Establishing Reference Condition for the Development of Numerical Biological Criteria in Ohio

Chris O. Yoder
Midwest Biodiversity Institute
P.O. Box 21561
Columbus, Ohio 43221-0561
db8177@dragonbbs.com

Ohio EPA
4675 Homer Ohio Lane
Groveport, OH 43125
chris.yoder@epa.state.oh.us
Fundamental Objectives of Adequate Monitoring and Assessment Approaches

**Function: Surface Water Assessment**
- Collect and analyze baseline information.
- Establish cause/effect (causal associations).
- Compare results to criteria and goals (use attainment).
- Publish results - statewide, regional, site-specific.

**Function: WQ Mgmt./Pollution Abatement**
- Attainability analyses and criteria development (maintain WQS).
- Formulate and revise abatement strategies (TMDL development).
- Assess effectiveness of programs (WQ Management).

**Function: Compliance Evaluation**
- Monitor to determine compliance.
- Monitor to support enforcement.

after 40CFR Part 35 (deleted in 1990?)
Five-Year Basin Monitoring

**Where**
- Historical emphasis on inland rivers & streams
- Extended to Lake Erie nearshore
- Developmental work in the Ohio R. mainstem

**What**
- Watershed scale, synoptic design
- Fish, macroinvertebrates, physical habitat
- Sediments, water quality, fish contaminants
- Biomarkers at selected sites

**Why**
- Support all water quality management programs
- Integrate traditional water quality management tools with real world measures
- Determine status of Ohio's aquatic resources in relation to agency mission and objectives
Ohio EPA 5-Year Basin Approach for Monitoring & Assessment

- Rotating basin approach for determining annual monitoring activities.
- Correlated with NPDES permit schedule.
- Supports annual WQS use designation rule-making.
-Aligned with 15 year TMDL schedule.
Ohio EPA Macroinvertebrate Methods: Field Procedures

Artificial Substrates are Set for a Six-Week Exposure (July - September Index Period)

The Artificial Substrates are Placed in Run Habitat With Constant Current

Artificial Substrates are Retrieved, Preserved, and Returned to the Laboratory for Processing

A Qualitative Dip Net/Hand Pick Method is Used to Supplement the Artificial Substrates or as a Stand Alone Evaluation
Ohio EPA Macroinvertebrate Methods: Laboratory Procedures

After Cleaning and Sorting, the Entire Sample is Scanned and Picked

Standard Procedures are Used to Produce Subsamples of Major Tax Groups

Identification to the Lowest Taxonomic Level Practicable is a Major Data Quality Objective

Portion of a Sample Ready for Identification
Ohio EPA Fish Assemblage Methods: Field Procedures

Wading Methods - Effort is Standardized by Distance Sampled

Wading/Headwater Methods

4 WD Vehicle with Winch

Small to Large River

Ohio R. Boat Methods

Lake Erie Nearshore

All Samples are Processed in the Field

Boat Methods - Logistics Can Be Intensive
The Qualitative Habitat Evaluation Index (QHEI)

QHEI Includes Six Major Categories of Macrohabitat

- Substrate - types, origin, quality, embeddedness
- Instream Cover - types and amounts
- Channel Quality - sinuosity, development, stability
- Riparian/Bank Stability - width, quality, bank erosion
- Pool/Riffle/Run - max. depth, current types, morphology, substrate embeddedness
- Gradient - local gradient (varies by drainage area)

Source: The Qualitative Habitat Evaluation Index (Rankin 1989)
Ohio EPA Chemical/Physical Field Procedures

Water column grab sampling

Depth integrated sampler

Automatic composite samplers

Time-of-travel dye injection
Ohio EPA Chemical Effluent & Exposure Sampling Procedures

Whole Effluent Toxicity (WET) Testing is Performed Primarily on Effluents

Permitted Discharges are Sampled for a Variety of Chemicals - This Provides Data to Determine Pollutant Loads

Biochemical Markers (Biomarkers) are Useful for Discerning Problem Pollutants

Fish Tissue Analysis Reveals Bioaccumulative Pollutants and Risks to Human and Wildlife Health
Sugar Creek Subbasin: Example of Geometric Site Selection Process

- Used in TMDL development
- 5 year basin watersheds
- Increased miles of assessed streams & rivers annually
- Resolve undesignated streams
- Close 305b/303d listing gaps
- Generate broader database for development of improved tools
- Part of 15 yr. TMDL development schedule beginning in 1998
- Augmented by 5-year basin approach process (1980-1997)
- Standardized biological, chemical, physical tools and indicators
Essential Principles of Adequate Monitoring and Assessment Approaches

• **Data Quality Objectives**: need to produce data and information at a sufficient level of resolution so as to assure accuracy and precision.

• **Watershed Scale Assessment**: essential to encompass the full gradient of response and exposure to multiple stressors and influences.

• **Comprehensive Assessments**: integrated and careful analysis of multiple indicators adhering to a disciplined approach (Hierarchy of Indicators).

• **Learn by Doing**: gain new knowledge and insights by iterative assessment and observing responses to management actions (what works?).
• Narrative ratings or numerical values which are based on the numbers and kinds of aquatic organisms (i.e., assemblage) which are found to inhabit a particular stream or river sampling location.
Biological Criteria: II

- Biological criteria are indexed to the reference assemblage of aquatic organisms within a particular geographical region (i.e., ecoregion) and with respect to stream and river size.
Biological Criteria: III

- Biological criteria represent a calibrated assessment tool which fosters an organized goal setting process in an effort to reconcile human impacts and guide restoration efforts.
Biological Integrity: Operational Definition

“The ability of an aquatic community to support and maintain a structural and functional performance comparable to the natural habits of a region.”

As modified from Karr and Dudley (1981)
Biological Integrity: Putting Theory Into Practice

Essential Elements of the Regional Reference Site Approach

- **Biological Performance** - need ways to measure (e.g., IBI, ICI, BI, RIVPACS, etc.).
- **Natural Habitats** - come to grips with the attainability issue (e.g., ‘‘least impacted’’reference sites.)
- **Region** - need to stratify and account for natural variability (e.g., ecoregions and tiered uses).
- **Reference site** ‘‘re-sampling’’ to account for broad scale, long term changes in attainable conditions.
Index of Biotic Integrity (Karr 1981)

12 Metrics
- Species richness
- #Darter species
- #Sunfish species
- #Sucker species
- %Intolerant species
- %Green sunfish
- %Omnivores
- %Insectivores
- %Top Carnivores
- %Hybrids
- %Diseased individuals
- Number of Fish

Community Composition
Environmental Tolerance
Community Function
Community Condition

• 5, 3, 1 metric scoring categories.
• 12 to 60 scoring range.
• Calibrated on a regional basis.
• Scoring adjustments needed for very low numbers.
### IBI Modified for Ohio Rivers & Streams

<table>
<thead>
<tr>
<th>OHIO EPA MODIFIED IBI METRICS</th>
<th>HEADWATER SITE TYPE (&lt;20 SQ. MI.)</th>
<th>WADEABLE SITE TYPE (20-300 MI.²)</th>
<th>BOATABLE SITE TYPE (200-6000 MI.²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total Native Species</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. #Darter Species</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>#Darters + Sculpins</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>%Round-bodied Suckers</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>3. #Sunfish Species</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>#Headwater Species</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>%Pioneering Species</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>4. #Sucker Species</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>#Minnow Species</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5. #Intolerant Species</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>#Sensitive Species</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6. %Tolerant Species</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>7. %Omnivores</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8. %Insectivores</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>9. %Top Carnivores</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10. %Simple Lithophils</td>
<td>X*</td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>11. %DELT Anomalies</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>12. Number of Individuals</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

* - Substitute for original IBI metric described by Karr (1981) and Fausch et al. (1984)
Invertebrate Community Index (Ohio EPA 1987; DeShon 1995)

- Taxa Richness
- #Mayfly taxa
- #Caddisfly taxa
- #Dipteran taxa
- %Mayflies
- %Caddisflies
- %Tanytarsini Midges
- %Other Diptera/Non-Insects
- %Tolerant taxa
- Qualitative EPT taxa

- 6,4,2,0 metric scoring categories.
- 0 to 60 scoring range.
- Calibrated on regional basis.
- Scoring adjustments needed for very low numbers of specific taxa.
<table>
<thead>
<tr>
<th>OHIO EPA MODIFIED IBI METRICS</th>
<th>BOATABLE SITE TYPE (Inland Rivers)</th>
<th>LAKE ERIE LACUSTUARY (Harbors/Rivers)</th>
<th>LAKE ERIE NEARSHORE (Shoreline)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total Native Species</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2. #Darter Species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Round-bodied Suckers</td>
<td>X*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Benthic Species</td>
<td>X*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. #Sunfish Species</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Centrarchid Species</td>
<td>X</td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>4. #Sucker Species</td>
<td>X</td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>#Cyprinid Species</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#Phytophilic Species</td>
<td></td>
<td>X*</td>
<td></td>
</tr>
<tr>
<td>5. #Intolerant Species</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>6. %Green Sunfish</td>
<td></td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>%Tolerant Species</td>
<td>X*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. %Omnivores</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>8. %Insectivores</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Phytophilic Individuals</td>
<td></td>
<td>X*</td>
<td></td>
</tr>
<tr>
<td>%Lake Species</td>
<td></td>
<td></td>
<td>X*</td>
</tr>
<tr>
<td>9. %Top Carnivores</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>10. %Hybrids</td>
<td></td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>%Simple Lithophils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Nonindigenous Species</td>
<td></td>
<td>X*</td>
<td>X*</td>
</tr>
<tr>
<td>11. %DELT Anomalies</td>
<td>X**</td>
<td>X**</td>
<td>X**</td>
</tr>
<tr>
<td>12. Number of Individuals</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

**X** - Substitute for original IBI metric described by Karr (1981) and Fausch et al. (1984)

** - Excludes highly tolerant species in all and additionally gizzard shad in the L. Erie IBIs.
Reference and Control Sites: There Are Important Differences - I

Reference Sites

- Typical ‘least impacted’ sites that occur within homogenous strata (region, stream size, etc.)
- Biological performance across multiple sites defines attainability and variability.
- Benchmark levels of performance are used to establish minimum criteria within a system of tiered uses.
- Reference data is used to calibrate indices (IBI, ICI); numerical biocriteria established in line with stratification factors.
- Re-sampling of reference sites on a regular basis provides opportunity to track long-term changes in condition.
Establishing Reference Condition

**Reference Sites**

- A collection of sites within a homogenous regional area which represent the best attainable conditions (unimpaired) for all waters *with similar physical dimensions and attributes* for that particular region.

**Control Sites**

- A *single site* usually located on or adjacent to the waterbody under study which represents the *best or most appropriate condition for that waterbody* whether it is impaired or unimpaired.
Misperceptions of Reference Condition: I

**Myth**
- Reference sites reflect a pristine condition.

**Reality**
- In developed States few, if any, reference sites reflect a truly pristine condition.
- Most reflect substantially altered conditions, the results of decades of settlement and land use.

**The Challenge**
- Setting realistically attainable endpoints that meet CWA goals (biological integrity, propagation, fishable/swimable).
- Incorporation into WQS (uses and criteria) and assessment.
Reference Site Selection: General Guidelines and Cautions

- Definition of biological integrity provides theoretical basis for design and selection, i.e., done in a biological context.
- Goal is to select least impacted sites which represent the best attainable background conditions for a homogenous area.
- Sites are selected based on the “cultural setting” independent of basic sampling data, especially chemical/physical data.
- Avoidance of sites with obvious impacts such as point sources, intensive urbanization, direct habitat degradation, gross nonpoint source impacts, and other influences (spills, kills).
- Representative distribution in accordance with principal stratifying factors such as regions, watershed size, physical attributes, and other factors which drive biological variance.
LEVEL III ECOREGIONS OF OHIO
(after Omernik 1987)
Ohio IBI Calibration & Biocriteria Derivation Process

I. Select & sample reference sites

II. Calibration of IBI metrics

III. Calibrated IBI modified for Ohio waters

IV. Establish ecoregional patterns/expectations

V. Derive numeric biocriteria: Codify in WQS

VI. Numeric biocriteria are used in bioassessments

<table>
<thead>
<tr>
<th>Metric</th>
<th>5</th>
<th>3</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Species</td>
<td>Varies x Drainage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Darter Spp.</td>
<td>&gt;3</td>
<td>2-3</td>
<td>&lt;2</td>
</tr>
<tr>
<td>No. of Sunfish Spp.</td>
<td>&gt;3</td>
<td>2-3</td>
<td>&lt;2</td>
</tr>
<tr>
<td>No. of Sucker Spp.</td>
<td>Varies x Drainage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intolerant Species</td>
<td>&gt;100 sq. mi.</td>
<td>5</td>
<td>3-5</td>
</tr>
<tr>
<td>&lt;100 sq. mi.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Tolerant Species</td>
<td>Varies x Drainage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Omnivores</td>
<td>&lt;19</td>
<td>19-34</td>
<td>&gt;34</td>
</tr>
<tr>
<td>%Insectivores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30 sq. mi.</td>
<td>Varies x Drainage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;30 sq. mi.</td>
<td>&gt;55</td>
<td>26-55</td>
<td>&lt;26</td>
</tr>
<tr>
<td>%Top Carnivores</td>
<td>&gt;5</td>
<td>1-5</td>
<td>&lt;1</td>
</tr>
<tr>
<td>%Simple Lithophils</td>
<td>Varies x Drainage Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>%DELT Anomalies</td>
<td>&gt;1.3</td>
<td>0.5-1.3</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Relative Abundance</td>
<td>&gt;750</td>
<td>200-750</td>
<td>&lt;200</td>
</tr>
</tbody>
</table>
**BIOLOGICAL CRITERIA CALIBRATION & DERIVATION PROCESS:**

**INVERTEBRATE COMMUNITY INDEX (ICI)**

I. Select & sample reference sites

II. Calibration of ICI metrics

III. Calibrated ICI applicable to Ohio waters

IV. Establish ecoregional patterns/expectations

V. Derive numeric bio-criteria/codify in WQS

VI. Numeric biocriteria used in assessments

---

**REGIONAL REFERENCE SITES: ICI (Statewide)**

- HELP (n = 27)
- IP (n = 22)
- EOLP (n = 54)
- WAP (n = 57)
- ECBP (n = 82)

**DRAINAGE AREA (SQ MI)**

<table>
<thead>
<tr>
<th>Metric</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Mayfly Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Caddisfly Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of Dipteran Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Mayfly Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Caddisfly Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Tribe Tanytarsini</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Other Dipteran &amp; Non-insect Composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Tolerant Organisms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Total Qual. EPT Taxa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**ECOREGION**

Cuyahoga R.
Distribution of Reference IBI Scores by Ecoregion for Wading Sites
Ohio Numerical Biological Criteria

- Two organism groups - fish & invertebrates
- Three indices - IBI, MIwb, ICI
- Three site types - headwater, wadeable, boat
- Three use designations - WWH, EWH, MWH
- Reference sites number >450 (sampled 1981-1989); 10% were resampled each year 1990-99
- Codified in WQS in 1990 (OAC 3745-1-07; Table 7-14)
The Regional Reference Site Approach: The Role of Stratification

Recognizing the relative importance of landscape, geographic, physical, and socioeconomic factors in deriving regionally relevant benchmarks or criteria

Inter-Regional Factors:
• Ecoregions - overall synthesis of taxonomy, biogeography, diversity, ecological function, and attainability.
• Water Quality Standards - define goals and criteria.

Intra-Regional Factors:
• Site-Specific Stratification - stream size (drainage area, width), gradient, temperature, elevation, latitude etc.
LEVEL IV SUBREGIONS OF OHIO and INDIANA (after Woods et al. 1996)
Effect of Increased Numbers of Reference Site Samples on IBI Biocriteria Derivation

E. Corn Belt Plains: Wading Sites
Effect of Increased Numbers of Reference Site Samples on IBI Biocriteria Derivation
Effect of Increased Numbers of Reference Site Samples on IBI Biocriteria Derivation
Basis for implementing controls & management under CWA.
Consist of uses and criteria.
Focus of watershed planning and implementation.
Benchmarks of evaluating effectiveness of controls, funding, permits, BMPs, TMDLs, etc.

States are the principal custodians of WQS and the associated designated uses and criteria.
Aquatic Life designated Uses

Ohio Water Quality Standards

• Uses are portrayed as narratives.
• Chemical and biological criteria are assigned to each in accordance with the attributes ascribed by the designated use narrative.

Uses Are Based on Demonstrated Potential (in order of importance)

• Attainment of the biological criteria.
• Habitat assessment demonstrates the potential to attain the designated use.
• Attainment of uses is tracked in State 305[b] reports.
Aquatic Life Use Designations: Ohio WQS

Based on Biological Community Attributes

• **Exceptional Warmwater Habitat (EWH):** preserve & maintain existing high quality.
• **Warmwater Habitat (WWH):** basic restoration goal for most streams.
• **Modified Warmwater Habitat (MWH):** attainable condition for streams under drainage maintenance or other essentially permanent hydromodifications (e.g., impoundments).
• **Limited Resource Waters (LRW):** essentially irretrievable, human induced (e.g., widespread watershed modifications) or naturally occurring conditions (e.g., ephemeral flow).
Use Attainability Analysis I: Are CWA Goal Uses Attainable?

**U.S. EPA regulations allow lower than CWA goal uses where precluded by:**
- naturally occurring pollutant levels;
- natural flow conditions (i.e., ephemeral)**;
- human-induced conditions which cannot be remediated;
- hydrological modifications (dams, diversions, channel modifications) which cannot be operated in a manner consistent with the CWA goal use;
- natural physical features (substrate, flow, depth);
- controls to attain use would cause widespread, socioeconomic impacts.

** - does not apply when flow is augmented by an effluent discharge.

Source: 40 CFR Part 131.10 (g)(1-6)
Influence of Modified Habitat Attributes on the IBI and Biological Integrity

![Graph showing the ratio of modified water habitat attributes across different IBI ranges.](image)

$N = 666$ Sites

Scioto River: Columbus to Circleville

EWH Criterion (IBI = 48)

VWH Criterion (IBI = 42)

Impounded

1980
1991
1994
The Stillwater R. is classified and attains exceptional status (EWH) in the larger mainstem.

The cumulative effects of hydro-modification, riparian encroachment, and nutrient enrichment are associated with widespread impairment in the upper Stillwater and all of the Wabash subbasins.
Biological Response Signatures: Key Attributes

- Heavy Tumor on a Carp
- Heavy Erosion on a Silver Redhorse
- Heavily Eroded Barbels & Deformities on a Yellow Bullhead
- Normal Barbles on a Yellow Bullhead
- Cricotopus Midge: A Key Indicator of Toxicity
- Oligochaetes: A Key Indicator of Organic Enrichment

Cricotopus Midge: A Key Indicator of Toxicity
Biocriteria Metrics Can Aid in Distinguishing Different Types of Impacts: Anomalies on Fish

after Yoder and Rankin (1995)
BIOLOGICAL RESPONSE SIGNATURES: Complex Toxic vs. Agric. NPS (Row Crop)

PRIMARY: Complex Toxic
SECONDARY: All (n = 106)

vs.

PRIMARY: Agricultural NPS
SECONDARY: All (n = 381)

after Yoder and Rankin (1995)
BIOLOGICAL RESPONSE SIGNATURES: Complex Toxic vs. Municipal WWTP

PRIMARY: Complex Toxic
SECONDARY: All (n = 106)

vs.

PRIMARY: Municipal Conventional
SECONDARY: All (n = 273)

HELP/ECBP Ecoregions

after Yoder and Rankin (1995)
MANAGEMENT RESPONSES AND OPTIONS ALONG THE BIOLOGICAL CONDITION AXIS

Quality State Gradient & Descriptors:
- Substantially Altered
- Highly Degraded
- Severely Degraded
- “Dead”

Management Responses/Options:
- Preservation
- Restoration
- Enhancement
- Irretrievable

“Pristine” to “Dead”

Maximum to Minimum Scale of Measurement

Low to High Stressor Effect
DESIGNATED USE OPTIONS ALONG THE BIOAXIS AND BIOLOGICAL CONDITION GRADIENT

- **Minimum**
- **Very Good**
- **Preservation Uses**
- **Good**
- **Marginal Good**
- **Restoration Uses**
- **Fair**
- **Modified Uses**
- **Poor**
- **Limited Uses**
- **Very Poor**
- **Exceptional**
- **Very Poor**
- **Low**
- **High**
- **Stressor Effect**
- **Scale of Measurement**
- **Condition Gradient**
- **Designated Use Options**

**Designated Use Options**
- Preservation Uses
- Restoration Uses
- Modified Uses
- Limited Uses
- Exceptional
- Very Good
- Good
- Marginally Good
- Fair
- Poor
- Very Poor
Using Indicators to Evaluate Causal Associations & Trends

**Rocky Fork Mohican River:** WWH Use (existing)

**Major Point Sources:**
- Mansfield WWTP
  - [Industrial Pretreatment]
- Armco Steel

**Other Stressors:**
- Luntz Corp. Scrap yard
- Channelization

**Key Indicators:** (Levels 4&6)
- Biological Response Signatures [IBI, DELT Anomalies]
- Chemical (Sediment Chemistry)
Using Biocriteria to Evaluate Chemical Contaminant Thresholds: Metals in Sediment

- Direct correlation of heavy metals in sediment with the IBI and %DELT anomalies statewide.
- Determine highest concentrations at which biocriteria are attained, thus evaluating protectiveness of threshold concentrations.
- Does not rule out adverse effects at lower concentrations - other test data needed.
- Can be used to evaluate the risk of toxic contamination in bottom sediments to aquatic life.
Biocriteria Can Be Used to Validate the Accuracy of Chemical Water Quality Criteria: Metals

- The Ohio EPA statewide database was used to correlate ranges of biological quality with heavy metals concentrations.
- Proposed criteria changes for copper, cadmium, zinc, & lead were evaluated.
- The results were used to develop biologically-based application guidelines for the use of dissolved metals in calculating wasteload allocations for point sources.
Channel Condition Affects the Abundance and Size of Smallmouth Bass in Ohio Streams & Rivers

- Smallmouth bass are one of the most popular and widespread game fish in Ohio and are a sentinel species for WWH and EWH streams and rivers.
- Adverse effects of channel modification to smallmouth bass include loss of cover, loss of pools, degradation of substrates, and food web alterations.
Aquatic Life Use Attainment Statistics By Cycle

- **Proposed Year 2010 Goal**
- **Previous Year 2000 Goal**

**Percent of Miles Attaining Aquatic Life Uses**

- **Predicted**
- **Actual**

<table>
<thead>
<tr>
<th>Assessment Cycle</th>
<th>Predicted</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>34.6%</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>39.4%</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>49.8%</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>45.4%</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>52.9%</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>57.4%</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>61.7%</td>
<td>52.3%</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td>66.1%</td>
</tr>
</tbody>
</table>

2000 Forecast Analysis:
Point/Nonpoint Source Impairment

2000 Forecast Analysis:
Point/Nonpoint Source Impairment

% Impairment Associated Primarily With Nonpoint Sources

% Impairment Associated Primarily With Point Sources


Assessment Cycle

% of Assessed Stream and River Miles

1988: 45.4%
1990: 41.7%
1992: 70.8%
1994: 8.7%
1996: 5.4%
1998: 82.0%
2000: 82.0%
2002: 5.4%

Forecasted

Nonpoint Source
Both
Point Source

Observed

Ohio 2010 Goal
Hierarchy of Environmental Indicators

**Adminstrative**
- **LEVEL 1**: Actions Taken by EPA/States

**Stressor**
- **LEVEL 2**: Responses by Regulated Community
- **LEVEL 3**: Changes in Discharged Quantities

**Exposure**
- **LEVEL 4**: Changes in Ambient Conditions
- **LEVEL 5**: Changes in Uptake & Assimilation

**Response**
- **LEVEL 6**: Changes in Health/Ecol. Condition
Misperceptions of Reference Condition: II

Some Solutions

• Use integrative measures such as biological criteria.
• Tiered uses in WQS foster stratified management goals.
• Understand full range of system response - gradient of quality and degradation.

Important Framework Elements

• Robust biological assessment tools with sufficient data quality objectives and calibration processes.
• Regionalization to support WQ management at the appropriate scale.
• Adequate monitoring & assessment using multiple indicators in their most appropriate roles.
QUESTIONS