

## Versatile Biological Indicators: A Cross-System Comparison



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## The Need for Biology

- The FWPCA (1972) requires all states to protect the *physical, chemical and biological integrity* of the nation's waters
- **Biological sampling** has been stressed as a critical component of an **integrated monitoring program**
- 44 states currently have invertebrate monitoring programs, 5 have programs in development and 3 have no biomonitoring program

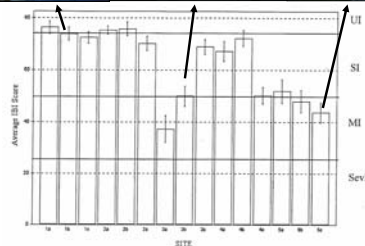
## The Multi-Metric Approach

- Focus on **multiple biological measurements** describing different components of biological communities (**metrics**)
- Comparison to minimally impacted "reference" sites
- Generation of an integrated **Index of Biotic Integrity** using combined scores from 7-10 metrics

### Examples of Metrics

Taxa Richness	Number of Genera
Tolerance	% Tolerant Taxa
Trophic Structure	% Omnivores
Individual Health	% Deformities

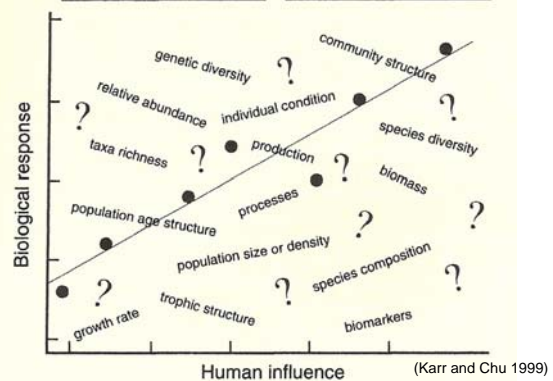
## IBI Scores & Assigning Class Condition



## Issues of Using Biology

- **Need to know the regional fauna** before you can establish a "reference expectation"
- **Need to know expected relationships** between biological characteristics and human influences to aquatic systems
- **Need to identify those biological characteristics** best correlated with human influences, water quality and habitat conditions

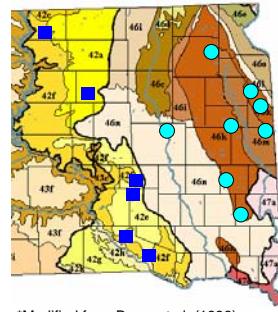
### What to measure? How to decide?



## Questions?

- With so many biological measurements possible, which might best discriminate differences in biotic integrity among sites differing in water quality and habitat characteristics?
- Are some biological measurements useful across different biophysical regions and system types?

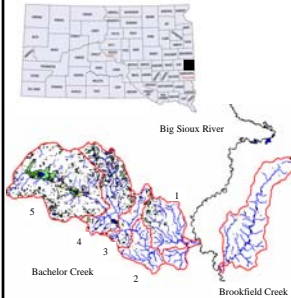
## SD AES Lake Survey



\*Modified from Bryce et al. (1996)

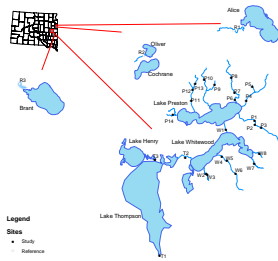
- Ag Experiment Station Project to characterize ecoregion differences in littoral zone invertebrates
- 14 lake basins sampled 1996 – 2000
- 2x during the summer
- Attributes:
  - Littoral invertebrates
  - Habitat
  - Limited Water Quality

## Bachelor Creek Assessment Project



- Moody Co., SD
- Project to develop TMDL for Bachelor Creek
- Brookfield Creek used as reference watershed
- Multiple sites on 2 streams sampled 1998-1999
- Monthly - April to September
- Attributes:
  - Invertebrates
  - Habitat
  - Water Quality

## Kingsbury Co. Lakes Assessment



- Kingsbury, Lake and Deuel Counties, SD
- Project to develop TMDL for Lakes Whitewood and Thompson
- Lakes Alice, Cochrane and Brant serve as reference basins
- 17 streams and 7 lake littoral zones sampled 2001-2003.
- Attributes:
  - Invertebrates
  - Habitat
  - Water Quality

## National Park Service I&M Effort



- 13 National Parks in ND, NE, SD, WY
- Collection of baseline data for future monitoring in network parks
- Sampled 2004, 2005
  - 12 Streams
  - 7 Rivers
  - 8 Springs
  - 5 Bison Watering Holes
- Attributes:
  - Invertebrates
  - Habitat
  - Water Quality

## Similar Methodologies

- Aquatic habitat, shoreline conditions, water quality and invertebrates were sampled in all studies
- Invertebrate sweepnet samples were collected from all sampled habitats
- Samples were collected from all sampled sites on multiple dates
- Invertebrate samples were subsampled and processed using similar counting methodology
- Sample identification was similar among all studies
- Metric screening procedures were similar in all studies

## Metric Screening Procedure

- 51-98 invertebrate community measures were calculated from raw counts for each aquatic system type
- Kruskal-Wallis F statistics or t-statistics were calculated to evaluate among versus within site variability for each metric and aquatic system type
- Metrics were ranked by DP within their descriptive groups (Composition, Diversity, Feeding Guild, Habit Guild, Tolerance)
- Obvious redundancy among highly ranking metrics within a class was eliminated by selecting that metric with the highest DP and/or greatest data range
- Metrics with a high percentage (>25%) of undefined values were eliminated (e.g., ratio metrics)
- Metrics with a greater range of values were selected over those with a narrower range of values
- Metrics exhibiting significant correlations with measures of chemical, habitat and landscape disturbance were selected over those without relationships

## Why use a selection procedure?

Class	Random	US EPA	PCA	Optimized
Unimpaired	-	-	47%	20%
Slight	60%	60%	53%	47%
Moderate	40%	40%	-	33%
Severe	-	-	-	-

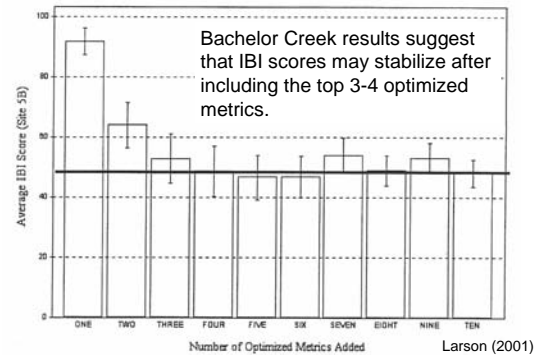
The Bachelor Creek study suggested that the U.S. EPA metric set would classify sites no different than a random set of metrics. Metrics selected based upon principle components analysis would tend toward a more lenient classification of sites than the other methods. The optimized metric set seemed to provide a greater ability to differentiate sites among different impairment classes (Larson and Troelstrup 2001).

## Use of KW-ANOVA to Evaluate Discrimination

Source	DF	SS	MS	F	P
Between	17	6488.5	381.7	2.76	0.0061
Within	33	4561.5	138.2		
Total	50	11050.0			

Selected metrics should discriminate well among sites which differ biologically. Good discriminatory power implies high between-site variability relative to within-site variability. Thus, discriminatory power might be evaluated using an F-ratio or t-statistic from a test of site differences.

## How many metrics do we need?

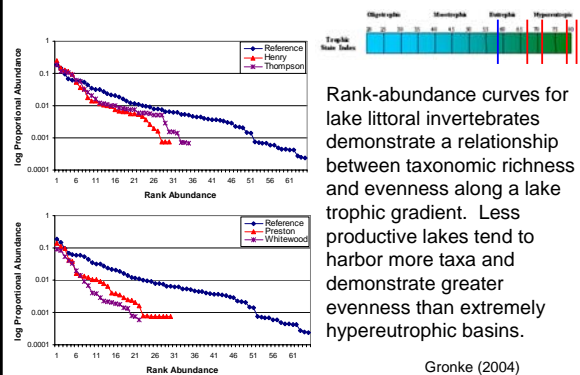


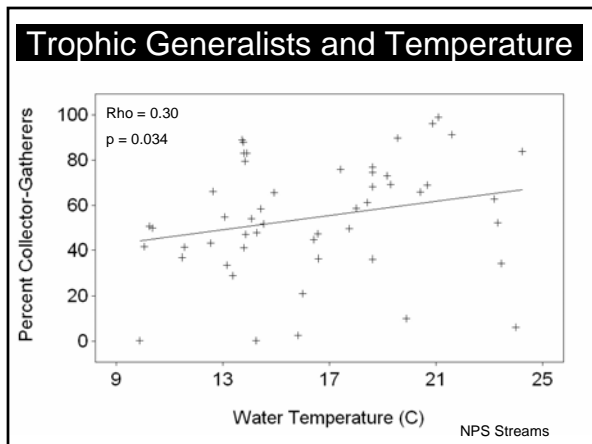
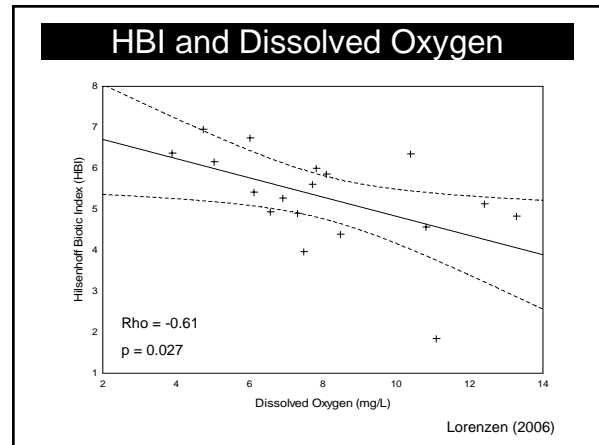
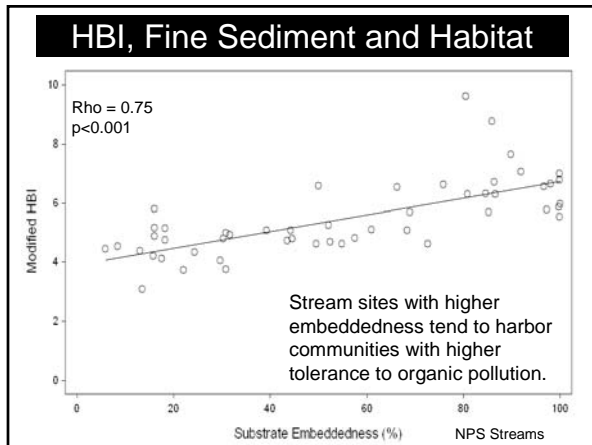
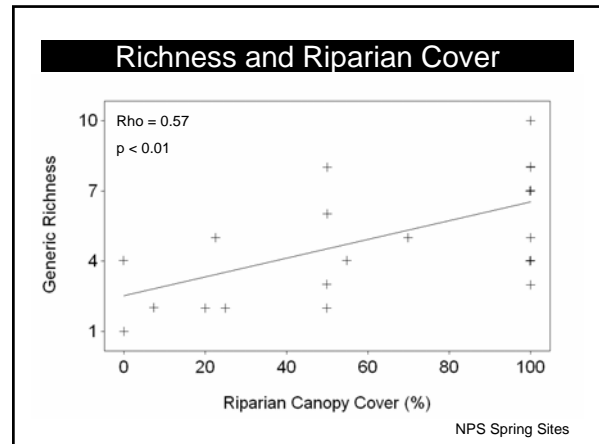
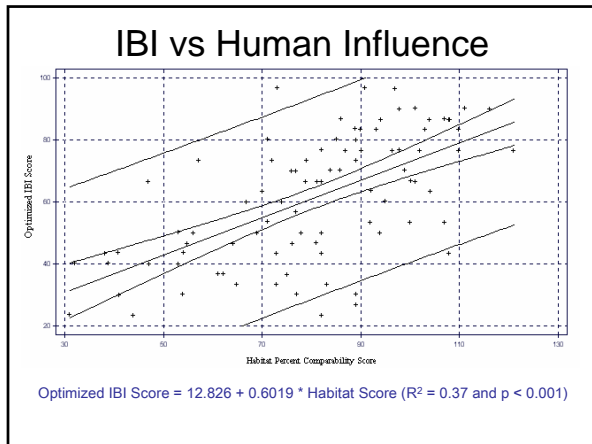
## Versatile Metrics

Metric	Metric Group
Hilsenhoff Biotic Index	Tolerance to Organic Pollution
EPT Generic Richness	Diversity
Total Generic Richness	Diversity
% Collector-Gatherers	Generalist Feeding Guild

These metrics discriminated well among sites which varied in water quality and habitat characteristics in three or more studies of different aquatic habitats.

## Diversity and Lake Trophic State





- ### Conclusions
- Discriminatory power provides an objective way to select metrics among many possible biological characteristics.
  - HBI, total richness, EPT richness and % collector-gatherers demonstrate high discriminatory power among geographic areas and system types.
  - Metrics with high discriminatory power correlate well with measures of human influence, water quality and habitat.

### Food for thought...

- Multimetric approaches typically rely on 7-10 metrics for development of IBI.
- Metrics chosen based upon discriminatory power and relationships to indicators of human influence provide greater resolution of differences in biotic integrity among sites.
- A core set of common metrics (3-4) would provide a common denominator among studies of different systems while still allowing for regional or watershed specific metrics highly sensitive to local influences.

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