Biological Data Answer Important Questions (Newsletter)*

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Everyone preparing an environmental impact assessment or holding a Clean Water Act (CWA) permit knows the questions that measures of water chemistry concentrations are intended to answer. These questions range from the general (whether project development and operation is likely to adversely affect water quality) to the specific (significant temporal changes at a location; relationships between concentrations of a constituent at different sites at the same time).

Water chemical concentrations are snapshots in time and space. They do not reflect ambient ecosystem conditions nor effectively reveal whether industrial activities might, or do, change these ambient conditions. Aquatic ecosystems are inherently highly variable. For example, water temperatures in streams and rivers vary diurnally influencing water chemistry and resident biota; ponds, lakes, and reservoirs in temperate climates turn over twice a year mixing temperature, dissolved oxygen, and chemicals such as nutrients. Given this variability, the information content of discrete water chemistry concentrations is limited. Despite these limitations such measures are required by statutes and regulations. The more robust approach to assessing interactions of resource industries and natural ecosystems uses aquatic biotic data.

Perhaps biota have not been used for impact assessments, permit compliance, and mine closure/reclamation bond release because of uncertainty about questions and the analyses and models that yield useful answers. Diversity and biotic indexes thought to summarize the complexity of natural ecosystems are either theoretical concepts or too easily tweaked to validate a priori answers. The range of possible questions is greater for biotic data than chemical data but determining valid answers is more complex and involves advanced statistical methods.

One important question is what environmental conditions are associated with various aquatic taxa. For example, trout prefer cold waters and largemouth bass prefer warm waters. Similar preferences exist among aquatic insects. This question is infrequently asked by regulators.

Biotic data answer two categories of questions, those of spatial and tempo-

ral relationships, and two types of relationships, those of association (correlation) and causation (regression).

Differences between specific locations along a stream channel, and between drainage basins, help define natural variability while change over time at the same location might reflect human activity. Appropriate statistical models can be parametric, nonparametric, mixed (both descriptive factors and numbers), or based on prior knowledge or expectations using various Bayesian models. In most situations multiple models are applied to answer a broad range of questions. In brief, we can look for common trends and sudden changes.

Biotic assemblages along the course of streams and rivers reflect the terrain, hydrology, channel width and depth, exposure to sunlight, and taxa-specific life history strategies. The assemblages are spatially correlated over comparatively short distances; that is, the taxa and relative abundances at a location are dependent on those upstream and influence those downstream. These spatial relationships and associations with a broad range of geomorphic, physical, and chemical conditions makes them much better indicators of water quality and human activities than do water chemical concentrations alone, especially single threshold concentration values applied everywhere.

Eventually, US EPA and state regulators will change water quality standards and evaluation of industrial activities from chemistry to biology. In the meantime, the insights you gain from properly analyzing aquatic biotic data allows you to make better planning and operational decisions and to prepare more technically sound and legally defensible permit applications and compliance reports.