The Effects of Single vs. Tiered Aquatic Life Uses, Multiple vs. Single Assemblages, and Bioassessment-Based vs. Chemical Criteria-Based Methods on Estimation of Aquatic Life Use Attainment and Impairment

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Importance of Adequate Monitoring and Water Quality Standards Program

- TMDL program and a myriad of other state water management programs are dependent on the structure of a state’s water quality standards program including:
  - its aquatic life use structure, and
  - monitoring efforts performed to measure attainment or impairment of these aquatic life goals

- Therefore, there is a need to know consequences of monitoring choices including organism groups, goals for waters and use of indicators to identify impairment
Restrospective Examination Of Ohio EPA Ecological Database

• Ohio has:
  - Tiered aquatic life uses
  - Biocriteria based on two organism groups (fish and macroinvertebrates)
  - Weight of evidence approach to assessment of aquatic life use impairment
  - Watershed/Geometric site design approach to monitoring
  - Tight integration with WQS and multiple uses and purposes for monitoring information (detecting impairment, UAA, stressor identification, TMDLs, hazardous waste assessments etc.,)
Sugar Creek Subbasin: Results of Geometric Design Assessment

• TMDL development scale: 11 digit HUC units, 328 statewide
• Mainstem rivers <500 mi² treated separately
• Watershed assessment results initially support UAA process
• Degree and severity of impairment then determined with biocriteria
• Causal associations determined via integrated analysis process
• Supports prioritization ranking
• More focused targeting of restoration activities
• Local stakeholder “buy in” enhanced by scale of design
Case History: Development of Tiered Aquatic Life Uses in Ohio

Rationale for Ohio WQS in 1978

• Natural history - published texts convey a general knowledge of variable, yet distinguishable resource attributes (e.g., Trautman - Fishes of Ohio).
• One-size-fits-all did not “sell”
• Promised more customized water quality management outcomes (WQS, permits, etc.).
EVOLUTION OF ASSESSING SURFACE WATER INTEGRITY: ADDING NEW & BETTER TOOLS

**WATER QUALITY**

- Simple Chemical Criteria
- General Aquatic Life Use (1974 - 1978)
- More Chemical Criteria
- Complex Chemical Criteria
- Tiered Aquatic Life Uses
- Narrative Biological Criteria (1980 - 1990)

**WATER RESOURCE**

- More Complex Chemical Criteria
- Tiered Aquatic Life Uses
- Numerical Biological Criteria
- Whole Effluent Toxicity Tests
- Physical Habitat Evaluation (1990 - Present)

**LESS ACCURACY** → **MORE ACCURACY**

(“Natural” convergence of independently developed tools?)
Ability to do “Retrospective” Watershed Assessments

• Ohio database consists of over 10,000 potential stations
• Fish, macroinvertebrates, water chemistry, habitat (QHEI) collected in a consistent manner over the past 20-25 years
• Assessments done of tiered aquatic life uses since early 1990s
Retrospective Analyses in this Study:
What are the consequences for assessment of condition??

- Chemical vs. biological indicators of aquatic life use attainment
- Fish vs. macroinvertebrates as indicators of aquatic life use attainment
- Tiered aquatic life uses vs. single aquatic life uses
Chemical vs. Biological Measure of Aquatic Life Use Status: How Do They Differ?

- Biological data – fish/macroinvertebrate data based on tiered aquatic life uses in Ohio – Biocriteria based on ecoregion and stream size expectations

- vs.

- Water chemistry indicators – conventional pollutants (D.O., pH, etc) and toxicants such as ammonia, metals, etc., and exceedences of water quality criteria
Chemical vs. Biological Indicators of Aquatic Life Use Attainment

Time Period A (1981-1987)
- Agreement Impaired: 7.48%
- Agreement, Attains: 35.03%
- Bio Imp, Chem Not: 23.1%
- Chem Imp, Bio Not: 34.4%

- Agreement Impaired: 9.2%
- Agreement, Attains: 36.9%
- Bio Imp, Chem Not: 34.2%
- Chem Imp, Bio Not: 19.7%

- Agreement Impaired: 7.52%
- Agreement, Attains: 46.5%
- Bio Imp, Chem Not: 35.5%
- Chem Imp, Bio Not: 10.5%
Fish vs. Macroinvertebrates

- Many stations in the Ohio database have both fish and macroinvertebrate data
- What would be the consequence of using a single organism group?
Aquatic Life Use Attainment: Fish vs. Macros

Aquatic Life Use Attainment Based on Fish Communities Only
- Attainment: 44.5%
- Partial Attainment: 20.2%
- Impairment: 35.3%

Aquatic Life Use Attainment Based on Macroinvertebrate Communities Only
- Attainment: 66.4%
- Impairment: 33.6%

Aquatic Life Use Attainment Based on Fish and Macroinvertebrate Communities
- Attainment: 36.4%
- Partial Attainment: 32.3%
- Impairment: 31.4%
Tiered Aquatic Life Uses vs. Single Aquatic Life Uses

- Ohio has gradually developed a tiered aquatic life use system from the late 1970s to the early 1990s
- Biological expectations change largely along an anthropogenic physical gradient
- Four primary uses in the tiers: Exceptional Warmwater Habitat (EWH), Warmwater Habitat (WWH), Modified Warmwater Habitat (MWH) and Limited Resource Water (LRW)
- Biological data is ultimate arbiter of use, QHEI and habitat data are important sources of information
Warmwater Lotic Systems

Primary HW Streams (<1-3 mi²)
- Class A
- Class B
- Class B Modified
- Class C

Headwater Streams (1-20 mi²)
- EWH
- WWH
- MWH

Wadeable Streams (20-300 mi²)
- EWH
- WWH
- MWH

Large Rivers (>200-300 mi²)
- EWH
- WWH
- MWH

Great Rivers (>6000 mi²)
- USH
- LRW

Shoreline Habitat Types (A,B,C)

Modified Habitat

Adopted in WQS
Assessment Tool
ORSANCO
DESIGNATED USE OPTIONS ALONG THE BIOAXIS AND BIOLOGICAL CONDITION GRADIENT

**Scale of Measurement [IBI, ICI]**

- **Maximum**
- **Minimum**

**STRESSOR EFFECT**

- **Low**
- **High**

**CONDITION GRADIENT**

- **Very Poor**
- **Poor**
- **Fair**
- **Marginally Good**
- **Good**
- **Very Good**
- **Exceptional**

**AQL DESIGNATED USES**

- **EWH**: Meets Interim CWA Goal
- **WWH**: Use Attainability Analysis Required
- **MWH**: Minimum Level of Protection Afforded by CWA
Kokosing River (Knox Co.)
State Scenic River

Lost Creek (Miami Co.)

Bluebreast darter
(Etheostoma camurum)
Ohio Threatened Species

Big Darby Creek (Madison Co.)
State and National Scenic River
EWH Streams

Stations in Streams with an EWH Aquatic Life Use Designation

Number of Stations

Aquatic Life Use Support

All Streams Considered WWH

Mutliple Use Tier System

ICI and IBI
Fish Only
IBI Only
ICI Only
All Indices

0
200
400
600
800
1000
1200
1400

Full
Partial
Non-Support
Full
Partial
Non-Support
Drainage Maintenance is Common in Western and Northwest Ohio: MWH - Channelization

Low-head Dam on the Scioto R. (Franklin Co.): MWH - Impounded

Non-Acidic Runoff From Abandoned Mine Lands Results in Severe Sedimentation: MWH - Mine Drainage

Crack Chub With Blackspot: MWH Streams are Predominated by Tolerant Species
MWH Streams

Stations in Streams with a MWH Aquatic Life Use Designation

Number of Stations

Aquatic Life Use Support

All Streams Considered WWH

Mutliple Use Tier System

Full
Partial
Non-Support

Full
Partial
Non-Support

All Indices
ICI and IBI
Fish Only
IBI Only
ICI Only
Causes of Impairment: EWH vs. MWH

Causes of Impairment in Reaches Where the Aquatic Life Use is EWH

- Nutrients
- Siltation
- Organic enrichment/DO
- Flow alteration
- Other habitat alterations
- Salinity/TDS/chlorides
- Unionized Ammonia

Miles

Causes of Impairment in Reaches Where the Aquatic Life Use is MWH

- Other habitat alterations
- Organic enrichment/DO
- Nutrients
- Siltation
- Flow alteration
- Priority organics
- Total toxics

Miles
AQUATIC LIFE USE CHANGES: OHIO WQS (1999 - 2001)

TYPE OF CHANGE

SEGMENTS

"UPGRADES"
"DOWNGRADES"
PREVIOUSLY UNDESIGNATED
USE CONFIRMED
Causes of Impairment

Sites With Chemical Exceedances
Biological Data Attaining All Data

Percent of Miles

- Exceedance Based
- 305b-Based

NUT  MET  DO  AMM  HAB  PH  TEMP  TSS/OTH  TOX  FLOW
Conclusions

• Indicators
  - Tiered Aquatic Life Uses resulted in more protection for high quality waters; did not over-protect more limited waters - this could have strong affect on TMDL lists
  - Multiple organism groups detected more impaired waters, largely though better identification of physically modified reaches
Conclusions, cont’d

• Water chemistry changes responsible for improvements in biota in Ohio waters
• Biological data better able to detect physical stressors not measured by water chemistry
• Some agreement between biology and water chemistry could also be coincidental
• Only a small proportion of sites show “independent application” conflict and most of these explainable