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EPA:

Monitoring

Theme/Topic:

Topic 2 Adaptive Monitoring Approaches: Integration

Title:

Integrating Effects Based Monitoring With Adverse Outcome Pathways and Population Models

Objective:

In addressing Beneficial Use Impairments (BUIs) at a Great Lakes Area of Concern (AOC), recovery from loss of fish and wildlife populations exposed to stressors is targeted for use in decision making. We describe a framework that can be applied in utilizing field monitoring efforts (e.g., through effects based monitoring programs) to link chemically induced alterations in molecular and biochemical endpoints to adverse outcomes in whole organisms and populations. Our approach employs a simple density dependent logistic matrix model linked to adverse outcome pathways (AOPs) for reproductive effects in fish caused by contaminants that impact different points within the hypothalamic-pituitary-gonadal axis. Application of this framework requires only a life table for the organism of interest, a measure of carrying capacity for the given population, and estimation of the effect of stressors on vital rates of organisms within the study population.

Results:

We demonstrate our applied framework using linked AOP and population models parameterized with long-term monitoring data for white sucker (Catostomus commersoni) collected from a study site at Jackfish Bay, Lake Superior. Individual-level responses of fish exposed to pulp mill effluent were used to

demonstrate the framework's capability to project alterations in population status, both in terms of ongoing impact and subsequent recovery after stressor mitigation associated with process changes at the mill.

Conclusions:

In summary, we show how individual-level measurements taken from field populations of an impacted fish species can be related to adverse effects in populations using a simple density dependent model construct that incorporates a life table, a measurement of habitat suitability, and measured effects of a stressor on vital rates. In addition, we demonstrate how the AOP framework can be implemented as an organizing principle by which mechanistic data can be effectively translated into endpoints meaningful to ecological risk (i.e. reproduction). Further, we provide an example of the practical utility of AOPs for ecological risk assessment of chemicals by showing how AOPs facilitate the use of biochemical endpoints for forecasting chemical impacts in conjunction with a population model.

Implications:

While the Jackfish Bay site has been routinely researched as part of effects-based monitoring studies, the implementation of predictive population modeling to investigate projected population status under different management scenarios could be envisioned at any of a number of impacted sites. A logical step is to utilize AOPs as a framework for organizing and communicating existing knowledge concerning the linkage between molecular initiating events and apical adverse outcomes (e.g., changes in reproductive capacity of the impacted population) relevant to risk assessment and management decisions. The present study demonstrates how an AOP can be utilized with a population model to investigate a before-after-impact control analysis, whereby the reduction in effluent toxicity at Jackfish Bay can be correlated with the demographic parameters becoming more similar to an un-impacted control site over time. Such an analysis is beneficial for examining the impact of remediation activities at the Jackfish Bay site, as well as to demonstrate the utility of this approach to investigate and monitor other sites under conditions representative of pre- and post-remediation efforts.