DATA QUALITY DOCUMENTATION FOR BIOLOGICAL ASSESSMENTS USING AN ERROR PARTITIONING FRAMEWORK

March 26, 2019

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2019 National Water Quality Monitoring Conference; Denver, Colorado; Session: "*Biological Assessment, Data Quality, and Comparability*"

PURPOSE OF PRESENTATION

- Describe a comprehensive quality control framework for biological monitoring procedures
- Describe use of quantitative performance characteristics
- Demonstrate error isolation and approach for correcting errors and error sources

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WHAT IS "RELIABILITY" OF AN INDICATOR?

- Merriam-Webster defines *reliability* as:
  - "The extent to which an experiment, test, or measuring procedure yields the same results on repeated trials"
- Thus, is very similar to consistency, repeatability, and precision
- And, the more variable an indicator is, the less reliable it is

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ANY BIOLOGICAL OR ECOLOGICAL ASSESSMENT PROTOCOL

- Site selection
- Field sampling
- Sample processing
- Data entry
- Data reduction
- Index calculation
- Site assessment

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} *"spreadsheet activities"*

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ERROR AT ANY STAGE OF THE PROCESS CAN INTRODUCE VARIABILITY

$$s^2_{total} = s^2 + s^2 + s^2 + s^2 + s^2 + s^2 + s^2$$

Field sampling

Sorting/subsampling

Taxonomy

Enumeration

Data entry

Metric calculation

Site assessment and interpretation

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ERROR PARTITIONING FRAMEWORK

Component method or activity	Performance characteristics				
	Precision	Accuracy	Bias	Representativeness	Completeness
1. Field sampling	●	na	Δ	Δ	●
2. Laboratory sorting/subsampling	●	na	●	Δ	●
3. Taxonomy	●	●	na	na	●
4. Enumeration	●	●	Δ	na	●
5. Data entry	na	●	na	na	●
6. Data reduction (e. g., metric calculation)	na	●	Δ	na	na
7. Site assessment and interpretation	●	●	Δ	Δ	●

● Quantitative
Δ Qualitative
na Not applicable

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FIELD SAMPLING

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PART OF THE SOLUTION FOR UNDERSTANDING VARIABILITY OF FIELD SAMPLING

- Recognize that field SOPs and field audits, while critical, are not sufficient
- Need to quantify and report variability of field sampling
  - Have some level of repeat sampling become routine and consistent, not just as part of special studies
  - Randomly select 10% of sites

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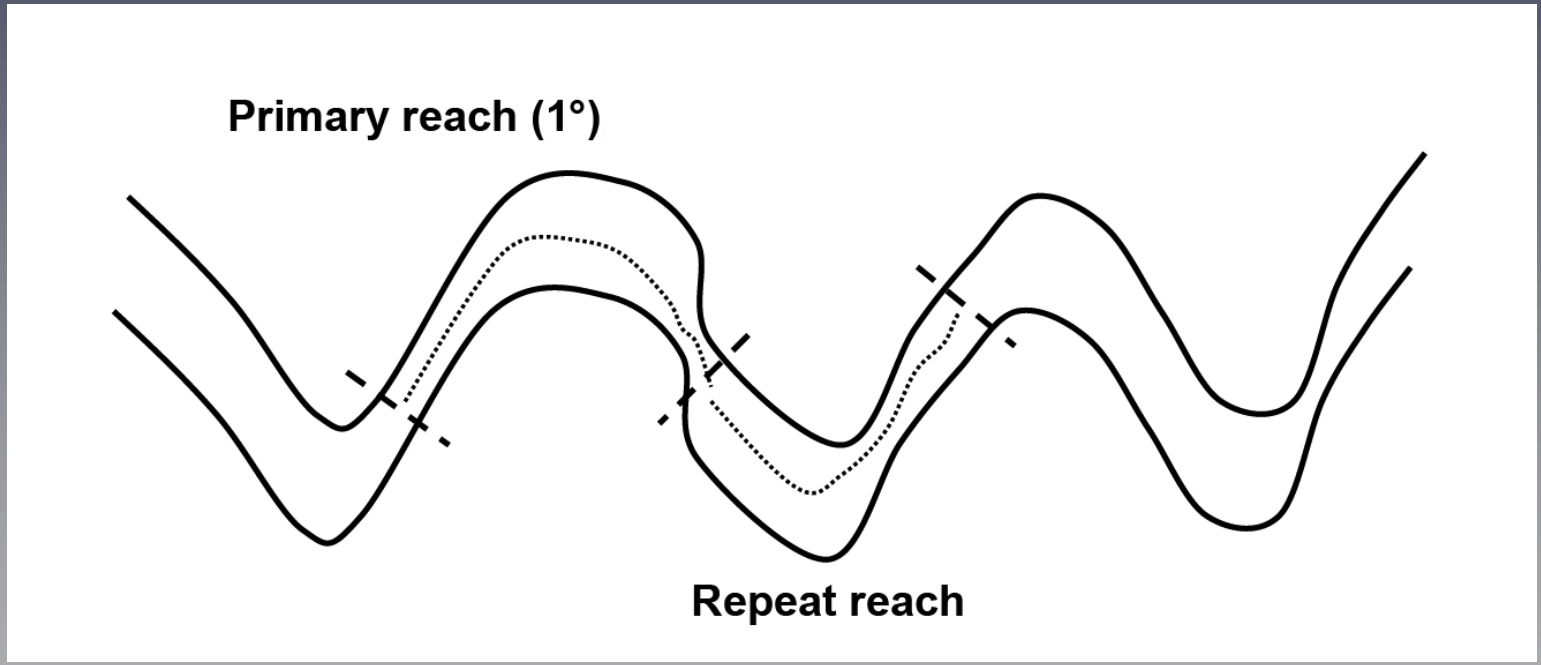
REPEAT SAMPLES AT ADJACENT REACHES
(WITHIN REACH VARIABILITY)



- In the field, treat repeated reach same as primary
- Objective is to be able to calculate measures of <u>field sampling precision</u> (repeatability/consistency)
  - Relative percent difference (RPD)
  - Confidence intervals (CI)
  - Coefficient of variability (CV)

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Field sampling variability (precision) cannot be calculated until after laboratory processing, so…

LABORATORY PROCESSING (BENTHIC MACROINVERTEBRATE SAMPLES)

- **Step 1. Sorting/subsampling**
  - QC (bias) - Independent sort residue rechecks, calculate performance measure (percent sorting efficiency [PSE])
- **Step 2. Taxonomic identification**
  - QC (precision) – Independent whole sample reidentification, calculate performance measures (percent taxonomic disagreement, difference in enumeration, taxonomic completeness [PTD, PDE, PTC])

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SORTING AND SUBSAMPLING

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SORTING/SUBSAMPLING QUALITY CONTROL

- **Checking/oversight**
  - Checks sort residue for missed organisms
  - Grid by grid, or by sample
  - Counts/records "recoveries" and adds to original
- **Internal checks (***example requirement***)**
    - Individual sorter meet >/=90% SE on 5 samples in a row
    - Follow by 10% check
    - If fail on 10% sample, then must start over on 5 in a row
- **External checks**
  - Ten percent (10%) of samples randomly-selected, sent out for re-checks
  - **Subsampling performance characteristic**
    - Applies to whole dataset, and/or lab
    - Less than 10% of the samples have PSE of less than 90%

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PERFORMANCE CHARACTERISTIC FOR SORTING/SUBSAMPLING

PERCENT SORTING EFFICIENCY (PSE)

$$PSE = \frac{n_0}{n_0 + n_r} * 100$$

- Measure of bias
- Where n_0 = original no. of organisms found by sorter, and
- Where n_r = no. of organisms missed and found by sort checker (recoveries)
- Recommended MQO - PSE>90

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TAXONOMIC IDENTIFICATION AND COUNTING

$$s^2_{total} = s^2 + s^2 + s^2 + s^2 + s^2 + s^2 + s^2$$

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TAXONOMIC IDENTIFICATION

- Purpose is to describe (sub)sample content in terms of:
  - Taxa present
  - Number of individuals of each
- Assigning the correct Latin nomenclature (name) to each individual organism in the sample
- Defined, targeted, level of effort – species, genus, "lowest practical taxonomic level (lptl)", or other

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CALCULATE THREE PERFORMANCE MEASURES

QUANTIFY TAXONOMIC ERROR RATES

- Percent taxonomic disagreement (PTD)
  - $PTD = (1 - \left[\frac{a}{N}\right]) * 100$
- Percent difference in enumeration (PDE)
  - $PDE = \frac{|n_1 - n_2|}{n_1 + n_2}$
- Percent taxonomic completeness (PTC)
  - $PTC = \frac{x}{N} * 100$

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CORRECTIVE ACTIONS

- Evaluate performance measures for exceedances
- Determine whether exceedances are isolated or part of broader pattern
- Determine acceptability of error rates
- If unacceptable, specify and implement actions needed to correct dataset

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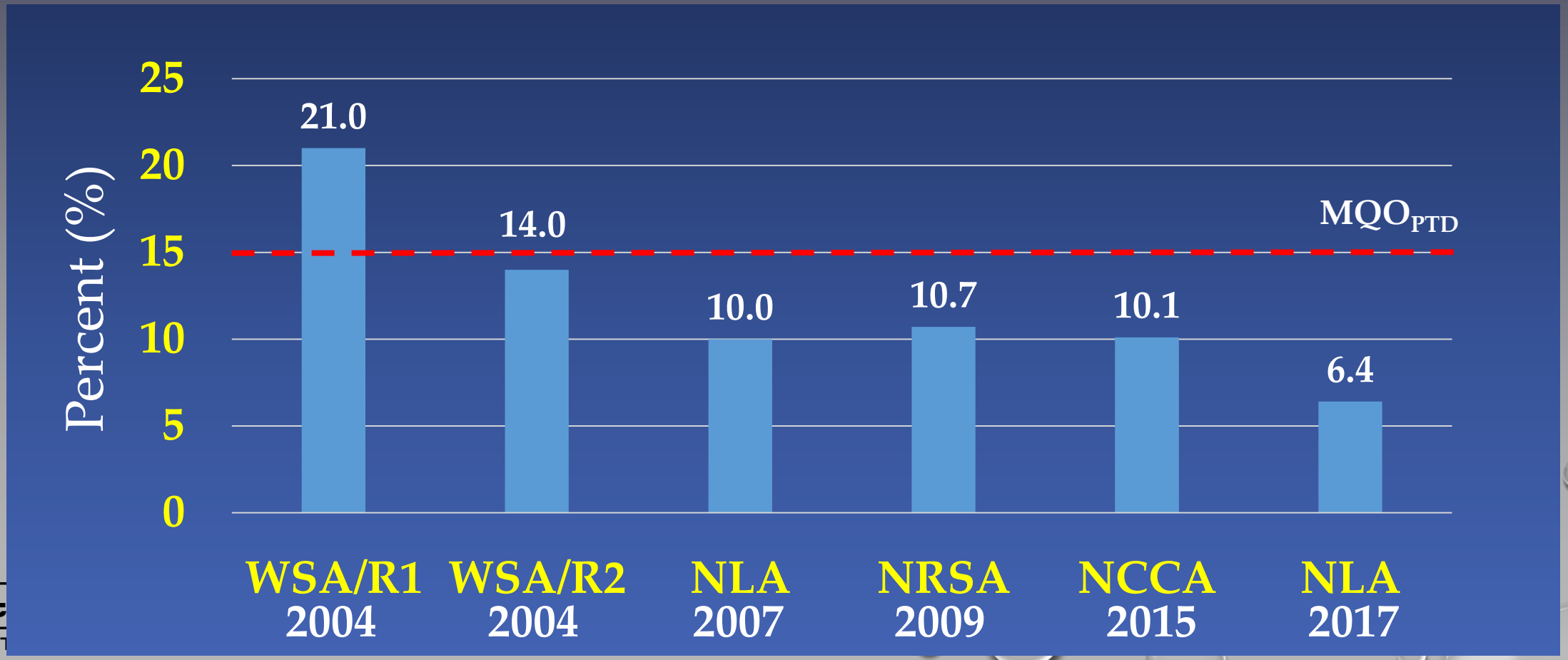
PERCENT TAXONOMIC DISAGREEMENT (PTD)
(NARS, BENTHIC MACROINVERTEBRATES)



FIELD SAMPLING

BACK TO THE PROBLEM

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NOW THAT DATA ARE FULLY QC'D

(I.E., OF KNOWN AND ACCEPTABLE QUALITY)

- Calculate measures of <u>field sampling precision</u> using data from repeated samples
  - Rate of replication, 10% (or minimum of 3)
- 90 percent confidence intervals (CI90)
  - MQO (examples), ±0.8 index points on a 5 point scale; ±8.1 index points on a 100 point scale
- Coefficient of variability (CV)
  - MQO, <10%
- Relative percent difference (RPD)
  - MQO, <15%

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AFTER ALL OF THAT, REPORTING CAN BE STRAIGHTFORWARD AND SIMPLE

EXAMPLE: PRINCE GEORGE'S COUNTY, MD (2010-13)

Performance characteristic	MQO	Observed
1. Field sampling precision (benthic MMI)	CV < 15%	10.6
	CI90 ≤ 1.0	0.8
2. Sorting/subsampling bias	PSE ≥ 90	96.7
3. Taxonomic precision	Median PTD ≤ 15%	5.4
	Median PDE ≤ 5%	0.5
4. Taxonomic completeness	Median PTC ≥ 90%	91
	mAbs diff ≤ 5%	1.5

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TAKE HOME MESSAGES

- Performance measures:
  - Tailor to specific method
  - Accept and acknowledge as routine in monitoring programs (<u>not as special studies</u>)
- Understood AND REPORTED performance measures improve defensibility
- Provide means for determining level of comparability
- Need to help managers understand utility
  - Controlling data quality, AND
  - Determining when changes are real

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QUESTIONS?

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