state's biological assessment program. Following the meeting, ACWA determined it would be valuable to collect this information from all states, as well as interstates and the District of Columbia, as part of a continuing effort to promote a "rich mosaic" of innovative solutions to the nation's nutrient pollution problems, recognizing that numeric nutrient criteria are only one tool in the nutrient reduction toolbox.

We are pleased to announce that this report consists of responses from every state, the District of Columbia, and the Delaware River Basin Commission [hereinafter "state(s)"].

Please note that these documents are for REFERENCE USE ONLY. These responses do not represent the full picture of each state's criteria or standards program. Responses provided are at a high level and meant to offer a general overview. For specific, detailed, or additional information on a particular state's program, please see the state's designated contact(s). The information in this report was current at the time each entity responded (between October 2011 and May 2012). Changes to state programs since the time of response are not reflected.

ACWA takes full responsibility for any errors or omissions. New information may be submitted to ACWA Environmental Program Manager Susan Kirsch at skirsch@acwa-us.org. As time and resources allow, ACWA hopes to produce periodic updates to this report.

EXECUTIVE SUMMARY AND OVERVIEW:

This report consists of responses from every state, the District of Columbia, and the Delaware River Basin Commission. The following provides a high level summary of responses ACWA received, categorized by question.

Questions 1 & 2 asked respondents to discuss the relevant biological/ecological assessment work their state is conducting and identify which indicators are being used or considered to assess nutrient impairment of aquatic life.

- Most states reported using some form of biological monitoring to assess their waters, with macroinvertebrates predictably the most common indicators of aquatic life support.
- Many states have developed indices of biological integrity (IBIs); some, such as Georgia, have also developed nutrient-specific pollution tolerance indices. Fish are also widely used, in combination with other measures, to assess waters.
- Biomass is often measured, particularly in lakes and reservoirs. Many states reported biological assessments based on algae, while others reported using periphyton, diatoms or chlorophyll a. Michigan considers "nuisance algal conditions" and plant cover, but acknowledged the subjectivity of such assessments. Some states use water clarity or Secchi depth.
- Several states noted the use of diurnal flux in dissolved oxygen as an indicator. For example, Utah is studying measures of whole-stream metabolism: Gross Primary Production and Community Respiration.

In Questions 3 & 4, respondents were asked about sensitivity of nutrients to the various biometrics and the correlation of causal and response variables.

- States generally reported limited ability to correlate nutrient concentrations in streams with measurable effects. New Hampshire reported a weak relationship between Total Phosphorus (TP) and macroinvertebrates in streams, but found "no indication that macroinvertebrate communities respond to total nitrogen." Further, Pennsylvania observed that "drawing the correlations between the causal and response variables [for streams] is difficult due to the confounding factors involved." Maryland also referred to "many confounding variables."
- New York and Tennessee documented relationships at the ecoregion level. Massachusetts likewise found correlation to be site-specific, noting that "phosphorus and nitrogen do not follow a typical dose-response relationship, as with toxic substances. Rather, waterbody-specific factors such as detention time, color, depth, light availability, Nitrogen/Phosphorus ratio, internal cycling, and local water chemistry also influence the response of aquatic systems."
- Better correlation was reported for lentic conditions. Indiana found "moderately strong correlation" between TP and chlorophyll a in lakes, Oklahoma found "[c]lear relations … for reservoir chlorophyll a and nutrients," and Florida saw a correlation not only in lakes, but springs as well.
- Other states reported that nutrients relate more to biomass than other response indicators, or that they simply did not see any relationship.

Question 5 asked states how biological/ecological assessment information is used in combination with chemical and physical data to make impairment decisions.

- Generally, states treat nutrients differently than other pollutants when making listing decisions. Many responders said they identify nutrient-impaired water by a combination of biological conditions and nutrient concentrations.
- Vermont said that, in contrast to most chemicals they monitor, nutrient criteria "have a high likelihood of generating false positive impairment determination." For Vermont, "placement of a reach or lake on the list of impaired waters without direct biological assessments is uncommon." New Hampshire reported that "[f]or nutrients, the response variable must exceed criteria for the nutrient parameter to be considered an impairment," but added that "[f]or other chemical measurements[, such as] pH, DO, toxics, … independent applicability applies." The Delaware River Basin Commission said that it uses "a list of chemical/physical parameters for aquatic life use assessment, though these results are secondary to the biological data in making impairment calls." Illinois cites "greater reliability of biological-assemblage data over water-chemistry measurements in assessing attainment of Aquatic Life Use."
- States also acknowledged that if they had numeric criteria for nutrients, they would list waters strictly on that basis. According to Iowa, "[a]vailable water quality data are compared against applicable water quality standards criteria. Impairment listing can occur independently on the basis of biological or water quality data, or from a combination of both." However, since their standards do not currently include numeric criteria for nutrients, "nutrient monitoring data are not utilized to make aquatic life use impairment determinations."
- The same principle applies to numeric biocriteria. Arizona reported that its "biocriteria standard (like all their standards) is applied independently for assessments." Likewise, Ohio has biological criteria for fish and macroinvertebrates, which are the basis for listing waters as impaired. Ohio then considers other information such as chlorophyll a and dissolved oxygen in determining if nutrient enrichment is to be listed as the basis for impairment.

Question 6 asked states if they consider biological assessment information when developing NPDES permits.

- Some respondents do not have National Pollutant Discharge Elimination System (NPDES) authority, and thus this question does not apply to them. Most states that did answer, however, reported either limited or no consideration of biological assessment information when developing NPDES permits.
- In other states, however, biological information does have a place in permitting. For example, in Florida, "Biological data is assessed as part of the NPDES permit cycle to provide reasonable assurance that the facility is, or is not, complying with criteria designed to protect aquatic life use." In addition, Michigan said that if there is evidence of nuisance aquatic plant conditions downstream of an NPDES facility, that information figures into permit decisions.

- Some states included a discussion of how bioassessments may be required by permits. For example, South Carolina said that many of its permits require one to four upstream/downstream macroinvertebrate bioassessments per year, which are paid for by the regulated entity, conducted by a certified laboratory, and reviewed by agency staff. New Jersey allows permittees on listed waters to study whether their nutrients cause impairment.

Following, please find a summary by state, along with helpful links and contact information.

Alabama

Contact: Lynn Sisk, LS@adem.state.al.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Alabama's Water Quality Monitoring Strategy includes assessment protocols for macroinvertebrate communities, fish communities, habitat, and periphyton in wadeable streams. In addition, the state has initiated the development of a macroinvertebrate community assessment and a fish community assessment for non-wadeable streams that should be available for use within a couple of years.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   - Macroinvertebrate community assessment
   - Fish community assessment
   - Periphyton assessment
   - Chlorophyll a

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Periphyton and chlorophyll *a* are somewhat sensitive to nutrient concentrations but are also influenced by other factors such as substrate and light availability. In studies conducted in support of nutrient TMDL development in the Cahaba River, AL found that periphyton densities in shallow, open stretches of the river increased considerably when a significant nutrient source was located upstream. In addition, the percent of the macroinvertebrate community considered to be nutrient tolerant increased as nutrient concentrations increased. Chlorophyll *a* concentrations in the embayed portions of tributaries to reservoirs increase in response to increased nutrient loading from the watershed. In the Sougahatchee Creek embayment of Yates Reservoir, a nutrient TMDL determined that a reduction in total phosphorus from point and nonpoint sources in the watershed was needed to reduce the growing season mean chlorophyll *a* concentration in the embayment. The Index of Biotic Integrity is still under development for fish community assessments in Alabama but it is suspected that fish communities will be good indicators of nutrient enrichment.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

To date, Alabama has not been able to establish strong correlations between causal and response variables, with a couple of notable exceptions. Alabama's Rivers and Reservoirs Monitoring Program has established a long history of chlorophyll *a* response to changes in nutrient loading in large reservoirs. In general, reservoirs which receive higher loads of total phosphorus have the highest mean growing season chlorophyll *a* concentrations. For example, Weiss Lake on the Coosa River in northeast Alabama receives nutrients (especially phosphorus) from naturally enriched soils and from various point and nonpoint sources in the watershed. The reservoir is shallow and experiences elevated chlorophyll *a* levels during the spring and summer. Harris Reservoir on the Tallapoosa River is located in a different physiographic region with nutrient-poor soils and chlorophyll *a* levels are much lower in the spring and summer. However, very little correlation between measured phosphorus or nitrogen concentrations and chlorophyll *a* concentrations exists beyond these general observations. In the Cahaba River, mentioned earlier, nutrients were contributing to significant periphyton densities (algae) downstream of an industrial wastewater source. Once the industrial source was removed the periphyton densities declined.

The state is still evaluating data from its Rivers and Streams Monitoring Program to determine if correlations can be established between causal and response variables in wadeable streams. A project currently underway with researchers at Auburn University is looking at biological, chemical, and physical data collected in 2010 from the Tallapoosa River basin to determine if causal – response relationships can be identified.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Chemical and physical data are used to identify likely stressors when a macroinvertebrate assessment results in a *poor* or *very poor* community rating. For example, nitrogen and phosphorus concentrations at a location receiving a poor macroinvertebrate community rating would be compared to concentrations at "least impaired" ecological reference sites to determine if nitrogen or phosphorus was significantly elevated. In addition, periphyton density information could be used to indicate if the macroinvertebrate habitat was degraded.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biological assessment information is generally not considered when developing NPDES permits unless the applicant is seeking a §316a temperature variance. In those cases, the applicant must submit biological community assessment information to demonstrate that the variance will not result in significant harm. In a few other rare cases, biological assessment data was required in NPDES permits to demonstrate that permit conditions were protective of water quality standards.

Alaska

Contact: Nancy Sonafrank, nancy.sonafrank@alaska.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Biological indices for macroinvertebrates have been developed for streams in two regions of Alaska (i.e. Southeast and Southcentral). Limited baseline biological data including macroinvertebrates, periphyton, diatoms and fish were collected for some regions, i.e. Interior, Southwest) and on a facility specific basis for large mines.

   Alaska is not planning to adopt biocriteria as water quality standards due to the limited biological data (usually 3 years or less). Biological monitoring is used in permits and nonpoint source assessments as to support standard water quality data in assessing the status of the designated uses for aquatic life.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   No waters have been listed as impaired for nutrients in Alaska. Biomonitoring is generally not used for permits outside of the mining sector. Nonpoint source assessment projects may (e.g. stormwater) or may not (e.g. heavy sport fishing recreation use) be related to marginally related to nutrients.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   This is unknown, since AK has not directly compared nutrient water quality parameters with biomonitoring results.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   AK has found correlations between persistent exceedances for water quality criteria for petroleum and turbidity with macroinvertebrate and fish monitoring.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

Biological information is used as supporting evidence that the designated use is impaired in addition to exceeding the chemical based water quality criteria based level.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biomonitoring is typically done for mining activity, both for pre-mine baseline data and to monitoring reductions (or improvements) in the biological condition during the life of the mine.

Arizona

Contact: Patti Spindler, Spindler.Patti@azdeq.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Arizona DEQ (ADEQ) is conducting macroinvertebrate and habitat surveys currently as part of targeted, reference condition and probabilistic surveys in our monitoring program. Arizona Game and Fish Department (AGFD) participated in the Western Ecological Monitoring and Assessment Program (EMAP) surveys 2000-04 and ADEQ participated in the National Rivers and Streams survey of 2008-09. In addition, ADEQ obtained a Regional Ecological Monitoring and Assessment Program (REMAP) grant to improve the statewide perennial map and conduct an example probabilistic survey of one basin using state sampling methods, producing 2 reports. A biocriteria standard was established in our WQS in 2009 and ADEQ is now conducting 305b assessments using the new standard, beginning in our 2010 Assessment report.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   ADEQ has drafted a nutrient survey plan to collect macroinvertebrate, plant cover, stream bottom habitat and chemical data by which to assess nutrient enrichment in streams, using a narrative –weight of evidence approach. Parameters of interest include: pH, DO, TN, TP, %algae & plant cover, macrophyte diversity, macroinvertebrate IBI score, pool sediment/organic condition & presence of bloodworms. ADEQ is in the 2nd year of a 5-year study. ADEQ's lakes program has established narrative/numeric standards for chlorophyll-a and other nutrient-related parameters in a weight of evidence approach for assessing nutrient enrichment in several lake types across AZ.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   ADEQ has not evaluated the response yet.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

ADEQ's Lakes program has conducted multivariate analyses and published a study on nutrient dynamics in AZ lakes.[1] Based on this study, numeric targets for 5 lake types and 9 parameters were developed and placed in our WQS. This has not been done for streams at this time.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   ADEQ's biocriteria standard (like all ADEQ standards) is applied independently for assessments.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   ADEQ has included bioassessment in several Arizona Pollutant Discharge Elimination System (AZPDES) permits for large mines, where impacts to the aquatic life in downstream perennial wadeable streams is of concern. The bioassessment is conducted as part of a receiving water ambient monitoring requirement rather than a permit condition.

[1] Study available here: http://www.azdeq.gov/environ/water/standards/download/draft_nutrient.pdf

Arkansas

Contact: Steve Drown, drown@adeq.state.ar.us; Mo Shafii, shaffii@adeq.state.ar.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Lentic
   Arkansas Department of Environmental Quality (ADEQ), in conjunction with Beaver Water District and United States Geological Survey (USGS), completed an extensive study of Beaver Lake in north Arkansas. The completion of the project through extensive hydrological and limnological modeling produced

   Arkansas recently completed evaluation of Type C and D (lowland) reference lakes and is currently investigating Type B (upland) reference reservoirs. Investigations of these least-disturbed lakes were began with the intention of developing water quality standards for lakes at the ecoregion level.

   Lotic
   Upper Saline River Pilot Study (USPS) was completed in 2010. This pilot study was the "Draft Evaluation Protocol for Assessing Nutrient Indicators for Streams and Rivers of the Upper Saline River Watershed, Arkansas." The purpose of the pilot study was to test and refine methodologies outlined in the State of Arkansas Nutrient Criteria Development Plan. Currently, no other nutrient based lotic studies are ongoing.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Lentic
   The Department is currently using Secchi depth, chlorophyll a, and dissolved oxygen profiles (vertical and diurnal).

   Lotic
   A suite of periphyton, macroinvertebrate, and fish assemblage metrics, in conjunction with extensive physical and chemical assessments will be used to evaluate systems.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Lentic
   See response below.

   Lotic
   Results of the USPS correlation tests indicated that four of eight fish metrics and eight of twenty-three macroinvertebrate metrics had significant ($p<0.05$) relationship with a given

nutrient constituent. Seventy-five percent of fish metrics (3 of 4) were most correlated to phosphorus concentrations. While 63% of macroinvertebrate metrics were most correlated to nitrate+nitrite nitrogen. Both fish and macroinvertebrate metrics which were correlated were those described in literature as being most indicative and predictive of nutrient enrichment.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Lentic
   Extensive limnological models which focused on stochastic variability were used by USGS, ADEQ, and Beaver Water District for Beaver Lake to look at chlorophyll a and Secchi depth, as related to total phosphorus concentrations. As lentic environments are drastically more stable and predictable compared to lotic systems, empirical model development and correlative approaches were effective in Beaver Lake criteria development. Total phosphorus and total nitrogen targets, not criteria, were recommended.

   Arkansas has yet to adopt numeric nutrient criteria.

   Lotic
   Arkansas has yet to adopt numeric nutrient criteria.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Waterbodies impaired based upon chemical and physical may be later assessed with biological assessments to determine if indeed physical and chemical exceedances are impacting aquatic life designated uses.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   In general, there is no consideration for biological assessments unless they pertain to threatened or endangered species.

California

Contact: Karen Larsen, klarsen@waterboards.ca.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The California State Water Resources Control Board's (CA State Water Board) Surface Water Ambient Monitoring Program (SWAMP) conducts a statewide perennial streams assessment using biological and habitat assessment methods. Indicators include benthic macroinvertebrates, algae, and physical habitat measures. Approximately 100 sites are assessed annually and are selected using a probabilistic study design. The study is designed to assess condition of perennial wadeable streams (i.e., number of streams miles in good, degraded or very degraded condition), to compare condition among streams based on predominant land use types, evaluate trends in condition over time, and to provide context for targeted monitoring and assessment. There also are regional programs in Southern California and the San Francisco Bay area that are designed to nest within the statewide program. This allows the statewide program to utilize data collected at the regional level for statewide assessments.

   In addition, SWAMP established a reference condition management program. An expert panel was convened in 2007 to develop a science-based plan for establishing and managing a pool of reference sites for the State. To date, the State has established a pool of over 600 reference sites, which provide coverage across the wide variety of natural gradients in the State. One notable exception is the Central Valley floor, where streams are so highly modified, reference sites do not exist.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   The CA State Water Board currently is initiating the process to develop a nutrient policy for inland surface waters. The nutrient policy could include objectives and control strategies to help improve water quality in aquatic habitats by providing the benchmarks that describe conditions necessary to protect beneficial uses. The State Water Board intends to develop narrative nutrient objectives, with numeric guidance to translate the narrative objectives. This numeric guidance, could include the Nutrient Numeric Endpoint (NNE) framework which establishes numeric endpoints based on the response of a water body to nutrient overenrichment. Indicators used include nutrient concentrations, algal biomass (chlorphyll a), dissolved oxygen, temperature, biological community structure, and physical habitat measures (e.g., shading).

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   The CA State Water Board currently is conducting a study to assess these indicators for sensitivity to nutrient impacts. The study will document the linkage between algal

biomass, pH, and dissolved oxygen to aquatic life uses measure using benthic macroinvertebrate and algal indices of biological integrity. The algae IBI, in particular, will be used to determine whether more precise, and possibly more cost effective, indicators of stream function can be identified (e.g., macroalgae cover).

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   The NNE tools provide scoping level analyses of nutrient targets. The challenge is that there is high variability in chlorophyll a concentrations so there is need to establish site specific targets for stream segments. The CA State Water Board are using case studies in streams impaired for nutrient enrichment to determine site-specific relationships between nutrients and response variables. The State also needs to conduct further studies to address downstream estuary response variables to determine upstream nutrient targets.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   The Policy for Developing California's Clean Water Act Section 303(d) List allows water bodies to be listed as impaired based on the index of biological integrity; however, the listing must be associated with a chemical contaminant that has exceeds water quality objectives (narrative or numeric). The CA State Water Board currently is in the process of developing biological objectives. It is likely that the California's 303(d) listing policy will need to be amended to incorporate the new biological objectives.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Some of the CA Regional Water Quality Control Boards have included biological assessment monitoring requirements in NPDES permits. However, the requirements are exploratory in nature and designed to provide information for future policy development. The CA State Water Board currently is in the process of developing biological objectives (criteria) that will describe how biological monitoring should be used for assessing compliance with NPDES permits.

Colorado

Contact: Sarah Johnson, Sarah.Johnson@dphe.state.co.us

1. Please provide a brief overview of relevant biological/ecological work your state is conducting.

   Colorado Department of Public Health and Environment (CDPHE) has developed a macroinvertebrate-based multimetric index (MMI) that is used for direct assessment of biological condition of Colorado's rivers and streams. The MMI is a general indicator of biological condition and Colorado has not used it in the context of stressor identification. Colorado has also adopted (in policy, not rule) MMI-based numeric thresholds for aquatic life use attainment for streams with watershed less than 2,700 mi^2.

   Colorado's MMI and the thresholds are described in WQCC Policy 10-1 and appendices which can be found at http://www.cdphe.state.co.us/op/wqcc/StatutesRegsPolicies/wqpol.html

2. Which biological indicators / parameters does your state use (or plan to use) to assess aquatic life use impacts due to nutrients?

   Colorado has not established (or proposed) any biological indicators for use specifically or impacts due to nutrients. CDPHE is using the MMI (see above) and Total Taxa in conjunction with nutrient concentrations to quantify the general stressor-response relationship between nutrients and aquatic condition (using Quantile regression).

3. How sensitive to nutrients have those indicator/parameters been? How did you determine that?

   Our assessment is that there is a significant stressor-response relationship between nutrients and aquatic condition in rivers and streams, using the log of TP and TN concentration and the 90th quantile.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach (es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   CDPHE already has subcategories of waters – warm vs cold. CDPHE also has the regulatory flexibility / processes set up to provide opportunity for site-specific numeric criteria. CDPHE has not anticipated what sort of evidence needs to be provided to support adoption of site-specific criteria.

For water quality-based effluent limit calculation, CDPHE proposes to use a 1 in 5 yr exceedance frequency and establish the critical low flow as the median of the July 1-October 31 daily average flow that can be expected in the second driest year in 5 years. That represents the post-runoff base flow that is expected to occur when aquatic community metabolism are highest (summer and fall).

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Where MMI scores fall below the aquatic life thresholds (see #1 above) and there is no known pollutant, the waterbody is included on the 303(d) list as "Provisionally Impaired". Where there is a known pollutant, the waterbody is listed as "Impaired". Waters that are listed as "Provisionally Impaired" are targeted for monitoring and assessment to determine if the impairment is caused by a pollutant or pollution. If it is determined that it is caused by pollution, the waterbody would then moved to the Integrated Report Category 4c list.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   No.

Connecticut

Contact: Traci Iott, Traci.Iott@ct.gov

1. Please briefly describe your biological/ecological assessment program and its goals. Please discuss what indicator/parameters your state uses to assess aquatic life impacts due to nutrients.

   Connecticut Department of Energy and Environmental Protection (CT DEEP) believes that developing nutrient criteria and establishing regulatory control programs must be focused on anthropogenic sources of nutrients and their effects on the biological integrity of affected surface waters. Based on work CT DEEP has conducted to date, they are focusing on nutrient loading inputs on a watershed scale, not concentration based criteria. Additionally, CT DEEP recognizes that the effect of nutrients on biological communities is not linear and is strongly impacted by other considerationssuch as habitat and stream morphology. For that reason, CT DEEP is working to evaluate nutrients in a manner to allow for the site-specific development of appropriate nutrient loading targets for individual watersheds within the State tied to the response of the biological community.

   Freshwater:
   Connecticut is in the process of developing phosphorus criteria for freshwater wadable rivers and streams based on biological responses as observed in the periphyton community. The periphyton community is a complex mixture of algae, bacteria and fungi which responds to varying stream conductions including nutrient loads. As primary producers, changes in the periphyton community provides a direct measurement of biological response to nutrients, among other factors, and can respond to changing water quality conditions more rapidly that secondary communities such as benthic invertebrates and fish. Connecticut has incorporated the use of a statistical technique, Threshold Indicator Taxa Analysis (TITAN), to evaluate shifts within the species composition within the periphyton community in response to varying Enrichment Factors. The Enrichment Factors are derived using a GIS based analysis to determine the anthropogenic loadings of phosphorus to each watershed in the State. A target Enrichment Factor is determined based on the threshold of species composition change within the periphyton community. This target Enrichment Factor is then used to develop necessary loading reductions in phosphorus throughout the watershed to promote attainment of a healthy periphyton community within watersheds affected by excessive loadings of anthropogenic-based phosphorus. As part of this effort, Connecticut is collecting physical, chemical, and biological data including measurements of habitat quality, general chemistry, nutrient concentrations, and data on the periphyton, benthic and fish communities.

   Marine:
   Connecticut, together with the State of New York, developed a TMDL for Long Island Sound, approved by EPA in 2001, to address aquatic life impairments due to low dissolved oxygen levels caused by excessive nitrogen loading. Necessary reductions in nitrogen loading were determined using the LIS 3.0 Model and implemented into a

general permit for wastewater treatment plant facilities. Dissolved oxygen level is currently the indicator parameter that is used to relate improvements in the aquatic life community as it is directly tied to the identification of impairments. However, extensive physical, chemical and biological sampling is conducted within the Sound including the analysis of general chemistry parameters, nutrients, and the phytoplankton community. Connecticut is seeking to use these data to develop a program for derivation of nutrient criteria for Long Island Sound. Additionally, CT DEEP is supporting research efforts to evaluate the potential impacts to eelgrass communities based on nutrient load inputs. This information will also be considered in any future efforts for criteria derivation.

2. What other aspects of your program do you consider important for informing the assessment of water quality for nutrients (e.g., designated uses and sub-categories of uses, monitoring strategies, quality and abundance of data)?

   Our water quality programs are focused on the established designated uses for each water body, such as restoration of maintenance of a health aquatic life community or recreational opportunities, for example. Therefore, our efforts to determine acceptable ambient levels of nutrients will be tied to these designated uses. Existing monitoring data is used where available and plans to collect additional information developed to support an evaluation of biologically based criteria for anthropogenic nutrient loadings. As with any program, there is a challenge to collect sufficient quantity and quality of data to support a robust and meaningful program. This is affected by both staffing and funding levels and relies on flexibility to shift resources from various program areas to maintain progress on nutrient criteria development and interim nutrient control strategies.
   In addition to the obvious challenges of deriving appropriate scientifically based water quality criteria, a strong partnership with the permitted community and other affected stakeholders both within and outside the agency is key to achieving progress on establishing appropriate nutrient thresholds and achieving necessary reductions.

3. Has your state tried to reduce the potential incongruity in causal and response nutrient variables at the criteria development stage? That is, has your state tried to develop site-specific numeric nutrient criteria by subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, streamlining site-specific criteria approaches, or other approaches? If so, please speak to the challenges and successes you have had.

   CT DEEP is focusing a development of a consistent approach to deriving acceptable nutrient conditions within surface waters but an approach which can be applied to yield site-specific results. It is our intention to have watershed specific criteria and do not expect to adopt any statewide values. Our successes have been in developing a scientifically sound and technically robust approach to evaluating the effect of anthropogenic nutrient loadings within target watersheds. CT DEEP has had success in explaining this method to affected stakeholders who prefer that their regulatory requirements reflect that which is necessary for achieving appropriate local water quality. The challenge CT DEEP has had is gaining acceptance of this method from EPA which has been focused on application of generic, statistically derived values within broad areas

of the country and has identified a concern that extensive use of site-specific approaches may prove to be difficult for timely review. Through committed dialog and effort, Connecticut and EPA Region 1 staff have been able to move forward on Connecticut's proposed interim approach; however, it is unclear if such an approach will satisfy national concerns in the long term.

4. How do you envision enhancing/refining your biological/ecological assessment program to address future environmental challenges?

   CT DEEP intends to continue to use a biologically and watershed based approach to establishing acceptable anthropogenic loadings of nutrients to Connecticut waters which will support attainment and maintenance of established designated uses. CT DEEP is most active currently in the development of freshwater phosphorus criteria for wadable stream and rivers but intend to move on to evaluate phosphorus in other freshwater habitats, such as lakes and impoundments, as well nitrogen within marine waters. CT DEEP intends to work closely with EPA on these issues and seek funding and other assistance to support our efforts.

Delaware

Contact: David Wolanski, David.Wolanski@state.de.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Delaware has a long standing program that uses biological assessments to look at biological communities and compare communities to reference/best available communities. That data is used to look at overall aquatic life impacts in waters of the state.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Delaware has been using macroinvertebrates as its main indicator since 1991. Studies were performed over a 5 year period using periphyton but were discontinued due to lack of correlation with nutrients. Delaware is planning a pilot study this summer to look at fish as indicators.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Delaware has worked with statisticians to look at links between nutrients and biological communities under the auspices of the Nutrient Scientific Technical Exchange Partnership (NSTEPS) program. Connections between nutrients and the biological community were extremely weak or nonexistent due to a lack of true reference conditions in the state and possibly other factors.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Delaware is unable to demonstrate an obvious cause/effect relationship at this time. See the answer to #3 above.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Delaware has used the biological assessments and physical habitat assessments to make listing decisions, for biological or habitat degradation, for waters where the communities/physical characteristics were significantly different from the reference

conditions. This has led to considerable challenges in determining the exact cause or source of the biological impairments. EPA, via Tetratech, is presently working on a stressor ID analysis in a Delaware watershed using biological, physical habitat and chemical analysis.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   No

Delaware River Basin Commission (Interstate – NY, NJ, PA, DE)

Contact: Thomas Fikslin, Thomas.Fikslin@drbc.state.nj.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The Delaware River Biomonitoring Program samples the Delaware River annually at 25 sites, with occasional sampling of large tributaries. Nutrient gradients are among the stressors examined for biological response in the macroinvertebrate and periphyton assemblages. The Delaware River Basin Commission (DRBC) also conducted an algal response to nutrients study using Matlock periphytometers.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   DRBC uses macroinvertebrates, diatoms, and soft algae metrics of diversity, abundance, balance, and pollution tolerance. DRBC also uses Chlorophyll a and ash-free dry mass.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Macroinvertebrate indicators appear to be indirectly associated with increased nutrients, though the data are noisy. DRBC observed more direct and less variable response from selected algal metrics, using both longitudinal plots of algal metrics vs. nutrient concentrations; and statistical comparison of diatom response to increased nutrients during the Matlock study.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   DRBC has not yet reached the point of numeric criteria for nutrients or the biological variables. The Matlock study was informative, and seemed to indicate a nutrient threshold related to dominance and relative abundance of high-nutrient and low-nutrient diatom taxa, but too few samples were taken to reveal a clear threshold. Macroinvertebrate data have not been analyzed extensively for nutrient responses, though DRBC intends to apply A.J. Smith's (NYSDEC) methodology. In short, DRBC needs to conduct more data analyses and increase the number of samples at each location. The most challenging aspects of criteria development are: 1. The indirect pathways of

biological response to increased nutrients, and 2. The difficulty of conducting in-stream experimental studies with sufficient statistical power to overcome natural variability of both nutrients and biological indicators. The common approach of relating nutrients to benthic or water column chlorophyll concentrations simply has not worked. Chlorophyll a is extremely variable and does not appear to directly respond to nutrient concentrations.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   DRBC applies an Index of Biological Integrity (multi-metric approach) to determine aquatic life use impairment. DRBC also uses a list of chemical / physical parameters for aquatic life use assessment, though these results are secondary to the biological data in making impairment calls. See DRBC's integrated assessment methodology.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   For some permits, especially those involving a TDS limit determination, DRBC requires before/after and upstream/downstream biological monitoring. Iterative use of the BACI (Before/After Control/Impact) approach reveals that if the TDS limit is set too high, DRBC will see a decline in macroinvertebrate community metrics. Similar studies are sometimes conducted for other types of NPDES permits, especially in high-quality streams.

District of Columbia

Contact: Shah Nawaz (DDOE), shah.nawaz@dc.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

    - The District Department of the Environment (DDOE) relies on biological/habitat data and chemical/physical standards to make aquatic life use (Class C) support decisions. Streams are evaluated using both conventional pollutant data and biological data.

    - The District uses a combination of the US EPA Rapid Bioassessment Protocols and the Maryland Biological Stream Survey (MBSS) to conduct benthic macroinvertebrate and physical habitat assessments.

    - Fish tissue studies are conducted to determine the use support for Class D human health criteria. This data is also used to issue fish consumption advisories for fish caught in waters within the boundary of the District of Columbia.

    - The biological effects-based approach which focuses on measuring chemical impacts such as toxicity and/or fish tissue contamination data used to issue advisories.

    - Biological Integrity class scores are determined using scoring criteria developed by the District using Maryland coastal plain and piedmont as reference streams. Habitat assessments were compared directly to each ecoregions' corresponding reference condition habitat evaluation.

    - The attainable level of biological integrity for any water is the state's determination involving public participation.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

    - Water quality criteria for Dissolved Oxygen, Water Clarity and Chlorophyll (a) are used for the tidal waters of the District. 2009 observations revealed 7 different species of SAV (District of Columbia Water Quality Assessment, 2010 Integrated Report). This is indicative of SAV recovery, as species diversity, and acreage has improved over the past six observation periods. These indicators are the evidence to demonstrate their effectiveness for the purposes of eutrophication.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

    - EPA's implementing regulations specify that states must adopt criteria that contain sufficient parameters to protect designated uses. In order to achieve and maintain water quality conditions necessary to protect the aquatic life of the Chesapeake Bay

and its tidal tributaries from the effects of nutrients and sedimentation pollution, EPA has developed Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries in April 2003. These ambient water quality indicators are vital because they are nutrient driven parameters as recommended by the EPA Chesapeake Bay Program.

The District has adopted water quality standards for dissolved oxygen, water clarity and chlorophyll (a) in accordance with the Chesapeake Bay Water Quality Criteria Guidance Document published in 2003 (EPA, April 2003). DDOE Water Quality Division (WQD) worked with the Chesapeake Bay Program to assess the tidal waters in the District using the 2003 guidance document and all the addendums published through 2010. For the 2008 listing, the tidal waters were assessed for the 30-day DO attainment and Chlorophyll (a).

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

    - DC water quality standards contain Magnitude, Duration and Frequency approach and the implementation procedures are within the body of the regulations and revised thru promulgation.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

    - See item 1

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

    - The District certifies EPA issued permits. The NPDES permits for point sources in the District reflect total nitrogen and total phosphorus effluent limits. The major permit holders in the District conduct Whole Effluent Toxicity tests as required by the permit.

Additional information:
DDOE has biological monitoring and assessment program which reports on the condition of aquatic biota in the waters of the District. The biological assessment information is published in the Integrated Report to Congress every two years.

The biological assessment provides information on the status of condition of the existing aquatic biota in a waterbody, provide the chemical characteristics of a waterbody, whether designated use is being met.

The other important uses of biological assessment component include identifying baseline biological conditions against which the effects of global climate change on aquatic life can be studied and compared. Such information could enable a water quality management program to calibrate biological assessment endpoints and criteria to adjust for long-term climate change conditions.

Florida

Contact: Russ Frydenborg, Russel.Frydenborg@dep.state.fl.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Florida Department of Environmental Protection (FDEP) conducts Stream Condition Index (invertebrates), Rapid Periphyton Survey, Linear Vegetation Survey, Habitat Assessment, Lake Vegetation Index, chlorophyll a, and Wetland Condition Index (plants and invertebrates) sampling for a variety of FDEP objectives and environmental decisions. These include studies for making decisions on point source permits, impaired waters assessments/stressor identification, nutrient criteria development and implementation, success of restoration activities and Best Management Practices, and discerning status and trends in the State's waters.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Chlorophyll a, Stream Condition Index (invertebrates), Rapid Periphyton Survey, Linear Vegetation Survey, Habitat Assessment, Lake Vegetation Index, and Wetland Condition Index (plants and invertebrates).

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   The Rapid Periphyton Survey was a line of evidence for Florida's 0.35 mg/L springs nitrate criteria, based on regression/change point analyses. The Lake Vegetation Index was correlated with a Human Disturbance Gradient, which includes nutrients. The Wetland Indices were correlated to the Landscape Development Intensity Index, which is associated with nutrient loading, in part.

   Chlorophyll in lakes was strongly correlated to nutrient concentrations.
   Despite intensive study, FDEP could not find convincing cause-effect relationships between nutrients and biological variables in streams (other than clear springs).

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Lakes and springs had strong cause-effect relationships, and FDEP based criteria on this evidence. In streams, the lack of cause-effect relationships led FDEP to use the reference

site approach coupled with biological information to assess impairment (or lack thereof). See the FDEP technical Support Document at: http://www.dep.state.fl.us/water/wqssp/nutrients/index.htm

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   See **Section 2.7** of *Sampling and Use of the Stream Condition Index (SCI)for Assessing Flowing Waters: A Primer* (Oct. 2011) available here: http://www.dep.state.fl.us/water/bioassess/docs/sci-primer.pdf

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biological data is assessed as part of the NPDES permit cycle to provide reasonable assurance that the facility is, or is not, complying with criteria designed to protect aquatic life use.

Georgia

Contact: Michele Brossett, Michele.Brossett@dnr.state.ga.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Georgia Department of Natural Resources (GA DNR) is currently collecting diatom and macroinvertebrate data in streams and zooplankton in lakes.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   GA DNR is currently working with Kalina Manolylov, Georgia State College and University, to develop a nutrient pollution tolerant index (PTI). With the nutrient PTI and water quality data the goal is to try to develop nutrient criteria for streams.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   This has not been determined yet, we are still in the development stages of data collection and correlation analysis with nutrient data.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   GA DNR is still in data collection and analysis phase and has not determined if there is a correlation between biology and water quality.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions? Biological data is generally assessed separately from chemical/physical data when making decisions as to whether a water is impaired.

   Currently, Georgia has chlorophyll *a* criteria on some of our major reservoirs. These criteria (along with a total nitrogen, an annual phosphorus lake loading criteria and an annual phosphorus loading criteria on the lakes' major tributaries) serve to protect the reservoirs from nutrient over-enrichment. When making listing decisions, each of these criteria is evaluated separately. If our biological parameter (chlorophyll *a*) exceeds the criteria then the lake will be listed as impaired whether the nitrogen and phosphorus criteria area exceeded or not.

Georgia assesses the results of fish and macroinvertebrate data when assessing its waters (this data is not specific to nutrient impairment though). If a Fish IBI scores poor or very poor, the water is listed as impaired for Bio F (Impaired Fish Community). If macroinvertebrate sites scored poor or very poor based on a multimetric index, then the water is also listed as impaired for Bio M (Impaired Macroinvertebrate Community). The actual cause of the impairment is not provided in the 305b/303d report unless GA DNR has the data to support the cause of impairment. The cause of the biological impairment is addressed in the TMDL process.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biological impairment listings on the 305b/303d list are considered in permitting. If a water has been listed for impaired for biology (chlorophyll a, Bio F, Bio M), then permits may be impacted. For instance, in our General Industrial stormwater permit, if the facility is located within 1 linear mile of an impaired stream, then the facility must sample for the parameter of concern and if the TMDL is completed, it must be in compliance with the TMDL. Similarly for the MS4 permits, if a city discharges to an impaired stream, they must sample for the parameter of concern. For the General land disturbing/construction permit, if a site is located within 1 linear mile of a stream impaired for Bio M or Bio F, they must do extra BMPs to protect the water. Permits for municipal and industrial wastewater facilities must be in compliance with TMDLs.

Hawaii

Contact: Watson T. Okubo, watson.okubo@doh.hawaii.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Hawaii Department of Health (HI DOH) has contracted with USGS in a joint funding agreement to develop a benthic macroinvertebate index of stream quality for Hawaiian Streams. HI DOH is waiting for the final report and will have more to say when the report is received. There has been a contract extension due to weather and personnel emergencies.

ATTACHMENT 1

SCOPE OF INVESTIGATIONS

DEVELOPMENT OF A BENTHIC MACROINVERTEBRATE INDEX OF STREAM QUALITY FOR HAWAIIAN STREAMS

U.S. Geological Survey
Pacific Islands Water Science Center
Proposal, January 2009

SUMMARY

The State of Hawaii Department of Health (HDOH) has been testing and refining the Hawaii Stream Bioassessment Protocol (HSBP) for the past several years and is interested in expanding the protocol to include benthic invertebrates. The HSBP is currently based on habitat characteristics and presence of native fish and macro-crustaceans as indicators of biological conditions (Kido and others, 1999). The HDOH uses the protocol to screen the biological health of Hawaii's streams for classification purposes and to identify water-quality problems associated with both point and non-point source pollution. Expansion of the HSBP to include benthic invertebrates will provide the HDOH with tools needed for an integrated and more robust assessment of stream quality in Hawaii.

Results from a recent study conducted by the U.S. Geological Survey (USGS) Pacific Islands Water Science Center (PIWSC) in cooperation with the HDOH demonstrated that benthic invertebrates could be used as indicators of stream quality in Hawaii (Wolff, 2005). This feasibility study, however, was based on information collected at only 19 sites on 14 streams on Oahu (14 degraded, and 5 reference) and at 9 sites on 7 streams on Kauai (6 degraded, and 3 reference sites). The study concluded that differences in the invertebrate assemblages between the islands should be examined further, and that a larger number of sites, especially from sites representing 'least disturbed' reference conditions on the other Hawaiian Islands would be needed to develop an effective state-wide benthic macroinvertebrate index of stream quality. Subsequently, the USGS and HDOH collected invertebrate, water quality, and habitat information at 40 randomly selected sites on Oahu as part of the U.S. Environmental Protection Agency (USEPA) probability-based Wadeable Streams Assessment in 2006-07. This sampling effort vastly increased the number of sites available to develop a benthic macroinvertebrate index of stream quality for Hawaii. In addition, 4 'least disturbed' sites on Maui were sampled in collaboration with Michigan State University researchers. This study proposes to collect invertebrate and habitat information at an additional 40 sites on Maui.

The overall objective of this study is to provide the HDOH with new tools needed to assess the biological condition of streams in Hawaii. The new assessment tools will be based on benthic invertebrates and will be applicable to both targeted and probabilistic monitoring designs employed by the HDOH Environmental Planning Office and Clean Water Branch. Specific objectives are to develop an effective island-specific benthic macroinvertebrate index of stream quality (BMISQ) for Oahu and Maui and to refine the preliminary state-wide index developed by Wolff (2005). To meet the objectives of this study USGS will (1) collect invertebrate and habitat information at 20-30 'least disturbed' reference sites and at 10-20 sites with varying levels of degradation on Maui, (2) create a database of available invertebrate, water quality, and habitat information for Oahu, Maui, and Kauai, (3) use statistical analyses to determine relations among land use, habitat characteristics, stream quality, and the distribution and abundance of benthic invertebrates, and (4) develop an island-specific BMISQ for Oahu and Maui and refine the preliminary state-wide index developed by Wolff (2005).

Results from this study will be published in the USGS Scientific Investigations Report series and made available on the internet. The study will take 2 years from the time work is commenced until the report is published and will cost $540,000. The total cost for this study will be shared equally by the USGS ($270,000) and the HDOH ($270,000). This work is being proposed at this time so that the new assessment tools will be available in time for the next USEPA Wadeable Streams Assessment scheduled to begin in 2011.

ADM. SERV. OFFICE
LOG NO. 10-123

Idaho

Contact: Mary Anne Nelson, Mary.Anne.Nelson@deq.idaho.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Idaho currently uses indices of biological integrity based on benthic macroinvertebrates, fish and periphyton to assess the support status of beneficial uses in the state's waters. These biological indices are multi-metric in design and incorporate various indicators of biological health of those communities.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Idaho does not currently incorporate measures of nutrient impairment in the biological indices used to determine impairment of beneficial uses. However, a study is currently being proposed that will evaluate the feasibility of incorporating both numeric nutrient thresholds as trigger values and biological response variables to help assess aquatic life impacts.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Not applicable

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Not applicable at this time

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Idaho's biological monitoring program is the basis for most of the impairment listing decisions made in the state. Following the Water Body Assessment Guidance document, biological data is considered in conjunction with chemical and physical data to determine beneficial use support. In Idaho, the majority of the data used to make these listing decisions come from the state's Beneficial Use Reconnaissance Program and are biological/ecological data.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Idaho does not have primacy for the NPDES program. However, Idaho Department of Environmental Quality does not have biocriteria in our standards so most often the permits are written based on TMDLs in the watershed or to meet numeric criteria. Idaho certifies that permits written by EPA conform to our state water quality standards and the current criteria for nutrients is a narrative criteria that states waters shall be free from excess nutrients causing a visible slime growth or nuisance algal growth. At this time it is not known if EPA permit writers are taking Idaho's biological assessment information into account when developing permit limits.

Illinois

Contact: Roy Smogor, Roy.Smogor@Illinois.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Illinois EPA uses macroinvertebrate-assemblage and fish-assemblage information to assess attainment of Aquatic Life Use in Illinois streams.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Illinois EPA currently does not use any direct biological indicators of nutrient impacts on aquatic life.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Not applicable. See #2.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   The scientific information available from Illinois streams indicates that simplistic statistical relations between nutrient concentrations and biological variables do not provide a sufficiently reliable basis for determining when specific nutrients are causing negative impacts on aquatic life.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Illinois EPA uses biological-assemblage information in a decision framework that recognizes and capitalizes on the greater reliability of biological-assemblage data over water-chemistry measurements in assessing attainment of Aquatic Life Use.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Not directly. Rather, biological information is used to assess attainment of Aquatic Life Use and a decision of non-attainment does affect permitting from a Clean Water Act 303(d)/TMDL perspective.

Indiana

Contact: Shivi Selvaratnam, sselvara@idem.IN.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   IBI looking at fish, macroinvertebrates, and algae

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   TBD for flowing waters, none for lakes.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   No response provided.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Analysis for flowing waters is on-going. Stressor-response analysis for lakes showed moderately strong correlation between TP and chlorophyll *a*.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Indiana Department of Environmental Management (IDEM) evaluates multiple lines of evidence using both qualitative and quantitative information.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Only through WET testing.

Iowa

Name: Tom Wilton, Tom.Wilton@dnr.iowa.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your states is conducting.

   Since 1994, the Iowa Department of Natural Resources (IDNR) and the State Hygienic Laboratory (SHL) cooperatively have monitored stream fish and macroinvertebrate assemblages along with physical habitat and water quality characteristics. The Iowa DNR has formed a technical advisory committee (TAC) to analyze data from the IDNR/SHL bioassessment program and review scientific/technical literature pertaining to relationships of stream nutrients and aquatic community indicators. The TAC is scheduled to complete its work and provide nutrient criteria recommendations in 2012. Additional information and notes from TAC meetings are available at: http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards/Nutrients.aspx.

   IDNR is supporting research by Iowa State University that is developing biological indicators for assessing the health of Iowa's lakes and reservoirs. The research includes analysis of aquatic community relationships with habitat and water quality conditions, including nutrient/trophic status. The anticipated time of completion for this project is December 2012.

   Since 2004, IDNR has been conducting monitoring of biological, chemical, and physical parameters in wetlands to determine the ecological condition of wetlands while documenting the leading contaminants and stressors found in these systems. Nutrient parameters are included in the suite of water quality analyses. Aquatic community assemblages monitored include fish, invertebrates, and plants. The program initially focused on developing standardized monitoring and assessment protocols for depressional 'pothole' wetlands in one region of the state, and has recently expanded monitoring to additional wetland systems including shallow lakes often impacted by excess nutrients. Additional information about the wetland monitoring program and wetland strategic plan are available at http://www.iowadnr.gov/Environment/WaterQuality/WaterMonitoring/MonitoringPrograms/Wetlands.aspx.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   For streams, the existing benthic macroinvertebrate and fish assemblage IBIs (Index of Biotic Integrity) are best-suited for assessing aquatic life impacts from nutrients. Work is currently underway to develop a freshwater mussel IBI that might provide additional insight into nutrient impacts. It is very likely that Chlorophyll A, serving as a measure of benthic and sestonic algal biomass, will serve as nutrient response indicator. It is too early in the development stages to predict which aquatic community indicators will be the

most useful for examining nutrient response relationships in lakes, reservoirs, and wetlands.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Iowa's analysis of stream nutrient-biological relationships has not yet been completed; however, evidence of two plausible causal mechanistic pathways has been found thus far. The first pathway links elevated nutrient levels with elevated seston algae chlorophyll a levels with decreased levels in certain benthic macroinvertebrate data metrics (e.g., taxa richness, relative abundance of tolerant and sensitive taxa, proportional abundance of scraper (functional feeding group) organisms. Visual examination of graphs and various statistical techniques such as correlation, quantile regression, regression tree, and conditional probability were used to examine and quantify the strength of relationships. While it is difficult to generalize, the sensitivity of Iowa stream benthic macroinvertebrate assemblages to elevated levels of seston algal chlorophyll A might be characterized as slight-to-moderate. One likely reason the sensitivity is not stronger is the potential co-occurrence of physical habitat and water quality co-stressors that make it difficult to isolate nutrient effects.

   The second causal pathway links elevated nutrient levels with elevated algal chlorophyll A levels and/or stream metabolic rates (e.g., primary production, respiration) with lower diurnal dissolved oxygen minima and/or elevated d.o. fluctuation with decreased benthic macroinvertebrate and/or fish IBI levels. In this case, the sensitivity of benthic macroinvertebrate and fish indicators can probably be characterized as moderate-to-strong, particularly with regard to sensitivity to low dissolved oxygen levels. Identical techniques described in the previous paragraph were used to examine aquatic community sensitivity via this mechanistic pathway.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Using conventional bi-variate, linear regression statistical techniques, significant relationships between stream nutrient parameters and some biological response variables have been found, yet these relationships typically account for a small minority of the variation between the nutrient and nutrient response variable in question. Analysis of potential stream classification schemes (e.g., stream watershed area, order, and ecoregion) is being conducted to determine their potential to reduce uncertainty in these relationships. Based on the outcome of the TAC data analysis and recommendations, the Iowa DNR will consider the available frequency and duration alternatives, as well as the advantages/disadvantages of site-specific implementation of nutrient criteria.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Stream benthic macroinvertebrate index and fish index monitoring results are compared against ecoregion-specific biological assessment criteria (BIC) to assess the support status of aquatic life uses. A stream segment for which at least one index consistently ranks below the BIC is a potential candidate for impairment listing. Available water quality data are compared against applicable water quality standards criteria. Impairment listing can occur independently on the basis of biological or water quality data, or from a combination of both. Iowa water quality standards (http://www.iowadnr.gov/InsideDNR/RegulatoryWater/WaterQualityStandards.aspx) do not currently include numeric criteria for nutrients; therefore, nutrient monitoring data are not utilized to make aquatic life use impairment determinations.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   There is no direct link of biological assessment information to NPDES permits that IDNR is aware of in their program. It may be used indirectly, however.
   IDNR looks at narrative toxicity implementation based on a pollutant-by-pollutant approach that considers which species may be present in certain waterbodies and uses bioassessment information to assist in these determinations.

   Bioassessment data are also currently used for impairment purposes. Thus, the same bioassessment data could be used for TMDL development, which could then result in water quality-based limits being included in the NPDES permit for point source discharges to the watershed.

Kansas

Contact: Mike Tate, mtate@kdheks.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Stream - sestonic chlorophyll-a, macroinvertebrate indices (MBI, EPT), fish tissue (bioaccumulatives), mussel count/loss

   Lake - chlorophyll-a, bluegreen algae percent composition, and microcystin concentration (ELISA method)

   USGS – algal toxins, geosmin, MIB

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   For lakes – chlorophyll-a

   For streams - exploring the use of periphyton. Currently use DO; pH; and total phosphorus as a screening mechanism to identify phosphorus hot spots and further study via a TMDL.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   In streams, not very sensitive. In lakes chlorophyll-a shows better sensitivity, however since all lakes in KS are manmade reservoirs, the morphology of those reservoirs can confound the relationships. Turbidity plays a significant role. Determined by the strength of statistical relationships.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   N/A yet

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

The two are used independently. Impairment listing decisions can be made on the basis of chemical, physical, or biological data – independent applicability if you will. Kansas Department of Health and Environment (KDHE) has been unable to consistently link the biological impairments to chemical impairments – particularly nutrients. This appears to be the major problem across the nation. Thus, the attractiveness of Florida's latest proposal to couple a mandatory biological impact to a chemical impact.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Not often, but it has been done. In one instance, a permittee for a new facility was required to model nutrient impacts on a receiving water via the antidegradation process. The model was adjusted for TN and TP to try to keep periphyton below 150 mg/m^2. TP permit limits were derived based on the model.

   Presence of mussels has also influenced ammonia limits in a small number of permits.

Kentucky

Contact: Randy Payne, Randall.Payne@ky.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The Kentucky Division of Water (DOW) is assessing streams and reservoirs statewide for the 2012 305(b) cycle. This entails data collected from our ambient water quality network, probabilistic biomonitoring, ambient biomonitoring, reservoir monitoring and special studies monitoring programs. All of these programs collect a minimum set of nutrient data. Our ambient water quality network provides trend information on nutrients on our larger watersheds while the biological data are collected with a suite of nutrient constituents. All data that pass QA are considered for 305(b) assessment. One ongoing special study related to nutrients is our chlorophyll study began in 2010 at select boatable river locations; this study is expected to continue for a minimum of five years.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Currently nutrient criteria development has been paired with biological community data. Response variables are being tested with macroinvertebrates, fishes and diatoms. Most of our boatable lentic waterbodies are created reservoirs, limiting our choice of biological indicators; currently chlorophyll *a* is under study.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Kentucky DOW's existing fish, macroinvertebrate and diatom community data from bioassessment sampling from 1999-2007 were analyzed to identify possible thresholds in TN and TP above which there were clear changes in biological integrity or community attributes. Kentucky bioregions were used as the regional classification, and relationships were examined using non-parameteric changepoint analysis and visual inspection of scatterplots with LOWESS smoothing functions. Results were used to identify regions with good or poor relationships, highlight potential confounding factors, and prioritize further data collection activities.

   Data from Kentucky's Reference Reach network were used as estimates of least impacted condition regionally. Data from the probabilistic bioassessment program were used to describe the typical range and distribution of nutrient concentrations across ecoregions and bioregions. Finally, nutrient data associated with all samples resulting in "Good" or "Excellent" scores on Kentucky's Macroinvertebrate Bioassessment Index were summarized to estimate nutrient concentration ranges in streams that fully support aquatic life use. Nutrient data for these summaries were primarily from one-time grab samples during spring or summer baseflow conditions (i.e., the index period for biological sampling for assessments).

A set of 30 sites selected from Kentucky's Reference Reach network to represent a full range of ecoregions and stream sizes. Nutrients were sampled twice during high flow or runoff conditions (spring 2006 and spring 2008) and twice during periods of low flow (summer 2006 and late spring 2007) in order to characterize nutrient conditions during those flow conditions.

Fish, macroinvertebrates, and diatoms were sampled in spring and summer 2008 at 22 streams selected to represent a gradient of expected nutrient inputs but with good to fair instream habitat. Nutrients were sampled monthly in order to capture short and longer-term antecedent nutrient conditions potentially impacting biological responses.
A USGS report on analysis of nutrient breakpoints in macroinvertebrate community attributes has been published:

Crain, A.S. and Caskey, B.J., 2010, Breakpoint analysis and relations of nutrient and turbidity stressor variables to macroinvertebrate integrity in streams in the Crawford-Mammoth Cave Uplands Ecoregion, Kentucky, for the development of nutrient criteria: U.S. Geological Survey Scientific Investigations Report 2010—5164, 29 p (http://pubs.usgs.gov/sir/2010/5164/)

Kentucky participated in a 2007 study conducted by EPA Region 4. Kentucky sampled benthic algae in 10 streams using the R4 methodology and submitted these samples along with nutrient data to the R4 project coordinator. The goal of the study was to examine response of algal communities to nutrients in the Southeastern US and to promote collaboration on regional studies. EPA's report on this study is under review with no expected release date available

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

In addition to the below, please see response to question 3. Data analyses are ongoing with some bioregion biological communities (primarily macroinvertebrates) indicating a response to nutrient gradation and others less so. For example, in the bluegrass region (inner bluegrass in particular), where naturally high concentrations of phosphorus occur due to the geology, the biological communities are adapted to these conditions and a clear threshold response has not been found.

As with most datasets, there is always a need for more data. Especially data collected of sufficient rigor and frequency under varying hydrologic as well as chemical conditions.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   At locations where biological and physicochemical data exist, all data are considered when making assessment decisions. Kentucky DOW has developed multimetric indices for fish, macroinvertebrate and diatom communities in its wadeable and headwater streams. When assessing warm- or coldwater aquatic habitat designated uses the weight of evidence is given to the biological community(s). Often two or more biological communities were sampled for a given waterbody or segment, adding to the robustness of the biological dataset. When less than two biological communities were sampled, the fish or macroinvertebrate community were used in making assessment decisions; the diatom community must have at least one other community in making such decisions (this multimetric index has not been through the same level of rigor of the other two).

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes, to the extent the biological information was used to list a water body or segment on the 303(d) list. If the stream is listed as impaired that affects whether the permit may be issued and if it is what limits may be placed on a discharger. For example, where nutrient enrichment is indicated a POTW permit renewal will have reduced TP concentration that can be discharged, and they'll come under sampling requirements specific to the pollutant(s) under scrutiny. With Kentucky's current nutrient criteria narrative rather than numeric, in addition to the necessity of requiring chemical data, biological information is required that indicates the stream is not supporting the aquatic life use. The biological community data provides information to assist interpretation of the chemical data.

Louisiana

Contact: Kris Pintado, kris.pintado@la.gov; Steph Braden, Steph.Brad@la.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The Louisiana Department of Environmental Quality (LDEQ) has adopted biological assessment criteria for wetlands based on above-ground vegetative productivity as a key measure of overall wetland ecosystem health. LDEQ has collected, and continues to collect, ecological and biological data sets to evaluate the attainable aquatic life communities throughout the different ecoregions in Louisiana and to evaluate and revise water quality criteria supportive of attainable uses. LDEQ's biological collections and data evaluations have focused on fish communities; however LDEQ has collected additional biological data sets (e.g. macroinvertebrates, chlorophyll-a) and is proposing to collect fish, macroinvertebrates, chlorophyll-a, and periphyton during an upcoming study.

2. Which biological indicators/parameters does your state us (or plan to use) to assess aquatic life impacts due to nutrients?

   LDEQ has not adopted indicators/parameters to assess aquatic life impacts due to nutrient enrichment; however, biological collections are planned as a component of a monitoring study designed to inform nutrient criteria development.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   This has not been determined yet.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   LDEQ is in the early stages of conducting a nutrient stressor-response study to inform nutrient criteria development. The study includes biological data collections as described above (in #1 and 2). Additionally, LDEQ is planning to collect information that can be used to evaluate whether water body classes, watershed sizes, temporal and other components are useful in streamlining nutrient criteria development and implementation processes. LDEQ (as are all states/territories) is challenged with understanding causal and response relationships and plans to thoroughly evaluate relationships in order to minimize confounding factors that could lead to inappropriate criteria and/or

assessments.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   LDEQ is in the early stages of determining how biological and ecological data sets can and should be used to support water quality standards attainment support decisions. Data sets evaluated may include LDEQ biological and habitat data, and general fisheries data (e.g. LA Wildlife and Fisheries, USGS, USEPA, USFWS, NOAA, USEPA, etc.).

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes, LDEQ considers biological assessment information when developing Louisiana Pollutant Discharge Elimination System (LPDES) permits.

   LDEQ reviews whole effluent toxicity (WET) and biomonitoring data reported in the permit application and/or discharge monitoring reports (DMRs) as part of the draft permit process. WET limits are established in permits if there is a reasonable potential for toxicity due to lethal and/or sub-lethal failures as indicated in the application and/or DMRs.

   Aboveground net primary production (NPP), marsh grass aboveground productivity, understory vegetation density and basal area, tree species composition, nutrient and metals analysis of green leaves, and sediment analysis for metals and nutrients are reviewed as part of a baseline study required for wetland assimilation projects and permitting.

   For facilities that operate a cooling water intake structure with a design intake of 50 MGD or greater, source water biological characterization data (species for all life stages of fish and shellfish in the vicinity of cooling water intake structures (CWIS) and their relative abundance (population) in the vicinity of the CWIS; identification and evaluation of periods of reproduction, larval recruitment, and peak abundance for species; data representative of the seasonal and daily activities; and identification of all threatened, endangered, and other protected species that might be susceptible to impingement and entrainment) are submitted and reviewed as part of the 316(b) requirement in LPDES permits.

Maine

Contact: Dave Courtemanch, Dave.L.Courtemanch@maine.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Biological assessment is the primary monitoring tool used in Maine waters. Presently, Maine has narrative standards in statute for rivers and streams, lakes and marine waters. Additionally, Maine Department of Environmental Protection (DEP) has numeric biological criteria established by rule (Maine DEP Chapter 579) that use macroinvertebrate data for rivers and streams, and has draft algae criteria prepared for adoption. Both use multivariate linear discriminant models to determine classification attainment. The macroinvertebrate models have been used since 1996 for listing decisions. The algae models have been used since 2008. The data is also used for stressor identification to set permit limits and define restoration plans.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Macroinvertebrates (multivariate), Algae (multivariate), Chlorophyll a

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Multiple lines of analysis have been used to establish the associations between nutrients (phosphorus) and biological effect. Publications in press. Reports available online: http://www.maine.gov/dep/blwq/docmonitoring/biomonitoring/material.htm

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Yes, extensive analysis is provided from a variety of waters including reference quality to severely impaired. See available report: http://www.maine.gov/dep/blwq/rules/Other/nutrients_freshwater/091202_report.pdf

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Physical, Chemical, and Biological information are used in an integrative manner to make impairment decisions. Biological information is the first line of evidence used

since it provides the most direct assessment of designated use attainment.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes. Biological information is regularly used in all permitting decisions including establishment of permit limits (see example in EPA Stressor Identification Guidance Document (EPA/822/B-00/025))

Maryland

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Maryland Department of Environment (MDE) uses biological data in the following ways: (1) fish and benthic community data in our nontidal streams to determine aquatic life use impairment; (2) benthic estuarine data in Chesapeake Bay to determine aquatic life use impairment; and, (3) fish tissue data in both tidal and nontidal areas to assess human health criteria and to protect public health. MDE has also used clams in special PCB studies to identify "hot spots", as well as used whole effluent toxicity in our permitting programs.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Currently, MDE does not use biological indicators in isolation as indicators of nutrient pollution, though MDE does use biology in a supportive role when they see reduced biology in conjunction with other nutrient indicators. In tidal areas MDE has water quality standards (WQS) for dissolved oxygen (DO) and ammonia to assess nutrient impacts. Chlorophyll is used as narrative criteria. Numeric Chl-*a* criteria are under consideration in tidal areas. In nontidal areas MDE has WQS for DO and ammonia. Additionally in drinking water reservoirs MDE has numeric Chl-*a* criteria as an indicator of nutrient enrichment.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   MD's experience is that the current biological indicators that are used (fish and benthos) are not sensitive to nutrient pollution unless it reaches the point of depressing DO below critical levels. As a result, MDE focuses more on DO.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   So far MDE has not found a direct correlation between causal and response variables. MDE has found many confounding variables that make sorting out nutrient maxima thresholds extremely challenging, and thus far, not possible. For example, a

periphyton/nutrient study was hoped to show taxa shifts at clear nutrient thresholds, yet there were wide range (nearly ten-fold) of "P" concentrations at taxa shifts. Nutrient loads and the exposure of periphyton assemblages to those loads over time are likely much more important and significant. A recently completed in-depth analysis of statewide nutrient concentration data paired with biological data (fish and benthic inverts) identified some potential to determine thresholds at small-scales (sub-watershed), yet confounding variables prevented the determination of clear causal/response relationships.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   MD basically uses the biology to determine aquatic life use impairment, then goes through a stressor identification process where they look at other chemical/physical parameters to identify the specific pollutant (or pollution/habitat alteration) causing the biological degradation.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes, not routinely, but on a case-by-case basis. For example, when facility discharge monitoring reports indicate WQS or permit limit exceedances, MDE has conducted special biological studies to see if the aquatic life use is being affected. If so, MDE tightens up permit limits. As mentioned above, MDE also requires WET testing for some permits. Further, when MDE knows trout are present, they require more stringent temperature limits for dischargers. Also, Tier II (high quality) waters are designated as such with the use of fish and benthic indices of biological integrity (FIBI and BIBI). If a new or significant increase to an existing discharge occurs in a watershed upstream of Tier II stream segment, case-by-case antidegradation police requires that consideration is given to protecting the Tier II segment when developing NPDES permits via consultation between the WQS and NPDES personnel.

Massachusetts

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

A strategic goal of the MassDEP is to implement a comprehensive monitoring program (biological, chemical, and physical integrity status/assessment , trends and flows, and targeted) that serves all water quality management needs and addresses streams, rivers, lakes, reservoirs, estuaries, coastal areas, wetlands, and groundwater. Major components of the monitoring program fulfill requirements of the Federal Clean Water Act (CWA) and are described in *A Water Quality Monitoring Strategy for the Commonwealth of Massachusetts* which is available at http://www.mass.gov/dep/water/resources/envmonit.htm.

MassDEP follows a phased holistic program for watershed-based assessment, Total Maximum Daily Load (TMDL) evaluation, permitting, and implementation, has been adopted by MassDEP's Bureau of Resource Protection (BRP) to address its Watershed Management goals.

The results from biological (and habitat), toxicological, and chemical investigations are integrated to assess "Aquatic Life Use". Data are collected for:

- Benthic macroinvertebrate (rivers),
- Fish population (rivers),
- Habitat and flow (rivers, lakes, estuaries),
- Eeelgrass bed habitat (estuaries),
- Non-native aquatic species (rivers, lakes),
- Periphyton/algal bloom (rivers, lakes, estuaries),
- Toxicity testing (rivers, estuaries), and
- Water quality (rivers, lakes, estuaries).

The quality of data generated in each of these information categories is also weighed during the assessment decision-making process. However, because the biological community integrates the effects of pollutants and other conditions over time, the biological community data are considered by MassDEP to be the best and most direct measure of the *Aquatic Life Use*, given equal levels of data quality. The weight-of-evidence gradient used by MassDEP analysts generally follows this line-- biological (including habitat), toxicological, and chemistry (physico-chemical, sediment chemistry guidelines, whole-fish tissue residue guidelines) are weighted most to least heavily in that order.

To address federal requirements for nutrient criteria development, components have been added to the monitoring program to enhance knowledge through data collection, method development, and research. This information is expected to provide additional information with respect to the general and site-specific factors that cause or contribute to nutrient impairment in Massachusetts fresh water systems.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

Massachusetts is considering biological response variables such as secchi disk, chlorophyll-a, filamentous algae coverage, duckweed, and dissolved oxygen, when performing use assessments for reporting the status of its fresh waters in accordance with Sections 305(b) and 303(d) of the Clean Water Act (CWA). Eelgrass Bed Habitat is uses to assess the "Aquatic Life use" for marine waters. Massachusetts has historically relied on best professional judgment and weight-of-evidence in its water quality assessment of "Aquatic Life" impacts due to nutrients.

MassDEP Division of Watershed Management (DWM), Watershed Planning Program, is in the process of developing a Comprehensive Assessment and Listing Method (CALM) document. Waters supporting the "Aquatic Life Use" are suitable for sustaining a native, naturally diverse, community of aquatic flora and fauna, including, but not limited to, wildlife and threatened and endangered species and for their reproduction, migration, growth and other critical functions. Below is an except from the DRAFT CALM for assessment of "Aquatic Life Use" that contains a list of biological response indicators that are under consideration in the evaluation of "Aquatic Life Use" and the identification of nutrients as the cause of impairment.

To evaluate a waterbody for nutrient related impairment, MassDEP analysts rely on whether or not there are indicators of nutrient enrichment. Such indicators include presence of nuisance algal blooms/algal mats, excessive macrophyte growth, or decreases in density or areal coverage of seagrasses or other submerged aquatic vegetation. Physicochemical indications of high productivity such as excessive diel oxygen/saturation/pH swings and/or elevated chlorophyll *a* concentrations are also evaluated. While total phosphorus or nitrogen concentration data alone are not utilized to determine impairment due to nutrient enrichment, these data do help to corroborate the other indicator data and occasionally help to identify potential sources (e.g., release of phosphorus from anoxic sediments). When these types of data are available but they do not indicate nutrient enrichment the *Aquatic Life Use* is assessed as support. When they do indicate nutrient enrichment the analyst must use best professional judgment (BPJ) to evaluate the severity of the problems based on the types of indicator data and any indication that they occur frequently or for prolonged periods. When combinations of indicators are present the *Aquatic Life Use* will likely be assessed as impaired.

DRAFT Aquatic Life Use Assessment		
Variable	**Support**	**Impaired**
	Data available clearly indicates no or minor modification of the biological community. Excursions from chemical criteria (MassDEP 2006) are not frequent or prolonged and may be tolerated if the biosurvey results demonstrate support.	There is moderate or severe modification of the biological community, presence of toxicity (acute and/or chronic), and/or frequent or severe violations of chemical criteria.
BIOLOGY		
Eelgrass Bed Habitat (Howes *et al.* 2003, Costello 2003, Costello 2008, MassGIS, 2008)	Increasing or stable (i.e., no or minimal loss), BPJ	Substantial decline in bed size or total loss of beds no matter their size. Determinations - assume a high confidence in the data sources, particularly 1951 data).
Plankton/Periphyton	No/infrequent algal blooms or growths of periphyton, ≤25% cover of aquatic plants such as *Lemna*, periphyton cover within riffle/reach ≤40%, chlorophyll a ≤200 mg/m^2.	Frequent and/or prolonged algal blooms, >25% noxious aquatic plant cover, percent periphyton cover within the riffle or reach >40%, cyanobacteria blooms result in advisories recurring and/or prolonged, chlorophyll a >200 mg/m^2.
CHEMISTRY-WATER**		
Indicators of nutrient enrichment (MassDEP 2006) All surface waters shall be free from pollutants in concentrations or combinations that settle to form objectionable deposits; float as debris, scum or other matter to form nuisances; produce objectionable odor, color, taste or turbidity; or produce undesirable or nuisance [growth or amount] species of aquatic life	None/infrequent algal blooms or growths of periphyton, physicochemical data generally in following ranges: chlorophyll a concentrations generally <3 – 10 mg/L, diel oxygen swings generally change ≤1.5 mg/L, saturation rarely >100 to 110%, pH in normal range. total phosphorus or nitrogen concentration data help to corroborate the indicator data	Frequent and/or prolonged indicators of enriched conditions (e.g., algal blooms, excessive macrophyte growth, decrease in the distribution (either in density or areal coverage) of seagrasses or other submerged aquatic vegetation, physicochemical data in following ranges: chlorophyll a concentrations >10 mg/L, excessive diel oxygen swings, saturation >110%, high pH. total phosphorus or nitrogen concentration data help to corroborate the indicator data

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   MassDEP has evaluated the relationship between ambient level of phosphorus and observed biological responses for freshwater systems. MassDEP has used linear regression between total phosphorus and chlorophyll, and has also used logistic regression to determine biological response indicators that determine support or non-support of uses as a function of total phosphorus.

   Preliminary results show that Secchi disk and chlorophyll a are sensitive to phosphorus at the low range 0-150 ppb if measured in lakes and/or some impoundments. Duckweed is under evaluation and appears to be somewhat sensitive, however, studies are ongoing. Filamentous algae appears to be somewhat sensitive in wadeable streams if light is

available. Secchi disk and chlorophyll a do not appear to be sensitive in running non-wadeable rivers. UMass Dartmouth's work on the Massachusetts Estuaries Project indicates that Eelgrass loss appears to be somewhat sensitive to nitrogen in shallow estuaries.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   In general the correlation between causal (chemical) and response (biological/ecological) variables for nutrients in river systems appears to be site specific. The primary reason for this is that phosphorus and nitrogen do not follow a typical dose-response relationship, as with toxic substances. Rather, waterbody-specific factors such as detention time, color, depth, light availability, Nitrogen/Phosphorus ratio, internal cycling, and local water chemistry also influence the response of aquatic systems. This results in the need to develop site-specific concentration targets for each waterbody.

   Over the last decade, Massachusetts has proposed the adoption of site-specific phosphorus standards for a number of ponds and determined that site-specific analysis should be used in deriving WQS criteria. On a parallel path, site-specific nitrogen criteria were promulgated in the SWQS in 2006 for a number of estuaries. These site-specific criteria were derived from a complex water quality modeling effort conducted by the University of Massachusetts /Dartmouth School of Marine Science and Technology (SMAST) and Massachusetts Department of Environmental Protection (MassDEP) under the Massachusetts Estuaries Program (MEP). The pace of work and resources needed to develop site specific criteria has not met EPA mandates.

   As a result MassDEP has been investigating other systematic approaches to developing numeric nutrient guidance (biological response indicators and numeric TP/TN). A MassDEP Nutrient workgroup analyzed a range of response indicators and concluded that there was a higher degree of confidence in nutrient-response relationships for lakes followed by wadeable rivers (<0.6 m). In order to assign TP or response indicator numeric guidance limits, waterbodies will need to be further sub-classified based on parameters like waterbody type (lake, river, impoundment) and physical-chemical characteristics like color, depth, residence time, slope, and substrate.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   MassDEP typically relies on the biological indicators for assessment and only uses nutrient concentrations to 'confirm' a problem with a nutrient source.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biological assessment is considered with BPJ to call for reduced TP or TN limits at WWTP discharges using an adaptive management approach. NPDES limits are typically set more to limit of technology which is moving effluent limits from 0.5 to 0.2 or 0.1 mg/l for phosphorus and 8 mg/L to 5 mg/L for total nitrogen.

   Biological response indicators have been used as targets in TMDL development. For example the Upper/Middle Phosphorus TMDL for the Charles River established an in stream target of <10 ug/L chlorophyll-a (seasonal mean) and <18.9 ug/L chlorophyll-a (peak). An HSPF model was used to evaluate a range of management scenarios that included a combination of point and non-point source load reductions. Water quality standards and the biological indicator targets were predicted to be met under worst case conditions (both extreme low flow and extreme high flow) through water quality modeling efforts when management scenarios set wastewater discharge limits for all WWTFs at 0.1 mg/L TP during the summer months and 0.3 mg/L TP during the winter months. The next round of NPDES permits will include these limits.

   For stormwater, the Upper/Middle Charles TMDL sets phosphorus discharge limits by land use category. The total phosphorus reductions from current conditions include: Open/Agriculture 35%; Low Density Residential 45%; Medium Density Residential 65%; High Density Residential/Multi-Family 65%; Commercial/Industrial 65%; and Transportation 65%. It is anticipated that these reductions will be include in future MS-4 permits.

Michigan

Contact: Gary Kohlhepp, kohlheppg@michigan.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

The primary biological assessment conducted by the Michigan Department of Environmental Quality (MDEQ) – Water Resources Division (WRD) includes fish and benthic macroinvertebrate community assessments in streams and rivers. The MDEQ-WRD has developed specific procedures and multi-metric indices for both communities, mainly to determine attainment with Michigan Water Quality Standards. For the most part, these bioassessments are conducted on a 5-year rotating basin schedule.
The MDEQ-WRD evaluates flowing waters and shorelines for nuisance algal conditions although these assessments are subjective. For rivers and streams, the presence of excess/nuisance growths of algae (i.e., Cladophera, Rhizoclonium, and cyanbacteria), or aquatic macrophytes are used to determine if the other indigenous aquatic life and wildlife use is being supported. A river or stream is considered impaired if one or more of the following conditions are present: (1) Cladophera and/or Rhizodonium strands are greater than 10 inches long covering greater than 25% of a riffle, (2) rooted macrophytes are present at densities that impair designated uses of the water, and (3) the presence of excess/nuisance growths of bacterial slimes. Field-based rapid bio-survey assessments of periphyton biomass and coarse-level taxonomic composition have been used on a limited basis to characterize macroalgae, microalgae, and substrate size to calculate algal cover and density. Best professional judgment would then be used to determine if excess/nuisance growths of algae occur, and whether or not designated uses are being attained.

Although the MDEQ-WRD does not routinely collect biological data on inland lakes, the department does conduct aquatic macrophyte surveys, and in conjunction with physical (i.e., secchi depth) and chemical (i.e., total phosphorus and chlorophyll a) data, uses this information to determine use support based on trophic status.

The Department of Natural Resources collects fish data in flowing waters and lakes, and this information is sometimes used to evaluate designated use support. The MDEQ-WRD also often uses water chemistry data to assess the aquatic life, wildlife, and fish community designated uses.

The MDEQ-WRD has provided grant funding since 1999 to a researcher at the University of Maryland (previously at Lake Superior State University and Clemson University) to assess bald eagle productivity and contaminant levels. The MDEQ-WRD also funds the Michigan Department of Community Health to analyze contaminant levels in fish tissues.
Finally, the MDEQ-WRD has provided grant funding since the late 1990s to a variety of local governments, universities, and watershed organizations for specific monitoring

projects which often include the collection of biological or ecological data from all types of waterbodies.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   The MDEQ-WRD currently makes limited use of aquatic macrophyte and algae (i.e., Cladophera, Rhizoclonium, and cyanobacteria) data to assess aquatic life impacts due to nutrients.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   The current approach using aquatic macrophyte and limited algal information to assess impairments has not been very sensitive, and evaluates only whether nutrients are in excess to cause, or contribute to, nuisance conditions. However, efforts are underway to develop a more sensitive process of evaluating nutrient contributions to surface waters. This process is necessary so that impacts due to nutrients can be detected before nuisance levels occur, and waterbodies with low nutrient conditions can be protected.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships? Please discuss challenges and successes you have experienced.

   This question was interpreted as asking "what relationships were found between causal (chemical) and response (biological/ecological) variables for nutrients". For lakes and reservoirs, relationships between total phosphorus and biological response variables such as algal biomass, macrophyte cover, and zooplankton metrics were evaluated. Linear regression was used to quantify linear relationships, and regression tree analysis was used to quantify non-linear relationships. These relationships were found to be moderately strong. In flowing waters, relationships between nutrients and response variables such as diatoms, benthic macroinvertebrates, and fish were examined. The strongest nutrient relationship was with diatoms.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   In general, most designated uses have one or more types of assessment that may be used to determine support. For example, to determine support for the other indigenous aquatic life or wildlife designated use, biological or physical/chemical assessment (e.g., rapid bioassessment of the macroinvertebrate community or chemical analysis of water samples) may be used. The assessment types include biological, habitat, physical, chemical, toxicological, pathogen indicators, other public health indicators, and other aquatic life indicators (default types from the USEPA Assessment Database (ADB)). In addition, a variety of parameters may be considered for the same assessment type. For

example, chemical assessments to determine fish consumption designated use support may include analysis of mercury concentration in fish tissue or PCB concentration in the water.

Michigan uses the principle of independent applicability when making a support determination for each designated use for each water body. If data for more than one parameter are available that are used to determine support for the same designated use, then each data type is evaluated independently to determine support for the designated use. If any one type of data indicates that the designated use is not supported, then generally, the water body is listed as not supporting that designated use. Some particular data types or situations require consideration of multiple data types in combination.

In regards to nutrients, Michigan currently does not have numeric nutrient criteria for assessing impacts to surface waters. However, narrative nutrient criteria (rule R323.1060), best professional judgment, and ambient water column total phosphorus concentrations, and secchi depth, in conjunction with biological indicators (i.e., algal biomass measured by chlorophyll a, aquatic macrophyte surveys, coarse-level algal taxonomy) are used to determine support of the other indigenous aquatic life and wildlife designated use.

For inland lakes, Carlson's trophic state index (TSI) uses secchi depth, total phosphorus concentrations and chlorophyll a concentrations in conjunction with aquatic macrophyte surveys to determine use support based on trophic status. The chlorophyll a component of the TSI is used as a surrogate for algal biomass. Lakes classified as oligotrophic, mesotrophic or eutrophic are generally determined to support the other indigenous aquatic life and wildlife designated use. Inland lakes classified as hypereutrophic are generally listed as having insufficient information to make an assessment of designated use support, or are considered to not meet designated uses. The non-attaining lakes are listed on the 303(d) list as impaired due to nutrients and are scheduled for TMDL development.

For rivers and streams, the presence of excess/nuisance growths of algae (i.e., Cladophera, Rhizoclonium, and cyanbacteria), or aquatic macrophytes are used to determine if the other indigenous aquatic life and wildlife use is being supported. A river or stream is considered impaired if one or more of the following conditions are present: (1) Cladophera and/or Rhizodonium strands are greater than 10 inches long covering greater than 25% of a riffle, (2) rooted macrophytes are present at densities that impair designated uses of the water, and (3) the presence of excess/nuisance growths of bacterial slimes.

Field-based rapid biosurvey assessments of periphyton biomass and coarse-level taxonomic composition have been used on a limited basis to characterize macroalage, microalgae, and substrate size to calculate algal cover and density. Best professional judgment would be used to determine if excess/nuisance growths of algae occur, and whether or not designated uses are being attained.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Biological assessment data are often considered when developing NPDES permits. If a new or increased use is being considered, then the MDEQ-WRD considers whether threatened/endangered species, or trout populations, may be impacted by the discharge. Likewise, fish and/or benthic macroinvertebrate community data also may be considered, especially if there are upstream/downstream data indicating potential impacts from a discharge. Fish data also are used to determine whether a receiving water is a coldwater stream/river.

   If the NPDES facility is known to have, or potentially has, one or more bioaccumulative chemicals in its discharge, then the MDEQ-WRD often will analyze fish tissue (native fish and/or caged fish studies) to look for the presence of these contaminants. In some cases, fish contaminant monitoring may be incorporated as a requirement into the NPDES permit.

   On a case-by-case basis, the MDEQ-WRD may conduct (or require a facility to conduct) special biological/ecological studies. For example, biological sampling has been conducted to assess impacts of biofilms resulting from an airport discharge and selenium impacts from a mining facility with an NPDES permit.

   Finally, if there is evidence of nuisance aquatic plant conditions downstream of an NPDES facility, this information will be considered in relation to nutrient loadings from the facility. Michigan's current nutrient rule (R323.1060) contains a numeric effluent standard of 1 mg/l that is generally applied to discharges that contain phosphorus. The rule also contains narrative language that allows control of phosphorus at lower levels to protect a waterbody from impacts due to nutrients if necessary. In those cases, the MDEQ-WRD may issue NPDES permits with a phosphorus limit less than 1 mg/l.

Minnesota

Contact: Shannon Lotthamer, shannon.lotthamer@state.mn.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The Minnesota Pollution Control Agency (MPCA) conducts biological assessment of streams based on fish and invertebrate IBIs, eutrophication assessment of lakes, and biological assessment of wetlands based on plant and invertebrate IBIs (among other assessments).

   Minnesota is implementing a rotating watershed approach whereby the biology, chemistry and physical characteristics of each of the state's 81 major (i.e. HUC-8) watersheds is intensively monitored two years out of every 10 (Figure 1). Using this watershed approach, the MPCA conducts monitoring in an average 8 major watersheds each year, and will complete statewide monitoring over a 10-year period.

   For streams, monitoring sites are selected following a "pour point" design, with biological, habitat and 1x chemistry monitoring at all the sites; more intensive chemistry monitoring at the 11-digit HUC sites; and a permanent flow and chemistry station at the mouth of the major watershed (see Figure 2). Data are collected over a two year period, and the data are then assessed for impairment determination.

   For lakes, MPCA and its partners collect paired phosphorus, Secchi depth and chlorophyll-a samples over at least two years for assessing the aquatic recreation designated use. The goal is to sample all lakes 500 acres or larger and at least 50 percent of lakes 100 to 500 acres in size over each 10-year cycle. This translates to sampling about 100 lakes each year. The MPCA primarily relies on local partners funded through state grants to sample lakes smaller than 100 acres in size, as well as additional lakes in the 100 to 500 acre size range. Through the state Department of Natural Resources, Minnesota is also developing IBIs for assessing aquatic life in lakes in the future.

   MPCA's wetland monitoring and assessment activities are not integrated into the watershed approach in a systematic way. MPCA does not routinely monitor wetlands for the purpose of watershed assessment, except for wetlands that are connected to or affect an adjacent or nearby impaired water body.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   As noted above, MPCA currently only assess lakes for aquatic recreation impacts due to nutrients; that assessment includes chlorophyll-a (i.e. suspended algae) and Secchi depth as indicators (along with TP). Minnesota is in the process of developing IBIs based on fish and (most likely) plants to use in future aquatic life assessments of lakes.

For streams, MPCA is using or plans to use chlorophyll-a (suspended algae), fish IBIs and invertebrate IBIs to assess for aquatic life impacts. Chlorophyll-a, along with dissolved oxygen flux (daily DO range), pH and BOD_5, represent the three response variables that are proposed for Minnesota's river eutrophication standard; while TP represents the causative variable. Benthic or periphyton chlorophyll-a will be used as a numeric translator for a portion of our narrative water quality standards. In the case of biological (fish or macroinvertebrate) impairments and periphyton chlorophyll-a, a stressor identification process will be used to determine the pollutant(s) or other factors causing the problem.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   For lakes, chlorophyll-a (and Secchi depth) is extremely sensitive to total phosphorus, with a very strong correlation exhibited. This was determined through regression analysis. The work to compare the lake IBIs under development to nutrients to evaluate their relationship is still underway.

   For streams, the relationship between total phosphorus, chlorophyll-a, DO flux and BOD is also very strong (see the MPCA's river eutrophication criteria technical support document at http://www.pca.state.mn.us/index.php/view-document.html?gid=14947 for details). MPCA also found strong relationships between total phosphorus and specific components of the fish and invertebrate IBIs; that data was also used in the development of the draft river eutrophication criteria. The sensitivity analysis was determined via quantile regression and changepoint analysis. Preliminary analyses indicate that rivers that fail to meet the proposed eutrophication criteria also fail biocriteria. Although multiple stressors can impact the biological community, these analyses indicate that the fish and macroinvertebrate IBIs are sensitive to eutrophication. Targeted research indicated that sestonic chlorophyll-a will be most applicable to medium- to high-order rivers, while periphyton chlorophyll-a will be most applicable to shallow low-order streams.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   For lakes the relationships among TP, chlorophyll-a, algal bloom frequency and Secchi transparency are well established in the literature and in the monitoring and research conducted in development of our lake eutrophication standards. All of this is detailed in the technical support documents and Statement of Need and Reasonableness (SONAR) developed in support of Minnesota's 2007-2008 water quality rule revision available at http://www.pca.state.mn.us/index.php/view-document.html?gid=7269.

For rivers MPCA has detailed the correlations and relationships used to develop our proposed river eutrophication standards in a series of technical support documents and the SONAR. These may be found at http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-rulemaking/proposed-water-quality-standards-rule-revision.html.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

For streams, data for individual parameters or biological indicators are first compiled, analyzed, reviewed and compared against the relevant criterion/benchmark for that parameter or indicator. Next the individual dataset reviews are brought forward to a comprehensive review organized either by major watershed, for watersheds that have been intensively monitored, or statewide for parameters that are monitored using a statewide design.

Following the "parameter-level" analysis, an interdisciplinary team of technical reviewers is convened for each watershed to review the data comprehensively. In cases where individual parameter/indicator datasets to not agree, the team looks further into the datasets – considering factors such as the relative robustness and applicability of the datasets, the timing of monitoring, etc. – to arrive at a proposed use-support decision for each stream assessment unit. That proposed decision is then carried forward to a Professional Judgment Group discussion that includes resource managers from other local and state agencies in addition to MPCA technical staff for additional review and discussion as needed.

MPCA employs a stressor-response approach to assessing lakes for aquatic recreation use-support. A lake is determined to be impaired for aquatic recreation use if phosphorus and either chlorophyll-a or Secchi depth do not meet the lake eutrophication criteria. For lakes to be assessed a minimum of eight paired observations of TP, Chl-a, and Secchi, collected over a minimum of two summers must be available. Mean measurements are compared to the standards. For rivers a similar approach is proposed whereby a minimum of 6-8 samples are collected per summer over a minimum of two summers. In most instances samples for TP and sestonic Chl-a will be collected; However diurnal DO flux, BOD_5 and pH may also be used as response variables. Again a river reach will need to exhibit elevated TP and one or more of the four response variables to be considered impaired.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Yes. At a minimum, where a biological impairment has been found and the stressor(s) identified, MPCA considers that impairment information in the development of the permit effluent limits if the facility is discharging a pollutant that could cause or contribute to the impairment. Biological information and modeling is also considered when developing NPDES permits for dischargers that may affect lakes. In addition,

Minnesota is currently working to develop tiered aquatic life uses (TALUs). In such a system, the biological assessment will be a major factor in determining the aquatic life use designation and therefore in setting NPDES permit limits.

Mississippi

Contact: Kim Caviness, Kim_Caviness@deq.ms.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Mississippi Department of Environmental Quality (MDEQ) has established the Mississippi Benthic Index of Stream Quality (M-BISQ) for wadeable streams throughout the state (excluding the Mississippi Alluvial Plain). The M-BISQ was developed in 2001 and was recalibrated in 2008.

   MDEQ is currently in the process of developing a benthic index for streams within the Mississippi Alluvial Plan (Mississippi Delta) as well as a benthic index for Mississippi's coastal and estuarine waters.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   MDEQ is currently in the process of developing numeric nutrient criteria for all water body types across the state. At this time, Mississippi is considering the use of benthic macroinvertebrate communities, fish communities, and chlorophyll a concentrations as biological indicators/parameters to assess aquatic life impacts due to nutrients.

   MDEQ will continue to use the M-BISQ to assess support ALUS. Once the other indices are complete, they will also be used to assess ALUS in those regions of the state.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   The M-BISQ was sensitive (significant decline) to both N and P, based on correlation/regression models using survey data. These relationships were considered sufficient by review of the Nutrient Technical Advisory Group (TAG) to be used as a line of evidence in deriving preliminary thresholds.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approaches) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experience.

   Mississippi has used classification to reduce variability associated with biological response. In addition, the state has incorporate propensity score analysis to verify the causal relationship between nutrients and invertebrate indices. These analyses have helped increased confidence in the basis for endpoints derived from the empirical models.

But this stressor-response relationship is also being weighed against other lines of evidence including reference based, modeled reference, mechanistic model output, and scientific literature.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   MDEQ's position is that biological community measures (especially, robust, well calibrated indices) provide a direct measure of ALUS. As such, biological data are given more weight in the assessment process. When a community is determined to be impaired (based on 25th percentile of the least disturbed condition), a stressor identification process is undertaken to determine the primary probable cause of impairment. During the stressor process, all chemical data are reviewed along with point source and land use information to determine the primary probable cause of impairment.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   In Mississippi, a biological assessment is made based on the M-BISQ program. The MDEQ Water Quality Assessment Staff determine, based on the data collected, if the water body is attaining its designated use(s). If not, the water would be listed on Mississippi's 303(d) List of Impaired Waters. The water body is listed for "biologically impairment." The water body will then go through a stressor identification process to identify the stressor (as described in #5 above). Once the primary probable stressor is identified, a TMDL is developed for that stressor.

   When issuing a NPDES permit, especially within an impaired water body, MDEQ will consider all available data and information for the receiving water body. All data and information are considered to ensure that protective permit limits are established.

Missouri

Contact: John Ford, john.ford@dnr.mo.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Missouri Department of Natural Resources (MDNR) has developed biocriteria for aquatic invertebrate communities in wadeable (3rd-4th order) streams (and accompanying sampling and enumeration protocols) and chooses about 50 sites each year which are monitored twice during the year. The Missouri Dept. of Conservation (MDC) monitors fish and invertebrate communities at about 70 to 100 sites each year. Sites are selected randomly from most 2nd to 5th order streams. MDC uses MDNR protocols for invertebrates and has developed fish community biocriteria for Ozark Plateau and Ozark Border streams but not for Prairie or Mississippi Embayment streams.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   MDNR has not looked at that question yet.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   MDNR did do one invertebrate survey of a stream below a large WWTP and found that some changes in the invertebrate fauna appeared to persist for over 20 miles downstream. Nearer the WWTP there were obvious differences but further downstream we were still seeing apparent substitutions of one species or genera for another even though diversity indices were similar. Thus, MDNR believes invertebrate surveys may be quite sensitive to nutrient levels.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   MDNR has not yet looked at cause/effect relationships for nutrients in any systematic way at this time.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

A water can be assessed as “impaired” if either physical or chemical wq standards or biological criteria are exceeded.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   If waters are rated as impaired, the pollutant(s) causing the impairment must be controlled by both point and nonpoint sources as per the allocations prescribed by the TMDL study. If a point source discharges a pollutant(s) that was subject to a TMDL allocation, the permit limits must reflect either the load allocated to this discharge or the best practical treatment technology, whichever results in the higher limits.

Montana

Contact: David Feldman, dfeldman@mt.gov; Michael Suplee, msuplee@mt.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The state of Montana conducts biological/ecological evaluations to aid sediment, and nutrient assessments when the physical and/or chemical data do not provide a clear answer. You can find an overview of the Montana water quality assessment methods online: http://deq.mt.gov/wqinfo/QAProgram/PDF/SOPs/FINAL_AssessmentMethod.pdf

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Montana Department of Environmental Quality (MT DEQ) uses benthic algal biomass, a diatom biometric, and a Montana-specific version of the Hilsenhoff Biotic Index (HBI) for macroinvertebrates, to assess aquatic life impacts due to nutrients.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   MT DEQ selected all three biological indicators using a combination of a literature review, and an analysis of empirical data collected over many years. MT DEQ extensively studied all three biological indicators, and selected them because they consistently responded to increased nutrient levels. MT DEQ posted a document online that provides an overview of the nutrient assessment method and how the biological indicators were selected at this link: http://deq.mt.gov/wqinfo/QAProgram/PDF/SOPs/final_nutrientmethod.pdf

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   A brief synopsis of the approaches used to make the correlations between biological variables and nutrient levels is provided below. Please refer to the nutrient assessment method link provided in response to question #3 for a detailed response to this question.

   MT DEQ employed different strategies to determine if any correlations existed between increased nutrient levels and instream biota. The streams in Montana were organized by whether they were Mountain, or Plains streams. MT DEQ grouped those streams that flowed through transitional areas between the mountains and plains with the mountain

streams. Each grouping was based upon TN and TP values measured from the DEQ reference site network.

MT DEQ intended the benthic algae portion of the assessment method to help protect the recreational use of streams. It was based upon scientific literature and a public opinion survey where people were shown a photo series where they had to answer the question: "Which photograph had too much algae?" MT DEQ collected benthic algal growth data at the same time that the photos were taken so as to be able to relate the two together. The people taking the survey were presented with photos from several streams with different levels of benthic algal growth. The people that were interviewed consistently selected photographs of streams with benthic algal levels greater than what was measured in reference sites. They consistently answered the question by selecting the photos that were taken from streams with benthic algal levels greater than 150 mg/m^2. MT DEQ used the results from that study combined with the levels measured from reference sites to justify that level (150 mg/m^2) as a potential numeric criterion to protect the recreational use of a stream.

MT DEQ developed the diatom biometric to show biological change associated with elevated instream nutrient, sediment, and metals values. First, the streams were classified by their location in mountain transitional or plains regions in Montana. MT DEQ then grouped the sites as either reference or impaired based upon any available data, and then used a discriminant function analysis to identify the "increaser" diatom taxa that consistently responded to the specific stressors within those streams.

MT DEQ has been using the Montana-specific Hilsenhoff Biotic Index (HBI) in different DEQ Multimetric Indices for many years. MT DEQ worked with the EPA and Tetra Tech and evaluated over 200 sampling events in Montana where they had both nutrient and macroinvertebrate samples. The macroinvertebrate data was organized into several hundred macroinvertebrate metrics. MT DEQ then compared those values to TN and TP values using a change-point analysis. That analysis consistently showed a noisy, but discernable (and significant) relationship between the HBI and nutrients. MT DEQ found a consistent shift in the macroinvertebrate population around an HBI score of 4, and also noticed that there was a precedent set for that HBI threshold because earlier versions of the DEQ macroinvertebrate SOPs, used the same threshold to indicate impairment.

There is one big success to mention. MT DEQ dosed a stream in eastern Montana with different levels of nitrogen and phosphorus. A BACIP (Before, After, Control, Impaired, Paired) study design was used. This allowed MT DEQ to evaluate any macroinvertebrate, diatom, or benthic algae community shifts before dosing began, during, and after the dosing event. MT DEQ measured significant shifts of all three biological indicators associated with the nutrient dosing event. This is a big deal because there has not been much luck relating nutrient impairment with biological indicators in plains streams. MT DEQ did discover that the Montana-specific HBI did not show a significant shift associated with the dosing event. This is interesting because it worked so well in the other analysis where we selected it for use with the Montana nutrient assessment method. MT DEQ will draft a technical report describing this study in 2012.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   MT DEQ uses biological and ecological assessment information to help clarify if the aquatic life use of a stream or waterbody is impaired by a given pollutant or pollution. This information is used when the chemical and physical data are close to the standard, or occasionally exceeded the standard. Please refer to the document referenced in question #1 for a detailed answer to this question.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   MT DEQ does not use biological information to develop NPDES permits.

Nebraska

Contact: Ken Bazata, ken.bazata@nebraska.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Nebraska Department of Environmental Quality (NDEQ) has used fish and macroinvertebrate biological assessments for stream evaluations since the mid-80s. However, the metrics were not finalized until the mid-90s. NDEQ used the REMAP data set as our source of standardization.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   The metrics are not set up for nutrients as such. Nutrients are a general consideration, but there is not enough data to do this. NDEQ does not have standards for nutrients.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Unknown.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   NDEQ used a reference site approach to setting criteria. The reference site selection sets up higher ratings. From there, trisections were used to calculate the various ratings. NDEQ also divided waters into cold/warm water, small/medium/large/river flows, and ecoregions. The state was divided into sandhills and western Nebraska versus the rest of the state.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   NDEQ uses chemistries, fish and macroinvertebrate bioassessments, fish kills, and fish tissue chemistries for the integrated report.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

At this time, NDEQ does not use the biological assessments for this.

Nevada

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Nevada Division of Environmental Protection (NDEP) has developed Nutrient Assessment Protocols for Wadeable Streams, which is a multi-tiered approach for assessing nutrient impairment status. Level I assessments are primarily qualitative visual surveys and estimation of algal biomass or the percentage of the stream bottom covered by filamentous algae, microalgae and macrophytes. Generally, if the coverage is greater than 25%, Level II assessments are conducted which include more quantitative measurements of algal biomass, daily minimum/maximum dissolved oxygen, pH and temperature.

   Nevada is also in the process of developing models to assess biological assemblages including the RIVPACS-based observed/expected indices and multimetric indices.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Algal characteristics including biomass, chlorophyll-a and ash free dry weight and macroinvertebrate assemblages.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   In general, high algae levels are seen in waters that exceed the numeric or narrative nutrient standards; however, exceptions have been documented.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Program is still under development and much more data is needed to quantify the correlation between causal and response variables.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   At this time, impairment decisions are made solely on exceedances of numeric criteria.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Not at this time.

New Hampshire

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Rivers are currently assessed for aquatic life use using fish and macroinvertebrates. Over the past five years, the NH Department of Environmental Services (NHDES) has collected nutrient and macroinvertebrate data from approximately 100 streams and rivers to assist in establishing numeric nutrient criteria. In 2011 NHDES began collecting algal abundance and composition data from rivers and streams in conjunction with the parameters noted above. Given our current level of staffing sampling is restricted to approximately 20 sites / year. Fish are not considered to be an important indicator for use in setting numeric nutrient criteria.

   In estuaries, seagrass habitat is mapped every year because New Hampshire has a small coastline and only one major estuary. Benthic invertebrates and pelagic fish are monitored every five years as part of national probabilistic surveys, although these species are not considered relevant to eutrophication.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   To assess the primary contact recreation designated use, NHDES uses a chlor a threshold of 15 ug/l in fresh waters and 20 ug/L chlor a in tidal waters.

   Freshwater Rivers: NHDES envisions macroinvertebrates and algae will serve as the primary response variable used to establish numeric nutrient criteria in freshwater rivers and streams for the aquatic life designated use.

   Lakes: Trophic class based total phosphorus and chlor a criteria is currently used to protect the aquatic life designated use in lakes. TP is assessed as a cause of impairment only when the response variable (chlor a) exceeds the threshold for a given lake's best historic trophic class. The criteria were primarily determined using the EPA reference approach. For more details see the NH 2010 Consolidated Assessment and Listing Methodology (CALM), page 57 at http://des.nh.gov/organization/divisions/water/wmb/swqa/documents/2010calm.pdf and http://des.nh.gov/organization/divisions/water/wmb/wqs/documents/20090122_lake_phos_criteria.pdf.
   Estuaries: In NH estuaries, the primary indicators of nutrient enrichment are seagrass habitat and dissolved oxygen. DES also uses proposed criteria for total nitrogen concentrations for make assessments of estuarine waters. See

http://des.nh.gov/organization/divisions/water/wmb/wqs/documents/20090610_estuary_criteria.pdf for details.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Rivers: Analysis of macroinvertebrate data with respect to nutrient levels is currently limited to approximately 70 locations. The preliminary results show this response variable to be coarse indicator. The difficulty in detecting a strong threshold using macroinvertebrate is reflective of the narrow and low range of nutrient concentrations found in NH waters. Additional results will be available in spring 2012 through a draft report submitted to EPA in order to satisfy a 104(b)(3) grant. A complete analysis of algal data will not be available until additional sites are sampled over the course of the next 4-5 years.

   Lakes : As discussed our response to question 2 above, the EPA reference approach was used to determine trophic based total phosphorus and chlor a criteria for the protection of aquatic life in lakes.

   Estuaries: DES completed a five year study of nutrients and eutrophication in the Great Bay Estuary. Dissolved oxygen and seagrass habitat were identified by an advisory committee as being the most sensitive endpoints for excess nutrients. Regressions of dissolved inorganic, total dissolved, and total nitrogen concentrations versus seagrass habitat and dissolved oxygen deficits were used to establish causal linkages between the nutrients and the effects. For details, see: http://des.nh.gov/organization/divisions/water/wmb/wqs/documents/20090610_estuary_criteria.pdf.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Rivers: As noted above, to date New Hampshire Discharge Elimination System (NHDES) has only explored the relationship between nutrients and macroinvertebrates. The techniques used include linear regression, weighted averaging (taxa optima), changepoint, conditional probability, and basic distributional plots. At this point, macroinvertebrate community condition is weakly correlated to total phosphorus concentration. It is believed that the strength of this relationship could be improved upon with additional samples, specifically if NHDES could expand the upper range of phosphorus concentrations. There is no indication that macroinvertebrate communities respond to total nitrogen. For these analyses, streams were broken into 3 classes in order

to limit the influence of natural variation. NHDES has not explored the development of site specific criteria.

Lakes: As discussed in the response to question 2 above, the EPA reference approach was used to determine trophic based total phosphorus and chlor a criteria for the protection of aquatic life in lakes.

Estuaries: Relationships between causal and response variables were improved when long-term average concentrations at stations were used, instead of individual results. Monthly grab sample results for chlorophyll-a and dissolved oxygen are highly dependent on weather patterns, zooplankton populations, and other factors. These covariates often mask the relationships between nutrient and primary productivity. This approach is discussed in the final report. For details, see: http://des.nh.gov/organization/divisions/water/wmb/wqs/documents/20090610_estuary_criteria.pdf.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   For nutrients, the response variable must exceed criteria for the nutrient parameter to be considered an impairment. For estuarine assessments using this approach see: http://des.nh.gov/organization/divisions/water/wmb/swqa/2008/documents/20090813_303d_list_update.pdf.

   For other chemical measurements; pH, DO, toxics,… independent applicability applies. In cases of sediment data, a sediment triad approach makes use of the Hazard Quotient-Threshold Effect Concentrations (HQ-TEC), then Bioassays, and then full biological surveys depending on the availability of data.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   NH is not a delegated State. All wastewater treatment facilities (WWTFs) in NH discharge to either rivers or tidal waters.

   For WWTFs that discharge directly to freshwater rivers, EPA typically uses the mass balance equation to establish WWTF phosphorus effluent limits where the downstream instream concentration is set at 0.1 mg/L, the upstream river flow is set at the 7Q10 low flow, the upstream concentration is based on background measurements, and the WWTF flow is set at the design flow.

   In estuaries, EPA is currently using the results of nitrogen loading models prepared by NHDES to estimate the nitrogen concentration in the estuary under different WWTF loading scenarios. The nitrogen loading models predict the maximum watershed load of nitrogen for which the estuary will attain standards for dissolved oxygen and seagrass habitat.

New Jersey

Contact: Debra Hammond, debra.hammond@dep.state.nj.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Benthic macroinvertebrates: Early on New Jersey Department of Environmental Protection (NJDEP) used the NJ Impairment (NJIS) score to assess wadeable streams. NJIS was based on family-level taxonomy and classified results into three conditions. In 2003, NJDEP began working on refinements to NJIS based on genus/species-level taxonomy that is more appropriate to the various ecoregions. NJDEP also worked with TetraTech to establish scores using the Biological Condition Gradient (BCG). NJDEP now uses three ecoregional indexes and is working to further refine these indices for application in assessing headwaters. http://www.state.nj.us/dep/wms/bfbm/amnet.html NJDEP is currently working to develop an IBI using benthic organisms for nearshore ocean waters and estuaries.

   Fish: NJDEP has a Fish IBI for high gradient waters and is currently working to develop a Fish IBI for NJ coastal plains. http://www.state.nj.us/dep/wms/bfbm/fishibi.html

   Diatoms: A diatom index for wadeable streams has been developed and is currently under review by the Science Advisory Board. NJDEP is also currently developing a lake diatom index. http://www.state.nj.us/dep/dsr/nutrient/streams.htm

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Freshwaters: Currently use benthic macroinvertebrates and fish to assess aquatic life use. NJDEP is adding periphyton chlorophyll *a*, and diatoms to further evaluate if the biological conditions could be due to excessive nutrients. The resources needed to conduct periphyton monitoring which is used to calculate chlorophyll *a* and enumerate diatoms so that the sites can be assessed by the index are not adequate.

   Estuarine waters: NJDEP is developing a benthic index but is also working to incorporate other nutrient related biological responses into a more comprehensive eutrophication index. These other indicators include chlorophyll *a*, brown tide, SAV.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   NJ adopted 0.1mg/l TP in the 1980's. NJDEP identified waters with higher levels with concentrations of phosphorus – fast flowing, full canopy, colored waters, with good biological conditions. Waters with very low concentrations of nutrients but exhibit significant biological responses were also identified. Generally macroinvertebrates don't display a strong relationship to nutrients. In many cases, benthic macroinvertebrates are

affected more by habitat disturbance. It's critical that there be some measure of productivity, which is why NJDEP has included diurnal dissolved oxygen. NYDEC has successfully created a nutrient biotic index but we didn't have enough nutrient data to create similar index for NJ waters. NJDEP decided to evaluate the development of diatom index that would better predict nutrient levels. The Science Advisory Board is reviewing this work and upon completion NJDEP will consider what revisions would be made to the assessment process.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   NJDEP's WQS include a narrative nutrient criteria and a numeric phosphorus criteria. The impacts of nutrients are best assessed through a weight of evidence approach. Load Allocations and wasteload allocations need to have a numeric phosphorus value to establish reductions when necessary. Since NJDEP's WQS do not specify averaging period or frequency, NJDEP has used Chlorophyll *a* as the end point, developed site-specific averaging periods, and developed reference conditions, while they continue working towards enhancing our nutrient criteria. To avoid rulemaking, NJDEP included a provision in its WQS that allow the TMDL program to develop response indicators or other criteria (DO, pH) or modify the state-wide TP criteria to ensure compliance with the narrative nutrient criteria as part of the TMDL. This provides the interested public an opportunity to review and comment on the criteria as part of the TMDL. Once adopted, a site-specific criteria can be added to the WQS.
   http://www.state.nj.us/dep/wms/bwqsa/swqs.htm

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   While NJDEP has been listing waters based on biological monitoring – benthics and fish, they only began using a weight of evidence approach based on biological monitoring for nutrient assessments 2010. NJDEP's 2010 Assessment Methods incorporated a narrative nutrient assessment for wadeable streams which required biological monitoring along with continuous dissolved oxygen. The assessment methods specified that 3ppm swing was an indication of excessive photosynthetic activity caused by nutrients. For inconclusive assessment (DO does not exceed the minimum criteria but does display diurnal fluctuation, NJDEP looked at seasonal periphyton chlorophyll *a* to determine whether nutrients are impacted the waterbody.
   http://www.state.nj.us/dep/wms/bwqsa/generalinfo.htm

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

NJ has a numeric phosphorus criteria which is used to develop WQBELs. NJDEP continues listing waters based on our numeric phosphorus criteria where the data is lacking to conduct an assessment, but will also be listing phosphorus based on the narrative nutrient assessment which will capture waters where the levels of nutrients are below the current numeric criteria but are sufficient to cause nutrient related impacts. NJDEP's permitting program imposes effluent limits for phosphorus if the water is listed on our 303(d) list regardless of whether it's based on exceeding the numeric or narrative nutrient criteria. However, the facility is provided an opportunity to conduct a water quality study to demonstrate that nutrients do not render the waters unsuitable for their designated uses. This study incorporates diurnal dissolved oxygen monitoring, periphyton chlorophyll a, and other parameters. http://www.nj.gov/dep/dwq/pdf/p-manual-07-30-08.pdf

New Mexico

Contact: Shelly Lemon, Shelly.Lemon@state.nm.us; Seva Joseph, Seva.Joseph@state.nm.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

    - Benthic Macroinvertbrates – New Mexico Environment Department (NMENV) developed multimetric index for mountainous region; use reference site comparison for other regions (plains/xeric); use these approaches to assess (and list if no other physical/chemical causes are identified). Benthic data has also been used to develop stream bottom sediment thresholds to assess the State's narrative criteria
    - Periphyton – have collected 10 years of species enumeration data – recent analysis has not found any relevant thresholds/ metrics useful for assessment purposes etc. NMENV also analyzes stream periphyton chlorophyll a concentration for its nutrient assessment protocol
    - Phytoplankton – in lakes and reserovoirs NMENV collects both chlorophyll a and species composition data; chlorophly a and %blue-green algal composition are currently being investigated for development of a lakes nutrient assessment protocol
    - Fish – NMENV has collected 10 years' worth of fish species enumeration and is in the process of investigating the possibility of a Fish IBI

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

    For wadeable perennial streams nutrient assessment – currently the only one which NMENV uses for 303d listing – NMENV looks at cause variables (TN and TP) concentrations and response variables (chlorophyll a, DO diel variability, pH). In general the sensitivity is dictated by the location – mountain streams are very sensitive whereas xeric (and turbid) streams are no sensitive and have much high thresholds for causal variables and typically do not show significant change in response variability (they are light limited systems not nutrient limited)

    For lakes MNENV is still in development but for response variables they are also considering water column chlorophyll a and % blue-green abundance

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

    See above. For wadeable streams NMENV furthered EPA's ecoregion approach to set TN/TP thresholds and followed a similar process for chlorophyll a targets; for DO and pH we uses values found in our standards.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the

frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

NMENV has not looked at this explicitly – rather our assessment approach (for a narrative standard) requires us to look at both causal and response variables in order to list a stream an impaired for nutrients. If a response variable was found without elevated TN/TP it would simply be listed for that parameter (e.g. DO) as nutrients are not the cause. Conversely if TN/TP exceeds the targets but there is not response variable impairment – then the level of nutrients in this stream is still acceptable (i.e. it does not lead to an exceedence of our narrative criterion which puts the limit on "produce undesirable aquatic life"). NMENV can use this approach because they have a narrative standard and it is one of the reasons why they do not intend to pursue numeric criteria.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   See above – regarding nutrients specifically. In general New Mexico does not list for biological/ecological (e.g. benthic index) or other response variables (e.g. DO) if a cause variable is identified (e.g. nutrients or excessive fines on the stream bottom)

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   New Mexico does not issue NPDES permits as we do not have primacy. EPA R6 issues New Mexico's permits and NMENV is not aware that they consider biological assessment information in the NPDES permit development.

New York

Contact: NYSDEC Division of Water (A.J. Smith, ajsmith@gw.dec.state.ny.us; Margaret Novak, manovak@gw.dec.state.ny.us; Jeff Myers, jamyers@gw.dec.state.ny.us)

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   New York Department of Environmental Conservation (NYSDEC) maintains an ongoing (40 year history) biological monitoring program using macroinvertebrates and diatoms, for assessing biological condition and water quality of flowing surface waters statewide. A four tiered assessment framework is used to rank water quality based on biological condition. In addition to this core program, efforts are underway to look at biological condition and develop appropriate assessment methodologies for lakes and high-elevation low-order streams. Recently NYS has begun to integrate its biological assessment methods into water quality standards development in the form of effects-based nutrient criteria. Biological response is an integral piece in identifying impairment and exceedence of criteria.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Benthic macroinvertebrae community metrics will be used to assess aquatic life impacts due to nutrients. While NYS uses diatoms in making water quality assessments, these metrics are not currently incorporated as a response variable in the nutrient criteria under development.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   In New York State, a nutrient biotic index for macroinvertebrates was developed, which has proven to be a robust measure of the effects of nutrient enrichment on these communities (Smith and others 2007). This has been incorporated into the multi-metric index used in NY, the Biological Assessment Profile (Smith and others 2009).

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   NYSDEC has found that as long as they use nutrient-specific community metrics they see significant response to chemical variables. Capitalizing on these metrics and integrating

them into regular assessment methods provides a mechanism for assessing nutrient condition and over-enrichment.

NYSDEC finds small differences in response variables between ecoregions and water body size. NYSDEC conducted several investigations including splitting data into ecoregional and/or various stream size classes. Differences were never great enough to warrant establishing separate criteria for each (Smith and Tran 2010).

NYSDEC has defined a mechanism of using a combination of assessing response variable condition along with chemical values to indicate impairment status. This provides something similar to site-specific nutrient criteria but allows the biological condition to be the driver in the decision making process.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   NYSDEC uses a combination of the chemical value (base criterion) and the status of biological condition within their four tiered assessment framework. The process is as follows:

	[Nutrient] < Base Criterion	*[Nutrient] ≥ Base Criterion*
Biological Condition Non-Slight	*Not nutrient impaired*	*Nutrient threatened*
Biological Condition Mod-Severe	*Nutrient threatened*	*Nutrient impaired*

   Surface waters that fall into the threatened category are allowed to exceed the "base criterion" up to a level defined as the "modified criterion" as long as biological condition is proven not to enter into the assessed condition of moderate-severe impact.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Occasionally, biological assessment information is used by permit writers when developing permits and very occasionally subsequent assessment work is required of the discharger, but this is not currently standard procedure used in NYS.

References

Smith AJ, Bode RW, Kleppel GS (2007) A nutrient biotic index (nbi) for use with benthic macroinvertebrate communities. Ecological Indicators 7: 371-386.

Smith AJ, Heitzman DL, Duffy BT (2009) Standard operating procedure: Biological monitoring of surface waters in New York State, New Yoprk State Department of Environmental Conservation, Stream Biomonitoring Unit. Technical Report, p. 159.

Smith AJ, Tran CP (2010) A weight-of-evidence approach to define nutrient criteria protective of aquatic life in large rivers. Journal of the North American Benthological Society 29: 875-891.

North Carolina

Contact: Dianne Reid, Dianne.reid@ncdenr.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Monitoring Chlorophyll-a. North Carolina Department of Environment and Natural Resources (NCDENR) has a strong biological assessment program (benthic macroinvertebrates, phytoplankton and fish) and has done some work to determine if benthic macroinvertebrates and periphyton can be used for assessment of nutrients. Budget constraints have hampered this work.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Chlorophyll-a is the main parameter as NCDENR has statewide numeric standards for chlorophyll-a.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Chlorophyll-a has proven to be very sensitive based on comparison to phytoplankton samples and visual observations. NCDENR regularly uses their data to determine Nitrogen and Phosphorus reductions necessary to meet the chlorophyll-a standards.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   NCDENR uses modeling to assess the correlation between causal and response variables. North Carolina has adopted nutrient management regulations based on modeling and chlorophyll-a numeric standard to achieve reductions in nitrogen and phosphorus from all sources.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   NCDENR uses the biological/ecological assessment information on its own to make impairment decisions.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes, based on NCDENR's chlorophyll-a numeric standard. For waters that are not currently impaired, NCDENR requires a demonstration that standard will be met if the permit is issued. NCDENR uses the demonstration (e.g. modeling) to set Nitrogen and Phosphorus permit limits.

North Dakota

Contact: Mike Ell, mell@nd.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The main focus of our work is Index of Biological Integrity (IBI) development. The North Dakota Department of Health (NDDoH) is implementing a systematic plan for the collection of reference site data within each of the four level III ecoregions in the state. Each year the state collects macroinvertebrate, physical habitat and chemistry data at 30-40 reference and "impaired" sites. The goal is to collect data at 30 reference and impaired sites each in each of the four ecoregions. These data are being used to develop IBIs on an ecoregion basis and using the reference data to set thresholds for making impairment decisions. Using IBIs and thresholds developed for the Red River basin, the Department also implemented a regional biological condition assessment using a probabilistic sampling design.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Macroinvertebrates and possibly periphyton

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   To date NDDoH has limited data to test the sensitivity of macroinvertebrates to nutrients in ND streams and no data for periphyton.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   These types of analysis have not been conducted.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Biological data are used independently from chemical data in making use impairment decision. Where impairments are identified using biological data, chemical and physical data are used to determine the source or cause of the impairment. Where chemical and

physical data are not available the waterbody is still assessed as impaired, but put on a list for further stressor identification/assessment.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   No.

Ohio

Contact: Robert J. Miltner, bob.miltner@epa.state.oh.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Ohio EPA conducts biological and water quality surveys of several river systems per year. The size of the systems vary, but typically range between 400 and 1000 square miles in surface area. Media sampled includes the water column and sediments for chemical quality, fish and macroinvertebrate assemblages, and algal abundance. Physical habitat quality is assessed at all sampling locations.
   - Watershed level chemical and biological surveys (fish & bugs)
   - Stream nutrient criteria study (as above + benthic chl a, continuous DO)
   - Lake and reservoir sampling on limited scale (classic parameters + algal toxins)
   - Lake Erie nearshore sampling (includes benthic invertebrates)

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Biological indicators include fish, macroinvertebrates, algal abundance as given by chlorophyll-a, and serial dissolved oxygen monitoring. Results from these data are rarefied into a composite index called the Trophic Index Criterion (TIC) to position a waterbody relative to the nutrient enrichment continuum.
   - Trophic Index Criterion (TIC, multi-metric built on IBI/ICI, chl a, DO and nutrient concentration data)

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Chlorophyll-a is very sensitive to nutrient concentrations as determined empirically through field observations. Fish and macroinvertebrates, being more distal to nutrients than algae, are comparatively less sensitive, but show significant associations with nutrient concentrations based on retrospective data analyses.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   The correlations between nutrients and benthic chlorophyll were from a prospective study wherein a nutrient gradient was defined based on historic observations and recent land use (from desktop GIS). The relationship is broadly applicable to streams less than 1000

square miles in drainage area. The prospective design deliberately excluded streams where the relationship between nutrients and enrichment would be confounded (e.g., low-gradient swamp streams, mine drainage, highly urbanized catchments).

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Ohio has biological criteria for fish and macroinvertebrates, and those criteria are the basis for listing waters as impaired. To assess nutrient enrichment, information from algae (chlorophyll-a) and dissolved oxygen regimes will be incorporated into condition assessments to determine where a given waterbody is positioned along the continuum of enrichment, such that waters where the existing biocriteria are met, but show signs of significant enrichment, can be listed as impaired or threatened.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   The use of the biological assessment information is contextual, but typically it is included when developing NPDES permits. The results of biological surveys trigger more stringent permit limits when impairment is demonstrated, and sometimes less stringent limits when survey results show biological communities are fully attaining the designated use. Limits for nutrient (usually total phosphorus) and in-direct but persistent low level toxic chemical (e.g., selenium, PAHs) get generated due to impact signatures seen in survey data.

Oklahoma

Contact: Phillip Moershel, PHMoershel@owrb.ok.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   For Streams/Rivers: Fish, macroinvertebrates, quantitative habitat data and **algae (both benthic and sestonic**) are collected. Both probabilistic and fixed sites are used. Fish are collected once every four years while macroinvertebrates are collected every other year. For small to medium streams, at a minimum, one site in every HUC 11 watershed is assessed every 5 years with 24 monthly water quality samples a fish collection and 4 benthic invertebrate collections. Qualitative periphyton ranking is included in the assessemtns.

   For Lakes: Zooplankton, phytoplankton, habitat data and macrophyte coverage are collected on small lakes.

   The biological assessment program goals are:
   - Clean Water Act responsibilities to report on beneficial use support of biological communities of our waterbodies.
   - Increasing the amount of biological data available which can be utilized for Water Quality Standards development.
   - The use of bio-indicators to help potentially develop other criteria.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Periphyton Chlor a
   Seston Chlor a
   Qualitative periphyton
   Benthic invertebrates
   Algal and diatom community metrics would be monitored if promulgated

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Below is a summary from a recently completed probabilistic survey of 51 stream sites in an Ozarkian watershed.

   FY-2005 Section 104(b)3 (CA# CP-966144-01)—Probabilistic Monitoring in the Illinois River Watershed to Determine Multi-Assemblage Biotic Condition and Stressor Relationships

   The relative risk analyses produced widely variable results depending upon both biotic condition and stressor. For the most part, the attempt to draw relationships of stressors to

fish and condition using relative risk produced mixed results depending on stressor category.

- For nutrients, only the Use Support Assessment Protocol (USAP) screening level for total nitrogen and available nitrogen produced significant associated risk to fish condition. With a highly inconsistent relationship of stressor to biological condition, nutrients become a poor predictor of fish and benthic macroinvertebrate (BMI) condition.
- Habitat stressors had some predictive capacity when considering fish and BMI. Fish condition was significantly related to both the overall habitat score and percentage of deep pools. The BMI-Riffle habitat was significantly related to the percentage of deep pools. Habitat does show more predictive capacity and appears to be related to overall habitat change and/or loss.
- General water quality stressors demonstrated the greatest predictive capacity when considering fish and BMI. Dissolved oxygen and turbidity related to water quality standards was significant for each assemblage, but it should be noted that only one site exceeded the respective criteria. However, the historical 75th percentile of dissolved oxygen (DO) percent saturation shows promising predictive capacity. It is significant for BMI-Riffle condition, but also produced non-significant relative risks for the other two conditions. In fact, for all conditions, a number of stressors were above 1.0 but not significant.
- When comparing both fish and BMI to a broad spectrum of stressors, it appears that stressor/condition relationships are difficult to pin down**.** This study looked at a very diverse set of stressors that represented a broad range of nutrient and general water quality values. Regardless of site concentrations, some notable relationship should have been formed between condition and stressor condition. This study also used IBI's as well as reference conditions that have been widely published in studies by both the Oklahoma Water Resources Board (OWRB) and Oklahoma Conservation Commission (OCC). However, either the IBI or reference may not be sensitive enough. Streams in the watershed are generally cool water aquatic communities and have exceptional habitat, including substrate and flow. In fact, habitat was likely the most relevant stressor for both BMI and fish. Because habitat is so exceptional, fish and BMI assemblages are often much more diverse and have many more sensitive species than other parts of Oklahoma. Using an IBI that is more refined to the particular characteristics of the Ozark Highlands may allow for a better defined relationship between condition and stressors.

For sestonic algal biomass, a number of notable significant relationships exist between stressor and condition.

- For nutrients, it appears that using the either the historical median or 25th percentile of chlorophyll-a for algal condition produces the most significant results. Each condition is highly related to total phosphorus in ranges from 0.018 mg/L to near 0.10 mg/L, and the highest relative risks are associated with the total phosphorus in the range of 0.018 mg/L to the 0.037 mg/L scenic river criterion. Low level total phosphorus appears to function well as a predictor of potential degradation due to increasing algal biomass.

- Similarly, all general water quality stressors, with the exception of pH, are significantly related to poor sestonic algal condition. Increasing temperatures, turbidity, and DO saturation all have significant predictive capacity.
- Habitat has no predictive capacity.

Conversely, benthic algal biomasses shows very few significant relationships.

- Significant risk relationships are present between nitrogen and DO percent saturation
- The most interesting significant relationship occurs when the percentage of deep pools is acting as a stressor. As pool width to depth ratios decrease, the stream area providing a suitable photic zone for algal growth may increase.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   In the probabilistic survey of the Illinois river watershed no clear cut relationships were found between the low levels of nutrients and the biological communities and periphyton (Chlorophyll a). Other Oklahoma ecoregions have not yet been analyzed in that fashion. Clear relations are seen across the state for reservoir chlorophyll a and nutrients. Chlor a Criteria was set at 10 µg/l for drinking water lakes. Other lakes require an impairment study to confirm the need for listing.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   In a rule separate from the WQS, nutrient threatened condition is assed based upon streams type, slope, canopy cover and substrate. They are also identified by periphyton and sestonic chlorophyll a. When the nutrient threatened condition is identified, a "nutrient impairment study" is required to determine if a stream should be listed. While an impairment study is not defined, nor a protocol established in Oklahoam rules, an impaired determination would be based upon impaired biological condition or on conventional things like DO and pH.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   At this time, only after a TMDL for an impaired condition is completed.

Oregon

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   For Oregon's 2010 Integrated Report (303(d)/305(b)), Oregon Department of Environmental Quality (DEQ) assessed aquatic life beneficial use support using biological assessments as an indicator. DEQ's protocol is based on biological assemblage information for freshwater macroinvertebrates collected at reference sites in Oregon. DEQ used a predictive model to analyze data for sample sites compared to expected or reference assemblages and developed numeric benchmarks to identify impaired and attaining conditions.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Oregon assesses aquatic life impacts from excess nutrients using indicators including excess aquatic weeds or algal growth and harmful algae blooms. Oregon also uses numeric water quality criteria such as pH, chlorophyll a, ammonia, and dissolved oxygen. During the TMDL process, Oregon determines whether nutrients are a limiting factor resulting in waters not meeting criteria for these pollutants.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   DEQ has used these indicators and parameters successfully to develop TMDLs for waters throughout the state to address and control nutrients causing beneficial use impairments. During TMDL development, DEQ determines the combination of pollutants, sources, and conditions that cause impairment. These pollutants and factors can vary given the characteristics and conditions of specific water bodies. During TMDL development, DEQ sets load limits and develops control strategies for the key pollutants. DEQ has seen improvements in waters and watersheds throughout the state as key pollutants loads are reduced or control strategies implemented.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

Oregon has not developed nutrient criteria per se, but has developed criteria for the pollutants discussed in (2). DEQ determines the correlation between those pollutants and response variables on a reach or water-specific basis during TMDL development.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Oregon applies a policy of independent applicability of pollutant criteria, data, and information to assess and make 303(d) impairment determinations. For the 2010 Integrated Report, DEQ identified impaired biological conditions without linking the beneficial use impairment to a specific pollutant or physical cause of impairment. DEQ's initial decision not to 303(d) list waters identified as biologically impaired, where pollutants were unknown, was disapproved by EPA in their March 2012 action. EPA is proposing to add those waters to Oregon's 303(d) list.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Environmental mapping and beneficial uses are considered during mixing zone evaluations and permitting, but Oregon DEQ rarely uses indices of biological integrity and other biological assessment information for individual permitting decisions. Oregon DEQ may be doing more in the future.

Pennsylvania

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   None, see #2

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   The Pennsylvania Department of Environmental Protection (PA DEP) is currently developing a more robust protocol to assess aquatic life impacts due to nutrients. Biological indicators such as macroinvertebrates, algal biomass, algal indicator species or community structure and diurnal oxygen fluctuations will be used in some capacity.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Currently evaluating the sensitivity/relationships.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   PA DEP finds that drawing the correlations between the causal and response variables is difficult due to the confounding factors involved.

   PA DEP has contracted several studies with Penn State, the Stroud Water Research Center, the Academy of Natural Sciences, USGS et al. to investigate the causal and correlative links between nutrients, algae and macroinvertebrates.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   The updated protocol for making impairment decisions in still in development.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Impairment status of the receiving water is considered when developing permits. Application of this information varies on a NPDES program by program basis (e.g., POTWs, stormwater, construction).

Rhode Island

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Rhode Island Department of Environmental Management (RIDEM) has a biological monitoring program that assesses benthic macroinvertebrates at over 200 monitoring stations in wadeable freshwater streams and rivers throughout the state. The data obtained by the benthic macroinvertebrate monitoring program is used for a general assessment of aquatic life, not specific to nutrients. Historically, this data was evaluated through the use of a reference station approach. RIDEM has recently completed a project to define the reference condition in RI and create a biotic index and relating this index to the Biological Condition Gradient (BCG) for interpretation of the biological responses. In deeper freshwater rivers and streams the state conducts limited artificial substrate sampling of the macroinvertebrate community for a general assessment of aquatic life, not specific to nutrients.

   As part of the numeric nutrient criteria development for rivers and streams, the state has recently initiated extended monitoring on wadeable streams for primary data on taxonomic identification of diatoms, chlorophyll *a* abundance of periphyton, percent coverage of periphyton and macrophytes, and habitat features.

   For lakes the state is collecting surrogates of biological indicators such as water column chlorophyll *a* and Secchi depth. Data on macrophyte coverage is also being collected for consideration in nutrient criteria development.

   RIDEM is not currently working on any projects related to bioassessment of estuarine waters. There is some work being done by researchers pertaining to potential applicability of the biological condition gradient conceptual framework to the benthic community in Narragansett Bay as well as work to develop ecological indicators, such as measures of eelgrass coverage, that may be pertinent to nutrient management in coastal waters.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   For freshwater lakes, aquatic life use impacts due to nutrients are assessed on a narrative criteria basis using water column chlorophyll *a* and macrophyte coverage as well as Secchi depth.

   For wadeable rivers and streams, the state is planning to evaluate the use of taxonomic identification of diatoms, chlorophyll *a* abundance of periphyton, percent coverage of

periphyton and macrophytes, percent coverage of non-vascular plants and duckweed, for nutrient criteria development and aquatic life use assessments.

For estuaries, nutrient impacts are assessed largely by evaluating dissolved oxygen. However, RIDEM is also monitoring for and considering chlorophyll *a*. The Narragansett Bay Estuary Program has also been monitoring macroalgae through aerial photography and is currently working on improved methods for algal identification and quantification with an aim toward developing the capacity to measure the response in this community to planned nutrient pollutant loading reductions from WWTFs to Narragansett Bay.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   For freshwater lakes, and rivers and streams, the statistical analysis and data collection is on-going and RIDEM has not yet reached conclusions on this question.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   RI's current nutrient criteria development strategy for freshwater lakes and streams is to evaluate sub-categorization of waters based on Bayesian treed analysis including many geographic and physical characteristics. Typical tree analyses for categorization defines groups based on a population measurement, such as the mean or median, a Bayesian treed analysis searches for groups based on the linear regression relationships in the final groups. This work is on-going.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   For lakes, the state's water quality regulations contain a numeric criteria for total phosphorus which is utilized to make aquatic life use impairment decisions.
   In rivers and streams, benthic macroinvertebrate data are currently the type of biological information used in an integrative manner with water chemistry and physical data to determine aquatic life use impairment decisions. The biological information is considered the core indicator during assessments since it provides the most direct measure of aquatic life use attainment/impairment status.

   A more complete description of RI's assessment process can be found in the state's Consolidated Assessment and Listing Methodology (http://www.dem.ri.gov/programs/benviron/water/quality/pdf/finlcalm.pdf).

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   RIDEM is delegated to administer the NPDES program, known as RIPDES, for Rhode Island. Regulated major facilities discharge into rivers and coastal waters. There are no RIPDES permitted discharges into lakes in the state. The RIPDES permitting program considers biological data in the development of permits. Information on observed conditions, including excessive macrophyte plant growth, nuisance algal blooms, etc. has been used in combination with other information to set targets for reducing nutrient pollutant loadings to rivers.

South Carolina

Contact: James B. Glover, Ph.D., gloverjb@dhec.sc.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   A. Bioassays (Toxicity Tests):
   The South Carolina Department of Health and Environmental Control (SCDHEC) requires effluent toxicity tests on NPDES permits, the results of which are used in a regulatory manner. Instream bioassasseys are not conducted on a routine basis but have on occasion been used for special investigations.

   B. Community Bioassessments of surface water
      i. Macroinvertebrate Bioassessments. The first bioassessment report by SCDHEC was produced in 1974 and the Agency has had a strong program for many years. Ambient data are used primarily for environmental surveys with the results being used for the 305b report, 303d listing, and watershed water quality reports. Other regulatory activities include special investigations involving spills and other point and non-point pollution events. In addition, there are instream macroinverterbate bioassessments required by many NPDES permits. The storm water permitting program and 401/404 programs may also require macroinvertebrate bioassessments. These studies are conducted by SCDHEC certified labs and reviewed by agency staff.
      ii. Benthic Algal Bioassessments. The Agency embarked on the development of a benthic algal bioassessment program of streams in 2007 and SCDHEC is nearing the point of being able to evaluate the data in a meaningful way. It is hoped that this assemblage can be linked with the macroinvertebrate data to provide a more holistic assessment of stream condition. SCDHEC is also hopeful that a linkage can be made between excess nutrients and various primary producer measures to inform regulatory decisions in the future.
      iii. Fish Community Assessments. At this time the SCDHEC is not conducting fish community assessment work as part of the ambient monitoring program. These studies are occasionally required through various permitting programs. Various other federal and state government agencies and universities often conduct such studies in SC but are often for a specific purpose related to the mission of their Agency.
      iv. Phytoplankton. There is a rather large dataset of phytoplankton community data that was generated by a recently retired SCDHEC phycologist. SCDHEC has yet to fully analyze these data in a meaningful way but hopes these can inform decisions regarding lake nutrient criteria. At this time the SCDHEC has criteria for TP and TN for lakes >40 acres that were developed using EPA guidance and assistance from EPA Region IV.
      v. Aquatic and Wetland Plants- SC is participating in the 2011 EPA National Wetland Condition Assessment project. Plants are the primary biological end point for this project. One of the goals of the project is to help states build

capacity and methods to assess wetlands. It remains to be seen if SCDHEC can continue these activities past the end of project. Much will depend on the results of the analysis and economic conditions.

vi. Amphibians- This assemblage will be used in 2012 during the southeastern wetland intensification project being conducted by AL, GA, SC, and NC. As in number 5 the utility of this assemblage to assess condition will depend on results.

vii. Chlorophyll *a* analysis- Chlorophyll *a sensu-stricto* is not a biological measure but, because living organisms produce this pigment, can serve as a surrogate biological end point. At this time the SCDHEC collects this measure in lakes of a least 40 acres in size and have set standards for Chlorophyll *a* in this waterbody type. Standards exist for TP and TN as well for this waterbody type. Because South Carolina does not have true lakes, but rather regulated rivers, having standards in these large reservoirs may drive regulatory decisions for the lotic portion of the rivers and streams in the watershed. For example see http://www.scdhec.gov/environment/water/tmdl/doc/Draft_Reedy_nut_TMDLs.pdf.

viii. Phytoplanton and Chlorophyll analysis from estuaries and coastal ponds. SCDHEC has been part of the Harmful Algal Bloom Related Surveillance Network (HABISS) for many years and have participated jointly with the SC Department of Natural Resources (SCDNR) with activities related to this project. While the primary goal and intent of the CDC grant, which fund various activities related to Harmful Algal Blooms, is the protection of human health SCDHEC has compiled Chlorophyll a and marine phytoplankton data for coastal waterbodies. These data have been published in various forms over the years primarily through staff with the SCDNR. Currently the SCDHEC and the SCDNR are collaborating with Dr. Dianne Greenfield of the Bell Baruch Institute for Marine and Coastal Sciences, University of South Carolina, on an EPA Region IV funded project titled "Development of monitoring and assessment tools for nitrogen and phosphorous in South Carolina coastal wetlands." This project will be examining seasonal changes in nutrients and phytoplankton community composition from various coastal sites in SC.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

In SC, the data analysis phase of examining nutrient criteria and biological end points is in its infancy. SCDHEC has conducted some cursory analysis using statistical techniques such as Spline and LOESS regression that have shown relatively good relationships between TP (but not TN) and Chlorophyll *a* in reservoirs. Benthic algal assemblage data are being collected statewide and it is hoped that these may prove useful as a biological end point for nutrients in flowing streams. In addition benthic algal and nutrient data are being collected within a watershed in which a nutrient TMDL has been developed (pending approval) and several years of pre-implementation data are available. SCDHEC

anticipates implementation efforts will begin on this stream 2011/2012 and continued monitoring will occur throughout the life of the project and beyond.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   As indicated above a relationship has been found between TP and Chlorophyll a for reservoirs but more analysis is needed. Because of the heterogeneity of waters of the US and the numerous stressors that have been placed on these waters for centuries a perfect indicator will likely remain elusive. It is the difficulty one has with trying to manage the natural world with numbers. That said, SCDHEC is moving forward with the goal of establishing a reasonably strong causal relationship between nutrients and an aquatic biological end point.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and succeses you have experienced.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Streams are listed as impaired or unimpaired for “Bio” based on the aquatic macroinvertebrate bioclassification scores.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Yes, macroinvertebrate bioassessments are required on many NPDES permits. These generally involve an upstream/downstream study in which a stream is assessed downriver of an effluent discharge point and compared with an assessment upriver of the effluent. It is the change in the bioassessment score that may result in a determination of impact.

   These studies are paid for by the regulated entity, conducted by an SCDHEC certified laboratory, and reviewed by agency staff. Compliance and enforcement activities can occur if there is evidence of impact. Instream assessment schedules generally range from 1 to 4 times annually, depending on several factors such as failure of toxicity tests.

South Dakota

Contact: Rich Hanson, Rich.Hanson@state.sd.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The South Dakota Department of Environment and Natural Resources (SD DENR) has contracted with South Dakota State University to develop a biological toolkit that may be used to assess aquatic life impairment or stream quality. The toolkit will primarily concentrate on macroinvertebrates but fish may also be included. In a few cases SD DENR used macroinvertebrate data to support water quality standards changes. SD DENR has no statewide biological monitoring effort and in only a few cases have they had biological monitoring as part of an assessment project.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Don't know. SD DENR has not gotten that far yet.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   SD DENR has not looked into this.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   SD DENR has not looked into this.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   See #1. In a few cases we've used biological data from an impaired site and compared that to a reference site to support water quality standard changes (when impaired versus reference data isn't different). SD DENR has very little biological data and so biological data is generally not used for impairment decisions.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Yes. As noted above, SD DENR has very little biological data available. However, in a couple of cases, SD DENR has required NPDES permittees to conduct biological assessments of their receiving streams. This information is reviewed annually and considered upon re-issuance of the permit. In addition, South Dakota requires whole effluent toxicity testing in a number of NPDES permits. This information is reviewed quarterly. If the testing data shows toxicity, the facility is required to identify the source and reduce the toxicity in the discharge.

Tennessee

Contact: Sandra Dudley, Sandra.Dudley@tn.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

    a. 305(b)/303(d) assessments – Semi-quantitative macroinvertebrate samples and nutrient samples (minimum total phosphorus and nitrate/nitrite) are collected at all wadeable streams on the 303(d) list for nutrients as well as those suspected of nutrient impairment. Results are compared to biological and nutrient criteria for each ecoregion. Biorecon screenings are collected at numerous other sites in each watershed. Failing scores will result in follow-up nutrient and possibly more intensive biological sampling if field observations, land-use or taxa lists indicate nutrient impairment is likely. In 2010, periphyton samples were added. Chlorophyll and nutrient samples are collected in lakes/reservoirs and non-wadeable streams.

    b. TMDL – For nutrient TMDLS, staff collect flow, ammonia, nitrate+nitrite, total phosphorus, orthophosphate, TKN, total suspended solids, turbidity total organic carbon, periphyton (wadeable) or chlorophyll (nonwadeable), pH, temperature, conductivity and diurnal DO (minimum 2 weeks during growing season). Water quality samples are collected monthly. Chlorophyll monthly during growing season. Periphyton once during growing season. Macroinvertebrates are collected once for assessment purposes but not used in TMDL.

    c. Ecoregion Reference – Macroinvertebrate, periphyton and nutrient samples are collected at approximately 100 reference streams on a five year rotational basis. Macroinvertebrates are collected in spring and fall; periphyton during growing season and nutrients quarterly. Periphyton data will be used to develop periphyton assessment index within the next five years.

    d. Headwater reference stream project - Five year project began in 2008. Goal to select and monitor 77 reference streams with drainage less than or equal to two square miles. Nutrients, macroinvertebrate and periphyton samples (along with flow and field parameters) are collected at each site. The goal is to develop biocriteria (macroinvertebrate and periphyton index) and nutrient criteria (numeric translators for narrative) for headwater streams. Macroinvertebrates and nutrients are collected spring and fall. Periphyton is collected once during growing season.

    e. Probabilistic monitoring – collect nutrients, macroinvertebrates and periphyton at 90 probabilistic monitoring sites. Target is every 3 to 5 years as funding allows. (Collected in 2007 and 2010).

    f. NPDES monitoring – In-stream macroinvertebrate and nutrient monitoring is incorporated in permits below dischargers in wadeable streams. Note that nutrient monitoring is only conducted for discharges to nutrient impaired waters.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Currently using:

   Tennessee macroinvertebrate index – comprised of seven biometrics designed to pick up a broad range of impairment. One of the biometrics (Tennessee Nutrient Tolerant Index -%TNTOL) is also looked at individually when nutrient levels are above ecoregion guidelines. Index includes taxa that were found to be dominant in known nutrient impaired waters. (Prior to 2011 used NUTOL (nutrient tolerant organism) developed by KY – recalibrated to TN bioregions in 2011).

   Kentucky Diatom Index – begin using in 2010

   Within next five years intend to develop:

   Tennessee Periphyton Index or recalibrate KY Diatom index to Tennessee bioregions.
   Headwater periphyton index (streams less than 2 sq mi drainage)
   Headwater macroinvertebrate index (streams less than 2 sq mi drainage)

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   During nutrient criteria development in 2002, Tennessee macroinvertebrate Index (TMI) scores were compared to nutrient samples in various ecoregions. There was an 85% agreement between sites that failed nutrient criteria and sites that failed biocriteria.
   In 2006, Tennessee adopted a nutrient tolerant metric developed by the state of Kentucky (%Nutol) into the TMI. There was an 86% agreement between sites that failed nutrient criteria and sites that failed to meet regional guidelines for this metric.

   In 2011 Tennessee recalibrated the %Nutol to Tennessee ecoregions. Calibration consisted of pulling any animal that was at least 20% of sample from each site exceeding nutrient criteria for that bioregion. Multiple samples from the same station were combined to avoid weighting = 284 sites. Taxa were ranked by percentage from each site. Trial and error (box and whisker plots) was used to determine a cut-off point for the percent dominant and frequency of occurrence that had the most sensitivity in the most bioregions. This worked out to the top 10 most frequently occurring taxa with at least one observation > 50% of the sample. Scores at reference sites and sites failing nutrient criteria using the Ky %Nutol and recalibrated Nutol in each bioregion were compared graphically. The revised scoring proved more sensitive to nutrient impairment in a wider range of bioregions and less likely to give false positives.

   The Kentucky Diatom index is currently used as a supplemental in conjunction with macroinvertebrate samples and has not been tested for sensitivity since WPC is developing an index calibrated to Tennessee ecoregions. Based on comparison of nutrient levels and macroinvertebrate samples, the index appears to be fairly sensitive in ecoregion 71 but is not sensitive enough in ecoregions 65, 73 and 74. It is overly

sensitive (false positives) in ecoregions 66, 68 and 69 in Tennessee. Confounding factors include canopy cover and abundance of scrapers. An attempt will be made to compensate for these factors during index development.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Nutrient criteria were developed by compiling total phosphorus and nitrate+nitrite data from 100 reference streams in 25 Level IV ecoregions (sub-ecoregions). Standard statistical methods were used to identify differences in nutrient concentrations between each sub-ecoregion. Where differences were significant, the adoption of sub-ecoregion based criteria was considered appropriate due to improved accuracy. Where differences were not significant, data were aggregated so that the resulting criteria could apply to streams that cross ecoregion boundaries. This resulted in 15 total phosphorus and 15 nitrate+nitrite criteria regions in the state (they are not the same 15). Criteria were based on the 90th percentile of reference data in each region. The 75th percentile was also tested but there was less agreement with biological response.

   Biological response was tested by comparison to biocriteria (The Tennessee Macroinvertebrate Index – TMI). The index is comprised of 7 biometrics from four distinct categories (richness, composition, tolerance and trophic state) that reflected various aspects of the whole macroinvertebrate community. Metrics that showed the most sensitivity to various pollutants in the most ecoregions were incorporated. Reference data were compiled to develop biometric ranges in each of 13 bioregions.

   Lessons learned (adjustments since original criteria development in 2002):
   a. Inclusion of a biometric calibrated specifically to nutrient tolerant organisms.
   b. Also use single biometrics sensitive to nutrient tolerance to determine possible nutrient impairment when TMI score passes but nutrient levels are high.
   c. Adjust %EPT (Ephemeroptera, Plecoptera, and Trichoptera) metric to exclude *Cheumatopsyche* (a nutrient tolerant EPT)
   d. Incorporate periphyton index and/or visual observations of algal growth in addition to TMI.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   When nutrient (TP or Nitrate+Nitrite) values exceed numeric translators for ecoregion (based on reference data) there must be an associated biological response. Examples of biological response include:
   Biorecon scores below 11

TMI scores below 32
%TNTOL exceeds expectations for bioregion
Kentucky Diatom Index is in fair or poor category
Field observations of excessive algae or aquatic plant growth
Elevated chlorophyll
Also consider low dissolved oxygen and/or excessive diurnal swings as possible evidence of algal growth.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Both chemical and biological data are used to asses for nutrients, and assessment data is considered when setting permit limits.

Texas

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   The development of biological sampling and assessment methods are coordinated through an interagency workgroup, which includes staff from the Texas Commission on Environmental Quality (TCEQ) and Texas Parks and Wildlife Department (TPWD). In general, assessments of fish and benthic communities are conducted to develop site-specific water quality standards and to determine status of attainment with criteria established for the protection of aquatic life. The Texas Surface Water Quality Standards have established exceptional, high, intermediate, or limited aquatic life use (ALU) categories; based on the physical, chemical, and biological characteristics exhibited by the water body.

   Procedures have been developed for the collection of benthic macro-invertebrates, fish, and habitat data, and are described in *Surface Water Quality Monitoring Procedures*, Vol 2, RG-416. These procedures include quantitative and rapid bioassessment methods for the collection of benthic macro-invertebrates, as well as electro-shocking and seine protocols for fish sampling. Habitat protocols have been developed primarily for wadeable streams. A habitat quality evaluation is accomplished by measurement of physical habitat parameters at evenly-spaced transects over a defined stream reach and are evaluated with a multimetric habitat quality index.

   Use attainment can be assessed for water bodies where ALU categories have been designated or presumed. Determination of attainment is based on the use of multimetric Indices of Biological Integrity (IBIs) which integrate structural and functional attributes of biotic assemblages. Regional IBIs incorporating characteristics of eco-regions and associated fish assemblages have been developed for freshwater streams and rivers in most of Texas. IBI's have not been developed for reservoirs or tidal streams. TPWD and TCEQ are coordinating to conduct additional sampling and evaluation of tidal streams and estuaries to develop and evaluate improved metrics to describe tidal fish communities, and TCEQ staff in the Houston/Galveston Region is working on preliminary indices for tidal benthic macro-invertebrates.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   The primary indicator to summarize biological data is the Index of Biotic Integrity (IBI) for fish and benthic invertebrates for freshwater streams. The IBI categories of aquatic life health have been tailored to different eco-regions for fish data, and eco-regional IBIs are in development for benthic invertebrates. IBIs for tidal rivers and estuaries remain under development. Over the past 5 years, the TCEQ has also coordinated a variety of supplementary freshwater stream nutrient surveys. These surveys included data on the

abundance of attached algae, and also included a comparison of different methods to estimate algal coverage. However, further work to implement estimates of periphyton in biological monitoring is needed for it to be a viable indicator. The TPWD has historical fisheries surveys of the major reservoirs in Texas that include estimates of the percent coverage of rooted macrophytes and other vegetation. TPWD has also sponsored aerial surveys and maps of coastal seagrasses. TCEQ and TPWD are coordinating on more extensive sampling to better define seagrass condition and coverage around the coast of Texas. Indicators of planktonic primary productivity and algal abundance in streams, reservoirs, and estuaries include substantial historical data on 24-hour dissolved oxygen ranges, water column measurements of chlorophyll *a*, and Secchi disk transparency.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   TCEQ is coordinating an extensive ongoing evaluation of statewide historical data for freshwater streams and reservoirs, conducted by researchers at the University of Arkansas, in order to identify nutrient response thresholds. Preliminary statistical evaluations include categorical and regression tree analysis on long-term median values of nutrient parameters and the above response variables for a large number of sampling stations. Initial analyses for stream and also for reservoirs have identified statistically significant threshold change points at relatively low concentrations of both total phosphorus and total nitrogen (derived using nitrate, nitrite and total Kjedahl nitrogen). Initial analyses in reservoirs showed statistically significant responses of total phosphorus and response variables – particularly Secchi disk transparency. These initial results indicate the parameters are relatively sensitive to nutrients, phase two of these statistical evaluations will continue through FY2013.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   The correlation of nutrient concentrations with response variables was partly addressed in the response to number 3. In freshwater streams, the relationships with most response variables are statistically significant but highly variable. For example, fish and benthic IBIs are more closely related to a habitat quality index than to nutrient concentrations. In reservoirs, median total phosphorus concentration had a fairly strong statistical relationship with both Secchi disk transparency and chlorophyll *a* concentration. One useful aggregation for statistical analyses appears to be geographic categorizing by Level III eco-regions, and potentially combining eco-region categorization with river basin categorization for larger watersheds. Another potentially useful categorization was dividing the dataset into high and low categories of total phosphorus. For reservoirs, simple regressions of total phosphorus versus chlorophyll are statistically relatively

strong using long-term medians for entire reservoirs; whereas regressions using individual sampling dates and stations as data points (even if various time lags are incorporated for chlorophyll *a*) are typically not statistically significant. TCEQ has adopted numerical criteria for 75 reservoirs in the form of chlorophyll *a*. These criteria, which are still under review by EPA, were calculated separately for each reservoir based on historical data. Ongoing challenges include (1) determining the levels and the amount of allowable change of response variables that are appropriate to define use-support, (2) statistically evaluating water bodies with numerous nondetects for nutrient parameters and/or chlorophyll *a*, (3) addressing changes in lab methods, sampling procedures, and reported quantification levels in long-term historical databases, and (4) incorporating multiple indicators (weight-of-evidence) to assess attainment of nutrient criteria in ways that are statistically valid and acceptable to EPA.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   When available, the determination of fish and/or benthic macro-invertebrate integrity is used in conjunction with physical and chemical data to provide an integrated assessment of support of the aquatic life use for water bodies identified in the Texas Surface Water Quality Standards. Support for a given water body is assessed according to the decision matrix specified below in Table 1.

   Attainment of bioassessment data (fish or macro-benthic) is based on the mean of a minimum of two samples collected from each of one or more representative sites within the water body, in conjunction with an eco-region coefficient of variability (CV) for the designated ALU. The ecoregion CV establishes an interval around the mean and incorporates the observed variability of historical sampling into the final results, increasing the level of confidence in the attainment decision.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   As part of TPDES permit application evaluations, TCEQ determines the stream flow characteristics (perennial, intermittent, or intermittent with perennial pools) for the receiving waters along the proposed discharge route. TCEQ uses these flow characteristics to assign assigning presumed uses to unclassified streams. Receiving Water Assessments (RWAs) are often conducted for wastewater permitting actions where additional site specific information is needed to determine that appropriate Standards criteria and effluent limits are applied to protect water quality. RWAs consist of a sampling of fish and invertebrate stream communities. The resulting data is evaluated using indices of biotic integrity to assign an appropriate aquatic-life category to the water body. The aquatic-life category dictates the applicable numerical and narrative criteria to protect the aquatic life uses of the water body.

   When an attainable aquatic life use for a particular unclassified water body might be lower than the presumed aquatic life use, a use-attainability analysis (UAA) is conducted. Data collection, compilation, and analysis may be conducted by TCEQ, the applicant,

river authorities, or governmental or other entities. The TCEQ reviews the UAA to ensure conformance with basic protocol. If the UAA indicates that the attainable use is lower than the designated use, the TNRCC sends the UAA to EPA for review. Preliminary approval of a UAA by EPA for classified streams constitutes a finding that the lowered aquatic life use is "approvable" as the new designated use for the classified stream. The change in the designated use is placed in the next revision of the Texas Surface Water Quality Standards.

The UAA procedure is as follows:

- Identify reference areas and define stream reach or reaches to be included in the assessment.
- Summarize stream morphometry, flow characteristics, and habitat characteristics in the reference area in accordance with:
    - a standardized stream characteristics form (from a TNRCC wastewater permit application), which also contains a description of the proposed or existing discharge; or
    - the *TNRCC Receiving Water Assessment Procedures Manual*, GI253, June 1999 or the most recent publication.
- Conduct fish sampling (or in some cases macroinvertebrate sampling) in the reference area in accordance with the GI-253 (see preceding bulleted item)
- Apply quantitative indices in accordance with the GI-253, cited above.

Table 1. Decision Matrix for Integrated Assessments of Aquatic Life Use (ALU) Support

Overall ALU Support based on Bioassessment, Dissolved Oxygen, Toxics in Water, and Ambient Toxicity in Water. For three or more lines of evidence, unless otherwise illustrated here, nonattainment of any line of evidence discussed here results in nonsupport of the ALU.

Bioassessment Data	**Aquatic Life Use Support Attainment**					
	Dissolved Oxygen Data Meets Criteria**	**Toxics in Water, Toxicity Testing All Meet Criteria**	**Dissolved Oxygen Data Do Not Meet Criteria**	**Toxics in Water, Toxicity Testing Do Not Meet Criteria**	**Habitat Assessment Meets Screening Criteria**	**Habitat Assessment Does Not Meet Screening Criteria (reported as a Concern)**
Benthic macroinvertebrate and fish bioassessments done and both attain designated ALU	Fully Supported	Fully Supported	Not Supported*	Not Supported	Fully Supported	Fully Supported *
Benthic macroinvertebrate and fish bioassessments done and one of the two does not attain designated ALU	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported	Not Supporting
Both benthic macroinvertebrate and fish bioassessment done and both indicate non-attainment of designated ALU	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported
Only fish bioassessment done and indicates nonattainment of designated ALU	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported
Only benthic macroinvertebrate bioassessment done and indicates nonattainment of designated ALU	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported
Only fish bioassessment done and indicates attainment of designated ALU	Fully Supported	Fully Supported	Not Supported*	Not Supported	Fully Supported	Fully Supported *
Only benthic macroinvertebrate bioassessment done and indicates attainment of designated ALU	Fully Supported	Fully Supported	Not Supported*	Not Supported	Fully Supported	Fully Supported *
Bioassessment data not available	Fully Supported	Fully Supported	Not Supported	Not Supported	Fully Supported	Not Supported**

Both fish and macroinvertebrate samples are required to make an ALU attainment determination for 305(b)/303(d) assessment purposes. In certain cases where it is only possible to collect one or the other, the ALU determination may be made based on only fish or benthic macroinvertebrates according to the framework presented in this table. Proper justification is required for why only one type of community was sampled.

* Long-term bioassessment monitoring will be conducted to determine if adverse effects to the fish and/or benthic macroinvertebrates are detected.

** When the habitat index indicates nonsupport, the habitat attainment status is reported as a Concern.

*** The average IBI and HBI scores are compared to the ALU point score ranges for fish, and for benthic macroinvertebrates, depending on what field protocols were followed. If sample results from multiple events are very different, the reasons will be determined, if possible, and it will be determined if the samples are appropriate for use.

Utah

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Macroinvertebrate empirical models (RIVPACS) are used to assess waters for 303(d) purposes. Model outputs (O/E) and several metrics have been related to changes in nutrient concentrations. Recently, Utah Department of Environmental Quality (UT DEQ) has been exploring creating nutrient-specific indicators to more directly tie macroinvertberate compositional measures to N & P concentrations.

   Measures of algae abundance have traditionally been used to identify sites with nutrient-related problems. Two measures of benthic algal abundance are obtained from streams—chlorophyll-a and Ash Free Dry Mass (AFDM). In lakes, UT DEQ primarily uses TSI indicators. Utah is in the process of strengthening compositional diatom biological assessment indicators.

   Utah's most unique program involves the development of functional indicators of stream conditions. Assessment methods that are under investigation include: bioassays to quantify nutrient limitation, measures of whole-stream metabolism (Gross Primary Production (GPP) and Community Respiration (CR)), reach-scale measures of organic matter standing stock, leaf pack decomposition, and nutrient spiraling. The intent of this research is to develop water quality indicators that provide quantitative linkages between nutrients and aquatic life uses.

   In another related project UT DEQ is developing ~15 Qual2K models for streams throughout the state. The intent of this work is to establish causal relationships between nutrients and other water quality parameters (i.e., pH, DO, SOD, BOD).

   Together, the field, laboratory, and analytical methods for all of these programs are being compiled into a single document that can be used by DWQ and our stakeholders to create site-specific nutrient criteria. Each of these methods is relatively inexpensive to incorporate into routine monitoring programs. These methods can be used together or individually whenever site-specific standard investigations are required.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Streams
   Macroinvertebrates: O/E and nutrient-specific metrics (e.g., % hydropsychids, Carlson Index)
   Algae: Benthic Biomass and compositional indicators

Functional Indicators: limiting nutrient bioassays, whole stream metabolism, reach-scale and habitat-specific organic matter standing stocks, and leaf pack decomposition

Lakes
Trophic State Index (TSI)
Algae Composition Metrics (i.e., % cayanobacteria)

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Developing and refining biological indicators with the express purpose of informing nutrient programs is an active area of research. To date our results suggest that O/E and other traditional macroinvertebrates measures are significantly albeit weakly related to nutrient gradients. UT DEQ determined this with different "best fit" measures, depending on the particular empirical model that was used to establish these relationships.

   Our recent work developing functional assessment tools is very promising, probably because these measures are more directly linked to nutrient responses. Again, UT DEQ is using a variety of analytical measures to quantify the sensitivity of these measures.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   As commonly observed elsewhere, initial efforts to establish causal relationships between compositional macroinvertebrate scores and nutrient concentrations showed fairly weak relationships. However, these approaches identified several key data gaps including: a paucity of reference site data and few measures of TN (TIN and Ammonia were more common). Measures of algae abundance were more reliable indicators, but UT DEQ did not have sufficient data to determine the extent of deleterious effects of increased algae growth on stream biota.

   Subsequent work as focused on improving these relationships using nearly all of the examples discussed above. Through these subsequent efforts UT DEQ is optimistic that they will be able to develop regional TN and TP indicators that can be used in concert with ecological response variables to identify sites with nutrient-related problems. Once these sites are identified, the TN and TP indicators can be promulgated as site-specific numeric criteria. Alternatively, studies can be conducted to verify these indicators or develop alternative site-specific criteria.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Utah currently applies "independent applicability" with chemical and biological data. However, UT DEQ has also stated, in Integrated Reports, that such approaches are not appropriate for non-toxic data. This policy is in revision.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Not generally. If the site was impaired and if the impairment was tied to a specific pollutant, then then permit limits would be affected through TMDL load allocations. Several load allocations have been established for nutrient-related TMDLs, particularly for reservoir and lake impairments.

Vermont

Contact: Neil Kamman, Neil.Kamman@state.vt.us

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Vermont Department of Environmental Conservation (VTDEC) maintains a comprehensive and mature monitoring and assessment program, supported by a standalone dedicated strategy featuring fixed and probability designs to assess indicators of biological, chemical, and physical integrity. Approximately 150 streams locations are sampled annually for multiple indicators, over 75 lakes, and typically 20-25 wetlands. There exist in some instances over 30 years of data on some reaches and lakes. Vermont's biological assessment system has been evaluated by the USEPA using the Critical Elements of State Bioassessment and Biocriteria Programs as a Tier 3+ program, one of only three programs nationwide to achieve this level of competence (top competence is Tier 4). A comprehensive description of Vermont's surface water assessment program is available via the monitoring portal of the Vermont Surface Water Management Strategy, at www.vtwaterquality.org.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   VTDEC has been involved for several years in the development of a scientifically defensible package of nutrient criteria, predicated upon causal nutrient parameters, and biological response parameters. VT's approach has been to evaluate nutrient – response relationships for two designated uses (aesthetics and aquatic life support), separately for three classes of lakes, and three classes of streams, as follows:

<table>
<tr><th rowspan="2">Designated Use</th><th colspan="2">Causal variables</th><th colspan="2">Response variables</th><th rowspan="2">Notes</th></tr>
<tr><th>Lakes</th><th>Streams</th><th>Lakes</th><th>Streams</th></tr>
<tr><td rowspan="2">Aesthetics</td><td colspan="2" rowspan="3">Total phosphorus
Total nitrogen</td><td>Secchi transparency</td><td>Visual assessment - micro and macroalgae from habitat assessment</td><td rowspan="3">-Three stream types and three lake classes used for bioattainment determination

-VT WQS contain TALU goals, and also tiered aesthetic goals.

-Empirical relationships derived for each tiered goal.</td></tr>
<tr><td>Chlorophyll-a</td><td>Scaled visual assessments of trophic condition</td></tr>
<tr><td>Aquatic Life</td><td>Lake Condition Index using phytoplankton</td><td>Nutrient-specific index of biotic integrity using macroinvertebrates</td></tr>
</table>

VTDEC submitted a technical document on Proposed Nutrient Criteria for Vermont's Lakes and Wadeable Streams to the Vermont Water Resources Panel in August 2009, along with proposed rule language to incorporate additional nutrient criteria into the Vermont Water Quality Standards. The analyses relied upon the conditional probability analysis tool promoted by Paul et al. of EPA ORD. Consideration of the VT proposal was subsequently deferred from rulemaking pending resolution of concerns raised by USEPA Region 1 about nutrient criteria proposals in both Maine and Vermont regarding the issue of independent applicability. In order to resolve these concerns and to refine the analysis overall, the VTDEC Water Quality Division has decided to conduct a reanalysis of the supporting data. The reanalysis is taking advantage of several more years of relevant water quality and biological data that are now available, and will explore the use of logistic regression as a potentially better statistical approach. Analyses will continue to rely upon the data described in the Table above. Using logistic regression, it will be possible to directly quantify the risk of impairment associated with any proposed criterion value, and to predict the rates of false positive and false negative impairment determinations. Criteria values can then be selected in a way that minimizes the risk of use impairment and assessment errors. A milestone schedule for adopting additional nutrient criteria in the Vermont Water Quality Standards for lakes and wadeable streams has been required of the VTDEC Water Quality Division by our Performance Partnership Agreement.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?
   -and-
4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   The relationship between nutrient concentration and use attainment based on the response indicators is variable. The strength of association was determined statistically, by examination of confidence intervals, p-values, and by examining probability distributions. These evaluations are robust, and VT has a high degree of confidence in the results. In descending order, nutrient-response relationships were tightest for aesthetic indicators for lakes, followed by biological indicators for streams, biological indicators for lakes, and least robust for aesthetic indicators in streams. VTDEC determined that relationships are sufficiently robust to support deriving proposed criteria thresholds for lake aesthetic and aquatic life uses, and stream aquatic life uses. VTDEC has used multiple statistical evaluation tools to verify these relationships (e.g., applying different lenses to the same date. Yet, despite reasonable strengths of association, there remains an unacceptably high likelihood of false positive determinations for impairment

if nutrient thresholds are not corroborated by independent aesthetic or biological use determinations for both lakes and streams.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Vermont's Surface Water Assessment and Listing Methodology describes the process of attainment determination. Typically, determinations of biological attainment are based upon direct measurement of biological and habitat indicators. In instances where only chemical data are available, these data may be used as a substantiation of impairment, but placement of a reach or lake on the list of impaired waters without direct biological assessments is uncommon in Vermont. Operationally, if there exists evidence of impairment based on surface water chemical or conventional measurements, biological assessments are prioritized. Exceptions to this are acidified lakes and acid mine drainage impacted streams, which may be assessed as impaired for aquatic life use based simply upon pH and alkalinity. To date in Vermont, there have been few to no instances where chemical measurements indicated impairment, but biological measures did not. This may not be the case for nutrient criteria, which have a high likelihood of generating false positive impairment determinations, based on analyses conducted to date. The Vermont Surface Water Assessment and Listing Methodology can be found at www.vtwaterquality.org.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   Vermont has developed an approved guidance for the assessing the likelihood that regulated effluent may cause or contribute to impairment, which includes the use of biological assessment. Wherever data are available, up and downstream biological attainment is evaluated during permit re-authorizations. This assessment includes physical, chemical and biological indicators. Vermont wastewater treatment plants in the Lake Champlain Basin are subject to a regulatory limit of 0.8 mg/L total phosphorus in effluent, in addition to wasteload allocations under the 2002 Lake Champlain TMDL. Vermont has recently modified its assessment cycle to harmonize the timing of sampling to basin planning cycles, thus providing updated information for wastewater facility re-authorizations. Biological assessments are also performed regularly on all stormwater-impaired streams that are or may be subject to MS4 permits, and as appropriate, on urban and suburban streams to document the cumulative impacts of development. Further, the documented biological condition of waters can affect the type of permit coverage available (e.g. general permit versus individual permit), and may influence monitoring requirements for discharges of industrial stormwater under the multi-sector general permit.

Virginia

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1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Virginia has a biological monitoring program that assesses benthic macroinvertebrates in freshwater streams, shallow rivers and also in estuaries. Multimetric scores have been calibrated for different ecosystems and are used to define expected aquatic life communities. The data provided by the benthic monitoring is used to assess whether the waterbody is meeting the designated use so that the waterbody contains a balanced community of aquatic life which might reasonably be expected to inhabit it.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   In freshwater streams and rivers, Virginia uses benthic macroinvertebrates in our biological monitoring program. Virginia is also investigating the use of fish community information in assessing some aquatic life uses.

   Chlorophyll a criteria are used in freshwater reservoirs and in some segments of the Chesapeake Bay.

   Also in the Chesapeake Bay, Virginia assesses the general narrative standard for aquatic life use through assessment of benthic invertebrate community condition, and use of segment specific criteria for submerged aquatic vegetation (SAV), "percent light-through-water "and "water clarity acres."

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Virginia currently has an Academic Advisory Committee composed of Virginia University scientists conducting a study in freshwater streams and shallow rivers, looking for correlations between nutrient concentrations and unacceptable changes in freshwater benthic community structure. The purpose of this study is to provide recommendations for the development of nutrient criteria in streams and shallow rivers. The study is attempting to find correlations between TN and/or TP and adverse changes to the benthic macroinvertebrate community. Initial results have indicated that the benthic invertebrates are not especially sensitive to nutrient concentrations. The study is continuing and a final report is due by the end of 2011.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values,

developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

Preliminary investigations by Virginia's Academic Advisory Committee have suggested that nutrients (TN and TP) do not have a pronounced effect on benthic macroinvertebrate communities in flowing freshwater ecosystems. The first round of investigations tentatively identified concentrations of nutrients that might be useful in identifying a "no observed effect concentration", below which there is no evidence of any adverse effect of nutrients on the aquatic life community. However, it has been difficult to identify any threshold concentration of nutrients above which adverse responses are seen in the benthic community that can be reliably attributed as a response to elevated nutrient levels. This is not surprising as it is recognized that due to a variety of site-specific factors, there is a general difficulty in identifying a specific concentration of TN or TP that can be reliably associated with an adverse change in aquatic communities. This makes it difficult to identify a specific concentration of nutrient to regulate as a criterion. Virginia's Academic Advisory Committee continues to work on this study.

Because of the difficulty in identifying a clear threshold of nutrient concentrations for use in establishing a criterion or as a threshold guideline, the Virginia Academic Advisory Committee (AAC) has recommended using a weight of evidence or decision-tree approach to determining when or if a freshwater stream or shallow river is impaired due to elevated nutrients. For assessing flowing freshwaters, the AAC has recommended identifying a combination of threshold concentrations of nutrient consisting of a low concentration referred to as a "no observed effect concentration" (NOEC) below which there is no evidence that a nutrient caused adverse change in the benthic community is likely to be caused by this level of nutrients. If nutrient concentrations are below this NOEC concentration, the waterbody should be judged as unimpaired based only on the nutrient concentration and no additional biological monitoring or assessment is needed. If environmental data can show that there is a higher concentration of the nutrient that is associated with adverse effects on the aquatic community and that these changes in the aquatic community are likely to be caused by the elevated nutrient concentration, then this higher threshold concentration of the nutrient can be used as another threshold. If this upper threshold concentration can be identified, it could be used as a threshold to assess the stream of river as impaired due to nutrients, without the need for additional biological monitoring. If the concentration of nutrients lies between the NOEC and the upper threshold nutrient concentration, then additional biological monitoring is needed to determine if the nutrients are the cause of the poor aquatic life community scores (or whether physical or other factors are the cause of the altered benthic community). The AAC is currently conducting a study to help identify concentrations of nutrients that can be used as the low NOEC and the higher upper threshold concentration. The AAC is finishing this study and a final report is due by the end of 2011.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

Currently in Virginia, impairment decisions are based on a variety of data or information, including:

a) Comparisons of concentrations of pollutants from chemical or bacteria monitoring data compared to water quality criteria concentrations.
b) Assessment of benthic macroinvertebrate community using a multi-metric score that represent a minimum expected community.
c) Comparisons of fish contamination concentrations compared to the concentrations of the toxic pollutant that is the basis for the "human health" water quality criteria that are based on human exposure via eating contaminated fish.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

Permit writers consider all ambient data, including biological data in permit development. If the receiving waterbody has been assessed as impaired, they would be expected to include a special condition that says when a Total Maximum Daily Load (TMDL) is approved (and the stressor identified); the permit will be opened to incorporate the limits needed. Biological assessment information may be used if developing NPDES permits, once a waterbody has been listed as impaired and a TMDL study has identified a stressor that can be addressed by a permit limit. The main implementation tool for biological assessment data for use in establishing NPDES permits is via a TMDL or a water quality management plan. An instream biological assessment could necessitate a TMDL where the stressor is identified (say for solids, nutrients or toxics) which would / could point to a WLA for a permit. By developing a TMDL in response to an identified impaired condition, the site-specific conditions that influence the biological community are taken into consideration and a site-specific stressor is identified and appropriate measures can be taken to provide the correct remedy for the site-specific problem.

Washington

Contact: Karen Adams, kaad461@ecy.wa.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Currently, Washington State Department of Ecology (ECY WA DOE) is using bioassessment in our monitoring programs, water quality assessment and effectiveness monitoring programs. ECY WA DOE uses both macroinvertebrates and to a lesser degree, periphyton, although as yet, have no bioassessment models built for periphyton.

   ECY WA DOE is beginning to use bioassessment as a parameter to measure for TMDL studies, particularly for stormwater studies. The Department recently laid out sample collection protocols and is promoting the standard use of these protocols by others across the state. This streamlines the data sharing process and allows us to compare stream health on a single standard of data quality. Specific studies related to nutrients using bioassessment are rare to this date, although ECY WA DOE is increasingly incorporating bioassessment into their activities as they continue to build bioassessment tools appropriate for the various regions of the state.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   ECY WA DOE currently uses as much information as they can pull together. The Department starts with multi-metric (IBI style) and multi-variate O/E analysis. In addition, other indices are looked at, including ratios of functional feeding groups including Scraper:Filterer and Hilsenhoff Biotic Index. ECY WA DOE has also started to collect and analyze periphyton, which are known to be more responsive to nutrient fluctuations.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Because of the relatively recent history of the use of bioassessment techniques in Washington State, sensitivity to nutrients has not been investigated. This is something the Department foresees investigating in the future as more data is collected.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

ECY WA DOE recently developed a stressor ID guidance document and intends to begin stressor ID studies this year. Because of the limited history with conducting stressor ID, the Department is unable to address this question at this time.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

   Currently, a stream can be listed as impaired (Category 5 of the Washington Water Quality Assessment, which is the 303d List) based on bioassessment alone. ECY WA DOE looks at the scores for the Western Washington O/E model (Utah State Bug Lab) or from the multi-metric model to determine impairment. The Department's policy is a narrative policy, but they have set numeric guidelines using the O/E model, stating that a score of >0.86 is not impaired (Category 1), while a score of <0.73 is impaired (Category 5). Scores between 0.86 and 0.73 are considered "of concern" (Category 2). ECY WA DOE hopes to develop similar guidelines for the various multimetric models as they are developed for each region of the state. These guidelines will be and have been established based on percentiles.

   Chemical and physical data are used to support the stressor ID process, and depending on the results of that study ECY WA DOE determines how to address the impairment. These data are either collected and submitted at the time of the biological data that led to the impairment or they are collected as part of the stressor ID when not available.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   At the moment, ECY WA DOE has not used biological assessment for NPDES permits. It is unclear at this point if or how the Department might do this.

West Virginia

Name: John Wirts, john.c.wirts@wv.gov; Kevin Coyne, kevin.r.coyne@wv.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Starting in 1998, West Virginia Department of Environmental Protection's (WVDEP's) Watershed Assessment Branch has annually collected benthic macroinvertebrate (~475 sites per year) data from streams and rivers (and to a lesser extent, fish community data) utilizing: a probabilistic/random sampling design approach; intensive monitoring to support-TMDL development; targeted monitoring using a rotating basin approach; and long-term monitoring from both our Ambient Monitoring (largest streams and rivers in the state) and LTMS (generally smaller streams) programs.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   WVDEP continues to investigate the use of both benthic macroinvertebrate and fish communities for nutrient related impacts. WVDEP has not ruled out the use of other indicators, including periphyton and algal communities that may exhibit better elevated nutrient response relationships.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Previous attempts to correlate benthic macroinvertebrate metrics with nutrient data revealed very weak relationships. WVDEP typically sees detectable levels of TP during higher flow events, which typically don't coincide with macroinvertebrate sampling events and is most likely impacting these results. WVDEP plans to continue this work utilizing new data, methods of assessment, and results from other studies.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   As stated in the answer to question #3, previous attempts to correlate benthic macroinvertebrate metrics with nutrient data revealed very weak relationships.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

Assessments of biological and chemical and physical data are all assessed independently (ie., if WQ bad and bugs good, WVDEP would list as WQ impaired)

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   WVDEP utilizes biological assessment information in various programs, including NPDES programs in the Division of Water and Waste and Division of Mining, granted the majority of the assessment work is not focused on nutrients. In places where a 316(a) thermal variances has been granted, WVDEP requires fish surveys to be conducted. WVDEP also requires toxicity testing on all major municipal facilities and typically on all major industrial process discharges, and may also require toxicity testing on minor permits where there is a large discharge to a small stream, a potential for impact due to a particular pollutant in the discharge, and/or if there is a known issue in the receiving stream. Historically, biological impairments to WV waters were not been attributed directly to specific sewage/industrial discharges. However, if there was a known issue that was linked to a particular discharge, WVDEP would likely consider any information available and develop appropriate requirements in a permit to ensure the discharge does not cause or contribute to the issue.

Wisconsin

Contact: Amanda Minks, Amanda.Minks@wisconsin.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

   Wisconsin Department of Natural Resources (WDNR) conducts baseline (Tier 1) monitoring at a broad spatial scale and includes collection of fish surveys and macroinvertebrate samples. WDNR also conducts targeted (Tier 2) monitoring at priority locations, which includes the collection of these biological data at multiple locations on a waterbody and replicate sampling events at a particular site.

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

   Streams and river biological condition is assessed using indices of biotic integrity (IBI) for both fish and macroinvertebrate communities. Lake and reservoir biological condition is primarily assessed using trophic state indicators, including measures of clarity (e.g., secchi depth and satellite imagery) and algal productivity (e.g. chlorophyll *a* concentration).

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

   Indicator responses to nutrients can vary greatly from site-to-site. Therefore, WDNR used reference conditions to determine baselines. WDNR used the information in Robertson et al. (2008) to help make this determination – http://pubs.usgs.gov/pp/1754/.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   This question is primarily answered in the Robertson et al. (2008) study. Again, the reference condition method was used to derive the statewide criteria for phosphorus. Nitrogen criteria have yet to be developed for the state. Wisconsin is also currently in the process of investigating a site-specific nutrient criteria methodology. Per the Robertson study, water subcategories and ecoregion did not seem to significantly change the effects of phosphorus on waters.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

Wisconsin Consolidated Assessment and Listing Methodology (WisCALM) uses a hierarchical approach for assessing waters when multiple data types/indicators are available. Generally, biological indicators are weighted more heavily than physical or chemical parameters. For example, Current WisCALM requires an observation of biological impairment in order to corroborate an impairment listing related to exceedance of total phosphorus criterion. Biological indicators for assessment of the fish and aquatic life use may have precedence over chemical/physical indicators, because they are direct measures of the health of aquatic life. Biological data alone may also be used to assess a water's fish and aquatic life use, but has a higher minimum data requirement than assessments based on a combination of biological and physical/chemical data.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   No. Wisconsin uses the provisions in s. NR 217.13, Wis. Ad. Code to develop limits for NPDES permits. Biological assessment is only considered when deriving site-specific criteria or assessing downstream protection.

Wyoming

Contact: Eric Hargett, eric.hargett@wyo.gov

1. Please provide a brief overview of relevant biological/ecological assessment work your state is conducting.

    Monitoring and Assessment Program objectives

    Primary Objectives

    1) Rotating basin probabilistic monitoring for wadeable streams and rivers to help fulfill 305(b) requirements
    2) Targeted monitoring on wadeable streams and rivers to assess designated use support and in support of 303(d) requirements
    3) Reference network monitoring - repeat visits to historical reference sites and identification of new reference sites on wadeable streams and rivers
    4) Overall condition and trends for water quality of large reservoirs

    Secondary Objectives

    1) Monitoring in support of state water quality standards
    2) Monitoring in support of TMDLs
    3) 319 or TMDL effectiveness monitoring
    4) Monitoring in support of Wyoming Pollutant Discharge Elimination System (WYPDES) Program permits and policies

2. Which biological indicators/parameters does your state use (or plan to use) to assess aquatic life impacts due to nutrients?

    Wyoming Department of Environmental Quality (WY DEQ) uses two primary biological indicators to assess aquatic life impacts: the multimetric Wyoming Stream Integrity Index (WSII) and the predictive Wyoming River InVertebrate Prediction And Classification System (WY RIVPACS) that both use benthic macroinvertebrates as the indicator taxa. The WSII and WY RIVPACS were redeveloped in 2006 and 2005, respectively, with new versions of both models due out in Spring 2012. Both models only provide information on the relative departure of the benthic macroinvertebrate community from some regional reference condition. They cannot directly be used to ascertain what pollutant(s) may be impacting the community.

    Wyoming also uses multiple periphyton/diatom metrics as secondary or supplemental indicators in the assessment of aquatic life condition. The biological indicator models in addition to periphyton; chlorophyll a, benthic macroinvertebrate metrics, other biological, chemical and physical information; and scientific literature are used as part of a weight-of-evidence approach to evaluate any potential impacts due to nutrient enrichment or other pollutants.

3. How sensitive to nutrients have those indicators/parameters been? How did you determine that?

Final output of the WY RIVPACS and WSII do not provide specific details as to what pollutant(s) are impacting the benthic macroinvertebrate community - only the relative degree of departure from an expected condition. Evaluation of specific metrics within the WSII and other benthic macroinvertebrate metrics that may be influenced by nutrient enrichment are also evaluated. If the WSII and/or WY RIVPACS indicate impacts to the aquatic community and particular benthic macroinvertebrate metrics or other information suggest nutrients as a possible stressor, then the periphyton/diatom metrics can be used to help validate this claim. Periphyton/diatoms metrics appear to be sensitive to nutrient enrichment in Wyoming and provide an enhanced level of resolution with respect to nutrient enrichment. These metrics help us evaluate the analyte(s) of concern (P or N), associated D.O. issues, origin (organic vs. inorganic) and/or relative frequency and magnitude of any enrichment. Inferences of nutrient enrichment from the biological data are then cross-referenced to the available chemical and physical data in a weight-of-evidence approach that includes comparisons to appropriate control sites to determine the relative risk/impact of any nutrient enrichment. Various stressor-response type analyses, analysis of targeted assessment work and/or multivariate statistics have been used to arrive at these conclusions.

4. During criteria development, how have you found the correlation between causal (chemical) and response (biological/ecological) variables for nutrients? If so, what approach(es) has your state used to refine those relationships (e.g., subcategorizing waters, adjusting the frequency and duration components of the criteria, using a range of TN and TP values, developing site-specific numeric nutrient criteria, streamlining site-specific criteria approaches, or other approaches)? Please discuss challenges and successes you have experienced.

   Stressor-response relationships between periphyton or benthic macroinvertebrate metrics/taxa and particular nutrients have seen limited correlation at the statewide level, though relationships are difficult to ascertain at local/regional levels. WY DEQ speculates this may be partially attributed to the frequency and duration of nutrient enrichment in streams of Wyoming. Our state has few instances where there is a continuous input of nutrients to a system that may impact aquatic life. Rather, episodic pulses of nutrients are more common in our state. Secondly, because of the high environmental heterogenity of our state, background nutrient concentrations are quite variable. This can be partially addressed through stream stratification by origin, ecoregion, bioregion, geology, flow regime, etc. though stressor-response relationships remain weak. Our other complicating factor is that streams where nutrient enrichment may be an issue are also subjected to other stressors such as channel degradation, excess sediment, etc. Interactions between the biota and multiple stressors make for weak relationships for any one stressor. Multivariate techniques help, but are not the cure-all.

5. How is your biological/ecological assessment information used in combination with chemical and physical data to make impairment decisions?

Wyoming has a credible data law that requires the use of biological, chemical and physical data to make use-support decisions. WY DEQ has applied this by using a weight-of-evidence approach of all three data types. No one data type or indicator (i.e. models) are used as 'black boxes', rather WY DEQ weighs the strength of each line of evidence to arrive at a conclusion for aquatic life use condition. Scientific literature and supplemental data from other sources are also used to arrive at a suitable aquatic life condition conclusion.

6. Do you currently consider biological assessment information when developing NPDES permits? If so, please describe how this is done.

   As standard practice...no. Though more information on this topic can be obtained from our WYPDES staff.

APPENDIX A: ACRONYMS

ACWA	Association of Clean Water Administrators
ALU	Aquatic Life Use
BACI	Before/After Control/Impact
BMI	Benthic Macroinvertebrate
BOD	Biological Oxygen Demand
Chlor a/chl-a	Chlorophyll a
CWA	Clean Water Act
DO	Dissolved Oxygen
EPT	Ephemeroptera, Plecoptera, and Trichoptera
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
POTW	Publicly Owned Treatment Works
REMAP	Regional Environmental Monitoring and Assessment Program
SAV	Submerged Aquatic Vegetation
SOD	Sediment Oxygen Demand
TALU	Tiered Aquatic Life Use
TDS	Total Dissolved Solids

TIN	Total Inorganic Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UAA	Use Attainability Analysis
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WET	Whole Effluent Toxicity
WLA	Waste Load Allocation
WQBEL	Water Quality-Based Effluent Limit
WQ	Water Quality
WQS	Water Quality Standard
WWTP/WWTF	Wastewater Treatment Plant/Facility