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David H. Baldwin  
NOAA Fisheries, United States, David.Baldwin@noaa.gov

Julann A. Spromberg  
NOAA Fisheries, United States, julann.spromberg@noaa.gov

Jessica I. Lundin  
NOAA Fisheries, United States, jessica.lundin@noaa.gov

Cathy A. Laetz  
NOAA Fisheries, United States, cathy.laetz@noaa.gov

Nathaniel L. Scholz  
NOAA Fisheries, United States, nathaniel.scholz@noaa.gov

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Assessing the impacts of toxic mixtures over a broad geographic scale: challenges and first steps

David H. Baldwin, Julann A. Spromberg, Jessica I. Lundin, Cathy A. Laetz, Nathaniel L. Scholz
National Marine Fisheries Service, NOAA, Northwest Fisheries Science Center, Seattle, WA.

Abstract
Assessing the risks posed by chemical mixtures is a complex process. Ideally, details are available on exposure (e.g. which chemicals and what concentrations) and effects (e.g. mechanisms of action and toxicity data). Even for a single location and time such as a lab or field site this can be challenging. Unfortunately, risk assessments often need to cover much larger scales such as an entire watershed or a wide-ranging species. This increase in scale substantially increases the risk assessment complexity. Thousands of chemicals in use lead to potential environmental mixture exposures, including pesticide runoff and municipal wastewater discharges. At the landscape scale the nature of chemical mixtures will vary across space and time. This increased complexity, available monitoring data are inadequate for describing realistic exposure scenarios and effects on aquatic species. Therefore, creative solutions are required to utilize sources of data that are available to identify where and when risk is the greatest. Sources of data are available for beginning to develop a less-detailed, but still useful, landscape scale risk assessment for mixtures. These include data on potential use (e.g. crop locations and pesticide labels) or release (e.g. mapping of NPDES permits) sites. For example, the use of crop designations to represent where pesticide use is allowed can be a surrogate of actual use to establish where the greatest potential for exposure occurs. This landscape scale risk assessment for mixtures can establish priority watersheds for monitoring and further study. Similarly, aquatic species exposure to complex mixtures discharged in wastewater can be related to urban land uses and permit distributions. The goal is to develop a process to prioritize the relative risks and identify important data needs necessary for more detailed mixture analyses in the context of a landscape scale risk assessment.

Range of ESA-listed species in the Columbia River Basin (CRB) encompasses many land uses

A single land use such as apple orchards in the CRB can produce a complex mixture of pesticides

CRB wastewater and runoff has numerous sources and contains a complex mixture of contaminants

Assessing the distribution of land uses across the CRB can highlight relative differences in risk

First Steps

- Develop a land use index to identify priority watersheds where contaminant exposures are more likely to pose a risk to endangered species.
- Identify important data needed to understand the risk posed by contaminants in these watersheds.
- Focus further data collection such as use surveys and monitoring studies of both contaminants and species in these watersheds.
- Target restoration and mitigation efforts that will reduce contaminant loading to these watersheds.

Challenges

- Over 85,000 synthetic chemicals are approved for use in the United States.
- Human activity leads to the widespread contamination of aquatic habitats.
- Stormwater runoff, effluent discharges, pesticides applications are regulated activities that contaminate aquatic habitats.
- Water quality monitoring shows that contaminants are present over large geographic areas as complex mixtures.
- Exposures to many contaminants are known to be toxic to aquatic species including those listed under the Endangered Species Act (ESA).
- Many ESA-listed aquatic species have broad ranges and are likely to encounter numerous contaminants.
- Detailed information on the locations and amounts of almost all contaminants is not available.
- Assessing the risks posed by contaminant exposures to endangered species is a necessary, but daunting, task.