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METHODS FOR DEVELOPING THE NEXT GENERATION OF AQUATIC LIFE CRITERIA

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LTG 1 Poster 08

Science Questions

- For toxic chemicals, what are the quantitative and causal relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide?
- How can stressor levels, biological-response relationships, classification schemes, bioassessment methods, ecological risk assessments, and indicators be applied across U.S. surface waters to set criteria for identifying/restoring impaired waters and maintaining designated uses?

How Research Addresses the Water Quality MYP Goals

This research includes development of the actual methods used for toxic chemical criteria for aquatic systems, and thus directly addresses Long Term Goal 1 of the Water Quality Multiyear Plan.

Research Objectives

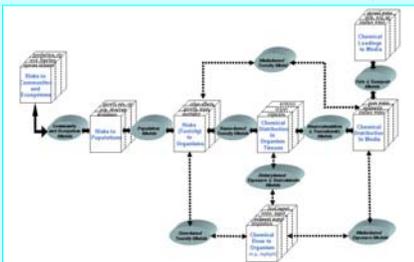
- Develop a framework for the derivation of water quality criteria for the protection of aquatic life and aquatic-dependent wildlife that is suitable for diverse species and chemicals, quantifies toxicity over a range of exposure conditions, and addresses effects at the population level.
- Based on existing information and methods for aquatic risk assessments, develop procedures for the components of the criteria framework, including toxic chemical dosimetry, population-level effects, and toxicity extrapolations among different taxa and endpoints.
- As part of efforts to address information gaps, conduct studies on the importance of dietary metal/metalloid exposure and photo-activation of polycyclic aromatic hydrocarbon (PAH) to the risk of these chemicals in natural environments.

Background

- Current water quality criteria for the protection of aquatic life have various limitations:
 - Effects are not well quantified as a function of exposure magnitude and duration.
 - Not suitable for chemicals for which dietary exposure or slow accumulation is important.
 - Effects on population-level variables are not considered.
 - Effects on aquatic-dependent wildlife are not adequately addressed.
 - Inadequate consideration of the effect of physicochemical exposure conditions.
 - Uncertainties due to omissions of certain taxa, life stages, and endpoints.
 - Effects of multiple stressors are not addressed.
- The Aquatic Life Criteria Guidelines Committee (ALCGC) was formed in 2003 to develop new guidelines for the derivation of water quality criteria for the protection of aquatic life and aquatic-dependent wildlife.
- Subcommittees of the ALCGC are addressing three general areas of criteria methodology: characterizing risks to individuals, populations, and communities when toxicity is best based directly on water concentrations; approaches when dosimetry is best based on tissue, not water, concentrations; and additional methods needed to address criteria for endangered, threatened, and other species of concern.
- Workgroups within these subcommittees address the development of specific methods needed in criteria derivation.
- ALCGC and workgroup membership includes representatives from OW, ORD, other EPA program and regional offices, U.S. FWS, and NOAA. ORD involvement includes ten individuals, two subcommittee chairmanships, primary responsibility for most technical evaluations, and a >3 FTE effort.

Aquatic Life Criteria Framework

- Routes of exposure important for criteria differ among chemicals and organisms.
- Toxic effects might be related directly to media concentrations, or to chemical in the food or in the receptor organism itself, in which case bioaccumulation relationships must be addressed.
- Effects on organisms must be quantified, and then in turn related to a meaningful measure of impact on populations and/or communities.
- Exposure concentrations specified by criteria need to be related to system loadings.



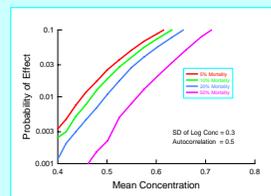
Tissue-Based Criteria

- Criteria for aquatic-life and aquatic-dependent wildlife sometimes must be based on tissue concentrations within the receptor organism or in its food.
- Procedures are needed both for relating toxicity to tissue concentrations and for translating those concentrations to environmental concentrations.
- Bioaccumulation assessment methods developed for human health water quality criteria are being further refined and applied to aquatic life criteria guidelines.



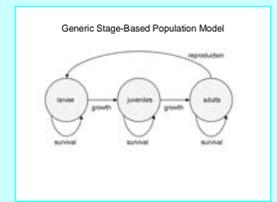
Waterborne Exposure Dosimetry

- Waterborne-exposure dosimetry models that address the dependence of toxicity on both water concentration and time are being refined and tested.
- These models allow quantification of effects for any exposure time series, and specification of how frequently various levels of effect would be expected based on the exposure characteristics for a site.
- Such models are a foundation for better defining risks in aquatic life criteria.



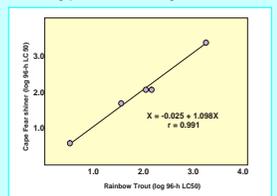
Population-Level Effects

- Population models can integrate diverse toxicity data into a metric informative of the impact of toxic chemicals on populations.
- Various model structures and output variables are being evaluated for their utility.
- A population-level endpoint was used in the formulation of the saltwater aquatic life criteria for dissolved oxygen.
- See LTG1 Poster 2 for other research regarding population models.



Intertaxa Toxicity Extrapolation

- Criteria must address the likely absence of toxicity data for endangered, threatened, or other species of special concern.
- Interspecies Correlation Estimates (below) and sensitivity distribution analyses were used in methodology for Endangered Species Act consultations regarding aquatic life criteria.
- Such methods are also potentially useful for addressing other data gaps needed for deriving criteria.



Dietary Metal/Metalloid Toxicity

- Dietary metal/metalloid toxicity is important for some metals, organisms, and exposure conditions.
- Work in this project has shown dietary arsenic toxicity is likely more important at some mining-impacted sites than dietary toxicity of various metals.
- Arsenic exposures at such sites is being better documented and related to laboratory effects.
- Recommendations will be made regarding the need to include dietary metal/metalloid exposure in criteria.

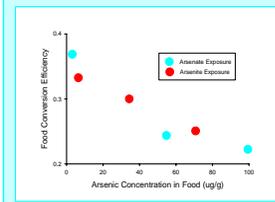
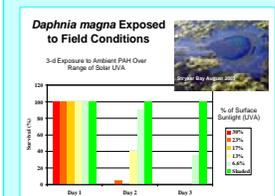


Photo-Activated PAH Toxicity

- Exposures of test organisms to ambient light and PAH contamination have shown photo-activated PAH toxicity to occur in natural systems.
- Prediction of such toxicity based on laboratory toxicity tests and field measurements/models for PAH bioaccumulation and UV intensity is being tested.
- Significance of photo-activated PAH toxicity relative to other sources of toxicity will be assessed to determine whether this is important for PAH criteria.



Conclusions and Future Directions

- Efforts to date indicate good possibilities for improving how well criteria define toxic chemical risks.
- Criteria guidelines efforts are shifting to developing prototype criteria and testing the utility of various methodologies in criteria.
- The greater complexity and data needs for this new criteria framework will require approaches for assigning missing information based on default values or extrapolations.
- Future efforts will address chemical mixtures; deriving criteria from limited data; and the relationship of criteria to effects in experimental and natural ecosystems and to EPA bioassessment/classification methods.

Interactions with Customers

- Efforts to develop improved methodologies for deriving criteria are an integrated effort of ORD with OW and other potential users of these methodologies.
- Efforts regarding dietary metal/metalloid toxicity and photo-activated PAH toxicity have been presented to OW through ORD planning documents and review meetings.

How Research Contributes to Outcomes

- By directly influencing criteria guidelines, these efforts will affect a variety of regulatory programs, including State water quality standards, point-source discharge permits, total maximum daily loads (TMDLs), Clean Water Act section 303d listings of impaired waters, Endangered Species Act consultations, and Superfund and other assessments that base risks on criteria.
- Research regarding dietary metals toxicity and photo-activated toxicity is addressing potentially important limitations of criteria and will be used to advise OW on what actions are needed regarding these issues.