Longitudinal Spatial Patterns in Riverine Ecological Indicators in the Pacific Northwest; Implications for River Survey Design

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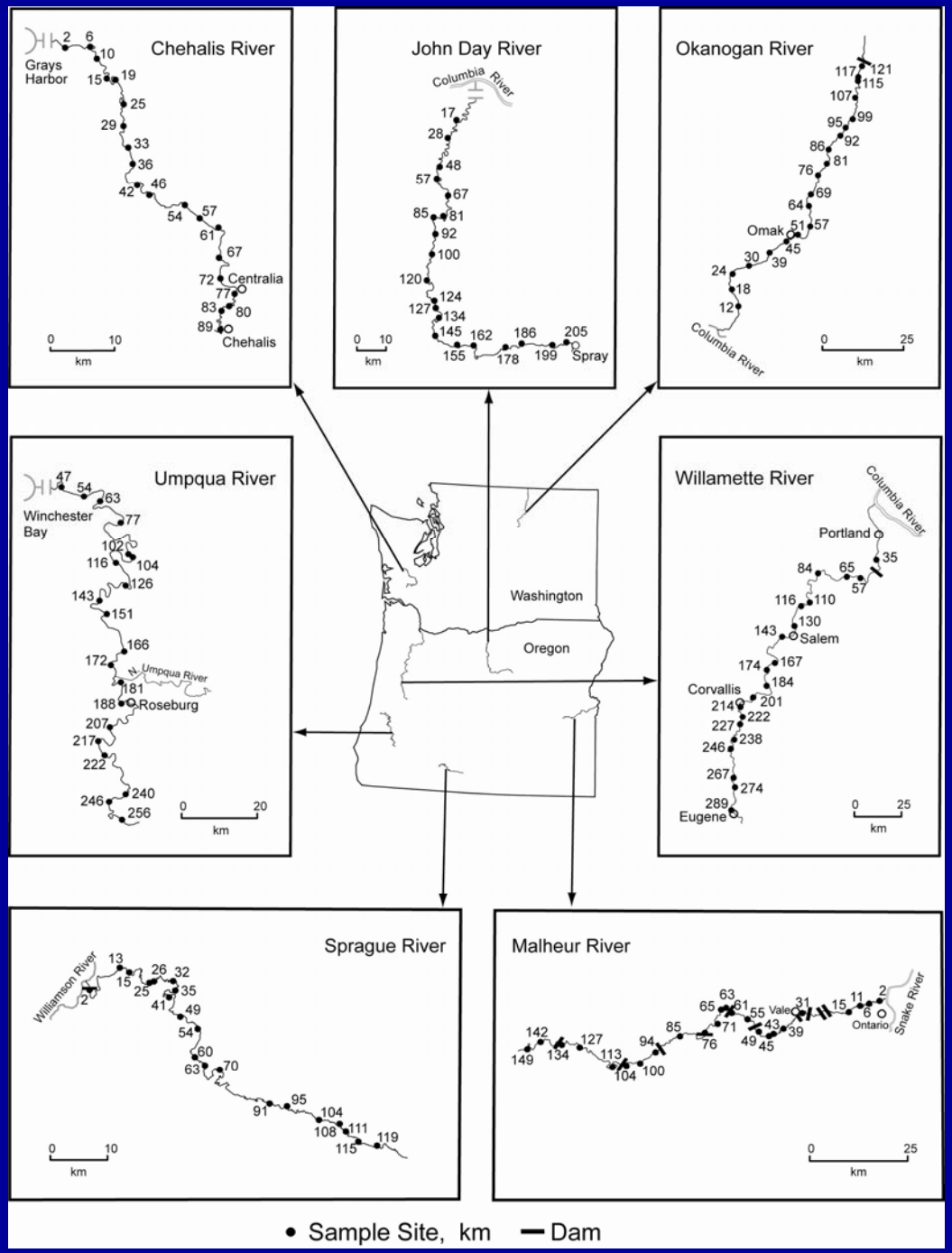
Project Objectives - RIVMAP

- Characterize ecological condition in boatable river length in seven Northwest Rivers
- Study spatial autocorrelation for typical bioassessment measures in rivers
- Target Rivers
  - 100-200 km boatable length
  - 20-120 m wide



Study Rivers

Summer

2006-2008

Sample Site Selection

- 20 sites per river
- EMAP systematic random sample
  - Spatially balanced
  - Not equal interval
- Can make estimates of condition for whole boatable river length

Sprague River

Indicators Measured

- Physical Habitat
- Macroinvertebrates
- Water Chemistry
- Fish
- Periphyton

Willamette River Grass Carp

Sample Reach Layout

- Length = 50 Times Mean Wetted Width
  - Range of 1–10 km Long Reaches
- Set 11 Equidistant Transects along Reach
  - Composite Macroinverts and Periphyton
  - Riparian Physical Habitat
- Between Transects
  - Habitat Thalweg Profile
  - Electrofish Alternating Banks

Field Sampling

Crew of 4

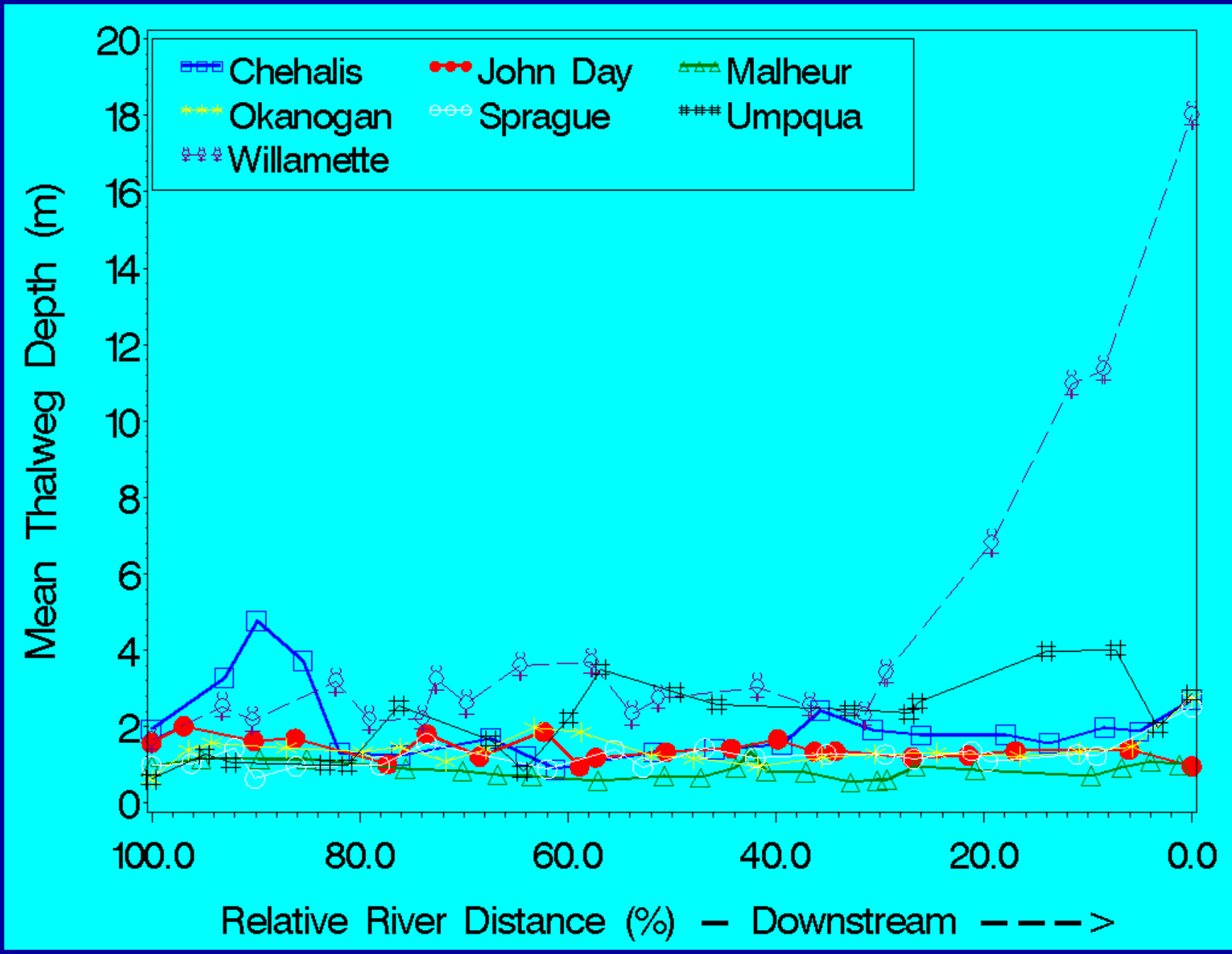
Electrofishing Raft

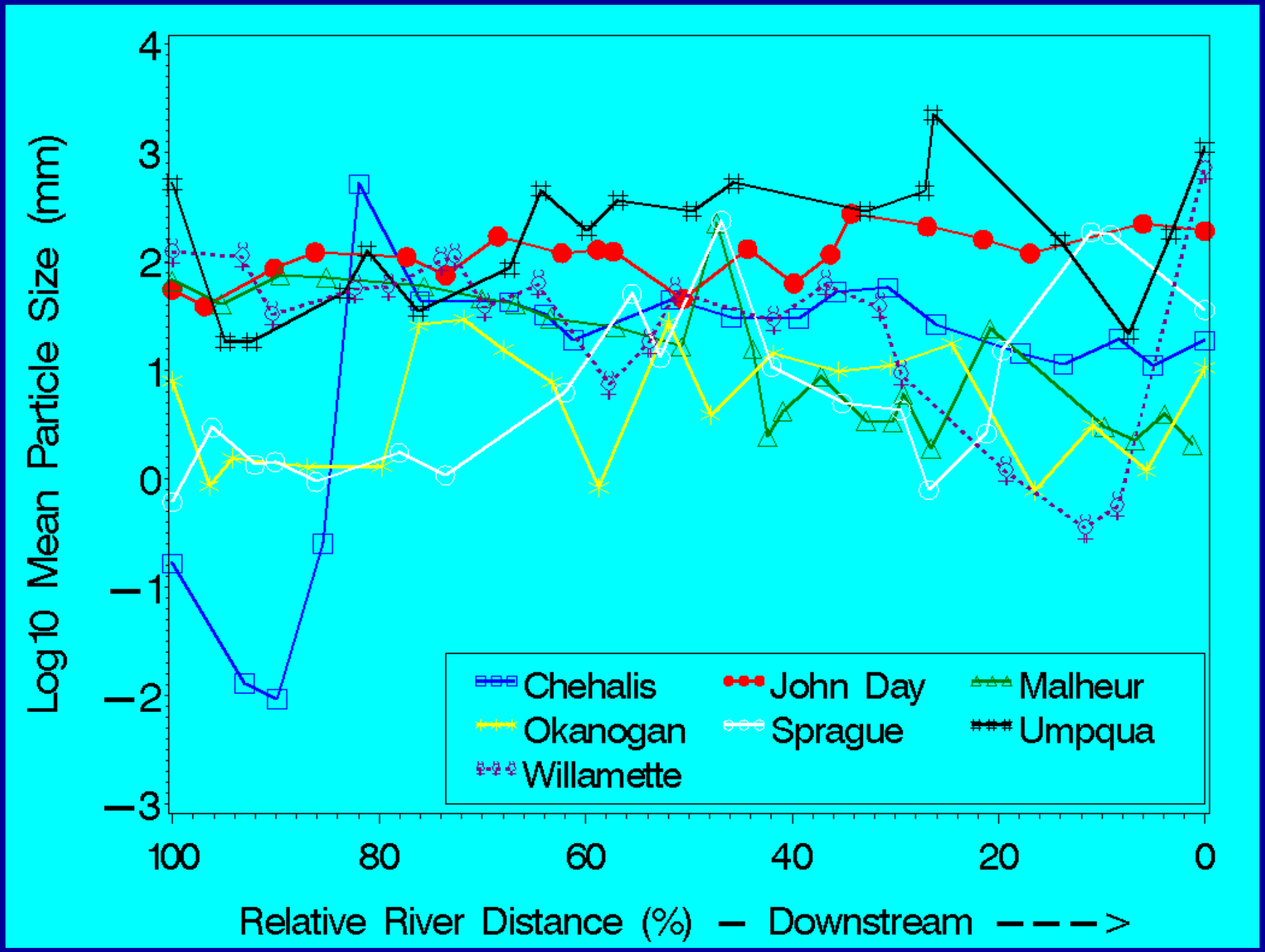
Habitat Raft

Study Rivers

River	Watershed Area (km^2)	Survey Length (km)
Malheur	9,050	153
Willamette	28,900	231
Okanogan	21,200	109
Sprague	4,170	108
Umpqua	10,500	208
Chehalis	3,550	87
John Day	17,800	190

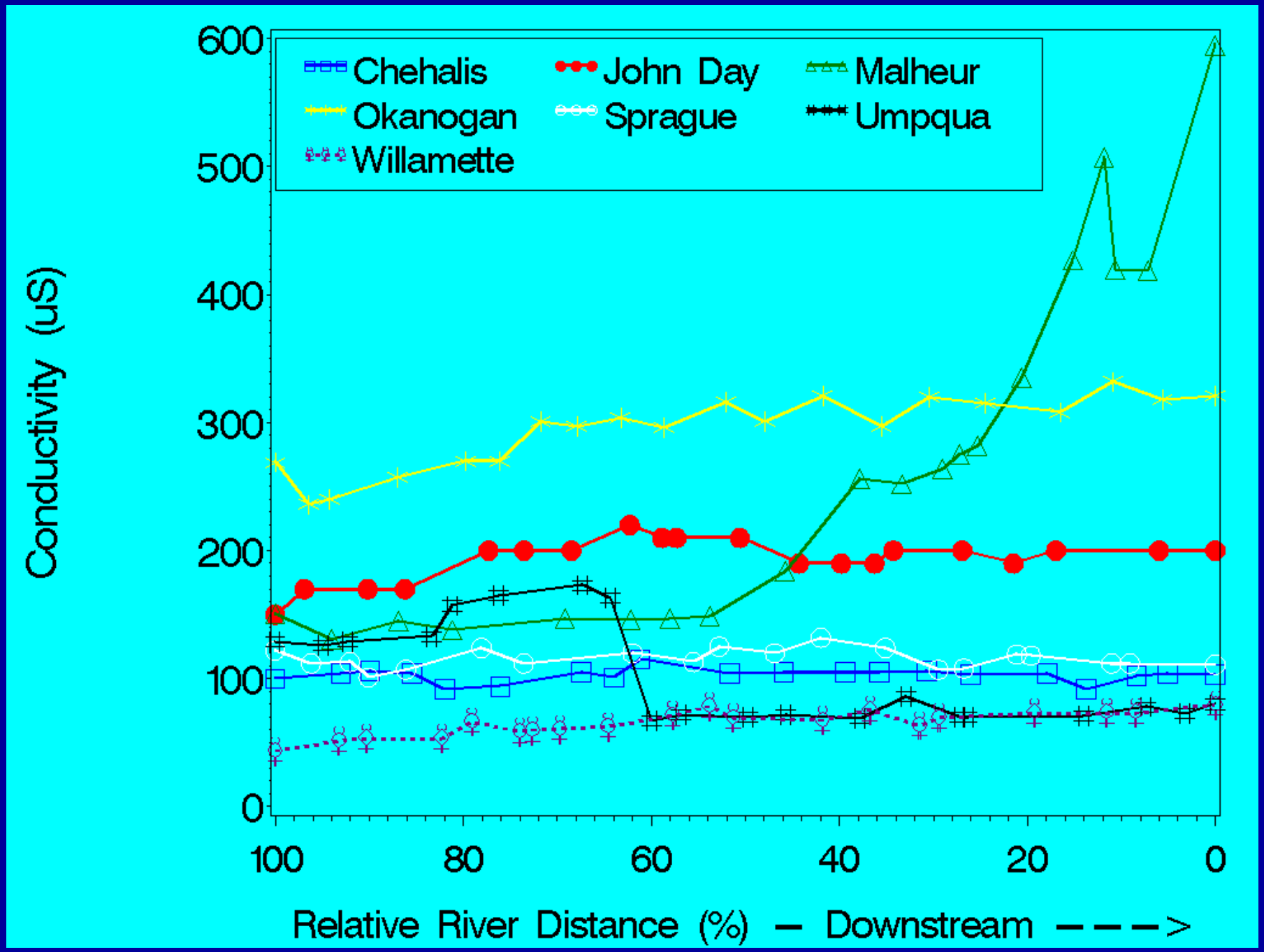
Physical Habitat


Chehalis
John Day
Malheur
Okanogan
Sprague
Umpqua
Willamette
Mean Thalweg Depth (m)
0
2
4
6
8
10
12
14
16
18
20
100.0
80.0
60.0
40.0
20.0
0.0
Relative River Distance (%) — Downstream ——>>


Log10 Mean Particle Size (mm)
4
3
2
1
0
−1
−2
−3
100
80
60
40
20
0
Relative River Distance (%) — Downstream —— >
Chehalis
John Day
Malheur
Okanogan
Sprague
Umpqua
Willamette

Water Chemistry

Malheur River



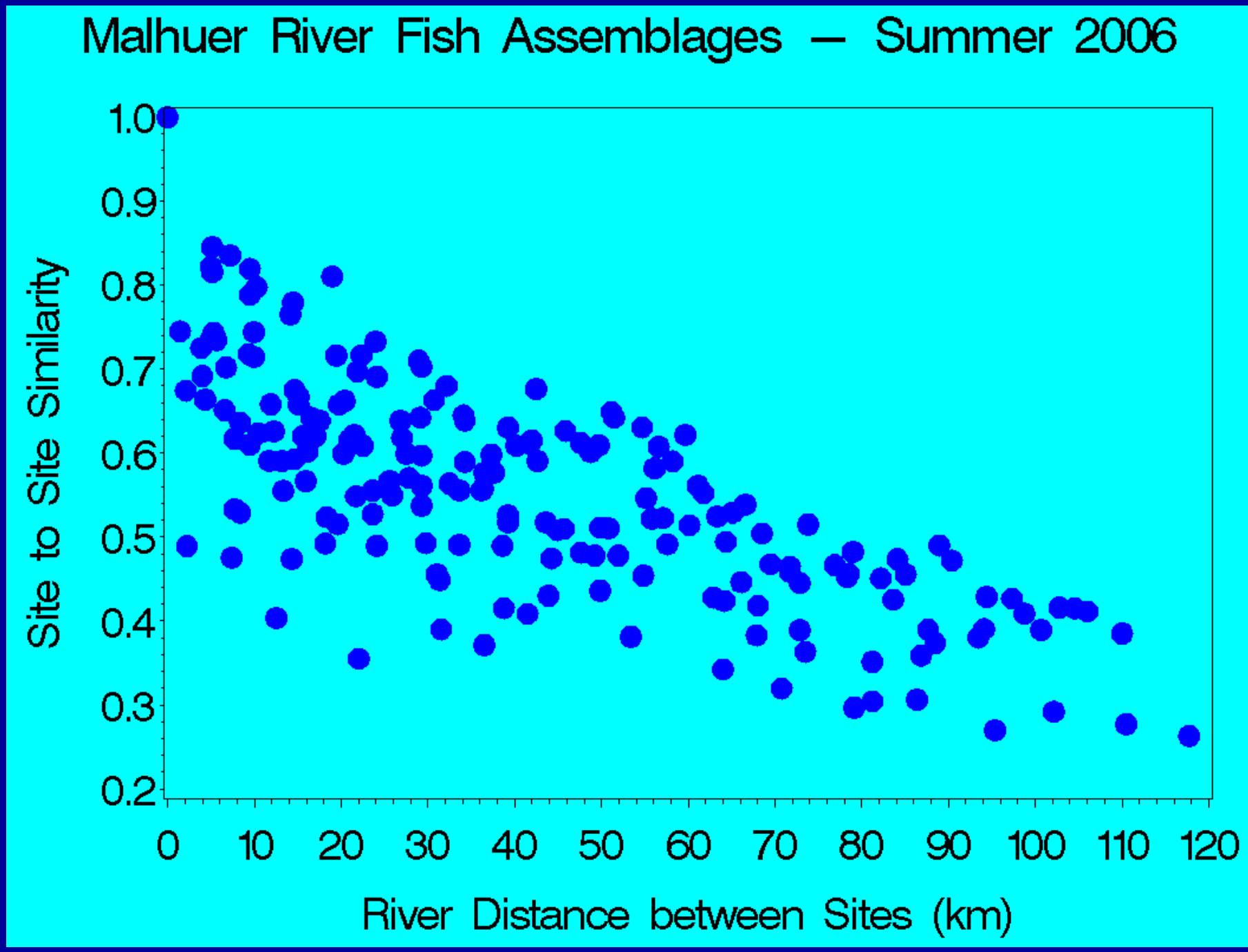
Chehalis
John Day
Malheur
Okanogan
Sprague
Umpqua
Willamette
Conductivity (uS)
600
500
400
300
200
100
0
100
80
60
40
20
0
Relative River Distance (%) — Downstream ---->

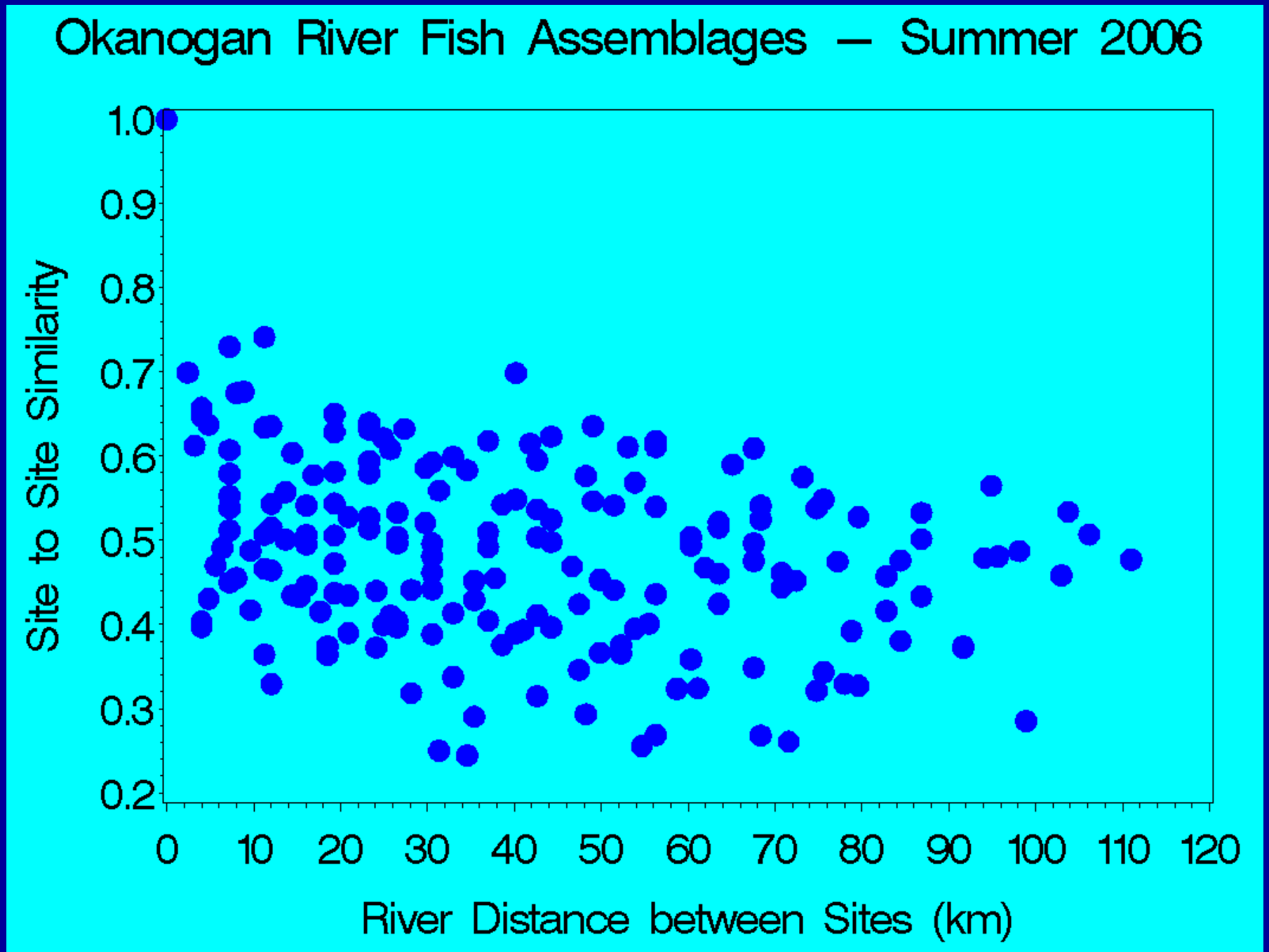
Fish

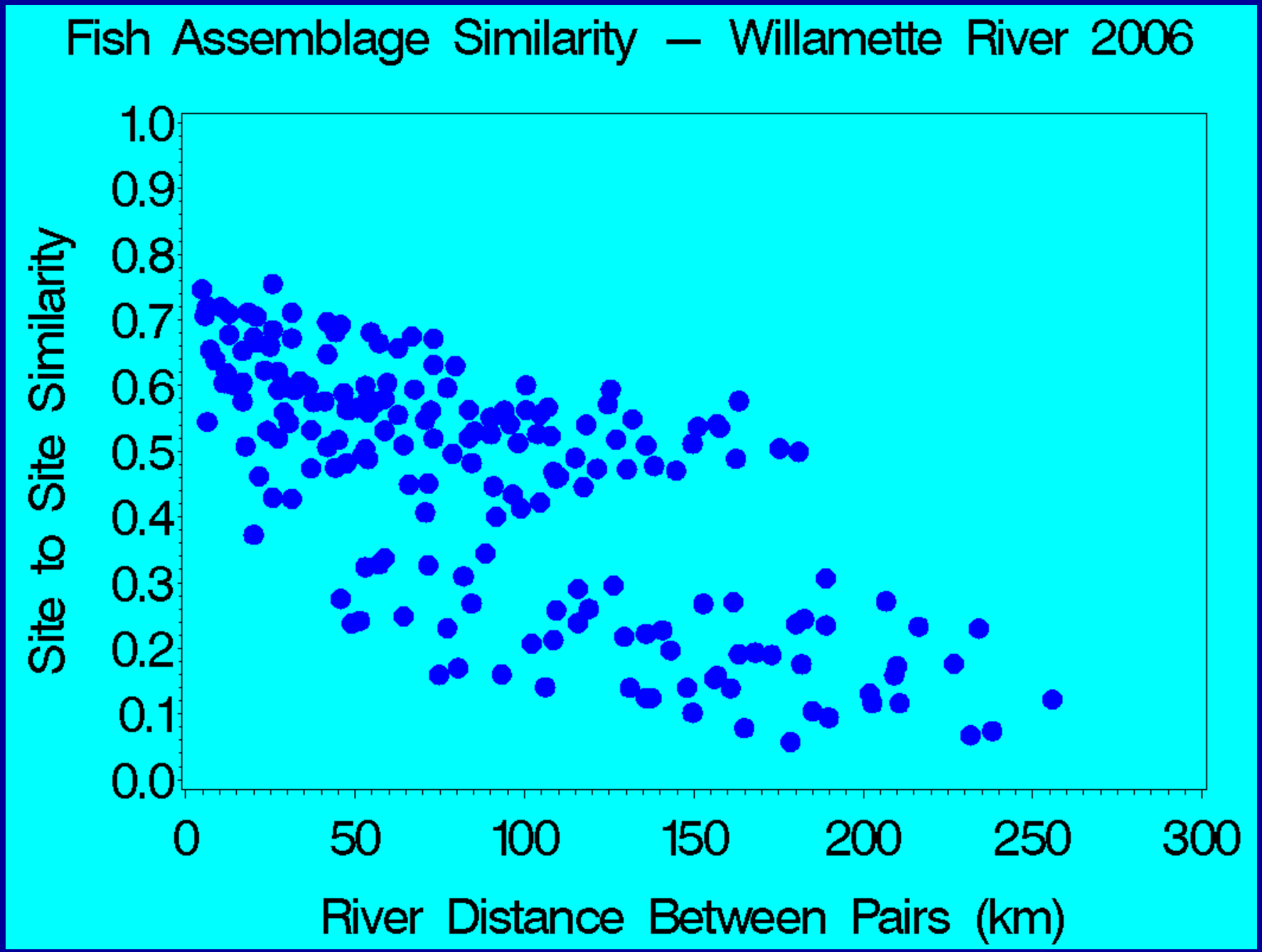
Umpqua River

Among-Site Fish Assemblage Similarity by Distance

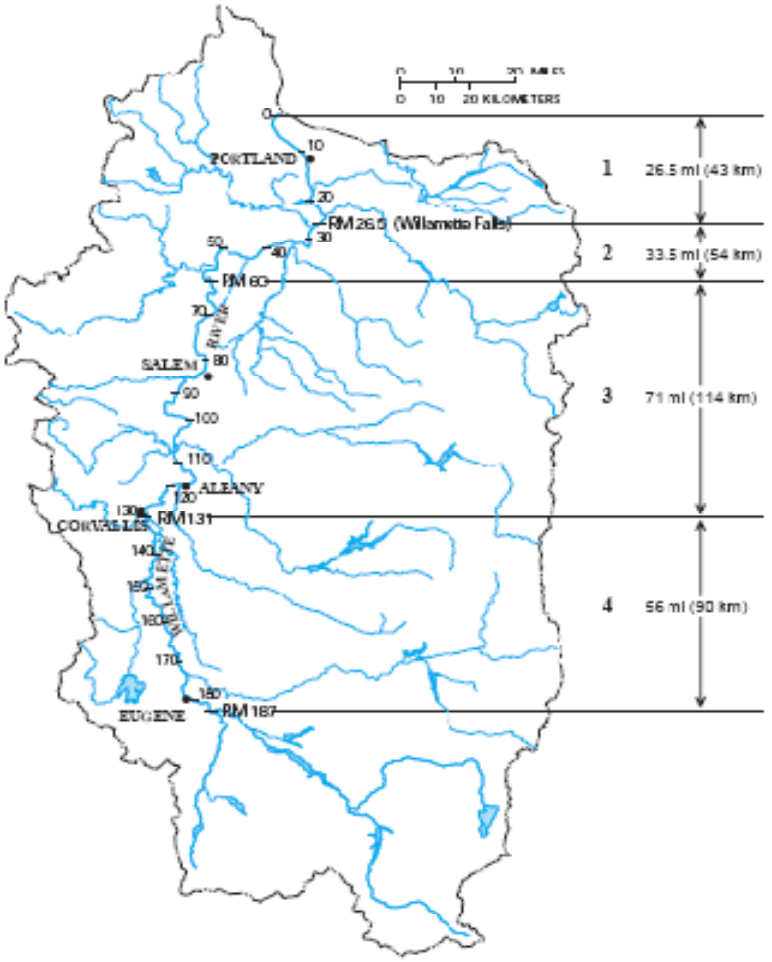
- For each river, calculated Bray-Curtis similarity between all pairs of sites
- 190 pairs for 20 sites
- Calculated river distance between each pair

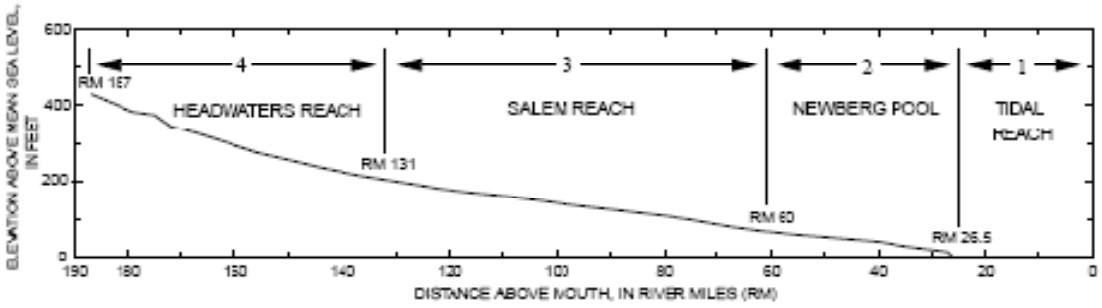

Malhuer River Fish Assemblages — Summer 2006
Site to Site Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
River Distance between Sites (km)

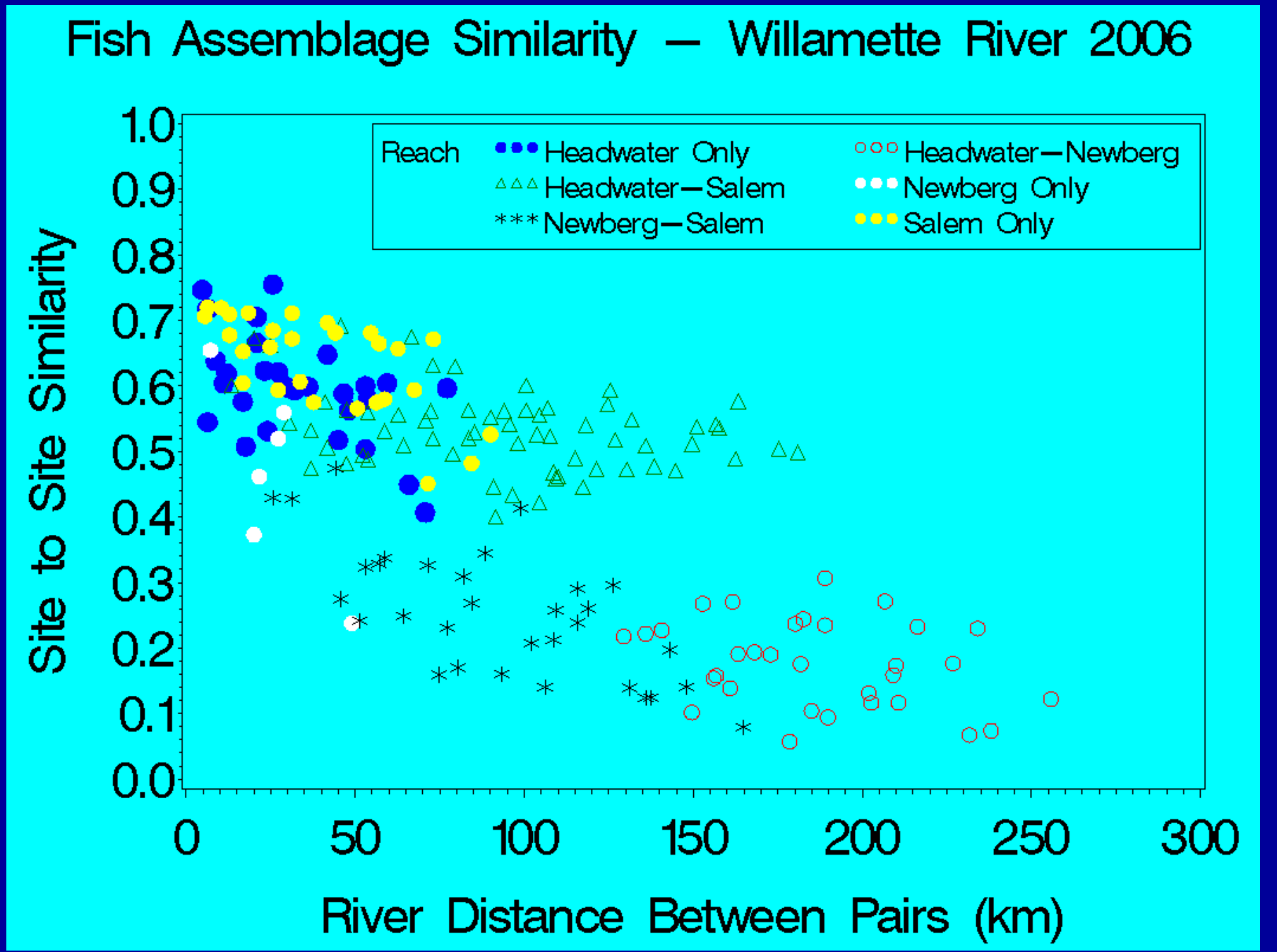

Okanogan River Fish Assemblages — Summer 2006
Site to Site Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
River Distance between Sites (km)


Fish Assemblage Similarity – Willamette River 2006
Site to Site Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
River Distance Between Pairs (km)

Willamette River






Fish Assemblage Similarity — Willamette River 2006
Reach
Headwater Only
Headwater—Newberg
Headwater—Salem
Newberg Only
Newberg—Salem
Salem Only
Site to Site Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
River Distance Between Pairs (km)

Similarity-Distance Relationship

- Continual Decline with Distance
  - Umpqua, Malheur
- Little/No Relationship
  - John Day, Okanogan
- Zonation
  - Willamette, Chehalis
- Initial Decline, then No Change
  - Sprague, Lower Chehalis ~25 km
  - Upper Willamette, ~50-100 km

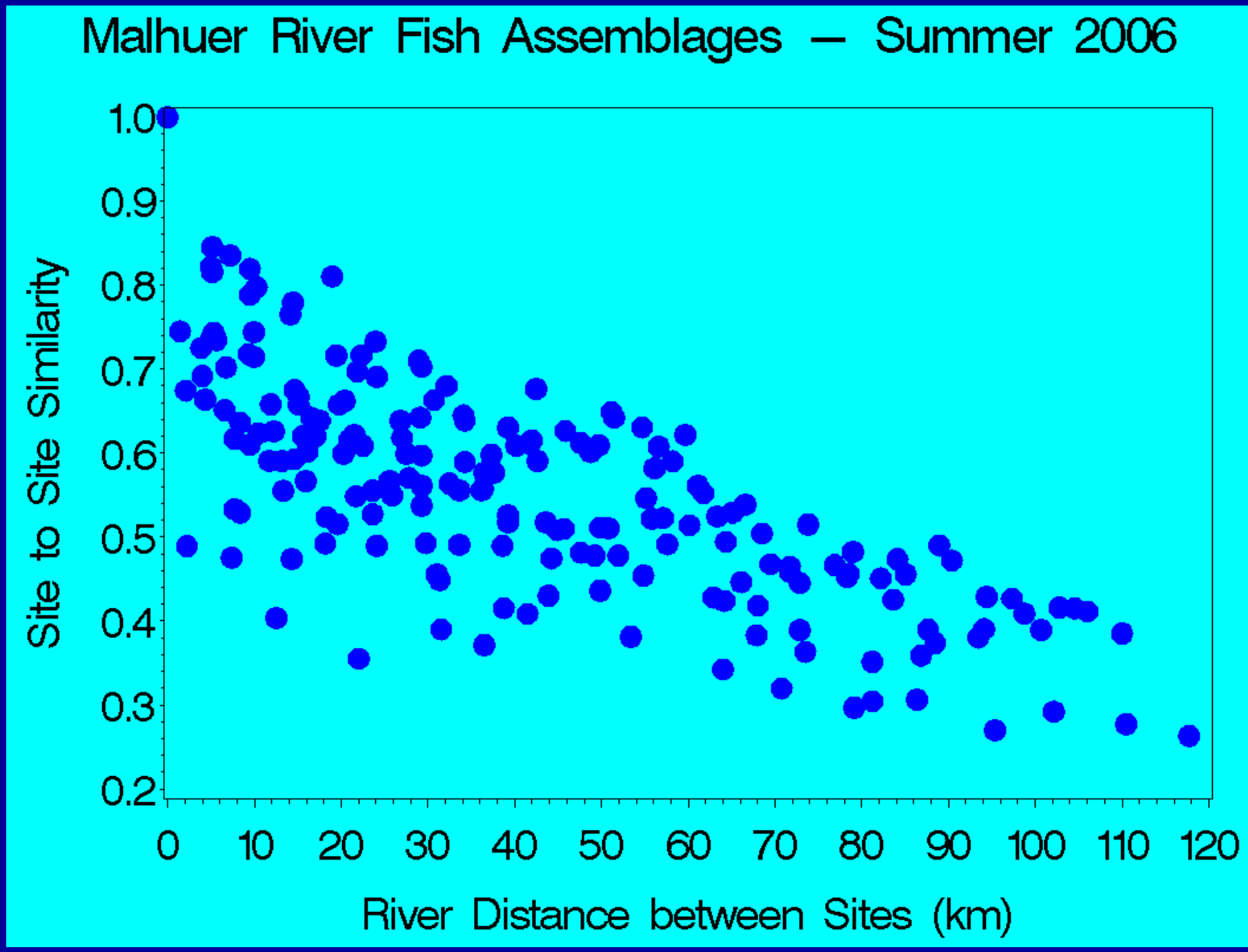
Mantel Test

Compares strength of relationship between two dissimilarity matrices (Spearman r)

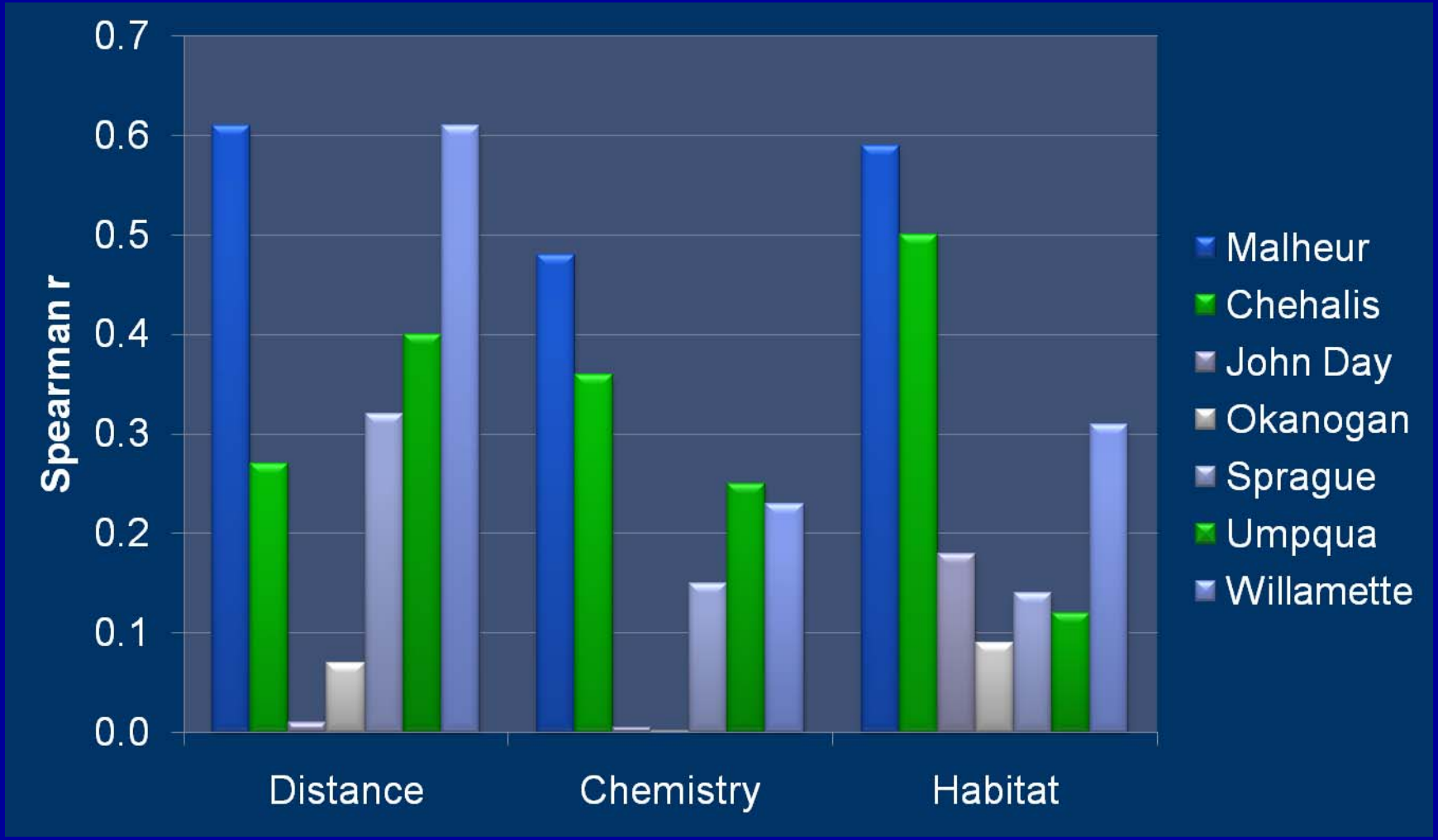
- Calculated Six Matrices
  - Fish, Macroinvertebrates, Periphyton
    - **Bray-Curtis Distance, log (x+1)**
  - River Distance (Euclidean)
  - Water Chemistry (Euclidean)
    - Total N,P, Cl, SO_4, Turbidity
  - Physical Habitat (Euclidean)
    - Substrate size, riparian disturbance, fast water habitat, fish cover

Malheur River - Mantel r

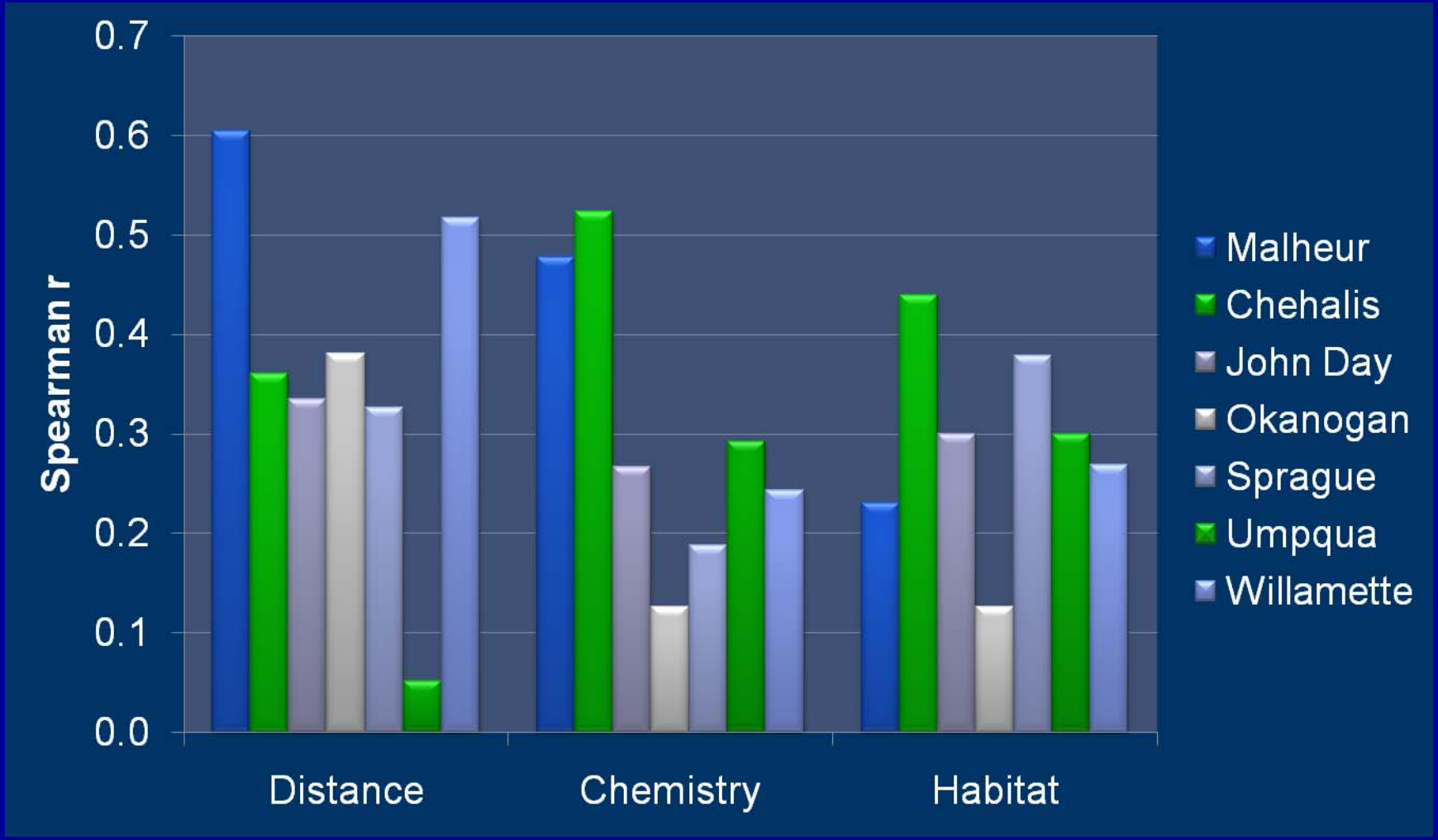
Matrix	Fish	Macr. Invert	Algae	Phys. Hab.	Water Chem	River Dist.
Fish	1	--	--	--	--	--
Invert	0.44	1	--	--	--	--
Algae	0.44	0.60	1	--	--	--
Phab	0.29	0.23	0.09	1	--	--
Chem	0.48	0.48	0.63	0.32	1	
Distance	0.62	0.60	0.61	0.27	0.52	1


Malhuer River Fish Assemblages — Summer 2006
Site to Site Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
10
20
30
40
50
60
70
80
90
100
110
120
River Distance between Sites (km)

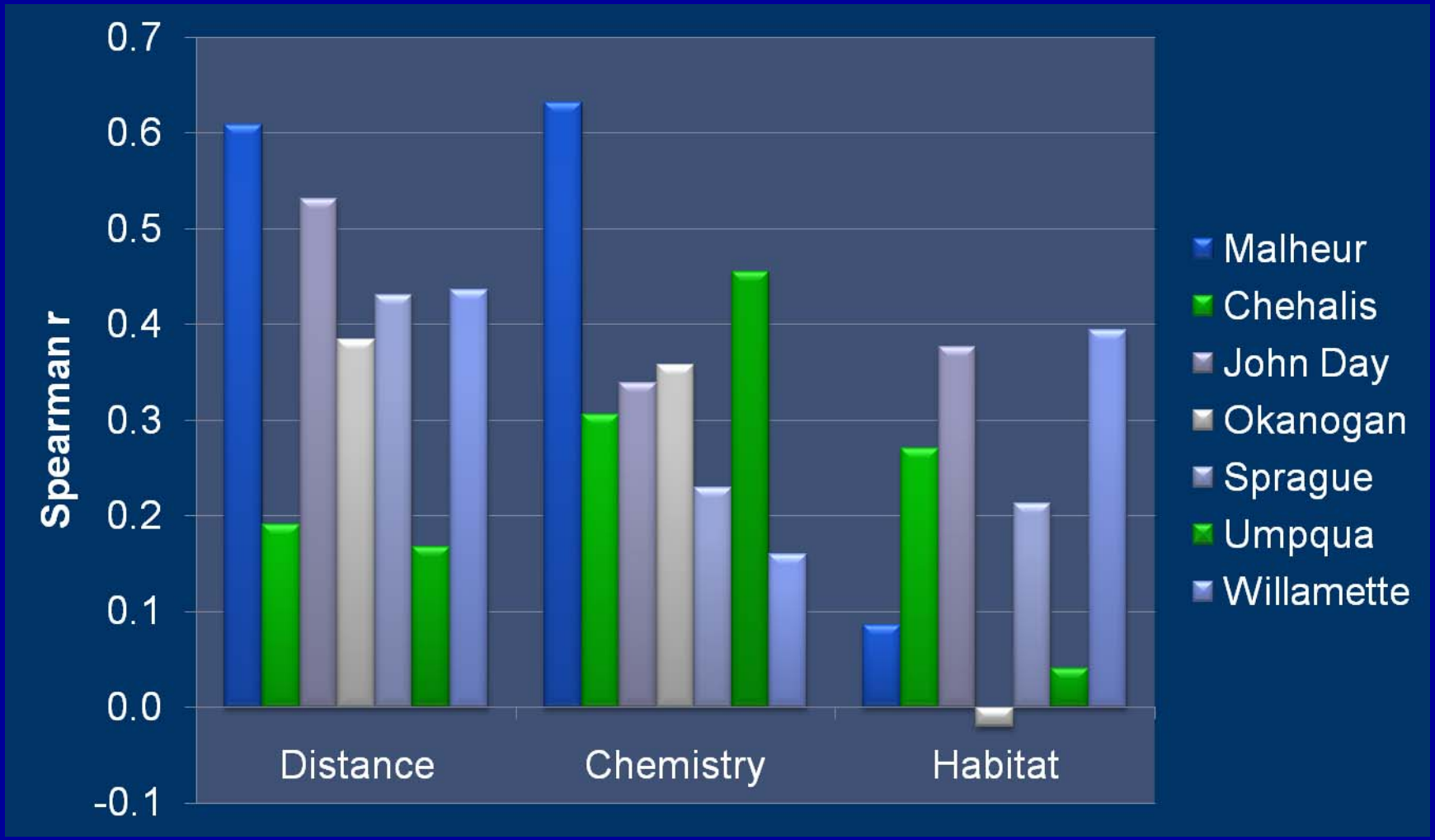
Fish – Environment Mantel correlations



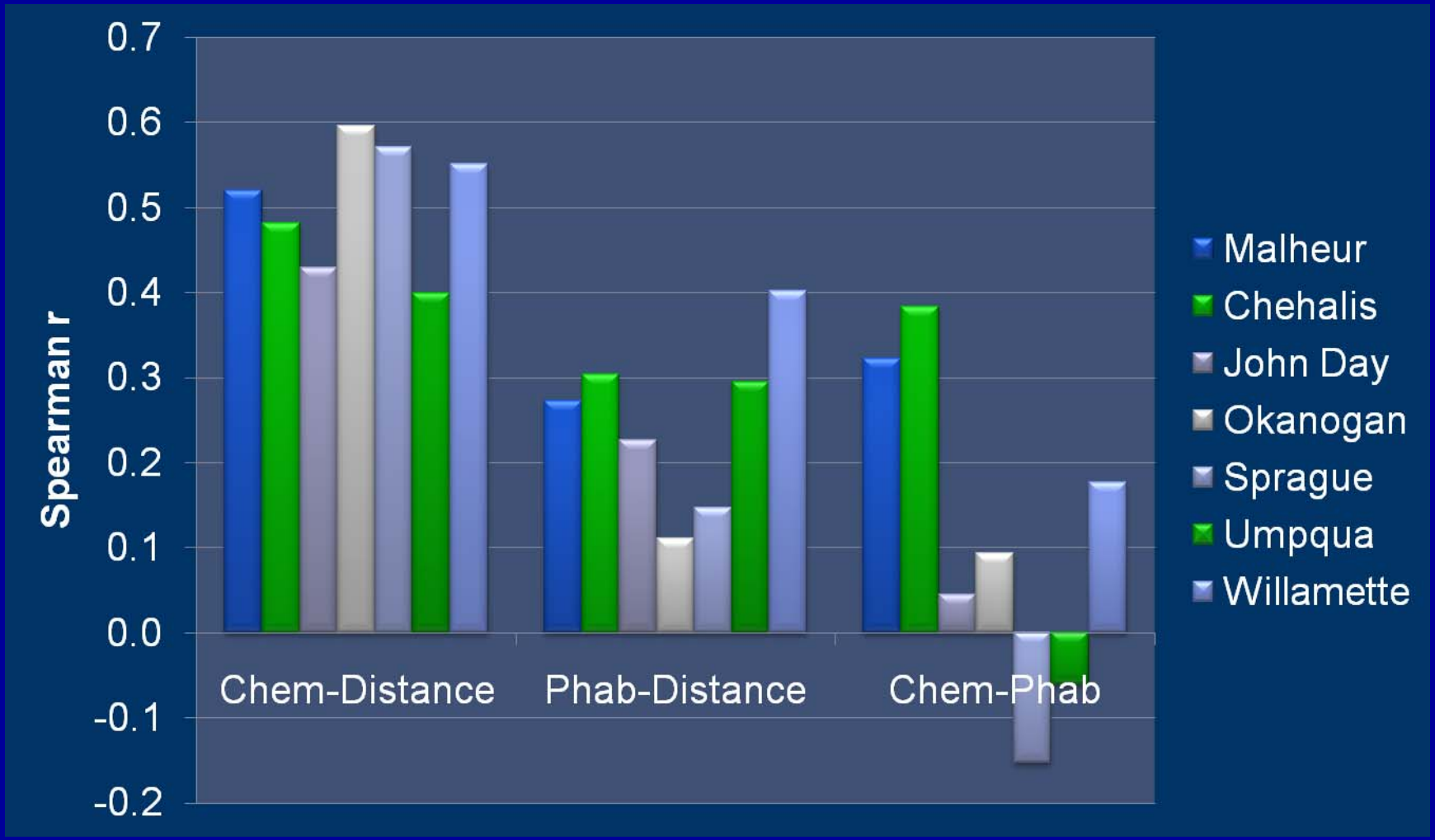
Macroinvertebrate – Environment Mantel correlations

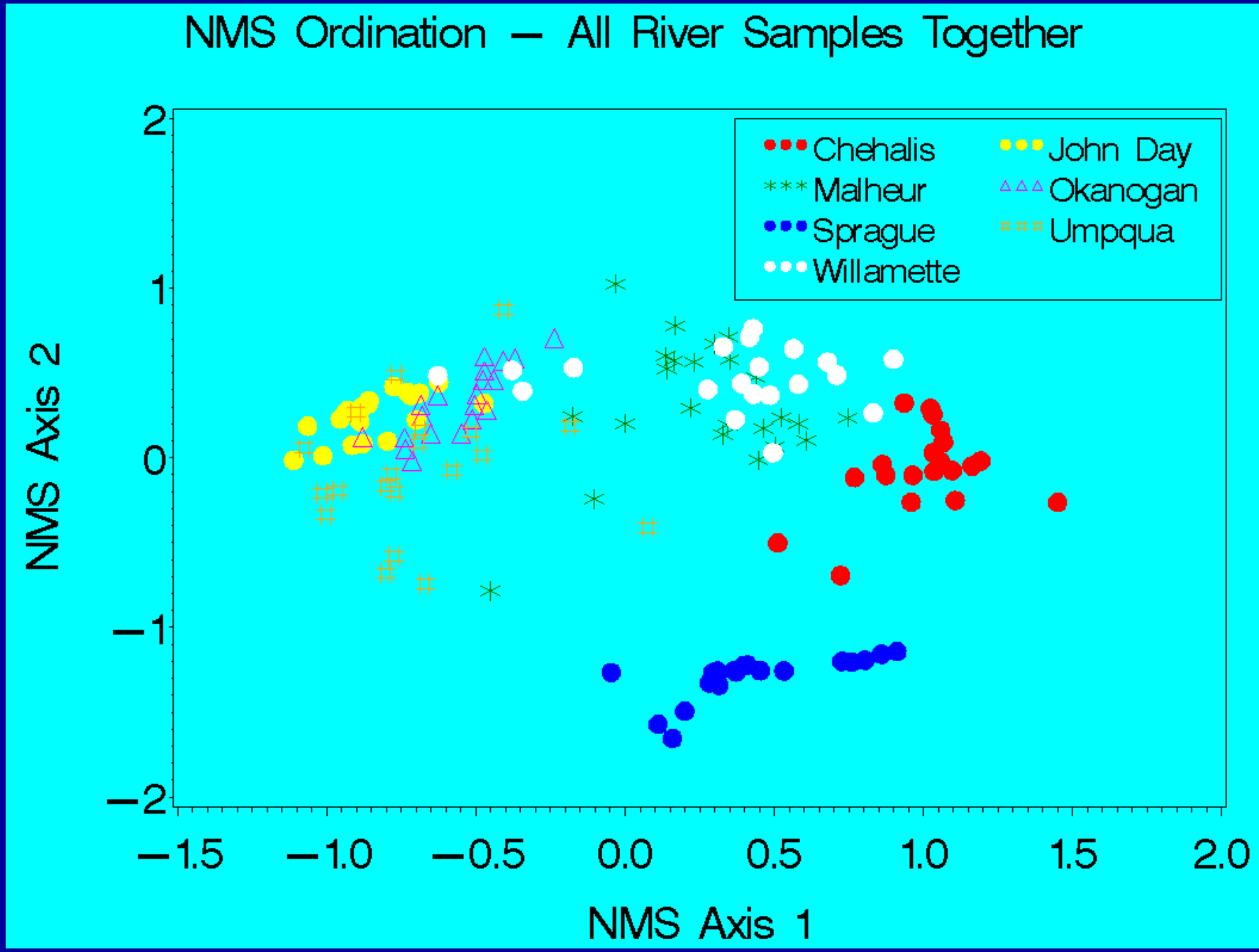


Diatom – Environment Correlations



Environment –Distance Correlations




NMS Ordination — All River Samples Together
Chehalis
John Day
Malheur
Okanogan
Sprague
Umpqua
Willamette
NMS Axis 2
NMS Axis 1
2
1
0
−1
−2
−1.5
−1.0
−0.5
0.0
0.5
1.0
1.5
2.0

Conclusions

- Among river variability >> within river longitudinal variability
- No consistent pattern in longitudinal similarity among either rivers or indicators
- Longitudinal spatial patterns in fish species assemblages is different among the seven study rivers
  - Continuous, No relation, Zonation
- Within-river similarity higher than I thought

Acknowledgements

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  - 2006, Hank LaVigne
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