National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

Coeur d'Alene, Idaho
31 March – 4 April, 2003

BIO 101

INTRODUCTION TO BIOLOGICAL ASSESSMENTS & CRITERIA

Course Presenters

William Swietlik, Michael Barbour, Chris Yoder

National Biological Assessment and Criteria Workshop

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BIO 101

Introduction

Presented by

William Swietlik, USEPA
Office of Science & Technology

Take Home Concepts

The Basics:

- What are biological assessments and criteria.
- How they are derived.
- How they fit into water quality standards.
- How they can be used in water quality management.

THEME

"The true health of our aquatic environments is reflected by the biological communities that reside within them"

Prof. J. Karr

University of Washington

CWA SECTION 101 Objective

To Restore & Maintain the Chemical, Physical, & *Biological Integrity* of the Nation's Waters

Elements of Ecological Integrity

ECOLOGICAL INTEGRITY

BIOLOGICAL INTEGRITY

Definition:

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.

STATUTORY AUTHORITY

Section 303(c)2(B):

"...where numeric criteria are not available, States shall adopt criteria based on biological.. assessment methods…"

STATUTORY AUTHORITY

Section 303(c)2(A):

...State water quality standards shall consist of designated uses of navigable waters and the criteria for protecting such uses.

...State water quality standards shall protect and enhance the quality of water and serve the purposes of the Act, including propagation of fish and wildlife.

THE LINKAGE FROM STRESSOR EFFECTS TO ECOSYSTEM RESPONSE

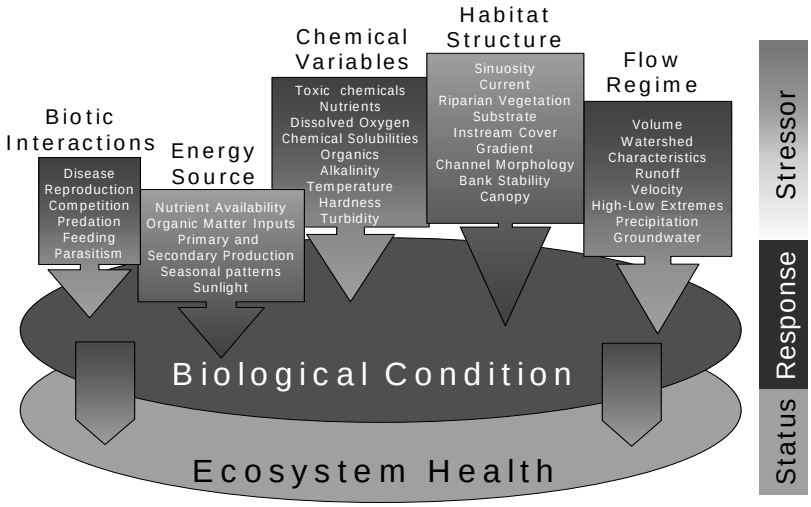
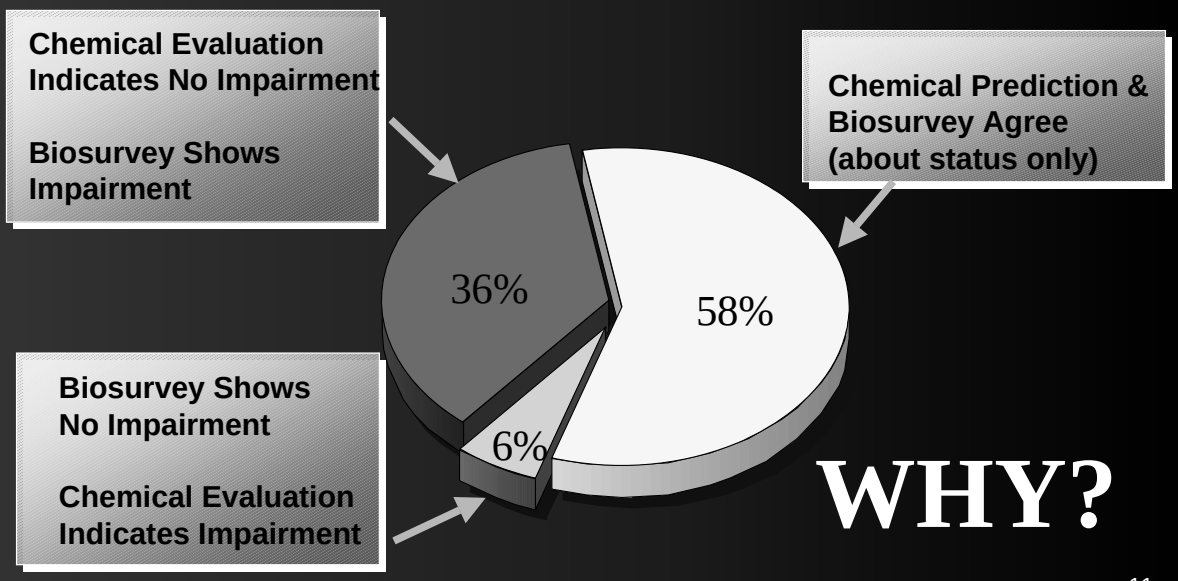


Figure 1. Five classes of environmental variables that affect water resource integrity and overall biological condition (modified from Karr et al. 1986).

VALUE OF BIOLOGICAL CRITERIA:
Ohio Comparison of Biosurvey with Chemical Evaluation



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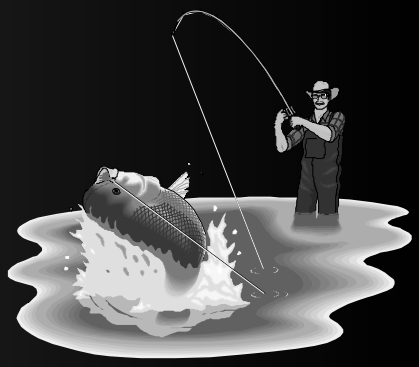
BIOASSESSMENT

Definition:

An evaluation of the biological condition of a water body using biological surveys of the structure and function of the community of resident biota.

BIOLOGICAL CRITERIA (Biocriteria- in Standards Sense)

Definition: ***narrative descriptions or numerical values of the structure and function of aquatic communities in a water body necessary to protect the designated aquatic life use, implemented in, or through water quality standards.***



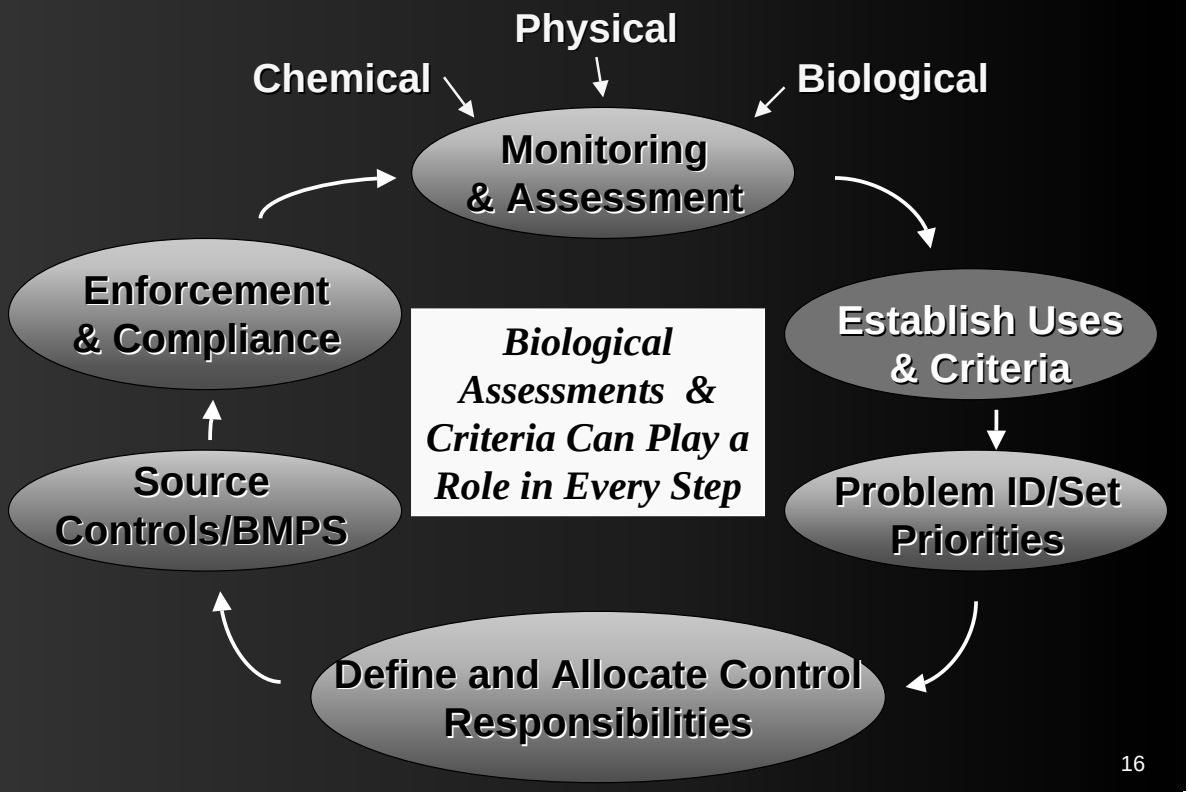
NARRATIVE AND NUMERIC BIOCRITERIA

- ✓ ***Narrative Biocriteria***- General Statements of the Structure and Function of Aquatic Communities in a Water Body Necessary to Protect the Designated Aquatic Life Use.
- ✓ ***Numeric Biocriteria***- Specific Quantitative Measures of the Structure and Function of Aquatic Communities in a Water Body Necessary to Protect the Designated Aquatic Life Use.

Other Meaning

- **Biocriteria– (scientific)** ***quantified values representing the biological condition of a water body as measured by structure and function of the aquatic communities typically at reference condition.***

CWA WATER PROGRAM



TYPICAL APPROACHES TO BIOCRITERIA DEVELOPMENT

✓***Multimetric Index*:** a number that integrates one or more biological metrics to express a site's condition or health. (IBI).

✓***Multivariate Predictive Model:*** a predicted value of the biological condition based on what is observed at a site versus what is expected. (RIVPACS)

✓***Discriminant Models:*** based on aquatic life use classes

MULTIMETRIC APPROACH

Attribute: any measurable component of a biological system.

Metric: attribute that shows a quantitative change in value along a gradient of human influence.

Multimetric Index: a number that integrates several biological metrics to express a site's condition or health. ***Index of Biotic Integrity (IBI).***

MEASURES OF COMMUNITY STRUCTURE AND FUNCTION (Metrics)

- ✓ Species Richness
- ✓ Tolerant/Intolerant Species
- ✓ Distribution of Trophic Feeding Groups
- ✓ Diseases and Anomalies
- ✓ Number of Individuals
- ✓ Non-native Species
- ✓ Reproductive Preferences
- ✓ Total Number of Species
- ✓ Mean Individual Size Measurement
- ✓ Biomass

PROCESS FOR DEVELOPING & IMPLEMENTING BIOLOGICAL CRITERIA

DEVELOPING BIOCRITERIA
(Multimetric approach)

1. Select Standardized, Consistent Biosurvey Protocols
2. Classify Water Bodies into Similar Groups or Classes
3. Identify Reference Sites in Each Class
4. Conduct Bioassessments at Unimpaired Reference Sites in Each Class
5. Derive Reference Conditions for Each Class
6. Conduct Bioassessments at Impacted Sites

DEVELOPING BIOCRITERIA

7. Test Attributes for Response to Gradient of Conditions
8. Select Responsive Metrics
9. Develop Scoring Criteria for Each Metric
10. Aggregate Metrics With Scoring Criteria to Derive Biocriteria Index
11. Develop Biocriteria for each Aquatic Life Use
12. Apply Biocriteria to Water Bodies to Protect Those Uses

Review Fish IBI Metrics for North America and Karr IBI

Multivariate Approach – (RIVPACS)

Figure out which taxa you should probably capture = E

Compare to what you actually observe = O

The final measure = percent of expected taxa present

= O/E

Steps in the Multivariate Process

1. **Describe the continuum of assemblage types using 'reference' streams**
2. **Link assemblage types to physical-chemical features**
3. **Predict expected (E) assemblage of a test stream based on physical appearance**
4. **Compare to the observed (O) assemblage**
5. **O/E provides a simple measure**




KEY COMPONENTS OF BIOLOGICAL CRITERIA

- ✓**Biological Surveys**
- ✓**Classification**
- ✓**Reference Condition**

KEY COMPONENTS OF BIOLOGICAL CRITERIA

Biological Surveys

SELECTING COMMUNITY COMPONENTS

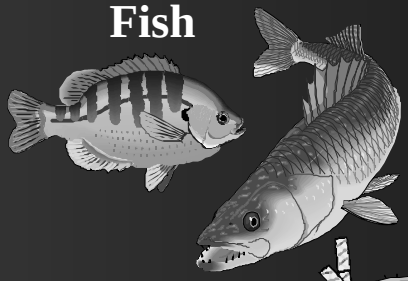
Target Species & Taxa

- ✓ **Serve as Effective Indicators of Biological Response to Effects of Human Activity**
- ✓ **Represent a Range of Pollution Tolerances**
- ✓ **Provide Predictable, Repeatable Results**
- ✓ **Are Readily Identifiable by State Personnel**

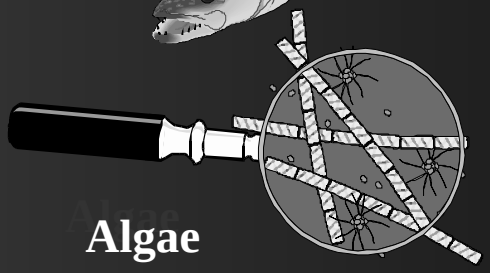
COMMUNITY COMPONENTS

Streams, Small Rivers, Lakes, Estuaries

Fish



Macroinvertebrates

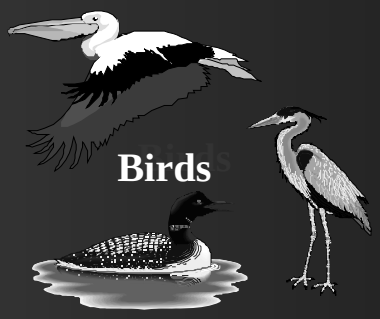


Algae

Zooplankton

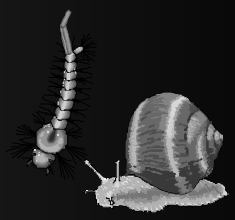
COMMUNITY COMPONENTS

Wetlands

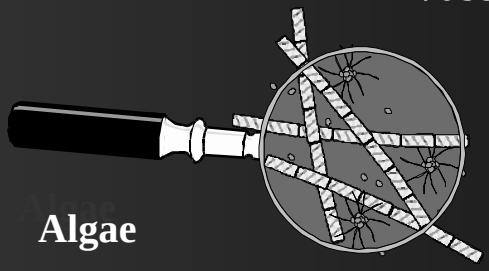


Birds

Macroinvertebrates



Vascular Plants



Algae

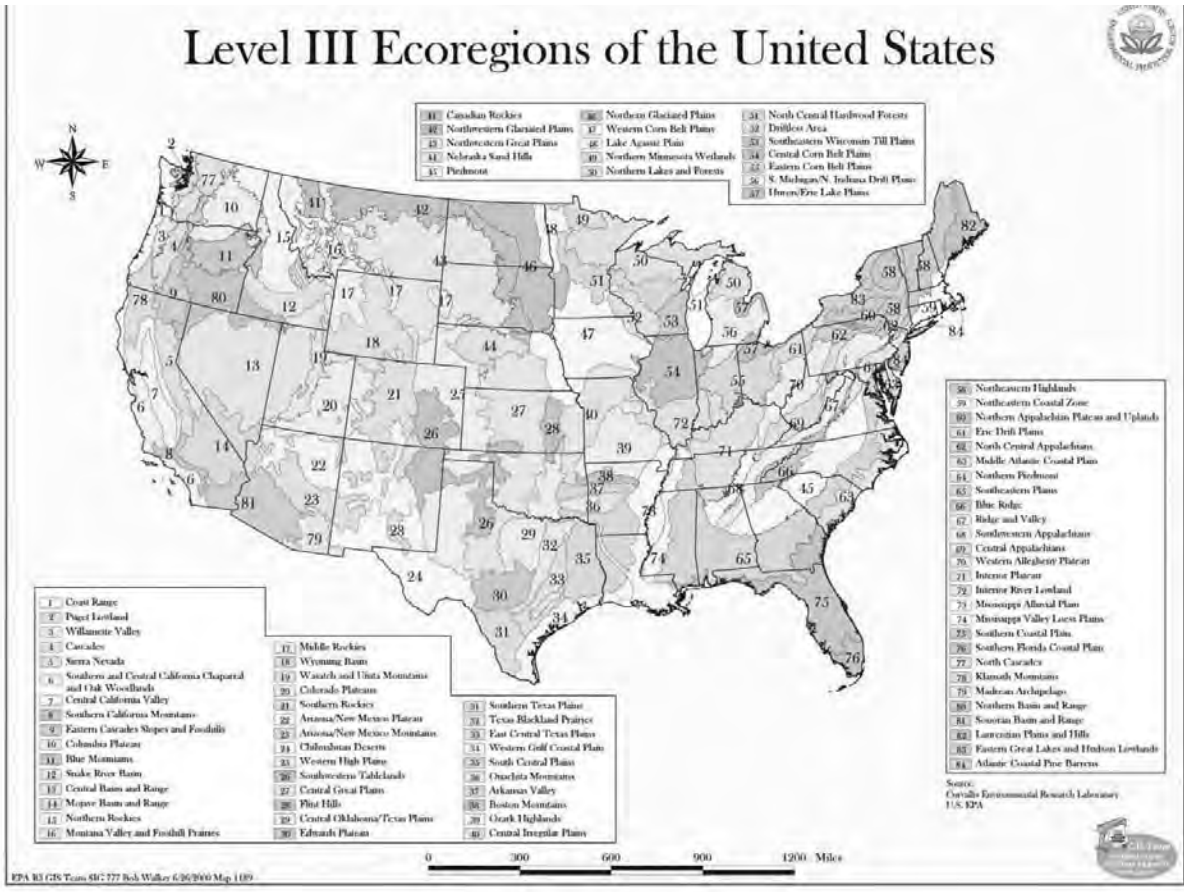
Amphibians

Bioassessment -- Streams and Small Rivers

Invertebrate community bioassessment using a kicknet

CLASSIFICATION

- ✓ **Identifies Regions of Ecological Similarity from Which To Select Reference Sites.**
- ✓ **Biological Conditions Expected to be Similar.**



REFERENCE CONDITION

The benchmark for determining biological conditions.

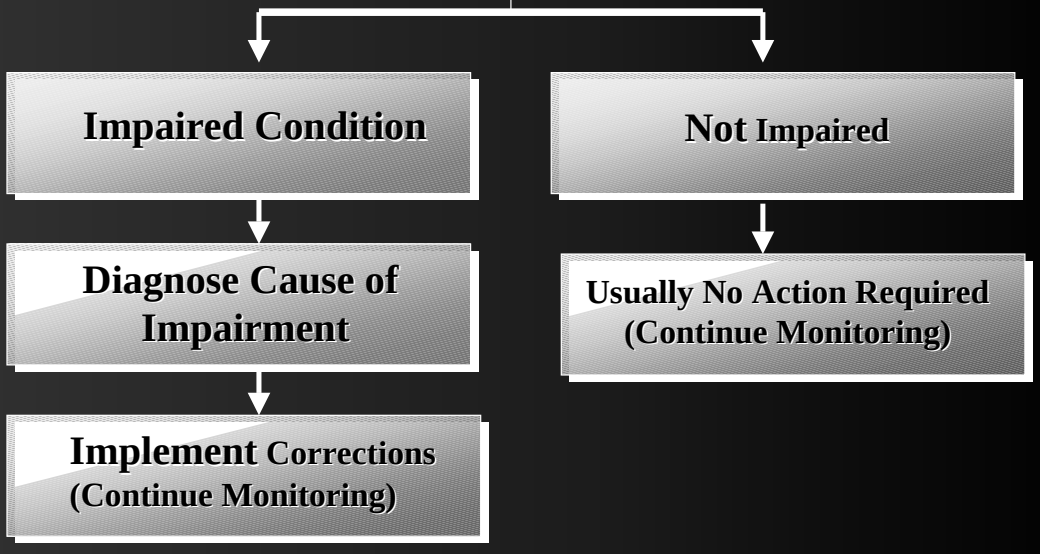
- **Regional Reference Sites**
- **Site-Specific Reference Sites**
- **Historical Data**
- **Model-Based Approach**
- **Expert Opinion**

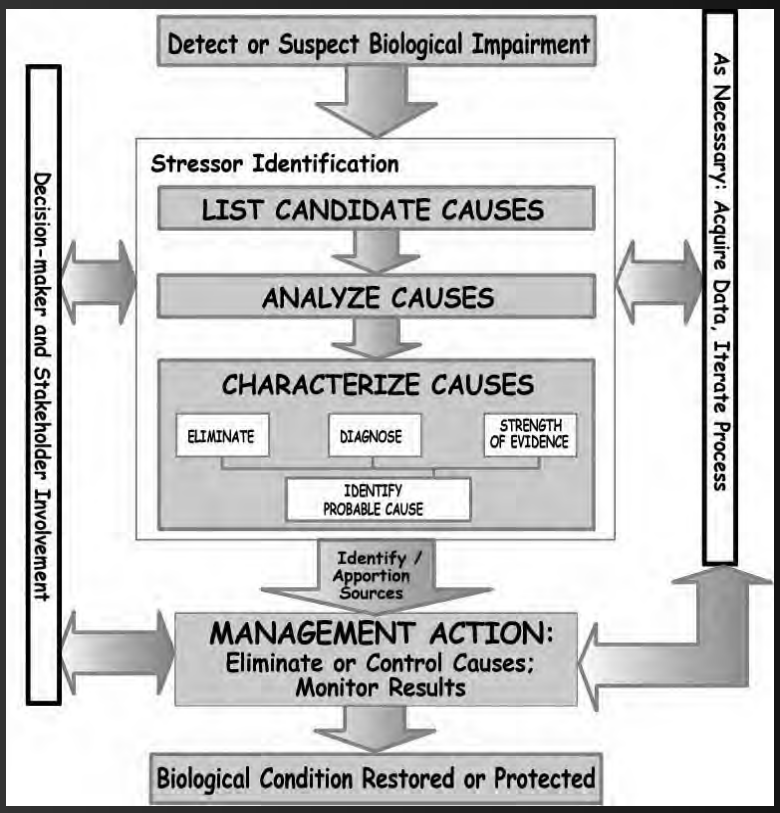
Review Examples of Narrative Biocriteria

Review Examples of Numeric Biocriteria

APPLYING BIOCRITERIA

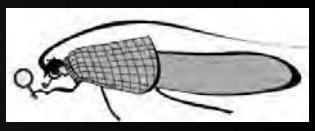
Sample test sites and compare to biocriteria





Stressor Identification

Identifying Unknown causes of biological impairment



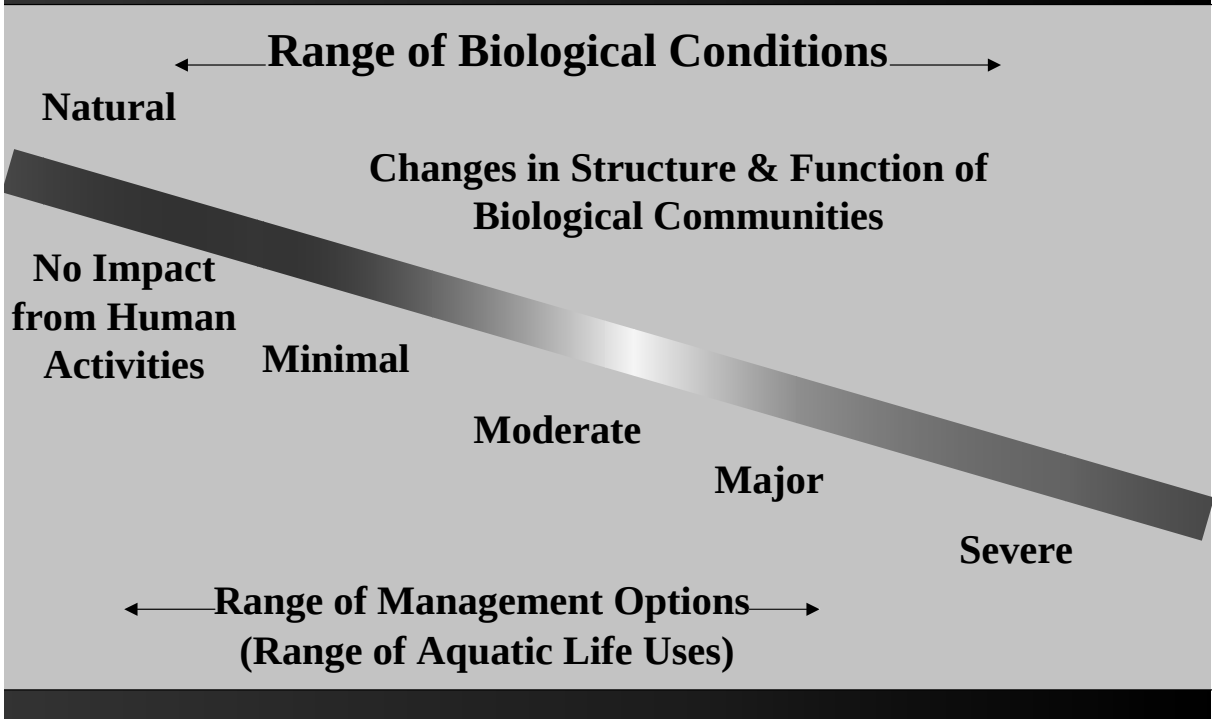
APPLYING BIOCRITERIA IN WATER QUALITY STANDARDS

Biological Assessments and Criteria Can Be Used to Better Define and Protect Aquatic Life Uses

- **"*Bioassessment-based*" designated uses can be subcategorized (or tiered) according to reference conditions, restoration potential, human disturbance and management objectives.**

- **Once *bioassessment-based* designated uses are established, they can be protected by biocriteria.**

BIOLOGICAL INTEGRITY AND DESIGNATED USES



Hypothetical Subcategorized Biologically-Based Aquatic Life Uses

Biological Condition

Designated Uses	
Cold water salmon fishery/natural spawning	IBI = 60
Cold water salmon nursery/rookery	IBI = 50
Cold water salmon passage	IBI = 40
Seasonal cold water salmon passage	IBI = 30
Habitat restoration	IBI = 20
Limited aquatic life habitat	IBI = 10

PROGRAM GOALS

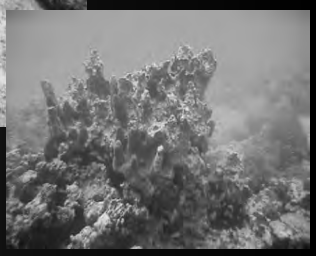
✓All States use bioassessments to **evaluate the health** of aquatic life in all waterbodies

✓Bioassessment data is used to **better define aquatic life uses**

✓**Quantifiable biocriteria** are in all State/Tribal water quality standards to protect aquatic life uses

✓Biocriteria/bioassessments used to **assess the effectiveness of water quality management efforts**

✓Bioassessment data and biocriteria used to better **communicate the health** of the Nation's waters



FUTURE DIRECTIONS

- **Great Rivers**
- **Coral Reefs**
- **Great Lakes**
- **Intermittent and ephemeral streams**

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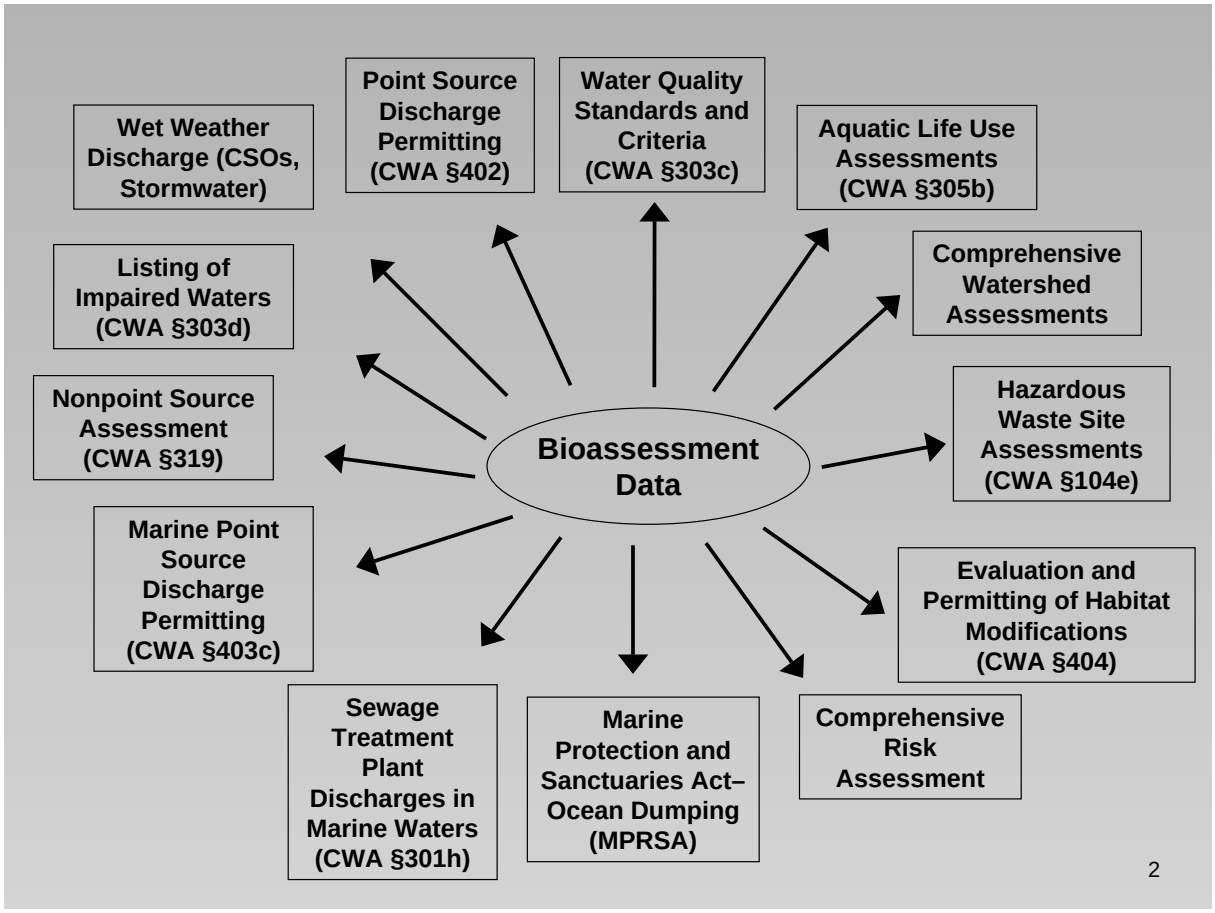
Technical Components of an Adequate Bioassessment Program

Michael Barbour, Tetra Tech, Inc.

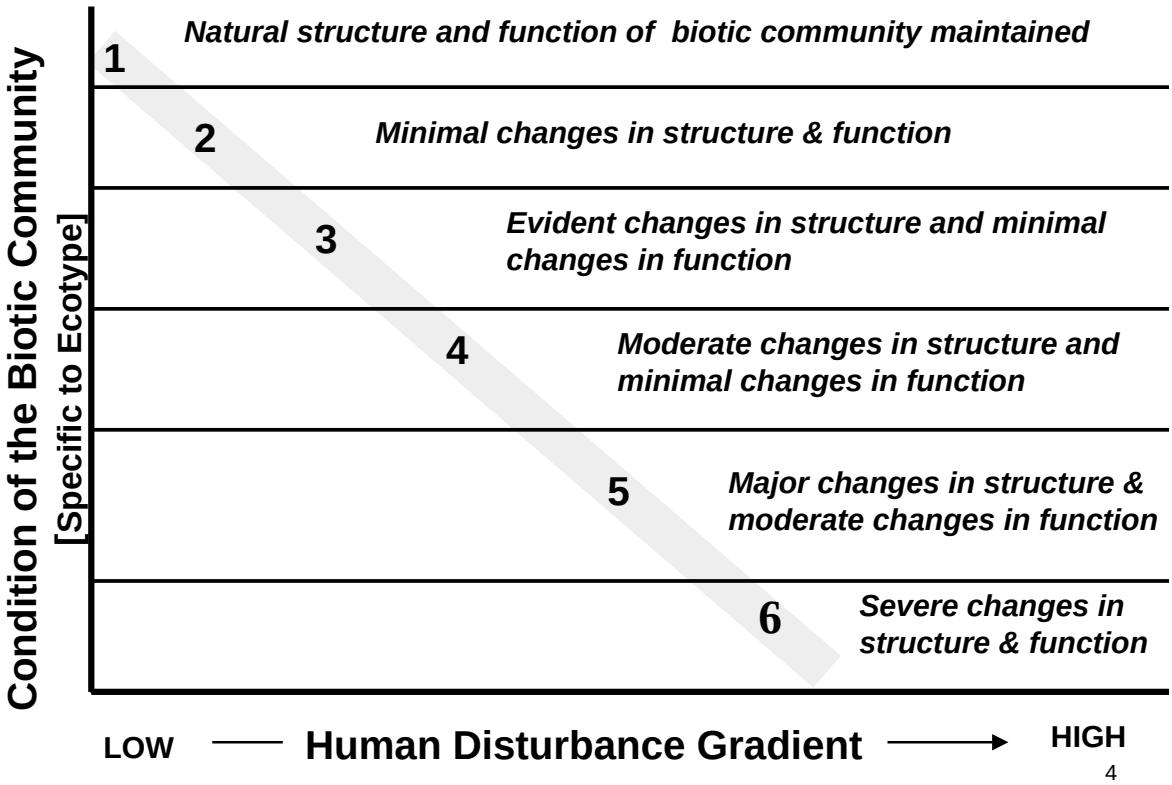
Chris Yoder, Midwest Biodiversity Institute



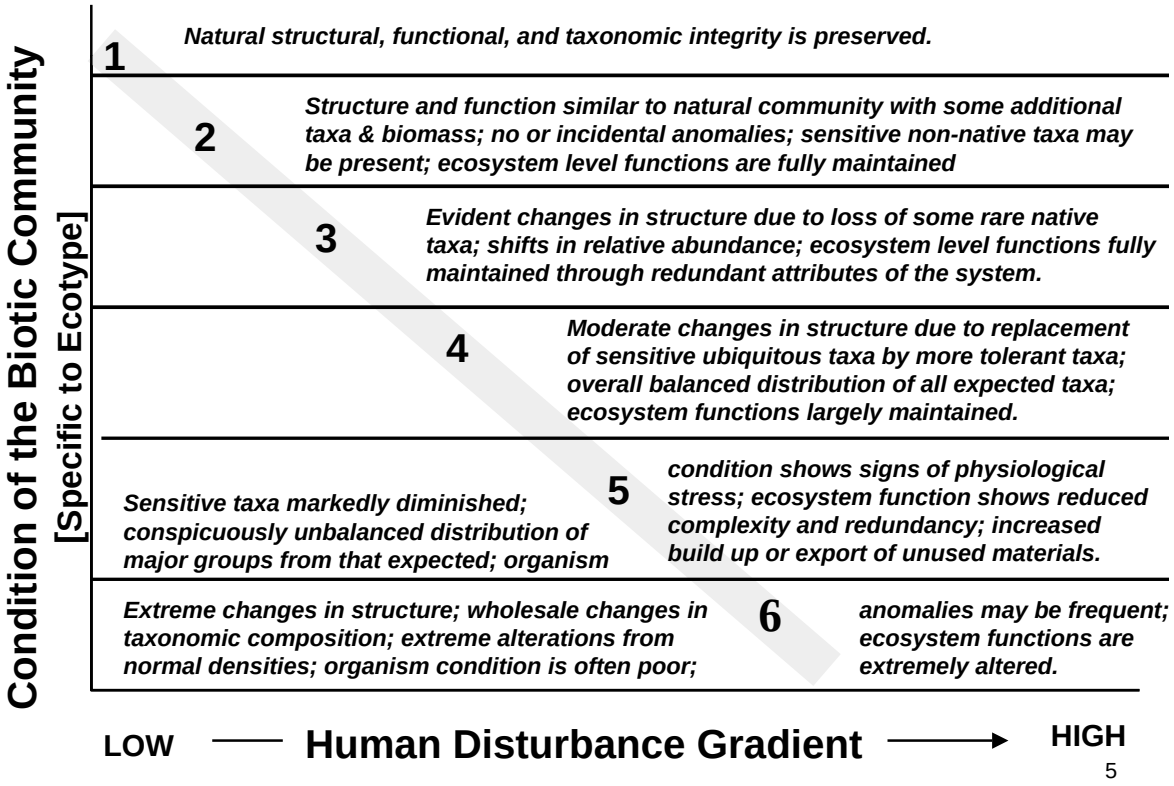
Levels of Rigor for Bioassessment

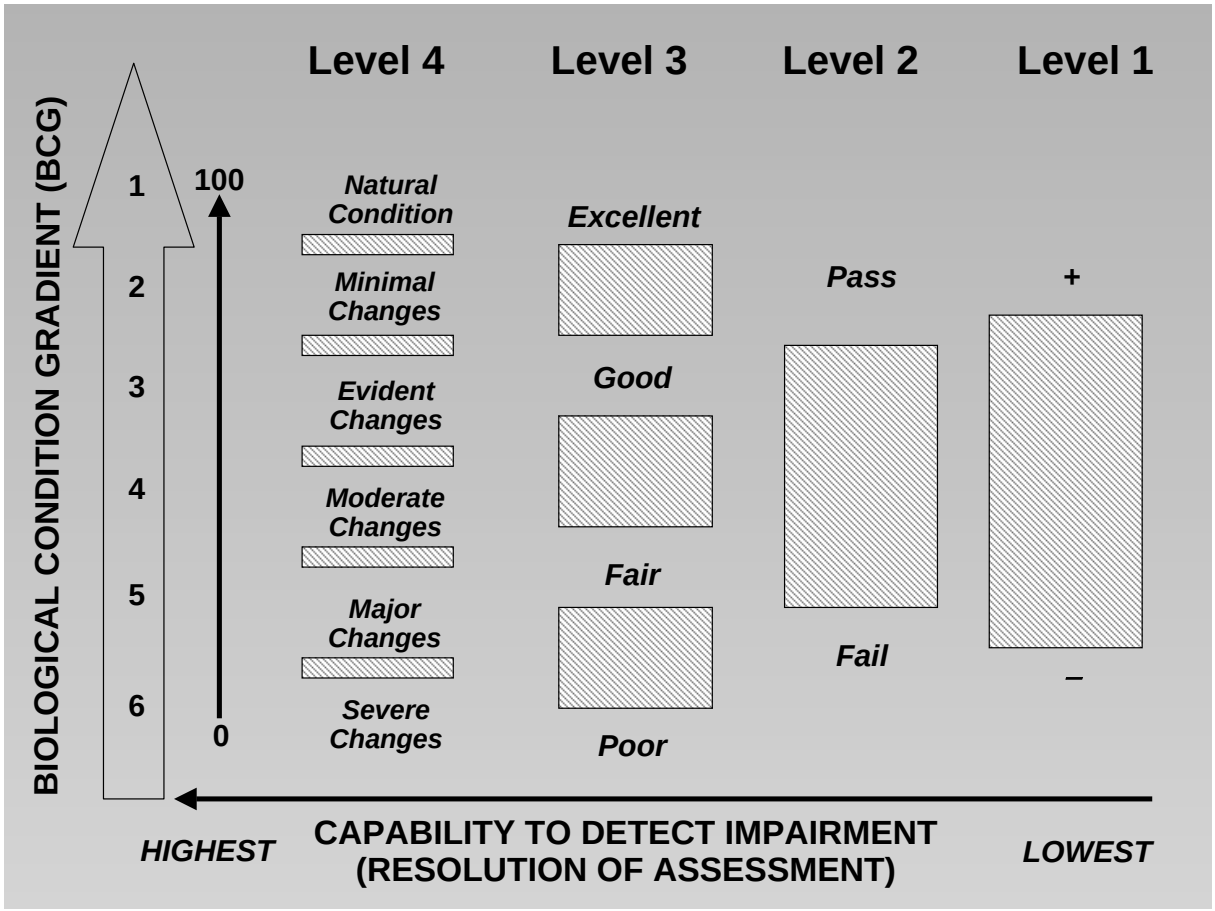
- Good quality ecological data are integral to effectively answer questions on condition, protection, restoration, etc.
- The rigor and quality of biological data are variable among agencies even though states and tribes use their data to address the same questions.
- Techniques with a low level of rigor will not be able to meet the levels of confidence required to support different decisions.

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers



Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers -2





Level of Bioassessment: Water Quality Management Program Support

Relative degrees to which the four different levels of bioassessment defined by the CALM process support selected water quality management program areas.

	Basic Reporting		WQS Program					Watersheds/NPS			TMDL/303d			NPDES/Other Permitting						
	Status	Trend	Tiered Uses	UAA	Refined WQC	Antideg.	Site Specific Crit. Mod.	NPS/ BMP Effect.	Habitat	Stressor ID	List/ Delist	TMDL Dev.	Severity/Extent	WQ BELs	Priority Setting	CSOs/ SSOs	Stormwater Ph I & II	WET Limits/ Cond.	Enforcement	Dredge & Fill
1	• • • •	•	—	—	—	—	—	• • •	•	—	—	—	—	—	—	—	—	—	—	—
2	• • • •	• •	•	•	—	• •	—	• • •	•	—	• •	—	• •	—	—	• • •	•	—	—	—
3	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •	• • • •
4	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •	• • • • • •

• • • • Comprehensively fulfills program support role by providing robust and complete assessment including scientific certainty, accuracy and relevancy of condition assessment, and causal associations.

• • • Capable of providing program support, but cannot provide sufficiently robust, detailed, or accurate assessment information in all cases or at all scales; determination of causal associations may be limited in given instances.

• • Insufficient to provide the level of detail and resolution needed to go beyond pass/fail assessments; accuracy is limited and little or no resolution for determining severity and magnitude and for causal associations.

— Inadequate for program support due to limited accuracy, resolution, detail, and power of assessment.

C. Levels of rigor for bioassessment ranging from the lowest (Level 1) to the highest rigor (Level 4). Make a check ☑ in the appropriate box for each topical category:

	L1	L2	L3	L4
I. Key Technical Elements for a Bioassessment Program				
1. Temporal Coverage				
o **No consistent index period**				
o **Index period for convenience, varies**				
o **Documented index period, may vary**				
o **Comprehensive coverage within index period**				
2. Spatial Coverage				
o **Simple design, no statewide coverage**				
o **"Synoptic" design (8 digit HUC)**				
o **Rotating basin; single design (8 digit HUC)**				
o **Statewide; comprehensive rotating basin; multiple designs (11-14 digit HUC)**				

1. Temporal Coverage

Level 1	Level 2	Level 3	Level 4
• No index period • Sampling can be scattered throughout the year	• Index period for convenience in sampling or to match existing programs • Sampling outside the index period may be done, but reserved for emergency response monitoring	• Well-documented seasonal index period(s), or coverage is comprehensive • Sampling outside index period is adjusted for seasonal influences	• Well-documented seasonal index period(s) • Multiple samplings at sites during index period(s) • Index period(s) based on known ecology to minimize natural variability and maximize gear efficiency

2. Spatial Coverage

Level 1	Level 2	Level 3	Level 4
• Individual site survey • Up/downstream and Fixed station design • No statewide assessment	• Multiple sites • Spatial design limited to a few basins • Synoptic design at 8-digit HUC common	• Well established spatial network • Statewide design using rotating basins • Single design	• Well established spatial network • Statewide design using comprehensive rotating basins • Multiple study designs

3. Reference Conditions

Level 1	Level 2	Level 3	Level 4
• No formal reference conditions • Basis may be presence and absence of key taxa • Professional opinion may be used	• Pre-established by professional and based on known ecology of area • Site-specific control or paired watershed approach • Regional sites generally not used	• Site-specific or watershed based • Regional reference sites developed but too few or do not reflect statewide coverage	• Regional reference conditions for each waterbody ecotype, consisting of sites and/or other means of establishing regional expectations

4. Criteria for Reference Sites

Level 1	Level 2	Level 3	Level 4
• Best professional judgment (BPJ) • Support from quantitative data lacking	• Based on "best biology", i.e., BPJ on what best biology would be at reference • Minimal non-biological data	• Non-biological criteria supported by narrative descriptors only • Combine BPJ with narrative description of land use and site characteristics	• Quantitative descriptors to support non-biological criteria • Best expectations established for a biological framework • Phys/chem secondary

5. Natural Classification

Level 1	Level 2	Level 3	Level 4
• No partitioning of natural variability in aquatic ecosystems • Minimal classification limited to watersheds or basins	• Statewide or regional classification based on one stratum	• Classification based on a combination of landscape features and physical habitat structure of waterbody type	• True regional classification that transcends jurisdictional boundaries to strengthen inter-regional classification

6. Aquatic Resource Classification

Level 1	Level 2	Level 3	Level 4
• Classification strata lacking • Single, general aquatic resource considered throughout waterbody type	• General classification recognizes sub-assemblage attributes, e.g., fishery based coldwater and warmwater streams • No subcategories	• Well-defined subcategories of aquatic resource with distinctive assemblages • May only be developed for one ecotype	• Fully partitioned and stratified classification of resource • All relevant ecotypes addressed and includes full range of BCG

7. Indicator Assemblages

Level 1	Level 2	Level 3	Level 4
• Single assemblage • Visual observation of biota • Poor taxonomic resolution	• Single assemblage (usually macro-invertebrates) • Low taxonomic resolution (family level or higher)	• Single assemblage • High data quality and reliable taxonomic resolution to lower levels (genus/species) • If multiple assemblages, one is low resolution or used infrequently	• Two or more assemblages • High taxonomic resolution to the lowest practical taxon (mostly genus/species) • Formal certification program

8. Sample Collection

Level 1	Level 2	Level 3	Level 4
• Cursory documentation of methods, usually not written as SOPs • Highly variable methods, relying primarily on best professional judgment (BPJ)	• Textbook methods documented • Training consists of short courses (1-2 days)	• Methods detailed for state purposes • Formal QA/QC program • Rigorous training for new staff; periodic for all staff	• Same as Level 3, but methods cover multiple assemblages • Certification program in place

9. Sample Processing

Level 1	Level 2	Level 3	Level 4
• Field processing using visual guides • Dependent on operator skill	• Field processing and enumeration • No estimates of precision or accuracy • If fish, cursory examination of presence and absence	• Laboratory processing of all samples when QC control is high • Precision and accuracy is known	• Same as Level 3, but methods cover multiple assemblages • Whole samples may be processed

10. Precision of Assessments

Level 1	Level 2	Level 3	Level 4
• Precision is not determined • Capability of indicator to distinguish between human and natural influences is unknown	• Precision is known; enables more consistent sampling and higher precision • Capability of indicator to distinguish between human and natural influences has been determined based on other state or region studies	• Moderately high precision • Capability of indicator to distinguish between human and natural influences has been documented within state or tribe, but without gradient of stressors	• Highest precision • Capability of indicator to distinguish between human and natural influences high and based on a gradient of stressors

11. Ecological Attributes (as per BCG)

Level 1	Level 2	Level 3	Level 4
• No linkage to the BCG • No adherence to the ecological attributes	• Only inferences made to a few simple structural attributes • Sensitive/ tolerant ubiquitous	• Ecological attributes used as foundation • May not be fully developed • Surrogate measures used for key functional attributes • BCG conceptual underpinnings	• Level of rigor adequate to directly or indirectly address ecological attributes • Multiple assemblages

12. Biological Endpoints and Thresholds

Level 1	Level 2	Level 3	Level 4
• No formal index or community-based endpoint • Presence/ absence of targeted species based on visual assessment • Attainment thresholds not specified	• Index established for specific water-bodies, but likely not calibrated • Index relevant to only one assemblage • Presence/ absence based on all taxa • BPJ thresholds based on single dimension attributes	• Index developed and calibrated for state or region • Index relevant to only one assemblage • Attainment thresholds based on discriminant model or distribution of reference sites, or some means of quantifying reference condition	• Indexes for multiple assemblages developed and calibrated for use throughout state or region • Multiparameter evaluations based on integrated data calibrated to a regional reference condition

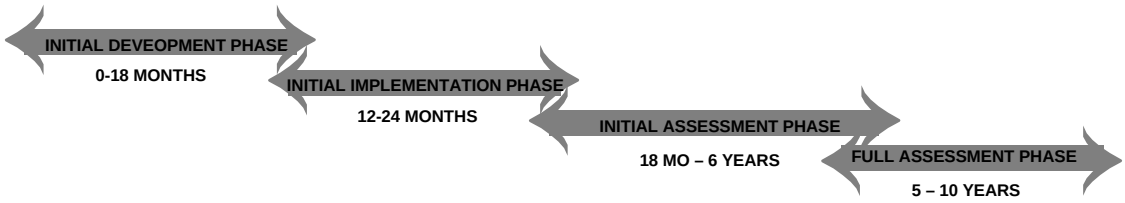
13. Sensitivity

Level 1	Level 2	Level 3	Level 4
• Coarse method (low signal) detects only high and low values	• Limited to pass/fail determinations of attainment status • No incremental measurement along BCG	• High signal to noise ratio • Power to detect 3 or 4 discrete levels on BCG • Quantitative support for narrative descriptions	• Integrated signal able to detect status on an incremental scale • Power to detect at least • 5 categories of condition

14. Diagnostic Capabilities

Level 1	Level 2	Level 3	Level 4
• No diagnostic capability due to lack of resolution • No interpretive experience	• Coarse indications of response via assemblage attributes • Little or no supporting analysis across spatial and temporal scales	• Development of indicator guilds and other aggregated attributes • Usually involves refined taxonomy • Supported by analysis of comprehensive datasets	• Response patterns are most fully developed and supported by case studies • Involves refined taxonomy for two or more assemblages

Bioassessment and Biocriteria Program Development Timeline



Start-Up Tasks: Logistics	Start-Up Tasks: Implementation	Program Implementation	Program Maintenance
Acquire Staffing: ▪ Professional biologists with expertise & training ▪ Database manager ▪ Interns/technicians (field work, lab tasks) **Acquire Facilities & Equipment:** ▪ Outfit laboratory and field facility ▪ Office accommodations ▪ Database support infrastructure **Methods Development:** ▪ Review and select candidate methods and protocols ▪ Consider MQO/DQO needs ▪ Test methods for applicability ▪ Analyze test results – select methods	**Initiate Field Sampling:** ▪ Review spatial designs ▪ Develop QA/QC and QAPP ▪ Develop sampling plans in accordance with monitoring strategy ▪ Pilot assessments **Classification Issues:** ▪ Consider spatial stratification issues ▪ Develop and test reference condition approach ▪ Select and sample reference sites ▪ Develop index development and calibration strategy	**Biocriteria Development:** ▪ Select candidate metrics and/or assessment tools ▪ Develop refined uses - narratives ▪ Test metrics and develop calibrated indices ▪ Evaluate via bioassessments **Water quality Program Support:** ▪ Develop capacity to support WQ programs (WQS/UAAs, TMDLs, permits, planning) ▪ Formalize water quality program support as capacity is developed	**Biocriteria Development:** ▪ Refine metrics and develop calibrated indices ▪ Develop reference benchmarks for calibrated indices according to classification scheme and by major aquatic ecotype **Water quality Program Support:** ▪ Fully functioning bioassessment program supports WQS (UAAs, aquatic life use support) and basic program needs (305b/303d) ▪ Program development should be fully initiated – e.g., integrated chemical, physical, and biological database supports criteria & policy development

Continuously evaluate program

Quality Improvement Process

Evaluate effectiveness of initial decisions – make needed adjustments

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Biological Assessments, Biocriteria & Water Quality Standards in Ohio

Presented by

Chris Yoder, Midwest Biodiversity Institute

Aquatic Bioassessments by Ohio EPA

Where

- Mainly rivers, streams, and small waterways
- In use and development for Lake Erie, Ohio River, and wetlands

What

- Fish, macroinvertebrates, physical habitat
- Sediments, water quality, fish contamination
- Biomarkers, other tools as developed

Why

- Provide empirical information for water quality management and decision-making
- Determine status of Ohio's aquatic resources
- Assure that waters are correctly classified

CORE INDICATORS

• Fish Assemblage • Macroinvertebrates • Periphyton
(Use Community Level Data From At Least Two)

Physical Habitat Indicators	Chemical Quality Indicators
• Channel morphology • Flow • Substrate Quality • Riparian	• pH • Temperature • Conductivity • Dissolved O_2

For Specific Designated Uses Add the Following:

AQUATIC LIFE
Base List:
- Ionic strength
- Nutrients, sediment

Supplemental List:
- Metals (water/sed.)
- Organics (water/sed.)

RECREATIONAL
Base List:
- Fecal bacteria
- Ionic strength

Supplemental List:
- Other pathogens
- Organics (water/sed.)

WATER SUPPLY
Base List:
- Fecal bacteria
- Ionic strength
- Nutrients, sediment

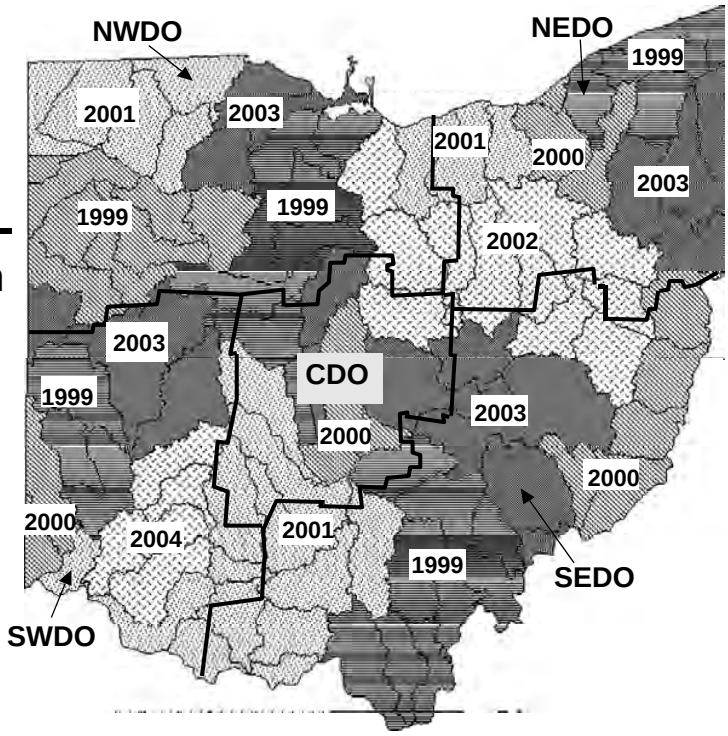
Supplemental List:
- Metals (water/sed.)
- Organics (water/sed.)
- Other pathogens

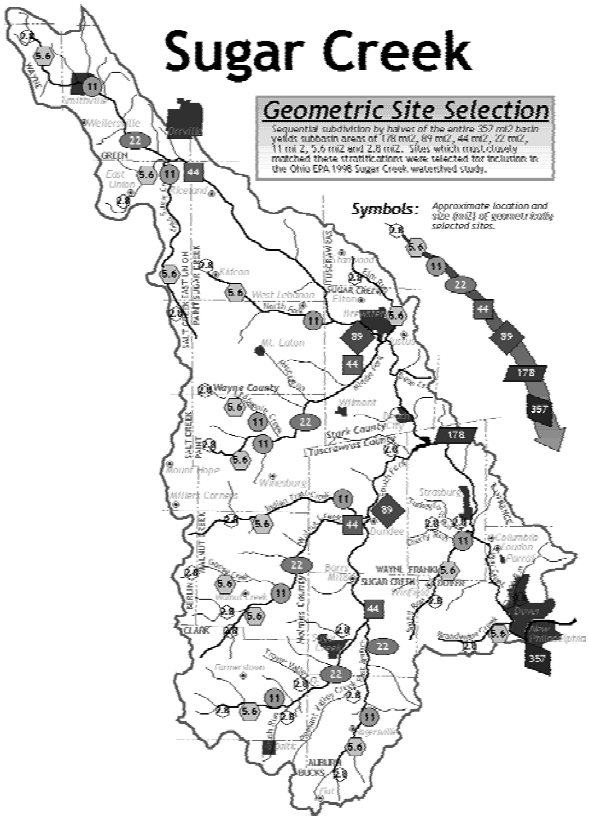
HUMAN/WILDLIFE CONSUMPTION
Base List:
- Metals (in tissues)
- Organics (in tissues)

ITFM Indicators

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.





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**

Ohio EPA Macroinvertebrate Methods: Field Procedures

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

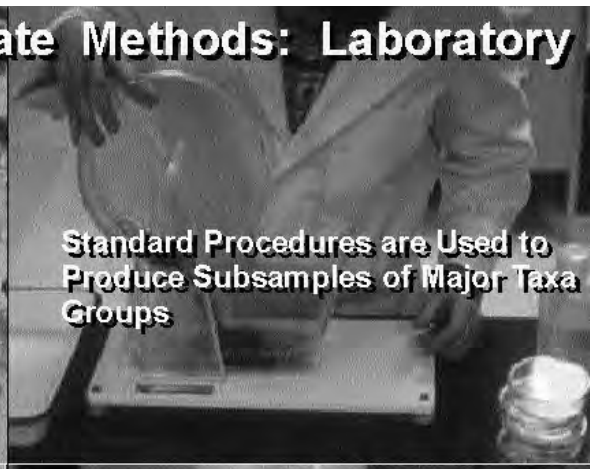
Artificial Substrates are Placed in Run Habitat with Constant Current

The 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 Taxa Groups

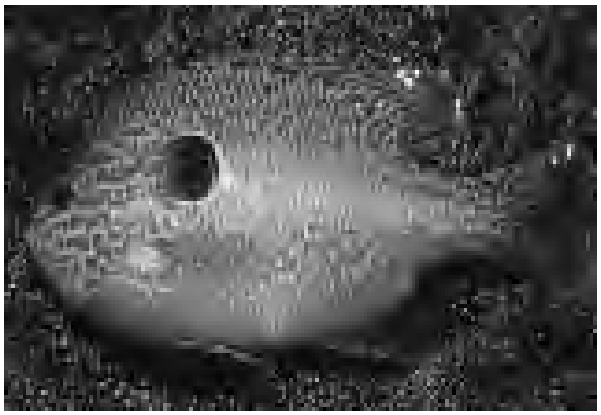
Portion of a Sample Ready for Identification

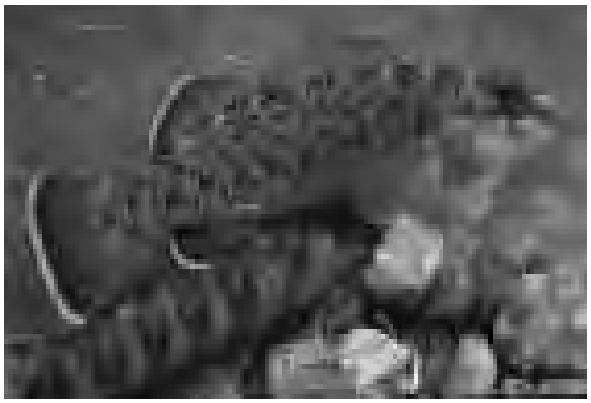
Identification to the Lowest Taxonomic Level Practicable is a Major Data Quality Objective

Macroinvertebrate Assemblage Assessment: Ohio EPA Approach

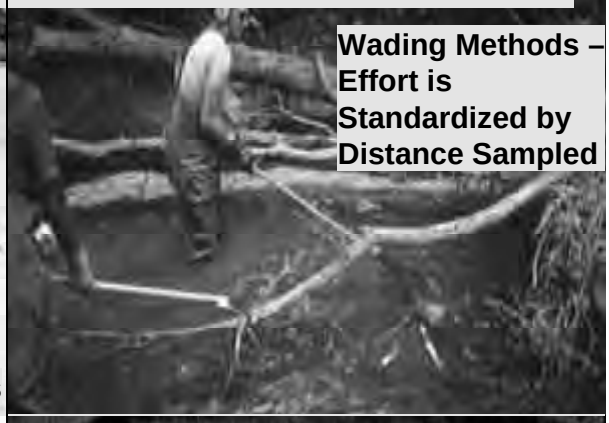
- Standardized & Representative Sampling - artificial substrates & qualitative dip-net/handpick methods, mid-June to late-September.
- Taxa Richness & Relative Abundance - counts and numbers per unit area (sq. ft.).
- Data Quality Objectives - lowest taxonomic level practicable for common orders/families (genus or species), standard keys.
- Key Component of Biocriteria - ICI and component metrics
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - ICI metrics are calibrated against stream and river size.
- Experienced Biologists - detailed familiarity with regional fauna, natural history, response signatures, impact types.

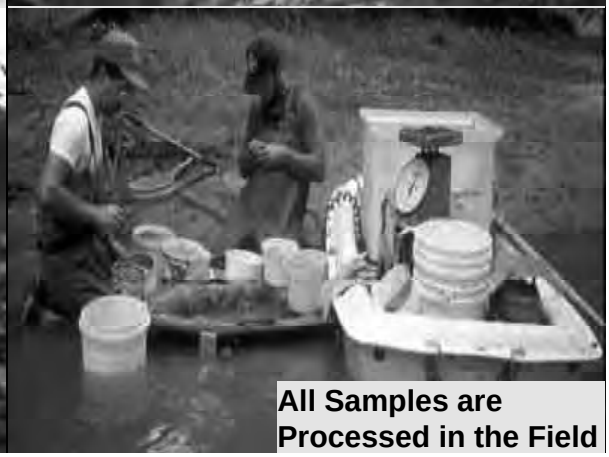
Fish are a widely identifiable component of aquatic systems and are valued for their recreational uses. Most species, however, are more obscure, and comprise the second most endangered group.





Ohio EPA Fish Assemblage Methods: Field Procedures

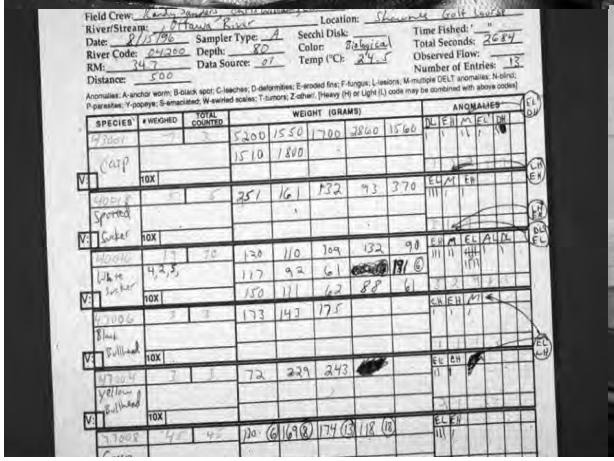




Fish Assemblage Assessment: Ohio EPA Approach

- Standardized & Representative Sampling - stratified pulsed D.C. electrofishing methods, mid-June to mid-October.
- Relative Abundance - numbers and weight (biomass) per unit distance (effort).
- Data Quality Objectives - genus/species based on regional ichthyology keys and AFS nomenclature.
- Key Component of Biocriteria - IBI, MIwb, and component metrics.
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - headwaters, wading, and boat sites; metric calibration accomplished for each strata.
- Experienced Biologists - regional fauna, natural history, response signatures, impact types.

Ohio EPA Fish Assemblage Methods: Sample Processing and Data Management Procedures



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)

QHEI: Qualitative Habitat Evaluation Index - I

What it is:

- A visual, qualitative method of measuring habitat quality
- Aids in designating aquatic life uses; ***may be conclusive in obvious cases***
- A set of stressor variables - it aids in assessing causes of impairments defined by the biological criteria
- Generally correlated with biological integrity
- Reach-level habitat quality is an important covariate
- Depends on standardized definitions of habitat types (training is very important)

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 Assigned Based on Demonstrated Potential (in order of importance)

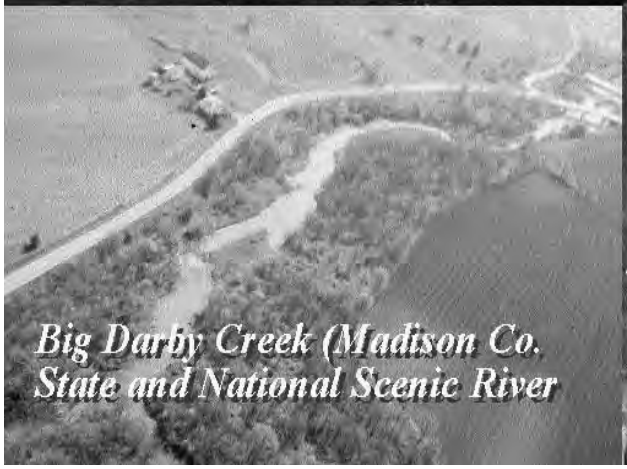
- Attainment of the biological criteria.
- Habitat assessment demonstrates the potential to attain the designated use.
- Attainment of uses is tracked in State 305[b] reports.

Aquatic Life Use Designations: Ohio WQS

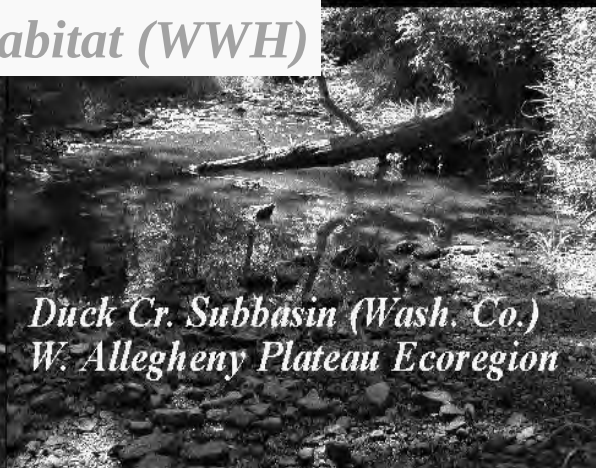
Based on Biological Community Attributes

- 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).

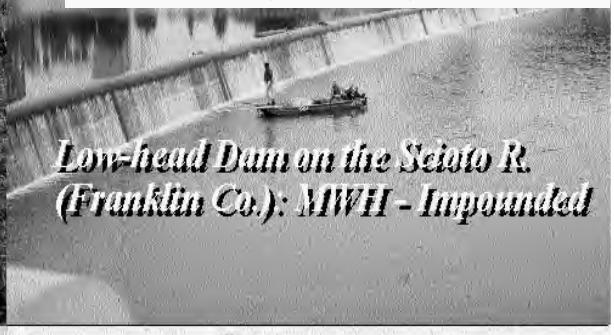
Exceptional Warmwater Habitat (EWH)

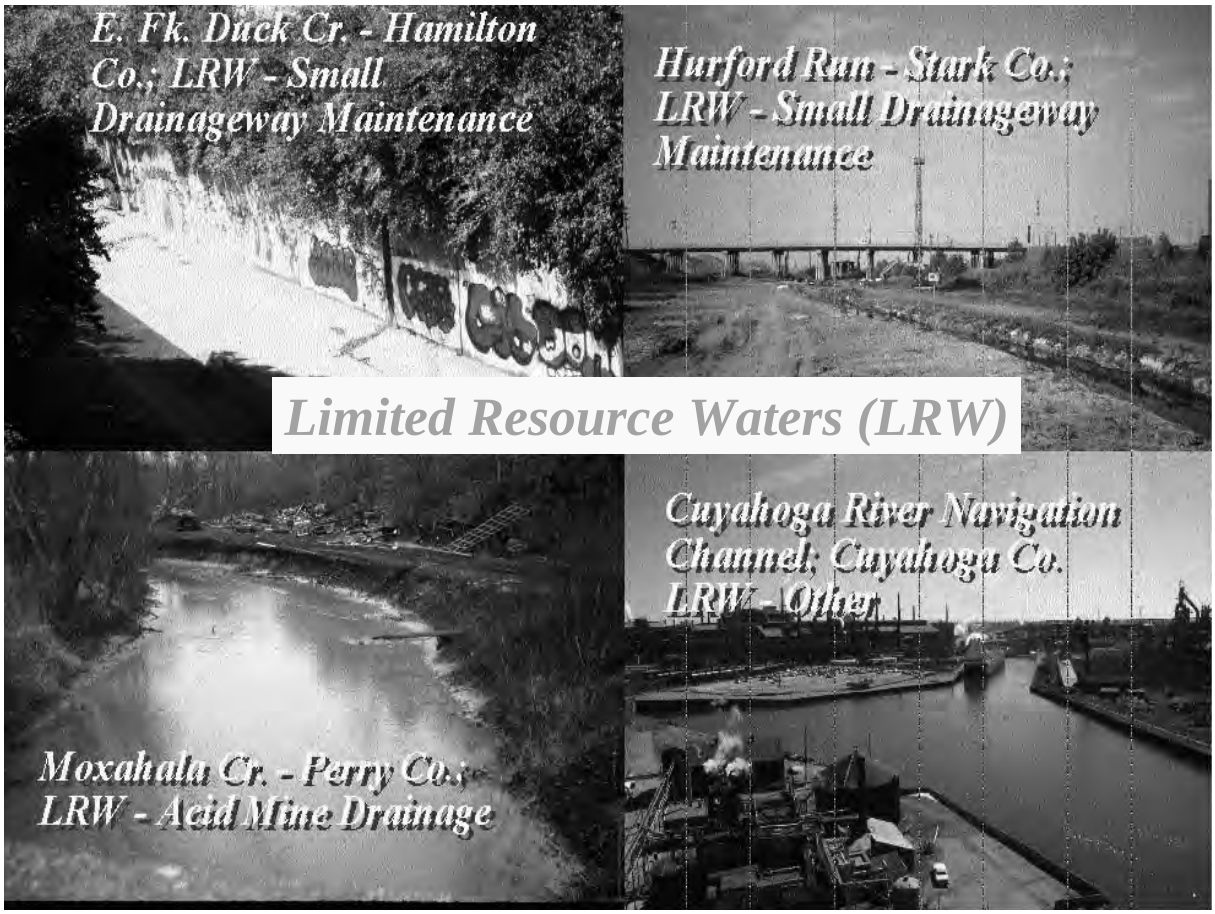


Warmwater Habitat (WWH)



Modified Warmwater Habitat (MWH)





Aquatic Life Designated Uses

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- Attainment of the biological criteria.
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- Attainment of uses is tracked in State 305[b] reports.

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)

Use Attainability Analysis II: Process and Information Requirements**

Use attainability analysis requires the following information and knowledge:

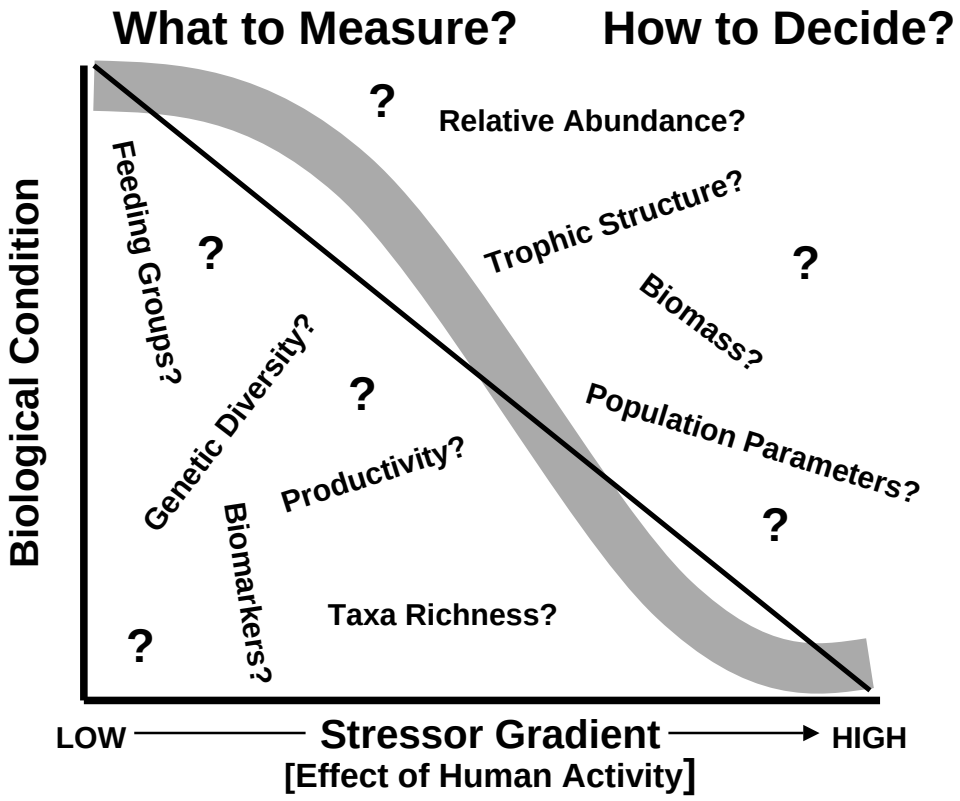
- existing status of waterbody based on biocriteria;
- habitat assessment to evaluate potential;
- reasonable relationship between impaired state and precluding activity based on assessment of multiple indicators used in appropriate roles;
- recommendation subject to WQS rulemaking process
- < CWA uses reviewable every three years - a "temporary" designation.

****** -All data collection and analysis must conform to Ohio WQS and Five-Year Monitoring Strategy data and design quality objectives.**

Important Considerations for Biological Criteria Programs

Six criteria that programs should satisfy:

- The measures used must be biological.
- The measures must be interpretable at or extend to multiple trophic levels.
- The measures must be sensitive to the conditions being assessed.
- The response range must be suitable for intended uses.
- The measures must be reproducible and sufficiently precise.
- The variability of the measures must be low enough to detect and quantify changes.



Symptoms of Ecological Degradation

A Partial List:

- Reduced populations of native species.
- Fewer size (age) classes.
- Reduced number of intolerant species.
- Increased proportion of exotic species.
- Reduced proportion of ecological specialists.
- Simplified trophic web and interactions.
- Increased incidence of serious disease & anomalies.

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.

Basic Premise of IBI Type Measures

- Least impacted biological systems have distinctive structural and functional attributes.
- Some attributes can be measured in the field and aggregated into metrics.
- Departure of metrics from a reference condition is correlated with the degree (severity) of a perturbation.
- Synthesis of multiple, representative metrics reflects the overall integrity of the community.

Invertebrate Community Index (Ohio EPA 1987; DeShon 1995)

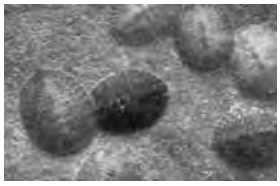
- Taxa Richness
- #Mayfly taxa
- #Caddisfly taxa
- #Dipteran taxa
- %Mayflies
- %Caddisflies
- %Tanytarsini Midges
- %Other Diptera/Non-Insects
- %Tolerant taxa
- Qualitative EPT taxa

- 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.

Key Invertebrate Metrics: Intolerant & Specialist Taxa

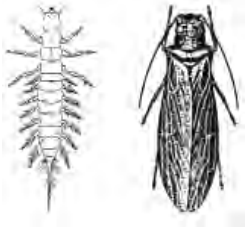
mayflies

stoneflies



water penny

bivalves



alderflies

dobson flies

snipe flies

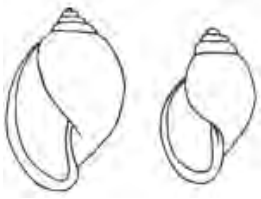
Expected Response to Stress: Declines in abundance and proportion of assemblage

Key Invertebrate Metrics: Highly tolerant taxa

Chironomid midges[1]

leeches

worms

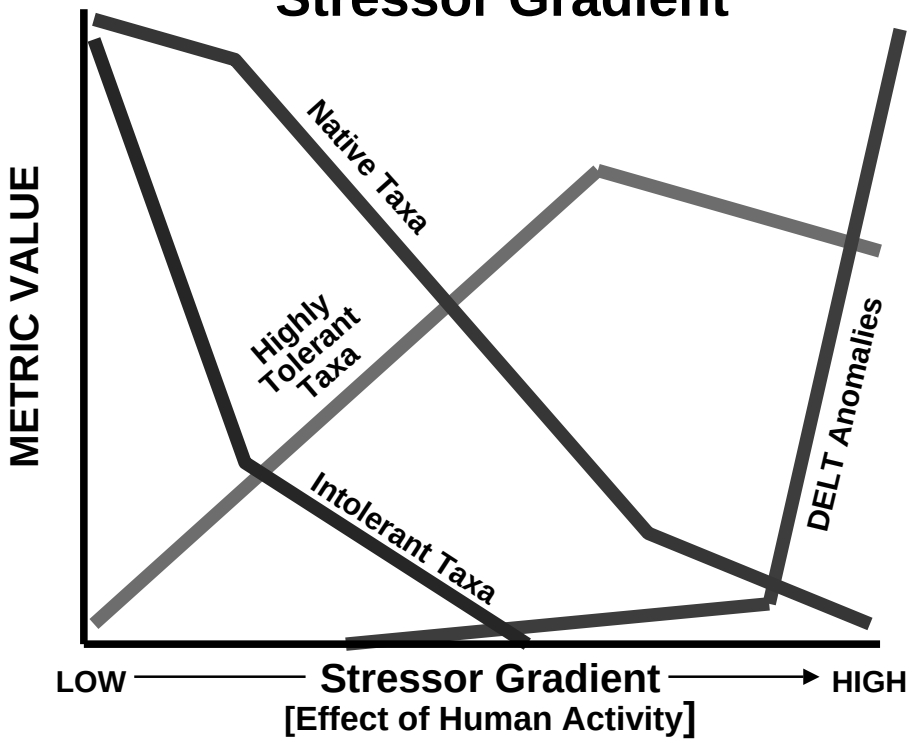


pouch snails

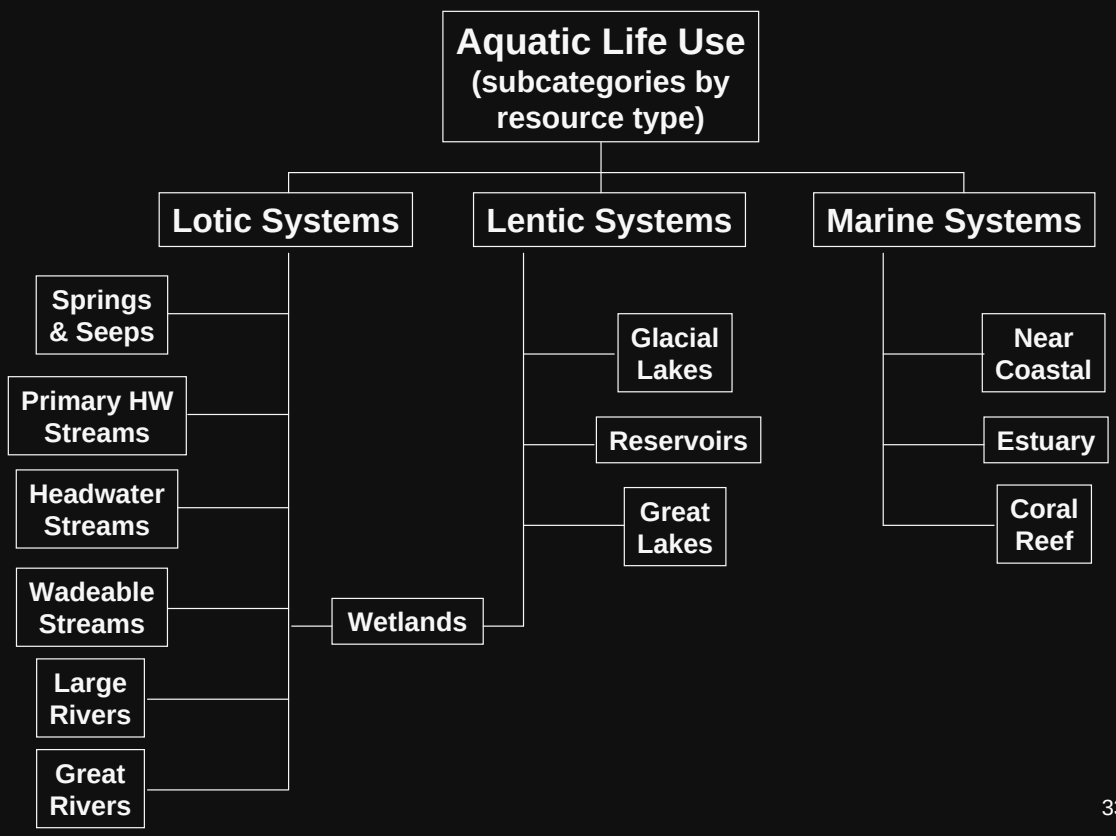
[1] There are at least three distinct responses exhibited by the Chironomidae; sensitive (*Tanytarsini*), facultative (*Glyptotendipes*), and toxic tolerance (*Cricotopus*); taxonomic resolution is needed at genus level.

Expected Response to Stress: Increased abundance or proportion of assemblage

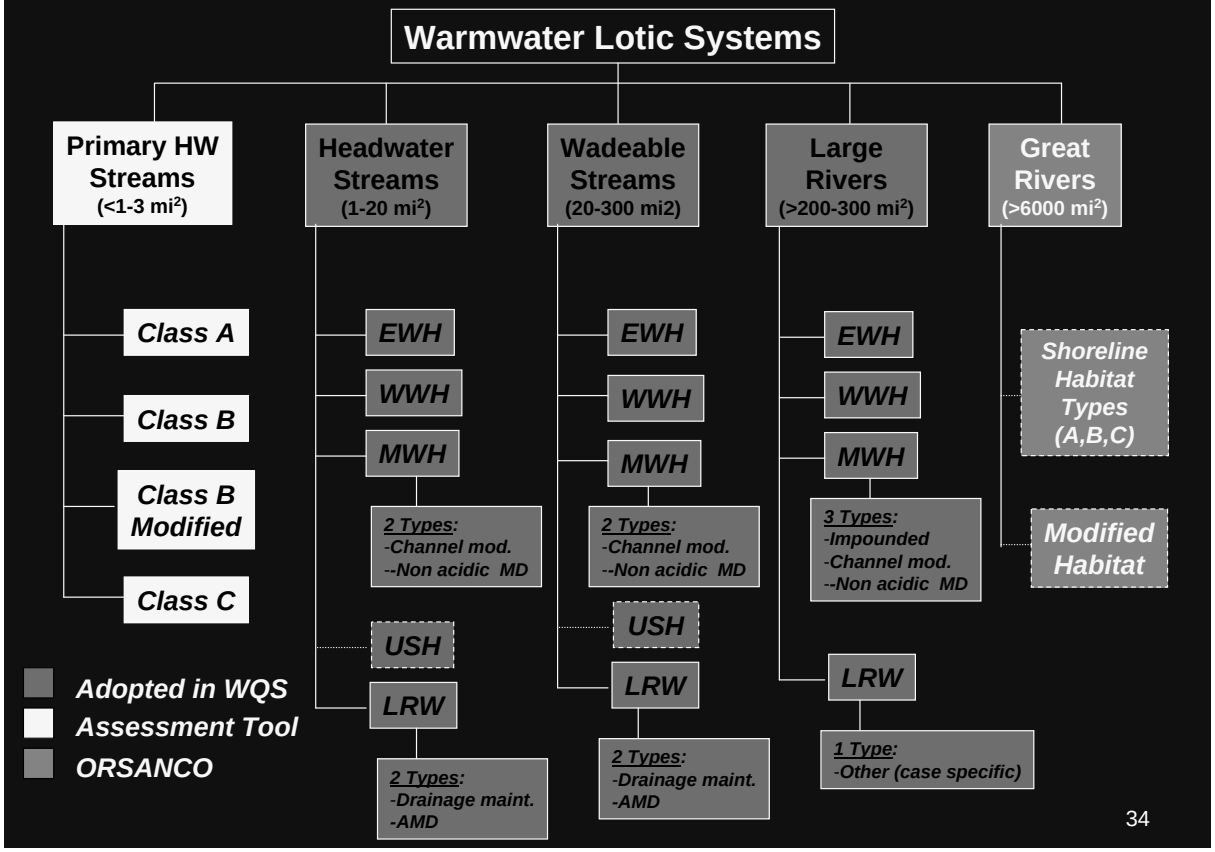
Metric Behavior Along the Stressor Gradient



GENERAL TEMPLATE FOR STRATIFYING RESOURCE TYPES



OHIO SPECIFIC TEMPLATE FOR STRATIFICATION

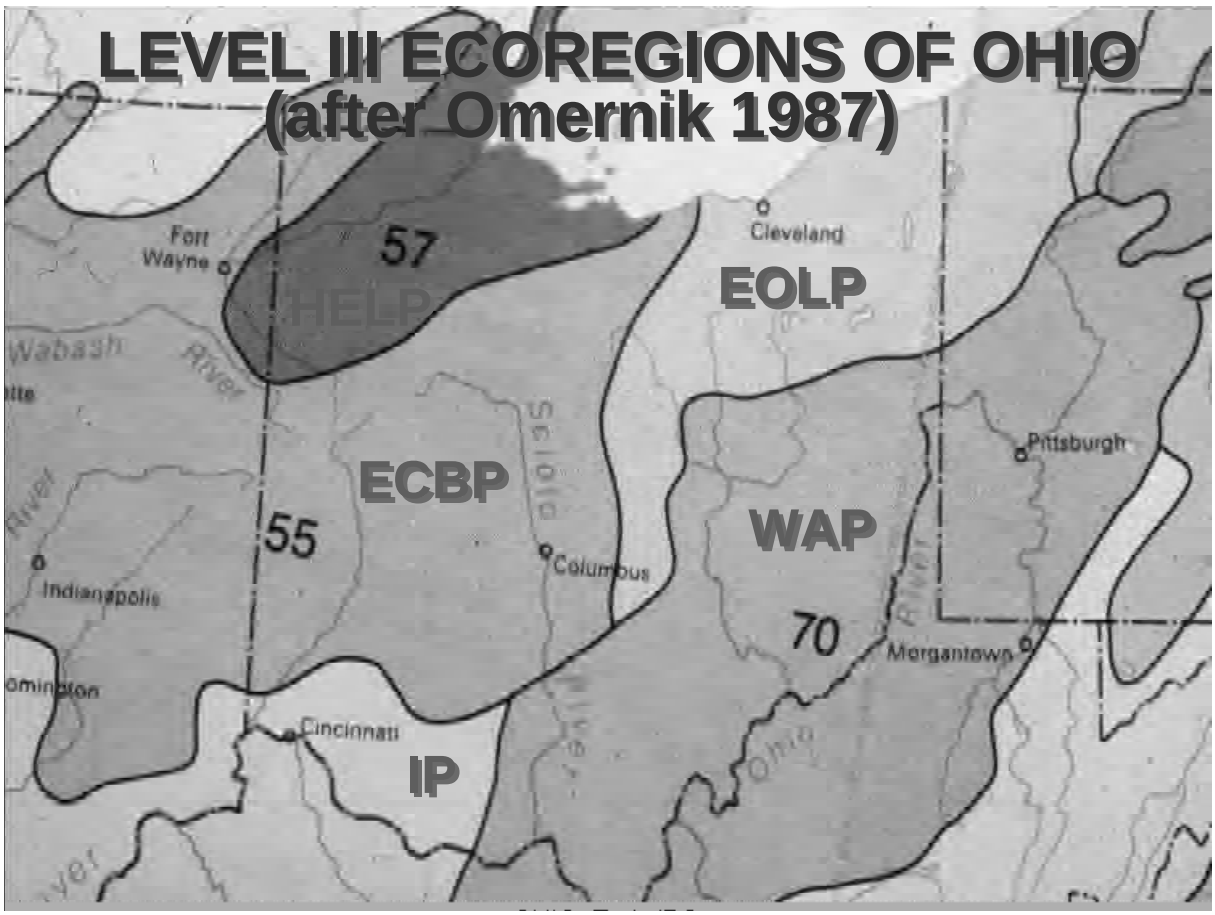


OHIO EPA MODIFIED IBI METRICs	HEADWATER SITE TYPE (<20 SQ. MI.)	WADEABLE SITE TYPE (20-300 MI.²)	BOATABLE SITE TYPE (200-6000 MI.²)
1. Total Native Species	X	X	X
2. #Darter Species		X	
#Darters + Sculpins	X*		
%Round-bodied Suckers			X*
3. #Sunfish Species		X	X
#Headwater Species	X*		
%Pioneering Species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

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

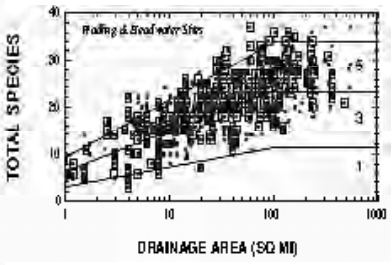
OHIO EPA MODIFIED IBI METRICs	BOATABLE SITE TYPE (Inland Rivers)	LAKE ERIE LACUSTUARY (Harbors/Rivers)	LAKE ERIE NEARSHORE (Shoreline)
1. Total Native Species	X	X	X
2. #Darter Species			
%Round-bodied Suckers	X*		
#Benthic Species		X*	X*
3. #Sunfish Species	X		
#Centrarchid Species		X*	X*
4. #Sucker Species	X		
#Cyprinid Species		X*	
#Phytophilic Species			X*
5. #Intolerant Species	X	X	X
6. %Green Sunfish			
%Tolerant Species	X*	X*	X*
7. %Omnivores	X	X	X
8. %Insectivores	X		
%Phytophilic Individuals		X*	
%Lake Species			X*
9. %Top Carnivores	X	X	X
10. %Hybrids			
%Simple Lithophils	X*		
%Nonindigenous Species		X*	X*
11. %DELT Anomalies	X**	X**	X**
12. Number of Individuals	X	X	X

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.



Ohio IBI Calibration & Biocriteria Derivation Process

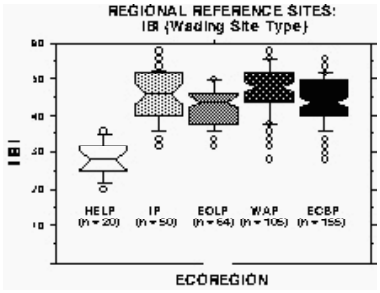
I. Select & sample reference sites



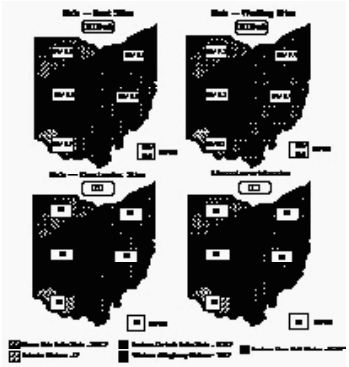
II. Calibration of IBI metrics

Metric	5	3	1
Number of Species	Varies x Drainage Area		
No. of Darter Spp.	Varies x Drainage Area		
No. of Sunfish Spp.	>3	2-3	<2
No. of Sucker Spp.	Varies x Drainage Area		
Intolerant Species			
>100 sq. mi.	>5	3-5	<3
<100 sq. mi.	Varies x Drainage Area		
%Tolerant Species	Varies x Drainage Area		
%Omnivores	<19	19-34	>34
%Insectivores			
<30 sq. mi.	Varies x Drainage Area		
>30 sq. mi.	>55	26-55	<26
%Top Carnivores	>5	1-5	<1
%Simple Lithophils	Varies x Drainage Area		
%DELT Anomalies	>1.3	0.5-1.3	<0.5
Relative Abundance	>750	200-750	<200

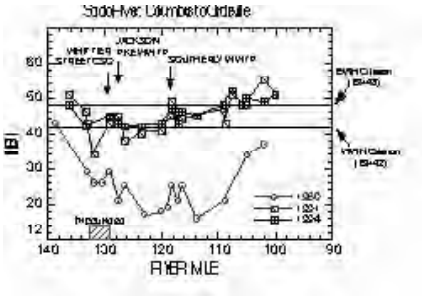
III. Calibrated IBI modified for Ohio waters



IV. Establish ecoregional patterns/expectations

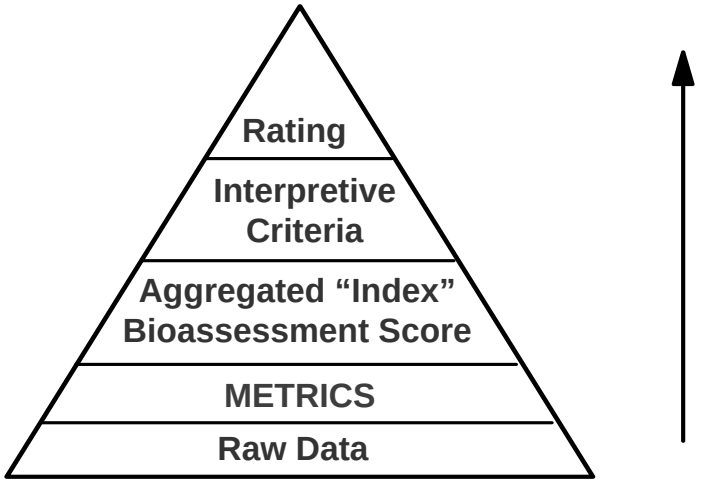


V. Derive numeric bio-criteria: Codify in WQS



VI. Numeric biocriteria are used in bioassessments

Data Manipulation Hierarchy of Field-Collected Biological Samples



Ohio Biological Criteria: Adopted May 1990 (OAC 3745-1-07; Table 7-14)

Huron Erie Lake Plain (HELP)

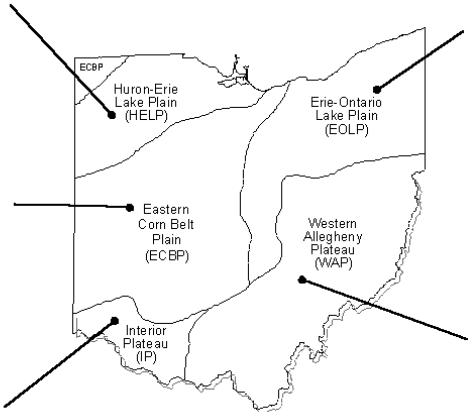
Use	Size	IBI	MIwb	ICI
WWH	H	28	NA	34
	W	32	7.3	34
	B	34	8.6	34
MWH-C	H	20	NA	22
	W	22	5.6	22
	B	20	5.7	22
MWH-I	B	30	5.7	NA

Eastern Corn Belt Plains (ECBP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	36
	W	40	8.3	36
	B	42	8.5	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Interior Plateau (IP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	30
	W	40	8.1	30
	B	38	8.7	30
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA



Erie Ontario Lake Plain (EOLP)

Use	Size	IBI	MIwb	ICI
WWH	H	40	NA	34
	W	38	7.9	34
	B	40	8.7	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Western Allegheny Plateau (WAP)

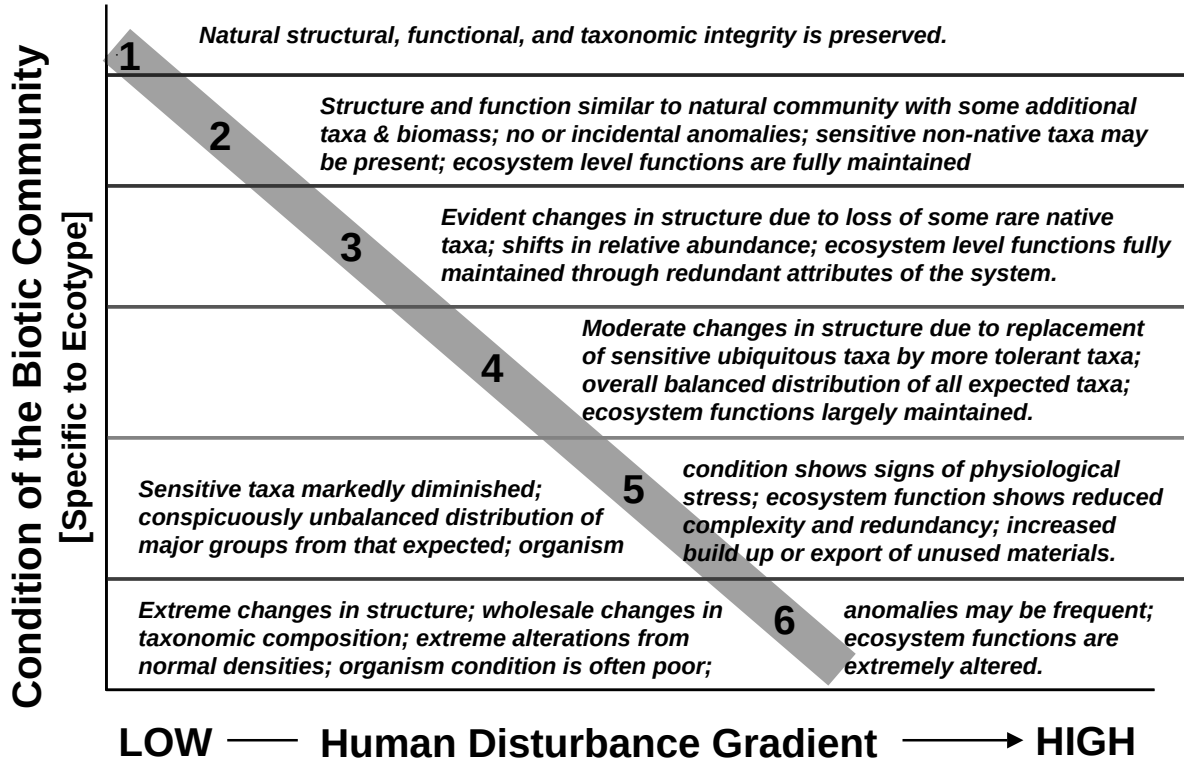
Use	Size	IBI	MIwb	ICI
WWH	H	44	NA	34
	W	44	8.4	34
	B	40	8.6	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

Statewide Exceptional Criteria

Use	Size	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers

(10/22 draft)



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.

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.

Biological Criteria "Maintenance"

- Reference sites "re-sampling" linked to basin monitoring cycle (10 yr. process).
- Keeps tabs on reference condition change.
- Update consistent with new technologies.
- Template for developing stressor thresholds and gradients.
- Formally linked to WQS via tiered designated use descriptions and derivation system.

Coping With Biological Data Variability

- **Compress Variability**: use multi-metric measures (e.g. IBI, ICI, etc.).
- **Stratify Variability**: use ecoregions (or subsets) and tiered aquatic life use classification system.
- **Control Variability**: select efficient sampling methods that yield informative and consistent results.

Resolution and Detail in WQS and Monitoring and Assessment Affect Overall WQ Management Program Effectiveness

Program Attribute	Least Accurate → Most Accurate	
WQS/Des. Uses:	General Uses (Generic AQLU)	Refined Uses (Tiered AQLU)
WQ Criteria:	Simple, Chemical (Conventionals)	Chemical & Biological (Acute/Chronic, Biocriteria)
Monitoring:	Fixed Stations	Rotating Basins (Stratified, Probabilistic)
Indicators:	Chemical, Narrative	Chem., Phys., Biological (Numeric, Calibrated)
Detail:	Coarse (Low Signal)	Refined (Integrated Signal)
Resolution:	Pass/Fail (No Increments)	Incremental (Continuous Scale)