National Biological Assessment and Criteria Workshop

Advancing State and Tribal Programs

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

LR 201

LARGE RIVER BIOCRITERIA DEVELOPMENT

Course Presenters and Contributors

Joe Flotemersch, Chris Yoder, Barry Poulton, Erich Emery, Chris Mebane

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ORSANCO: Biological Criteria Development for the Ohio River

Presented by

Erich Emery, ORSANCO

Introduction

- ORSANCO
  - Interstate water pollution control agency for the Ohio River Basin
  - Compact Signed in 1948
  - Eight States (NY-VA-PA-WV-OH-KY-IN-IL)
  - Committee Structure (All States represented; multiple levels).
  - Regulatory Authority
    - Wastewater Discharge Requirements
    - Pollution Control Standards
    - Ohio River 305(b)

Introduction (Cont'd…)

- ORSANCO
  - Unique Organization
    - Regulatory Authority
      - Standards Development
      - Expanding Role (TMDLs)
  - Expanding role from a 'Mainstem' Agency to a 'Basin' Agency
  - New concept of developing biological standards across multiple state boundaries.

Program Objectives

- Future pollution control standards for the Ohio River to include, or reference numeric biological criteria.
- Expand community condition indicators to the basin.
  - Next step; large Ohio River tributaries.

Sampling Design

- Fish
  - Lockchamber rotenone surveys (1957 – present)
  - Night Electrofishing (1991-2001)
    - Targeted sampling of individual pools (2 mile resolution).
    - Provided resolution to detect critical spatial and temporal aspects of background variability.
  - Night Electrofishing (2002 and beyond)
    - Employing a random probability design with a spatial systematic component developed by US EPA's EMAP program.
- Macroinvertebrates
  - Hester-Dendy artificial substrates
    - Gathering background information (1991-2000)
      - 2mi. Resolution; entire river (1997-1998)

Quality Assurance Measures

- In-Field
  - Gear efficiency
  - Seasoned biologists in place as crew leaders
  - Redundancy of expertise in the field
  - Vouchers
    - Site; Pool; Regional
    - Small specimens preserved for in-house ID
- In-house
  - Panel review of results

Data Applications

- Assessment and reporting of biological condition for 305(b) report.
  - 303(d) list; TMDL's
- Supplement to State Programs.
  - NPDES, 404, 319 etc..(at states request)
- Temporal and spatial trend assessments.
  - Public reports and documentation.

Scales Addressed

- Past
  - Mainstem Ohio River
- Present
  - Moving into major tributaries with the States
- Future
  - More comprehensive basinwide assessment

Design Features

- Site Selection
  - Past: Targeted Intensive Surveys (2mi. Res.)
  - Present: Probability-based site selection
- Sampling Period
  - Targeting low flow, stable period of July through October.
    - Reduces flow-induced variability; most YOY large enough to be identified; worst-case-scenario for WQ impacts such as thermal, DO etc.

Indicators

- Fish (500m night electrofishing)
  - Most information in place at program inception (1991).
    - Lockchamber rotenone sampling
      - 1957 to present!
- Macroinvertebrates (Hester-Dendy multiplates, composite of 5)
  - Began baseline collections in 1991; expanded program in 1997 (2 mile resolution –1997-1998)

Future Indicators

- Algae
  - Collections of phytoplankton ongoing
    - Initiated by drinking water utilities
      - 10 locations / semimonthly / species counts / Chl.a
    - Community indices under development
      - May influence nutrient standards
- Mussels
  - Workload carried by USFWS
  - Future work may be geared to developing community expectations
  - Excellent measure of historic perturbations (habitat loss)
  - Historic collection in existence
- Genetic Diversity (fish community)
- Impacts from endocrine disruptors
  - Feminization of males (fish)

Obstacles to Program

- Scale
  - Samples, Samples, Samples
- Lack of 'True' Reference Condition
  - Best attainable condition defined as ceiling for expectation.
  - Set as a 'moving target', designed to reflect condition as system continues to improve.
- Lack of Defined Methods
  - Methods modified from stream techniques (OH EPA)

Existing Biocriteria

- Panel of experts established to help develop an IBI for the Ohio River.
  - Reviewed, reconsidered and reclassified all Ohio River species.
  - Over 70 metrics developed for testing; 13 selected for index.
  - Metrics scored following traditional methods.
    - Over 800 'least impacted' sites utilized to derive expectations for metrics.
      - Equally distributed over entire length of river
      - Captures full range of variation within all possible segments

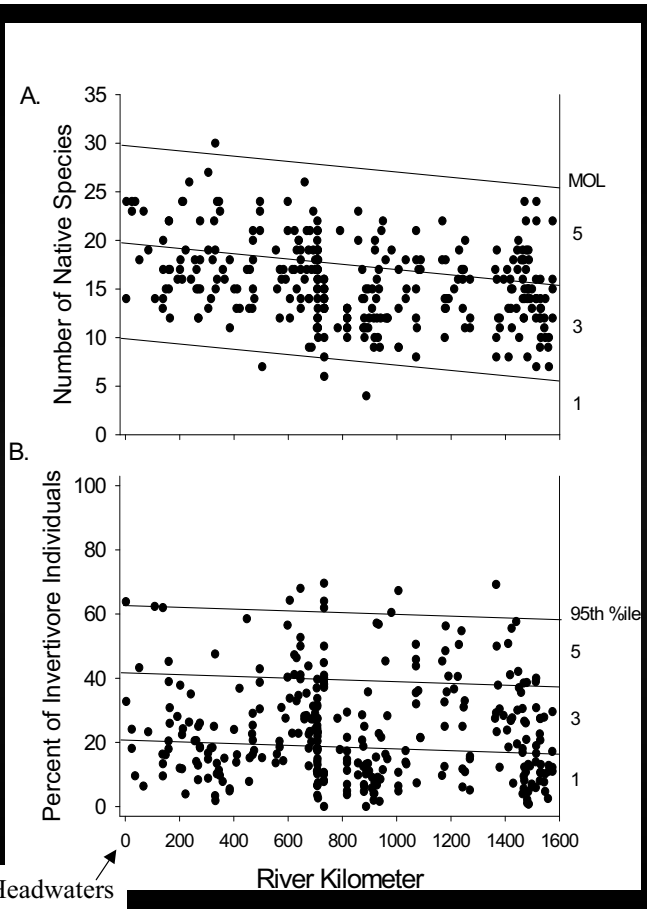
Ohio River Fish Index (ORFIn)

- Number of Native Species
- Number of Sucker Species
- Number of Centrarchid Species
- Number of Great River Species
- Number of Intolerant Species
- Percent Tolerant Individuals
- Percent Simple Lithophils
- Percent Non-Native Individuals
- Percent Detritivores
- Percent Invertivores
- Percent Top-Piscivores
- Relative Number of DELT Anomalies
- Catch Per Unit Effort

Metric Scoring

- Least – Impacted sites used as reference for developing scoring expectations.
- Data plotted longitudinally along river-mile, acting as a surrogate for drainage area.
- Data was trisected following conventional methods.
  - 95th Percentile (Proportional Metrics) –OR- Maximum Observed Line – MOL (Species Richness Metrics)
    - Drawn parallel to regression line
    - Trisected beneath

Metric Scoring



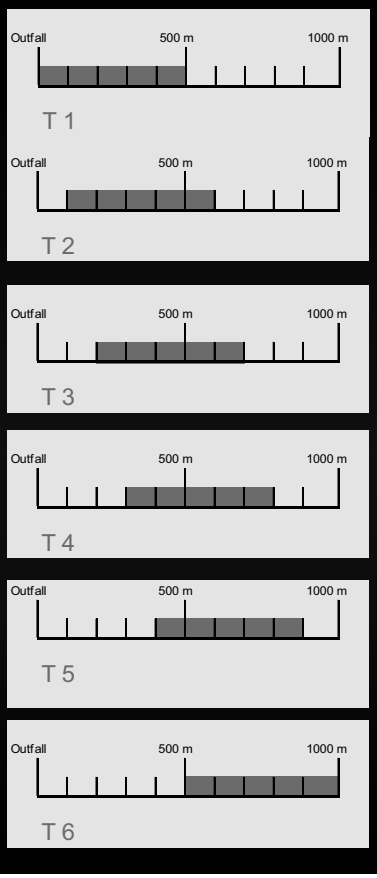
Metric Testing

- Are metrics responsive?
  - Do they respond as expected?
- Do they reveal disturbance?
  - Do they reveal the magnitude of the disturbance?

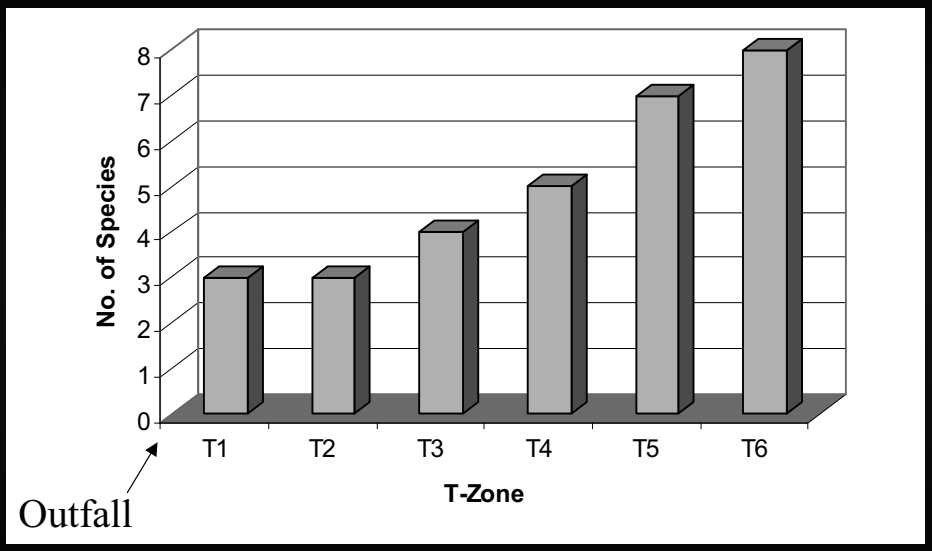
Metric Testing

- Two 500-m electrofishing zones (data collected in 100m increments) were conducted simultaneously, back-to-back, in an area where a known water quality gradient existed.
- Design allowed data reconfiguration /compilation for 6 500m traveling or T-zones, each beginning progressively further downstream from the area of impact.

Metric Testing (T-Zones)



T-Zone Example



Flow →

Reducing Variance

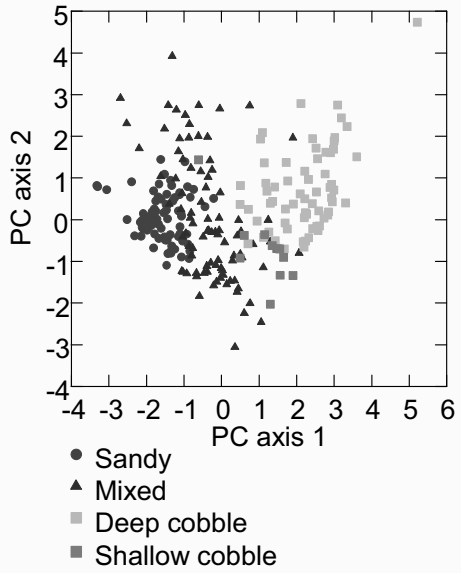
- Spatial
  - Ecoregions?
    - Data suggests 3 river reach segments may exist
  - 3 Distinct habitat types defined.
- Temporal
  - Seasonal shifts in water quality (temperature and DO) result in shifts in aquatic community over certain habitat types.
  - Seasonal expectations may be set for these habitats.

Defining Habitat Types

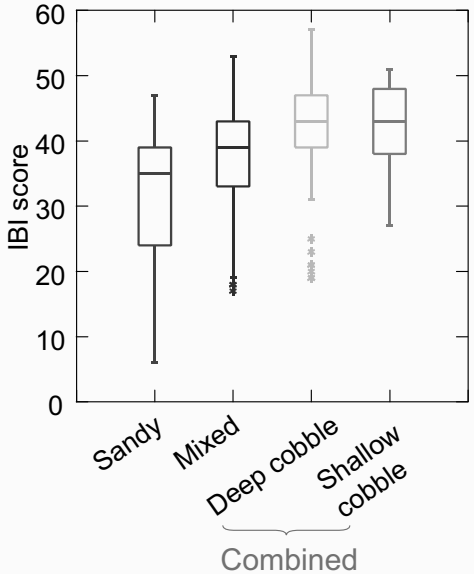
- Use first visits to least impacted sites only.
- Principal Components Analysis (PCA) on habitat variables: measures of depth, woody cover and substrate composition.
- K-means clustering based on PCA axis.
- Use CART with cluster as dependant and habitat variables predictor variables.

New Habitat Clusters

First visits – least impacted

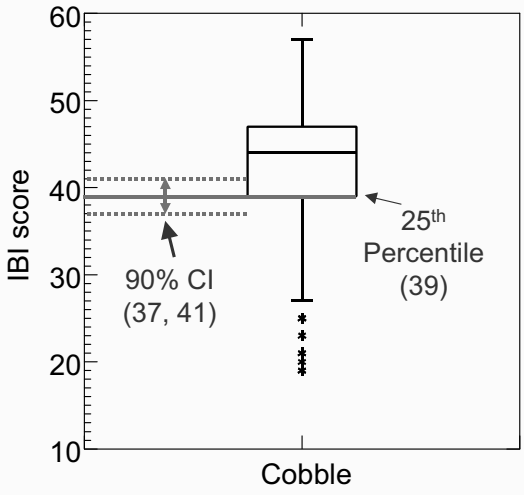


All visits – least impacted



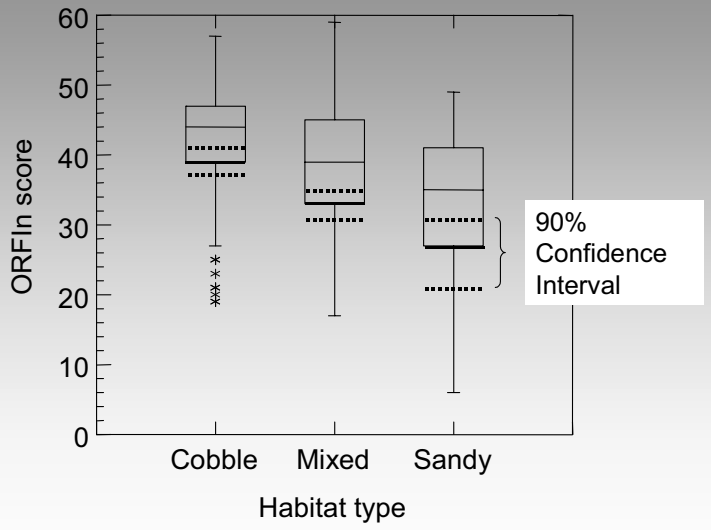
Calculation of Biocriteria

- Calculate 25th percentile value for least impacted sites (all visits)
- Calculate the nonparametric 90% confidence interval around percentile using binomial distribution
- Use lower confidence bound as biocriterion for that habitat class



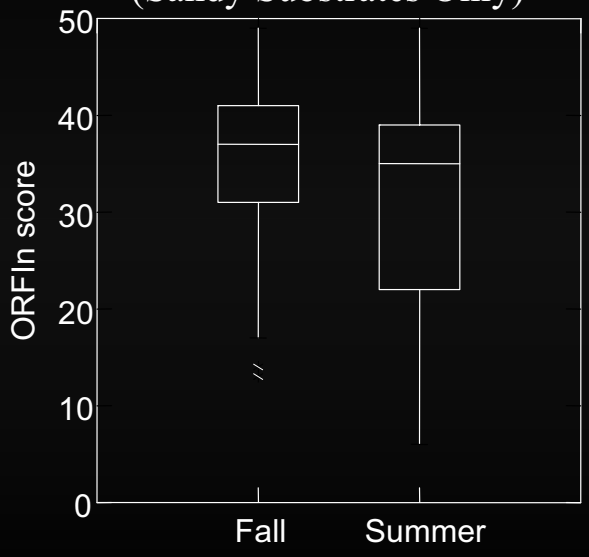
3 Habitat types defined based on substrate composition

Least impacted sites



Indications of Seasonal Differences Within Annual Timeframe

(Sandy Substrates Only)



Deriving Biocriteria

- Current
  - Using 3 habitat types
    - 25th percentile for each type
      - Lower 90th confidence interval around the 25th will serve as criteria.
      - Revisits required to sites falling within 90th bands.
      - Multiple passes used for assessment
- Future
  - Additional data collection needed
  - May incorporate seasonal and reach-specific expectations.

Regulatory Changes

- A more thorough and accurate 305(b) assessment.
- Demonstrated use of biological indices to detect and delineate areas of degraded condition.
- Action against dischargers.

Is it worth it?

- Yes!
- Very labor intensive.
- Many samples required.
- Results allow us to tap into the ability of large rivers to 'tell their side of the story'.
  - The integrity, stability and beauty of the biotic community of large rivers can be measured, understood, and revealed to those who care to look.

Questions ?

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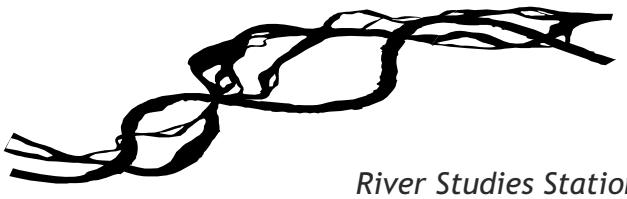
Bioassessment and Potential for Biocriteria Development in the Lower Missouri River: A Case Study Using Benthic Macroinvertebrates

Presented by
Barry C. Poulton, U.S.G.S



River Studies Station
Columbia Environmental Research Center

Components Included in this Presentation

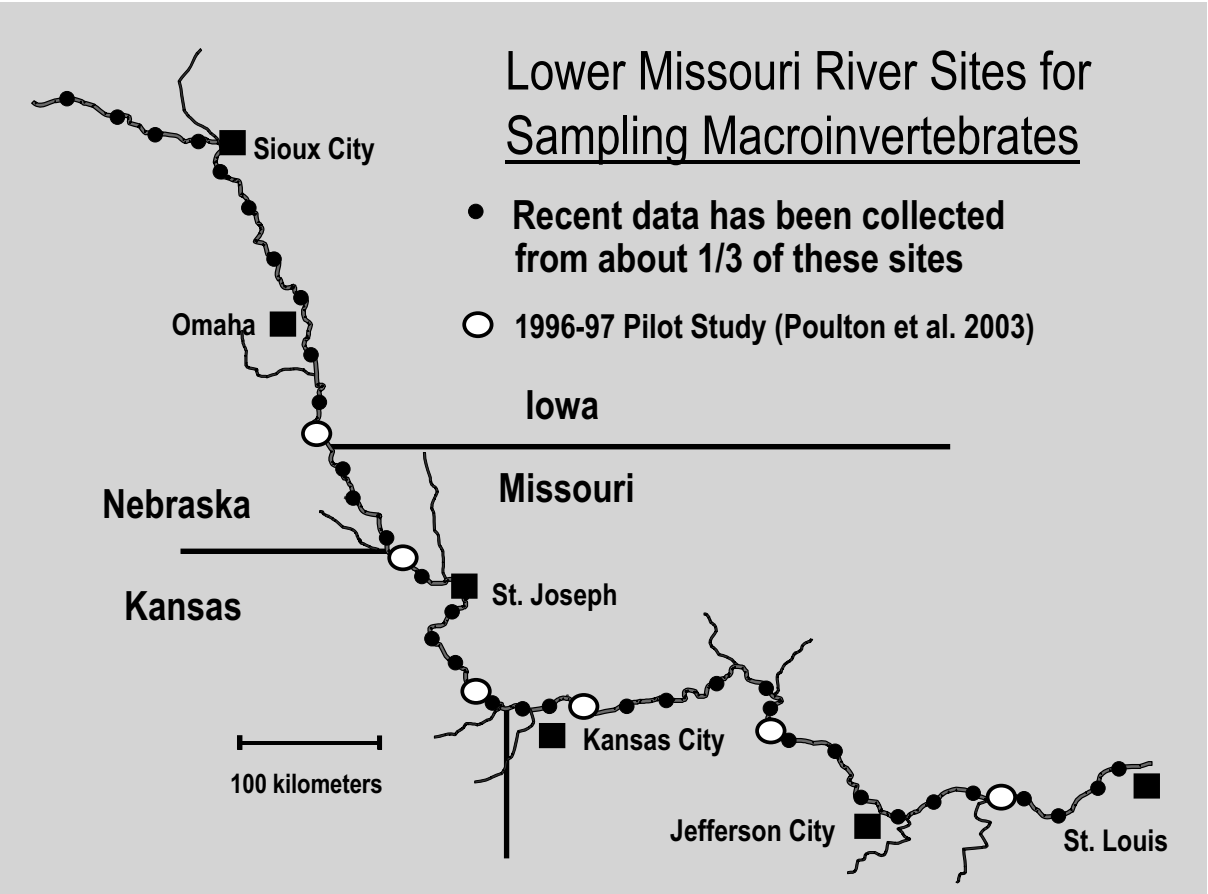
A. Background, history and emphasis of past studies
- **1.** Map of sampling sites
- **2.** Large River alterations

B. Summary of goals and objectives
- **1.** Large river bioassessment and biocriteria issues
- **2.** Flow chart – sequence of recent studies

C. Summary of recently completed and current pilot studies
- **1.** Results of 1996-1997 pilot study
  - **a.** Methods slides (2), showing key habitats
  - **b.** Bar graph of macroinvertebrate species distribution
  - **c**. List of candidate metrics
- **2.** Ongoing EPA-funded study (2002-2004)
  - **a.** Large river bioassessment assumptions
  - **b.** Summary of design and approach

D. Potential evaluation approaches for bioassessment
- **1.** Examples of other similar studies
- **2.** Graphs showing examples (5 total) of options for Lower Missouri

E. Summary
- **1.** What we think we know so far
- **2.** Future research needs (wish list)



Alterations Observed in Large Rivers

- ✓ Relative Contribution and Distribution of Habitats and Substrate Types
- ✓ Organic Matter (Storage, Transport, Entrainment)
- ✓ Hydrology (Flow Regime, Depth & Velocity)
- ✓ Cumulative Urban (CSO's, Wastewater, Contaminants)
- ✓ Collective Agricultural (Contaminants, Nutrients)
- ✓ Water Quality (D.O., turbidity, thermal effects)

USGS science for a changing world

✓ Free-flowing Lower Missouri River (1211 km or 752 miles)

Summary of Large River Bioassessment / Criteria Issues

1. Basic Ecological Knowledge of Fauna
2. Sampling Methods / Habitats
3. Index Period
4. Statistical Design & Analysis
5. Degree of Similarity with Wadeable Streams
6. Response Attributes (Metrics)
7. Metric Expectations (Reference ?)

USGS science for a changing world

Goals, Objectives, and Sequence of Macroinvertebrate Studies

Lower Missouri River

Past

Characterize community in different habitats & substrate types

↓

Examine efficiency and suitability of sampling methods

↓

Ongoing

Identify longitudinal response gradients due to cumulative impacts

↓ ◄····· *We Are Here*

Validate large river metrics and develop multi-metric indices

↓

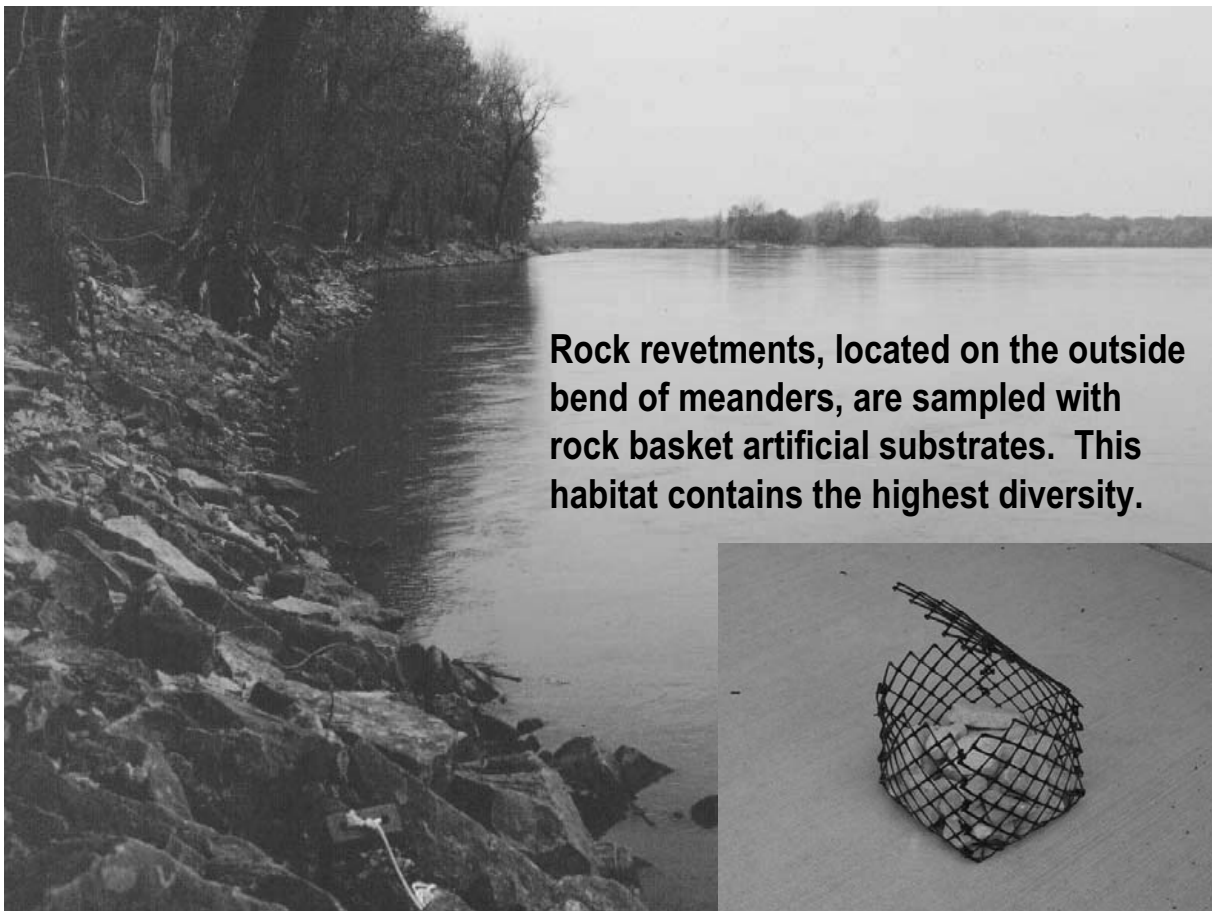
Future

Identify best reaches and evaluate relative biological condition

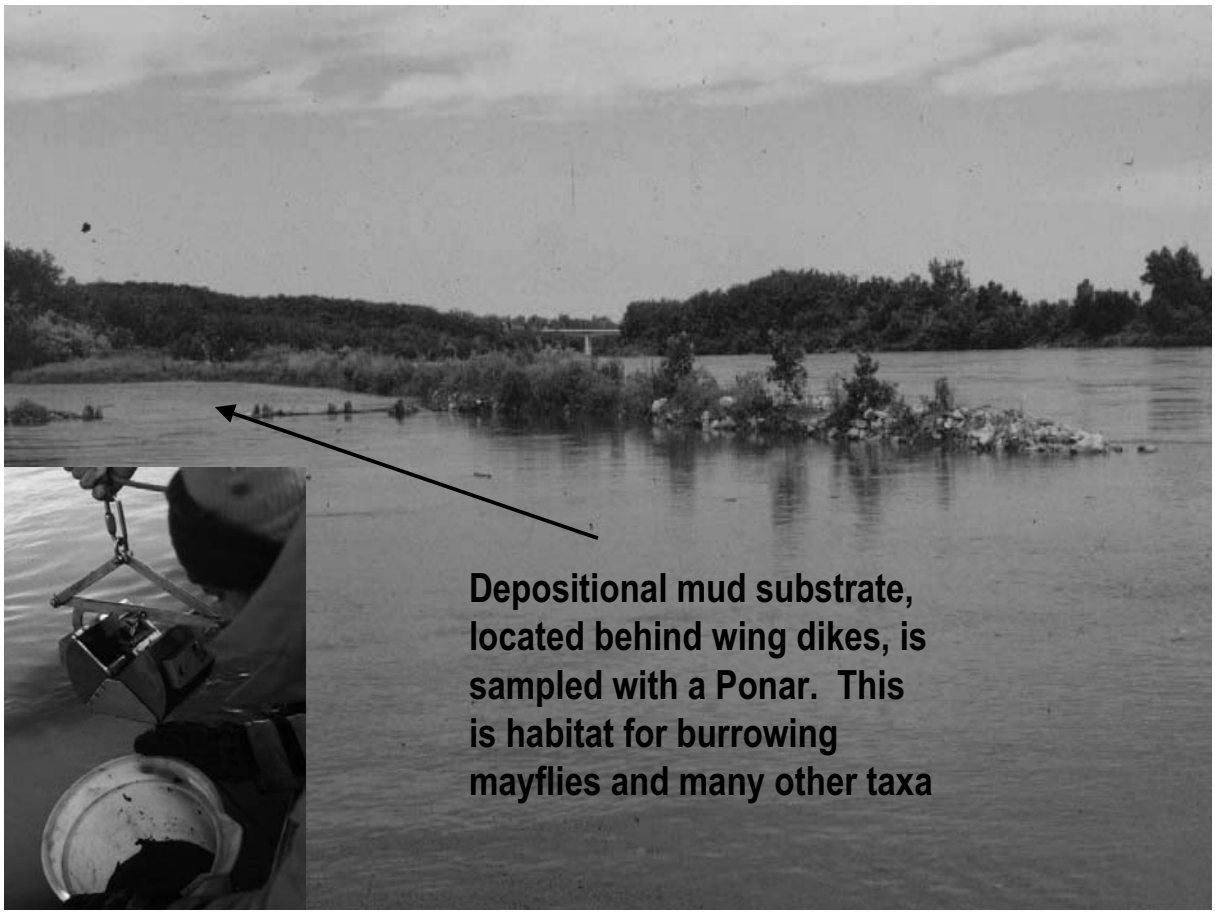
↓

Develop biocriteria & evaluate water resource use attainment status

Bold = Partially covered in this presentation



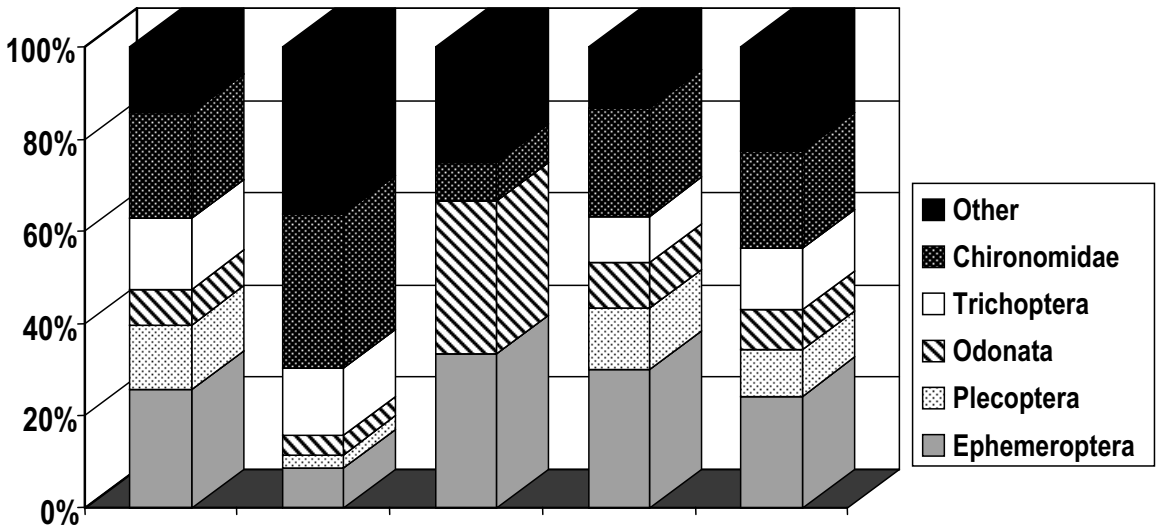
Rock revetments, located on the outside bend of meanders, are sampled with rock basket artificial substrates. This habitat contains the highest diversity.



Depositional mud substrate, located behind wing dikes, is sampled with a Ponar. This is habitat for burrowing mayflies and many other taxa

Percent (%) of Taxa Richness in 4 Substrate Types

Benthic Invertebrates - Lower Missouri River mainstem



	Rock	Mud	Sand	Organic	Total	
	78	69	12	30	132	Total No. Species
	49	21	4	2	X	Unique Species within habitat

Total # Species unique and restricted to large rivers = 21

List of Candidate Metrics

Lower Missouri River Macroinvertebrates

For Coarse Substrate (Rock)

* % Filtering Trichoptera
* EPT (% and richness)
* EPOT (% and richness)
* Hilsenhoff Biotic Index

  Scraper/Filtering Collector Ratio

  EPT/ Chironomidae Ratio
* % Large River Taxa

> * **Response trend or statistical significance among sites detected in '96-'97 pilot study**

For Depositional Substrate (Mud)

* % Ephemeroptera

  Density (# / m^2)
* Chironomidae Taxa Richness

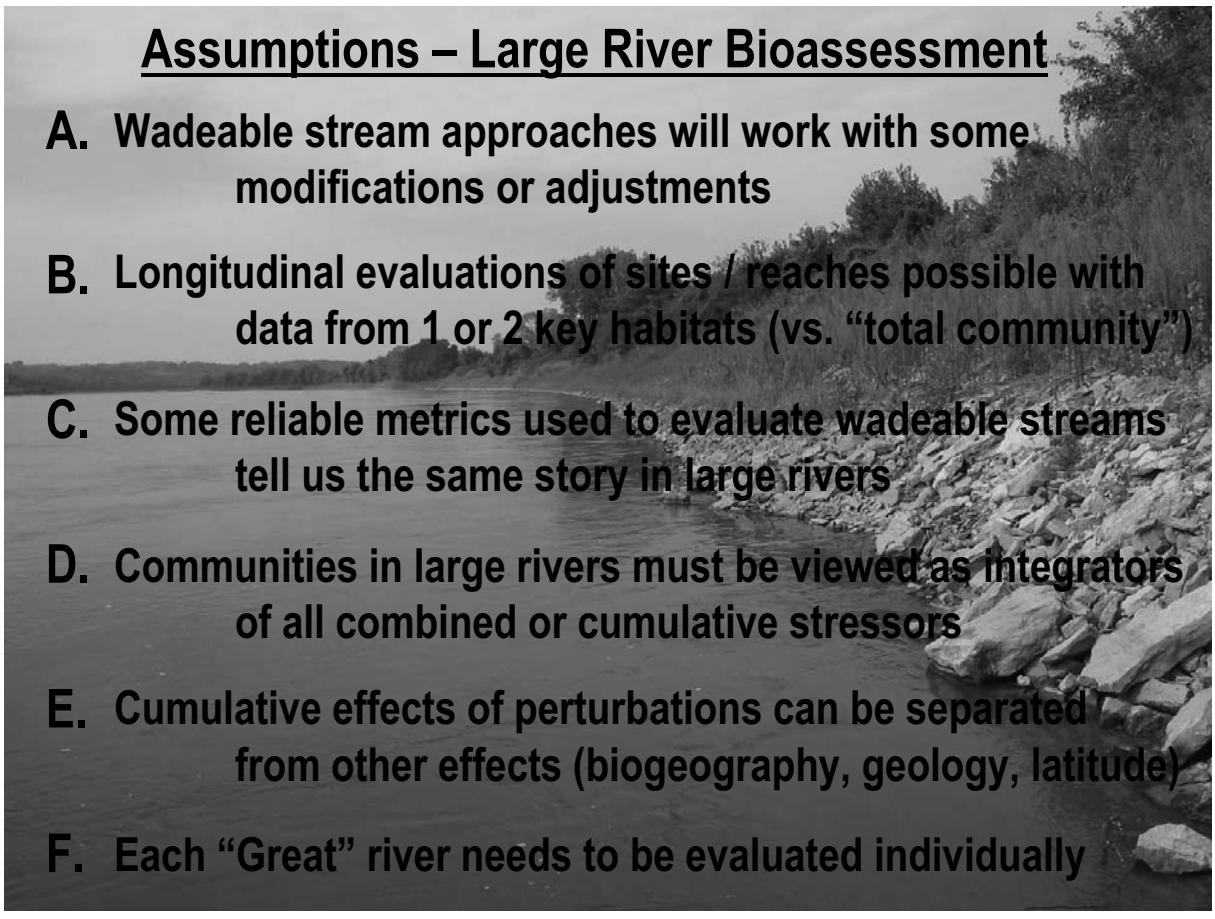
For Both Substrates

Shannon - Wiener Diversity Index

% Chironomidae

* Total Taxa Richness
* % Oligochaeta

% Dominant Taxon



Summary - Ongoing Lower Missouri Benthos Study

USEPA 104 (b) Grant, WQ Cooperative Agreement with Missouri DNR

Goal

Establish longitudinal response gradient to validate endpoint metrics

- 18 sites, 2 habitats, 3 methods, Autumn index period
- Simultaneous basic water quality and sediment contaminants

Sampling Design & Approach

- Upstream/downstream site selection based on longitudinal features (urban areas, tributaries), with pre-stratification by habitat
- Identification of "best" sites, or reaches with highest metric scores

"Site" Definition

A 10 km reach that includes repetition of the 2 selected habitats

Evaluation Approaches for Bioassessment – Example studies

Modifying an existing IBI or develop new indices for a specific water body or region

A. Ohio River IBI – Simon & Emery 1995
B. Coldwater Wisconsin streams – Lyons et al. 1996
C. Benthic IBI - Kerans & Karr 1994
D. Invertebrate Community Index (ICI), Ohio streams – DeShon 1995
E. Florida streams - Barbour et al. 1996
F. Lower Missouri River - Poulton et al. 2003

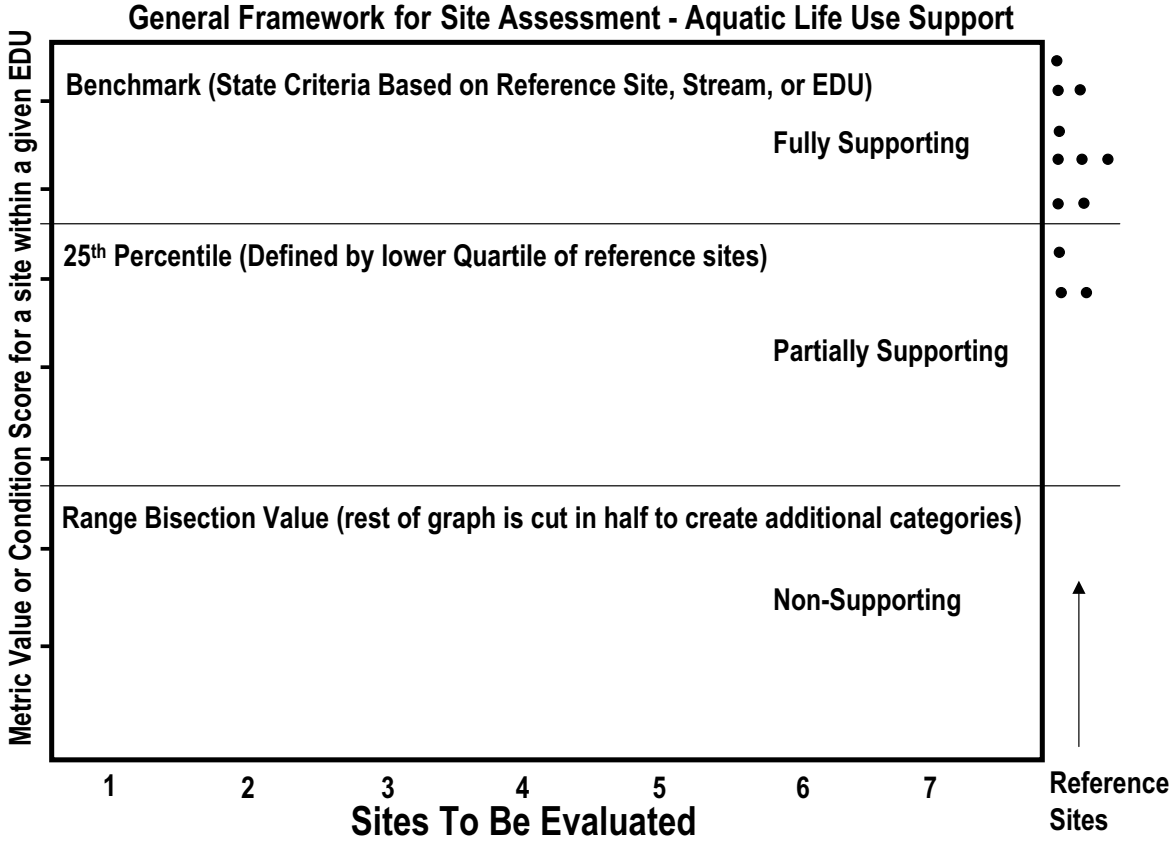
Options For Establishing Benchmarks, Criteria, or Metric Expectations

*** Example slides given for each**

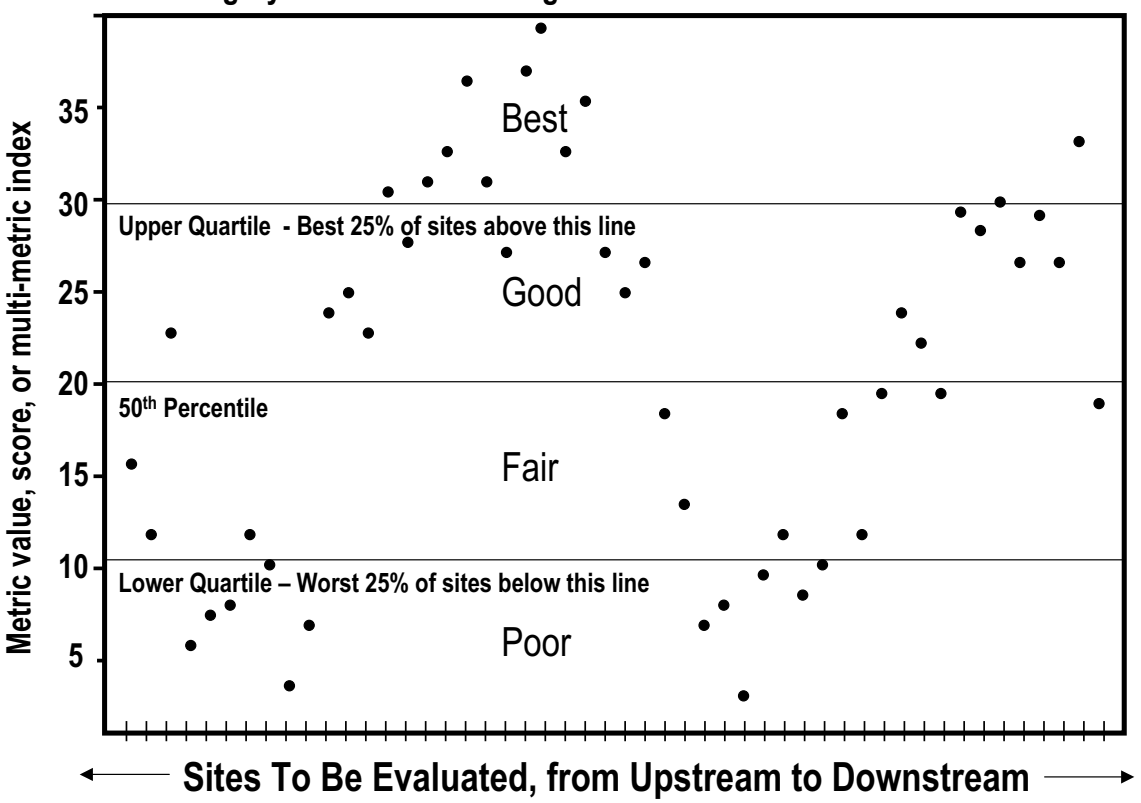
A. Existing data distribution of reference sites – **Example #1**
✓ B. Existing data distribution of all sites (true reference unknown) – **Example #2**
✓ C. Data from sites / reaches with best overall scores – **Example #3**
✓ D. Percent of reference (best value for a metric) – **Example #4**
E. Data from nearest, adjacent, or most similar watershed – **Example #5**

✓ Option for Lower Missouri

Example #1 - State of Missouri, Wadeable/Perennial Streams (MDNR)

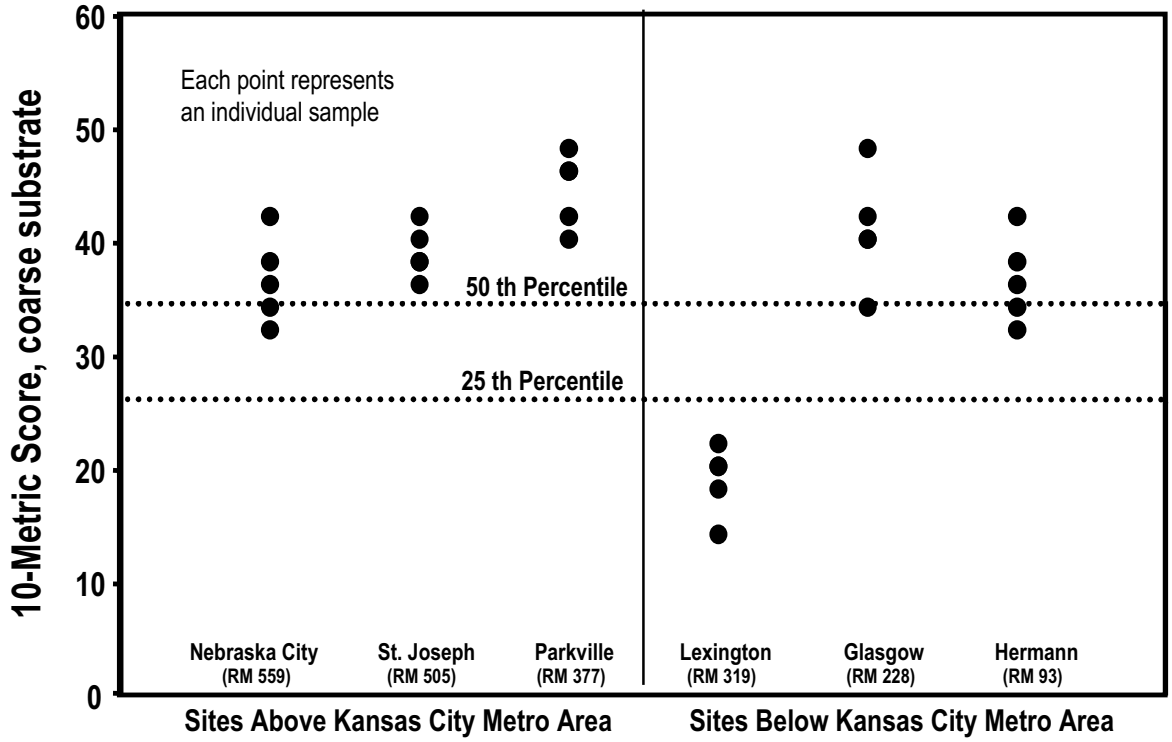


Example #2 – Possible approach for Lower Missouri River



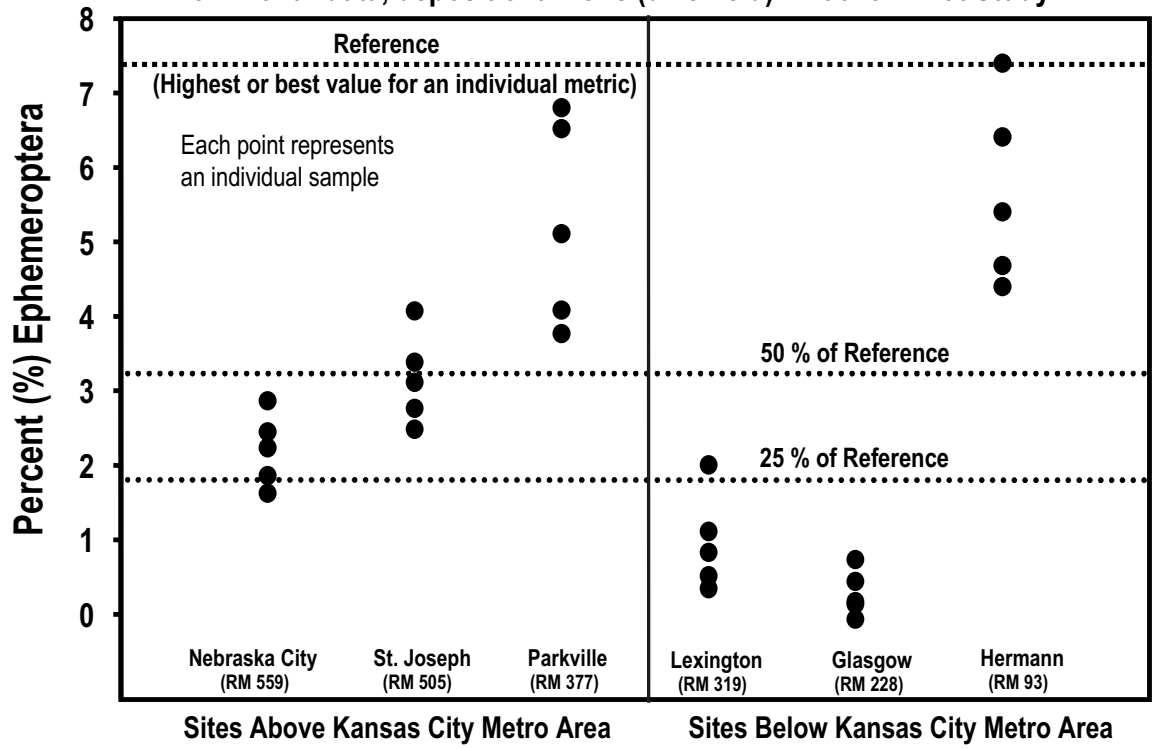
Example #3 – Site evaluation using overall multimetric scores

Lower Missouri River rock basket data and 10-metric score – '96-'97 Pilot Study



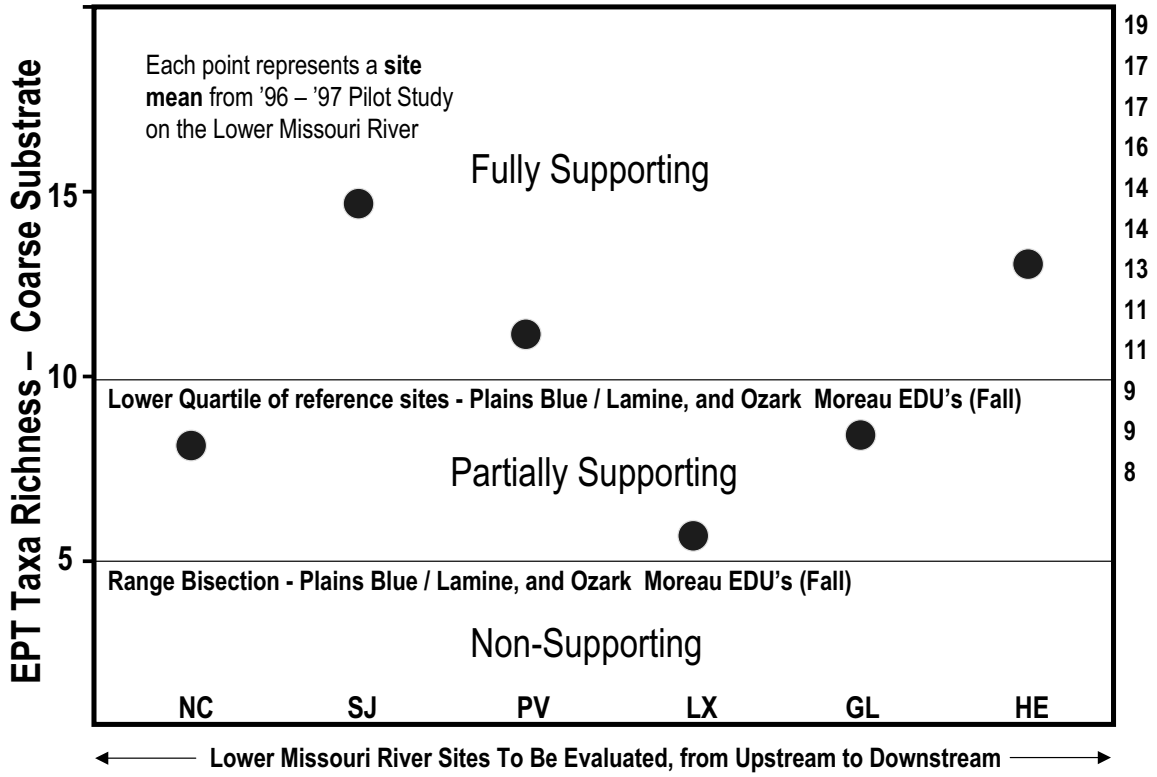
Example #4 – Percent of reference, defined by best value for a metric

From Ponar data, depositional zone (dike field) - '96-'97 Pilot Study



Example #5 – Nearest, adjacent, or similar watershed used for reference

From State of Missouri Wadeable / Perennial stream data - MDNR



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- ✓ B. Summary of goals and objectives
  - 1. Assumptions to consider - large river bioassessments
  - 2. Flow chart – sequence of recent studies
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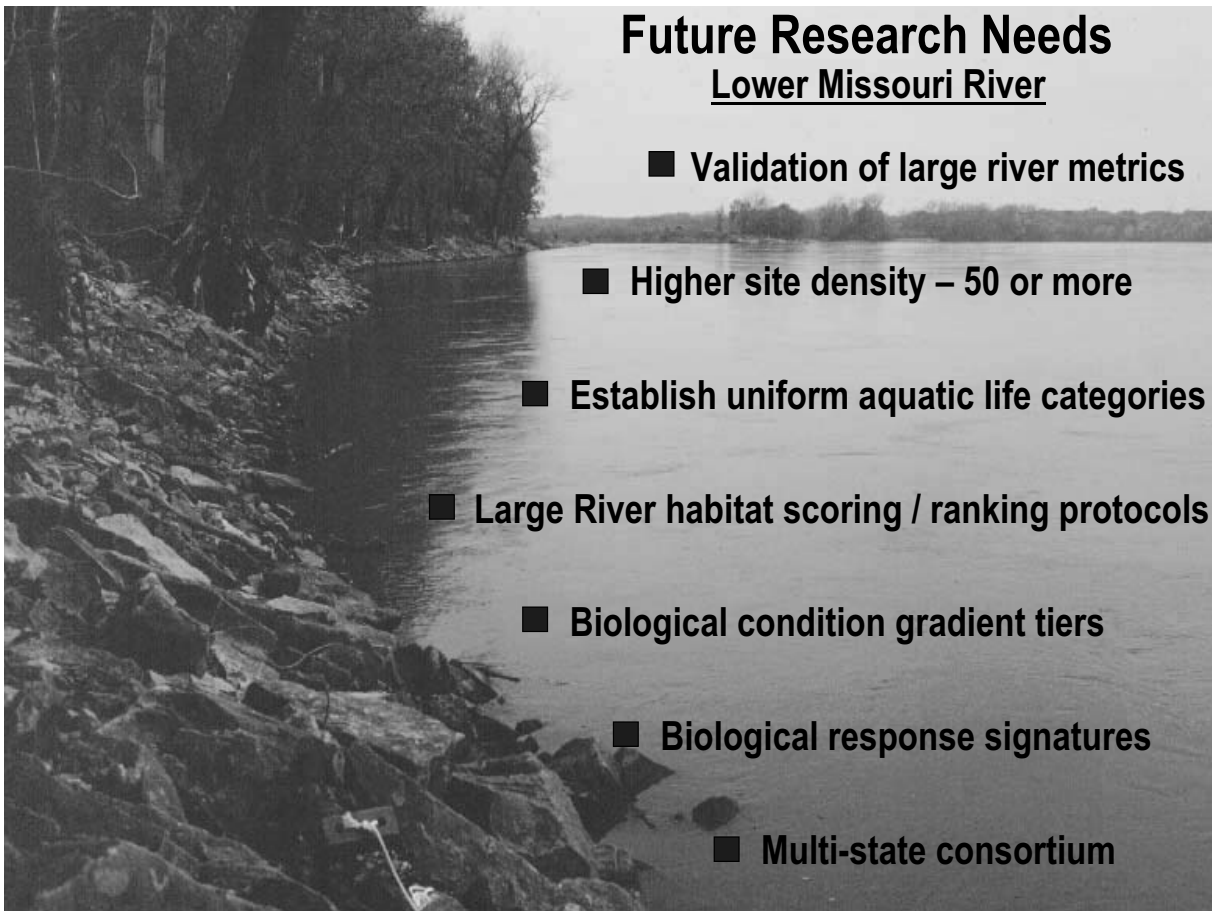
E. Summary

- **1. What we think we know so far**
- **2. Future research needs (wish list)**

What we know so far about Lower Missouri River Bioassessment

- Habitats / substrates are distinct and longitudinally repeatable, and can be successfully sampled using standard methods
- Community contains both generalists and habitat specialists, including some taxa that are restricted to large rivers
- Most of the rock is artificial, but has the highest diversity, and yields data parallel to that from coarse substrate in wadeable streams
- Site assessment possible with standard metrics and approaches, but modifications needed are not yet well understood
- Relative condition assessment probably requires "best site / reach", "highest value", or data distribution analysis for defining reference
- Longitudinal evaluation & relative site / reach comparisons involving benthos in large rivers may not require complete spatial coverage or inclusion of all habitats in the sample design



Future Research Needs
Lower Missouri River

- Validation of large river metrics
- Higher site density – 50 or more
- Establish uniform aquatic life categories
- Large River habitat scoring / ranking protocols
- Biological condition gradient tiers
- Biological response signatures
- Multi-state consortium

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Idaho River Ecological Assessment Framework

Chris Mebane and Cyndi Grafe, ID DEQ

Beneficial Use Reconnaissance Program (BURP)

- Rapid bioassessment program
- Provides statewide consistency in nonpoint source reconnaissance monitoring
- Data used in 305(b) reports, 303(d) lists, and Subbasin Assessments (TMDL component)

BURP Modules

- Small streams (since 1993)
- Rivers (since 1997)
- Lakes and reservoirs (since 1997)

Parameters & Methods General Components

- Work under classification framework
- Use reference sites to identify benchmarks
- Collect physicochemical and biological data
- Reconnaissance approach using combination of quantitative (Q) and subjective (S) methods

Diverse streams and rivers in Idaho




When does a stream become a river?

- Needed both a biological and operational distinction

When does a stream become a river?

- Average ratings by size

Water Body Size Category	Stream Order	Average Width at Baseflow (m)	Average Depth at Baseflow (m)	Rating
Rivers	≥5	≥15	≥0.4	3
Streams	<5	<15	<0.4	1

River Overview

- Index period: August - October
- 2 visits: site reconnaissance, field work
- 1 Coordinator
- 1 crew (3 people) plus regional contact
- Central training
- Average 35 sites/year
- Equipment and safety issues

River Parameters

- Flow (Q)
- Width, Depth (Q)
- Bank condition (S)
- Riparian vegetation (S)
- Channel alteration (S)
- Floodplain disturbance (S)
- Substrate (S)
- Embeddedness (S)
- Gradient (S)
- Water Clarity (S)
- pH (Q)
- Dissolved Oxygen (Q)
- Temperature (Q)
- Conductivity (Q)
- Macroinvertebrates (Q)
- Bacteria (Q)
- Periphyton (Q)
- Fish (outside sources)

Periphyton Sampling Method




Macroinvertebrate Sampling



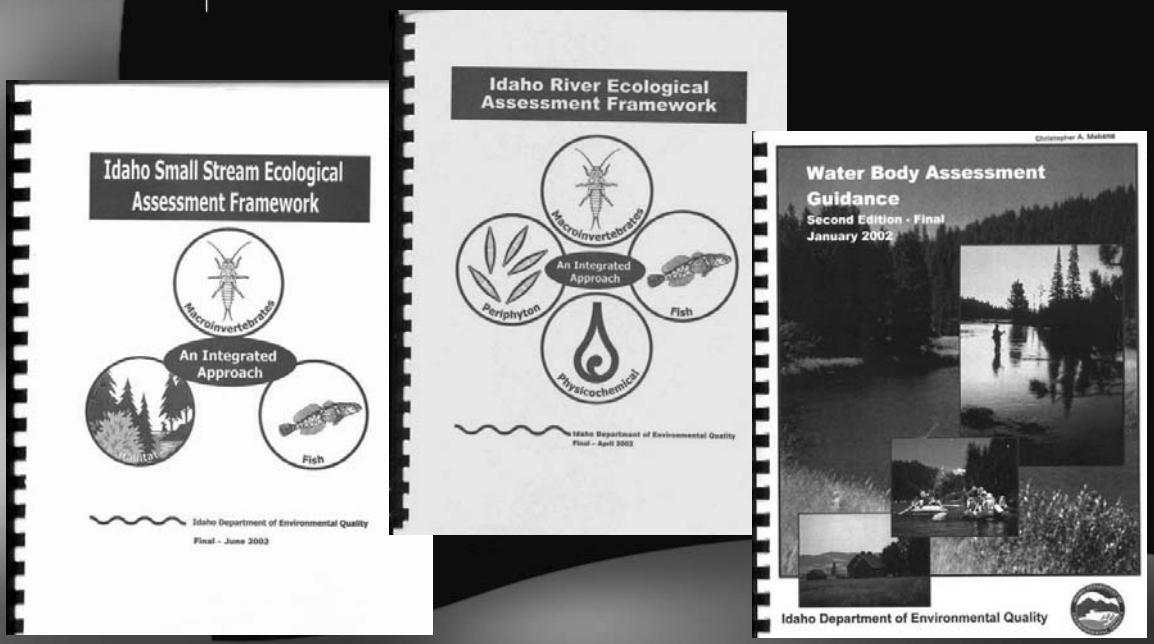

Fish Sampling

- Cooperated with USGS and EPA-EMAP for fish data from rivers

Data Management & Analysis

- Collect vouchers, identify to species
- Data housed in relational database
- QA/QC manual for data management
- Assessment methods - use multi-metric indexes (macroinvertebrate, fish, diatom, physicochemical and biology)
- Water Body Assessment Guidance - defines numeric criteria exceedances, uses, data integration

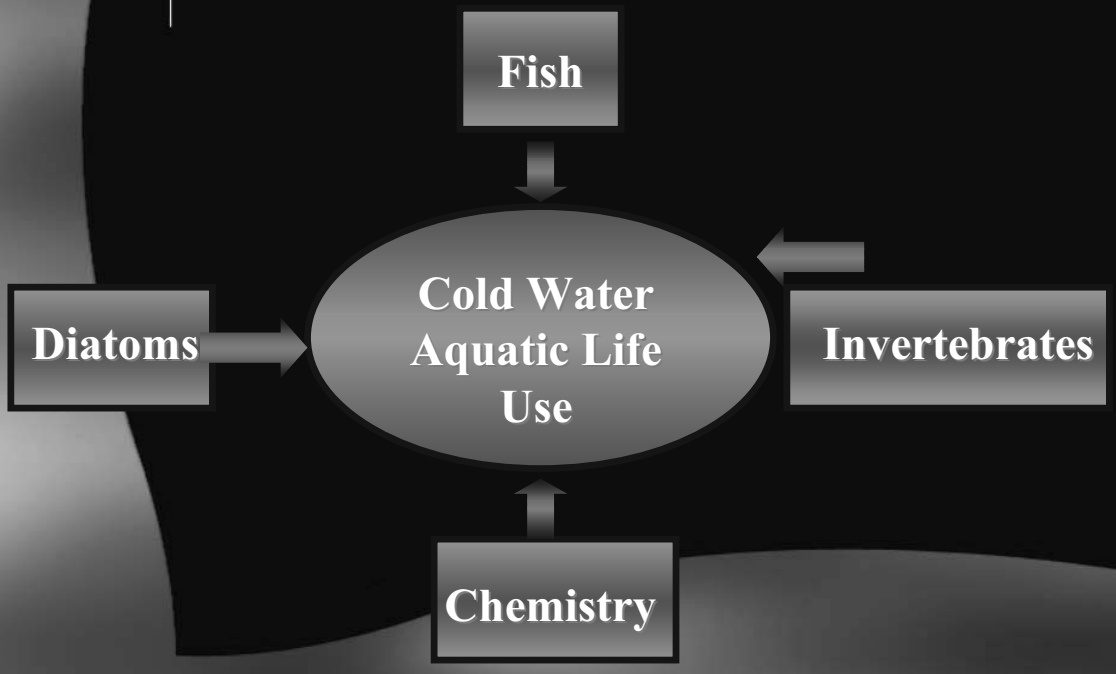
Assessment Frameworks



Ecological Assessment Approach
(Cold Water Aquatic Life Use)

- Use biological indicators
- Developed several multi-metric indices
- Use indices in a lines of evidence approach

Lines of evidence approach



River Macroinvertebrate Index *(RMI)*

- ISU performed 4-year study under contract (1995-1999)
- Used a reference - disturbed site comparison approach
- Selected 22 sites statewide to develop macroinvertebrate index
- Tested 24 metrics
- Used 1, 3, 5 scoring system
- Selected 6 sites to validate the IRI

RMI Metrics

- Taxa Richness
- % Dominance
- % Elmidae
- % Predators
- EPT Richness

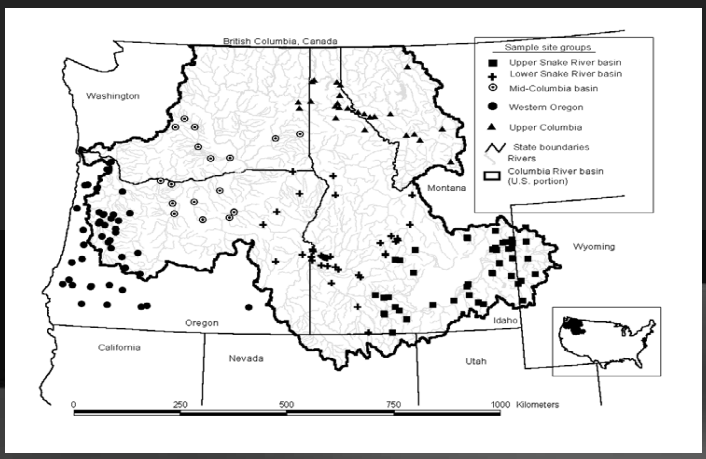
Royer, T. V., C. T. Robinson, and G. W. Minshall. 2001. Development of macroinvertebrate-based index for bioassessment of Idaho Rivers. *Environmental Management* 27:627-636.

River Fish Index (RFI)

- Used sites from one large river basin (Upper Snake) to develop multi-metric index.
- Used a reference - disturbed site comparison approach
- Tested 16 metrics used for cold water streams/rivers in the Northwest
- Used continuous scoring system, 0-100
- Validated the index with sites from other Pacific NW river basins

River Fish Index (RFI)

- Cost, difficulty of river sampling, limited reference sites argue for regional cooperation in monitoring and assessment
- Rivers do not respect political boundaries



RFI Metrics

- **# of Cold Water Native Species**
- **% Cold Water Individuals**
- **% Sensitive Native Individuals**
- **% Tolerant Individuals**
- **# of Non-Indigenous Species**
- **Presence of Carp**
- **% Sculpins (Cottids)**
- **# of Salmonid Age Classes**
- **# of Cold Water Individuals Per Minute of Electrofishing**
- **% of Fish with DELT Anomalies**

Mebane, C. A., T. R. Maret, and R. M. Hughes. 2003. An index of biological integrity (IBI) for Pacific Northwest rivers. *Transactions of the American Fisheries Society* 132:239-261.

River Diatom Index *(RDI)*

- Selected 59 sites statewide to develop index
- Identified 35 attributes and tested 86 metrics
- Instead of a reference - disturbed site comparison approach, tested human disturbance ratings
- Used 1, 3, 5 scoring system

Fore, L. S., and C. S. Grafe. 2002. Using diatoms to assess the biological condition of large rivers in Idaho (U.S.A.). *Freshwater Biology* 47:2015–2037.

RDI Metrics

- **% Sensitive Species**
- **% Very Tolerant Species**
- **Eutrophic species richness**
- **% Nitrogen heterotrophs**
- **% Polysabrobic**
- **Alkalaphilic species richness**
- **% Species requiring high oxygen**
- **% Motile species**
- **% Deformed cells**

River Physicochemical Index— *RPI*

- Application of the Oregon Water Quality Index using Idaho data
- Selected 10 sites to test the index
- Used OWQI regression for initial scoring
- Index results not directly used in aquatic life use assessments because non-biological; interpretive tool

Cude, C.G. 2001. Oregon water quality index: a tool for evaluating water quality management effectiveness. *Journal of the American Water Resource Association* 37:125-138

PCI Metrics

- Temperature
- Total Solids
- Dissolved Oxygen
- Ammonia + Nitrate Nitrogen
- Biochemical Oxygen Demand
- Total Phosphorus
- pH
- Fecal Coliform

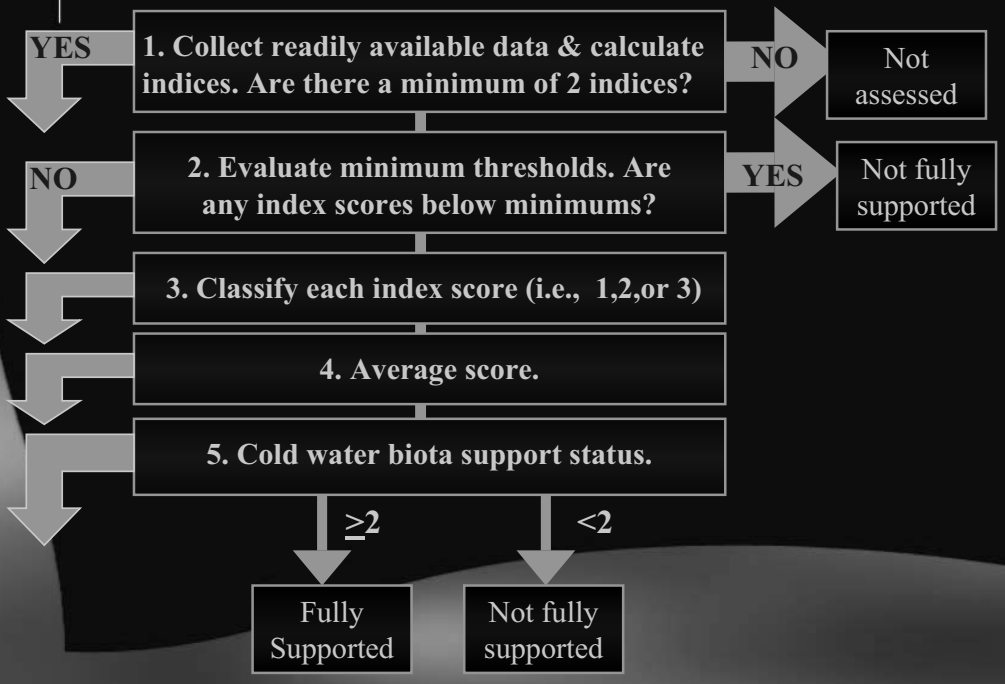
Index Integration

- Weight of evidence approach, except
- Set minimum thresholds for each index
- Normalize each index score to a 1, 2, or 3 rating based on deviation from expected condition
- Minimum of 2 index scores required to evaluate aquatic life use (ALUS)
- Average site score <2, ALUS not supported; ≥2 ALUS supported

Normalizing Different Index Scores

	Minimum threshold	1	2	3
RMI (%-tile of reference)	< minimum reference score	min. – 10 %	10 –25%	>25th %
RDI (%-tile of all waters)	None	25 – 50 %	50-75%	>75th %
RFI (%-tile of reference)	< 5th %-tile	5 – 10 %	10 –25%	>25th %

River aquatic life assessment process



River index score results

Site	RMI	RDI	RFI
Payette River below city WWTP	15	16	21
Little Wood River near Carey	21	42	78

River condition ratings

Site	RMI	RDI	RFI
Payette River below city WWTP	2	1	<Minimum threshold
Little Wood River near Carey	3	3	3

Other plans

- Currently use the low end of the statistical distribution of scores to identify waters with impaired uses
- Perhaps the high end of the distribution could be used to identify "high quality" waters for antidegradation reviews

LR 201 – COURSE DESCRIPTION

- Considerations for biocriteria derivation for large rivers
- Case studies representing various scales and monitoring designs
- Lessons learned in different large river systems

LR 201 - TAKE HOME CONCEPTS

- Familiarity with existing programs and technical contacts
- Exposure to the issue of biocriteria development in large rivers
- Identification of major issues and considerations facing large river biocriteria