Derivation and Application of Macroinvertebrate Tolerance Values for the Western United States

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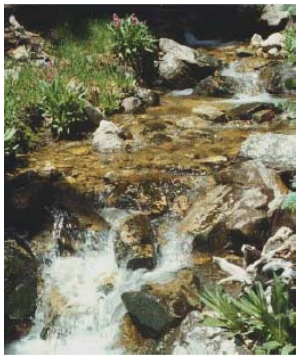
What is Bioassessment?

An aquatic bioassessment consists of determining whether the numbers and types of organisms in a water body (lake, stream, or estuary) differ from those that are expected. Bioassessment is used frequently to evaluate attainment of designated life uses. In addition to determining biological condition, biologists are increasingly called upon to use their data to make a determination of the causes of impairment in different streams. Invertebrates are frequently used in bioassessment, and estimates of the tolerance or sensitivity of different species to different stressors provides a basis for making such diagnoses.



What are Tolerance Values?

Macroinvertebrate taxa can be classified in terms of their sensitivity or tolerance to anthropogenic disturbance. One of the most commonly used sets of tolerance values was derived by Hilsenhoff[1] based on observed responses to a gradient of organic pollution.

[1] W..l. Hilsenhoff 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist 20:31-39

Will Tolerance Values Work in the Western States?

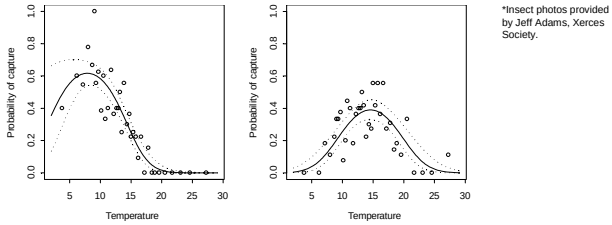
Although tolerance values have been successfully applied to assess the condition of streams in the Midwest and Eastern United States, their use in the Western United States is currently limited by two factors: different species are typically collected in the West, and stressors other than organic pollution are often important. We therefore need to derive tolerance values for western taxa.

How are Tolerance Values Derived?

The probability of observing a particular species varies across different environmental gradients, and these *species-environment relationships* can be derived from field observations (Figure 1).

*Heterlimnius**

*Malenka**



*Insect photos provided by Jeff Adams, Xerces Society.

Figure 1. Relationships between probability of capture and temperature for *Heterliminius* (left plot) and *Malenka* (right plot). Solid lines: mean response determined by maximum likelihood estimation. Dotted lines: Estimated 90% confidence limits. Each open circle represents the average occurrence probability in approximately ten samples surrounding the indicated temperature.

Tolerance values are single values that summarize the important characteristics of a species-environment relationship (Figure 2).

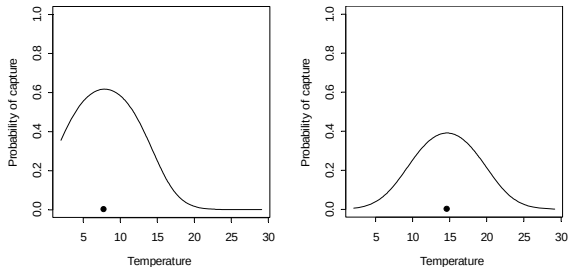


Figure 2. Tolerance values (shown as solid circles) for *Heterlimnius* (left plot) and *Malenka* (right plot). Here, the tolerance value is defined as the point along the environmental gradient where the probability of observing the species is maximized. Other tolerance value definitions include integrated averages and cumulative percentiles of the species-environment relations.

Using tolerance values, different species can be designated as sensitive or tolerant to a particular anthropogenic stressor. Then, at a site where we wish to diagnose the causes of impairment, we can compute different tolerance metrics (e.g. the relative abundance of tolerant taxa) based on the observed assemblage of organisms. To determine the likely causes of impairment at a site, tolerance metrics can be compared to expectations. In Figure 3, comparisons between sediment and temperature tolerance metric values and expectations suggest that sediment is the likely source of impairment for this test site.

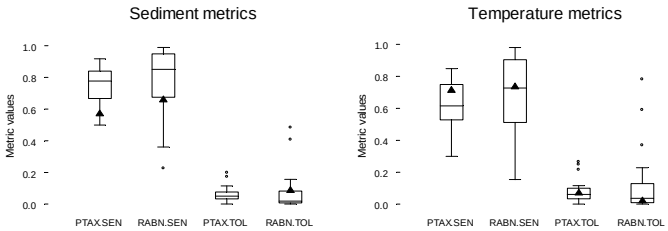


Figure 3. Comparisons of sediment (left) and temperature (right) tolerance metric values at a test site (solid triangle). Values are plotted for proportion of taxa that are sensitive (PTAX.SEN) or tolerant (PTAX.TOL), and relative abundance of sensitive taxa (RABN.SEN) and tolerant taxa (RABN.TOL). Expected metric values derived from least-impacted reference sites are shown as box and whisker plots.

FY03 RARE Tolerance Values Workshop Outcomes:

In February 2004, the US EPA and the Council of State Governments, with funding through the Region 9 RARE (Regional Applied Research Effort) Program and ORD NCEA (National Center for Environmental Assessment), convened a workshop of biologists from western state agencies, EPA and academia to review methods that are currently available for deriving and applying tolerance classifications. The workshop resulted in the following conclusions:

- Tolerance values can discriminate between different types of anthropogenic stress.
- Different derivation methods produce equally defensible tolerance classifications.
- The choice of derivation method depends strongly upon how the tolerance classifications will be used for assessment.
- Existing state water quality programs (303d, 305b, permitting and restoration) will benefit greatly from the availability of improved tolerance classifications.

What are the Next Steps?

USEPA will publish a technical report (*The Derivation and Application of Macroinvertebrate Tolerance Values*) in early 2005. Future research is planned that will be funded by the Regional Methods program.