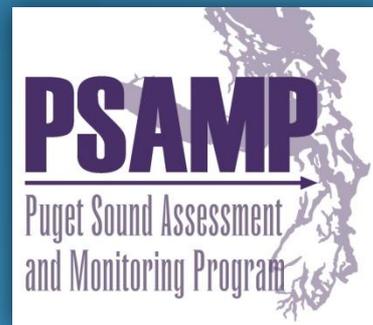
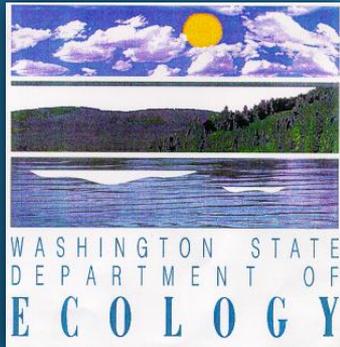


Use & refinement of the *Sediment Quality Triad Index* in Puget Sound

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Sandra Weakland
Valerie Partridge
Kathy Welch
Ed Long



Washington State Department of Ecology
Marine Monitoring Unit

Presentation to PSP Science Panel 11/17/09

What is the Sediment Quality Triad?

- Long and Chapman, 1985; Chapman, 1986
- Multiple-lines of evidence - 3 SQ measures:
 - Chemistry
 - Toxicity
 - Benthic infaunal community structure

Why Use the Sediment Quality Triad?

- Premise:
 - *None alone can consistently/accurately predict behavior of other two*
 - *All 3 needed to provide strong, complementary evidence of stressor-induced degradation*
- Used in fresh, estuarine, saltwater systems nationally and worldwide since 1985
- 6,000+ Google scholar hits for SQT

SQT Indicator Relationships to PSP Goals

PSP Goals:

- Human health
- Human well-being
- Species & food-webs
- Habitat
- Water quality
- Water quantity

2008 Action Agenda: Provisional Indicators

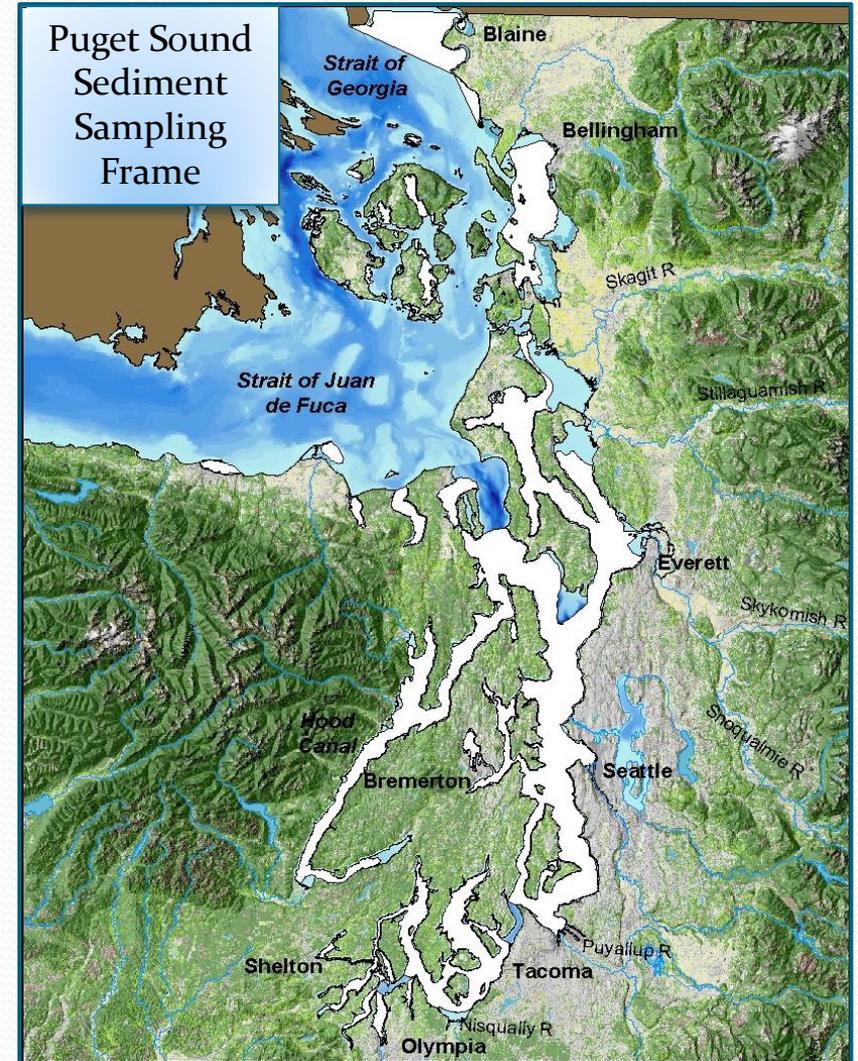
- Benthic Invertebrates
- Benthic Invertebrates
- Sediment Chemistry
- Sediment Chemistry
- SQT Index

2009 State of the Sound

- Sediment Quality Triad

SQT to assess Puget Sound sediments

- Sediment samples collected annually
 - Sediment Quality Triad to examine:
 - Spatial patterns
 - Spatial extent of degradation
 - change over time:
 - *Stations*
 - *Regions*
 - *Strata*
 - *Puget Sound-wide*
- (see SQTI poster handout)



Puget Sound Sediment Quality Triad Index

- Tabular decision matrix/Benchmark comparisons:

Sediment Parameter	Classification
Chemical contaminant level	Exceeds/Does not exceed WA standards
Toxicity in laboratory	Exceeds/Does not exceed WA or other
Benthic invertebrate communities	Affected/Unaffected using indices & BPJ

- PSAMP SQTI classification:

Sediment Quality Category	Description
High	0 parameters degraded
Intermediate/High	1 parameter degraded
Intermediate/Degraded	2 parameters degraded
Degraded	3 parameters degraded



Spatial Patterns & Gradients

1998-1999

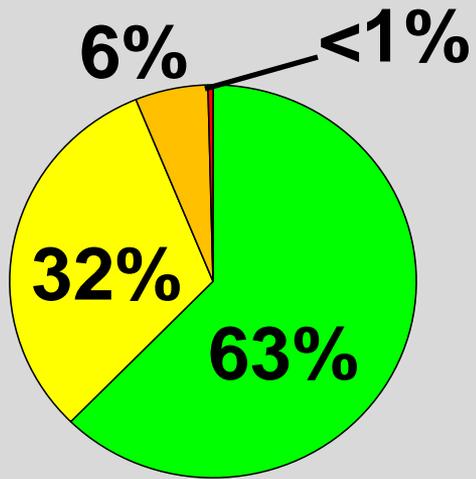
Central Puget Sound

Sediment Quality Triad Index

- High
- Intermediate/High
- Intermediate/Degraded
- Degraded

- PSAMP SQT I**
- High
 - Intermediate/High
 - Intermediate/Degraded
 - Degraded

**% area with each
SQTI category:
Puget Sound-wide**

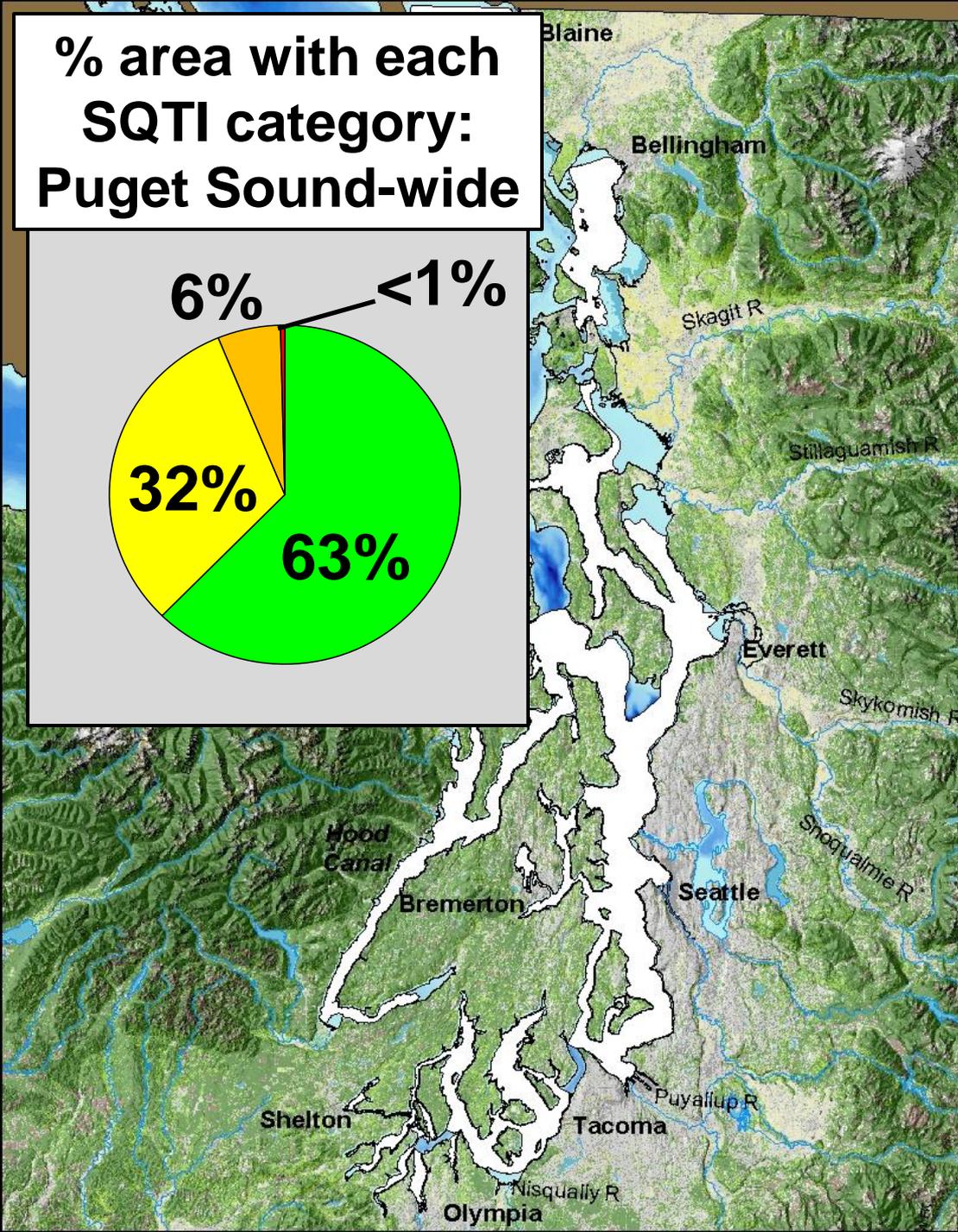
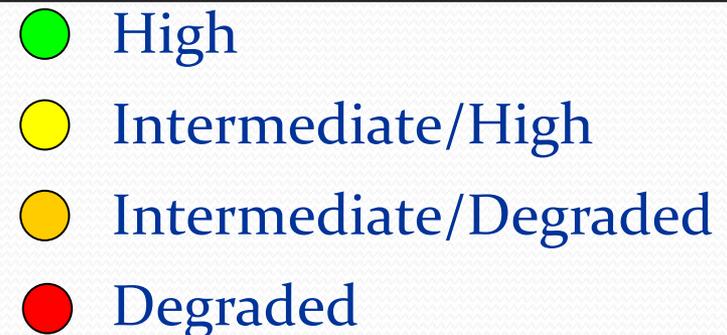


Spatial Extent of Sediment Quality Degradation

1997-2003

Puget Sound-wide

Sediment Quality
Triad Index



Puget Sound SQTI – Why refine?

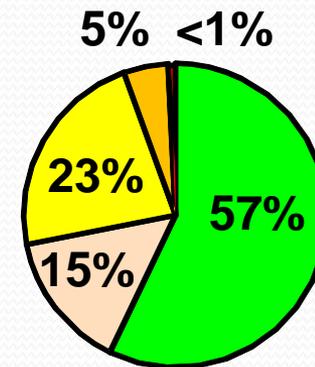
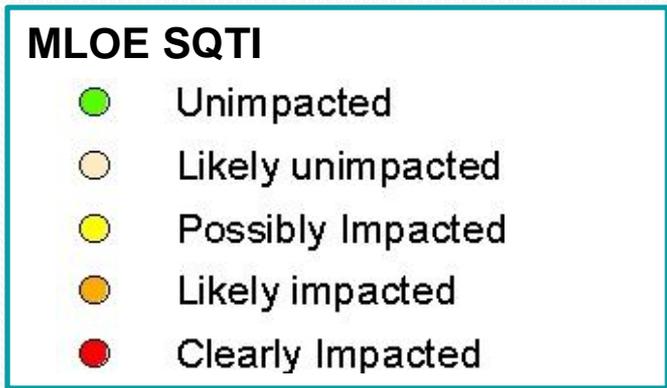
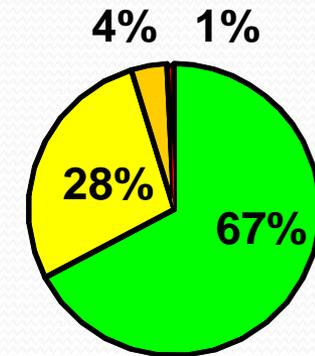
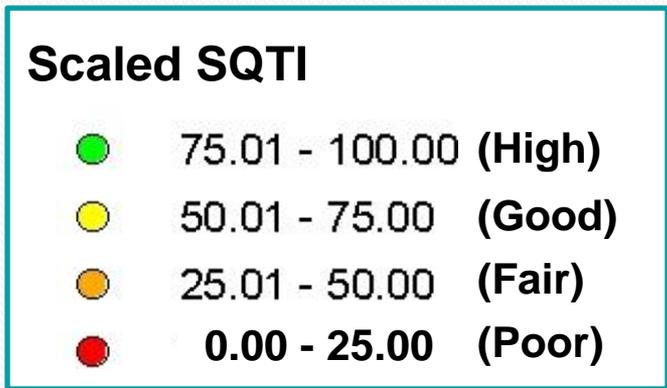
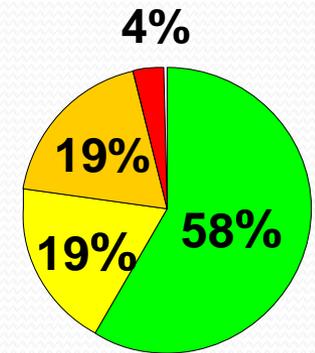
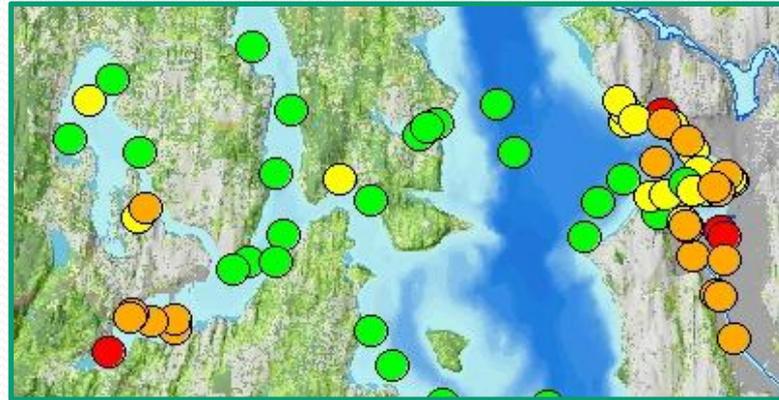
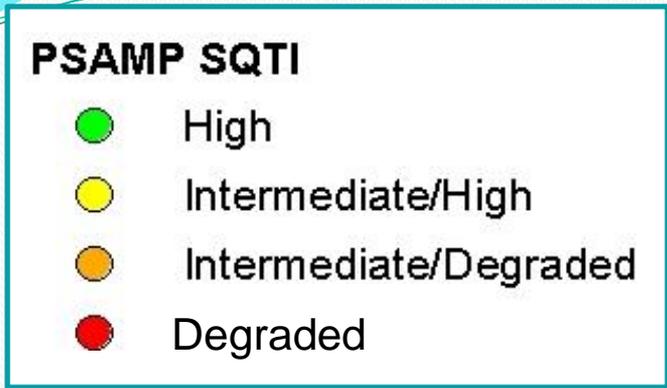
- PSP choosing indicators for Puget Sound
- PS SQTI developed 10 years ago
- Advantages and drawbacks
- New methods in literature
- Possible coordination with Fresh and Marine WQ indicators

SQTI Refinement Approaches

- Additional environmental parameters
 - *DO, nutrients, fish tissue contamination*
- Strengthen underlying parameter interpretation
 - *Chemistry – Sediment SMS revisions*
 - *Benthos – development of BRI, BQI, M-AMBI, RIVPACS*
- Alternative SQTI methods
 - *Scaled/ranked*
(Kreis, 1988; Canfield et al, 1994)
 - *Multiple Lines of Evidence*
(Bay et al., 2009)

Comparison of Spatial Patterns

Central Puget Sound Region



% of stations

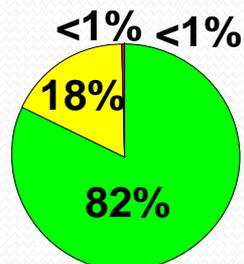
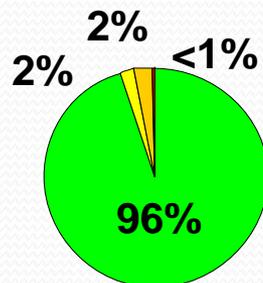
Comparison of Spatial Extent (% of study area)

Central Puget Sound Region

Whidbey Basin Region

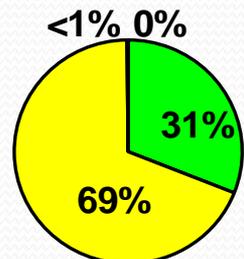
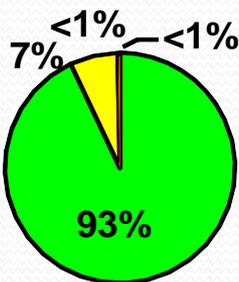
PSAMP SQTI

- High
- Intermediate/High
- Intermediate/Degraded
- Degraded



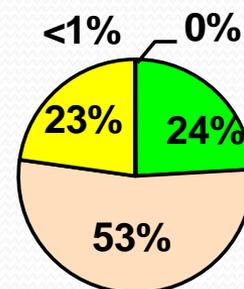
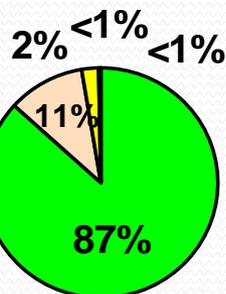
Scaled SQTI

- 75.01 - 100.00 (High)
- 50.01 - 75.00 (Good)
- 25.01 - 50.00 (Fair)
- 0.00 - 25.00 (Poor)



MLOE SQTI

- Unimpacted
- Likely unimpacted
- Possibly Impacted
- Likely impacted
- Clearly Impacted



- Percent of “highest quality” decreasing
- Increased distinction between “higher quality” categories

Comparison of SQTI approaches

Method	PSAMP	Scaling	MLOE
Attributes			
Benchmarks	yes	no	yes
All parameters used	no	yes	no
Scaling	no	yes	no
Ecological Interpretation (spatial patterns)	more severe	less severe	less severe
Ecological Interpretation (spatial extent)	less severe	more severe	more severe
Resolution of reporting scale	4-point	unlimited	6-point
Ecological relevance of scale	medium	lower	higher

Summary

- SQT and Index used world-wide, should continue to be used in Puget Sound
- SQTI interpretation strongest when examined together
- While we are happy with the PSAMP SQTI... refinements could include:
 - *Additional parameters*
 - *Strengthen underlying parameter interpretation*
 - *Different SQT integration methods*
- Different integration methods yield different results
- Choice of integration methods depends on users need

Comments/Questions

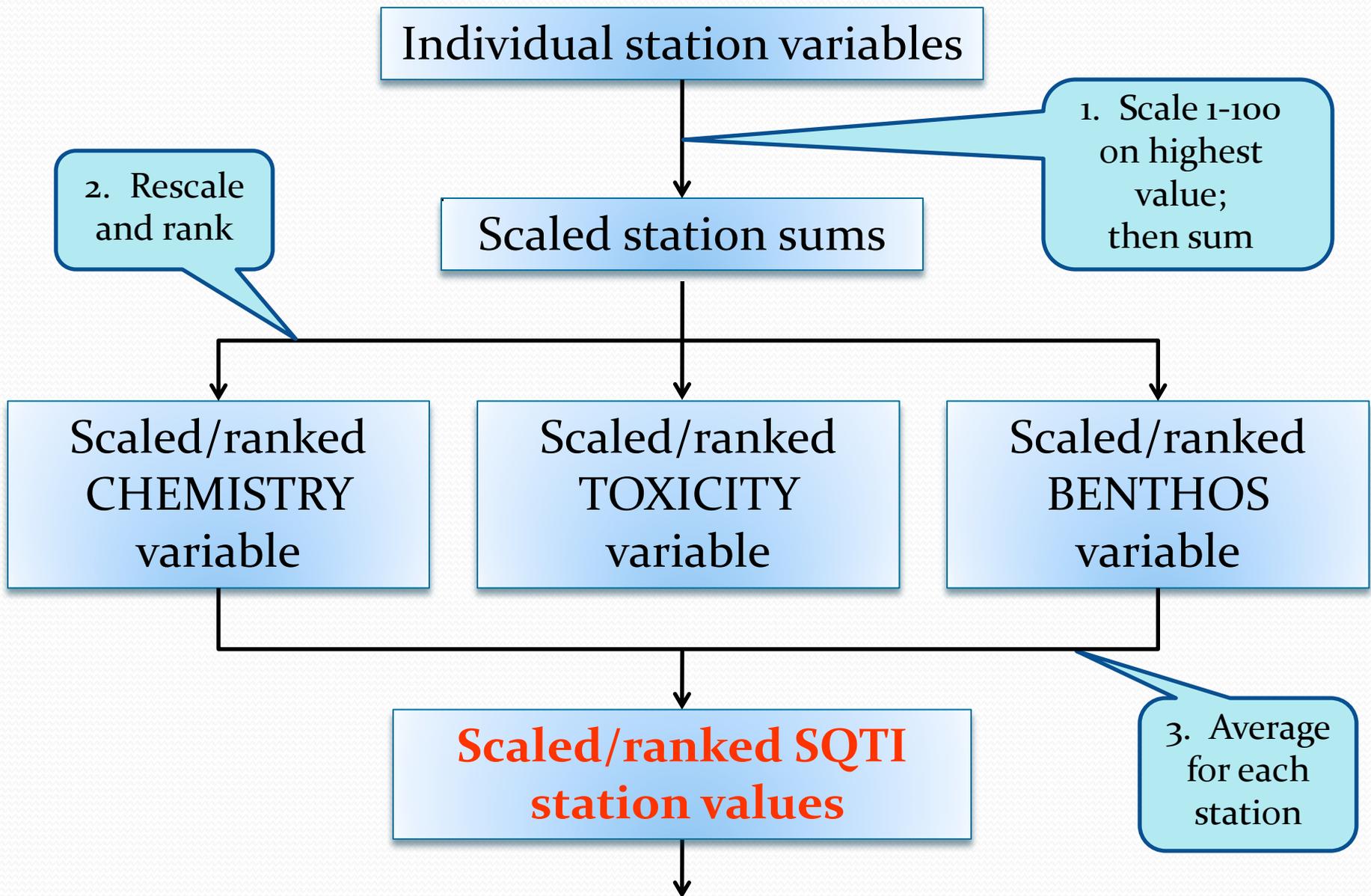


Ecology's Sediment Monitoring Website:
<http://www.ecy.wa.gov/programs/eap/psamp/index.htm>



Additional Information...

Scaled/ranked SQTI (after Kreis, Jr. 1988; Canfield et al., 1994)



Scaled/ranked SQTI (after Kreis, Jr. 1988; Canfield et al., 1994)

Scaled/ranked SQTI values grouped into a chosen (arbitrary) scale (e.g., 4-point scale).

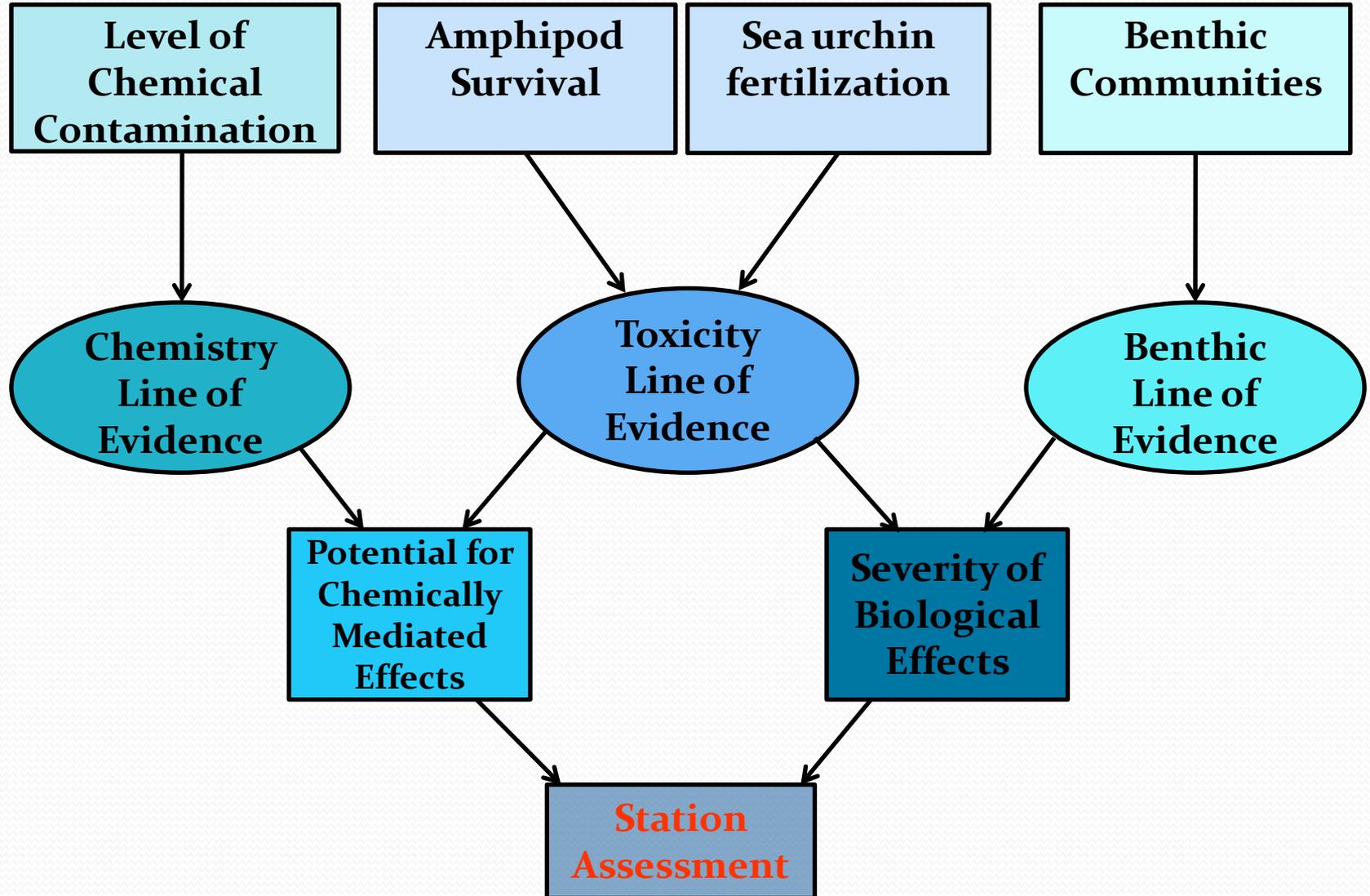
Scaled/ranked SQT Index value	SQTI designation
75.01 to 100	High
50.01 to 75	Good
25.01 to 50	Fair
0 to 25.00	Poor

- Plot **spatial distribution** and calculate **spatial extent**

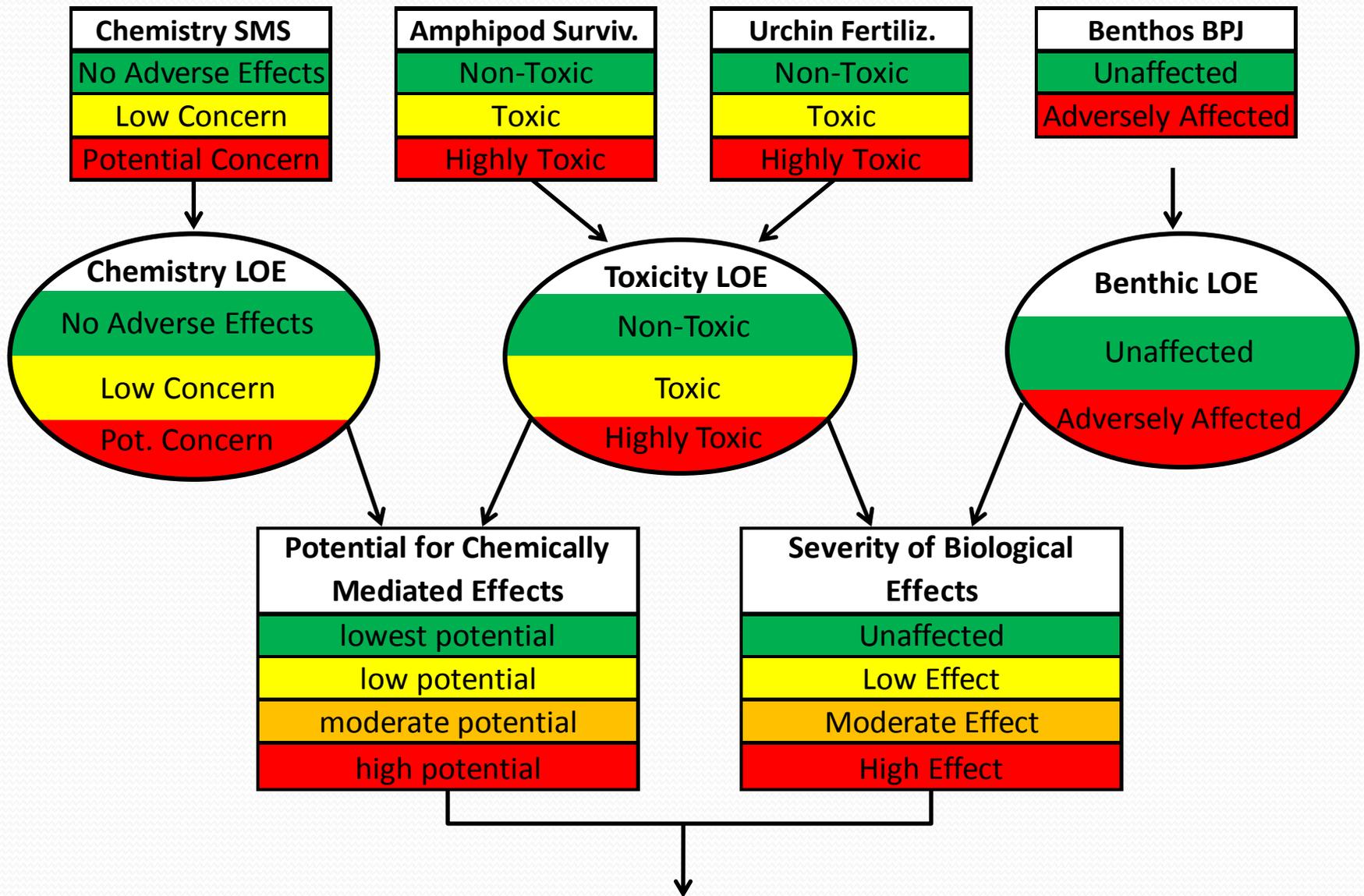
PSAMP 1997-2003 Multiple Lines of Evidence (MLOE)

(modified from Bay et al., 2009)

Conceptual Model – 3 integrative stages of sediment assessment:



PSAMP 1997-2003 MLOE (after Bay et al., 2009)



- Station assessment – match combined station LOEs to:

1 of 54 LOE combinations:

1 of 6 final station assessments:

Toxicity	Chemistry Exposure	Potential for Chemically Mediated Effects	Station Assessment	Severity of Biological Effects	Benthic Disturbance	Toxicity
Highly Toxic	Potential Concern	High Potential	Inconclusive	Unaffected	Unaffected	Non-Toxic
Highly Toxic	Low Concern	High Potential	Inconclusive	Unaffected	Unaffected	Non-Toxic
Non-Toxic	No Adverse Effects	Lowest Potential	Inconclusive	Highly Impacted	Adversely Affected	Highly Toxic
Toxic	No Adverse Effects	Low Potential	Unimpacted	Unaffected	Unaffected	Non-Toxic
Non-Toxic	Potential Concern	Low Potential	Unimpacted	Unaffected	Unaffected	Non-Toxic
Non-Toxic	Low Concern	Low Potential	Unimpacted	Unaffected	Unaffected	Non-Toxic
Highly Toxic	No Adverse Effects	Moderate Potential	Likely unimpacted	Unaffected	Unaffected	Non-Toxic
Toxic	Potential Concern	Moderate Potential	Likely unimpacted	Unaffected	Unaffected	Non-Toxic
Toxic	Low Concern	Moderate Potential	Likely unimpacted	Unaffected	Unaffected	Non-Toxic
Toxic	No Adverse Effects	Low Potential	Likely unimpacted	Low Effect	Unaffected	Highly Toxic
Toxic	No Adverse Effects	Low Potential	Likely unimpacted	Low Effect	Unaffected	Highly Toxic
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Non-Toxic	No Adverse Effects	Lowest Potential	Likely unimpacted	Moderate Effect	Adversely Affected	Non-Toxic
Highly Toxic	No Adverse Effects	Moderate Potential	Possibly impacted	Low Effect	Unaffected	Highly Toxic
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Toxic	Low Concern	Moderate Potential	Likely impacted	Moderate Effect	Adversely Affected	Toxic
Toxic	Low Concern	Moderate Potential	Likely impacted	Moderate Effect	Adversely Affected	Non-Toxic
Highly Toxic	Potential Concern	High Potential	Clearly impacted	High Effect	Adversely Affected	Highly Toxic
Highly Toxic	Potential Concern	High Potential	Clearly impacted	Moderate Effect	Adversely Affected	Toxic
Highly Toxic	Potential Concern	High Potential	Clearly impacted	Moderate Effect	Adversely Affected	Non-Toxic
Highly Toxic	Low Concern	High Potential	Clearly impacted	High Effect	Adversely Affected	Highly Toxic
Highly Toxic	Low Concern	High Potential	Clearly impacted	Moderate Effect	Adversely Affected	Toxic
Highly Toxic	Low Concern	High Potential	Clearly impacted	Moderate Effect	Adversely Affected	Non-Toxic

Station Assessment

Inconclusive

Unimpacted

Likely unimpacted

Possibly impacted

Likely impacted

Clearly impacted

- Plot spatial distribution and calculate spatial extent

Puget Sound SQTI – Why refine?

Advantages

- Simple/transparent
- Incorporates benchmarks
- Conservative/protective
- Comparison among sampling frames; years
- Benthic response is surrogate for unmeasured stressors
- Parameters can be added

Drawbacks

- Benchmarks don't exist for all parameters; some require revision
- Binary decisions only
 - *no measure of scope, frequency, amplitude*
- Unmeasured stressors
- Gradient of response scale narrow