Developing numeric biological thresholds using reference site information: Role for BCG

Susan Jackson
US EPA Biological Criteria Program

National Water Quality Monitoring Council Meeting
Denver, Colorado
April 27, 2010
Monitoring and BC Program Coordination (2008 - current)

HQ Biological Programs: Wayne Davis, Chris Faulkner, Thomas Gardner, Susan Jackson, Sara Lehmann, Lester Yuan

Regional Biological Programs: Maggie Passmore, Louis Reynolds, Jim Harrison, Edward Hammer, Gary Welker, Tina Laidlaw, Terry Fleming
CWA
Section 101
Objective
To Restore & Maintain the Chemical, Physical, & Biological Integrity of the Nation's Waters
Biological Integrity

The ability of an aquatic ecosystem to support and maintain a balanced adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.
Biological Integrity

The ability of an aquatic ecosystem to support and maintain a balanced adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.
Biological Integrity

QUANTITATIVE MEASURES

The ability of an aquatic ecosystem to support and maintain a balanced adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.
Biological Integrity

QUANTITATIVE MEASURES

The ability of an aquatic ecosystem to support and maintain a balanced adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.
Developing Reference Condition Using Reference Sites

ALL SITES

Applying Initial Screening Criteria
Important consideration: Coarseness of filter

CANDIDATE REFERENCE SITES

Evaluating Quality and Representativeness
Important consideration: Readjustment of filter’s coarseness

REFERENCE SITES for Reference Condition

Applying Final Screening Criteria
Important consideration: Coarseness of filter; Reference site variability

REFERENCE CONDITION for Biocriteria
Reference Site Approach

**Primary Task:** Developing a representative sample of range of natural conditions (no or minimal anthropogenic disturbance) within the study area and establish reference site criteria that approximate natural condition.

**Challenge:** Anthropogenic disturbance widespread across landscape
Reference Site Approach

Issues to address:

Defining reference site quality

Selection of biological threshold protective of aquatic life
Technical Guidance on Variability in Reference Site Population

Biological observations at reference sites are subject to three sources of variability:

- Within site variability
- Natural variability
- Anthropogenic disturbance
Within Site Variability

Variations in biological observations observed across different samples at same reference site

If variability in reference site values was only due to sampling variability, a reasonable threshold to select would be a percentile of observed values at low end of distribution
Within Site Variability

Reference site distribution

X% represents the probability that these sites are a member of the distribution

X % of ref distribution
Natural Variability

Variations in biological observations across different reference sites due to changes in the natural template (e.g., stream size, climate)

After controlling for natural variation, a reasonable threshold to select would still be a relatively low percentile of observed values.
The Biological Condition Gradient: Biological Response to Increasing Levels of Stress

Levels of Biological Condition

1. Natural structural, functional, and taxonomic integrity is preserved.

2. Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

3. Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

4. Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

5. Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

6. Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.

Levels of Exposure to Stressors

Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.
The Biological Condition Gradient: Biological Response to Increasing Levels of Stress

Levels of Biological Condition

1. Natural structural, functional, and taxonomic integrity is preserved.

2. Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

3. Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

4. Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

5. Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

6. Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.

Level of Exposure to Stressors

- Watershed, habitat, flow regime and water chemistry as naturally occurs.
- Chemistry, habitat, and/or flow regime severely altered from natural conditions.
### Levels of Biological Condition

1. **Natural structural, functional, and taxonomic integrity is preserved.**

   - Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

2. **Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.**

3. **Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.**

4. **Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.**

5. **Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.**

6. **Watershed, habitat, flow regime and water chemistry as naturally occurs.**

   - Chemistry, habitat, and/or flow regime severely altered from natural conditions.

---

**Multiple thresholds may be appropriate to protect biological communities at upper end of reference range.**
Natural Variability

Issue: There is a wide range of biological values within the reference site distribution and further work may be needed to parse out classification.

Multiple thresholds within the reference site database may be appropriate.

Problem solve: work through scenarios with data sets.
Anthropogenic Disturbance

Influences the degree to which reference sites approximate natural conditions

Reference sites that are disturbed by human activities may require a higher percentile
Anthropogenic Variability

Unimpacted/minimally impacted

X % of ref distribution

Observation (value)
Anthropogenic Variability

Unimpacted/minimally impacted threshold

Least impacted threshold?
Levels of Biological Condition

1. Natural structural, functional, and taxonomic integrity is preserved.
   - Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

2. Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.
   - Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

3. Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.
   - Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.

Watershed, habitat, flow regime and water chemistry as naturally occurs.

Chemistry, habitat, and/or flow regime severely altered from natural conditions.
Anthropogenic Disturbance

**Issue #1**: Measurements of human disturbance (especially in reference sites) are not generally available or well defined.

**Issue #2**: Human disturbance and natural templates are often correlated. Difficult to discriminate between variability due to natural vs human disturbance.
Status of Effort

Work in progress: example reference data sets will be used to work through different scenarios

Objective: clarify and update technical guidance