United States Environmental Protection Agency

REGION/ORD WORKSHOP ON AQUATIC LIFE CRITERIA

SUMMARY REPORT

December 4-7, 2001
Seattle, WA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

APR 16 2002

OFFICE OF
RESEARCH AND DEVELOPMENT

MEMORANDUM

SUBJECT: Regional/ORD Aquatic Life Criteria Workshop Report

FROM: William H. Farland, Ph.D.
Acting Deputy Assistant Administrator
for Science (8101R)

TO: All Workshop Participants

Thank you for your participation in the *Regional/ORD Workshop on Aquatic Life Criteria* held December 4 - 7, 2001 in Seattle. Attached is the final workshop report. The report summarizes the key points made in the workshop presentations, discussion periods, and break-out sessions.

I hope the workshop opened new ways for you to think about your specific work on aquatic life criteria and provided you with an expanded network of EPA scientists also interested in this topic. Hopefully this report will allow you to revisit Regional science issues in a way that inspires you to explore collaborative efforts with other scientists across the Agency.

For additional information on this workshop, please contact Pat Cirone, Region 10 workshop chair at (206) 553-1597 or John Helvig, Region 7 Regional Science Liaison to ORD and workshop manager at (913) 551-7018. Please contact David Klauder, Office of Science Policy/ORD at (202) 564-6496 for information on other workshops in the ORD Regional Science Topic Workshop Series.

Attachment

cc: ORD Executive Leads (w/o attachment)
Regional Science Liaisons to ORD
Regional Water Division Directors
Regional Libraries

TABLE OF CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

FOREWORD

The *ORD/Regional Training Workshop on Aquatic Life Criteria* was the eighth in a series of Regional Science Topic Workshops sponsored by the Office of Science Policy (OSP) in the Office of Research and Development (ORD) at the United States Environmental Protection Agency (EPA). Other workshops in this series included:

- *Asthma: The Regional Science Issues*
- *Communicating Science: Waves of the Future Info Fair*
- *Fully Integrated Environmental Location Decision Support (FIELDS)*
- *Non-Indigenous Species*
- *Pesticides*
- *Endocrine Disruptors*
- *Emerging Issues Associated with Aquatic Environmental Pathogens*

The objectives of the Regional Science Topic Workshops are to: 1) establish a better cross-Agency understanding of the science applicable to specific region-selected human health and/or ecological topics, and 2) develop a network of EPA scientists who will continue to exchange information on these science topics as the Agency moves forward in planning education, research, and risk management programs.

Each year, EPA regions identify priority science topics on which to conduct workshops. The workshops address the science issues of greatest interest to the regions on the selected topic area. Each workshop is planned and conducted by a team of regional, ORD, and interested program office scientists, is led by one or more Regional Science Liaisons (RSLs) to ORD and is facilitated by a regional chairperson. Participants maintain the cross-Agency science networks they establish at the workshops through planned post-workshop projects and activities such as the identification of collaborative research opportunities, the creation of information sharing mechanisms (e.g., interactive web sites), and the development of science fact sheets for regional use.

For additional information on a specific workshop or on the Regional Science Topic Workshop series in general, contact David Klauder in ORD's Office of Science Policy (202-564-6496).

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

The *ORD/Regional Training Workshop on Aquatic Life Criteria*[1] was held on December 4 - December 7, 2001, in Seattle, Washington. The workshop was chaired by Patricia Cirone (Region 10) with support from John Helvig (Region 7's Regional Science Liaison).

The workshop was organized into three sessions:

I. Plenary: Overview of Aquatic Life Criteria
II. Biocriteria and Nutrients
III. Toxic Chemicals

Scientists from EPA (Regions and Office of Research and Development), US Fish and Wildlife Service, National Marine Fisheries Service, and states presented the status of scientific methods to derive aquatic life criteria as well as the limitations of these current criteria for setting standards. The need for new and better science came up as a frequent item for discussion, as did questions and concerns on the implementation and regulatory feasibility of some new advances.

General Overview

The Plenary session was co-chaired by Bob Spehar (ORD/NHEERL) and Patricia Cirone (Region 10). This session provided brief overviews of the science dealing with major water quality research areas including: toxic chemicals, habitat, sediments, nutrients, and biocriteria. The Regional presenters described their short term and long term problems with applying scientific research to regional decision making. Scientists from the EPA Office of Water discussed the status of guidance for determining criteria. The ORD presenters described the current and future scientific research for developing new or improved aquatic life and aquatic dependent wildlife criteria.

Habitat and clean sediments were only discussed in the plenary session. It is clear from the discussion in the plenary session that the concept of criteria has been expanded to include all elements of aquatic ecosystems. However, it is not clear how to move from concept to application. The speakers presented an excellent case for the importance of habitat parameters in determining the quality of the nations waters. They also presented an excellent overview of the

[1] Aquatic life criteria = reference concentrations for the protection of organisms that rely on aquatic ecosystems to sustain life; exposure is through direct contact with water or ingestion of prey items that inhabit aquatic ecosystems.

scientific advances. The EPA Total Maximum Daily Load (TMDL) guidance documents on nutrients and sediments are a good example of the types of documents which are useful to Regions, states, and tribes.

The plenary session was followed by two days of in-depth discussions of biological, nutrient, and toxic chemical criteria. During these sessions scientists from other federal and state agencies were invited to present information and join in the workshop discussions. The goal of the in-depth discussions was to prepare an outline of the concerns and considerations in establishing aquatic life criteria.

The Biocriteria and Nutrients session was co-chaired by Gary Welker (Region 7) and Susan Cormier (ORD/NERL). This session first provided brief overviews of the science for determining reference sites for development of biocriteria and nutrient criteria and then dealt specifically, in breakout sessions, with approaches for establishing multi-use reference sites, development of statistical methods for bioindicators, and the development of methods for establishing an aquatic life use support system.

The conclusions and recommendations of the groups were that the use of reference sites is the preferred method for aquatic life criteria. The groups also agreed that biocriteria are important. However, the methods for implementing the desired procedures for establishing reference sites are difficult. More guidance is needed on how to apply these research and guidance procedures to regional decision making.

The Toxic Chemicals session was co-chaired by Rick Bennett (ORD/NHEERL) and Lisa Macchio (Region 10). This session provided overviews of the science regarding current aquatic life criteria guidelines, emerging issues involving the Endangered Species Act (ESA), extrapolation techniques for assessing risk of species using limited data, risk-based water quality criteria (WQC), and issues involving the risks of both inorganic and persistent bioaccumulative chemicals to aquatic life and aquatic dependent wildlife.

The participants in the toxic chemical session concluded that there was not enough time to discuss all the important issues. However, this workshop provided an opportunity to establish partnerships and exchange information. The group also encouraged EPA headquarters to move some of the research conclusions into guidance which could be implemented by states and regions. In particular, the wildlife discussion was too limited to reach any conclusions regarding the status of the scientific approaches.

Regions requested implementation guidance to assist states in selecting test species and methods for permits limiting toxic chemicals. There needs to be some interim guidance on sediment criteria while methods are being developed. It is unclear where OW and ORD are in their combined efforts.

Summary of Discussion

Discussions during the three sessions included questions and answers regarding the presentations on current and future work involving aquatic life and wildlife criteria, as well as new EPA regulations or improved approaches for biological assessments. The need for new and better science to develop improved criteria came up often in the discussions, as did questions and concerns about the implementation and regulatory feasibility of some of the new approaches being developed. Many participants expressed a wish to have similar workshops on an annual basis because the workshop provided an informal way of maintaining contact with individuals in similar fields and situations, as well as a way of keeping informed of new developments.

The group discussed the inconsistency in applying criteria across the regions. The gap between science and implementation is huge. Regions need some type of national guidance to transfer known scientific methods to applications of criteria.

Regions need to be included in the joint Office of Water and ORD research strategy meetings. Regions also need to be included in the discussions with other agencies (USFWS, NMFS) so that there is a clear understanding across all levels of agency scientists regarding implementation of science knowledge to criteria development.

There is a need for ORD to provide short term technical advice to states, tribes, and regions. Hopefully, the contacts made at this workshop will continue to be available as technical advisors.

There was much discussion about the new process for developing criteria by following the risk paradigm. This process has yet to be evaluated by regions or states. Although the existing criteria fit well within the risk paradigm, there are aspects of criteria development which need to be improved e.g., time variability, dose response curves.

Due to lack of data there is a need to develop criteria based on best professional judgement. Because of the subjectivity of best professional judgment, participants at the meeting were encouraged to engage in dialogue with their scientists in all agencies.

The scientists from the US Fish and Wildlife Service, National Marine Fisheries, and states were particularly thankful for an opportunity to interact with EPA scientists. The discussions and exchange of information helped to form the basis for improved working relationships for different resource agencies with similar missions to understand the limitations that each faces when attempting to derive criteria for agency decision making.

Due to the breadth of topics in this workshop, posters and computer software demonstrations were on display throughout the meeting. In addition, the participants were asked to prepare a short description of any tools (workshops, software, sampling & analytical techniques, etc.) for developing aquatic life criteria. One objective of the workshop was to put these tools into a matrix which could be shared by all meeting participants.

WORKSHOPS, MODELS, SOFTWARE, AND WORKGROUPS ASSOCIATED WITH THE DEVELOPMENT OF AQUATIC LIFE CRITERIA

Strategic Planning and Research Coordination

Contact: Bob Spehar (ORD/NHEERL/MED-Duluth)

The Office of Water and ORD have conducted joint exercises that have outlined the long-term strategy and implementation plans for research in the area of WQC. These include the Strategic Planning and Research Coordination (SPRC) document, Aquatic Stressors: Framework and Implementation Plan for Effects Research, and the Water Quality Standards and Criteria Strategy (WQSCS). The SPRC document is currently being finalized and has been developed as a joint effort between OW and ORD to establish cross program contacts for a joint research planning process and to initiate cross program working teams in the areas of: toxic chemicals, modeling (TMDLs), ecological assessments and restoration, nutrients, critical aquatic habitats, and microbial and pathogen contamination. The Aquatic Stressors document, developed by ORD/NHEERL, is based in part on the SPRC discussions and outlines the long-term *effects* research for developing new or improved criteria for habitat alteration, nutrients, suspended and bedded sediments, and toxic chemicals. This document also delineates the research that will help develop diagnostic tools for a decision support system for resource managers. The WQSCS document is currently being developed by OW to provide a customer-focused, long-term strategic vision and direction for the water quality standards and criteria program. This strategy is intended to be fully integrated with the needs of the people and programs depending upon standards or criteria as environmental endpoints. This strategy will set near-term (2-3 years) and long-term (5-7 years) priorities for national water quality standards and criteria for use by both headquarters and the Regions to meet regulatory mandates.

Ecological Risk Assessment Support Center (ERASC)

Contact: Mike Kravitz (ORD/NCEA-Cincinnati)
http://intranet.epa.gov/ncear/erasc/index.htm

Habitat

Contact: Doug Norton, (OW/OWOW)
Habitat Cluster (1992)
Watershed Restoration Action Strategies
Watershed Assessment, Tracking, and Environmental Results (WATERS) database
http://www.epa.gov/waters/

TMDL tracking system:
http://oaspub.epa.gov/watrs/national_rept.control?p_cycle=1998
CALM guidance: http://www.epa.gov/owow/monitoring/calm.html
Integrated listing guidance: http://www.epa.gov/owow/tmdl/2002wqma.pdf

Contact: Patti Tyler (ORD/RSL, Region 8)
Critical Ecosystems ORD/EPA workshop to be held in Denver in June 2002

Contact: Steve Ralph, USEPA, Region 10
Bauer, Stephen B. and S.C. Ralph. 1999. *Aquatic habitat indicators and their application to water quality objectives within the Clean Water Act*. EPA-910-R-99-014: http://www.epa.gov/region10/ or
http://www.pocketwater.com/documents/ahi.pdf

Contact: Bill Swietlik (OW) and Chris Zabawa (OW)
National Sediment Workgroup in 1998
Draft Technical Framework to Support the Development of Water Quality Criteria for Clean Sediment
Protocols for Developing Sediment TMDLs by OWOW

Nutrients

Contact: George Gibson (EPA/OW/OST)
Technical guidance manuals the program has published or is drafting for Streams & Rivers, Lakes & Reservoirs, Estuaries & Coastal Marine Waters, and wetlands.
National Strategy for the Development of Regional Nutrient Criteria (July 1998)
A map of the continental United States (U.S.) illustrating Draft Aggregations of Level III Ecoregions for the National Nutrient Strategy (ORD/NHEERL, Corvallis)
Regional Technical Advisory Groups (RTAGS)
EPA nutrient criteria web site

Contact: Emile Lores (ORD/NHEERL)
Submerged aquatic vegetation model

Biocriteria

Contact: Susan Jackson (OW/OW)
ALUS: Aquatic Life Use Support

Contact: Susan Cormier (ORD/ Cincinnati)

ORD/NHEERL and OW/OST guidance document on data analysis methods used for biocriteria development
Empirical statistical models - River Invertebrate Prediction and Classification System (RIVPACS) and its derivative, AusRivAS (Australian Rivers Assessment System) are empirical (statistical) models that predict the aquatic macroinvertebrate fauna that would be expected to occur at a site in the absence of environmental stress.

Contact: Jeanne DiFranco (jeanne.l.difranco@state.me.us)
Dave.l.courtemanch@state.me.us
Biomonitoring retrospective, 15 year summary for Maine Rivers and Streams

Contact: Maggie Dutch mdut461@ecy.wa.gov
Estuarine Bioindicator Development
Puget Sound Ambient Monitoring Program (PSAMP)

Contact: Laura Gabanski (OW/OWOW) and Teri Laidlaw (Region 8)
National Biocriteria Workshop - Training Clinic - December 2002 - Region 8

Contact: Frank McCormick (ORD/NERL-Cincinnati)
Biocriteria development
Ohio River Valley Water Sanitation Commission - www.orsanco.org
Kentucky Division of Water (Mike Compton)
Indiana Department of Environmental Management
Pennsylvania Fish & Boat Commission (Rick Spears)
West Virginia Department of Natural Resources (Dan Cancotta)
US Fish & Wildlife Service, Bloomington, Indiana (Tom Simon)
US Forest Service Southern Region (Mark Hudy, Mel Warren)

Contact: Lester Yuan (ORD/NCEA)
Progression of Ecological Degradation model

Toxic Chemical Session

Contact: Russ Erickson (ORD/NHEERL)
Ecological Risk Assessment Guidelines - http://www.epa.gov/ncea/ecorsk.htm

Contact: Chris Tatara and Tracy Collier (NMFS)
Research papers on toxic chemicals http://research.nwfsc.noaa.gov/ec/ecotox

Contact: Brian Thompson (OW/OST)
Endangered Species Act and Clean Water Act National Memoranda of Agreement

Contact: Foster Mayer (ORD/NHEERL)
Description of the Interspecies Correlation Estimation Software (ICE)
Interspecies correlations are developed using Model II least squares methodology for linear regression (both variables are independent and subject to measurement error). Slopes and intercepts are derived from the equation, $\log X_2 = a + b(\log X_1)$, where X_1 equals the actual toxicity value for a surrogate test species (e.g., rainbow trout) and X_2 equals the estimated toxicity value for another species (e.g., listed species). Species with paired tests for ≥ 5 chemicals are the minimum requirement for inclusion in each analysis. When either one of the paired values include more than one EC or LC_{50} value, the geometric mean is used. Levels of statistical significance of slopes in all analyses are $P \leq 0.05$ or ≤ 0.01. The Interspecies Correlation Estimation (ICE) software is based on a Windows® platform and includes two estimates of uncertainty: 1) 95% CL for each individual model, and 2) 95% CL for uncertainty due to surrogacy, based on pooled error mean squares for each species.

Contact: Phil Cook (ORD/NHEERL) and Patricia Cirone (EPA/Region 10)
Framework for the application of toxicity equivalence methodology to ecological risk assessment for PCDDS, PCDFs, and dioxin like PCBs, in progress

Contact: Rick Bennett (ORD/NHEERL)
Great Lakes Water Quality Initiative (GLWQI).

Contact: Sue Norton (ORD/NCEA)
Report on empirical models for screening sediment contamination - Sometime 2002

Welcome: Janis Hastings (Region 10) and William Farland (ORD)

Workshop Goals/Logistics: John Helvig (Region 7)

Workshop Structure: Patricia Cirone (Region 10), Meeting Facilitator

PLEASE NOTE: Slides from the Workshop presentations are available at:
http://intranet.epa.gov/ospintra/regsci/aquatic.htm

PLENARY SESSION: OVERVIEW OF AQUATIC LIFE CRITERIA

Co-chairs: Bob Spehar (ORD/NHEERL) and Patricia Cirone (Region 10)

This session consisted of brief overviews of the current science approach(es), scientific application by the states and regions, and program office guidance. Opening remarks were made by Patricia Cirone, who introduced Janis Hastings (Region 10) and William Farland (ORD). Farland acknowledged the Regional Science Program, including funding for Regional Science Liaison positions, and the Regional Applied Research Effort (RARE) which provides research dollars to support short-term projects.

Toxic Chemicals

Programmatic Overview of Science – Charles Delos (OW/OST)

Methods for deriving an aquatic life criterion were described, in addition to aquatic life methodology and the associated scientific issues. The intent of the methodology is to protect a very high percentage of species. The methodology produces two criteria values: acute and chronic; and protects an assemblage of species, including tested "important" species. There are two criteria because ORD, in the late 1970s, was working primarily with two types of tests: acute, and chronic. The methodology does not consider interaction between species. Effects on different life stages are mixed together and treated as equivalent, as are effects involving different endpoints (survival, growth, and reproduction).

Scientific issues related to aquatic life methodology were listed. When applied to the time-variable exposures that occur in the real world, the mixing together of effects involving different endpoints and life stages comes into question. Population modeling suggests that effects on survival, growth, and reproduction are not equivalent, and should not be treated as such. However, the work the program started about ten years ago to address this issue became mired in modeling complexity and did not reach completion due to competing work priorities.

Currently, there is no standard procedure for deriving the duration (the averaging period to be applied to the criterion) and the allowable frequency for exceeding the criterion. These criteria components are supposed to address the time variability that occurs in the real world. In spite of being the least supportable facets of the criteria, duration and frequency have been the most difficult components of the criteria to change because there are no agreed upon approaches for deriving their values. Among the states the implementation procedures involving the criteria averaging period and the allowable exceedance frequency provisions are not consistent.

Before the project slowed to a standstill, much of the Guidelines revision effort was applied resolving time variability issues. The allowable exceedance frequency can be addressed via population modeling considerations. Population modeling, however, leads into other interesting issues, for example, regarding spatial variability and the importance of the size of the affected area. It may be noted that ecological risk assessment within the Superfund program does address the size of the affected area. Water quality criteria, on the other hand, do not generally address spatial area.

Other issues raised in recent years relate to bioavailability, other toxic endpoints, aquatic dietary exposure, and toxicant additivity. It was suggested that perhaps metals toxicity research is using resources to an extent greater than the problem.

Two issues were further discussed, exposure through food chain contamination, and additivity of effects from different toxicants.

The concern about exposure through food chain contamination stems from differences between exposure in chronic toxicity tests and exposure in the real world. In chronic toxicity tests, test organisms are fed uncontaminated food. In the real world, if the contamination affects a large enough area for enough time, then the entire food chain may become contaminated, yielding an additional pathway of exposure not included in the toxicity tests underlying the criteria. Some have argued that metals criteria should be expressed as total recoverable metal to account for this. Reverting to total recoverable criteria, however, does not correctly account for food contamination. Rather it is necessary to recognize that the dietary concentration is linked to the dissolved concentration through a partition coefficient or bioaccumulation factor. Toxicity is not determined by the total μg/L, but by the dissolved μg/L, after adjusting the criterion for the additional exposure route through diet.

With regard to additivity of toxicity of several metals, an example was shown using New York Harbor data. At the New York site, assuming additivity of acute toxicity, the total toxicity of six metals was, on average, only ten percent greater than the largest single contributor. In this large water body, receiving a wide variety of municipal and industrial contaminant inputs from a heavily populated area, additivity was thus not a significant issue.

Questions and Comments

Question: Is there any way to obtain acute-chronic ratios with the same species?
Response: Yes, it is done for the same species from the same lab and the same water.

Question: How do aquatic life criteria relate to biological criteria?
Response: [After some discussion] . . . we really don't know how they relate.

Question: Can we predict bioavailability and synergy?
Response: Bioavailability, yes through chemical modeling using the Biotic Ligand Model, so named because it treats the fish gill as another chemical ligand in the water. Metal synergy, no we can't do that.

Water Quality Toxics: Short- and Long-Term Needs – Debra L. Denton (Region 9)

This talk covered the USEPA Regions list of short-term (within 3 years) and long-term (3-7 years) water quality toxics needs, our challenges, and take home points. A brief overview of the 1985 Guidelines (*Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*) was presented. The following are the EPA Regions short- and long-term needs for the water quality toxics program.

Short-term Needs

Water Quality Criteria (WQC) are needed for the National Pollutant Discharge Elimination System (NPDES) permitting and the Total Maximum Daily Load (TMDL) programs. A numeric target needs to be identified to achieve the Water Quality Standards (WQS) which would be equivalent to a numeric WQS. An indicator needs to be selected which is applicable to the water body and local conditions. The scientific and technical validity are factors to consider. More WQC need to be established for chemicals such as; diazinon, atrazine, pyrethroids, and total mercury. There are different approaches (e.g., approaches to derive the criteria numbers) among EPA programs which need to be resolved. The same test species and methods should be used across the Agency to derive criteria. Approved 304(a) criteria for toxicity are needed. The appropriateness of the Technical Support Document (TSD) numeric benchmarks (0.3 TUa and 1.0 TUc) needs to be evaluated, as well as the default acute-chronic ratio [(ACR) = 10)]. The additive, synergistic, and antagonistic effects of various chemical interactions need to be addressed. Understanding the toxic mode of action can be used to understand potential chemical interactions, such as diazinon plus the pyrethroid, esfenvalerate (more than additive). Statistical models and endpoints may need to be re-evaluated and enhanced, (e.g., the alternative point estimate models and confidence intervals; the hypothesis testing approach; and bioequivalence testing). With the advancement of enhanced statistical models, should confidence intervals and different effect levels (LC_{10} for survival) be evaluated?

Long-term Needs

Threatened and endangered (T&E) species need to be considered by either using cold water species to protect for warm water T&E fish, or by improving the overall test power. USFWS's consultation must be on the criteria development approach, not the individual chemical numbers. Additional species (e.g., amphibians) need to be included. Endpoints need to be sensitive, precise, and at environmentally and ecologically relevant levels. Additional sublethal endpoints need to be evaluated, such as swimming performance. Swimming, as a measure of performance in fishes, is a key factor in linking an organism's phenotypic character with its environmental resources for the overall reproductive output and survival of the individual and the population.

Conclusion

WQS are needed to implement the permitting and TMDL programs. Clients' needs must be considered; the USEPA Regions have both short-term (within 3 years) and long-term (3-7 years) needs. EPA needs to examine lessons learned, successes, and technical transfer from programs such as permitting and whole effluent toxicity to be used in the TMDL program. We need good science plus the regulatory tools -- hand in hand. Training, technical transfer and feedback loop mechanisms are needed. Maintaining open communication among ORD, OW, and the Regions is of key importance.

Questions and Comments

Question: Strategically, what do you do when you need to select a numeric target for the TMDL program?

Response: Based on the mandate from the Clean Water Act, I follow the 1985 water quality guidelines to derive criteria.

Habitat

Impaired Habitat: A Water Program Retrospective/Perspective – Douglas J. Norton (OW/OWOW)

A brief overview of the EPA habitat history was presented. While the EPA mission and statutory goals broadly support habitat protection, the specific regulatory tools are limited. In 1992, the Habitat Cluster took on this issue and developed a strategy (unpublished). Six key action areas were recommended: 1) improve the use of regulatory authorities, 2) focus on non-regulatory programs, 3) improve the science base, 4) provide better habitat information management, 5) form effective partnerships, and 6) set risk-based priorities. This presentation revisited four of the six 1992 recommendations and, as an evaluation of our progress since then, focused on the current TMDL program, new data and guidance, and future steps.

A framework for restoring impaired waters was outlined. In short, it consists of determining the maximum load (TMDLs) and allocating the load reductions among point sources (PS) and nonpoint sources (NPS). Point sources are controlled via NPDES permits and nonpoint sources are managed via partnerships, grants, and voluntary programs.

Regarding the first Habitat Cluster recommendation, how well does the TMDL process fit habitat protection and restoration? Habitats are being improved by some TMDLs, partly as TMDLs use a watershed approach. The TMDL approach ("allocation-based" formula) is not a good fit for some habitat impairments, e.g., invasive species and riparian habitat loss. NPS pollution is the greatest threat to habitats, but EPA has little regulatory power relative to NPS pollution. The top 12 impairments (some pollutants, some not) were listed from the 1998 Impaired Waters Lists [303(d)]. States are going beyond the Federal regulations by listing reports of "habitat alteration" specifically. It is unclear what the impairment is for most of these reports. The regulatory "fit" is not optimal; however, there appears to be potential for creative use and state initiative to go farther for habitats.

With regard to the second Habitat Cluster recommendation, much about TMDLs is non-regulatory due to lack of NPS authority. The watershed approach has benefitted habitat (Watershed Restoration Action Strategies [WRAS]). The incentive approach, such as in the CWA Section 319, has undergone enormous growth. Section 319, originally best management practices (BMPs) for pollution control, has become an incubator for restoration and the watershed approach, and now for TMDLs for NPS pollution.

Habitat Cluster recommendation four is the area of greatest advances in information technology such as the TMDL tracking system; a National Geographic Information System (GIS) incorporating land cover, surface water, and other data; landscape ecology monitoring applied to watershed ecosystems; and Watershed Assessment, Tracking & Environmental Results (WATERS) database links to the afore mentioned. Relevant web site addresses, including two new guidance documents, were provided:

- TMDL Tracking System: http://oaspub.epa.gov/waters/national_rept.control?p_cycle=1998
- WATERS database: http://www.epa.gov/waters/
- CALM guidance: http://www.epa.gov/owow/monitoring/calm.html
- Integrated listing guidance: http://www.epa.gov/owow/tmdl/2002wqma.pdf

Habitat Cluster Recommendation Six looks to the future and considers priority setting. Two key points of priority setting are: 1) target what is recoverable, and 2) focus on critical areas. Targeting "fixable waters" produces results. There is greater recovery potential when working on the just moderately impaired vs. the "hopeless." Less impaired sites often have better/faster recovery and high biodiversity/habitat dividends. Critical areas, not just habitats, are of key importance to the overall sustainability of the Nation's aquatic ecosystems and watersheds. Critical area protection should be applied at the site scale (e.g., coral reefs, riparian zones, wetlands, headwaters, T&E species habitats), and at the regional scale as a network. A regional science workshop on critical ecosystems will be held in June 2002.

Strengthening the Use of Aquatic Habitat Indicators in the Clean Water Act – Steve Bauer (Pocket Water, Inc. – Idaho)

A dominant natural resource issue in the Pacific Northwest is reversing the decline of native salmonids, attributed in part to the loss of freshwater fluvial habitats. The regulatory aspects of the Clean Water Act (CWA) have the potential to assist in recovery efforts if habitat evaluation and assessment are integrated into water quality programs in an effective way. Although fisheries professionals have evaluated aquatic habitats for a long time, the transferability of these methods to a regulatory program needs to be assessed before habitat variables can be used to direct pollution control programs such as state water quality standards or Total Maximum Daily Loads (TMDLs).

Commonly measured variables for freshwater streams, encompassing flow regime, habitat space, channel structure, substrate quality, stream-bank and riparian condition, were evaluated based on four primary characteristics: 1) relevance to the environmental endpoint, specifically salmonid fish 2) applicability to the landscape and stream network in which they are used, 3) responsiveness to human-caused stressors, and 4) the degree of measurement reliability and precision. Integrating these indicators into the CWA is hampered by the state of the science as well as the existing framework for water quality standards. There is general agreement on the habitat requirements of salmonid fishes and the effect of non-point source activities on these habitats. There is less certainty on quantifying the biological effect and on the reliability of habitat assessment techniques, both of which are required elements for application to the CWA. These obstacles can be overcome by applying the principles of landscape and stream network classification to indicator development, identifying and quantifying reference area conditions at the regional level, calibrating relevant indicators to specific locales, and developing systematic monitoring procedures that meet rigorous data quality objectives.

Examples of aquatic habitat indicators were presented for the Salmon River Basin in central Idaho and the Tongas National Forest in southeastern Alaska. These examples are provided as Appendices in the EPA document cited below.

This presentation is based on the publication completed for EPA Region 10, Seattle, Washington and an article published in Fisheries. The citations and availability are listed below:

Bauer, Stephen B. and Stephen C. Ralph. 1999. Aquatic habitat indicators and their application to water quality objectives within the Clean Water Act. EPA-910-R-99-014. US Environmental Protection Agency, Region 10, Seattle, Wa. Available at the EPA Region 10 library website: http://www.epa.gov/region10/ ,Publications, or http://www.pocketwater.com/documents/ahi.pdf

Bauer, Stephen B. and Stephen C. Ralph. 2001. Strengthening the use of aquatic habitat indicators in Clean Water Act Programs. Fisheries, vol. 26, no. 6, 14-25

Questions and Comments

Question: Is habitat an integrator?
Response: I say, no, in the sense that biota is an integrator vs. habitat.

Comment: I think habitat is really important. Aquatic biota is the endpoint.

The ORD/NHEERL Approach to Habitat Alteration Research – James H. Power (ORD/NHEERL)

The National Health and Environmental Effects Research Laboratory (NHEERL) began by developing an Aquatic Stressors Framework (GPRA Goal 2). Framework objectives were listed in a memo from the NHEERL Director. Five NHEERL workgroups were formed to address: 1) habitat alteration, 2) suspended and bedded sediments, 3) nutrients, 4) toxics, and 5) diagnostics. Members of the Habitat Alteration Workgroup were listed: there are two members from each of the four Ecology Divisions within NHEERL. The workgroup problem statement was presented. The focus will be on habitat, because habitat alteration may cause a water body to not meet its designated use. EPA has mandated that research focus on fish, shellfish, and wildlife, and that it address the life-support functions of habitat.

Annual Planning Goals (APGs) for FY02-FY08 were summarized. The APGs are intended to scope out the problem, because in some cases the multi-year plan implies a shift of research focus. The emphasis on fish, shellfish, and wildlife required an initial identification of species endpoints. Selected species endpoints were listed for each Ecology Division. Goals were presented for four research areas: 1) Coastal Vegetated Habitat research, 2) Shoreline, Lake, and Estuary-scale Habitat research, 3) Landscape-scale Habitat research (for salmon and native fish habitat), and 4) Landscape-scale Habitat research (for mercury risk to common loons and other piscivorous birds) (see slides 11-14). NHEERL evaluated gaps in the research and recognized that they cannot address all the gaps. A limited list of some of the gaps identified was provided (see slide 15). There are currently 27.3 FTEs in NHEERL devoted to Altered Habitat research. This is not a very large number of resources, which is why the research focus is on species endpoints. In regard to EPA Plan Reviews, NHEERL expects to be collaborating with other Federal and state agencies, as well as non-governmental organizations; however, their travel budget is limited.

The next steps for the Aquatic Stressors Plan include: peer-review of the Plan by external scientists; development/formalization of contributions by the Ecology Divisions; development of cross-divisional proposals and Quality Assurance Project Plans (QAPPs) following Plan guidance and incorporation of internal and external review comments; peer-review of research proposals; and implementation of the Plan.

Questions and Comments

Question: The development of these plans historically are EPA problems; did you integrate with the program offices?

Response: Not to the extent I would have done internally for speed although several of us on the planning committee had the opportunity to participate in the joint Office of Water - ORD Science Planning and Research Coordination meeting while we were preparing our document.

Sediments

Suspended and Embedded Sediments: Status Report and Update from the Office of Water – Susan K. Jackson (OW/OST)

A status report and update was presented on EPA activities related to suspended and embedded sediments from the perspective of the Office of Water (OW). For additional information, contact either Bill Swietlik (OW) or Chris Zabawa (OW), the two primary scientists working on sediments in the Office of Water. Suspended and embedded solids refer to: "clean sediments", total suspended solids (TSS), excessive or too little sedimentation, bed deposits, transported bedloads, and water column turbidity or cloudiness. Typically, OW does not mean sediments that have been contaminated with chemicals, thereby making them toxic. EPA has been working on chemical criteria for sediments to address this problem for some time. Suspended and embedded sediments include: particulate organic and inorganic matter that suspends in or is carried by the water, and/or accumulates in a loose, unconsolidated form on the bottom of natural water bodies.

Suspended and embedded sediments problems refer to imbalances in sediment in aquatic ecosystems. Too much sedimentation is a common, major water quality problem. As with other water body features such as nutrients, dissolved oxygen, flow, alkalinity, carbon, etc., all water bodies need and depend on certain natural levels and fluctuations of sediment. Too little sediment can be as much of a problem as too much. Therefore, one of the basic objectives in managing suspended and embedded sediments in water bodies is to ensure that a water body is getting the right amount of sediment given the natural characteristics and management objectives for the water body. To achieve this, a better understanding is needed of the natural or optimum regime of sediment a water body should have, and of the effects variations from this level will have on an intended use of that water body.

Some of the more common impacts of imbalances in suspended and embedded sediments were listed (see slide 6). The complexity of the issue was highlighted. Protecting aquatic life and wildlife, enhancing recreation, and protecting drinking water sources may all have different optimum suspended and embedded sediments regimes at which these different water body uses will be protected. In addition, natural variability exists in the suspended and embedded sediment regimes different water bodies have based on natural classification schemes.

Sediment is the single largest stressor identified as the cause of impairment for 303(d) listed waters. On a water body basis, using data from the 305(b) reports also submitted to EPA by the states, the most highly impacted water bodies, in priority order are: rivers and streams, followed by lakes, reservoirs, ponds, and estuaries. States and tribes are faced with controlling excessive sediment in water bodies without having the necessary tools to do so, including good water quality criteria, monitoring methods, modeling techniques and control measures. There is a disconnect between the immediate needs facing states and tribes meeting court ordered TMDLs, and the future development of tools. EPA's programmatic solution is to provide what is needed, as soon as possible, starting with the highest priority needs. Collaboration is needed between the regions, states, and tribes to achieve that end.

Existing EPA water quality criteria were developed in 1976 and are listed in EPA's Quality Criteria for Water, known as the Gold Book (1986). Very few states are using this value in their TMDL effort, and are instead using some form of a turbidity level (e.g., nephelometric turbidity units) or TSS as criteria in their standards. Of highest priority is the development of effective water quality criteria by EPA (OWOW, OST, ORD/NHEERL, NCEA, NERL, NRMRL) along with other Federal partners (USDA-Agricultural Research Service). Most of the research necessary for improved water quality criteria development will be conducted by ORD-NHEERL.

Past and present suspended and embedded sediments efforts were listed. Highlights include the formation of the National Sediment Workgroup in 1998, the development of the *Draft Technical Framework to Support the Development of Water Quality Criteria for Clean Sediment*, the development of the *Strategic Planning and Research Coordination (SPRC) Action Plan* listing all identified research needs, publication of a guidance manual on *Protocols for Developing Sediment TMDLs* by OWOW, and preparation for conducting research necessary for developing better water quality criteria for suspended and embedded sediment under the Aquatic Stressors Research Program (ORD/NHEERL). ORD/NHEERL has prepared a research strategy to address five key research questions in preparation for developing suspended and embedded sediment criteria (see slide 13). Additional programmatic work under consideration by OW includes: developing a sediment web site for information exchange, providing technical assistance to the states/tribes, holding a National sediment workshop, publishing guidance on monitoring methods for sediment, guidance on permitting to control sediment, developing a database on control effectiveness (point sources and BMPs), and holding informational meetings.

Questions and Comments

Question: When will we have a narrative standard? We need to develop a collaborative effort between regions, states, ORD and OW.
Response: Sediments is an area that ORD is focusing on.

Comment: Comment and discussion on the need for a workshop on managing an interim approach while sediment criteria are being developed. Additionally, there was discussion on the benefit of having a regional lead identified and charged with the task of coordinating OW program and ORD research efforts with the regions on sediment criteria. A regional program expert on detail or a dedicated FTE modeled after the Wetlands Program/ORD coordinator based in the Corvallis Laboratory were suggested.

Suspended Solids and Sediments Risk Management Research – Christopher T. Nietch (ORD/NRMRL)

Traditionally, sediment management and assessment has been approached from specific land-use contexts. For example, much more attention has been given to erosion processes in agricultural lands compared to suburban and urban lands. As a result, many of the management measures used are not well tested in different land use classes. At issue is linking the anthropogenic causes and ecological effects of sediment stress. Conceptual linkages between anthropogenic sources of sediment stress and ecosystem effects were shown in a flow diagram, as well as conceptual linkages among anthropogenic causes of sediment stress and aquatic ecosystem health.

Two primary processes of concern are hillslope erosion and channel erosion. Channel erosion has historically been studied within a geomorphic context and theoretically is related to balances between sediment supply and discharge. Presently, channel erosion is addressed within the context of habitat disturbance. It is necessary to manage both flow and hillslope sediment supply, which may change disproportionately in space and over time as a watershed undergoes land-use change. Controlling hillslope erosion may not solve the problem, and may in fact exacerbate it, if receiving waters are inadvertently starved of their natural sediment source. In these instances, the channel erodes to fill the unused sediment carrying capacity of the flow.

The framework was presented for ORD-wide sediment work and the NRMRL approach to conducting the type of risk management research necessary to make scientific decisions with respect to the control of sediment stress at the watershed scale. Quantitative steps involved in making risk management decisions and assessing if they are effective include: 1) allocating sources (or lack thereof), and determining how they behave relevant to the sediment reference; 2) determining the Best Management Practice (BMP); 3) linking source allocation and BMP over multiple scales for Decision Support System (DSS); and 4) evaluating the decision with effective monitoring programs.

Research called for relies heavily on modeling. The relative accuracy and reliability of models of diffuse pollution was shown in a graph. NRMRL feels this is justified, based on the low levels of uncertainty for models of flow and sediment compared to other aquatic ecosystem stressors. Several entities within ORD are involved in source allocation modeling because of the direct crosswalk to sediment TMDL preparation and regulation. Specifically with respect to sediments, research that focuses on source allocation models needs to address the following:

- Hillslope sediment yield models,
- Hydrologic load models,

- In-channel sediment fate and transport models, and
- Developing packages that link the loading and receiving water models in space and time to allocate sources in mixed land use watersheds.

A figure showing a prototype watershed of mixed land use was used to demonstrate the spatial complexity involved in developing appropriate load allocation models. The complexity of sediment fate and transport models depends on the nature of the simulated waterbody (e.g., a one dimensional model for a 1st or 2nd order stream may not be appropriate for a large and deep body of water such as a reservoir). Concurrently, much effort is being placed toward providing scientifically sound structural and non-structural BMP alternatives. Examples of BMP alternatives with recommended designs are ponds and wetlands. Other types of BMPs that are given considerable attention are buffers, dry detention, and bioretention. Recently, dry detention ponds have been reported as not working well for reducing SSAS. Low impact development options / low-structural BMPs include grassed swales, silt fences, porous pavement, elimination of curbs and gutters, and disconnection of roof top runoff. A diagram was presented depicting the processes that need consideration in a BMP performance model for sediment removal (see slide 14). Land-use, treatment, development, and acquisition predicates that BMPs be implemented on the field scale, which may vary between one and several hundred acres.

BMP performance modeling can be used to make sediment management decisions at the field scale. First a problem is identified, then a model is used to guide design and predict the results in an iterative process. This is the same approach put forth by the USDA to guide stream restoration projects. Two fundamental questions that need to be addressed at larger scales to make the BMP approach useful for the protection or restoration of aquatic ecosystem health are:

- Where to place an individual BMP for the most water quality benefit?, and
- How to model the cumulative effects of BMPs at a larger scale?

These questions are addressed within the context of a watershed-scale decision support system. Major issues and requisites for the decision support system (DSS) were presented along with a conceptual diagram of a simulation model for sediment management. An example of what the output of such a system may look like was illustrated. Monitoring drives source allocation model development and is also essential for determining the effectiveness of the management decisions in the post-implementation phase. With effective monitoring programs in place, each time a management decision is made, the result becomes a case study that tests the utility of the DSS. A flow diagram was described illustrating the framework for using a decision support system in an adaptive management context from integration of source allocation and BMP performance models to the DSS to the evaluation of that decision through effective monitoring programs.

Nutrients

USEPA National Nutrient Criteria Program Approach to Reference Condition Development – George Gibson (OW/OST)

Eutrophication of surface waters in the United States has been recognized as a long standing problem. Much of the Nation's waters do not adequately support aquatic life because of excess nutrients. Nutrient levels vary from region to region due to geographical variations in geology and soil type. EPA is publishing recommended National nutrient criteria for fourteen nutrient ecoregions by water body type including lakes and reservoirs, streams and rivers, estuarine and coastal marine waters, and wetlands. The criteria can be used for: identification of problems, standards development, regulatory assessments, project planning and evaluation, and determination of resource status and trends.

Illustration Of Nutrient Criteria Development Using Lakes As An Example

A critical part of the nutrient criteria process is establishing lake reference conditions for the physical lake classes within each ecoregion. Reference conditions for each of these classes are the quantitative descriptions of lake conditions used as a benchmark for comparison purposes. Realistically, reference conditions represent the least impacted conditions, or what is considered to be the most attainable approximation of natural conditions; land use practices and atmospheric pollution have so altered the landscape and quality of water resources that truly undisturbed lakes are rarely available. When establishing reference conditions, identify those lakes of a given physical class which are least impacted by human behavior, then measure and assume nutrient levels represent normal levels for a natural setting for lakes of that type. Reference lakes must be representative of a region and their conditions should represent the best range of minimally impacted conditions that can be expected of similar lakes within a region.

An outline was provided of the format of the technical guidance manuals the program has published or is drafting for Streams & Rivers, Lakes & Reservoirs, Estuaries & Coastal Marine Waters, and *wetlands.* Preparation of these documents relied on the *National Strategy for the Development of Regional Nutrient Criteria* document (released July 1998), in addition to information developed from a 1995 nutrient technical conference of experts held by the program as well as from earlier experience developing the national biocriteria program and consultations with the USEPA Science Advisory Board. It is expected that the technical manuals for the development of nutrient criteria will be updated approximately every five years. The ORD National Health and Environmental Effects Research Laboratory (NHEERL) in Corvallis, Oregon has created a map of the continental United States (U.S.) illustrating Draft Aggregations of Level III Ecoregions for the National Nutrient Strategy, which was presented to illustrate the initial regionalization approach for nutrient criteria development.

Regionalized reference condition based criteria development is a key aspect of cultural over-enrichment management for water quality protection and management. Elements of criteria development were listed, and are described in the National Nutrient Strategy and the technical guidance manuals. It was noted that initial data used for the freshwater systems criteria development dated back approximately ten years (1990 to present), and did not draw on STORET database randomly; the data were first screened for the removal of reports on obviously degraded water quality . The headquarters nutrient team and Regional Technical Advisory Groups (RTAGs) evaluated total phosphorus, total nitrogen, nitrite and nitrate, total Kjeldahl nitrogen, chlorophyll *a*, dissolved oxygen, and Secchi depth, to determine regional reference condition values (see also the EPA nutrient criteria web site).

A regional reference condition can be selected using approaches. In both instances, the intention is to select an optimal reference condition value from the distribution of an available set of lake data for a given physical class of lakes or reservoirs. The preferred approach is to select the upper quartile from the distribution of measured variables of known reference lakes. The other approach is to select the lower quartile from all lakes in the class or from a random sample distribution of all lakes in the class. A diagram illustrating the two approaches was presented using total phosphorus as the example together with independent demonstration studies by states and agencies reflecting the apparent similarity of the values derived from this approach, however, further investigation is required [See also "Use of Reference Sites and Conditions in the Development of Nutrient Criteria" below]. The framework used for developing nutrient criteria was presented as a flow diagram.

EPA expects that the states and tribes will make a good faith effort to adopt and incorporate the nutrient criteria recommendations into water quality standards. Consequently, States and tribes will have flexibility in the development of nutrient criteria in the following areas: measured variables, use of EPA technical guidance, designated uses, antidegradation, reference condition versus criterion, the role of outliers, and use attainability assessments and site specific evaluations.

Nutrient Criteria: Challenges Facing Regions and States – Danielle Tillman (Region 5)

Options for Criteria Development

The regions and states have been given a lot of flexibility in developing nutrient criteria. The three options for states and authorized tribes are the following: 1) to adopt EPA's 304(a) criteria recommendations; 2) to develop criteria to reflect local conditions and protect specific designated uses, using EPA's guidance (recommended option); and 3) to develop criteria protective of designated uses using other scientifically defensible methods and appropriate data. Most states are not considering using option 1. In Region 5, all states are pursuing some form of option 2, either refining the reference condition (option 2a) or establishing effect thresholds (option 2b) or developing some combination of the two.

Ongoing Data Collection and Analyses

The New York State Department of Environmental Conservation, the Wisconsin Department of Natural Resources (and the U.S. Geological Survey), and Indiana University are among those groups collecting and analyzing additional data to support nutrient criteria development. They each have ongoing projects aimed at identifying effect thresholds appropriate for protecting designated uses.

State Questions and Needs

States are looking for answers to science, policy, and resource questions such as how aquatic ecosystems function, and what parameter values are expected in minimally-impacted sites. EPA is trying to reassure states that there is flexibility; however, states are still leery about coming up with a number dramatically different from existing, published EPA numbers. States want clear and timely answers to policy issues, and they are also seeking additional resources. States need continued access to experts for study design and data analysis advice. They are looking to EPA to help them address water bodies that are shared by multiple jurisdictions, and water bodies that have, so far, been "falling through the cracks."

Conclusions

States and tribes are interested in refining EPA's nutrient criteria; many want to use effect-threshold information in their criteria development. State, tribal, Federal, and academic groups are collecting and analyzing data to address some of the questions, but research gaps remain. EPA research should coordinate closely with and integrate ongoing efforts to ensure that resources are targeted as effectively as possible. Finally, EPA scientists can contribute both by conducting research and by providing technical advice (e.g., via Regional Technical Assistance Groups).

Biocriteria

National Framework for Tiered Aquatic Life Uses in State and Tribal Water Quality Standards - Update on Guidance Development – Susan K. Jackson (OW/OST)

Since the early 1990s, states and tribes have used biological assessments to refine their water quality standards; this is a long-term goal involving milestones and incremental steps. An EPA workgroup is in place: 1) to develop guidance on the use of biological assessments and criteria to refine designated aquatic life uses in water quality standards; 2) to propose how to apply existing state and tribal water quality standard programs; 3) to identify pitfalls and barriers to implementation; and 4) to solve problems and propose solutions. Technical guidance documents have been produced for biocriteria, but not for the uses part of the standard. It is now a program priority to focus on the "uses" because of issues of National consistency, as well as the need for better public communication and engagement in decision-making.

The workgroup is developing a conceptual model (framework) predicting the biological response to increasing human disturbance. This biological condition gradient should: 1) encompass the entire range of possible conditions (natural and departure from natural all the way to "dead"); and 2) include scientifically defensible (and ecologically meaningful) increments of change, or benchmarks, along the gradient. The conceptual framework will be used to support establishment of thresholds for different levels of protection for aquatic life.

The designation of aquatic life uses is a public process, which takes into consideration the existing condition of a waterbody, the potential to achieve higher water quality (restoration potential), and social and economic factors. By using biological assessments to provide more accurate and direct descriptions of aquatic life goals, public dialogue and decision-making are enhanced. The workgroup is developing a tiered aquatic life use conceptual model of draft biological tiers; the draft biological condition gradient, illustrating the general concept of tiers, was presented along with thumbnail definitions of the six tiers. The workgroup is defining specific attributes for the tiers, and working with the regions to test.

The purpose of the National framework is to provide an ecologically-based model for the communication of biological conditions. The descriptive, incremental gradient should improve communication about where goals may be set, and enable a better, more accurate understanding of current conditions. Key points to emphasize: the framework is conceptual, the number of tiers will be determined by states and tribes (the six tiers are meant to provide a highly resolved gradient to assist states and tribes to think about how to characterize the condition and goals for their waters), "best fit" of data approach is recommended (the list of attributes should not be considered a checklist), and the framework is applicable to different methods.

A third workgroup meeting is planned for next spring. The current draft will be used as a discussion document to engage a broader audience, including internal EPA discussions, additional states, and other Federal agencies and stakeholders. Proposed breakout session topics and organization were listed.

Biological Assessments in Region 10 - Approaches, Application and Research Needs – Gretchen Hayslip (Region 10)

A brief summary was presented of the use of biological assessments in Region 10, including approaches, and application and research needs. All states in Region 10 use bioassessments in their water quality management programs. In addition, some tribes use bioassessments in their water management programs. Most states have some form of "tiered" aquatic life uses and most states have some sort of narrative biocriteria. No state or tribe in Region 10 has numeric biocriteria, although Oregon is very close. Idaho's Waterbody Assessment Guidance was provided as an example of bioassessment use in water quality management programs. Additional examples of aquatic life uses were listed for Idaho, Oregon, and Alaska. Numeric biocriteria development in Oregon was outlined. Issues currently being addressed are reference site selection and use, and beneficial use categories. Biological assessment research needs in Region 10 include: application of existing tools to the diverse conditions in Alaska, stressor indicator indexes (e.g., sediment, nutrients and metals), a small set of quantitative CWA habitat indicators (that are repeatable, reliable and widely applicable), and research for other waterbody types (e.g., large rivers, lakes, and wetlands).

THIS PAGE INTENTIONALLY LEFT BLANK

BIOCRITERIA AND NUTRIENTS SESSION

Establishing Multi-Use Reference Sites for Biological & Nutrient Criteria Development – Don Huggins (University of Kansas)

Outcomes of the recent USEPA Region 7 Central Plains Biocriteria Workgroup, and Nutrient Regional Technical Advisory Group (RTAG) meeting on establishing multi-use reference sites for biological and nutrient criteria development were presented. The Central Plains within Region 7 is a diverse area ranging from the Sand Hills in the northeast to the Western High Plains of Kansas. Many of the streams in the Central Plains have sandy bottoms, and can become more diverse where there are man-made activities present. Reference condition criteria were described for given ecoregions in the Central Plains. The Workgroup identified factors for designation of reference sites, then selected eleven core factor groups that would be accepted across the region. The group wanted to work toward a rule-based approach.

Characteristics of several core factors under reference conditions were described in more detail including: instream habitat, riparian habitat, land use / land cover (site-specific), and biological metrics (not a stand-alone factor). The Workgroup applied the use of reference sites / systems to define biological and nutrient criteria values to Region 7. Reference sites are proposed for use in identifying both biological and nutrient conditions that would lead to determination of biological and nutrient criteria values. Broadly defined and quantified reference conditions should identify high quality sites or systems that possess minimally altered physical, chemical and biological states. Reference sites or systems exhibiting high quality biological systems should be indicative of acceptable and above average water and habitat quality. Approximately 120 reference lakes were identified by regional biologists and experts. The tri-section method was applied using chlorophyll a values as biological indicators to select potential reference lakes. Comparisons of total phosphorus, total nitrogen and chlorophyll a for all lakes versus reference lakes and for all lakes except Sand Hill lakes were illustrated. All values were expressed in µg/L. The Sand Hill lakes were not included in the data since they represent a geographically unique population of least impacted lakes in the region. Based on these results the group was able to propose benchmarks for lakes and reservoirs. Another example of a joint reference use approach involved assessment of a total of 787 streams. Reference streams reflected both good fish IBI scores and low nutrient levels but there was a slight drop in nutrient levels when the fish IBI was selected as the single reference value of concern. Overall reference conditions were thought to be the best measure of health rather than a single factor score, such as low phosphorus or highest fish IBI.

Questions and Comments

Question: How do you establish a reference site for large rivers (e.g., the Snake River)?
Response: In Region 7, we stay with wadable streams because we are not sure how to go about it for large rivers.

Comment: The Ohio River Valley has been developing methods, and have established criteria. They have used the minimal impact fish assembled - difficult to model with 165 fish species. Minimal distances from discharges is what they shoot for.

Reference Condition for Biological Integrity – Phil Larsen (ORD/NHEERL)

Larsen explained that our basic interest, regardless of time in history, is: what effect does human activity have on aquatic ecosystems. One way of getting at this is to characterize conditions under no or minimal human disturbance, and use that as a reference condition against which to make future comparisons. Context can be time-independent. The general sense is that the term "natural" connotes the condition in the absence of human disturbance, even though arguments have been advanced that humans are a part of nature, therefore natural always implies human effects. The use of "natural" as a conceptual tool to stand for no human disturbance / effects is useful to frame discussions. At present, no place on earth can be considered without human disturbance given the broad dispersion of human derived pollutants. Consequently the phrase "minimal human disturbance" is useful for approximating a natural condition.

The reference condition for biological integrity was evaluated and characterized for regions where minimally disturbed reference sites still exist, as well as regions where they do not. Some issues currently being addressed are: how human activities affect aquatic biota, "natural" versus minimum human activity, and the status of the reference condition for biointegrity under minimal contemporary human disturbance. The need for reference conditions was described for the Environmental Monitoring Assessment Program (EMAP), biocriteria, and watershed management. Natural variability produces a range or distribution of reference condition scores, i.e., reference variability, and can be accounted for through associations (e.g., ecoregion, waterbody size, elevation, and gradient). The concept of reference variability was illustrated in several graphs. Particularly challenging is the ability to characterize the reference condition in regions where minimally disturbed reference sites no longer exist. In these regions, a combination of methods are implemented such as historical reconstruction from times with minimal stress, use of best ecological judgement (including models), restoration experiments, and inference from data distributions. A graph was shown modeling reference condition in heavily disturbed regions using fish data to extrapolate to the Y-axis.

The distinction between "minimal" versus "least disturbed" was described. "Minimal" implies an absolute (e.g., sites should meet a set of criteria), while "least" implies relative disturbance (e.g., any region contains a set of sites that are least disturbed, even if there are no minimally disturbed sites). Of key importance is the selection of reference sites so the outcome is repeatable. Two sets of criteria were independently applied to sites in an EMAP pilot study in Region 3 (Appalachia). The resultant description of reference sites was the same in one subregion but differed in a second subregion demonstrating the need for care in the selection of criteria by which to identify reference sites. Reference sites should be representative of the natural gradients in the region of interest, e.g., elevation, latitude, longitude, and stream gradient. Slides depicting the sample population and reference site gradients were presented to illustrate whether reference sites were in fact representative of the target population. Challenges regarding reference conditions include: assuring that the outcome of characterizing a reference condition is repeatable; assuring that the reference condition is representative of the resource of interest; standardizing reference site selection criteria; accounting for natural variability (how to and how much); identifying alternatives to reference sites, especially for regions with few or no minimally disturbed sites; and using appropriate classification scales.

Questions and Responses

Question: [Question regarding use of historical reconstruction methods to characterize the reference condition]

Response: In the Northwest, the best we have available are land surveys dating back 150 years. In Region 7, there are some good historical data.

The Use of Reference Condition in Support of Surface Water Assessments and Criteria Development in Ohio – Chris O. Yoder (Midwest Biodiversity Institute, Columbus, OH)

[Slide 1] The Midwest Biodiversity Institute, Inc., incorporated in 1997, is an umbrella organization currently consisting of 124 institutions and corporations and its primary affiliate, the Ohio Biological Survey. The membership of MBI and OBS, encompassing 12 states and the Province of Ontario, overlap to a great degree, with institutions and corporations from outside of Ohio joining MBI and becoming affiliates of OBS. MBI is a 501(c)(3) nonprofit corporation, which is governed by a Board of Trustees. An Advisory Board, comprised of designated representatives from member institutions, provides input to the Board of Trustees. The goals and objectives of MBI differ somewhat from OBS in that an additional emphasis is to leverage field-trained taxonomists and ecologists back into college and university departments and curators into museum positions. MBI also seeks funding to provide undergraduate and graduate students with the financial means to pursue degrees in field-oriented, organismal biology. Projects undertaken by MBI, which fall under the same goals and objectives as OBS, tend to be outside of Ohio and multi-state in nature. In other regards, objectives, and philosophy, MBI parallels OBS except in its greater geographic extent. MBI is presently executing a cooperative agreement with U.S. EPA in support of biological criteria implementation and environmental indicators development. MBI has also provided expertise via consulting agreements to a number of organizations.

[Slide 2] Establishing reference condition is done by selecting and sampling reference sites which are defined as a collection of sites within a homogenous regional area which represent the best attainable conditions ("least impacted") for all waters with similar physical dimensions and attributes for that particular region. [Slide 3] Reference sites differ from the traditional control site concept in that multiple sites define reference condition within a regional context. A control site is a single site usually located on or adjacent to the waterbody under study that represents the best or most appropriate condition for that waterbody whether it is impaired or unimpaired. Reference sites will always function as control sites, but some control sites may be unsuitable for determining reference condition. Reference condition is updated every decade by the regular and continued monitoring of reference sites. [Slide 4] Guidelines for the selection of reference sites are needed to ensure that reference condition reflects least impacted conditions. These guidelines are presently based on qualitative guidelines. Keeping the selection process apart from the data analysis process is an important procedural issue as inappropriate mingling of the two processes may introduce unintentional bias into the development of reference condition. [Slide 5] Misperceptions of reference condition include the notion that reference sites reflect a pristine or unimpacted condition, free from the effects of human disturbance. In reality, few if any reference sites in the conterminous U.S. reflect a truly pristine condition with most representing substantially altered conditions, the results of decades of human settlement and resource exploitation. This leaves us with the significant challenge of setting realistically attainable endpoints that meet CWA goals (biological integrity, propagation, fishable/swimable).

[Slide 6] Biological criteria are narrative and numerical ratings based on the numbers and kinds of aquatic organisms (i.e., the assemblage) that inhabit a sampling site. [Slide 7] Biocriteria are indexed to the reference assemblage within a geographic region and with respect to the size properties of the aquatic ecotype. [Slide 8] As such, biocriteria represent a calibrated assessment tool that fosters an organized goal setting process to reconcile human impacts and guide restoration efforts. [Slide 9] The calibration and derivation of the Ohio EPA Index of Biotic Integrity (IBI) was described in six steps: 1) selection and sampling of reference sites, 2) calibration of IBI metrics, 3) a calibrated IBI modified for Ohio waters, 4) establish ecoregional patterns and expectations, 5) codify numeric biocriteria in the Ohio WQS), and 6) numeric biocriteria are used in assessments. [Slide 10] The calibration of IBI metrics was detailed and includes the calibration vector (e.g., stream size), determination of the 95% "maximum" richness lines, and the trisection procedure for determining IBI metric scoring. This method reduces the influence of substantially altered sites and keys on the upper 5% of reference condition. [Slide 11] The effect of increased numbers of reference site samples on IBI biocriteria derivation was depicted to illustrate the minimum number of reference sites that are needed to adequately represent the central tendency of reference within a region.

[Slides 12 and 13] A descriptive biological condition axis provides a common basis for communication about a gradient of biological degradation and tiers around which stratified designated uses can be set. [Slides 13 and 14] The position of designated aquatic life uses in Ohio along the biological conditions axis was shown. National application of the biological condition axis will provide for the following:

- Translate different analytical approaches to a common yardstick;
- Provide a common basis to derive bioassessments from different methods;
- Enable consistent reporting on biological condition;
- Communicate ecological relevance of sampling results to the public; and
- Enable management within smaller increments of biological change, i.e., to protect for the best attainable conditions and document incremental improvements as restoration occurs.

[Slide 15] The reference dataset anchors the biological condition axis in the range of least impacted reference condition. This step merges the calibration of the bioassessment mechanisms (i.e., IBI) with the descriptive biological condition axis and ultimately tiered designated aquatic life uses. [Slide 16] This was illustrated with the actual set of data used to establish the tiered designated uses for the Exceptional Warmwater Habitat, Warmwater Habitat, Modified Warmwater Habitat, and Limited Resource Water uses. [Slides 17 and 18] The resulting biocriteria are organized by aquatic organism group (fish and macroinvertebrates) and biological index (IBI. Miwb, and ICI), and are further stratified by use designation, site type (headwater, wading, boatable), and ecoregion. In all, more than 40 sets of numeric biocriteria exist in the Ohio WQS.

Bioassessments are used in a variety of ways to describe watershed health and diagnose impairments. [Slide 19] Using biocriteria to describe changes in river segments through time and before and after the imposition of pollution control programs was demonstrated with results from the Scioto River. This particular example shows the positive response of the fish assemblage to 15 years of water quality based pollution controls. [Slide 20] More recently, biocriteria are being used in support of TMDL development to portray the spatial extent and distribution of quality throughout watersheds. The Stillwater and Wabash River basin examples show the influence of agricultural land use and riparian management practices in addition to the recent concentration of large Confined Animal Feeding Operations (CAFOs) in parts of both watersheds. [Slide 21] Bioassessments and attendant chemical and physical assessment tools demonstrate the complex interaction between habitat and nutrient dynamics in Ohio watersheds. The cumulative effects of habitat degradation and its associated consequences are frequently exported into downstream reaches resulting in reduced assimilative capacity and lower quality biological assemblages, the latter of which may contribute to an impairment of the designated use as measured by the biocriteria. The example shown is the correspondence of headwater stream habitat with total phosphorus. The reduced ability of degraded headwater segments to process and sequester nutrients was illustrated in an inverse relationship between total P and habitat quality as measured by the Qualitative Habitat Evaluation Index (QHEI).

[Slide 22] The preceding sequence of calibrating, deriving, and using biocriteria illustrates the regional reference site approach in which consideration of inter-regional and intra-regional factors are blended in an appropriate fashion to derive regionally relevant and attainable biological criteria. Examples of the further use and value of biocriteria include the validation and evaluation of chemical water quality criteria for ammonia-N [Slide 23] and metals [Slide 24]. A similar correspondence with physical habitat quality was also described [Slide 25]. This has lead to the tiering of chemical water quality criteria and thresholds for a variety of chemical parameters.

The principles of adequate monitoring and assessment are essential to the successful implementation and use of biological assessments and criteria [Slide 27].

Questions and Comments

Question: Reference conditions - did you ever adjust for natural conditions (e.g., wildfires)?
Response: We have had extremes that include serious droughts and wet weather periods, but this did not seriously alter reference condition at least impacted sites.

Comment: We are talking about a broad, independent cluster of ecoregions (a stratifying layer). Do we calibrate on a large uniform basis?

Response: We definitely need to calibrate across a broad enough spatial region to encompass the full range of reference potential. If we calibrated only by ecoregion, I think we would have a less descriptive and distinct biological condition axis.

Comment: We don't have a good definition in the landscape of what indicators are and how they are being used.

Response: The critical vector against which biological condition and response is positioned is human disturbance. Our problem is that in many cases our measures of human disturbance are first order approximations at best and we can only compare them one or two at a time. The best measure is biological response as it captures the sum total of human stressors in the proper sequence.

Use of Reference Sites and Conditions in the Development of Nutrient Criteria

– George Gibson (OW/OST)

EPA's National Nutrient Criteria Program approach to reference condition development was presented. Two aspects of the approach discussed were: 1) the initial experience with freshwater lakes and streams; and 2) the planned approach for coastal waters. The area of aggregate nutrient Ecoregion 7 and the stations within that ecoregion were illustrated. Sources of data include STORET data and data from the states and academic institutions in Ecoregion 7 (NY, PA, MI, WI, MN, IN, OH, and VT including the New York State Department of Environmental Conservation, and the Lake Champlain Monitoring Project. Data were collected over the period of 1990-1999 during all seasons. The majority of the data (80-90%) was from STORET. The Nutrient Criteria Program was aware of the limitations and quality of the STORET data and made an effort to "clean up" the data. This was done by removing duplications; reviewing remark codes and deleting irrelevant and likely poor data; contacting sources of data to determine sampling and analytical methods used; and verifying the locations of stations and water body names.

Coordination was sought across EPA regions and among states through the Regional Technical Assistance Groups (RTAGs) in each EPA Region. The lower quartile of STORET derived data was presented for Ecoregion 7 lakes, ponds, and reservoirs for all seasons. Data parameters include: concentration of chlorophyll-a measured with a fluorometer, concentration of chlorophyll-a as measured by spectrophotometry, dissolved oxygen, nitrate, nitrite, total nitrogen, total Kjeldahl nitrogen, total phosphorus, and Secchi data. Statistical analysis of Ecoregion 7 data shows:

- Percentiles for the entire Ecoregion and subecoregions correlate reasonably with state data on reference lakes (e.g., MN),
- Variability is high when all data are lumped,
- There are differences between subecoregions,
- There are seasonal differences, and
- It is likely that variability will be reduced when we classify lakes according to physical characteristics.

It was felt that the study was data poor in estuary and coastal data, and efforts are being made to develop methods to collect more data in these areas. In addition, it was noted that the Minnesota Lakes guidelines were developed independently and concurrently with the drafting of lakes and reservoirs technical guidance and the results were comparable.

Datasets evaluated were presented for New England Lakes (Matt Liebman, December 2000), Minnesota Lakes (Steve Heiskary, April 2000), New York State Lakes (Scott Kishbaugh, September 2000), Tennessee Streams (Greg Denton, October 2000), U.S. Geological Survey (Richard Smith, May 2001), Delaware Streams and Ponds (John Davis, March 2001), and Delaware Estuaries (Kent Price and Brian Glazer, June 2001).

An example of an initial coastal marine monitoring project conducted off the mid-Atlantic coast extending from just north of Delaware Bay and south of the mouth of the Chesapeake Bay to the area of Kitty Hawk, NC was illustrated in several figures showing the location of stations, as well as results for a two-year summer nutrient survey. The variables addressed include: TN, TP, Chlorophyll-a, and Secchi depth. The influence of data from estuaries can be seen in the graphs and potential reference condition values are identified. An illustration of a stratified random grid sample design for reference condition cells as related to an estuarine or other significant discharge was provided. States can assist by providing data and needed monitoring support, especially for riverine or estuarine and similar discharge sites. Contact information was listed for EPA's National Nutrient Criteria Program Regional Nutrient Coordinators, and headquarters personnel.

Developing Nutrient Criteria Using Multi-Metric Indices: A case study in the Mid-Atlantic – John Hutchens (ORD/NERL)

Development of nutrient criteria is of key importance for several factors. Nutrients are one of the top three stressors to streams, impacting both human and ecological health. In addition, upstream inputs can lead to problems for downstream receiving waters. Criteria development was illustrated in a flow chart beginning with the identification of goals to monitoring and reassessing criteria ranges. Nutrient criteria can be established by using frequency distributions of all streams or reference streams, predictive relationships, and published thresholds or criteria. A method of selecting reference values was illustrated for total phosphorus concentration (μg/L) using percentiles from reference streams and total stream populations. Reference streams selected include the 25th percentile of frequency distribution for all streams and the 75th percentile of frequency distribution of reference streams using best professional judgement (targeted), meeting criteria, and Indices of Biotic Integrity (IBIs). The benefits of using IBIs were outlined.

The objectives of this Mid-Atlantic Highlands case study were to determine the total phosphorus criteria using IBIs based on different assemblages of stream biota, and to compare criteria using confidence intervals. Stream sites (1st - 3rd order) in New York, Pennsylvania, West Virginia, Virginia and Maryland were sampled from 1993 to 1995 using an index period from April to June. IBIs for macroinvertebrates and fish resulted in four of seven and four of nine metrics, respectively, sensitive to nutrient enrichment. Specific percentiles from frequency distributions were determined. Confidence intervals were then computed around the percentiles using resampling techniques (i.e., bootstrapping). Ecoregion stream classification by Omernik (1994) and Woods et al. (1996) was lumped to highlands versus lowlands. Minimally impacted sites were compared. A comparison of total phosphorus criteria from "good" streams was presented from various data sets such as: EMAP (all streams); macro-invertebrate biotic integrity index (MBII) ("good" streams); Fish IBI ("good" streams); Nutrient Ecoregion XI; and Ohio EPA Western Allegheny Plateau (OH-EPA WAP). Total phosphorus criteria data sets from "fair" streams were compared as well. Using one nutrient criterion value means a stream is either acceptable or impaired. An additional criterion set in the IBI "fair" category provides more options for managers, while still meeting a certain level of biotic integrity.

Conclusions

- This "simple" method to set nutrient criteria based on IBIs can be linked to designated use classification;
- The method can be applied to other stressors to set criteria;

- EMAP data can be used to extrapolate to population of 1st to 3rd order Mid-Atlantic streams;
- The criteria based on the "all streams" method was more protective than the "IBI-reference" method; and
- Total Phosphorus criteria based on invertebrates and fish were not significantly different, although invertebrates tended to be lower.

A summary of future directions was highlighted. Some proposed steps were to conduct experiments to "fine tune" criteria in specific locations, and to examine the relationship between local criteria and downstream conditions.

Questions and Comments

Question: Four out of seven metrics responded in the macro invertebrate IBI and four out of nine metrics responded in the fish IBI - was it a positive or negative response?
Response: It was a mixed result, depending on the individual metric.

Comment: You can add nutrients to a system and increase its diversity, but that does not explain why phosphorus levels increase in a stream that is naturally phosphorus-limited. In the mid-western streams, if you increase the phosphorus, you increase the number of some types of fish. If nitrogen is increased, the result is a negative response. There isn't necessarily a toxic threshold response with nutrients (nutrients are not necessarily toxic). Excessive nutrients may be bad, but can also be beneficial.

Comment: Some states get funding by selling fishing licenses, and want to have high levels of nutrients [in streams and lakes] because of the increase in the numbers of fish.

NHEERL National Nutrients Research Implementation Plan – Emile Lores (ORD/NHEERL)

The National Health and Environmental Effects Research Laboratory's (NHEERL) National Nutrients Research Implementation Plan provides the scientific basis for developing and supporting nutrient criteria in the Nation's waters by defining nutrient load-ecological response relationships. Nutrient issues were described as human activities changing the distribution and movement of major nutrients across landscapes and waterbodies, in particular the increasing nutrient loads to receiving waters. While EPA is developing guidelines, mandated by the Clean Water Act, for setting nutrient criteria protective of aquatic systems, many scientific uncertainties exist, and it is difficult to predict when a given nutrient concentration or loading will have measurable adverse effects.

Research priorities for waterbodies include coastal receiving waters, streams and wetland, and watersheds of which there are thirty-two (32) Full Time Equivalents (FTEs) focused primarily on coastal receiving waters. Three critical endpoints of concern are: 1) low dissolved oxygen (DO); 2) the loss of submerged aquatic vegetation (SAV); and 3) shifts in food webs leading to a loss of commercially important fisheries and reduced aquatic biodiversity. NHEERL will be looking at network analysis to see how systems process nutrients. Conceptual nutrient load-response relationships were described for each of the three endpoints. Classification schemes must be developed that group waterbodies by: susceptibility to low DO; importance of SAV in ecosystem function and susceptibility to SAV loss; food web dynamics; biodiversity; susceptibility to harmful or nuisance algal blooms; and fisheries loss. Currently, there are plans for development of empirical and box models. The generic and SAV approaches to model development were described and illustrated as flow charts. NHEERL would like to build a model that combines both empirical and numeric modeling, i.e., to develop and validate the SAV model. In addition, NHEERL plans to feed into and go beyond the Office of Water's reference conditions. FY02 task activities were listed for DO, food web, and SAV-related issues.

Aquatic Life Use (ALUS) Concept of Reference Sites – Susan K. Jackson (OW/OST)

The objective of the tiered aquatic life uses framework is to identify a common pattern of biological response to human disturbance. The framework may be used to help establish reference conditions, including clarifying the difference between minimally disturbed and least disturbed reference conditions and identify reference conditions according to a region's ecological potential.

A decision tree for establishing regional reference conditions and designating aquatic life uses was presented; three scenarios for establishing reference conditions were included. Scenario 1 reflects a natural/undisturbed or minimally disturbed condition where the best existing conditions are "natural" and should exhibit biological integrity. Scenario 2 portrays the least disturbed condition; the best existing conditions are impacted, but the Clean Water Act (CWA) 101 (a) protection and propagation goal is met. Scenario 3 represents restoration targets where the best existing conditions are impacted and the CWA 101 (a) protection and propagation goal is not met. In some places there may be insufficient data to establish regional reference conditions; however, aquatic life uses should still be designated based on restoration targets and other applicable information. These uses should be periodically reviewed. Steps involved to designate appropriate aquatic life uses were outlined for each scenario, and hypothetical examples were provided.

Questions and Comments

Comment: Concern was expressed that the tiered aquatic life use model could result in downgrading waters.
Response: We are aware of this concern and will address this in implementation guidelines. The guidelines will recommend a comprehensive monitoring program and adequate data for the appropriate classification of a waterbody.

Question: Are you trying to address antidegradation?
Response: Greater specificity in classification of waters supported by data should result in more effective implementation of antidegradation provisions in State and tribal water quality standards.

Question: How does this model overlay with the T& E Species Act?
Response: The biological assessments on which aquatic life use classification and biological criteria are based measure attributes of different assemblages of the aquatic community (e.g. benthic invertebrates, fish, periphyton, amphibians etc). Ambient

habitat and chemical assessments are an integral component of the biological assessment. These assessments are measures of the health of an aquatic community - not one specific species. However, these assessments are " information rich" - and detailed information on specific T&E species can be a component of the biological assessment.

Question: How do you go back up the gradient without eliminating humans?
Response: The intent is to emphasize incremental, achievable goals for restoration of the ecological potential of a waterbody or segment. Humans are an integral part of the ecosystem - and there are ways to minimize to the extent possible degradatory impacts on aquatic systems. For example, riparian buffers and stormwater retention ponds are best management practices that can be implemented. It is useful to articulate the full range of biological response to increasing human disturbance to provide the public with a better understanding and context for existing conditions. This should contribute to a more informed public process for decision making and setting goals for waterbodies.

Comment: Back to cause and effect. From a biological standpoint, the chemical composition of water, organic enrichment and sediment are associated with land use. In criteria development, the challenge is how to technically go from a reference condition and the designated use (goal) to something that actually protects the use from the stressors to the system.

THIS PAGE INTENTIONALLY LEFT BLANK

CONCURRENT BREAKOUT SESSIONS

BREAKOUT SESSION I: Multi-Use Reference Sites

Facilitator: Bobbye Smith, USEPA/Region 9
Co-chairs: Don Huggins, University of Kansas
Gary Welker, USEPA/Region 7
George Gibson, USEPA/OW/OST

Objectives of Session

USEPA Region 7 is attempting to establish reference sites and is struggling with the definition of a reference site that all states in the region can agree upon. A repeatable method is needed for determining reference sites. USEPA Region 7 and Central Plains Biocriteria Workgroup, formed in 1998, are working to develop reference conditions and site selection guidelines for streams.

In this session, participants developed a working definition of a multi-use reference site for wadeable streams; identified core factors (*de minimus* list) that should be considered when selecting multi-use reference sites for wadeable streams; and arrived at a group consensus on the definition of each core factor for the selection of multi-use reference sites.

Facilitated Discussions

A facilitated discussion was held to develop an operational definition of "reference site" for wadeable streams. The term "reference condition" in relation to wadeable streams was first defined as a cumulative distribution of variables (parameters) from reference sites. Reference sites need to be selected by some common physical parameters (e.g., size, water temperature, homogeneity, or geographic location). Examples of similar, recent efforts by the Biocriteria Workgroup in Region 7 were given. Some participants proposed using reference conditions as a method for raising the "standards bar," while other suggested "keeping the bar in place" and applying resources where "things can be fixed."

A list of 38 factors to consider in the selection of reference sites for wadeable streams, developed by the Biocriteria Workgroup, was presented for discussion. Participants discussed the various factors, elected to lump some of them together, voted on which factors were a priority, and reduced the list to eight core factors.

The group then discussed and developed a definition for the core factor "representativeness" based on the definition developed by the Region 7 Biocriteria Workgroup. A definition was also developed for the core factor "biotic diversity and biomass." Discussion followed on the ability to attain absolutes in the Ecological Condition Gradient. Some participants argued that "absolute" never happens, while others disagreed. In addition, the presence or absence of threatened and endangered species was discussed in terms of defining a reference site.

The question was raised: "what do we do if there are no sites in the upper left hand corner [of ecological condition gradient - highest historical biological integrity]?" A suggestion was made to rank the core factors on a scale from one to ten, and then identify how much row crop, pasture and remaining forest exist. The Regional Environmental Monitoring and Assessment Program (REMAP) should provide benchmark measures. In agricultural ecological regimes, it is important to look at historical reconstruction information and measure the percentage of change in land use/land cover from historical data to present day. The TMDL program can address when criteria are not met, but may not meet biotic integrity. It would be resource-intensive for a state to implement this type of approach.

Summary of Participant Comments

The sharing of information and communication between states in a region is of key importance. Some states do not have reference sites or performance criteria. For Region 7, the "people process" was the most difficult part of the process, and it was much easier to begin discussion between states with a strawman on the table at a neutral party facility. There is a need to go beyond geopolitical boundaries to establish reference sites. An evaluation of methods used for determining reference sites is also needed.

ORD science needs included:

- Assumptions behind "random sampling";
- Resources;
- Use existing state sites;
- QA / QC for data sampling;
- Refined / practical modes for extrapolating;
- How many different types of systems are there; and
- Bring people together.

Conclusions - Reporting Out

The above discussions were summarized in the report out to the larger group. Developed definitions and identified core factors for reference sites were listed as follows:

Reference Site for a Defined Environmental System

A location in the landscape that is representative of natural conditions (minimum anthropogenic impacts) for that system and can be used as a benchmark to address multiple resource management objectives.

Core Factors for Reference Sites

1. Land use/Land cover broad-scale
2. Land use/Land cover site-specific
3. Altered hydrologic regime
4. Biotic diversity and biomass
5. Physical and chemical parameters
6. Representativeness
7. Habitat, instream
8. Habitat, riparian

Representativeness

- Reference sites should represent the range of biological, physical, and chemical conditions of the ecoregion.
- These sites should be minimally disturbed by anthropogenic activities; and
- A sufficient number of sites should be selected to adequately represent the ecosystem type and capture the natural variability among specific types.

Biotic Diversity and Biomass

- Biotic diversity is consistent with both historical assemblages (where available) and current distributions:
  - Presence of rare/unique communities;
  - Limited number of exotics;
  - Temporal variations considered;
  - Few native species lost; and
  - Presence of threatened or endangered species.

- Take into account stream classification and size;
- Migration possibilities should be taken into consideration: dams, reservoirs and drainage divides can prevent recolonization of reaches.;
- No nonindigenous species (no measureable effect on trophic structure);
- Species composition;
- Species diversity;

- Trophic structure;
- Biomass;
- Departure from native assemblages; and
- Presence of sensitive species.

BREAKOUT SESSION II: Charting a Statistical Course for Navigating the Murky Waters of Bioindicator Development

Facilitators: Susan Cormier, USEPA/ORD
David Pfieffer, USEPA/Region 5
Presenters: Jeroen Gerritsen, Tetra Tech, Inc.
Michael Paul, Tetra Tech, Inc.

Objectives of Session

USEPA ORD/NHEERL and USEPA Office of Water/OST are developing a guidance document on the data analysis methods used for biocriteria development. The guidance is intended to provide states and tribes with the statistical and other analytical and interpretation tools needed to develop biocriteria. At this point, the focus of the document is on methods used for analyzing data from stream bioassessment in the United States.

In this session, the proposed contents of the guidance document were presented as a workshop to potential users. The objectives were to teach the audience the methods and their application (technology transfer) and to obtain feedback and responses from potential users on the utility, completeness, and organization of the proposed contents of the document. Three analysis methods were covered in the session:

1. Multi-Metric Index of Biotic Integrity (IBI);
2. Empirical statistical models (RIVPACS); and
3. Biocriteria discriminant analysis.

For each method, an introductory overview was presented, followed by example calculations and hands-on demonstration of a single case study, using a single database provided by Wyoming. Following each overview and demonstration, the group held a discussion of the method to elicit comments and opinions on how best to present the methods, and on the needs of users.

Multi-Metric Index of Biotic Integrity (IBI)

A central premise of biological assessment is comparison of the biological resources of a water body to an expected reference condition. Impairment of the water body is judged by its departure from the expected condition. This approach presumes that the purpose of management is to prevent, identify, and subsequently repair anthropogenic damage to natural resources.

Biological assessment of waterbodies depends on our ability to define, measure, and compare an assessment endpoint between similar systems.

Data analysis for the multimetric approach includes the classification of reference sites into natural divisions so that appropriate comparisons can be made within classes; calculation of metrics (biological attributes) to characterize biological condition; selection of metrics that respond to stressors; and standardizing and aggregating responsive metrics into a dimensionless index of biological condition.

Empirical statistical models (RIVPACS)

River Invertebrate Prediction and Classification System (RIVPACS) and its derivative, AusRivAS (Australian Rivers Assessment System) are empirical (statistical) models that predict the aquatic macroinvertebrate fauna that would be expected to occur at a site in the absence of environmental stress. A comparison of the invertebrates predicted to occur at the test sites with those actually collected provides a measure of biological impairment at the tested sites. The predicted taxa list also provides a "target" invertebrate community to measure the success of any remediation measures taken to rectify identified impacts.

Model-building begins with the classification of reference sites, as in the multi-metric development. Following classification, a multivariate discriminant model is developed to predict (assign) class membership of assessment sites. Actual assessment is done by comparing the taxa found at a site to those expected to occur at the site. Expected taxa are determined from the taxa found at the reference sites. Reference conditions are made site-specific by the discriminant model, which may place a site intermediate among the reference classes, based on the site's physical characteristics.

Biocriteria discriminant analysis

This approach develops assessment directly from statutory designated aquatic life uses. Aquatic life uses are determined from the state's regulations. Professional biologists identify a set of calibration sites meeting each of the aquatic life uses, as well as a set of sites that are degraded (non-attainment) and do not meet any of the designated uses. Multivariate discriminant analysis is used to develop one or more models that will discriminate the use classes from one another using biological attribute variables (metrics). The resultant discriminant models quantify the best professional judgment of the biologists into a statistical model that can then be applied uniformly by anyone to assess sites and determine whether the sites are meeting their designated aquatic life uses.

Summary of Participant Comments

Participants' comments and discussions on the proposed guidance document were wide-ranging and diverse. A critical issue was the definition of the audience for the document, and its use. Some suggested alternatives included:

- A complete, step-by-step "cookbook" for development of biological indices;
- User-friendly introductory material to familiarize state managers with the analytical methods so they could make an informed selection of consultants or employees to develop an index for them;
- Introduction to the concepts of biological assessment and biocriteria; and
- Web-based training modules and FAQs (frequently asked questions).

Suggestions on content included:

- General conceptual and theory overview with a conceptual review for each specific method;
- One or more detailed case studies to illustrate the methods;
- Discussion of the advantages and disadvantages of each method, and guidance, or a step-by-step key to determine which method is optimal for a state's particular objectives and situation; and
- Research to examine performance of the alternative methods under different conditions, and to identify ways to integrate the methods to use the advantages of each.

There was considerable discussion on the identity of the end users, and why states and tribes have not used guidance documents in the past to proceed with developing their biocriteria. Several participants pointed out that a guidance document, no matter how good, is in itself not enough to spur development of biocriteria. Nearly all successful state development has required financial and technical support from EPA, in the form of grants and technical support from experts to lead workshops, teach methods, and analyze data from identifying and selecting reference sites to final data analysis. A barrier analysis was suggested to determine why many states have not implemented biocriteria.

Conclusions - Reporting Out

The above discussions were summarized in the report out to the larger group. In order to improve EPA's technical assistance to the states, and to improve the scientific basis of assessment, the session concluded with several recommendations:

- Support research to combine the advantages of the multiple alternative approaches;
- Identify the relationships of biocriteria to toxicity testing, chemical monitoring and assessment, and habitat assessment;
- Develop firm relationships between bioassessment, biocriteria, and Aquatic Life Use (ALUS); and
- Provide support to states in getting started on biocriteria development and in application of biocriteria to regulations.

The session developed a partial consensus on tools to advance biocriteria:

- Training courses and tapes;
- Web-based training;
- Frequently asked questions;
- Software and technical support (including personal contact); and
- Guidance document to include:
  - Basic concepts;
  - Sufficient information to create "informed consumers" for technical support;
  - Reference to more detailed documents; and
  - Detailed case study as appendix.

BREAKOUT SESSION III: Aquatic Life Use Support (ALUS)

Facilitators: Susan Jackson, OW/OST
Sue Norton, ORD/NCEA
Gretchen Hayslip, Region 10
Susan Davies, State of Maine

Presenters: Susan Davies, State of Maine
Lester Yuan and Susan Norton, ORC/NCEA
Rick Hafele, Oregon Department of Environmental Quality
Cyndi Grafe, Idaho Department of Environmental Quality

Objectives of Session

Susan Jackson opened the Aquatic Life Use Support breakout session and stated the objectives of the session:

1. To road-test the draft biological condition gradient;
2. To identify the relevant scientific issues and research questions and plans; and
3. To discuss issues relating to program implementation and communication.

Specifically, the session was intended to identify some of the practical issues with standards and identify the benefits and potential pitfalls of this tool. Input from participants outside of EPA's water program would be especially valuable in determining the potential impact on various programs. Implications for resource protection and restoration could also result from the session.

A brief introduction session followed, where each participant stated their name and affiliation, as well as an issue they wished to bring up for discussion or consideration during the session. A list of these issues has been included in the flip chart notes (Appendix D).

Presentations were made by representatives from three states (Maine, Oregon, and Idaho), describing the way in which ALUS could be applied to each state's existing use classification.

The Biological Condition Gradient – Susan P. Davies

The United States Clean Water Act offers no explicit definitions to facilitate implementation of the Act's long-term goal to "restore and maintain...biological integrity of the Nation's waters," nor the interim goal to provide for "the protection and propagation of fish." Even so, many states across the Nation are collecting biological data and attempting to develop biological criteria to address pressing management needs.

Operative definitions that are independent of any of the various assessment methodologies in use are needed to provide for uniform interpretation of stages of biological degradation across the country. A narrative, six-tier gradient of biological condition categories is proposed. The Biological Condition Gradient attempts to: be consistent with ecological theory; accommodate commonly observed biological responses to common stressor gradients; and to be consistent with a common and broadly agreed upon understanding of "good" versus "bad" biological conditions.

The dialogue among scientists that is required to describe these operational tiers entails an heuristic problem-solving process of constructing, then refining, descriptions that are successive approximations of imperfectly understood biological responses to stress. This process serves to clarify the extent of scientific consensus, and the current level of certainty associated with various elements of ecological theory.

Progression of Ecological Degradation in Mid-Atlantic Streams – Lester Yuan and Susan Norton

The presentation described a project undertaken to develop a better understanding of how the composition of a stream community changes when various types of anthropogenic stress are increased. The intent of the study was to:

1. Develop a method to compare the relative severity of ecological effects across different stressors; and
2. Provide analytical tools to help define aquatic life use tiers.

Data was collected from 726 sites – mostly first to third order streams – during summer low flow conditions, from 1993 to 1998. Data included the recording of physical habitat and water chemistry information, as well as the collection of benthic macroinvertebrates and fish. Stressor-response curves were generated using that data; examples were presented showing the plots of relative abundance over pH for Plecoptera and Ephemeroptera (slide 4). In this case, the two insect groups showed markedly different responses to pH, illustrating the point that the curves would need to be re-scaled in order to be combined into a community response curve.

Metrics were scaled by the means and variances expected under unimpaired conditions. Reference sites were included in the plots – the criteria for their selection are listed on slide 6. The means and standard deviations (of each metric) for reference streams of varying sizes were computed using regression techniques. A mathematical formula was developed for scaling biological responses.

Stressors considered included:

- Acidification (indicated by pH);
- Nutrient enrichment (indicated by total phosphorus concentration);
- Habitat degradation (indicated by RBP habitat score); and
- Human disturbance (indicated by chloride ion concentration).

To isolate the effects of acidification, samples were selected that satisfied all reference criteria except for the criteria for ANC. For the other three stressors, multivariate Loess surfaces were computed to control for the effects of multiple stressors.

Scaled responses of metrics were then plotted on the same graphs with plots of several insect taxa, showing varying responses depending on the stressor. The pH curve shows acidification to have no effect on the number of tolerant taxa. Decreased pH, however, did result in an increase in Plecoptera, and a decrease in Ephemeroptera and total taxa richness. The nutrient enrichment plot shows increased phosphorus levels to result in increased numbers of tolerant taxa, and in total richness, although Ephemeroptera and Plecoptera decreased in abundance. Increased habitat degradation (indicated by low RBP [Rapid Bioassesment Protocol] habitat scores) were correlated with decreases in the abundance of Ephemeroptera, Plecoptera, and total taxa richness, but an increase in the abundance of tolerant taxa. Finally, the response to increased chloride concentration (indicating increased human disturbance) showed somewhat decreased relative abundances of Ephemeroptera and Plecoptera.

This type of data could be used in defining aquatic life use tiers; a schematic representation of the aquatic life use tiers in comparison with the scaled response plots for acidification was presented in slide 13. Tiers three (3) and four (4), for instance, can be distinguished by a defined level of decline in the relative abundances of sensitive and rare taxa (e.g., Ephemeroptera). Tiers four (4) and five (5) can similarly be differentiated by a specified decline in total taxa richness.

Conclusions

Standardizing biological response allows the display of multiple metrics in a common framework. The relative sensitivities of biological metrics change with changes in stressors. Data displayed as scaled stressor-response curves can lend support to establishing aquatic life use tiers.

Numeric Biocriteria – Rick Hafele

The state of Oregon currently has a narrative biocriteria standard which states that, "... waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities." There are twelve definitions that further describe the narrative statement (see full text of narrative standard at end of this discussion). Furthermore, Oregon has additional standards, intended to protect beneficial uses for aquatic life. These beneficial uses include salmonid passage, spawning, and rearing, and protection of fish and aquatic life.

The development of numeric biocriteria is underway by the Department of Environmental Quality during the current triennial review process. This will allow for technical input, review, and public comment.

Characterizing the reference condition is one of the first steps in developing these standards. Reference sites are selected using Geographic Information Systems (GIS) data on surrounding land use, human uses, population and roads density and other similar factors. The sites are then categorized based on stream size, elevation, latitude and ecoregion. Final selection is based on characteristics such as low human population density and road density followed by ground-truthing. Data collection on all sites selected includes habitat assessment and water chemistry parameters, and fish and macroinvertebrate assemblages.

Multi-metric (such as the Index of Biological Integrity [IBI]) and multivariant techniques are used to analyze the data from reference sites, as well as test sites, and determine the degree of change from the reference condition. Conspicuously absent taxa are also considered in this assessment, as specific taxa can often point to specific stressors. Metrics such as the Hilsenhoff biotic index are also used for the purposes of stressor identification.

Analysis of the data led to the realization that not all the reference sites chosen represented ideal conditions. A classification system was devised dividing the reference sites into three categories:

1. Class A: Ideal watershed and stream condition; a watershed with virtually no human disturbance;
2. Class B: Good watershed and stream condition; some limited human disturbance, and/or best management practices (BMPs) are well-implemented;
3. Class C: Marginal watershed and stream condition. Human disturbance is present, but the site is the best one available. Replace if better quality reference sites are located.

Tiered uses can be matched directly to these three types of reference sites: Class A reference sites represent tiers one (1) and two (2). Classes B and C represent tiers three (3) and four (4), respectively. Matching aquatic life use tiers to classes can draw attention to the fact that, in some cases, the best available reference site is still only a mediocre quality stream. This is a point that must be made carefully, in order to avoid the tendency to make the current "best available" condition the goal for all other waters in the area. In some cases, however, that is the only option available. As the condition of the reference sites improves over time, expectations should be raised for other streams/sites.

Oregon's Narrative Biocriteria Standard

Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Definitions

"Aquatic species" means any plants or animals that live at least part of their life cycle in waters of the State.

"Biological criteria" means numerical values or narrative expressions that describe the biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use.

"Designated beneficial use" means the purpose or benefit to be derived from a water body, as designated by the Water Resources Department or the Commission.

"Indigenous" means supported in a reach of water or known to have been supported according to historical records compiled by State and Federal agencies or published scientific literature.

"Resident biological community" means aquatic life expected to exist in a particular habitat where water quality standards for a specific ecoregion, basin, or water body are met. This shall be established by accepted biomonitoring techniques.

"Without detrimental changes in the resident biological community" means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.

"Ecological integrity" means the summation of chemical, physical and biological integrity capable of supporting and maintaining a balanced, integrated adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region.

"Appropriate reference site or region" means a site on the same water body, or within the same basin or ecoregion that has similar habitat conditions and represents the water quality and biological community attainable within the areas of concern.

Idaho Stream Classification compared to ALUS - Cyndi Grafe

There are no numerical biocriteria standards in the state of Idaho The water quality standards state, however, that streams must maintain a healthy, balanced biological community as part of supporting beneficial uses and cite specifically the Idaho Water Body Assessment Guidance (WBAG). The WBAG uses several ecologically based multi-metric indices to assess stream condition. The numeric scoring associated with these indices is, by definition, relative to the reference condition. Consequently, Idaho can improve or change the biological assessment in the WBAG without having to initiate formal rulemaking.

Idaho uses multiple lines of evidence or a minimum of two indices. Presently, for streams, Idaho uses macroinvertebrates, fish, and habitat information. When determining beneficial use support, each index receives a condition rating based on its index score relative to reference condition. The condition ratings are integrated by taking an average. The condition ratings were determined based on an analysis of discrimination efficiencies and Type I/II errors. The result is three categories of condition which could match with the aquatic life use tiers. For example, the macroinvertebrates use:

1. Streams with scores above the 25th percentile receive a condition rating of 3;
2. Streams with scores between the 10th and 25th percentile receive a condition rating of 2;
3. Streams with scores between the minimum of reference condition and 10th percentile receive a condition rating of 1; and
4. Streams below the minimum of reference condition are in violation of the minimum threshold for a single assemblage.

These scores support the development of the 305(b) report, supplement subbasin assessments (a section of the Idaho TMDLS) and determine which waters will be listed on the 303(d) list (Impaired Waters List).

This approach captures information on stressors through analyzing biological indicators. Idaho uses this in combination with assessing existing chemical numerical criteria (e.g., for dissolved oxygen).

These condition ratings fit relatively well into the ALUS model, but, some flexibility will be necessary to refine this system as more data is obtained, and the reference condition is fine-tuned. In addition we should be able to refer to a process such as WBAG, rather than having to go through rule-making to classify all state waters. Lastly, as the program stands now, we could not have the six categories in ALUS, but could incorporate the model into the three existing categories.

[A comment was made to clarify that coming up with six tiers is not necessary; showing where Idaho's three existing tiers fit into the ALUS diagram is sufficient.]

Summary of Participant Comments

Participants' comments were documented throughout the breakout session on flip charts; the complete list can be found in Appendix D: Flip Chart Notes.

Some of the main topics of discussion included the potential link between ALUS and aquatic life water quality criteria, and how it relates to the Endangered Species Act. Concern that it might result in downgrading quality, particularly when moving to implementation; questions regarding how the model will help; how it can be implemented into different programs; and what it will look like in the permitting process.

Conclusions - Reporting Out

The presentations and discussions were summarized in the report out to the entire group. The ALUS concept was shown to be applicable and consistent scientifically. Discussions focused on how to adapt the rule-making process to refine uses. Some options were proposed by the states (Oregon and Idaho presentations). Collaboration between the regions and headquarters will be key in working through the implementation issues and determining if this approach is valid, and of benefit to the states. In addition, flexibility with the model will be necessary if it is to be adapted for use by the states (e.g., Idaho can use the model if it limits the number of tiers to three instead of six and can reference a process in its water quality standards).

Research needs (ORD) and opportunities for collaboration were also identified and are listed in the report out; the list of these needs can be found in Appendix D – Flip Chart Notes.

THIS PAGE INTENTIONALLY LEFT BLANK

TOXIC CHEMICALS SESSION

The Toxic Chemicals session was co-chaired by Lisa Macchio (Region 10) and Rick Bennett (ORD/NHEERL). Macchio opened the session and identified its main objective as sharing of information. Several speakers who work in the area of developing aquatic life criteria participated in the session, and time was scheduled for discussion following each talk. Bennett explained that speakers were chosen after many discussions attempting to narrow down the number of topics, since not all relevant issues could be covered in the span of this workshop. Speakers gave the essence of the issues in brief presentations, then engaged in discussion and answered participants' questions.

Risk-Based Criteria – Russ Erickson (ORD/NHEERL)

Erickson began by presenting the basic definition of risk – probability of adverse effect – and how that definition is modified in terms of ecological risk assessment and probabilistic risk assessment:

Ecological Risk Assessment: The process evaluating the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors (FERA 1992).

Probabilistic Risk Assessment: A risk assessment that uses probability distributions to characterize variability of or uncertainty in risk estimates (RAGS 1999).

The current water quality criteria are risk-based, with criteria concentrations defining levels of effects, while return frequency defines the probability of occurrence. However, they are based on a weak definition of risk. The critical maximum concentrations are based on toxicity to aquatic organisms: the value is derived by taking the concentration at the 5^{th} percentile of the LC_{50} curve and dividing by two. This value was based on analysis, but provides no information on any non-lethal effects that might occur at that concentration, or about the percent of mortality at lower concentrations.

A schematic diagram was presented (slide 6) to illustrate the steps taken in defining risk. Problem formulation considers the properties of: the ecosystem and the toxic(s); community and population dynamics; exposure sources and pathways; ecological effects; and critical species and endpoints. A conceptual model is developed and becomes the basis for designing exposure analysis and effects analysis studies to determine the exposure profile and response profile. These can in turn be used along with risk estimation and uncertainty analysis to complete risk characterization and description. This process was followed when water quality guidelines were first being developed, so a lot of the risk characterization information already exists. Some parts of the process, however, should become more sophisticated and based on data-driven analyses.

Plots of exposure concentration over time were presented as examples, showing greater variability in concentrations measured in the "real-world" as opposed to those used in a typical toxicity test (slides 7, 8). In this situation, the results of the toxicity test would not necessarily reflect real-world conditions. The test exposure levels need to be adjusted to derive the criterion.

Current criteria are based on 96-hour LC_{50} tests – taking into account only what happens following 96 hours of exposure. In reality, there are other effects to consider: for example, as exposure time goes on, lower concentrations can kill most organisms. Currently all organisms and conditions are treated in the same way, based on the one-hour average used to determine the criterion. The exposure concentration is adjusted to meet the criterion (slides 11, 12). Using detailed risk curves, however, information can be gained on the concentrations resulting in lower percentages of mortality (e.g., five or ten percent). Models can help determine the probability of reaching these concentrations (slides 17, 18). Time series plots can also give information on toxicity effects occurring before 96 hours, such as those that might occur with "fast toxicity" compounds.

Obtaining accurate field data on concentration over time can also have implications on determining compliance: if compliance is determined by specific values, one extreme value taken would result in an exceedence. By looking at the data from a broader perspective, risk can be better defined, and compliance issues improved, perhaps by using mean concentration values.

Questions and Comments

Question: In terms of concept analysis, those curves [slide 8] did not look very different from each other. Would they be different in the real world?

Response: There will not necessarily be large differences – they may only differ by a factor of two or three, or even less. This is only one of the aspects of toxicity data, so small changes in several aspects could add up to a significant change in the total.

Question: Did you use real toxicity data, and have you thought about new toxicity tests to fill the existing gaps?

Response: Regarding the toxicity data, there is not always enough data available; also, some toxicity tests are not designed to be able to make intermediate observations. We have supported some efforts to test models in the past, but we do not, as a lab, have the time that it takes to conduct broad toxicity testing.

Comment: I concur with using more of the data, specifically, different endpoints and lower mortality percentiles. Have you thought about how to apply this to situations where there is a mixture of chemicals?

Response: We have only dealt sporadically with multiple chemical effects. Trying to combine chemicals' effects leads to some complexity, but it can conceivably be done.

Question: How would this new approach affect implementation, specifically 303(d) listings and total maximum daily loads (TMDLs)?

Response: We have worked through some of this, and it goes back to efforts ten years ago. The simplest way to deal with the permitting process is if you are only worried about one species; and, if there is good toxicity data, criteria can be set. This value could be tied into an amount of discharge allowed, using a calculation to set compliance limits to meet a certain level of risk. Compliance can also be monitored on an average basis, or on a percentile basis. In general, if we can express a certain concentration, it can be tied in to the permitting process.

Question: How would you look at chronic toxicity exposures?

Response: We have looked at many models for chronic toxicity and found this somewhat more difficult to deal with than acute toxicity. Toxic effects differ at different stages, such as critical reproduction and development stages. This also involves the issue of multiple chemicals. There are some modeling approaches that can be taken, but acute-to-chronic ratios are something we are attempting to move away from or handle in a different way.

Question: If you are seeing effects on an endangered species, would you modify criteria to take into account sub-lethal effects? Also, how would you modify this approach to include bioaccumulative effects?

Response: For endangered species, we might look at a lower mortality percentage with an uncertainty factor added. The criteria do not currently handle bioaccumulative chemicals. Theoretically, these can be handled in the same way using the model. Issues of multiple routes of exposure have to be considered as well.

Question: When you develop criteria, do you monitor for exceedences using ambient data?

Response: Ambient and permit compliance monitoring would be put on a better footing with this approach. For example, at present, if we take ten measurements and find one percent exceedence, we cannot be clear on what this means. Better criteria have the potential for making the process more meaningful.

Discussion of Proposed Guidelines Revisions – Charles Delos (OW/OST)

Pursuant to Section 304 of the Clean Water Act, EPA from time to time publishes numerical water quality criteria intended to protect the beneficial uses of ambient waters. Since 1980 all criteria for toxic pollutants, whether for the protection of aquatic life or human health, have been derived following written procedures that are termed "Guidelines." These Guidelines indicate the amount and type of data that should be obtained, and the procedures to be used for interpreting and using the data to derive water quality criteria.

EPA is currently working on revisions to these Guidelines. This presentation dealt specifically with proposed revisions to the aquatic life criteria guidelines. Because the revisions being considered built from principles set forth in the 1985 Guidelines, it is useful to have some understanding of how those guidelines are ordinarily applied: (1) Acute toxicity test data must be available for species from a minimum of eight diverse taxonomic groups. The diversity of tested species is intended to assure protection of various components of an aquatic ecosystem. (2) The Final Acute Value (FAV) is derived by extrapolation or interpolation to a hypothetical genus more sensitive than 95% of all tested genera. The FAV, which represents an LC_{50} or EC_{50}, is divided by two in order to obtain an acute criterion protective of nearly all individuals in such a genus. (3) Chronic toxicity test data (longer-term survival, growth, or reproduction) must be available for at least three taxa. Most often the chronic criterion is set by determining an appropriate acute-chronic ratio (the ratio of acutely toxic concentrations to the chronically toxic concentrations) and applying that ratio to the acute value of the hypothetical genus more sensitive than 95% of all tested genera. (4) When necessary, the acute and/or chronic criterion may be lowered to protect recreationally or commercially important species. (5) When evaluating time-variable ambient concentrations, 1-hour average concentrations are considered to be appropriate for comparison with the acute criterion, and 4-day averages with the chronic criterion. (6) The allowable frequency for exceeding a criterion is set at once every three years, on the average.

Much of the current work effort has focused on improving the applicability of the criteria to time-variable concentrations, currently handled through the criteria averaging period and the allowable frequency. In addition, significant effort has been directed at reducing potential uncertainties in chronic effects levels. It now appears that some significant changes in the framework perspective may have potential for addressing a number of issues.

Kinetic-based Modeling of Toxicity

The kinetic-based model of toxicity is intended to consider the speed at which effects appear in different individuals and at different concentrations. As such, data should include survival counts taken at various times, rather than at 96 hours, as in the current Guidelines. Such analysis would yield, for each species: (a) an effect concentration normalized to a standard duration of exposure; (b) a rate coefficient, reflecting how quickly the toxicant acts on the organisms; and, (c) a variability parameter, reflecting the range in the time-to-death of different individuals. This approach evaluates the frequency of lethality in any long series of time-variable concentrations, and can be used to calculate toxic stress for a group of organisms (formula presented). A parallel approach can be applied to sub-lethal stresses, by taking sensitivity differences between lethal and sub-lethal effects into account in the kinetic-based approach.

Assessing the Impact of Toxic Events

Establishing a measure of impact can be approached in various ways; to gauge the full impact that a particular time series of concentrations would have on the exposed population of an aquatic species, it was proposed that impact be defined as the resulting absence of individuals. Any approach selected for obtaining the information should recognize, in a quantitative way, that: (a) sub-lethal effects ultimately affect the number of organisms present, and (b) it takes time to replace organisms that are lost due to lethal or sub-lethal toxic stresses. Applying the analysis to a species exposed to a long series of time-variable toxicant concentrations will yield the overall degree of impairment of the species, and can be integrated over time.

Derivation of a Criterion

The following example was used to illustrate the approach used to determine the impact on a single species: for a series of toxicant concentrations, the percent lethality is predicted using the kinetic-based toxicity model, and the percent of individuals absent plotted over time to show the population deficit. To portray the effect of variable toxicant concentrations on an aquatic community, this analysis would be applied to a diverse assemblage of tested species, evaluating lethal and sub-lethal impacts on each species. This modeling approach is intended to characterize real-world time series in terms of statistical properties. To evaluate impairment of the assemblage of tested taxa, a very long time series would be generated, such that it had the characteristics of a real-world time series. The impairment caused by a very long time series with a given median concentration could be evaluated, and would yield a particular degree of impairment stemming from concentrations having a particular median. The results from other time series would indicate the relationship between median concentration and impairment of the tested assemblage, and can be illustrated on a curve of impairment.

A decision would then need to be made on the appropriate level of protection. In the proposed approach this level of protection would be expressed in terms of overall impairment, but can be narrowed down to a single, critical species where necessary. Having selected the target level of protection, one could then determine the associated criterion from the impairment curve. This would yield a single criterion, consisting of a criteria concentration and an allowable frequency for exceedences, the combination of which is protective of both lethal and sublethal effects. Built into the derivation of such a criterion is a recognition of the relative difference in severity of lethal versus sublethal effects.

Conclusion

The framework under consideration appears to have the potential for advancing the derivation of aquatic life criteria, particularly with regard to the handling of time-variable pollutant concentrations, and lethal versus sublethal stresses. Much of this may be possible through improved use of data rather than by increasing the data base requirements. Furthermore, by explicitly incorporating whole-assemblage and long time-frame considerations, the framework might help provide a better link between chemical-specific criteria and field-biological measures, and might contribute to improvements in ecological risk assessment.

Questions and Comments

Question: How do the input from toxicity tests and the input from this approach compare?
Response: We are interested in lethal versus sub-lethal ratios, and in integrating different times of exposure. This approach does not handle the effects on different life stages well. We need to characterize different sensitivities among the life stages of an organism, but need additional data in order to do this.

Question: What about applying this to the real world? For example, there might be refugia for recruitment that are not taken into account by the model.
Response: We were interested in addressing this by considering the spatial extent of the contaminated area. This could incorporate the idea that this is a real ecosystem, with possibilities for immigration and emigration.

Question: While the method described is better, it is not very realistic.
Response: It is not, and that is why it refers to an assemblage, rather than a community of organisms. We cannot assume or account for interactions between organisms.

Question: The sensitivity of some of the organisms (such as the ones listed in the graph) is known. How would you deal with organisms that might not be on that list, and whose tolerance is not known?
Response: We cannot really apply this to T&E species. Those would be considered separately, especially in cases where immigration is not possible.

Comment: There is an example of a case in California where all invertebrates were heavily impacted; an endangered fish in the same stream eats both zooplankton and clams. Food web relationships are another aspect of community interactions that are not

always known, or taken into account, increasing the possibility that we might miss something.
Response: That is a really good point. We are not able to cover everything when using models.

Question: Were these proposed changes intended to be applied on the National level?
Response: That was the initial idea, but this might be too big a change. We might use this process just to get the allowable frequency, which currently has a very weak technical basis.

Question: Are we still protecting at the organism level?
Response: I am not sure that we have ever protected at that level.

Comment: It would be essential to collaborate on pertinent ESA work with counterparts in Fish and Wildlife, and to consult all methodologies rather than only chemical methods.
Response: Informal consultation with those agencies is already taking place.

Question: How far are we from being ready to use these models?
Response: This particular model got more complicated and is almost beyond what we could handle. In addition, people got re-directed to other projects. We are now back to the "old" way, of not using time variability.

Comment: ORD remains interested in this project and we are trying to start it again. Efforts continue to develop these new population methods, as are some efforts on bioaccumulative chemicals. Moving this project along has been slow because it is a big change from the current way. However, it can be considered from the viewpoint that putting together all this information is not an accurate reflection of the situation, but a useful synthesis of information that can be used for regulation and related to biocriteria - not necessarily to make accurate predictions, but support the process.

Comment: Natural history characteristics of aquatic communities may be something that is needed, as is early involvement (simultaneously with chemical tests of toxicity).

Question: What are you looking forward to from this workshop? Are you hoping to start some engagement with the regions?
Response: The reason the Guidelines revision effort stopped was insufficient resources - not because of the technical aspects or lack of interest. The project could start again if ORD and OW had the resources.
Comment: ORD will tailor resources to more developments, but try to get more out of the directions we are working in. If there are collaborative efforts to help this project along, it could be picked up again.

Comment: It seems that it would be a straightforward exercise to develop a matrix, by modeling species and populations, and figure out the most sensitive life stages.

Response: We do not do much of our own testing, but I agree that the optimum way of doing this is to start with modeling, and find out from there what testing is needed.

Question: There are some real needs in criteria development; some of the things in Russ [Erickson's] presentation can be enacted. However, some of the things brought up seem to be for long-term needs. What can we do now to translate information into better permit conditions? How do we present this to management to get criteria and implementation?

Response: The main problem with this is that it is too big a project. It is easier to complete small projects with distinct endpoints, because they deliver a product.

Comment: The planning process should be addressing regional needs. If something will help the regions, but might take ten years to complete, it should be funded anyway, and in the interim regions will need something to work from.

Response: ORD does have a planning process, and regional representatives are on the Research Coordination Teams to communicate regional priorities.

Comment: EPA and Fisheries are collaborating to some extent on addressing these issues, through ESA. This can grow to a technical assistance dialogue.

Response: Such consultation should be on the methodologies, rather than the numbers.

Response: We are doing both; we do have to consult the numbers, since they are in the [Endangered Species] Act.

Comment: Regions are told to voice their concern to several different places / agencies; yet they still seem to not be heard.

ESA Consultation on Toxic Pollutant Criteria – K.M. Kubena (Region 10)

Issues considered during a consultation of Toxic Pollutant Criteria as they relate to the Endangered Species Act (ESA) included concerns about how well studies translate to the real world, gaps in what existing criteria account for, and disagreement with methodology, among others.

Concerns with applying experimental studies to real-world situations were raised. Surrogate species, often used in experiments to represent effects on threatened and endangered (T&E) species, vary in their ability to accurately reflect T&E species' responses. Test methodologies (e.g., flow-through versus static) can over- or underestimate toxicity. Studies based on individual endpoints, such as LC_{50}, do not give information on the dose-response curve; for example, there may be a steep descent below the LC_{50}. New information and new technologies can allow previously unreachable concentrations and previously unknown endpoints to be detected.

Current criteria exist for toxic pollutants, but do not account for dietary routes of exposure, or the interactions of chemical mixtures; the effects on critical species and prey; and the effects of bioaccumulation, including maternal transfer. In addition, neither increased susceptibility to pathogens, nor lowered thresholds to toxics due to metabolic stressors were accounted for in derivations of the existing criteria.

Disagreements involving the methodology used include debate on whether to use LC_{50} versus LC_{10}, Lowest Observed Effect Concentrations (LOEC), or Incipient Lethal Endpoints (ILL) in the development of criteria. Differences of opinion also exist on methodology regarding speciation of chemicals, the effects of other water quality parameters on toxicity, and the use of dissolved metals criteria. Discrepancies were also encountered in the enforcement of criteria and the level of protection deemed acceptable, such as protecting at the level of the individual when dealing with T&E species.

Other topics brought up included accounting for the dangers of banned chemicals; dealing with a lack of information; limiting analysis to priority pollutants and, banking on the protection afforded by human health criteria.

Examples were presented of two states' current criteria. The Idaho Standards include 124 toxic pollutants – recently narrowed down to 22 and seven conventional pollutants. Some uncertainty issues were addressed in a biological assessment, and the National Marine Fisheries Service (NMFS) is currently drafting a biological opinion. In California, the Toxics Rule primarily addresses selenium (Se), mercury (Hg), and penta-chlorophenol (PCP), and their effects on 40 species. Agreement at the highest organization levels was reached for resolution of this Rule.

Recommendations and suggestions included:

- Regional scientists need to know the state of the science and research efforts being undertaken nationally;
- Best professional judgement decisions need to be made together (i.e., uncertainty factors); and
- Continued cooperation between agencies and within agencies is necessary (i.e., National and regional Memoranda of Agreement [MOA]).

Data Quality, New Information, and Interagency Research Coordination –
Chris Tatara and Tracy Collier (National Marine Fisheries Service)

New information was presented on sub-lethal endpoints, the additive neurotoxicity of organophosphate and carbamate insecticides, and the impacts of copper on salmonid fishes, along with implications on criteria development and interagency research coordination. The Endangered Species Act (ESA) requires decisions to be made using the "best scientific and commercial data available." The U.S. Fish and Wildlife Service/National Marine Fisheries Service (FWS/NMFS) information standards policy was presented.

Data were presented suggesting that short-term, sublethal exposures to environmental contaminants can interfere with the sensory biology of chinook salmon in ways that might negatively impact their survival or migratory success. The specific details of the study can be found in the following scientific publication: Scholz, N.L., Truelove, N., French, B., Berejikian, B., Quinn, T, Casillas, E., and Collier, T.K. (2000). Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). *Canadian Journal of Fisheries and Aquatic Sciences,* 57:1911-1918. The potential sublethal impacts of contaminants on olfactory function in salmon is of particular concern because olfaction and olfactory-mediated behaviors are critically important for the survival and reproductive success of anadromous species.

New data were presented showing the interactive effects of pesticide mixtures on acetylcholinesterase extracted from the chinook olfactory nervous system. Threatened and endangered species of Pacific salmon are commonly exposed to complex mixtures of current use pesticides. The new study demonstrated that the inhibitory effects of organophosphate and carbamate insecticides are additive when these chemicals are presented as mixtures. The results are currently being prepared for publication.

Finally, a sensitive technique for measuring sublethal neurotoxicity in salmon was presented. In the example given, short-term exposures to copper were shown to inhibit the responsiveness of the peripheral olfactory nervous system to natural odorants. *In vivo* electrophysiological recordings from the salmon olfactory epithelium are very sensitive and reproducible indicators of sublethal neurotoxic injury in fish. Thirty-minute exposures to copper (at nominal concentrations in the low ppb range) significantly reduced the sensitivity of primary olfactory receptor neurons to chemical cues. Presumably, sublethal copper exposures in salmon habitat could interfere with behavioral patterns (e.g. home stream migration) that are critical for the viability of natural populations.

The experiments summarized above make a strong case for using physiological and behavioral effects as endpoints in criteria development. In addition, the additive effects of chemicals that share a common mechanism of action should be considered. Criteria that are set as single-chemical concentrations may not be protective of aquatic organisms that are exposed to mixtures. The averaging period, currently determined by policy, should be data-driven and include experiments using sub-lethal endpoints. Exposure concentrations should also be revisited, as new data is showing significant effects at measured environmental concentrations.

Increased interagency collaboration would expedite resolution of ESA issues in criteria development. Communication between EPA and NMFS can ensure that experimental designs meet the data quality objectives for inclusion in criteria development, and that sufficient data is submitted during pesticide registration to derive Aquatic Life Criteria (ALC) for pesticides when they are registered. Three areas of contaminant research at the Northwest Fisheries Science Center with implications for enhanced criteria development were identified:

- Integrate the total exposure of the animals (e.g., through diet, water, sediment);
- Utilize appropriate endpoints which cover the life history of the species (e.g., olfaction for salmon); and
- Consider cumulative exposure of multiple contaminants, as well as contaminants plus additional stresses.

Critical body residue approaches were presented (slide 17) for determining the direct and indirect effect thresholds of polychlorinated biphenyls (PCBs) and tributyl tin (TBT), respectively, on ESA listed salmon. A segmented regression approach was presented to determine the direct effect threshold of polycyclic aromatic hydrocarbons (PAHs) on groundfish. The research papers on PCBs, TBT, and PAHs, can be found at the following web site:

http://research.nwfsc.noaa.gov/ec/ecotox

Emerging ESA Issues – Steven Schwarzbach (U.S. Fish and Wildlife Service)

Criteria based on the concentration of chemicals in fish tissue are under development for some bioaccumulative elements (selenium, cadmium, polychlorinated biphenyls [PCBs]), and a fish tissue criterion has already been established for mercury. Whether these criteria will be effective in protecting threatened and endangered (T&E) species will depend on several factors. Criteria should be designed to take into account dietary intake to endangered biota other than fish. Both statistical and mechanistic approaches should be considered, particularly to understand site-specific variability. Special cases need to be considered, such as fishless waters with benthic invertebrate pathways that are significant in dietary exposure. Implementation issues should include measurements of concentrations in fish and other matrices, pathways, non-fish endpoints, transformations and bioaccumulation factors. A mercury criterion has already been established by EPA, designed to protect humans eating fish, based on estimates of Nationwide average consumption rates.

Several studies were listed that have examined the effects of dietary mercury on fish eating birds, along with the values found in each study to produce effects in certain species of birds (slide 4). Endangered bird species which are potentially at risk from mercury in freshwater and estuarine environments in California include the bald eagle, California least tern, California clapper rail, snowy plover and the marbled murrelet. Studies are under way to determine how much mercury each might be exposed to.

Data was presented showing the amounts of mercury measured in eggs of several species of birds collected from San Francisco Bay. One of these species, the clapper rail, is not a fish eating bird, but it forages when mercury methylation is taking place in the Bay. The egg methylated mercury hatchability benchmark has been determined from previous studies for pheasants and mallards and the clapper rail has been found to be equally as sensitive as the pheasant, with a "safe" egg concentration of 0.5 ppm. Concentrations higher than 1 ppm were measured in some clapper rail eggs from San Francisco Bay.

A fish tissue criterion for selenium is also under development, designed to protect fish, but other aquatic dependent wildlife may be considered. In California, the Sacramento splittail and giant garter snake are the two species at greatest risk from selenium and should be considered in implementation. EPA has convened a peer review group to make recommendations regarding species sensitivity, which tissue to use, warm versus cold water fish and lotic versus lentic ecosystems. One of the recommendations made was to use smaller fish and measure whole-body selenium. Some studies exist that have measured whole-body selenium in different fish species (slide 11), and some recommendations of safe tissue concentrations have been made by different investigators (slide 12).

Data was presented in graphs combining the water and whole-body concentrations of selenium from 1991 to 2000 for fish and invertebrates (slides 13, 14). Measurements were off-set in time, so that a measurement of water concentration would have occurred one week before its corresponding measurement of fish body concentration. A graph was also presented showing the relationship between the average selenium concentration in fish tissue and in water (slide 16).

Selenium concentrations in the tissues of several species of fish were also correlated with two different food webs (clams and crustacea). Water concentration of selenium was measured at 0.2 ppm – however, fish dependent on benthic food webs all had higher concentrations in their tissues due to recycling of selenium through trophic transfer. A food web selenium model of the Bay-Delta was presented to illustrate transfer through trophic relationships (slide 18). Specific food webs may result in different rates of selenium accumulation: white sturgeons feeding on benthic clams – who in turn feed on crustaceans– had higher accumulations of selenium than fish who feed only on (non-benthic) crustacea.

Some of the growth effects of selenium on birds were illustrated at the end of the presentation; two avocet chicks of the same age, but noticeably different in size were shown (slide 20), the smaller one of which had been exposed to selenium while in the egg.

Questions and Comments

Question: Has any work been done on determining [mercury] methylation rates?

Response: Not yet, although there is a proposal to do this in some tidal wetlands. There are concerns that if we create wetlands without resolving the mercury issues, we might create a lot more places where methylation can occur. Channels in wetlands, where very high concentrations have been measured, are also an important habitat for some species of birds.

Comment: Organisms cannot be protected by basing criteria on LC_{50} values. Comparing that to human health rules (cancer rates threshold, for example) reveals the extent of the discrepancy. As the previous presentation (on salmon and diazinon) made apparent, there may be mechanisms of effects that we have not thought of, at sub-lethal levels. Linking lethality to other observable effects is needed, and this connectivity will be critical in planning future research.

Response: The LC_{50} values are intended to demonstrate lethal effects – not necessarily to be used for setting protective criteria. The emphasis is on other endpoints.

Response: There is no lethality paradigm; lethality is not what is driving criteria development.

Question: The 0.3ppm fish-tissue mercury concentration criterion was based on a National average of fish consumption – is this number a problem for wildlife?

Response: The state has to determine that and adjust the number where necessary. It should be lowered, in some cases.

Comment: The National Average is better than it used to be, but still not protective of all individuals. However, we should not be engaging in a discussion on human health – there is a different meeting scheduled on that subject. It seems that there is a lot of data on effects, however I am concerned about the sharing of data, especially collaboration across agencies.

Response: There is some concern among scientists about releasing draft data, but collaboration is still very important.

Response: ESA maybe be a vehicle for crosswalking and collaboration.

Surrogate Species in Assessing Contaminant Risk for Endangered Fishes –
Foster Mayer (ORD/NHEERL)

The presentation addressed the issues of sensitivity to chemicals, in particular whether endangered species are more susceptible to toxicants than non-endangered forms. The possibility of using surrogate species to determine the sensitivity of endangered species was examined.

Several species of fish and one bufonid species were tested (slide 6) in a static acute toxicity experiment, with mortality observations taken at intervals between 6 and 96 hours of exposure. Five toxic chemicals were tested to try to represent the majority of modes of action: carbaryl, copper, 4-nonylphenol, penta-chlorophenol, and permethrin. The known effects of these chemicals are listed on slide 22. With some of the species tested, there were not enough individuals available for replicates – due to mortality – and only one run of the test was conducted.

General tolerance trends were presented for the five chemicals (slides 24-28), plotting the species tested in order of most tolerant to least tolerant. These results were combined to produce an overall rank of species sensitivity using all chemicals tested (slide 29). A system was then developed to estimate species sensitivity using a simple linear regression model (slide 30). A short demonstration of the model was performed at the end of the presentation, using rainbow trout to predict the sensitivity of another species. Interspecies correlations – derived from the model – were presented using fathead minnows, rainbow trout, and sheepshead minnows (slides 31, 32 and 33, respectively). Comparisons showed that using rainbow trout and fathead minnows as surrogates gave the best results as far as predicting the sensitivity of other species (slide 34).

Conclusions

- Endangered species do not appear to be any more sensitive to xenobiotic chemicals than other species;
- The question is not one of sensitivity to xenobiotic chemicals, but one of vulnerability of endangered populations to additional environmental insults;
- Surrogate test species are representative of endangered species;
- Interspecies correlations are reliable estimators of acute toxicity to endangered species; correlations are best within a family;
- A factor of 0.5x the rainbow trout geometric mean LC_{50} also provides an estimated LC_{50} for endangered fishes;

- Present approaches to establishing National water quality criteria appear to be protective of endangered aquatic species; and
- State recalculation of National water quality criteria by eliminating certain species from the data set (e.g., rainbow trout) may leave endangered species inadequately protected.

Questions and Comments

Comment: One issue with PCB is that there is a commercial and a purified form, and that it affects early life stages in salmonids.

Response: This model does not address that issue.

Question: Do you think the correlation between the two species of minnows could have been due to external effects, rather than their taxonomic relation?

Response: Probably not, because they still show strong similarities when using a larger database.

Question: Hard water was used for these experiments; there might be a different hardness slope for some species that is not reflected in the criteria. Did you choose the high hardness level to improve correlation?

Response: No, the higher hardness was chosen to help reduce stress in species not normally cultured or tested under laboratory conditions. The hardness slope would not matter since the estimated result would be based on the water hardness of the surrogate species test value entered into the model.

Predicting the Toxicity of Metals to Aquatic Organisms: The Biotic Ligand Model – Charles Delos (OW/OST)

Ligands are any chemical structures that can bind with another chemical or metal. Both organic and inorganic ligands are found in water. Organic ligands include dissolved organic carbon (DOC) and humic and fulvic acids - from the breakdown of animal and plant matter; inorganic ligands vary in importance, depending on the metal in question. Ligands can also be biological, one example being the gill membranes of fish. Copper, and possibly other metals, bind to chloride cells on the gill membrane, where copper can interact with specific enzymes that regulate sodium levels in the organism. Sodium uptake is inhibited, resulting in ionic imbalance and the eventual death of the organism. Silver binding to chloride cells has a similar effect, as another antagonist for sodium binding.

In deriving criteria for metals, a problem has been their interactions with other water quality parameters; these can cause the same concentration of metal to exert varying toxicity depending on other water quality values. For example, copper's key controlling water quality constituents are pH, calcium, carbonate and DOC. The conventional approach in dealing with this problem has been to derive a regression relationship between total hardness and effect concentration. Hardness is the measure of total calcium and magnesium concentration (predominantly). It can be correlated with pH and alkalinity, and is used in this case as a surrogate parameter. Conventional criteria derived in this manner can be over-protective if DOC concentration is high, or under-protective at low pH. In addition, the water effect ratio (WER) must be calculated to obtain the effect concentration for each site.

The Biotic Ligand Model

The Biotic Ligand Model (BLM) was developed as an alternative, and consists of three main types of interactions: metal-inorganic ligand; metal-organic matter, and biotic ligand interactions. A schematic diagram was presented showing these three potential interactions (slide 17). A dose-response curve was presented plotting 120-hour rainbow trout percent mortality versus short-term, 24-hour gill copper, using two different tests at different DOC concentrations. The curve can be used to predict a gill LC_{50} concentration. A fundamental assumption of the BLM is that the net metal accumulation that is associated with a fixed effect, such as 50% mortality, is uniquely defined, and therefore independent of site water chemistry. If this is the case, one would only need to predict the dissolved metal concentration that will result in this critical metal accumulation to predict the corresponding LC_{50}. This is precisely what the BLM does.

A plot was presented showing a summary of predicted LC_{50} for copper using five species of invertebrates, compared with measured LC_{50} concentrations. The plot (slide 19) shows that the BLM is able to accurately predict concentrations in these invertebrates. A similar comparison plot (slide 10) was presented for silver LC_{50} concentrations in rainbow trout, fathead minnows and *Daphnia*. The BLM does not currently account for species sensitivity; however, mechanistically-based approaches for doing so are being developed, and may eventually lead to further refinements of the model.

Implementation Issues

The BLM exhibits time variability related to input and output, since hardness, pH, alkalinity and DOC can vary over time. Each sample generates a different criterion, and different copper concentration, requiring a comparison of the sample's concentration to the criterion calculated for that sample. This is not a new implementation issue: for example, current metal criteria are hardness-dependent, and the ammonia criterion is pH and temperature-dependent. Another limitation is that the design conditions do not define the allowable frequency of exceedence, which would have to be determined. Implementation is complicated by the number of degrees of freedom in the model. Working with any particular data set, the resulting site-specific criterion will be affected by what the analyst chooses to consider or not to consider.

Questions and Comments

Question: Is chloride a parameter which affects silver?
Response: Some early toxicity experiments with minnows did not show an effect, but later work with trout does. It could be that silver forms complexes that are somehow able to pass through membranes to some extent.
Comment: Chloride should definitely be a consideration in fresh water; for marine water, ingestion, rather than contact with the gills, might be a pathway.
Response: The parameters are also flexible, and can be changed if something is found to have an effect.

Question: Were the binding affinities of different metals considered?
Response: Yes, each metal requires its own development in the BLM.

Question: How would this model deal with chemicals which exist in multiple valence states, such as arsenic?
Response: Nobody has talked about either arsenic or chromium in the context of the BLM. The model functions with metals where the +1 or +2 ion is important. We have not explored the possibility of expanding it yet.

Dietary Metals: How Important Are They? – Russ Erickson

Dietary routes of metals exposure have been of importance for some time, especially in regard to ESA issues. They can contribute to toxicity – chronic toxicity in particular – and add to the exchange between organisms and the ambient water. Toxicity experiments usually face the problem of the food eventually contaminating the initially "clean" water, if only to a small extent. Current criteria are consequently based on studies where the food route of exposure is under-represented. Diet can nonetheless be the dominant route of metal accumulation, and cause effects on survival, growth and reproduction.

Although not independent of water borne exposure, dietary exposure to metals can result in different disposition and effects. In naturally contaminated bivalves, for example, 95% of accumulated metals occur in the digestive gland, where they form mineral deposits. These metals remain in the digestive tract and cannot have systemic effects. By contrast, metals taken up through the water are circulated and can have more effects than those accumulated through the diet. Measuring whole-body metal concentration would not, in this case, give an accurate picture of exposure; more information would be gained by studies designed to examine dietary and water borne uptake separately.

Some studies have been conducted which considered dietary routes of exposure, particularly copper exposure of rainbow trout, both through natural contamination and salt-amended diets (slides 4,5). The ratio of copper concentrations in food and water in natural systems is generally 5,000-10,000, and water effects concentrations correspond to about 100μg Cu/g in food, well below the threshold identified for dietary effects (500μg Cu/g dry food).

Survival data was also presented for the amphipod *Hyallela azteca* exposed to lead through diet, and a drop in survival was observed, although it was not statistically significant. Effects on reproduction, however (measured as neonates per survivor) showed significantly lowered reproduction rates in those individuals exposed to lead through their diet (slide 7).

A similar study examined the relative importance of water and dietary routes for silver effects in copepods. Individuals were exposed separately to food and water contaminated with silver. No effects on survival were observed in individuals exposed to up to 5nmol/L of silver in water, but significant effects are evident at 2nmol/g concentrations in food. The pattern is similar when the body burden of silver was measured instead of survival (slide 8). Another study, however, using a closely related organism, found no effects caused by the dietary route of exposure. Finally a study where naturally contaminated *Lumbriculus* (earthworms) were fed to fish, resulted in few effects, although a similar study by a another investigator did show noticeable effects.

Due to these differences in study outcomes, some of the data has become questionable, but still cannot be overlooked. This area is still unresolved and ambiguous, but it can be said with certainty that many organisms will be grossly under-protected if the dietary route of exposure is not considered when setting criteria.

Questions and Comments

Question: What was the difference between the control and the lead-contaminated diet [in the amphipod study]?

Response: The same formulation of food was used (rabbit food) but for the lead diet it was equilibrated in a chamber that had received the test concentration of lead. Various lead concentrations were used in the test. The control food may have been run through the same procedure, but without the lead.

Question: Did you look at all the total recoverable metals, rather than just dissolved metals?

Response: It would be comparing apples and oranges, even though suspended metals, like suspended solids can have some effects. Even though doing this would add a small level of protection, there is no real, direct relationship between the two.

Question: If diet were an important pathway for exposure for an organism, how would you address that with criteria?

Response: I don't have a good answer to that, but one option is to use an additive model. You would correlate additive effects and design criteria to correct for it (using data for separate dietary, water and combined to come up with a relative toxicity value of some kind).

Comment: If the goal is to lower the criteria value, and the diet component is also influenced by sediments, you may want to de-regulate that component.

Response: You would need an exposure rate calculation. Most contaminated sediments were contaminated because of high water concentrations which no longer exist. Part of the process is to ask the question: "If we have criteria based only on water concentration, without considering the incidental contamination of food, will we allow that in the field?" If so, how much does the food get contaminated from the water? A partition coefficient between food and water is needed, and it may need to be site-specific. This process would take into account distribution from water to food, to sediment, etc. A problem with this is that partition coefficients vary with metal concentrations.

Question: What biota would you use?

Response: Rainbow trout, most likely juvenile growth tests assuming the worst case. Also, we have looked at the literature on macroinvertebrates, and are considering studies looking at invertebrate metal concentrations relative to water metal concentrations. This will not, however, apply to contaminated sediments.

Question: Since these are dynamic systems, have you considered going to different systems, with large populations, to compare populations and test reproductive success in the field?

Response: The problem with field data is that there are very few areas that are contaminated to this degree with silver and other metals in sediments. It would certainly be useful to run such a study if we can find appropriate sites; I am not aware of anyone who has done that yet, however.

Question: Are you aware of any similar effects as a result of bioaccumulation – which is very dependent on diet?

Response: Yes, there are effects of that kind.

Question: Do you have any information on algae?

Response: Periphyton tends to be in the same magnitude as macroinvertebrates in regard to metal contamination. Some invertebrates store accumulated metals in less reactive compounds – such as metal granules – which are not absorbed.

Question: Did you consider detritus-based food routes?

Response: Yes, the food used could emulate detritus or algae, or another organism.

Comment: It was mentioned already in a previous presentation that endangered species are not **uniquely** sensitive to toxics.

Response: That was the case for fish species, but there are many other organisms for which we don't have that kind of information. It would be dangerous to lump all endangered species into one category.

Comment: That information should hold for closely related groups – they should respond to toxins in similar ways, whether or not they are listed as endangered.

Comment: Species with similar biological requirements should also respond the same way and exhibit the same effects to toxins.

Response: Right now, most of the information we have is on taxonomic relationships, we do not know as much about all species' biological requirements.

Comment: Endangered species did not become endangered because of chemical exposure. Even if only fish have been studied, we can still understand the concepts behind that study. Most likely, endangered species should not be any more sensitive to chemicals than non-endangered species.

Response: We don't know for sure the reasons why they became endangered, chemical exposure may play a large role.

Response: There may be exceptions, but, in general, chemical exposure was not the reason for the populations' decline.

Question: Is there any information suggesting that endangered species are especially sensitive? I am not aware of any specific cases.

Response: Selenium has played a role in the decline of the razorback sucker (a fish), but we do not know that it is especially sensitive to it, compared to other related fish.

Question: What data do we have that indicates that is **not** the case [i.e., endangered species being particularly sensitive to toxic chemicals]?

Response: There is evidence that exposure of a population to chemical stress reduces its genetic diversity, which might ultimately have an effect.

Comment: For example, certain genotypes of mosquitofish are tolerant of acute toxicity, while others are more tolerant of chronic toxicity. That variation is needed to ensure a healthy population.

Comment: If guidance cannot be developed on the biotic ligand model, what would the consensus be on setting criteria?

Response: We could put out criteria and see what the states do with them, or tell all the states that they must do something; both of these are ways we could approach implementation guidance.

Question: Could ORD interpret all the data on dietary exposure?

Response: It is difficult to see what actions could be taken right now on that, since there are so many contradictory studies, many using the same organism. More work is needed to sort out that data, more resources need to be put in. As far as risk based criteria, there is an understanding within ORD of the need to do something better with the biotic ligand model guidance.

Comment: We are already linking criteria with other ecosystems endpoints, and I hope they will also be linked at the community level. We have been successful in measuring this in the field, and hope future work will include all scales of biological communities, rather than being limited to populations.

Response: Improving water quality criteria so that they can be protective of communities is worthwhile. Some critical processes that are important in assigning risk cannot be incorporated in the grand analysis, however we could do a more limited synthesis of the data.

Comment: Continuing to study new situations and creating new tools is key; the information on dietary exposure is a good example of that.

Response: If we are talking strictly about dietary routes of exposure, we are not yet at the point of being able to make even a good guess. Because of all the contradictions in the data I would not now be comfortable including it in criteria – even if some of the data suggests dietary exposure should be a concern.

Numerical (Criteria) for Sediment-Associated Chemicals – David R. Mount (ORD/NHEERL)

Toxic chemicals in sediments can affect organisms that live directly in sediments, as well as other species in the same ecosystem through contamination of the water column and food chain. This talk focuses on the former. In the early 1990s, EPA's Office of Research and Development and Office of Water (OW) began work on the derivation of sediment quality criteria – later changed to sediment quality guidelines.

Toxicity of sediment contaminants to benthic organisms can vary with the characteristics of the sediment. This is well demonstrated by studies published by Adams et al., in which midges were exposed to three different sediments, each spiked with a range of kepone concentrations. Survival as a function of sediment kepone concentration varied significantly among the sediments (slide 2). However, if one plots the survival data on the basis of kepone concentration in interstitial water, survival responses were similar (slide 3). The idea that the toxicity of chemicals in sediment is proportional to their chemical activity in interstitial water is captured by the theory of equilibrium partitioning (EqP; slide 4). In sediment, biota can be exposed both directly through the sediment, and through interstitial water. EqP proposes that the toxicity of chemicals in sediment can be represented by assuming an equilibrium among the organism, the interstitial water, and the sediment.

Bioavailability of non-polar organic chemicals, such as kepone, is related to the organic carbon content of the sediment. In the kepone experiment shown previously, the different responses observed in each sediment (see slide 2) were related to the differing organic carbon content or the sediments. If one replots these data as concentration of kepone per gram organic carbon (OC), we see that much of the variability in response is explained (slide 5). The organic carbon partition coefficient (K_{OC}, slide 6) can be used to relate the concentration of chemical in the sediment to that in interstitial water. Using this relationship, one can predict the concentration in sediment that will cause toxicity based on the concentration that causes toxicity in water (slide 7). The draft sediment guidelines EPA has developed are based on the level of protection offered by ambient water quality criteria. The sediment guideline concentration is calculated by inserting the final chronic value (from the water quality criterion) for the chemical as the interstitial water concentration associated with effects (slide 8). A plot of organic carbon normalization in sediments spiked with six chemicals showed good predictions in a wide range of sediments (slide 9). The generic calculation formula for a sediment quality guideline for a non-ionic organic, using equilibrium partitioning, was also presented (slide 10).

Equilibrium partitioning provides a mechanistic basis for management decisions and can be adapted easily to new chemicals and to expanded partitioning models. Toxicity of mixtures can also be incorporated into the model, and the level of protection altered to meet site-specific objectives.

Misconceptions about the equilibrium partitioning theory include observations that it can only be applied to a limited number of chemicals, that it erroneously treats all organic carbon as identical, and considers interstitial water as the only route of uptake. While specific guideline documents have been prepared for only a few chemicals, the concept can be applied to any non-ionic organic compound. Organic carbon is, indeed, currently treated in the same way by the model; this is a first order approximation, but is very effective in reducing unwanted variability. In addition, the model can be adjusted to take into account additional information on the specific type of organic carbon in question, when such information is available. Finally, the conceptual model of chemical exposure shows a tendency toward equilibrium whether exposure is from interstitial water or other sources. The fact that chemical concentration in interstitial water is used as an index of bioavailability does not mean that it is the only route of uptake as is sometimes suggested.

The ingestion pathway of exposure was also considered and equations presented for the calculation of water and sediment exposure for sediment-ingesting infauna. Graphs of survival over sediment kepone concentration were presented, noting that if ingestion were driving toxicity, the mortality curves plotted over concentration should be similar, regardless of the percentage of organic carbon in the sediment.

In regards to the importance of EqP guideline values in management decisions – whether they should be screening, intermediate, or definitive assessment tools – the weight of the evidence should be proportional to the weight of the decision, and the magnitude of exceedence and level of protection should be considered. As a general rule, exceedences for organics are intermediate. Expensive remedies should not be undertaken without verifying that the sediments are "behaving." The status of the documents for endrin, dieldrin, metals, and polycyclic aromatic hydrocarbon (PAH) mixtures were reported, along with contact for further information and copies (slide 18).

Some data on the toxicity of metals in sediments were also presented, specifically mortality curves with dry weight metal concentrations in sediment for five metals (slide 19). When these results were normalized for interstitial water, no toxicity was evident when metals were below toxic concentrations (slide 20). Metals used were: cadmium, copper, nickel, lead, and zinc. In order to normalize the effects of metals in sediment, the acid volatile sulfide (AVS) and simultaneously extracted metal (SEM) need to be determined. AVS is produced by bacterial breakdown of organic material and describes the amount of sulfides in the sediment. SEM represents the metals extracted during the AVS procedure, and should be less than the "total metals." Subtracting AVS from SEM yields a number that can be used in ranking sediments. The effectiveness of normalizing data in this way was demonstrated by plotting the same mortality data over total nickel concentration (µg/g), and over SEM-AVS (slides 23, 24). This relationship can be used to derive a solid-phase criterion, and an interstitial water criterion can also be derived using the final chronic value (from water quality criteria). If either criterion is met, sediments should not be toxic due to metals.

While SEM-AVS can predict lack of toxicity, as indicated above, that value divided by fraction organic carbon (F_{OC}) can be used to predict toxicity. Mortality plots, over SEM-AVS/F_{OC}, can be used to determine which concentrations, expressed in SEM-AVS/F_{OC} will result in 95% mortality (slide 28). Equilibrium partitioning theory was compared to empirically-derived guidelines, which typically use large databases of field-collected information. Such guidelines do not account for the known effects on bioavailability.

Equilibrium partitioning can also be applied to a mixture problem: PAHs were used as an example, and values were initially developed for single PAHs. These chemicals do not, however, exist in the field as single compounds, and PAH toxicity to benthic organisms appears to be additive. The approach was therefore altered to account for multiple PAHs. Data were presented of the percent mortality of amphipods exposed to one PAH compound from contaminated sediments (slide 32). When these results are plotted over the organic carbon-normalized concentrations of 12 PAH compounds, a criterion can be derived which will take into account the additive effects of a mixture of chemicals.

Questions and Comments

Question: How would you deal with patchy distribution of sediments?

Response: One assumption behind this theory is that small organisms will spend most of their time in a small part of a large mosaic of sediment types. Many benthic organisms do not really "travel" appreciably.

Question: Have you looked at other endpoints [besides mortality] in terms of the additivity associated with PAHs?

Response: The current approach is based on narcosis, and does consider things other than lethality to the extent that those sublethal endpoints are induced through the narcosis mode of action. Other endpoints could be included if we had an alternate toxicological model. The question is: "If a sediment is clean enough to pass this test, will it be clean enough for fish?" Understanding the effects of sediment PAHs on fish also requires dealing with metabolism, which we ignore for invertebrates.

Question: Is there a specific set of PAHs that was used?

Response: All PAHs that are present contributed to narcosis, but we do not measure every one of them. "Total PAH" refers to several different commonly measured subsets. The specifics are included in the PAH document, which also includes an uncertainty analysis based on which subset is used. Ideally, however, a site-specific correction factor should be developed for each case.

Question: Can this approach be used for mercury?
Response: No, it does not apply to methyl mercury. Inorganic mercury does behave in this way, however it is not normally a concern.

Question: For the PAH data, was a correction factor applied to convert from the thirteen compounds to total PAH?
Response: No, it was not.

Comparing WQC to Site-Specific Ecological Risk Assessment Results at R9 $fund Sites – Ned Black and Clarence Callahan (Region 9)

Several case studies were presented to illustrate risk assessment and risk management of Superfund sites in region 9. The eight-step ecological risk assessment process for Superfund was outlined, consisting of screening and problem formulation, study design, field sampling design verification, site investigation and data analysis, followed by risk characterization and risk management (slides 6,7,8). Hazard quotients are calculated by dividing the on-site concentration of a contaminant by a literature-based estimate of the toxicity to a particular receptor. A hazard quotient value greater than one indicates the potential for ecological harm to the receptor. Some of the toxicity benchmarks used are ambient water quality criteria, sediment effects range, industry soil screening levels and local toxicity reference values.

In Mansfield Canyon, Arizona, EPA was asked to check for presence of arsenic in small pools from old mine shafts and adits. Arsenic levels found were well below the concentrations protective of aquatic life. Since an endangered species of bats lives in the region, however, water quality criteria were compared to the observed levels of arsenic; arsenic concentrations were above those criteria. Further studies revealed that the endangered bats did not use these pools for drinking water, as the pools were too small for the bats, who skim water while in flight. The possibility that bats may feed on insects which grow in the pools was considered but not pursued, as EPA involvement ended at that time.

A risk assessment was undertaken for creeks in McClellan Air Force Base near Sacramento, California. Water samples from the creeks had detections for cadmium and PCBs – with the PCBs stemming from a recently begun removal action. Cadmium levels were well below chronic criteria, and PCB levels approaching, but still below such criteria. Sediments from the same reach were also tested and found to be toxic to the amphipod *Hyallela*. Sediment toxicity in this case, however, could not be correlated to any contaminant gradient. Work is continuing to identify the toxicity drivers.

Mather Air Force Base, also near Sacramento, California, was considering a removal of sediments from creeks contaminated with chlorinated pesticides. EPA was consulted regarding how much sediment should be removed. The regional water board's recommendations were based on ambient water quality criteria for maximum concentration of dieldrin. Sediments were treated as landfill, and the water board converted the instant maximum of 2.5µg/L to a sediment concentration of 2.5µg/kg. The Air Force did not accept this suggestion, citing a chironomid assay showing the no observable adverse effect concentration (NOAEC) to be 7.5µg/kg – an opinion initially shared by EPA. Further consultation between EPA and the California Department of Fish and Game, however, resulted in an agreement that NOAEC should be

3.3µg/kg. Once EPA and the California Department of Fish and Game presented a united opinion, the Air Force and water board agreed to the 3.3µg/kg concentration.

Leviathan Mine is another Superfund site in California, where contamination of a nearby stream was a result of evaporation ponds which had overflowed on twelve of the fifteen years following their construction. The responsible parties agreed to try lime neutralization of the ponds followed by the release of treated water to drain ponds. The short field season in the area made a quick decision necessary on what the effluent limitations should be. Chronic fresh-water criteria concentrations for arsenic, copper and nickel were used, and the ponds have been drained successfully in two out of the past three years.

In a risk characterization performed at the McCormick and Baxter Superfund site, NOAECs were calculated for sediment pore water from chronic criteria concentrations using equilibrium partitioning (for various PAHs). The concern in this case was that values derived from water quality criteria would be too low for any Superfund site. NOAECs derived from these criteria, however, were higher than those from any other derivation – although the slough would still present a risk, regardless of the NOAECs.

The final case presented concerned an extensive ecological risk assessment in Lauritzen Channel, near San Francisco Bay, contaminated with dichloro-diphenyl-trichloroethane (DDT). The risk assessment involved equilibrium partitioning, invertebrate bioassays, site tissue analysis, and laboratory bioaccumulation tests. Remediation goals were set as a result for total DDT and dieldrin concentrations in the water column, although subsequent monitoring has shown the removal action was not completely successful.

Conclusions

- Agreements between ecological risk assessment results and water quality criteria is variable;
- Water concentrations are often not measured at Superfund sites; sediments are measured instead;
- Modeling from sediments to water works better than was expected.

Questions and Comments

Comment: It has become obvious as we talk about setting criteria that these criteria have many different uses across the board. Superfund is an example, as those sites are impacted in different ways than watersheds. In developing new criteria, I hope that there will be consideration of their uses in different programs.

Comment: Superfund used to be good at taking National standards and coming up with a number appropriate to a site.

Response: We often have site-specific data, and they do not always agree with the National standards – however they do sometimes agree more than would be expected.

Comment: The threshold numbers for sediments could be used to help focus investigations, and to make risk-based recommendations where large monetary decisions need to be made.

Persistent Bioaccumulative Toxicants -- Philip M. Cook (ORD/NHEERL)

A conceptual model was provided to show how the ecological risk assessment framework can be incorporated into water and sediment quality criteria development for chemicals whose effects are related to residues in tissues in the organisms at risk or their diet. The multidirectional flowchart links human health, fish and wildlife populations, and ecological community conditions to the potential loadings of toxicants into an environment through a series of data types and the models which link them. An important example is the use of bioaccumulation factors and food chain models to determine concentrations of bioaccumulative chemicals in water and sediment that correspond to residues in organisms associated with toxicity.

The persistence characteristic of persistent bioaccumulative toxicants (PBTs) was noted to influence:

- PBT accumulation in sediments and food webs;
- Chemical transport over long distances and between ecosystems;
- Reductions in the magnitude of temporal variations in exposures;
- Increased probability of exposures to vulnerable life stages, populations and communities; and
- Long time frames required for natural attenuation.

Potential effects of PBT exposure were illustrated with a salmonid fry example, which showed cranial-facial malformations, hemorrhaging, yolk sac edema, etc. as a result of exposure to PCB126. The mortality rate of embryonic fish was shown to increase dramatically with an increase in concentration of PCB126. These observations are the same as those reported for 2,3,7,8-tetrachlorodibenzo-p-dioxin except that the dose required for PCB 126 is approximately two hundred times greater.

Cook reviewed the process by which bioaccumulation factors (BAFs and BSAFs) are calculated for water and sediments. The results of an eighty percent drop in chemical loading to an ecosystem on relative concentrations in water and sediments was reviewed, showing a very quick associative drop in water, while the response in sediments was gradual over the course of many years.

Cook displayed graphs which illustrated how critical residue values for effects of a PBT on trout and bald eagles relate to specific concentrations in the sediments and water in different ecosystems. The disequilibrium between sediments and overlying water was explained, where differences in sediment and water concentrations are calculated, and the structure of the food chain of an ecosystem is taken into consideration when determining the acceptable levels of water and sediment concentrations. A food chain that relies more on benthic versus pelagic sources will result in different acceptable concentrations than one in which the pelagic organisms factor higher than the benthic organisms. These factors are further influenced by the rates of metabolism of the PBT in the receptor organisms involved. The five major determinants of bioaccumulation were listed as:

- Hydrophobicity of the chemical (as measured by K_{ow}, the octanol-water partition coefficient);
- Metabolism of the chemical in the food chain and the receptor organism;
- Π_{socw}, the sediment-water concentration quotient;
- Trophic level of the receptor organism; and
- Fraction of the food web that is benthic versus pelagic.

Equations were presented for the method by which a BAF for a species can be calculated from a field-measured BSAF and simple hybrid bioaccumulation model which incorporates food chain model predictions with relative metabolism ratios determined from measured BSAFs. Toxicity equivalence factors (TEFs) applied to mixtures of dioxin-like chemicals in an organism's tissues allow calculation of a toxicity equivalence concentration (TEC) that should not exceed a 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) Residue Quality Criterion (RCQ_{tcdd}). The WHO Toxicity Equivalence Factors for twenty-nine congeners were reviewed as they apply to mammals, fish and birds. The tiering scheme for the determination of Relative Potency (REP) Values indicates that Tier 1 values from the endpoint species in question are the best source for Ecological Risk Assessments.

The history of Lake Ontario lake trout toxicity risks was based on exposure of eggs as expressed by TEC_{egg}s in dated sediment layers derived from concentrations of dioxin-like chemicals and the respective TEFs. Peak concentrations of TEC_{egg}s from the 1950s through the 1970s coincide with a one hundred percent mortality rate in fry from either native or stocked lake trout over the same time frame. The reproductive success of Lake Ontario bald eagles was also predicted to follow a similar historical TCDD toxicity induced mortality pattern but with PCBs making a greater contribution to the toxicity than for fish.

Cook gave a description of frameworks used to calculate water and sediment criteria:

- Framework for calculation of a water quality criterion for the protection of lake trout from the effects of TCDD and related chemicals;
- Sample calculation of a safe $(C^d)_{tcdd}$ for the protection of lake trout from the effects of TCDD and related chemicals;
- Framework for calculation of a sediment quality criterion for the protection of lake trout from the effects of TCDD and related chemicals; and

- Sample calculation of a safe (C_{soc}) for the protection of lake trout from the effects of TCDD and related chemicals.

A Waste Load Allocation Model using a TMDL TEQ-SQC approach for mixtures of TCDD and related chemicals was displayed, indicating the flow of relevant factors and calculations between the models to the acceptable contamination level. Each dioxin-like chemical in the mixture has to be mass balance modeled in order to relate loadings to specific exposures of organisms that result in the TEC.

Questions and Responses

Comment: Doug Norton said the other day that we were missing out on restoration opportunities.

Response: Research on a problem like Lake Ontario lake trout reproduction is a slow, deliberate process. And even so, this was a particularly convenient investigation because dioxin exposures were so great. With PBTs it is difficult to make a prediction based on a hypothesis involving a singular cause and effect and then validate the prediction with environmental data which must be interpreted from a changing multi-stressor perspective; it may take a decade.

Question: Do you have riverine systems that you have applied this to?

Response: I have reservations about the applicability of monitoring data which may not be adequate for measuring bioaccumualtion. The kind and quality of data that needs to be collected needs to be better defined for assessors.

Question: What are the monitoring needs?

Response: When we collect fish samples, we should collect surface sediment samples that are related to them. It is also important for any samples to be properly collected. This would allow a BSAF data base to be formed that would help in providing cross ecosystem extrapolations.

Question: Where can you get a published copy of the graphs showing temporal response of the ratio Π/Kow?

Response: We are presently submitting a paper for peer review, so we should be able to send out copies of that paper soon. We are better off if people understand what it is they are doing when using this model. At times these concepts use are more likely to publish tables of Pow, food chain loads, etc.

Question: Do you have any plans to do predictions, and then go out and try the model after a restoration has been done?

Response: We have limited resources for doing that sort of thing. We are still missing effects information. There is less than one order of magnitude of uncertainty when it comes to protecting lake trout. We would need to wait for enough time to go by before we are able to test our prediction.

Question: Are you still data-driven?
Response: We have been trying to get a supreme data set for Lake Michigan for years now and are finally nearing completion of a minimum data set.

Question: If people send you data can you help them understand it?
Response: We try to do that all the time.

Toxic Chemicals Session: Assessing Risks to Wildlife – Rick Bennett (ORD/NHEERL)

Rick Bennett (NHEERL) provided an overview of the wildlife criteria development project, which arose from concern that ambient water quality criteria would not be sufficient to protect the wildlife who feed upon aquatic biota. Wildlife Values (WV) are based upon the highest concentration within the water column that will not harm wildlife which use the water for drinking and foraging. The criteria used to determine harm to wildlife are tracked over multiple generations, and include:

- Significant reduction in growth;
- Significant reduction in reproduction; and
- Significant reduction in viability or usefulness.

Bennet reviewed the equation by which wildlife values are calculated, and provided descriptions of the variables involved in the equation [Slide 4].

The Great Lakes Water Quality Initiative (GLWQI) has selected several representative species: otter, mink, bald eagle, herring gull, and belted kingfisher; and several chemicals: DDT, mercury, PCBs, and 2,3,7,8-TCDD. The model parameterization process was explained, which included:

- Development of guidance for literature review of the most appropriate test dose;
- Development of guidance for determining uncertainty factors (UF);
- Guidance for determining chemical specific BAFs and BMFs; and
- Guidance for determining species-specific data such as body weight and diet.

Bennett reviewed the tiered approach to establishing the GLWQI criterion. Tier I wildlife criteria establish a geometric mean of wildlife values for the birds and mammals represented, with the criterion being set as the lower of the two. Uncertainty factors in tier one can range from one to one hundred. Tier II wildlife criteria establish a geometric mean of representative species for either birds or mammals, and uncertainty factors can range from one to one thousand, for a taxonomic group without data. Study duration for tier I is 90 or more days for mammals, and 70 or more days for birds, while tier II study duration for mammals and birds is 38 or more days.

Bennett identified several uncertainties in regards to the establishment of wildlife criteria, which include:

- Limitations of the toxicity database;
- Variability in measured BAFs; and
- Limitations on life history information.

The mercury Report to Congress included modifications to the GLWQI model. The herring gull was replaced with the osprey and the common loon, because these species have a wider distribution. Bennett listed site-specific modifications, the inclusion of tissue-based criteria, and the development of methods to understand risks of multiple stressors as the next steps in wildlife criteria development.

Derivation of New Jersey-Specific Wildlife Values as Surface Water Quality Criteria for: PCBs, DDT, and Mercury – Dana Thomas and Dan Russell (U.S. Fish and Wildlife Service)

Dana Thomas (Region 2) and Dan Russell (USFWS) provided an overview of the New Jersey Wildlife Criteria effort, a cooperative undertaking with participation from EPA, USFWS, and the New Jersey Department of Environmental Protection. The goal of this effort was to derive New Jersey-specific surface water quality criteria for the protection of wildlife, using the EPA's Great Lakes Water Quality Initiative (GLWQI) methodology. The contaminants of concern for this project were polychlorinated biphenyls (PCBs), dichlorodiphenyltrichloroethane (DDT), and mercury.

The technical committee conducting the criteria derivation followed the GLWQI's Tier II methodology, which generates Wildlife Values using only one wildlife taxon. New Jersey Wildlife Values were generated using data for bald eagles and peregrine falcons, as contaminant risks to these avian species were the impetus behind this effort. The osprey was used as the third representative species in the Wildlife Value calculations. Adoption of the Tier II methodology must provide assurance that the taxonomic class not considered is protected by the calculated Wildlife Values.

After an extensive literature review, it was determined that the same avian test dose studies used in the GLWQI to calculate wildlife criteria would be used for the New Jersey Wildlife Values. Similarly, the same uncertainty factors used in the GLWQI for PCB and DDT calculations were used for the New Jersey Wildlife Values. For mercury, Wildlife Values were calculated using the uncertainty factors from the EPA's 1997 Mercury Study Report to Congress (MSRC).

Chemical-specific bioaccumulation factors (BAFs) for all three contaminants were revised from the original GLWQI by the EPA, based on subsequent methodology re-evaluations. For the New Jersey Wildlife Value effort, the BAFs for PCBs and DDT were further revised by using New Jersey-specific dissolved (DOC) and particulate (POC) organic carbon data. For mercury, BAFs from the MSRC were used in the calculations.

Various exposure parameters were determined for each representative species, including adult body weights, water ingestion rates, and food ingestion rates (defined for each trophic level prey type consumed). For peregrine falcons, the diet composition of piscivorous and non-piscivorous prey was determined by a study of New Jersey nest site prey remains. The trophic level composition of osprey diet was determined based on New Jersey's physical geography (prevalence of shallow lakes and ponds) and observations of prey capture (largemouth bass, chain pickerel).

The GLWQI methodology calculated chemical-specific geometric means for each taxon, Aves and Mammalia, and used the lower of these values in setting regulatory water quality criteria. The technical committee also calculated chemical-specific geometric means, using the single Aves taxon, but determined that the resulting Wildlife Values would not be stringent enough to protect all wildlife species of concern. For each contaminant evaluated, the calculated geometric mean was greater than the species-specific value necessary to protect the peregrine falcon. As the focus of this effort was to develop water quality criteria protective of bald eagles and peregrine falcons, the technical committee recommended the peregrine falcon-specific Wildlife Values generated for each of the three contaminants be adopted as regulatory criteria.

The resulting New Jersey Wildlife values are lower than those generated for the GLWQI, and have been recommended to the New Jersey Department of Environmental Protection for adoption as regulatory criteria.

	PCBs	DDTr	Mercury
GLWQI Wildlife Criteria	120 pg/L	11 pg/L	1300 pg/L
New Jersey Wildlife Values	72 pg/L	4 pg/L	530 pg/L

Questions and Responses

Question: Did you include TEF or TEQ?
Response: No, we did not include an analysis for TEFs or TEQs in our PCB calculations. We were only using the methodology for total PCBs, not specific congeners or Arochlors.

Question: Did this include brackish water?
Response: No, this is just for fresh water.

Question: I wanted to first thank the presenters, because there has been concern on whether the GLWQI was being used by other people to come up with guidelines. Did you include mussels in the formulation of criteria?
Response: No, we did not include mussels in the formulation of the Wildlife Values. The technical committee felt that the danger of exposure by mussels to the contaminants of concern should be less than with the higher trophic level organisms examined.

Question: How long [did the study take]?

Response: The technical committee first convened in April 1999. The final Wildlife values were determined by the end of 2000, and the final report was completed in September 2001.

Question: Does New Jersey have the document now?

Response: The document is going to be published in the New Jersey State Register. They will have until October to provide an answer, but will likely ask for more time.

Response: New Jersey agrees with the number but there are concerns about implementation.

Question: What impact would this have on decisions about hazardous waste, or the Superfund program?

Response: We haven't given it much thought beyond this first step. The goal was to develop water quality criteria for these contaminants that would be protective for bald eagles and peregrine falcons.

Question: Did you ever go through a process where you considered fish as a receptor with regard to PCB?

Response: No, we focused on raptors - peregrine falcon, bald eagle, and osprey. The effort began because of the threat to listed species - the peregrine falcon and bald eagle. Because of the bioaccumulative nature of these contaminants, the technical committee felt that higher trophic level predators were more at risk than fish.

Question: Uncertainty factor - lowest number is one - should we use a number less than one for more sensitive species?

Response: This depends on the uncertainty factor referred to (i.e., interspecies, low observable adverse effect level [LOAEL] to no observable adverse effect level [NOAEL], subchronic-to-chronic). Generally, these factors don't address differences in organism sensitivities. But if you wanted to adjust the interspecies uncertainty factor because your species of concern is more sensitive than the species used to determine a test dose, then the uncertainty factor should be higher, not lower.

Question: Where does it account for amphibians and reptiles (other than fish birds and mammals)?

Response: We did not take amphibians or reptiles into account when developing these values. The focus was on threats to listed piscivorous birds (peregrine falcons and bald eagles).

Comment: They were not listed at that time. There are new species that are listed. It is a dynamic document.

Question: Can you use this methodology on organisms other than birds and mammals?
Response: Yes, [we can].
Comment: We need to go back and refine/re-tune the database.

Question: What are the background concentrations in these areas, or in a pristine area?
Response: We don't know, those areas are harder and harder to find in New Jersey.

Question: What are the piscivorous birds in the peregrine falcon's diet?
Response: Wading birds, not exclusively piscivorous birds, occasionally some gull remains.
Comment: Gulls in San Francisco had almost no mercury in their systems. Are the birds eating KFC? Gulls do tend to scavenge refuse, particularly those living near urban areas.

Question: How did you come up with criteria in the range of 500 picograms? This is a very low, almost unmeasurable criterion.
Response: It is very hard to measure and very expensive as well. We expect a lot of complaints because it costs between one and two thousand dollars per test.
Comment: Because these numbers are so low, we will need to ground truth these. They are the best numbers we can come up with at this time.

Question: How comfortable are you with your numbers?
Response: We are very comfortable with the numbers, based on the information presently available. However, we recognize that data gaps exist, and filling these gaps would allow for further refinement of the values...which would in turn increase the comfort level.

NHEERL Wildlife Research Demonstrations Project: Methods to Assess Risks to Piscivorous Bird Populations – Rick Bennett (ORD/NHEERL)

Rick Bennett (NHEERL) indicated that there are questions which arise from assessments based upon single value criteria. The Loon Demonstration Project was developed with the objectives of:

- Developing approaches for assessing the risks to wildlife populations from multiple stressors by integrating information from population biology, toxicology, and landscape ecology; and
- Using demonstration projects to apply these approaches to specific agency issues, while considering the possibility of extrapolation to other issues.

Bennett indicated that the availability of rich data sets on life histories for loons, from a number of agencies, universities and private conservation groups was a factor in the criteria for selection of this project. Planning activities have included an expert seminar and planning meeting, and the submission of a draft planning document to the aquatic stressors planning committee, and the upcoming development of work plans through the aquatic stressors planning committee.

Bennett talked about the organization of research activities into the following inter-dependent steps:

- Geographically referenced data collection;
- Stressor response modeling;
- Population modeling, population genetics; and
- Spatial modeling.

Under the conceptual approach, landscape characterization data and exposure data are used to define the exposure-response and habitat-response stressor effects relationships. This data is fed into the population models for the creation of spatially-explicit models. Efforts in landscape characterization have included the development of a data management system based upon EMAP design. Stressor-response relationship characterizations have focused upon the effects of mercury on the common loon, and the effects of habitat alterations and environmental factors upon the common loon. Dose-response effects of mercury on the reproduction of the common loon will be estimated through the development of physiologically-based toxicokinetic (PBTK) models to extrapolate effects from laboratory studies with American kestrels. NHEERL is cooperating with the state and federal agencies and loon monitoring groups to create quantitative relationships between environmental stressors and the survival and productivity of the common loon. Research is underway to develop genetic markers for the common loon and other avian species, and will contribute to the creation of simple and more realistic population models in a spatial context for avian species.

Questions and Responses

Question: How many more resources would it have taken to look at more chemicals and more bird species in this project?

Response: With the EMAP-based data management system, it would have been relatively easy to include information layers on other chemicals and species when compatible information exists. We are trying to do that now without losing sight of the specific project.

Question: The actual response of toxicity of mercury may not necessarily be affecting the embryo, it could be maternal effects (reproductive, rather than developmental)?

Response: We are looking at parental effects as well as embryo effects. There are numerous steps in the life history where effects can originate, we cannot just study one of these stages.

Response: There are many ways in which mercury can affect animals just in reproduction. For example, it can affect male brooding behavior – there is no way to study such an effect in a laboratory setting.

Comment: There was a three-generation duck study that found effects in duckling response to maternal calling, and effects on flight feather growth – with aerodynamic flight loss of about ten percent.

Question: Can you see doing work like this from existing environmental data without the need for modeling?

Response: Many of the species we are interested in cannot be studied in the laboratory setting, but we can do field studies. Breeding them successfully in the lab is not feasible because of the inherent stress of captivity.

Comment: We look at parental effects and embryo effects. Juveniles have to feed in lakes where they hatch. What if the lake is contaminated? A whole suite of stages/periods in life stages with various factors is involved.

Appendix A: Agenda and List of Posters

Appendix B: List of Participants

Appendix C: Slides from Presentations

Appendix D: Plenary Flip Chart Notes

Appendix E: Breakout Sessions Flip Chart Notes

Appendix F: Workshop Participant Evaluation Summary

THIS PAGE INTENTIONALLY LEFT BLANK

Appendix A: Agenda

Region/ORD Workshop on Aquatic Life Criteria
Hilton Hotel, 1301 Sixth Avenue, Seattle, WA
December 4-7, 2001

December 4 - *MORNING*

8:00-8:30 Registration
8:30-9:00 Welcome - Janis Hastings, Region 10 and William Farland, Office of Research and Development

PLENARY SESSION
OVERVIEW OF AQUATIC LIFE CRITERIA
Co-chairs: Bob Spehar, ORD/NHEERL and Patricia Cirone, Region 10
Brief overviews of the current science approach(es), scientific application by the states and regions, and program office guidance.

9:00-9:30 Toxic Chemicals
Programmatic Overview of Science: Charlie Delos, OW/OST
Regional/State Problems: Debra Denton, Region 9

9:30-10:15 Habitat
Programmatic Overview of Science: Doug Norton, OW/OWOW
Regional/State Problems: Steve Bauer, Pocket Water, Inc. Idaho
ORD Approach: Jim Power, ORD/NHEERL

10:15-10:30 BREAK

10:30-11:00 Sediments
Programmatic Overview of Science: Susan Jackson, OW/OST
ORD Approach: Christopher Nietch, ORD/NRMRL

11:00-11:30 Nutrients
Programmatic Overview of Science: George Gibson, OW/OST
Region/State Problems: Danielle Tillman, Region 5

11:30-12:00 Biocriteria
Programmatic Overview of Science: Susan Jackson, OW/OST
Regional/State Problems: Gretchen Hayslip, Region 10
12:00-1:00 LUNCH

December 4 - *AFTERNOON* 1:00 - 4:45 PM

BIOCRITERIA and NUTRIENTS SESSION

Co-chairs: Gary Welker, Region 7 and Susan Cormier, ORD/NERL

All Workshop participants will hear presentations that will introduce the topics to be discussed in more detail during the breakout sessions to be held Wednesday, December 5.

1:00-1:30 Establishment of multi-use reference sites for biological and nutrient criteria development
Don Huggins, Univ. of Kansas (Visiting Scholar, Univ. of California - Davis)

1:30-2:00 Use of random selection in the determination of reference sites and the utility of probability based reference sites for EPA Regions
Phil Larsen, ORD/NHEERL

2:00-2:30 Establishing and use of reference sites and conditions in the State of Ohio
Chris Yoder, Midwest Biodiversity Institute, Columbus, OH

2:30-2:45 BREAK

2:45-3:15 Use of reference sites and conditions in the development of nutrient criteria
George Gibson, OW/OST

3:15-3:45 Nutrients - John Hutchens, ORD/NERL

3:45-4:15 Nutrients - Emile (Skeet) Lores, ORD/NHEERL

4:15-4:45 Aquatic Life Use (ALUS) concept of reference sites
Susan Jackson, OW/OST

December 5 - *ALL DAY* 8:30 AM - 5:00 PM

(BIOCRITERIA and NUTRIENTS CONTINUED)
CONCURRENT BREAKOUT SESSIONS

Breakout Session I: Multi-Use Reference Sites	Breakout Session II: Charting a Statistical Course for Navigating the Murky Waters of Bioindicator Development	Breakout Session III: Aquatic Life Use Support (ALUS)
Co-chairs: Don Huggins, U of CA-Davis Gary Welker, Region 7 George Gibson, OW/OST	Co-chairs: Susan Cormier, ORD/NERL Dave Pfeifer, Region 5	Panel: Susan Jackson, OW/OST Sue Norton, ORD/NCEA Gretchen Hayslip, Region 10 Susan Davies, State of Maine

4:00 - 5:00 WRAP-UP BIOCRITERIA SESSION

5:00 PM to 7:00 PM Poster Session: Presentations and Model Demonstrations

December 6 - *MORNING* 8:30 AM - 12:15 PM

TOXIC CHEMICALS SESSION

Co-chairs: Rick Bennett, ORD/NHEERL and Lisa Macchio, Region 10

8:30 - 9:15 Risk-Based Criteria
Russ Erickson, ORD/NHEERL

9:15 - 10:30 Discussion of Proposed Guidelines Revisions
Discussion of Proposed Guidelines Revisions: Charles Delos, OW/OST

10:30 - 10:45 BREAK

10:45 - 11:30 Emerging ESA issues
ESA consultation on Toxic Criteria: Kellie Kubena, Region 10
Data quality, new information, and interagency research coordination:
Chris Tatara and Tracy Collier, NMFS
Considerations regarding tissue based criteria approaches for selenium and mercury
Steven Schwarzbach, USFWS

11:30 - 12:15 Interspecies Extrapolation of Toxicity Information
Endangered Fish Sensitivity to Chemicals and Interspecies Correlations for Acute Toxicity: Foster "Sonny" Mayer, ORD/NHEERL

12:15 - 1:15 LUNCH

December 6 - *AFTERNOON* 1:15 - 4:30 PM

TOXIC CHEMICALS SESSION (CONTINUED)

1:15 - 2:45 Inorganic Chemicals
The Biotic Ligand Model: Charles Delos, OW/OST
Dietary Metals Exposure: Russ Erickson, ORD/NHEERL

2:45 - 3:00 BREAK

3:00 - 4:30 Sediment toxicity
Overview of issues: Dave Mount, ORD/NHEERL
Comparing AWQC to Site-Specific Ecological Risk Assessment Results at Superfund Sites: Ned Black and Clarence Callahan, Region 9
Dave Mount, ORD/NHEERL

December 7 - *MORNING* 8:30 AM - 12:00 PM

TOXIC CHEMICALS SESSION (CONTINUED)

8:30 - 9:30 **Bioaccumulative Chemicals**
Phil Cook, ORD/NHEERL

9:30 - 9:45 **BREAK**

9:45 - 11:00 **Assessing Risks to Wildlife**
Basic issues with wildlife criteria: Rick Bennett ORD/NHEERL
Regional Case Study: New Jersey Wildlife Criteria: Wayne Jackson and Dana Thomas, Region 2; Dan Russell, USFWS
Future directions of wildlife criteria for mercury: Rick Bennett ORD/NHEERL

11: 00 - 12:00 **MEETING WRAP-UP**
Chairs of all sessions: Cirone, Spehar, Macchio, Bennett, Cormier, Welker

Appendix B: List of Participants

Last Name	First Name	Affiliation	Telephone	Email Address
EPA Regional Offices				
Beckwith,	William	Region 1	617-918-1544	beckwith.william@epa.gov
Hillger,	Robert	Region 1	617-918-1071	hillger.robert@epa.gov
McDonald,	David	Region 1	617-918-8609	mcdonald.dave@epa.gov
Thomas,	Dana	Region 2	212-637-3743	thomas.dana@epa.gov
Borsuk,	Frank	Region 3	304-234-0241	borsuk.frank@epa.gov
Hammer,	Ed	Region 5	312-886-3019	hammer.edward@epa.gov
Moerke,	Ashley	Region 5	312-886-6822	moerke.ashley@epa.gov
Pfeifer,	David	Region 5	312-353-9024	pfeifer.david@epa.gov
Tillman,	Danielle	Region 5.	312-886-6056	tillman.danielle@epa.gov
Crisp,	Terri	Region 6	214-665-6693	crisp.terri@epa.gov
Helvig,	John	Region 7	913-551-7018	helvig.john@epa.gov
Welker,	Gary	Region 7	913-551-7177	welker.gary@epa.gov
Hoff,	Dale	Region 8	303-312-6690	hoff.dale@epa.gov
Laidlaw	Tina	Region 8	303-312-6880	laidlaw.tina@epa.gov

Tyler,	Patti	Region 8	303-312-6081	tyler.patti@epa.gov
Baxter,	Jan	Region 9	415-744-1064	baxter.jan@epa.gov
Black,	Ned	Region 9	415-972-3055	black.ned@epa.gov
Denton,	Debra	Region 9	916-341-5520	denton.debra@epa.gov
Fujii,	Laura	Region 9	415-744-1601	fujii.laura@epa.gov
Smith,	Bobbye (Barbara M.)	Region 9	415-744-1633	smith.bobbye@epa.gov
Brough,	Sally	Region 10	206-553-1295	brough.sally@epa.gov
Burges,	Sylvia	Region 10	206-553-1254	burges.sylvia@epa.gov
Cabreza,	Joan	Region 10	206-553-7369	cabreza.joan@epa.gov
Cirone,	Patricia	Region 10	206-553-1597	cirone.patricia@epa.gov
Cohen,	Lori	Region 10	206-553-6523	cohen.lori@epa.gov
Duncan,	Bruce	Region 10	206-553-8086	duncan.bruce@epa.gov
Fisher,	Carla	Region 10	206-553-1756	fisher.carla@epa.gov
Goulet,	Joe	Region 10	206-553-6692	goulet.joe@epa.gov
Hastings,	Jan	Region 10	206-553-1852	hastings.jan@epa.gov
Hayslip,	Gretchen	Region 10	206-553-1685	hayslip.gretchen@epa.gov
Hoffman,	Erika	Region 10	360-753-9540	hoffman.erika@epa.gov
Karna,	Duane	Region 10	206-553-1413	karna.duane@epa.gov
Keeley	Karen	Region 10	206-553-2141	keeley.karen@epa.gov

Kubena,	Kellie	Region 10	206-553-1904	kubena.kellie@epa.gov
Lidgard,	Mike	Region 10	206-553-1755	lidgard.michael@epa.gov
Leinenbach,	Peter	Region 10	206-553-0524	leinenbach.peter@epa.gov
Macchio,	Lisa	Region 10	206-553-1834	macchio.lisa@epa.gov
Narvaez,	Madonna	Region 10	206-553-1774	narvaez.madonna@epa.gov
Pedersen,	Rob	Region 10	206-553-1646	pedersen.rob@epa.gov
Pimentel,	Theresa	Region 10	206-553-0257	pimentel.theresa@epa.gov
Schwarz,	Judi	Region 10	206-553-2684	schwarz.judi@epa.gov
Vaga,	Ralph	Region 10	206-553-5171	vaga.ralph@epa.gov
Vanhaagen,	Paula	Region 10	206-553-6977	vanhaagen.paula@epa.gov

EPA Program Offices

Delos,	Charles	OW/OST	202-260-7039	delos.charles@epa.gov
Gabanski,	Laura	OW/OWOW	202-260-5868	gabanski.laura@epa.gov
Gibson,	George	OW/OST	410-305-2618	gibson.george@epa.gov
Jackson,	Susan	OW/OST	202-260-1800	jackson.susank@epa.gov
Norton,	Doug	OW/OWOW	202-260-7017	norton.douglas@epa.gov
Thompson,	Brian	OW/OST	312-353-8640	thompson.brian@epa.gov

Office of Research and Development (ORD) Labs and Centers

Bennett,	Richard	ORD/NHEERL	218-529-5212	bennett.rick@epa.gov
Borst,	Michael	ORD/NRMRL	732-321-6631	borst.mike@epa.gov
Cook,	Philip	ORD/NHEERL	218-529-5202	cook.philip@epa.gov
Cormier,	Susan	ORD/NERL	513-569-7995	cormier.susan@epa.gov
Erickson,	Russell	ORD/NHEERL	218-529-5157	erickson.russell@epa.gov
Henry,	Tala	ORD/NHEERL	218-529-5159	henry.tala@epa.gov
Hutchens,	John	ORD/NERL	513-569-7639	hutchens.john@epa.gov
Kravitz,	Michael	ORD/NCEA	513-569-7740	kravitz.michael@epa.gov
Larsen,	Phil	ORD/NHEERL	541-754-4362	larsen.david@epa.gov
Lores,	Emile	ORD/NHEERL	850-934-9238	lores.emile@epa.gov
Mayer,	Foster	ORD/NHEERL	850-934-9356	mayer.foster@epa.gov
McCormick,	Frank	ORD/NERL	513-569-7097	mccormick.frank@epa.gov
Mount,	Dave	ORD/NHEERL	218-529-5169	mount.dave@epa.gov
Nietch,	Christopher	ORD/NRMRL	732-321-6665	nietch.christopher@epa.gov
Norton,	Susan	ORD/NCEA	202-564-3246	norton.susan@epa.gov
Power,	James	ORD/NHEERL	541-867-4027	power.jim@epa.gov
Spehar,	Bob	ORD/NHEERL	218-529-5123	spehar.robert@epa.gov
Farland,	Bill	ORD/NCEA	202-564-6620	farland.bill@epa.gov

Sergeant,	Anne	ORD/NCEA	202-564-3249	sergeant.anne@epa.gov
Yuan,	Lester	ORD/NCEA	202-564-3284	yuan.lester@epa.gov

Office of Research and Development/Office of Science Policy (OSP)

Klauder,	David	ORD/OSP	202-564-6496	klauder.david@epa.gov
Morris,	Jeffrey	ORD/OSP	202-564-6756	morris.jeffrey@epa.gov

Invited Guests

Grafe,	Cyndi	Idaho Department of Environmental Quality	208-373-0576	cgrafe@deq.state.id.us
Davies,	Susan	Maine Dept. of Environmental Protection	207-287-7778	susan.p.davies@state.me.us
Yoder,	Chris	Midwest Biodiversity Institute	740-597-1755	yoder@ntserver.ilgard.ohiou.edu
Collier,	Tracy	National Oceanic & Atmospheric Administration	206-860-3312	tracy.k.collier@noaa.gov
Johnson,	Lyndal	National Oceanic & Atmospheric Administration	206-860-3345	lyndal.l.johnson@noaa.gov
Meador,	James	National Oceanic & Atmospheric Administration	206-860-3321	james.meador@noaa.gov
Tatara,	Chris	National Oceanic & Atmospheric Administration	707-575-6094	chris.p.tatara@noaa.gov
Acker,	Steve	National Park Service		
Ralph,	Steve	National Park Service		
Fitzpatrick,	Martin	Oregon Department of Environmental Quality	503-229-5656	fitzpatrick.martin@deq.state.or.us

Hafele,	Rick	Oregon Department of Environmental Quality		hafele.rick@deq.state.or.us
Sturdevant,	Debra	Oregon Department of Environmental Quality	503-229-6691	sturdevant.debra@deq.state.or.us
Bauer,	Steve	Pocket Water Inc., Idaho	208-376-3263	stevebauer6@cableone.net
Gerritsen,	Jeroen	Tetra Tech, Inc.	410-356-8993	jeroen.gerritsen@tetratech.com
Paul,	Michael	Tetra Tech, Inc.	410-356-8993	michael.paul@tetratech.org
Arena,	Sandra	U.S. Fish and Wildlife Service	618-453-6930	arena@siu.edu
Burch,	Susan	U.S. Fish and Wildlife Service	208-378-5243	susan_burch@fws.gov
Davis,	Jay	U.S. Fish and Wildlife Service	360-753-9568	jay_davis@fws.gov
Henry,	Mary	U.S. Fish and Wildlife Service	703-358-2148	mary_henry@fws.gov
LaTier,	Andrea	U.S. Fish and Wildlife Service	360-753-9593	andrea_latier@fws.gov
Noble,	Sandra	U.S. Fish and Wildlife Service	612-713-5172	sandra_m_noble@fws.gov
Russell,	Daniel	U.S. Fish and Wildlife Service	916-414-6638	daniel_russell@fws.gov
Schwarzbach,	Steven	U.S. Fish and Wildlife Service	916 414 6591	steven_schwarzbach@fws.gov
Huggins,	Donald	University of California - Davis	530-754-9192	dghuggins@ucdavis.edu
Johnson,	Mike	University of California - Davis	530-752-8837	mbjohnson@ucdavis.edu
Shephard,	Burg	URS Corp.		
Dutch,	Maggie	Washington State Department of Ecology	360-407-6021	mdut461@ecy.wa.gov
Plotnikoff,	Robert	Washington State Department of Ecology		
ZumBerge,	Jeremy	Wyoming Department of Environmental Quality	307-672-6457	jzumbe@state.wy.us

Appendix C: Slides from Presentations and Poster Session

These slides can be found at
http://intranet.epa.gov/ospintra/regsci/aquatic.htm

PLENARY SESSION: OVERVIEW OF AQUATIC LIFE CRITERIA

1. *Region/ORD Aquatic Life Criteria Workshop - Welcome* — **William H. Farland**
2. *Toxic Chemicals: Programmatic Overview of Science* — **Charles Delos**
3. *Water Quality Toxics: Short- and Long-Term Needs* — **Debra L. Denton**
4. *Impaired Habitat: A Water Program Retrospective/Perspective* — **Douglas J. Norton**
5. *Strengthening the Use of Aquatic Habitat Indicators in the Clean Water Act* — **Steve Bauer**
6. *The ORD/NHEERL Approach to Habitat Alteration Research* — **James H. Power**
7. *Suspended and Embedded Sediments: Status Report and Update from the Office of Water* — **Susan K. Jackson**
8. *Suspended Solids and Sediments Risk Management Research* — **Christopher T. Nietch et al.**
9. *USEPA National Nutrient Criteria Program Approach to Reference Condition Development* (not available) — **George Gibson**
10. *Nutrient Criteria: Challenges Facing Regions and States* — **Danielle Tillman**
11. *National Framework for Tiered Aquatic Life Uses in State and Tribal Water Quality Standards - Update on Guidance Development* — **Susan K. Jackson**
12. *Biological Assessments in Region 10 - Approaches, Application and Research Needs* — **Gretchen Hayslip**

BIOCRITERIA AND NUTRIENTS SESSION

1.	*Establishing Multi-Use Reference Sites for Biological & Nutrient Criteria Development*	**Don Huggins**
2.	*Reference Condition for Biological Integrity*	**Phil Larsen**
3.	*The Use of Reference Condition in Support of Surface Water Assessments and Criteria Development in Ohio*	**Chris O. Yoder**
4.	*Use of Reference Sites and Conditions in the Development of Nutrient Criteria* (not available)	**George Gibson**
5.	*Developing Nutrient Criteria Using Multi-Metric Indices: A Case Study in the Mid-Atlantic*	**John Hutchens**
6.	*NHEERL National Nutrients Research Implementation Plan*	**Emile Lores**
7.	*Aquatic Life Use (ALUS) Concept of Reference Sites*	**Susan K. Jackson**

BREAKOUT SESSION I: Multi-Use Reference Sites

1.	*Progress on Development of Reference Conditions & Site Selection Guidelines for Streams*	**Don Huggins**

BREAKOUT SESSION II: Charting a Statistical Course for Navigating the Waters of Bioindicator Development

1.	*Overview*	**Susan Cormier**
2.	*Multimetric Biological Index Development*	**Jeroen Gerritsen**
3.	*Case Study: Developing a Multimetric Index for Wyoming*	**Jeroen Gerritsen**
4.	*Predictive Models in Bioassessment: RIVPACS and beyond*	**Michael Paul**
5.	*Predictive Models: Hands On*	**Michael Paul**

6. *Discriminant Function Models: Utility in Biocriteria Development* — **Michael Paul**

7. *Discriminant Function Models in Biocriteria - Hands On* — **Michael Paul**

BREAKOUT SESSION III: Aquatic Life Use Support (ALUS)

1. *The Biological Condition Gradient* — **Susan P. Davies**

2. *Progression of Ecological Degradation in Mid-Atlantic Streams* — **Lester Yuan and Susan Norton**

3. *Numeric Biocriteria [State of Oregon Department of Environmental Quality]* — **Rick Hafele**

4. *[Idaho Stream Classification Compared to ALUS]* (not available) — **Cyndi Grafe**

TOXIC CHEMICALS SESSION

1. *Risk-Based Criteria* — **Russ Erickson**

2. *Discussion of Proposed Guidelines Revisions* — **Charles Delos**

3. *ESA Consultation on Toxic Pollutant Criteria* — **K. M. Kubena**

4. *Data Quality, New Information, and Interagency Research Coordination* — **Chris Tatara and Tracy Collier**

5. *Emerging ESA Issues* — **Steven Schwarzbach**

6. *Surrogate Species in Assessing Contaminant Risk for Endangered Fishes* — **Foster Mayer**

7. *Predicting the Toxicity of Metals to Aquatic Organisms: The Biotic Ligand Model* — **Charles Delos**

8. *Dietary Metals: How Important Are They?* — **Russ Erickson**

9. *Numerical (Criteria) for Sediment-Associated Chemicals* — **David R. Mount**

10. *Comparing WQC to Site-Specific Ecological Risk Assessment Results at R9 $fund Sites* **Ned Black and Clarence Callahan**

11. *Persistent Bioaccumulative Toxicants* **Philip M. Cook**

12. *Toxic Chemicals Session: Assessing Risks to Wildlife* **Rick Bennett**

13. *Derivation of New Jersey-Specific Wildlife Values as Surface Water Quality Criteria for: PCBs, DDT, and Mercury* **Dana Thomas and Dan Russell**

14. *NHEERL Wildlife Research Demonstration Project: Methods to Assess Risks to Piscivorous Bird Populations* **Rick Bennett**

POSTER PRESENTATIONS AND MODEL DEMONSTRATIONS:

These slides can be found at
http://intranet.epa.gov/ospintra/regsci/aquatic.htm

1. Ankley, G.T., M.D. Kahl, K.M. Jensen, J.J. Korte, E.A. Makynen, and J.E. Tietge. 2001. The Effects of Methoxychlor and Methyltestosterone on Reproduction in a Short-Term Assay using the Fathead Minnow *(Pimephales promelas)*. ***Society of Toxicology Annual Meeting, San Francisco, CA, March 25-29, 2001.*** (ORD/NHEERL)

2. Cook, P.M. MED Contaminated Sediment Research: Assessing Ecological Effects - Persistent Bioaccumulative Toxicants. (ORD/NHEERL)

3. Davoli, D. and P. Cirone. Assessment of Chemicals in Columbia River Basin Fish. (Region 10) (not available)

4. DeFoe, D.L., K.M. Jensen, S.A. Diamond, and G.T. Ankley. 2001. Characterization of Relative Sensitivity of Amphibians to Ultraviolet Radiation. ***Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MD, November 11-15, 2001.*** (ORD/NHEERL)

5. Diamond, S.A., G.S. Peterson, G.T. Ankley, and J.E. Tietge. 2001. Evaluation of UV Radiation Dose in Northern Minnesota Wetlands. ***Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MD, November 11-15, 2001.*** (ORD/NHEERL)

6. Duncan, B. and M.S. Greenberg. Incorporating Contaminated Ground Water Discharges into the 'Traditional' Ecological Risk Assessment Approach. (Region 10) (not available)

7. Henry, T. R., J. Denny and P. Schmieder. Relative Binding Affinity of Alkylphenols to Rainbow Trout Estrogen Receptor. (ORD/NHEERL) (not available)

8. Henry, T.R., M.W. Hornung, J.S. Denny, M. Tapper, B.R. Sheedy, and P.K. Schmieder. An *in vitro* Approach for Screening for Environmental Endocrine Disruptors in Rainbow Trout. ***Gordon Conference on Environmental Endocrine Disruptors, Plymouth, NH, June 2000.*** (ORD/NHEERL)

9. Henry, T.R. Fish Tissue Residue-Based Wildlife Values for Piscivorous Wildlife: Chlordane, DDT, Dieldrin, Endrin, Hexachlorobenzene, Mercury and PCBs. ***American Chemical Society, New Orleans, LA, August 1999.*** (ORD/NHEERL)

10. Henry, T.R., et al. Rainbow Trout *in vivo* Assays for Species Comparisons and SAR Model Development. (ORD/NHEERL)

11. Jensen, K.M., M.D. Kahl, J.J. Korte, E.A. Makynen, M.W. Hornung, and G.T. Ankley. 2001. Evaluation of Fadrozole as an Endocrine Disruptor in Fathead Minnows (*Pimephales promelas*). ***Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MD, November 11-15, 2001.*** (ORD/NHEERL)

12. Johnson, L.L., B.H. Horness, and T.K. Collier. An Analysis in Support of Sediment Quality Thresholds for Polycyclic Aromatic Hydrocarbons (PAHs) to Protect Marine Fish. (NOAA/NMFS) (not available)

13. Kinzinger, B.P., C.L. Russom, D. Grunwald, C. Kowalczak, A. Pilli, and C. Podeszwa. 2001. Evaluation of Literature Establishing Screening Levels for Terrestrial Plants/Invertebrates. ***Society of Environmental Toxicology and Chemistry Annual Meeting, Baltimore, MD, November 11-15, 2001.*** (ORD/NHEERL)

14. Lawonn, M., I.K. Loeffler, E.A. Andreason, R.E. Peterson, W. Fredenberg, and P.M. Cook. 1998. Early Life Toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and PCB 126 to Bull Trout. ***Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, NC, November 15-19, 1998.*** (ORD/NHEERL)

15. Mayer, F. Interspecies Correlation Estimation Software (ICE). (ORD/NHEERL)

16. Mount, D., C. Stephan and R. Erickson. Clark Fork River Risk Assessment. (ORD/NHEERL)

17. Norberg-King, T.J., et al. Results of Applying Toxicity Identification Procedures to Field-Collected Sediments. (ORD/NHEERL) (not available)

18. Russom, C.L. U.S. EPA's ECOTOX Database and Associated Applications. (ORD/NHEERL) (not available)

19. Scholz, N.L., et al. Biochemical and Electrophysiological Measures of Pesticide Neurotoxicity in Pacific Salmon. (not available)

20. Sergeant, A. Planning for Ecological Risk Assessment: Developing Management Objectives. (ORD/NCEA) (not available)

21. Stephan, C. and R. Erickson. Ammonia Water Quality Criteria Update. (ORD/NHEERL)

Appendix D: Flip Chart Notes

Breakout Session I: Multi-Use Reference Sites (Day 2)

Attendees:

Duncan, Bruce	(Region 10)
Fitzpatrick, Marty	(Oregon Department of Environmental Quality)
Gibson, George	(OW/OST)
Huggins, Don	(University of Kansas)
McCormick, Frank	(ORD/NERL)
McDonald, Dave	(Region 1)
Smith, Bobbye	(Region 9)
Thompson, Brian	(OW/OST)
Tyler, Patti Lynne	(Region 8)
Vaga, Ralph	(Region 10)
Welker, Gary	(Region 7)

Goals / Objectives:

- Develop a working definition of "multi-use" reference site for wadable streams.
- Identify core factors that should be considered when selecting multi-use reference sites for wadable streams.
- Arrive at a group consensus on the definition of each core factor for the selection of multi-use reference sites.

Ground Rules

- Let everyone speak
- No interruptions

Selection of Multi-use Reference Sites for Wadeable Streams

Reference Condition

- Some portion (value, statistic)
  - Cumulative distribution of variables (parameters) from reference sites.
- Reference site vs. reference condition

- Multi-use?
- Beneficial use?
- Based on outcome?
- Designated use ?

Multi-use

- For many parameters
- Scientific
    - Attainable vs. designated

Reference sites

Benchmark to measure the condition of wadeable streams

Order ? 1, 2, 3

- Systematizing
- A subset of population
- What is "good?"
- Common physical characteristic
- Want to classify based on what reference site is vs. is not
- Place in time represents least (minimally) impacted
- How to address human impact (managed)
- Loss of certain ecosystem values, yet "functional"

Multi-use

- Multiparameter
- Best attainable for some function
- ID physical, chemical, biological parameters that define some condition / function
- Minimal landscape disturbance
- "Condition" = state + parameter-specific
- Features used to pick reference sites → data → population of values ≡ reference condition
- Find "sites" - read just once data is taken
- Characteristics / rules
    - Certain gradient
    - "Natural" vegetation
    - ± Feet from bank
- Clear that reference condition ≠ pristine
- No NIS [Non-Indigenous Species]
- ↓ Management
- ↑ h [historical?] system function

- Identify parameters first?
- "Function" of reference condition ≠ BPJ [Best Professional Judgement]
- Least disturbed vs. attainable - impact on cleanup in $F [Superfund]
  - Background vs. attainable
- Why can't I.D. the lower limit? - restoration vs. what will you settle for?
- From scientific standpoint vs. management strategy
- How to classify vs. reference site
  - ?urban "reference" stream
- Keep bar in place / put resources where things can be "fixed"
- Address urban streams thru UAA [Use Attainability Analysis] – public process
  Biotic integrity gradient
- Slopes from minimally to least impacted (top to bottom)
- "Best attainable" based on class
- Integrity ≡ Nutrients

Operational Definition of Reference Sites

- Multipurpose site
- Location in time that represents natural [least (minimally - not significant difference from historic condition) impacted] conditions
- Natural [close to historic] ≡ minimally impacted
- Natural ≅ historic > minimally impacted
- [Also], a location that is representative of the "natural" (minimally impacted by human activities; multipurpose) condition
- A reference site is "absolute value"
- Sufficiently robust to address multiple resource management objectives

Core Factors for Wadable Streams

- No point sources
  - "Definable" level of impacts
- Physical structure - hydrogeomorphology
- Primary productivity
- Minimal anthropogenic impacts
- Chemical parameters
- Biological parameters
  - Including "habitat structure"
- Faunal assemblage ≡ biotic assemblage
  - No exotic, introduced biota
- No alteration
- No altered hydrology (hydrologic regime)
- No non-indigenous species (channel as well as watershed)
  - Natural communities [no manipulation / stocking]

- No human impact on embankment
- Biotic assemblage
- WWTP [Wastewater Treatment Plant] ≡ non-point sources
- Biotic diversity and biomass
    - No non-indigenous species! - No measurable effects [of exotics]
    - Species composition
    - Species diversity
    - Trophic structure
    - Biomass
    - Departure from native assemblage
    - Presence of sensitive species
- Ground truth → implementation
- Developing a process / procedure - iterative
- How to deal with "least / minimally" impacted (don't have "reference" sites)
    - Rank, score, index ≡ quantify (the "best")
- Not sure yet about defined process for implementation
    - Use of historic data at landscape level can give "relative" answer
    - Ambient ≡ reference for R-7
    - No reconstruction of historic, but ↑ function of current system

Two Issues

- Definitions can → hypothesis testing
- "Good," but "not enough"
- TMDL [Total Maximum Daily Load] interplay (DO [Dissolved Oxygen] / nutrients)
- What resources will be needed? ↑↑$, will it go to finding the sites or sampling?
- Kansas - 60 years, now no high plains streams - but may use other states' reference sites
- Method comparability
    - Performance criteria
    - DQOs [Data Quality Objectives]
- EMAP - tool for crossing geopolitical boundaries
    - Translators
- Use reference sites as a way to translate methods
- Science process + "people process"
- RTAGs [Regional Technical Assistance Groups] provide vehicle for cross-communication
- Strawman - approach is attractive
- Neutral party facilitates cross-communication among states, tribes

What Research "Weakness"

- Assumptions behind "random sampling"
  - Resources
  - Use existing state sites
- QA/QC for data sampling
- Refined / practical models for extrapolating
- How many different types of systems are there (stream types, lake types?)
- Bringing people together

Core Factors for Reference Sites

1. Land use / land cover broad-scale
2. Land use / land cover site specific
3. Altered hydrologic regime
4. Biotic diversity and biomass
5. Physical and chemical parameters
6. Representativeness
7. Habitat, instream
8. Habitat, riparian

Breakout Session II: Charting a Statistical Course for Navigating the Waters of Bioindicator Development (Day 2)

Attendees:

Baxter, Jan	**Region 9**
Bennett, Rick	**ORD/NHEERL**
Borst, Mike	ORD/NRMRL
Cormier, Susan	ORD/NERL
Denton, Debra	Region 9
Dutch, Maggie	Washington State Department of Ecology
Gabanski, Laura	OW/OWOW
Gerritsen, Jeroen	Tetra Tech, Inc.
Hammer, Ed	Region 5
Hillger, Robert	**Region 1**
Hutchens, John	ORD/NERL
Johnson, Mike	University of California - Davis
Kravitz, Michael	ORD/NCEA
Laidlaw, Tina	Region 8
Larsen, Phil	ORD/NERL
Moerke, Ashley	Region 5
Nietch, Chris	ORD/NRMRL
Norton, Doug	OW/OWOW
Paul, Michael	Tetra Tech, Inc.
Pfeifer, Dave	Region 5
Yoder, Chris	Midwest Biodiversity Institute
Zumberger, Jeremy	Wyoming Department of Environmental Quality

* Names in bold were listed on the preliminary sign-up sheet, but not on the actual sign-in sheet.

1. What dimension of integrity do we capture?

2. Which stressors do metrics respond to?

3. Guidance of frequency and magnitude of response / score for decisions

4. Strengths and limitations of methods

5. Statistical basis of decision

6. Keep conceptual thread throughout:
   - Explain conceptual background up-front
   - Conceptual lead in each mathematical section

Breakout Session III: Aquatic Life Use Support (Day 2)

Attendees:

Arena, Sandra	U.S. Fish and Wildlife Service
Bauer, Steve	Pocket Water, Inc.
Beckwith, Bill	Region 1
Black, Ned	Region 9
Borsuk, Frank	Region 3
Burch, Susan	U.S. Fish and Wildlife Service
Cirone, Patricia	Region 10
Crisp, Terri	Region 6
Davies, Susan	Maine Department of Environmental Protection
Delos, Charles	OW/OST
Fujii, Laura	Region 9
Grafe, Cyndi	Idaho Department of Environmental Quality
Hafele, Rick	Oregon Department of Environmental Quality
Hayslip, Gretchen	Region 10
Jackson, Susan	OW/OST
Leinenbach, Peter	Region 10
Lores, Emile	ORD/NHEERL
Macchio, Lisa	Region 10
Mayer, Foster	ORD/NHEERL
Narvaez, Madonna	Region 10
Noble, Sandra	U.S. Fish and Wildlife Service
Norton, Susan	ORD/NCEA
Pimentel, Theresa	Region 10
Plotnikoff, Rob	Washington State Department of Ecology
Power, Jim	ORD/NHEERL
Russell, Dan	U.S. Fish and Wildlife Service
Spehar, Bob	ORD/NHEERL
Tillman, Danielle	Region 5
Yuan, Lester	ORD/NCEA

Objectives:

- Road test draft biological condition gradient.
- Scientific issues and research questions – technical assistance and research plans (ORD participants).
- Program implementation and communication (water program coordinators).

State Standards:

- Applicability of draft model to existing state use classifications.
- All three states (Oregon, Idaho, Washington) – applicable to scientific / ecological tiers.

Note: States may not have sufficient database to distinguish six (6) tiers – Idaho (currently) has three (3) tiers. Framework works at this level of resolution.

Implementation Issue:

- Concern regarding rule-making process to refine uses.
- States propose options: to incorporate conceptual model into existing standards construct through reference to a process (Idaho), or methods of interpretation and quantification of current use classes (Oregon).
- Washington: potential implementation along lines of Oregon approach.

Session outcome:

- Headquarters and regions collaborate with states to work through implementation options; determine if valid and identify benefits (added value) to states.

Most frequently asked questions:

1. Linkage with aquatic life water quality criteria?

2. Result in downgrades? (303d listing)

3. How does this relate to Endangered Species Act?

4. How does this concept / model help?

5. How can this be implemented in different programs?

6. What will this concept / model look like in permit?

ORD: Opportunities for collaboration and research needs:

1. More stressor-response in context of tier use (more regions, types of stressors, habitat / sediment-related variables).

   Important: Strengthen threshold establishment.

2. Linkage with nutrients – collaboration opportunity: Skeets Lores / estuaries food web indicator.

3. Alternate ways to reference condition.

4. Tiers and applications in TMDL model – Restoration Goals.

5. Potential collaboration – Superfund, Ned Black / Mila Kravitz.

6. Restoration tools – evaluating effectiveness in achieving biological targets (e.g. shared objective with Fisheries and Wildlife regarding focus on enhancing recovery of species).

Issues brought up during introduction / "around the room"

- More technical underpinnings of ALUS
- Nightmares for permits?
- Biocriteria usage in states
- ALUS: revisions of Washington State criteria ↑ biomonitoring role
- Oregon's biocriteria and beneficial uses standards and permits
- Linking ALUS with AWQC [Ambient Water Quality Criteria]
- Describe communities associated with particular use designations – get a picture
- Advances in framework – applications to wetlands?
- Nutrient – Food web – Criteria: better linking with states
- Linkage with Ecorisk – broaden beyond tox [toxics]
- Moving to implementation concerns regarding downgrading quality, independent applicability
- Concerns on misuse of beneficial uses: listed species, ESA [Endangered Species Act] linkages
- Use Attainability Analysis (UAA) as a means to downgrade
- Incentives to upgrade – carrot
- Can TMDL [Total Maximum Daily Loads] accommodate a sliding scale?
- Changing target complicates modeling for TMDLs
- How do you derive numerical standards – ESA issues
- Linking tiers with indices:
  - Use to develop anti-degradation
  - Implications for large rivers

  - Concerns over moving "least impaired"
  - Obstacles to upgrading
- Improve research directions
- How to apply framework to reviews of standards, frameworks of other agencies

Comments / Questions on Davies

- Historically documented taxa: what is the time point? (1975? Clean Water Act?)
- Make it consistent with existing uses, non degradation
- Distinguish 1975 time point from good reference condition
- Do you "OR" attributes together?
- Distinguish "rare" from threatened and endangered species
- Circularity between how valued a species is and degree of human influence; more valued species defined as sensitive to human influence
- Headwater streams normally have tolerant species
- Ecosystem function – elaborate
- Numbering attributes implies an order - confusing with tiers
- Linkage to Clean Water Act goals?
- What scale? (Spatial)
- Implications for chemical targets: can states do both biomonitoring and chemical [monitoring]?
- Emphasize role of independent app. [applications?] up front

Yuan (questions / comments)

- Combining across assemblages
- Demonstrate method across other regions
- WV [West Virginia] data set
- Where do tiers 1 and 2 fit on pH diagram?
- Might be used to regionally modify national criteria
- May want to have different AWQC for different tiers
- Data driven – might be able to distinguish additional categories
- Difference between designated uses and aquatic life uses and condition
- Moving from condition to uses can take a lot of time
- Connection with volunteer monitoring
- Degree of sophistication needed to implement tiers
- Unassessed waters – more lawsuits

Toxic Chemicals Session (Day 3)

Toxicity data

- Problems
- Any support to collect / do new toxicity data / tests
- Lab is not in the position currently to do this
- Limitations with toxicity data – what can be done about this?
- Is there something that can be done generically with the data?

Cumulative action

- Conceptually can be done
- Can be accomplished with models

Implementation

- Permitting: process would need to change
- Need site-characteristic inputs; could be a software tool

Chronic

- Taking the model and applying it to chronic
- Has not been worked out
- Probably could be – modeling approaches

ACR: We want to get away from these

Bioaccumulative / ESA

- Can you adjust the model to incorporate these issues?
- Same tools can be applied
- Problem formulation – adjusted

Monitoring in an ambient sense?

- Has this been considered with the model?
- It could be more specific method to determine compliance
- It would make compliance monitoring more meaningful

Endpoints

- How can this be handled?
- Data-poor

Landscape matters

- Connectivity / Spatial matters
- An issue – immigration rate?

Communities

- Were not thought about when developed

How does it handle rare species?

- Not a model for T&E [threatened & endangered] species
- If immigration low or not happening this is problematic in this model / framework

Community interactions

- Prey shifts
- Complex
- Was viewed as a national scheme
- EPA backed off from this somewhat – viewed as too risky
- Protection at the organism level?
- ESA methodology consultation stressed
- Natural life history of communities / species may be a portal
- Methodology: we need to agree at the methodology level – ESA, CWA

Support for this framework / model

- No resources
- ORD needs to assign resources
- Management support is there
- Fewer research for toxic chemicals
- Perhaps not a large leap to get to the next phase; could incorporate other issues in the model
- Testing of key indicator species

Needs / Challenge

- We have the needs now: short-term and long-term
- Deb Denton
- How do we handle the needs now?

ESA NEEDS

- Methylation rates – did not do it, but is going to be done by CALFED. Did look at methylation in sediments.

- Adequacy of current methodologies:
  - LC_{50}s cannot protect adequately
  - Effects level / endpoint – shouldn't assume not protective?

- Observable effects / expected in the field; salmon return data was valuable, maybe / maybe not a good place to be

- Research agenda:
  - Good train of evidence to link
  - Connectivity is important
  - Lines of evidence: share data

- What is more important or bigger issue? Fish tissue number, human health-based criteria, or wildlife value?

- Can we try to work together prior to publishing data:
  - Across Agency
  - NMFS [National Marine Fisheries Service] Science Center / ORD
  - Who is the contact within each agency?

- [Section] 7(a)(1) Consultation – proactive approach:
  - Gets to the process
  - Steps down to the field level
  - Pesticide / Water Quality criteria consultation
  - How to crosswalk these two – two programs
- PCB issue:
  - Mixture vs. purified form
  - Early life stage for salmonids
  - Temperature / pH influences
  - Sonny's model does not address the PCB issue
  - Embryo / larval salmonids – sensitivity not constant

- Correlation between some species; seems to be a taxonomic effect.
- Hardness slope: is it different for different species?

Planning process in EPA:

- SPRC
  - Strategic Planning and Research Coordination
  - ORD/OW Coordination
  - Contact: Mary Reiley, HQ
    Laura Gabanski, HQ/OW/OWOW

- Aquatic Stressors
  - ORD/NHEERL Research Plan
  - Contact: Bob Spehar, ORD/NHEERL

- EPA Research Coordination Teams
  - Rank research annually
  - Regional input
  - Contact: Pat Cirone, Dick Garnas, EPA Region 10

- Multi-Year Plan (ORD)
  - Goal 2 – Water: Lee Mulkey
  - Goal 8 – Multimedia: Tom Barnwell
  - Regional input
  - Contact: Same as above

Relationship

- Assumption: the closer the relationship taxonomically, the closer the relationship of toxicity is, whether or not endangered
- Endangered species did not become endangered due to toxic chemicals
- Are threatened / endangered species especially sensitive? Is there any data? (Razorback sucker / selenium)

Genetic Diversity

- Populations → individuals
- Bioavailability a bigger issue than population, individuals
- Exposure to individuals or populations
- Where is the BLM [Bureau of Land Management?]
- Copper is coming – no implementation

Dietary Exposure

- More resolution needed
- Collaboration / resources from all agencies needed
- Linking criteria to community structure endpoints
- Need to work all scales – not just population level

Appendix E: Workshop Participant Evaluation Summary

Most participants found that the workshop gave them a better overall understanding of the issues associated with aquatic life criteria. The responses regarding the most useful topic varied widely, with attendees explaining they were particularly interested in topics related to their own field (e.g., biological metrics to establish criteria, aquatic life, and toxics). In general, the topic found to be least useful was sediment criteria. Topics identified as missing included: wetland and lake efforts, applicability to implementation of aquatic life criteria and other EPA programs (e.g., wildlife criteria, TMDLs, National Pollution Discharge Elimination System), and sediment tools.

The breakout sessions were thought to be a good opportunity to delve deeper into specific topics. Several attendees did caution that there was not enough time to develop meaningful, well-thought-out results. In addition, some participants expressed the desire to spend more time identifying regional and program office needs and the ORD research to address those needs. Attendees found the inclusion of speakers from outside EPA to be valuable, in particular at the state level.

The majority of participants considered the format of the workshop to be a good balance of presentations, discussions, and small group sessions; some, however, thought the time for questions should have been more flexible to accommodate presentations that elicited longer discussions. Attendees thought the posters were effective in presenting information related to the workshop and suggested increasing the diversity of poster presenters and including case studies.

Many participants appreciated the opportunity to establish contacts between ORD and the Regional Offices. Suggestions for continuing this interaction included creating an email listserv, posting meeting presentations and other follow-up material on the EPA intranet, and conducting clinics on short-term needs and issues (e.g., ESA issues). Overall, meeting evaluations reflected the desire for an annual meeting, workshop, or clinic to identify ORD research and tools to meet region and program office needs and how to implement those tools.