Assessment of Stream Physical Habitat Quality

Can Qualitative be Accurate and Comprehensive?

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Purpose of Presentation

- Importance of assessing physical habitat quality
- Relationship to fluvial geomorphology AND biological condition
- Visual-based assessment of physical habitat quality (á la RBP)
- Information needs and the required precision and accuracy

Importance of assessing physical habitat quality

- one of five categories of "environmental factors" affecting biological integrity (Karr et al. 1986)
- the template within which favourable conditions exist for optimal reproductive success (Southwood 1977) = favourableness
- as indirect (surrogate) indicator of one type of stressor limiting the biology

What is good physical habitat quality?

- Within range of geographic expectations/natural conditions
- Capacity to support a “healthy” biota (in the absence of other stressors)
- Spatially and temporally *complex* (May 1974)
- Habitat is a mosaic (Forman 1983, Pringle et al. 1988, Resh et al. 1988)
- Complex habitat allows more rapid recovery of stream biota (Pearsons et al. 1992, Raven et al. 1998, Shields et al. 1995)

What is good stream physical condition?

- Dynamic stability within range of geographic expectations/natural conditions
- “Capacity” to maintain normal rates of erosion
- Substantial overall channel roughness (=Manning’s *n*?) within range of geographic expectations/natural conditions
- Dissipation of erosive flow energy

What stream channel physical factors contribute to “roughness”?

- Channel flow access to floodplain (connectedness)
- Vegetation status of streambank and floodplain
- Size diversity and distribution of substrate materials (particle sizes)
- Gradient
- Depth
- Bottom topography
- Meander pattern/ratio
- Woody debris/snags/organic detritus
- Macrophyte beds (presence/density/expanse)

Calculation of Manning's *n* from field observations

- $n = (n_0 + \mathrm{n}_1 + n_2 + n_3 + n_4)\ m$
- n_0 geologic material
- n_1 degree of streambank irregularity
- n_2 variation of thalweg in channel x-section
- n_3 effect of flow obstructions
- n_4 instream and riparian vegetation
- m degree of meandering

modified from Gore 1996, in Hauer and Lamberti 1996

TABLE 3.1
Calculation of *Manning's* "*n*" from Field Observation

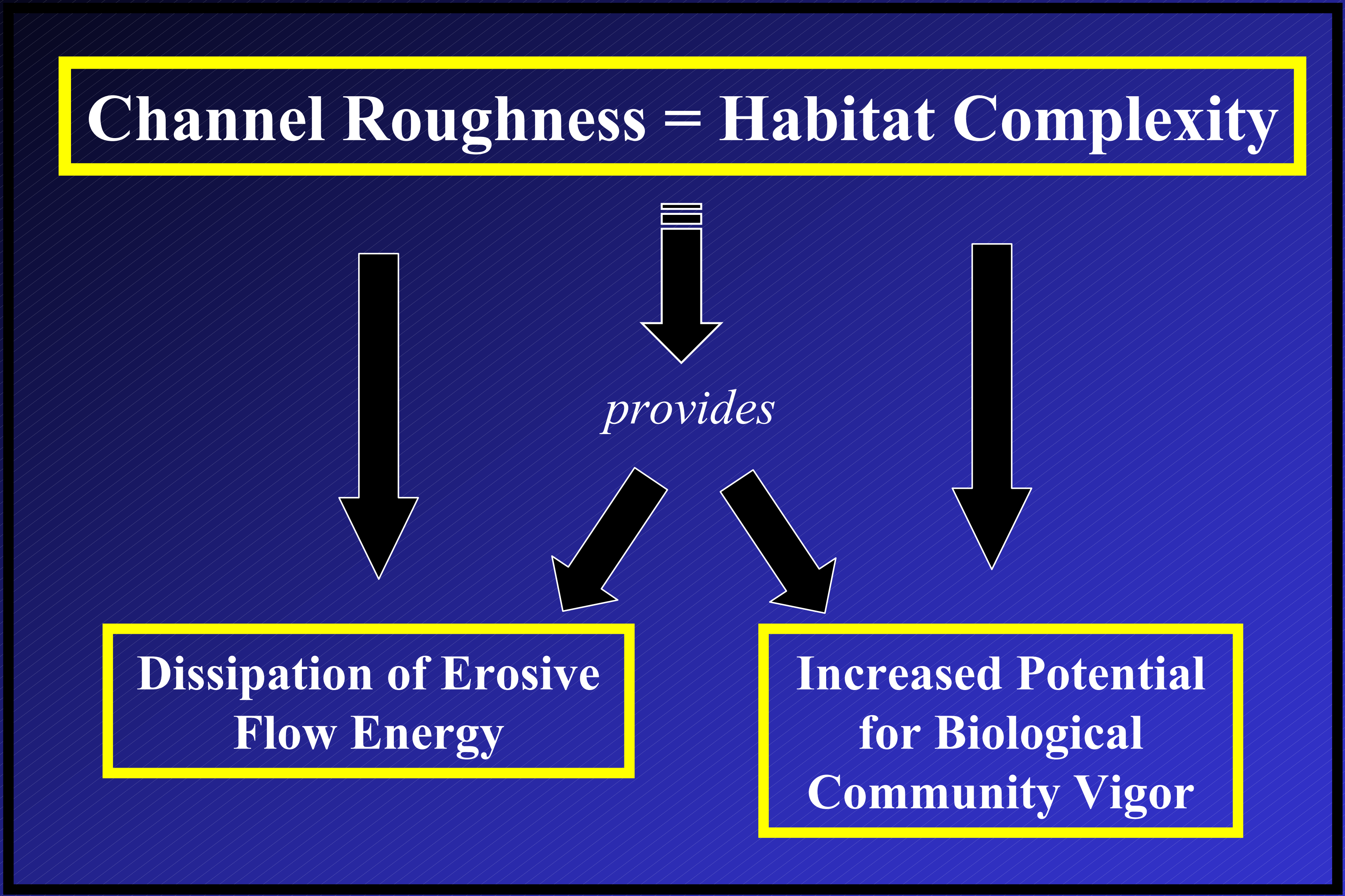
Channel condition	Value
$n = (n_0 + n_1 + n_2 + n_3 + n_4)\,m$	
Additive factors	
Material involved	n_0
Earth	0.020
Rock Cut	0.025
Fine Gravel	0.024
Coarse Gravel	0.028
Cobble	0.030–0.050
Boulder	0.040–0.070
Degree of irregularity	n_1
Smooth	0.000
Minor (slight scour)	0.015
Moderate (slumping)	0.010
Severe (eroded banks)	0.020
Variation in channel cross section (location of thalweg)	n_2
Gradual	0.000
Alternating occasionally	0.005
Alternating frequently	0.010–0.015
Effect of obstructions	n_3
Negligible	0.000
Minor (15% of area)	0.010–0.015
Appreciable (up to 50%)	0.020–0.030
Severe (>50% is turbulent)	0.040–0.060
Vegetation	n_4
None	0.000
Low (grass/weeds)	0.005–0.010
Medium (brush, none in streambed)	0.010–0.025
High (young trees)	0.025–0.050
Very high (brush in streams, full grown trees)	0.050–0.100
Multiplicative factors	
Degree of Meandering	m
Minor	1.000
Appreciable	1.150
Severe	1.300

Note. Adapted from Cowan (1956).

taken from Gore 1996, in Hauer and Lamberti 1996

Dissipation of Erosive Flow Energy is Key to Dynamic Channel Stability

Complex physical habitat is not only the template upon which a vigorous biota can develop, it simultaneously provides structure to stream channels that breaks up erosive flows.


Channel Roughness = Habitat Complexity
provides
Dissipation of Erosive Flow Energy
Increased Potential for Biological Community Vigor

High Gradient

High Gradient

Low gradient

Low gradient

Assessment of Physical Habitat Quality using the EPA/RBP Procedure

- Barbour et al. (1999)
- Data Sheets completed in-field:
  - Physical Characterization and Water Quality
  - Habitat Assessment
- Visual-based, on-site observation
- 125m segment (begin approx. 75-100m upstream of biological sampling segment)
- Parameter ratings scored as average over entire length

Assessment Parameters - High Gradient

1. Epifaunal substrate/available cover
2. *Embeddedness*
3. *Velocity/depth combinations*
4. Sediment deposition
5. Channel flow status
6. Channel alteration
7. *Frequency of riffles (or bends)*
8. Bank stability
9. Bank vegetative protection
10. Riparian vegetative zone width

Assessment Parameters - Low Gradient

1. Epifaunal substrate/available cover
2. *Pool substrate characterization*
3. *Pool variability*
4. Sediment deposition
5. Channel flow status
6. Channel alteration
7. *Channel sinuosity*
8. Bank stability
9. Bank vegetative protection
10. Riparian vegetative zone width

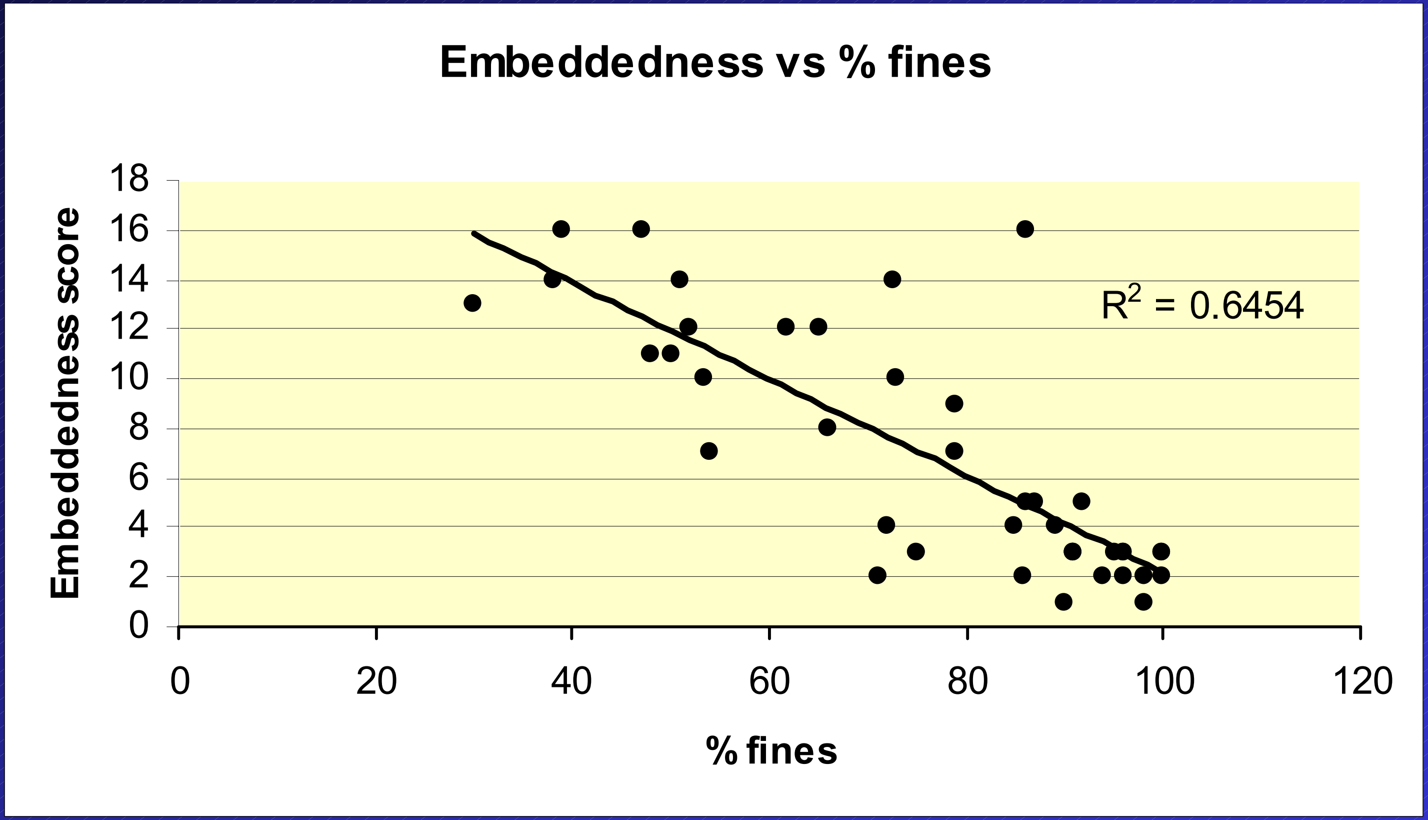
Additional Quantitative Measures

- Modified 100-particle Wolman pebble count
- Stream channel cross-sectional profile

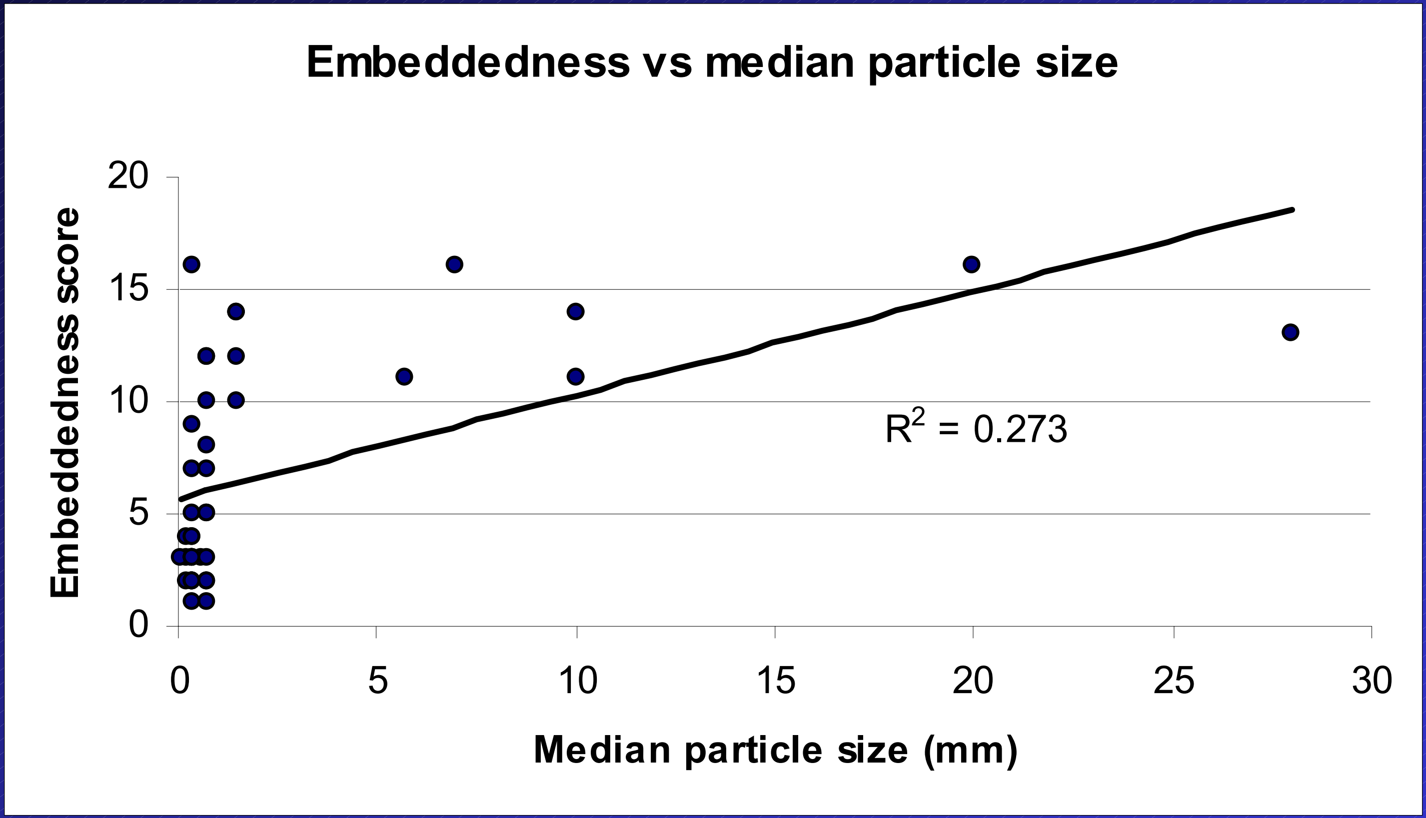
Approach

- Grades each of 10 habitat parameters based on their complexity
- Greater complexity → higher score
- Numeric decision criteria divided into ordinal, heirarchical categories of optimal (20-16), suboptimal (15-11), marginal (10-6), and poor (5-0)
- Individual parameter scores summed for total habitat scores
- In general, as stream habitat becomes degraded, it becomes more simplified

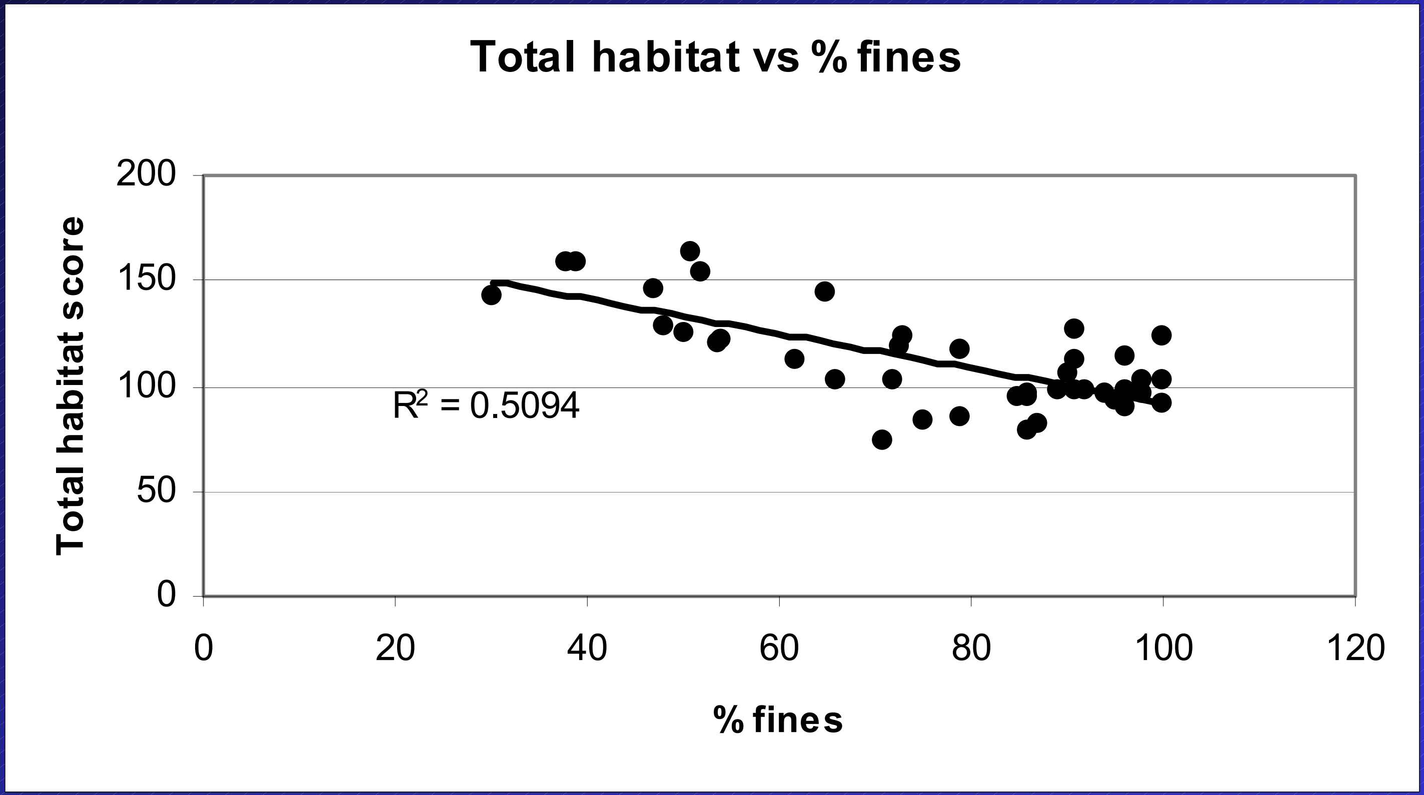
RBP Embeddedness vs. % Fines



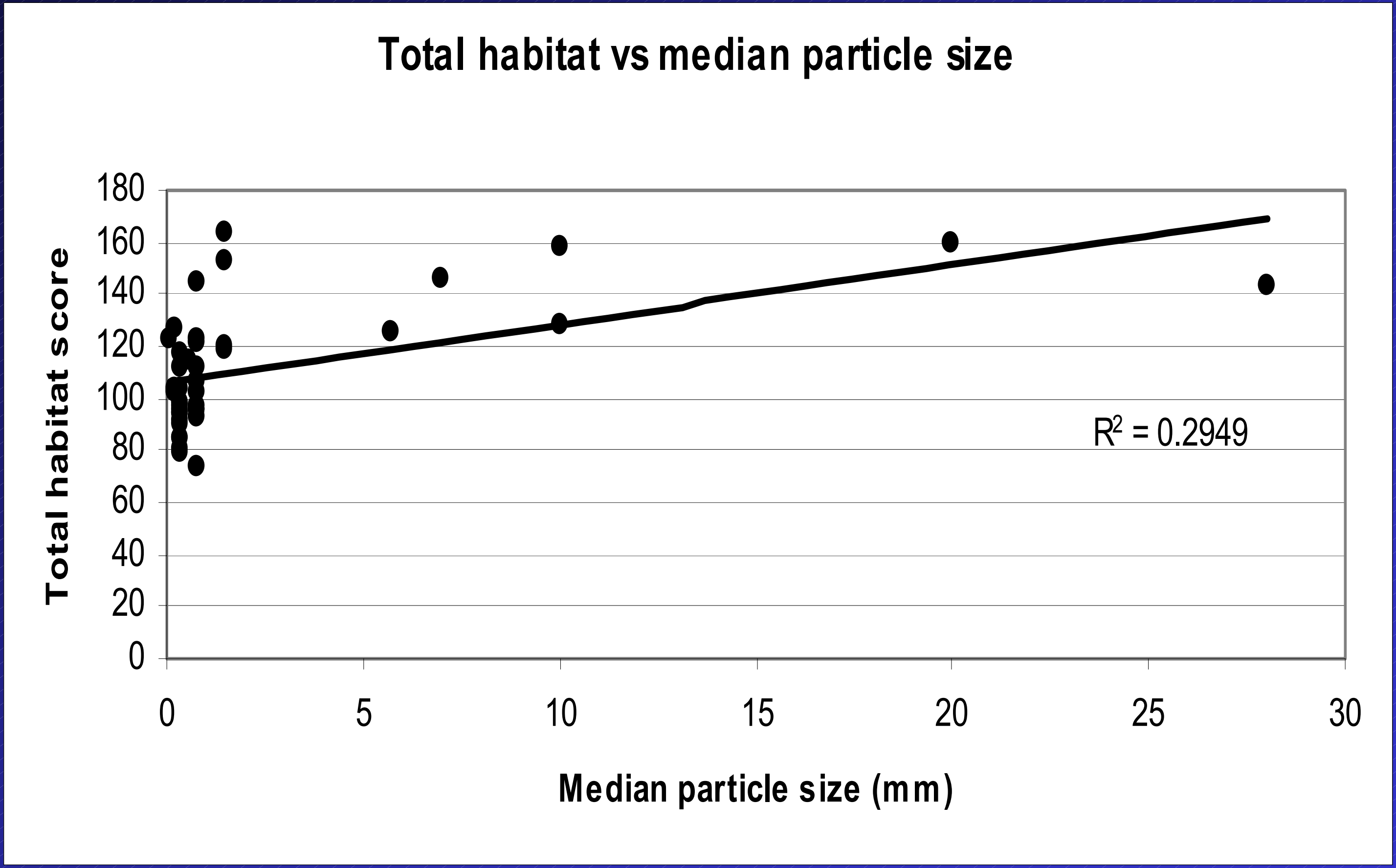
RBP Embeddedness vs. Median Particle Size



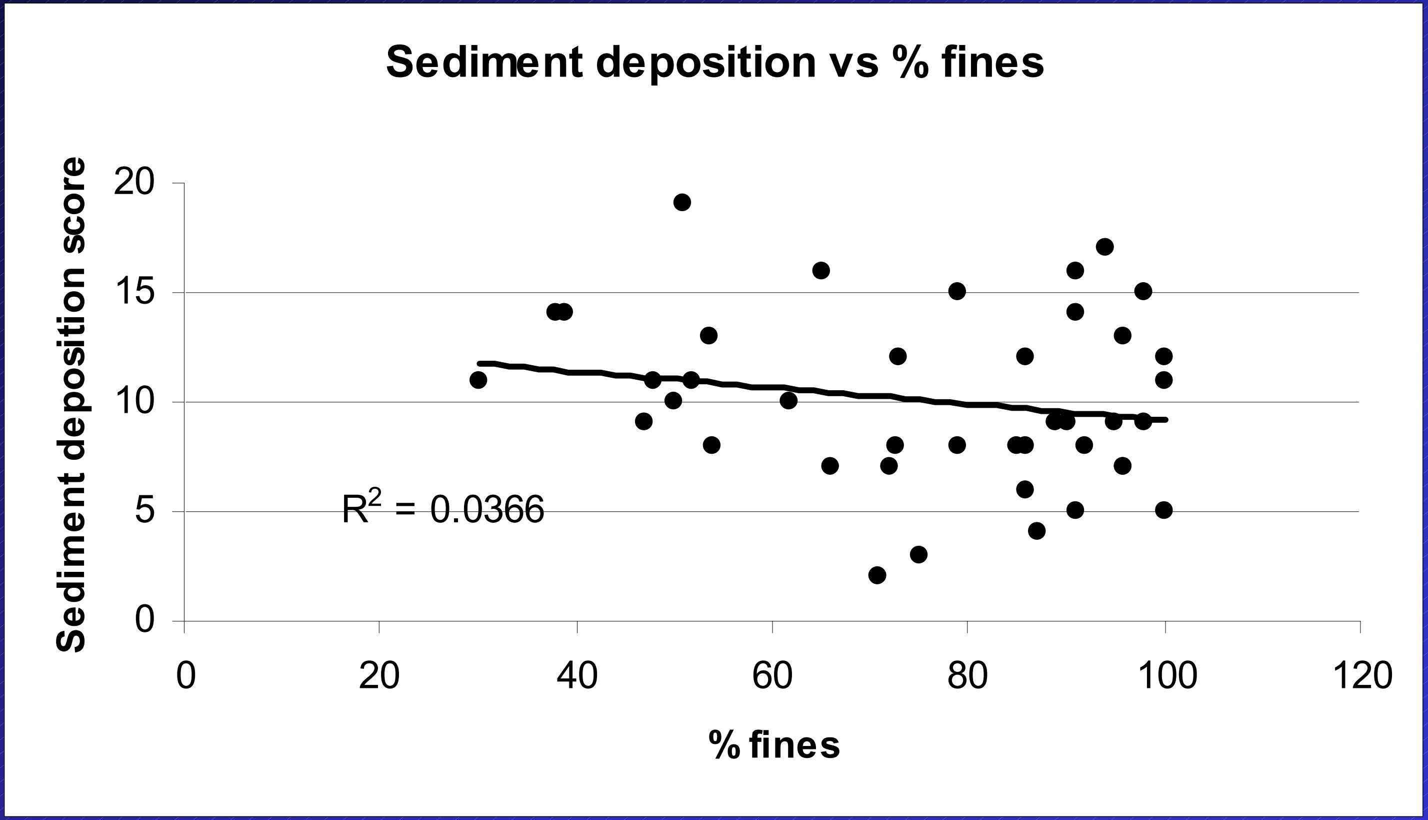
RBP Total Habitat vs. Percent Fines



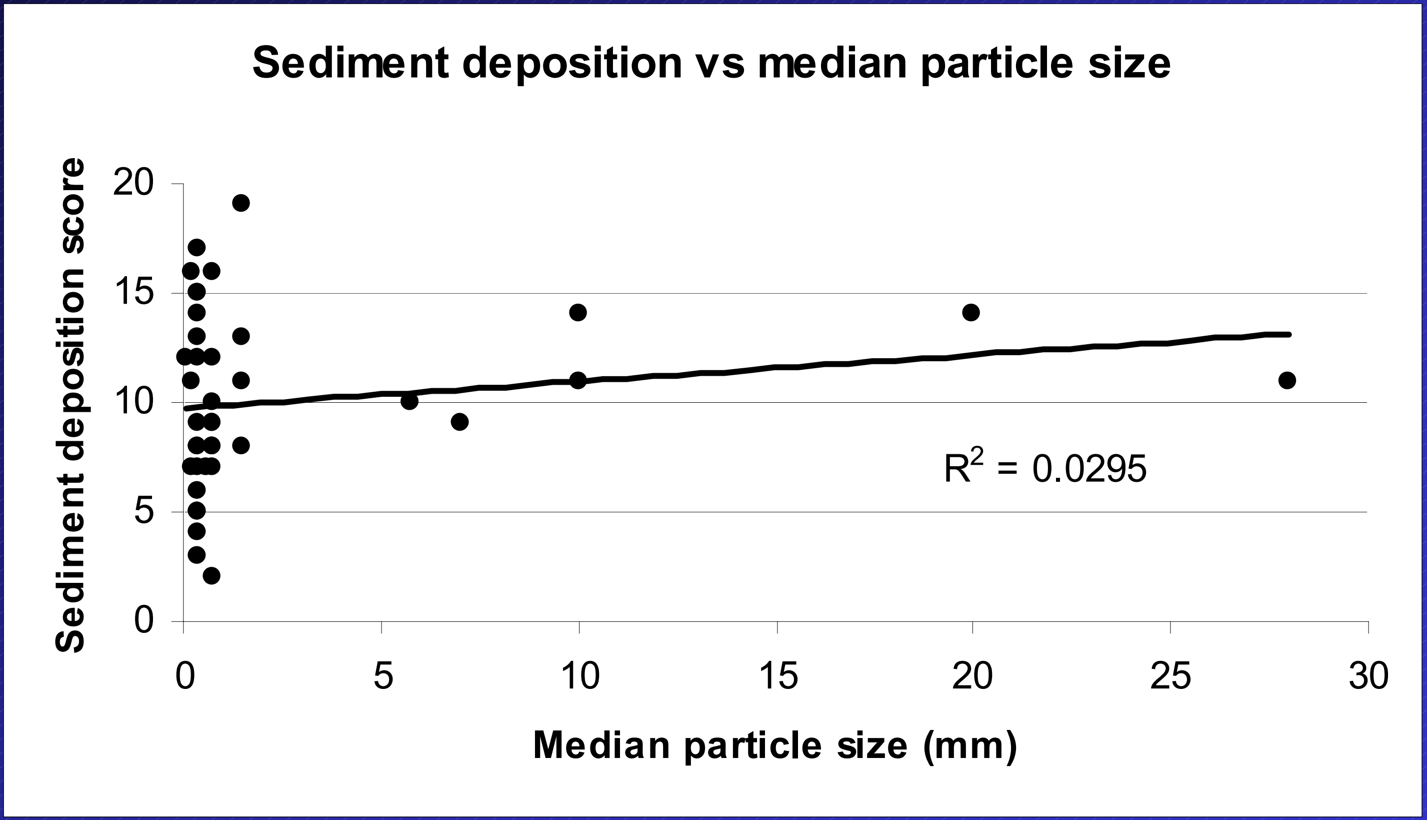
RBP Total Habitat and Median Particle Size



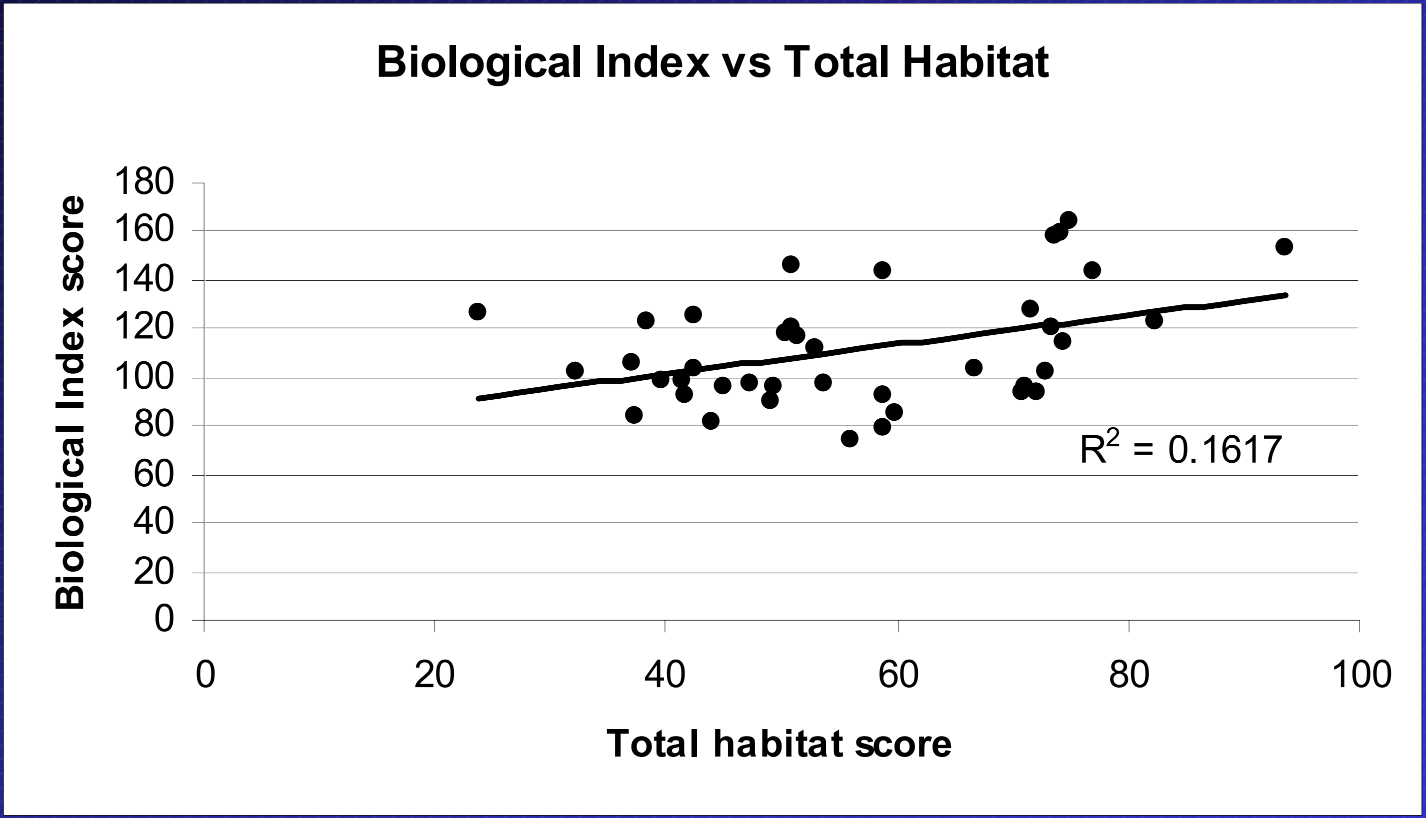
RBP Sediment Deposition vs. % Fines



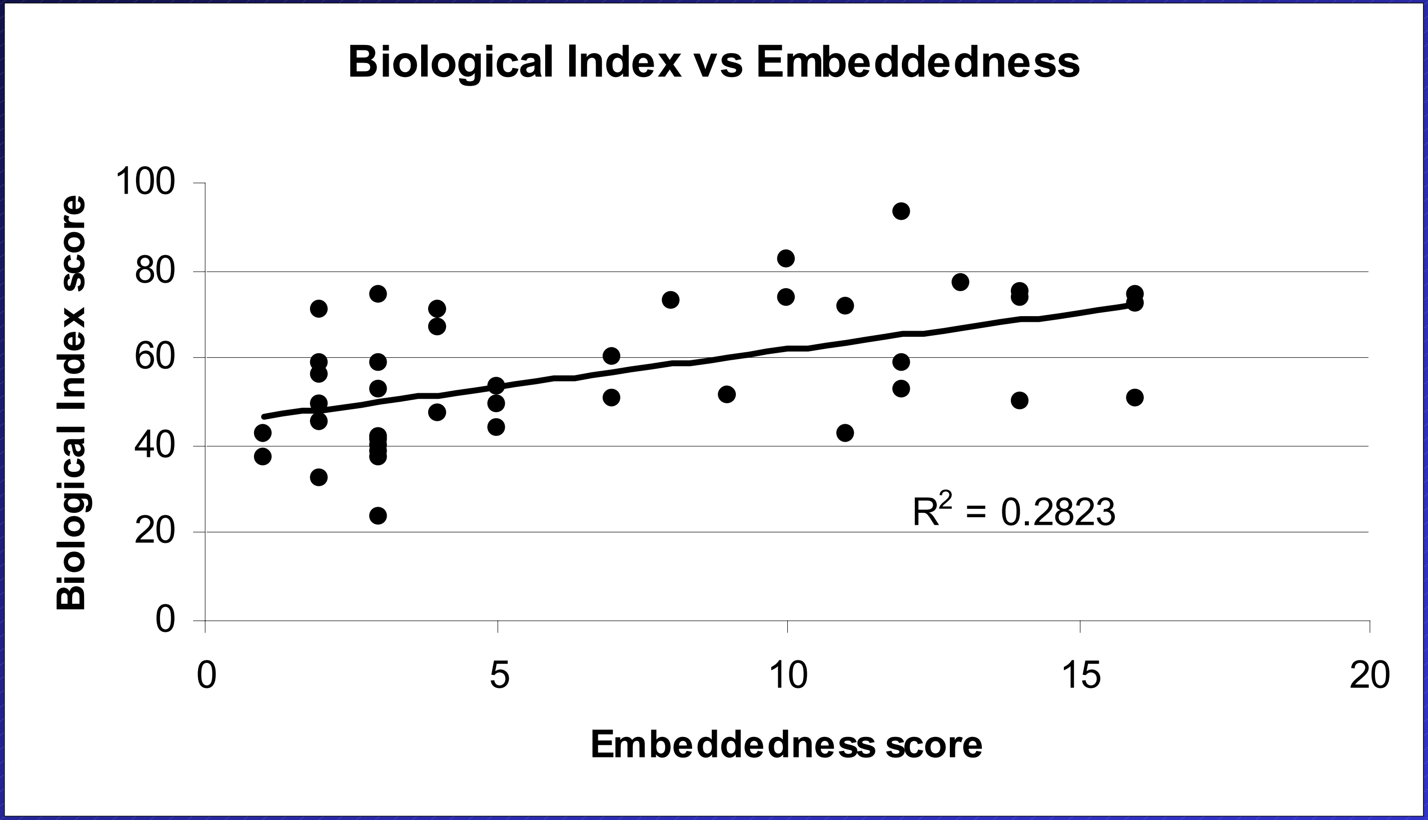
RBP Deposition vs. Median Particle Size



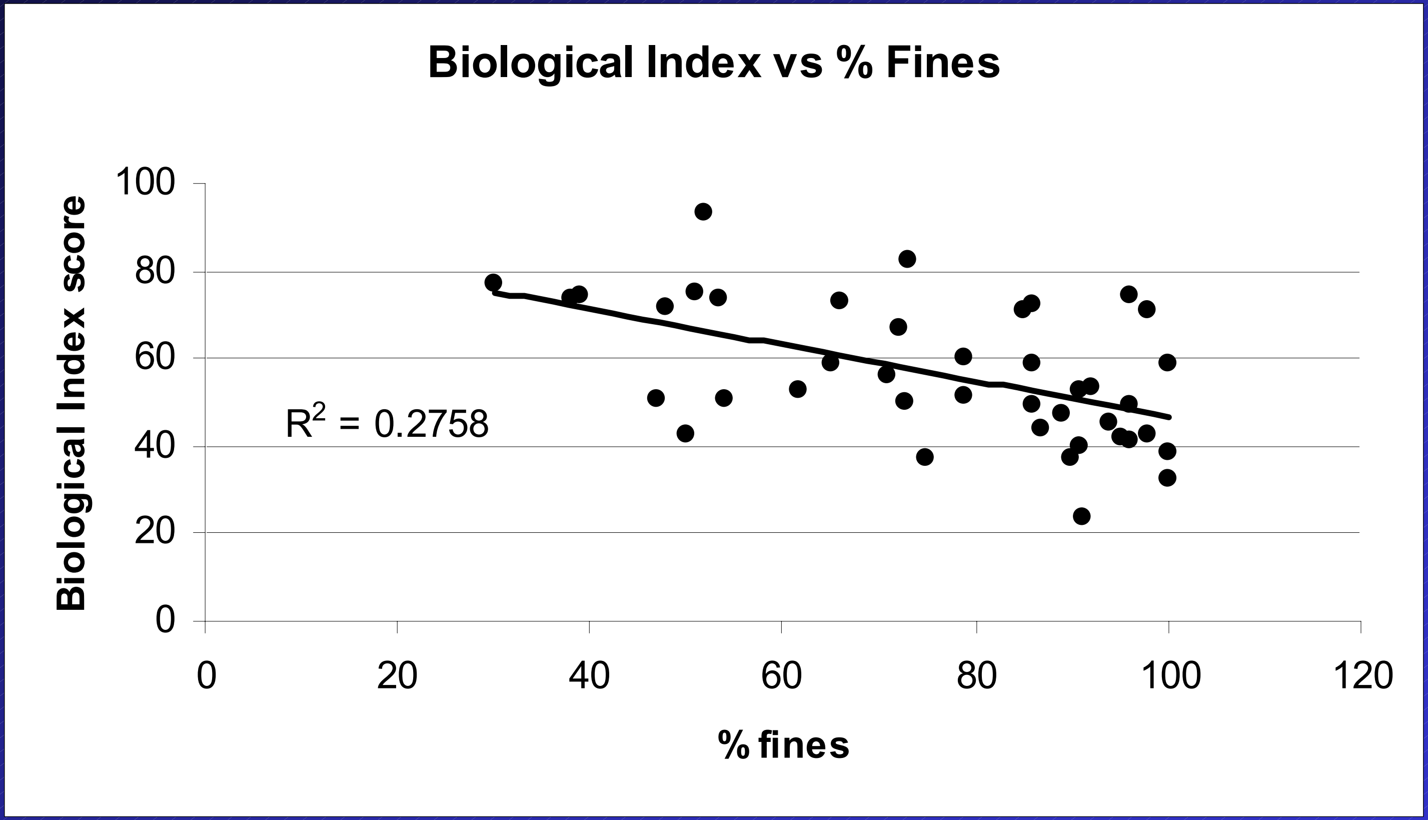
Benthic IBI vs. RBP Physical Habitat



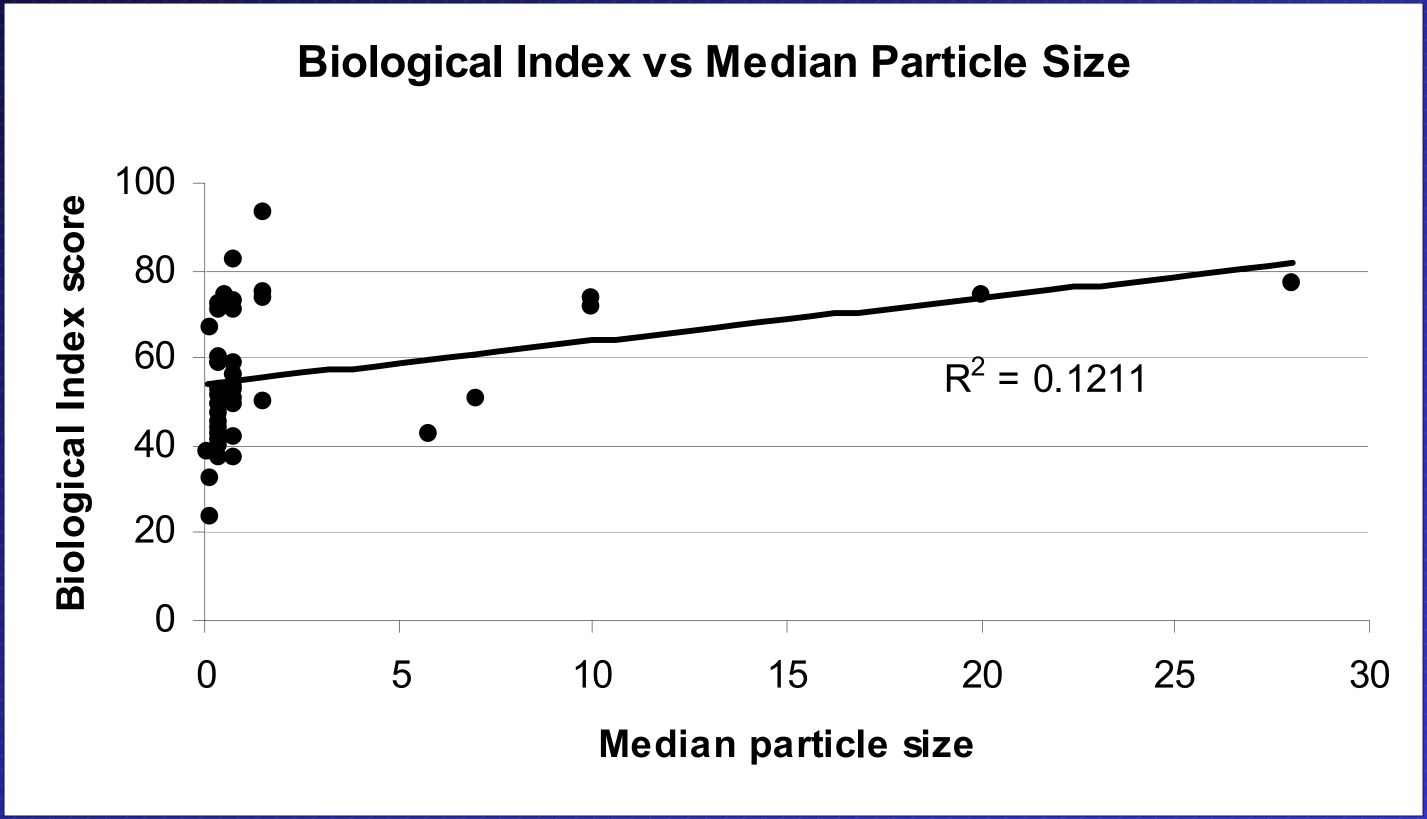
Benthic IBI vs. RBP Embeddedness



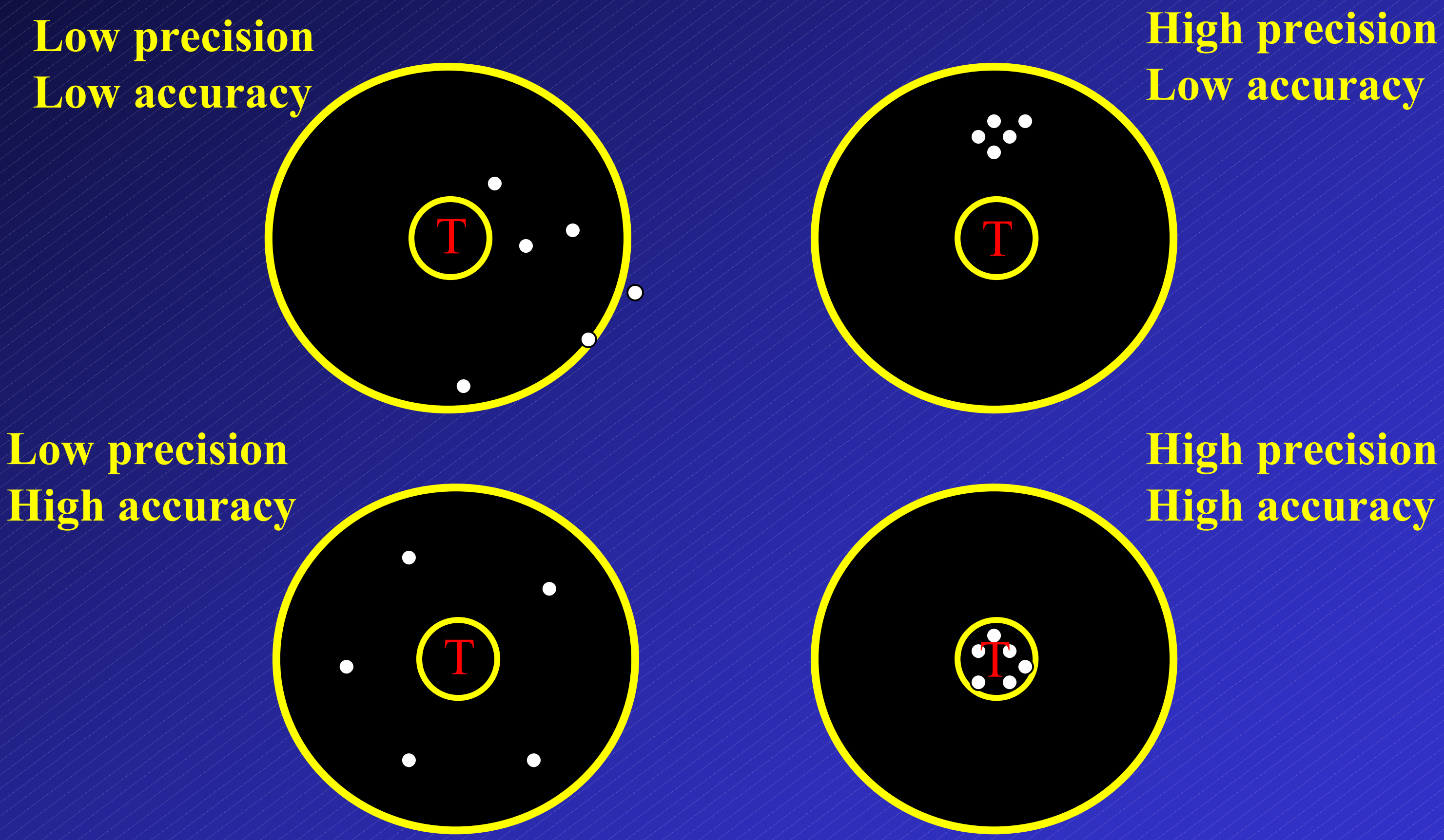
Benthic IBI vs. % Fines



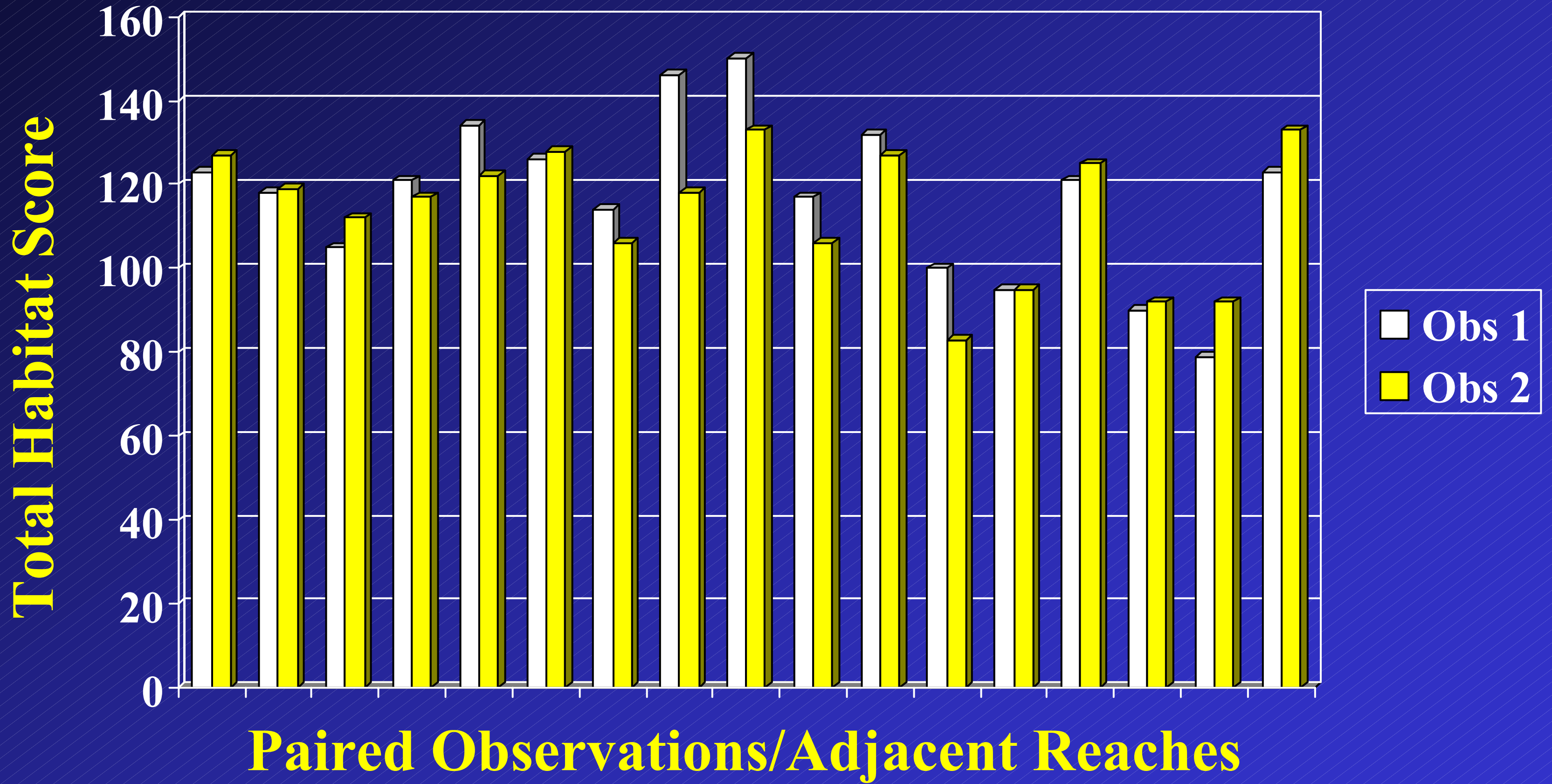
Benthic IBI vs. Median Particle Size



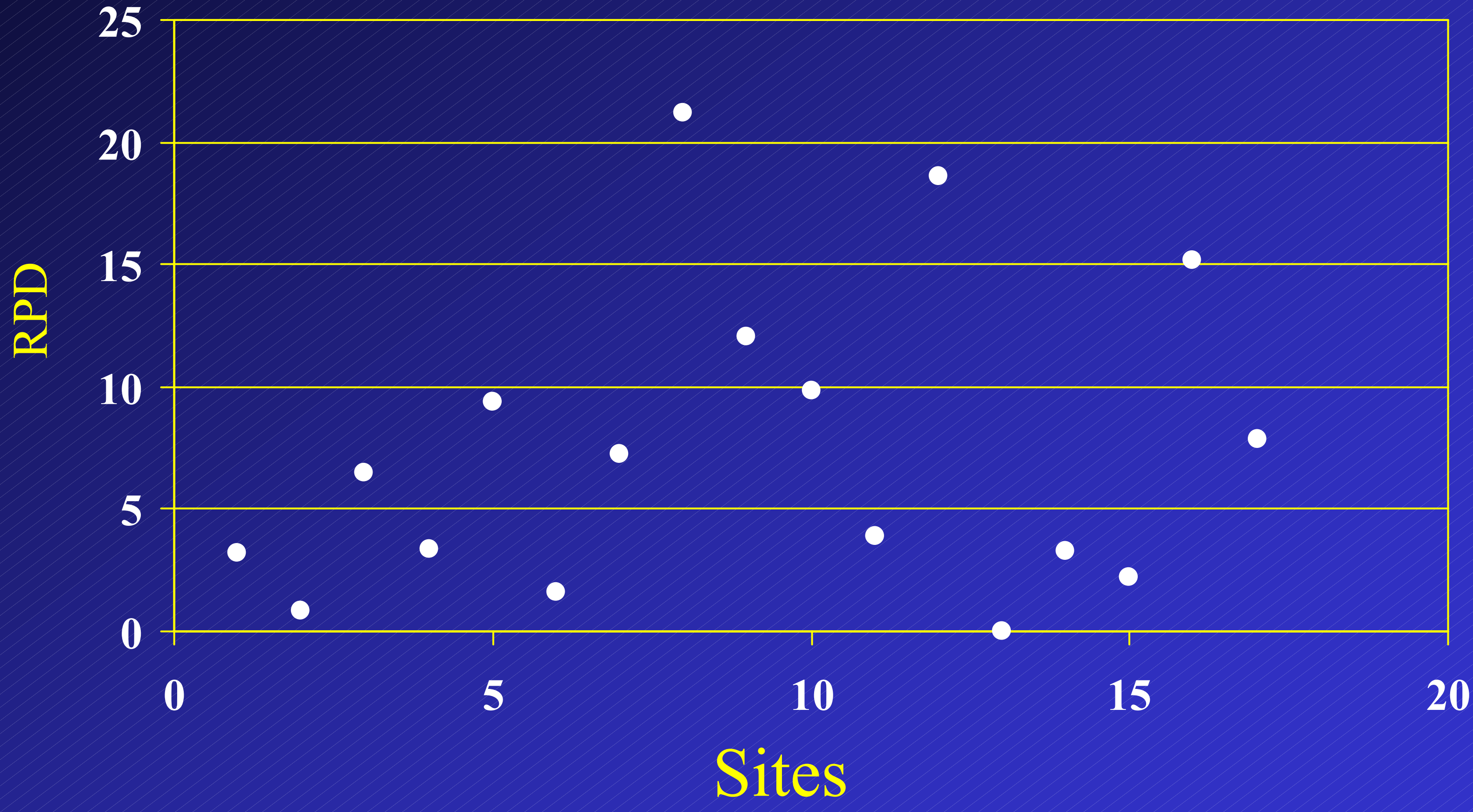
Precision and Accuracy



Duplicate Habitat Assessments



Relative Percent Difference (RPD) of Repeated Habitat Assessments



Measurement Error vs. Sampling Error

- The most meaningful data = ME < SE
- No method is completely unbiased
- Measurement (systematic) error results from methods of low precision
- Sampling (random) error results from inadequate designs, e.g., inappropriate distribution or number of samples

On data quality…

"...there are many scientific situations where the best available data may be of relatively low precision (high spread), but can nonetheless be quite reliable as a representation of the thing being measured..."

Costanza, R., S. O. Funtowicz, and J. R. Ravetz. 1992. Assessing and communicating data quality in policy-relevant research. Environmental Management 16(1): 121-131.

What RBP Habitat Assessment is NOT intended to do…

- Provide direct cause-effect linkage with biological condition
- Provide an indicator of environmental conditions as a means within itself
- Provide data that can be *directly* used in engineering calculations for fluvial restoration in watersheds
- Provide the information that would supplant more detailed diagnostic fluvial hydrologic or sediment transport measurements

What RBP Habitat Assessment is intended to do…

- Provide coarse estimate of the biological potential of the site
- Provide coarse estimates of the relative stability AND complexity of the stream
- Allow comparison to regional site or stream classes or types
- Provide direction for subsequent diagnostic measurements

Take Home Message…Biology Doesn't Lie

- If there's no problem with the biology…there's no problem
- Question. But what about violations of chemical standards?…Answer. Maybe the standard is wrong
- Sample more locations for biology as overall indicator of stream or system health, optimize field efficiencies

Questions