Longitudinal Variability in Pacific Northwest Rivers: Implications for Regional River Survey Design

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Project Objectives - RIVMAP

- Characterize ecological condition in raftable river length in six Northwest Rivers
- Study spatial autocorrelation for typical bioassessment measures in rivers
  - When do samples get too close together?
- Target Rivers
  - 100-200 km boatable length
  - 20-120 m wide

Study Rivers

2006

- Malheur River, OR
  - Juntura to Mouth
- Willamette River, OR
  - Eugene to Portland
- Okanogan River, WA
  - Oroville to Mouth

2007

- Sprague River, OR
  - Beatty to Mouth
- Umpqua & South Umpqua, OR
  - Canyonville to Tidewater
- Chehalis, WA
  - Chehalis to Tidewater

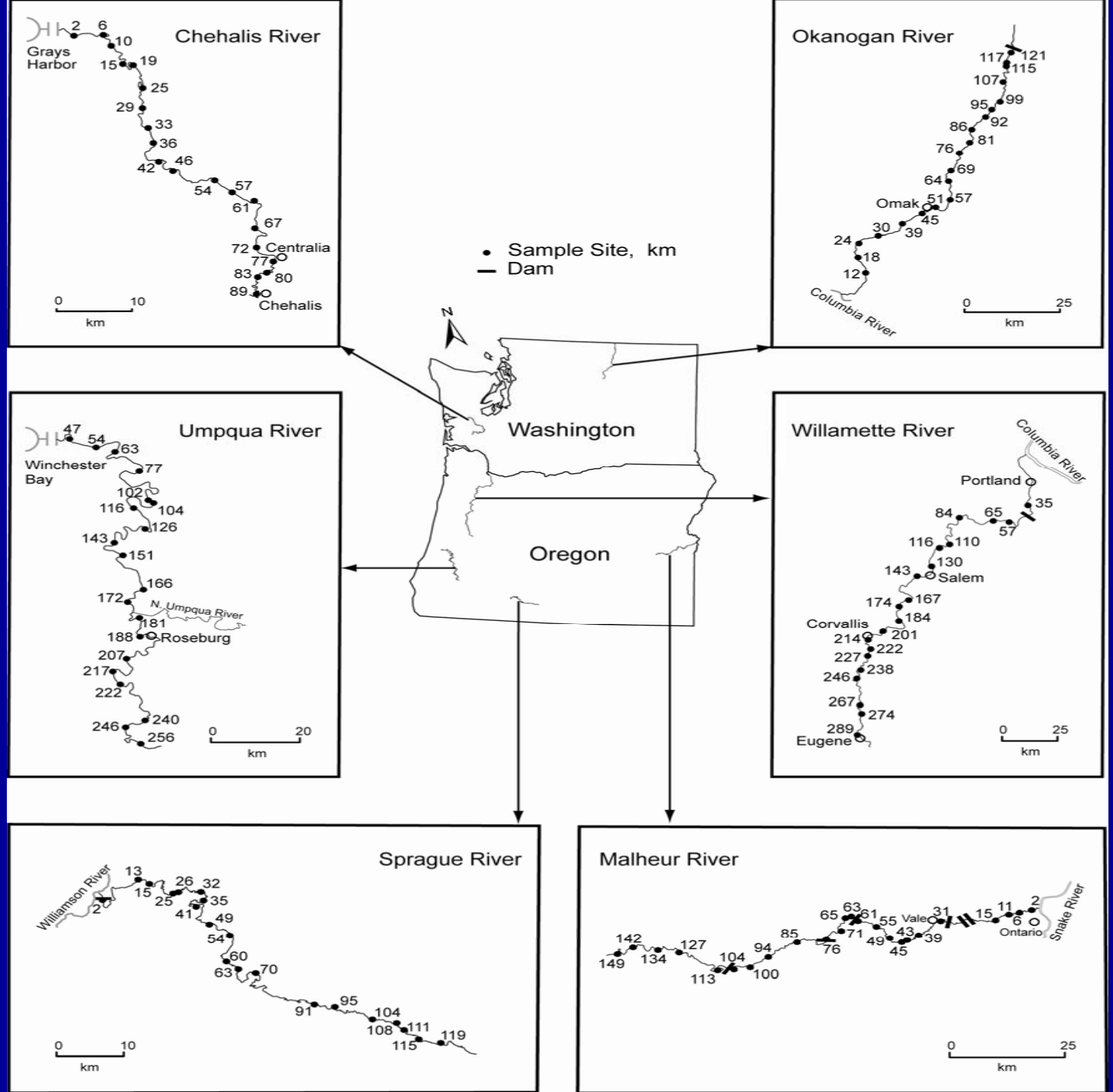
Study River Dimensions

River	Basin Area (km^2)	Target Length (km)
Malheur	8,700	123
Willamette	29,500	256
Okanogan	21,200	110
Sprague	4,140	110
Umpqua	12,000	208
Chehalis	5,560	86

Sample Site Selection

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

Sprague River


Chehalis River
Grays Harbor
2
6
10
15
19
25
29
33
36
42
46
54
57
61
67
72
Centralia
77
83
80
89
Chehalis
0
10
km
Okanogan River
117
121
115
107
99
95
92
86
81
76
69
64
Omak
51
57
45
30
39
24
18
12
Columbia River
0
25
km
Sample Site, km
Dam
N
Washington
Oregon
Umpqua River
47
54
63
Winchester Bay
77
102
116
104
126
143
151
166
172
N. Umpqua River
181
188
Roseburg
207
217
222
240
246
256
0
20
km
Willamette River
Columbia River
Portland
35
84
65
57
116
110
130
143
Salem
174
167
184
Corvallis
214
201
222
227
238
246
267
274
289
Eugene
0
25
km
Sprague River
Williamson River
13
15
25
26
32
2
35
41
49
54
60
63
70
91
95
104
108
111
115
119
0
10
km
Malheur River
142
149
134
127
113
104
100
94
85
76
65
63
61
71
55
49
43
45
Vale
31
39
15
11
6
Ontario
2
Snake River
0
25
km

Indicators Measured

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

Chehalis River Bryozoan

Field Sampling

Crew of 4

Electrofishing Raft

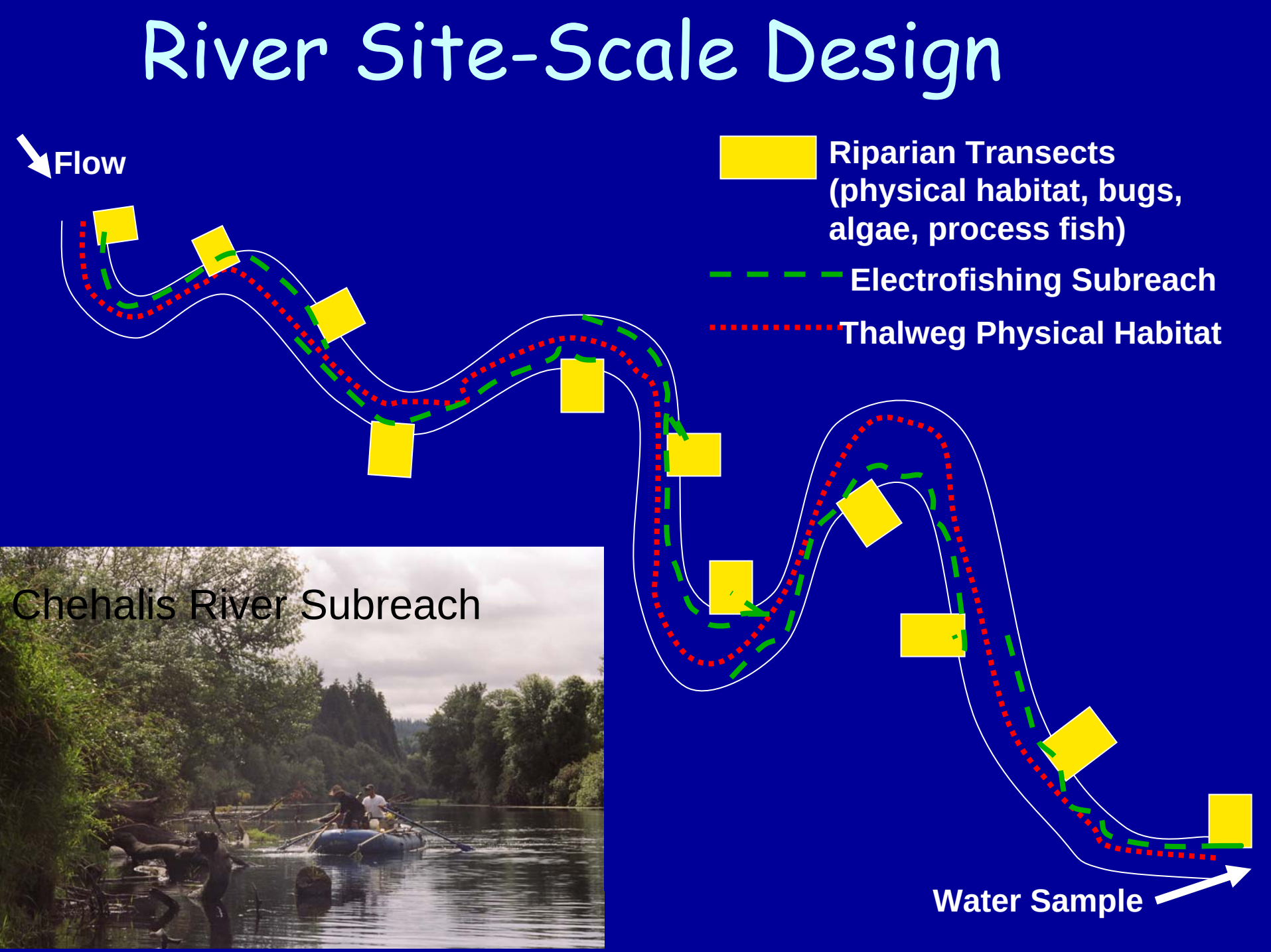
Habitat Raft

Starting Willamette River Subreach

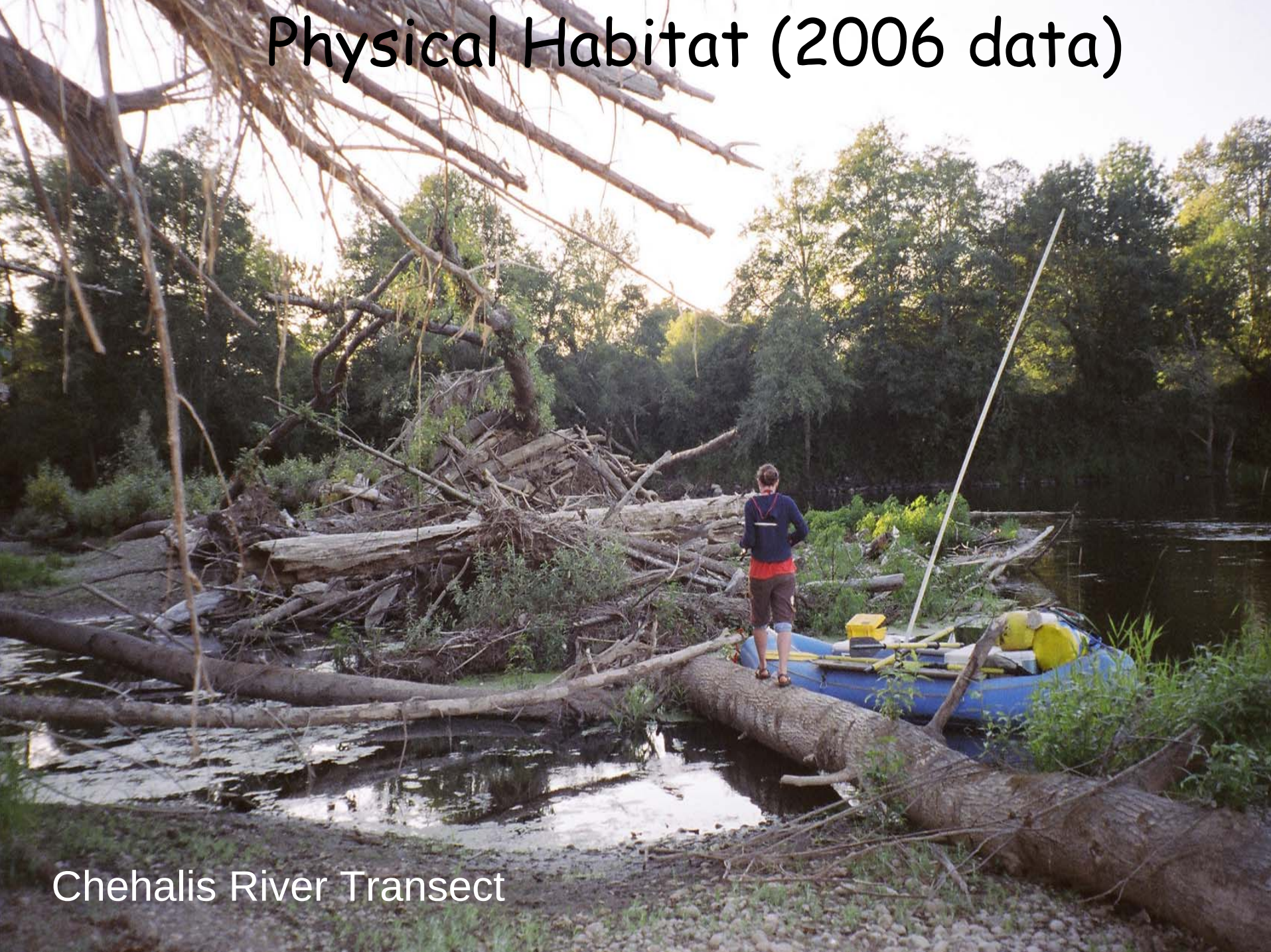
River Site-Scale Design

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

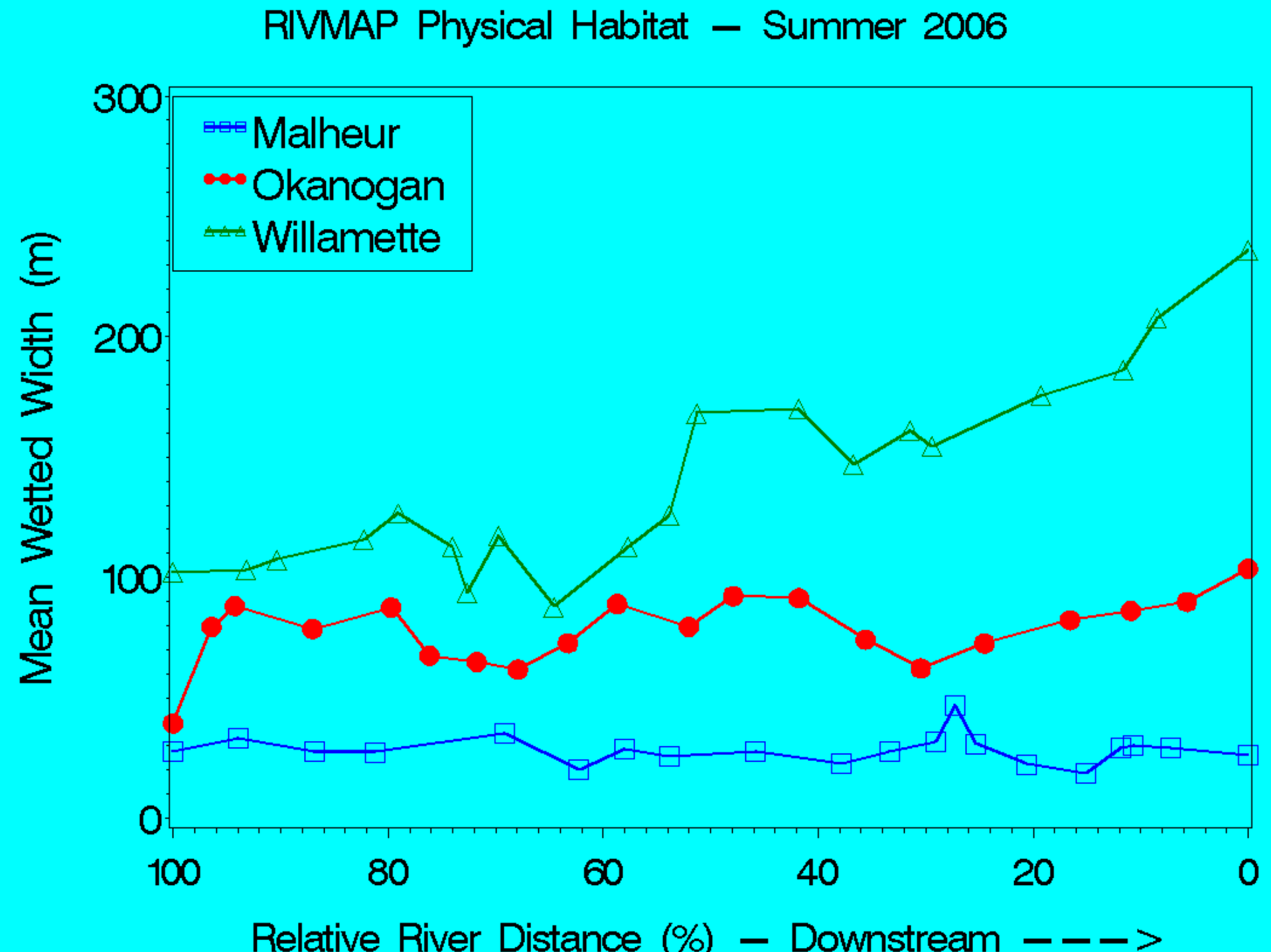
River Site-Scale Design

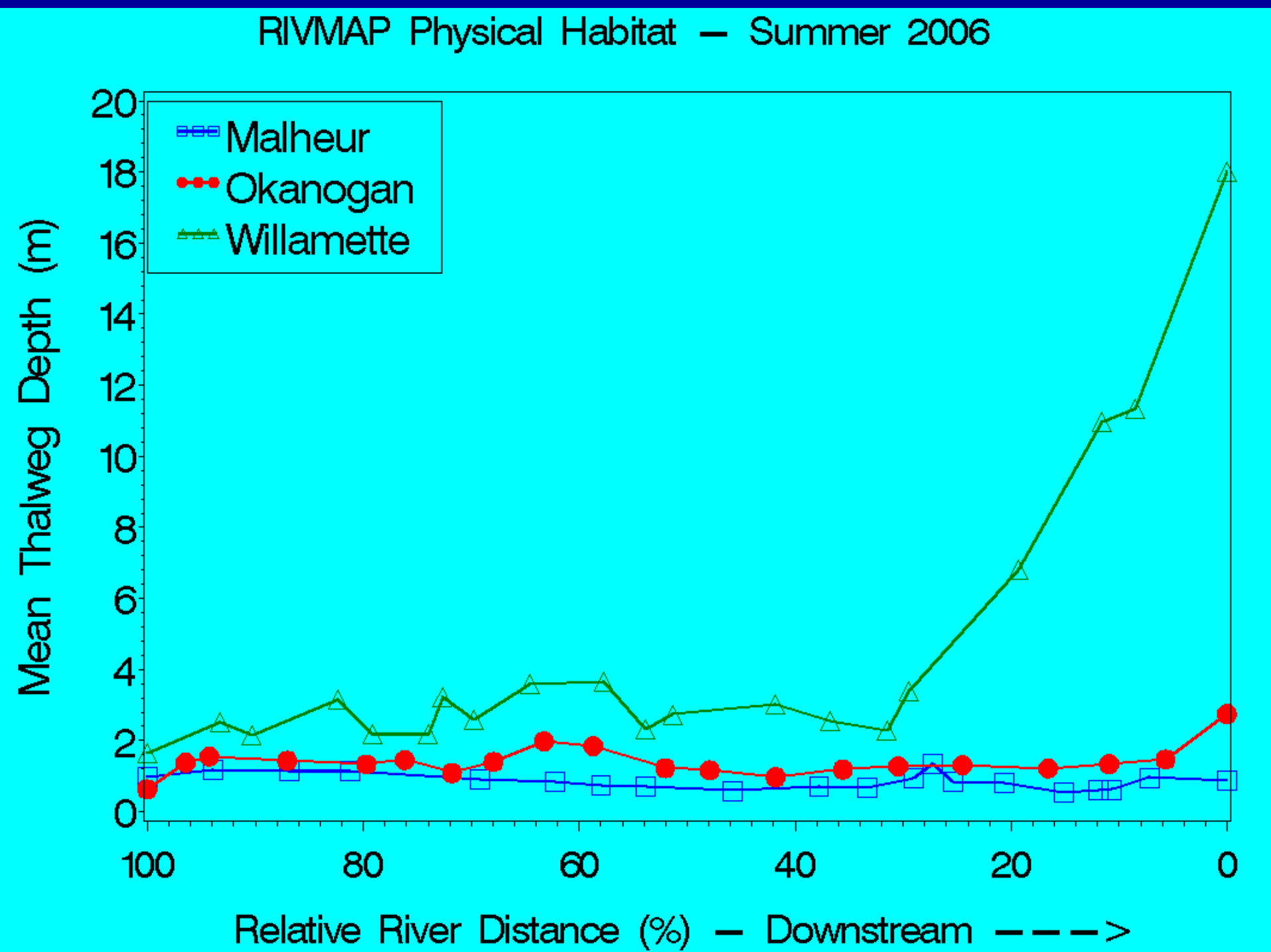


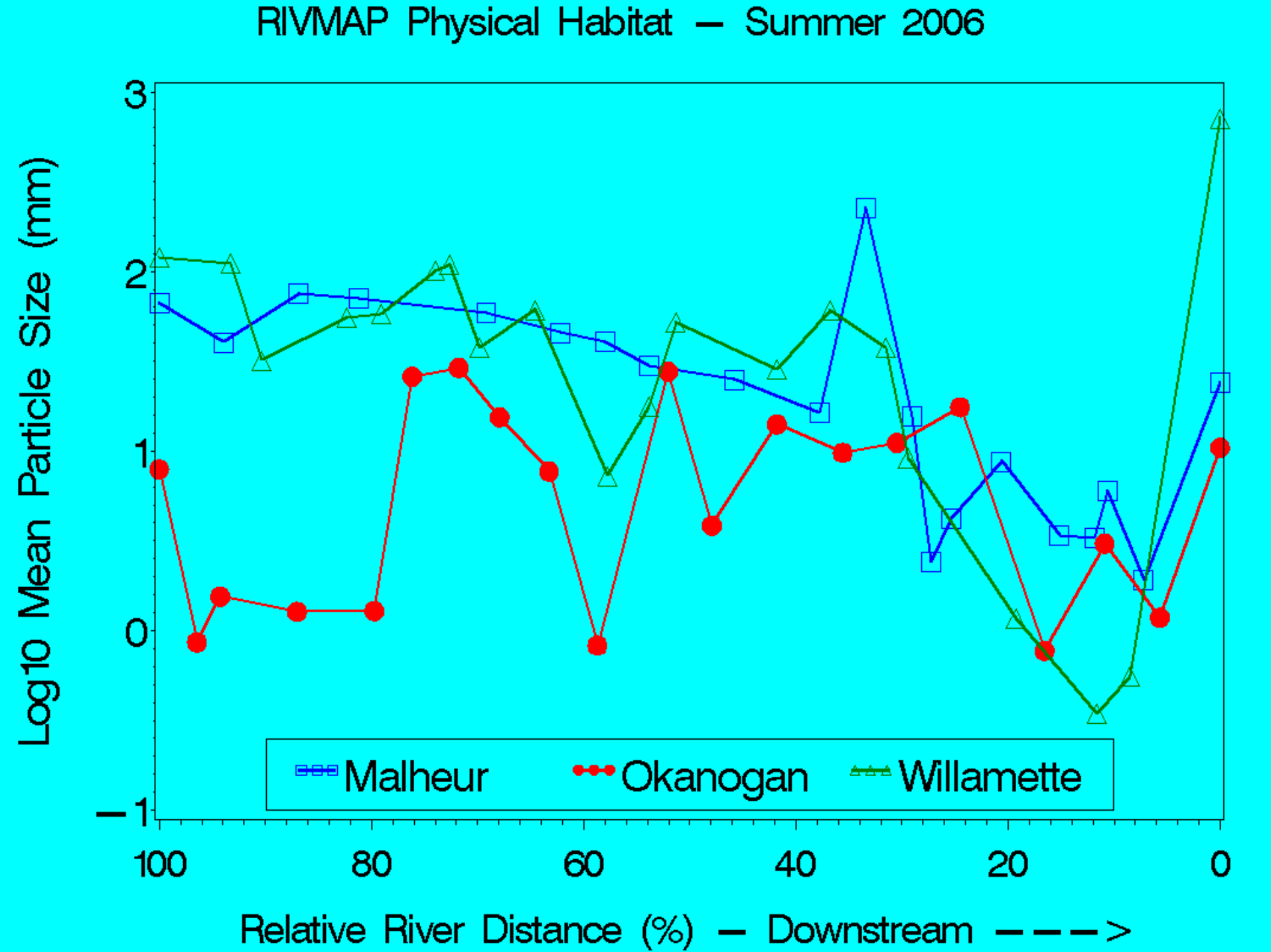
Physical Habitat (2006 data)



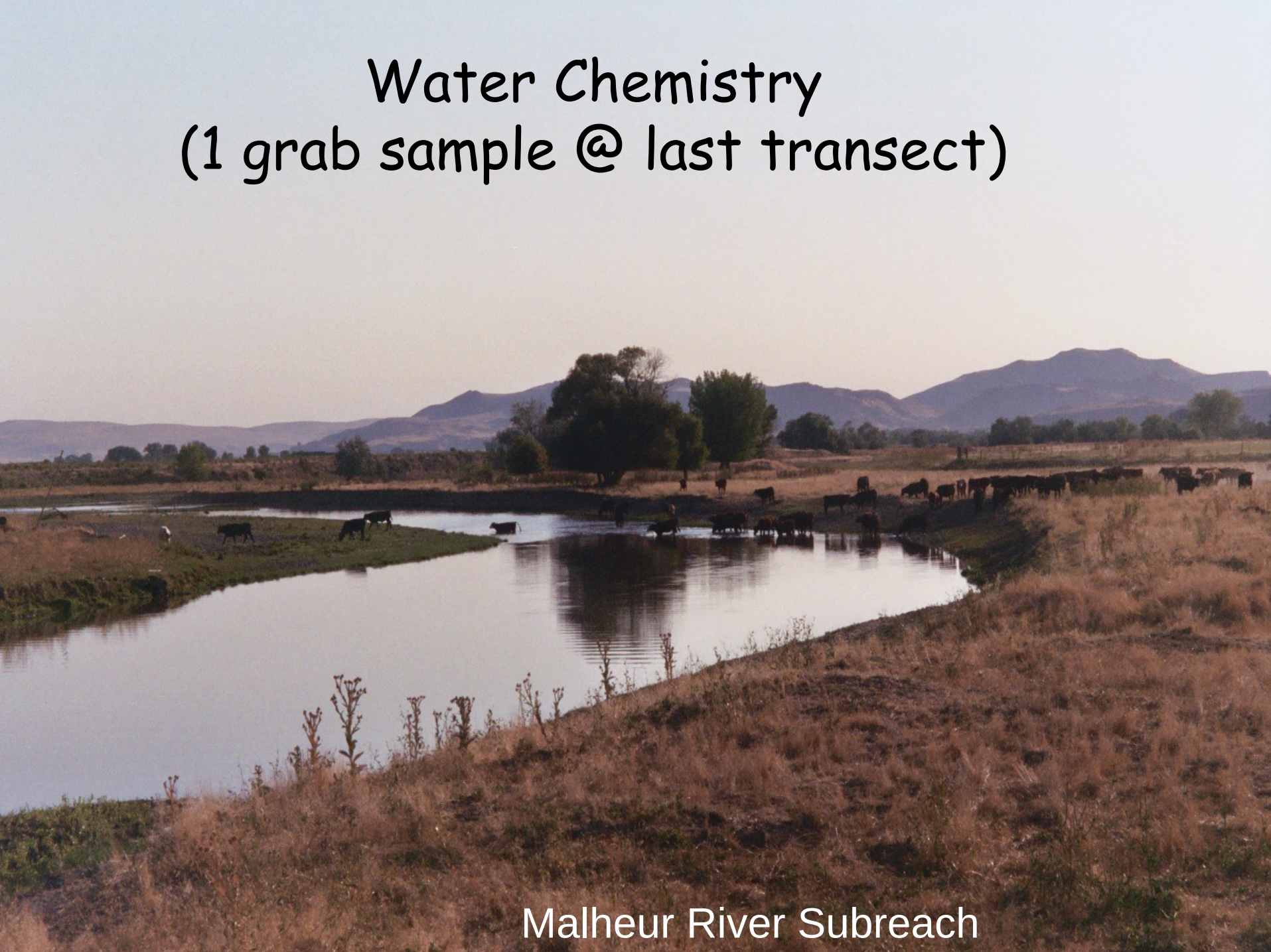
Chehalis River Transect

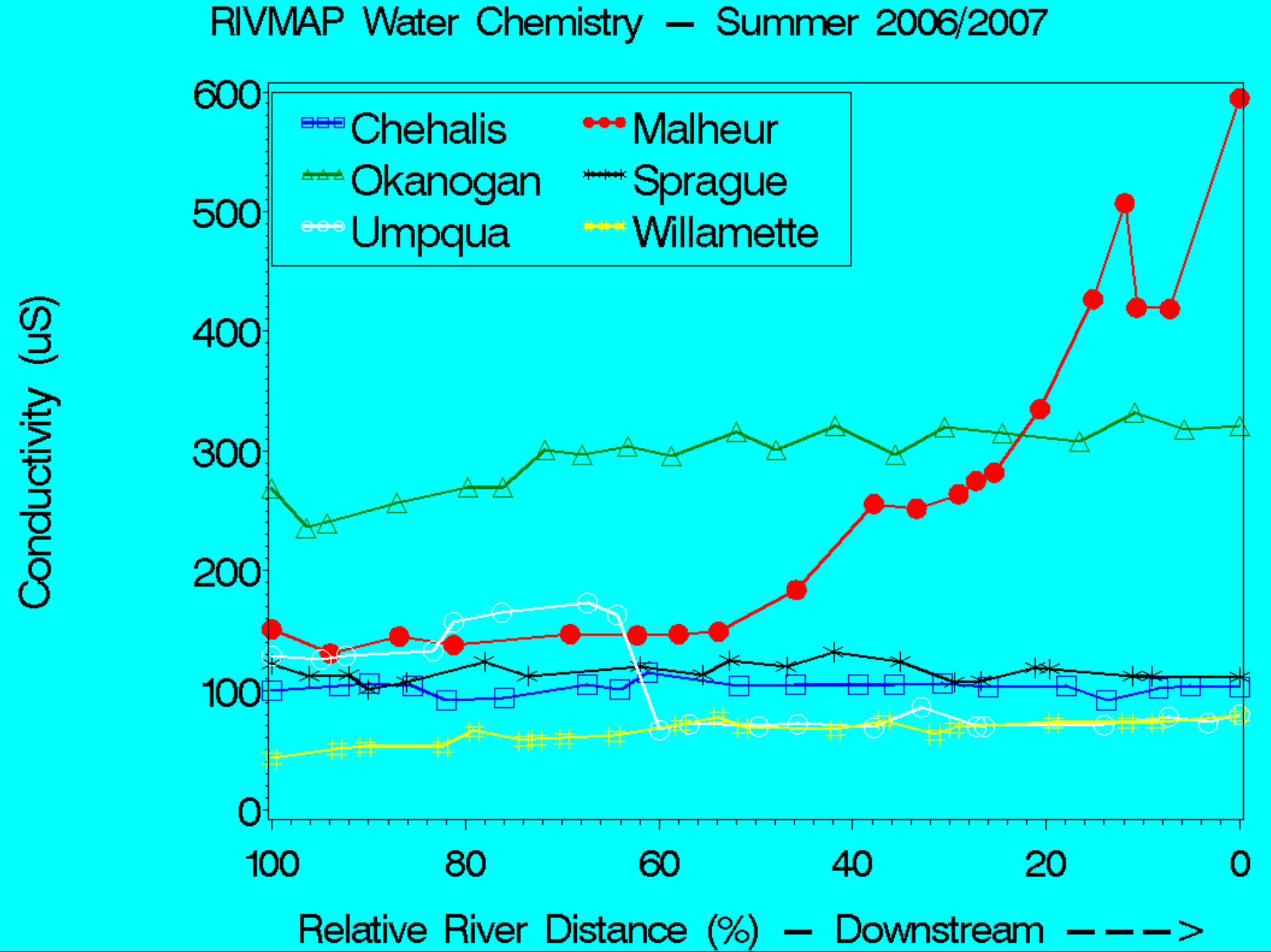

RIVMAP Physical Habitat — Summer 2006
Malheur
Okanogan
Willamette
Mean Wetted Width (m)
300
200
100
0
100
80
60
40
20
0
Relative River Distance (%) — Downstream --->

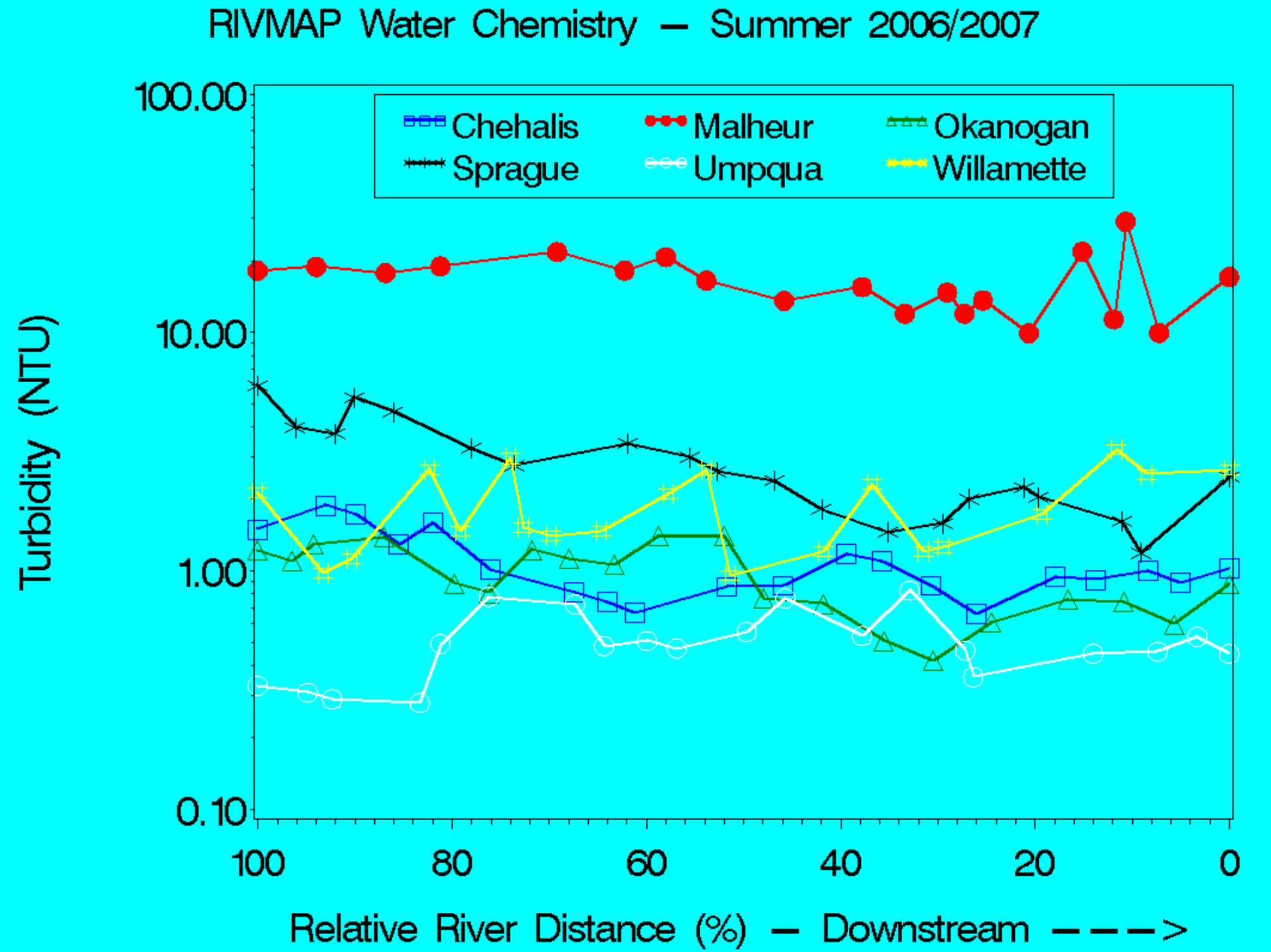

RIVMAP Physical Habitat – Summer 2006
Malheur
Okanogan
Willamette
Mean Thalweg Depth (m)
0
2
4
6
8
10
12
14
16
18
20
100
80
60
40
20
0
Relative River Distance (%) – Downstream --->

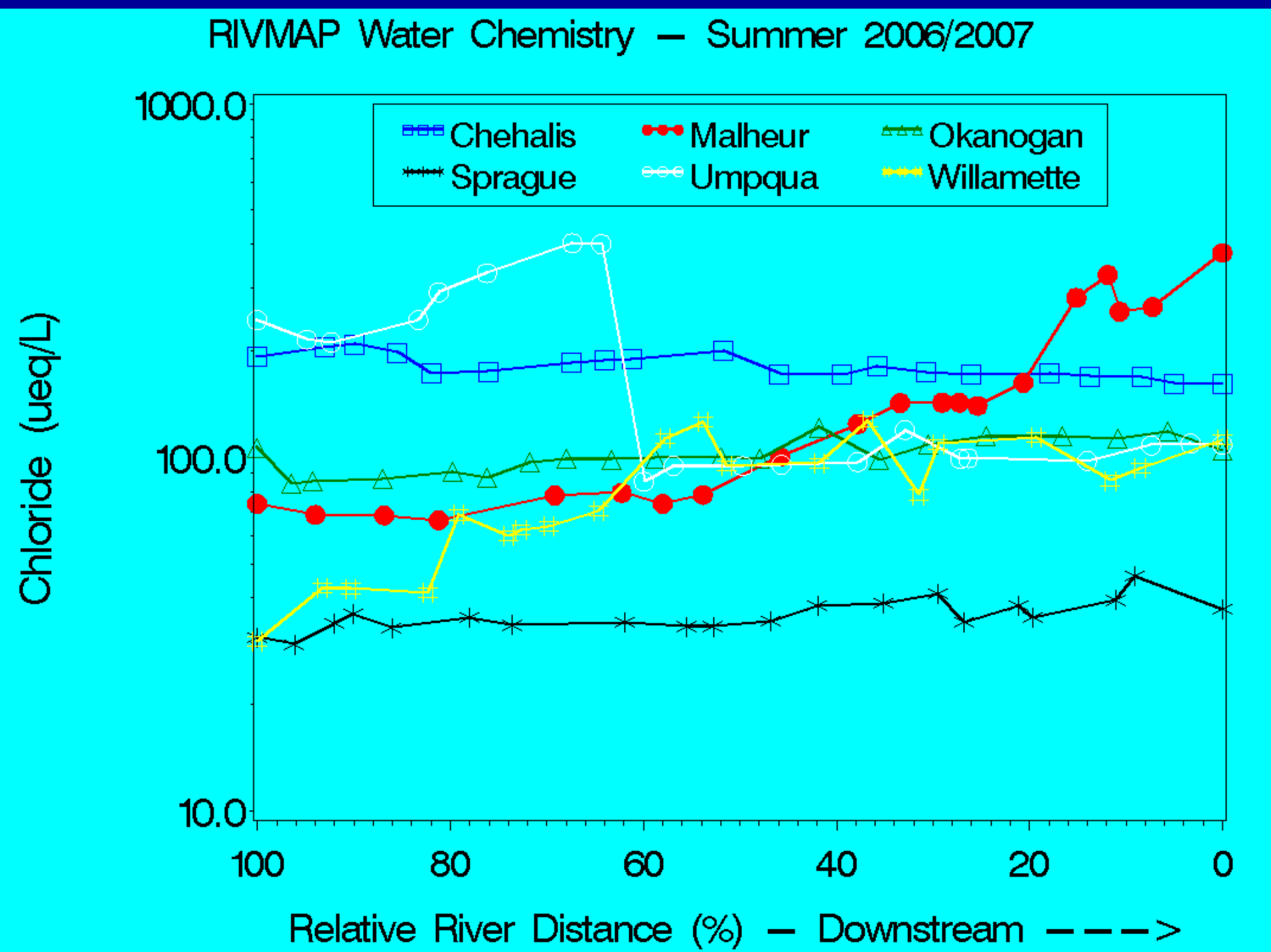

RIVMAP Physical Habitat – Summer 2006
Log10 Mean Particle Size (mm)
3
2
1
0
−1
100
80
60
40
20
0
Relative River Distance (%) – Downstream –––>
Malheur
Okanogan
Willamette

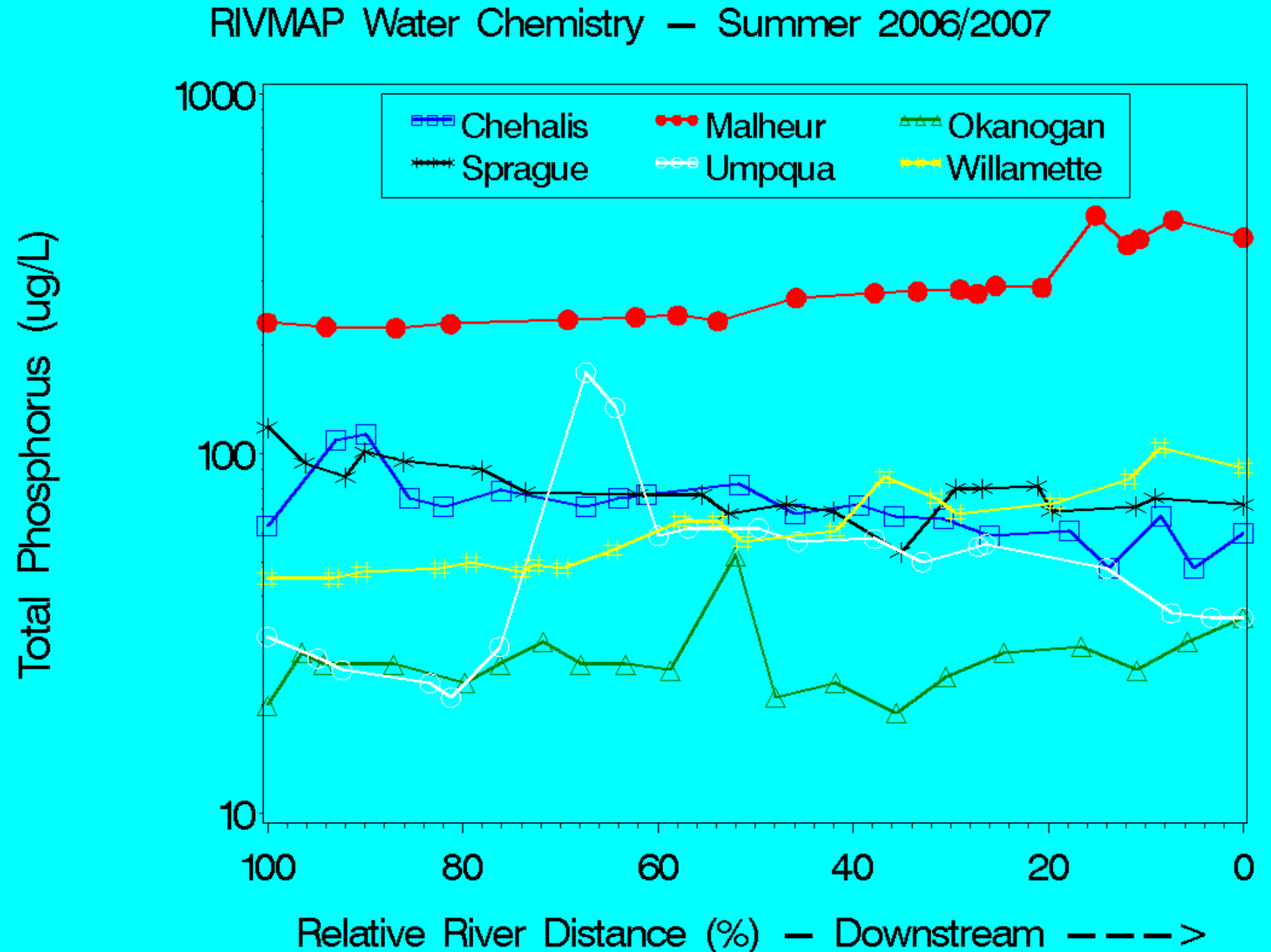
Water Chemistry
(1 grab sample @ last transect)

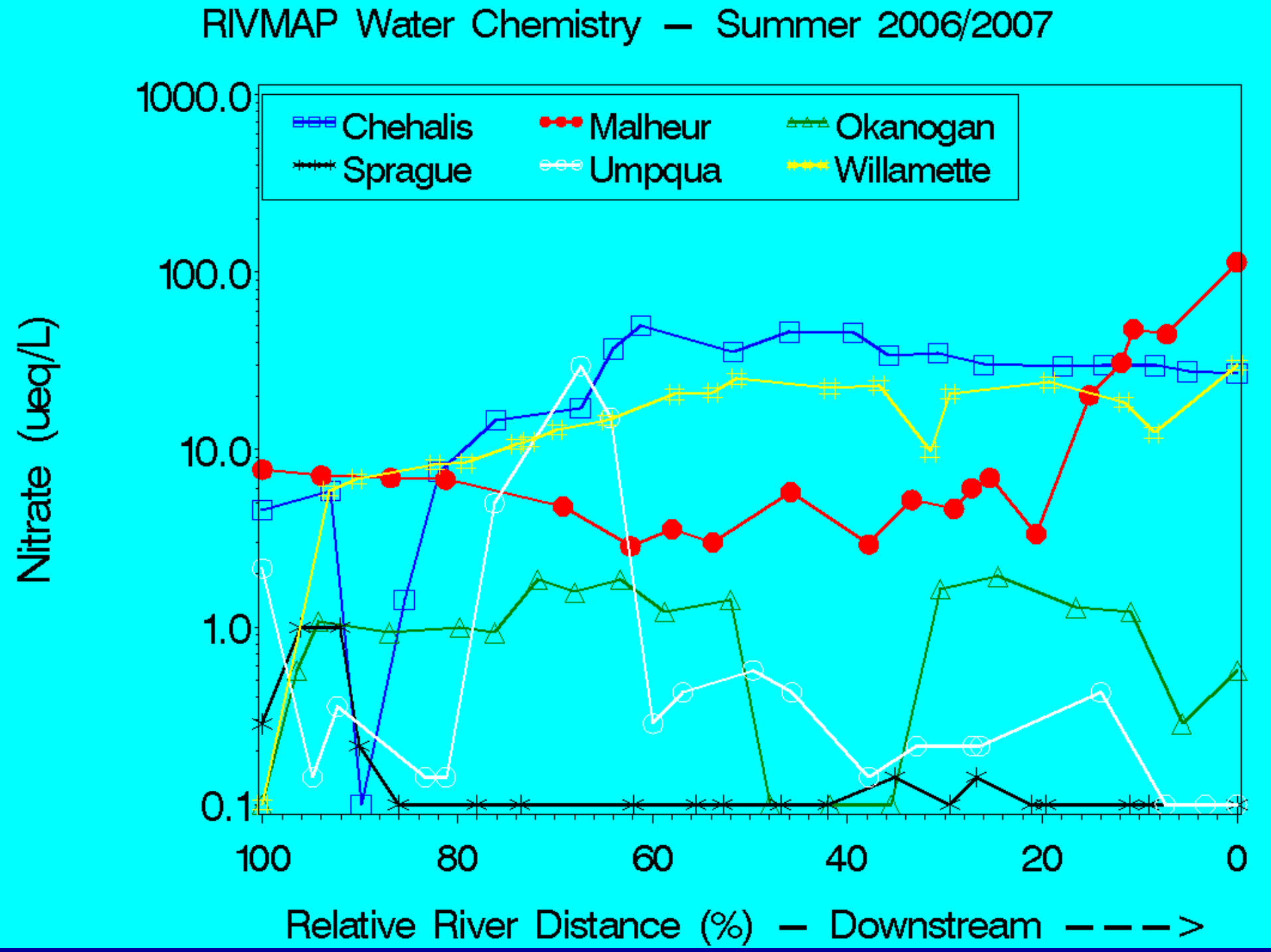



RIVMAP Water Chemistry — Summer 2006/2007
Chehalis
Malheur
Okanogan
Sprague
Umpqua
Willamette
Conductivity (uS)
600
500
400
300
200
100
0
100
80
60
40
20
0
Relative River Distance (%) — Downstream --->


RIVMAP Water Chemistry – Summer 2006/2007
Chehalis
Malheur
Okanogan
Sprague
Umpqua
Willamette
100.00
10.00
1.00
0.10
Turbidity (NTU)
100
80
60
40
20
0
Relative River Distance (%) – Downstream --->

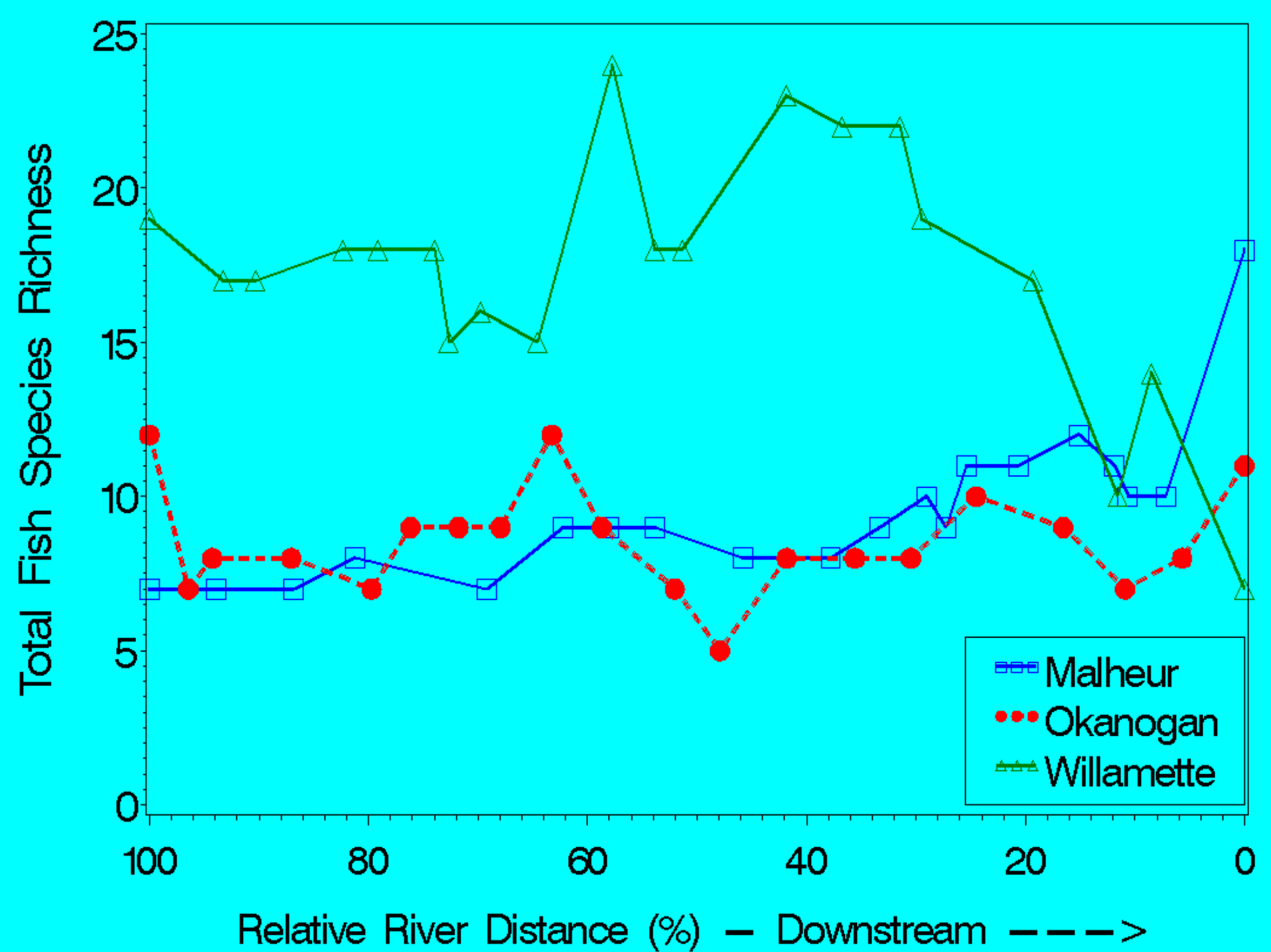

RIVMAP Water Chemistry — Summer 2006/2007
Chehalis
Malheur
Okanogan
Sprague
Umpqua
Willamette
1000.0
100.0
10.0
Chloride (ueq/L)
100
80
60
40
20
0
Relative River Distance (%) — Downstream --->

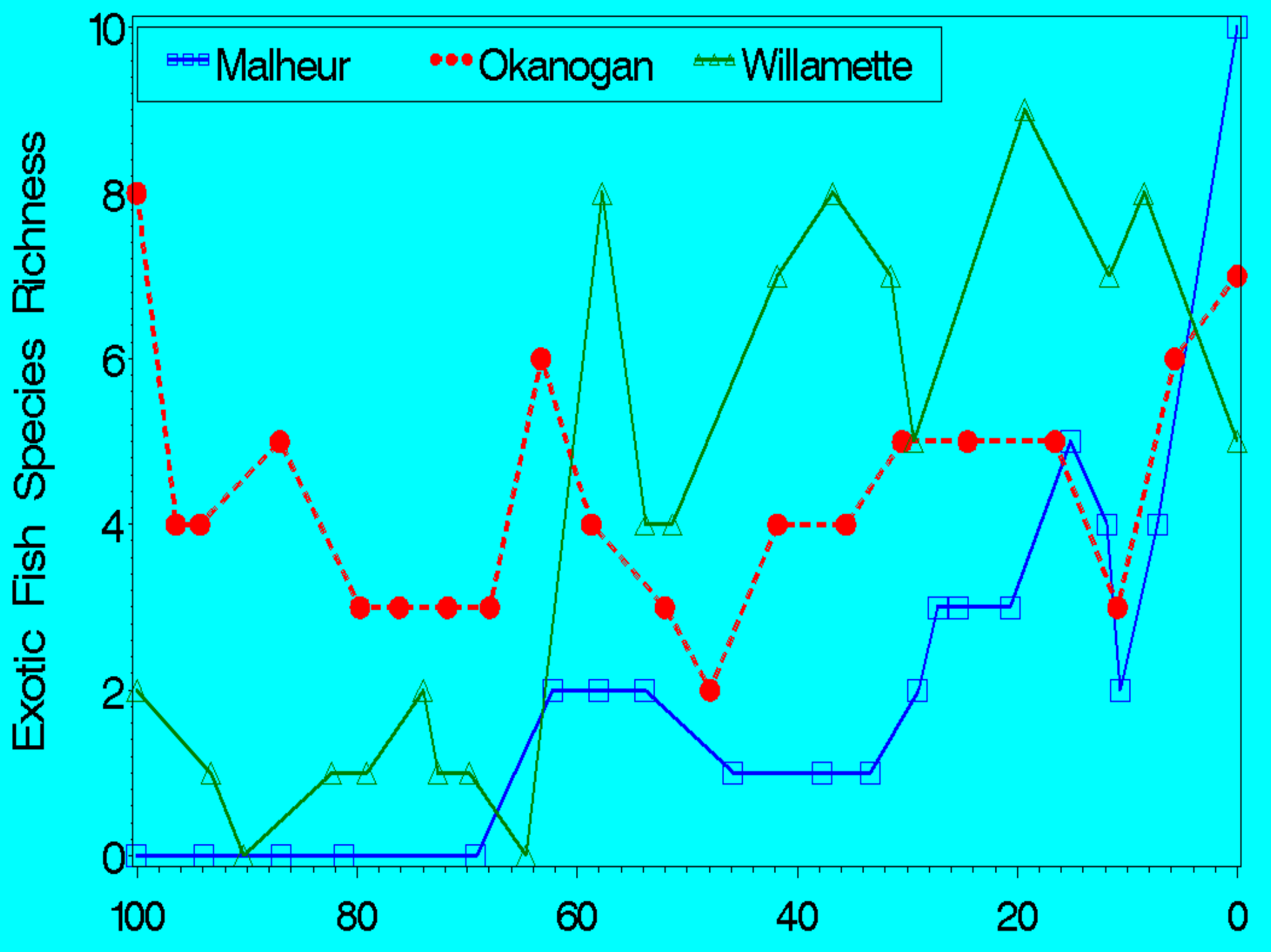

RIVMAP Water Chemistry — Summer 2006/2007
Chehalis
Malheur
Okanogan
Sprague
Umpqua
Willamette
1000
100
10
Total Phosphorus (ug/L)
100
80
60
40
20
0
Relative River Distance (%) — Downstream --->

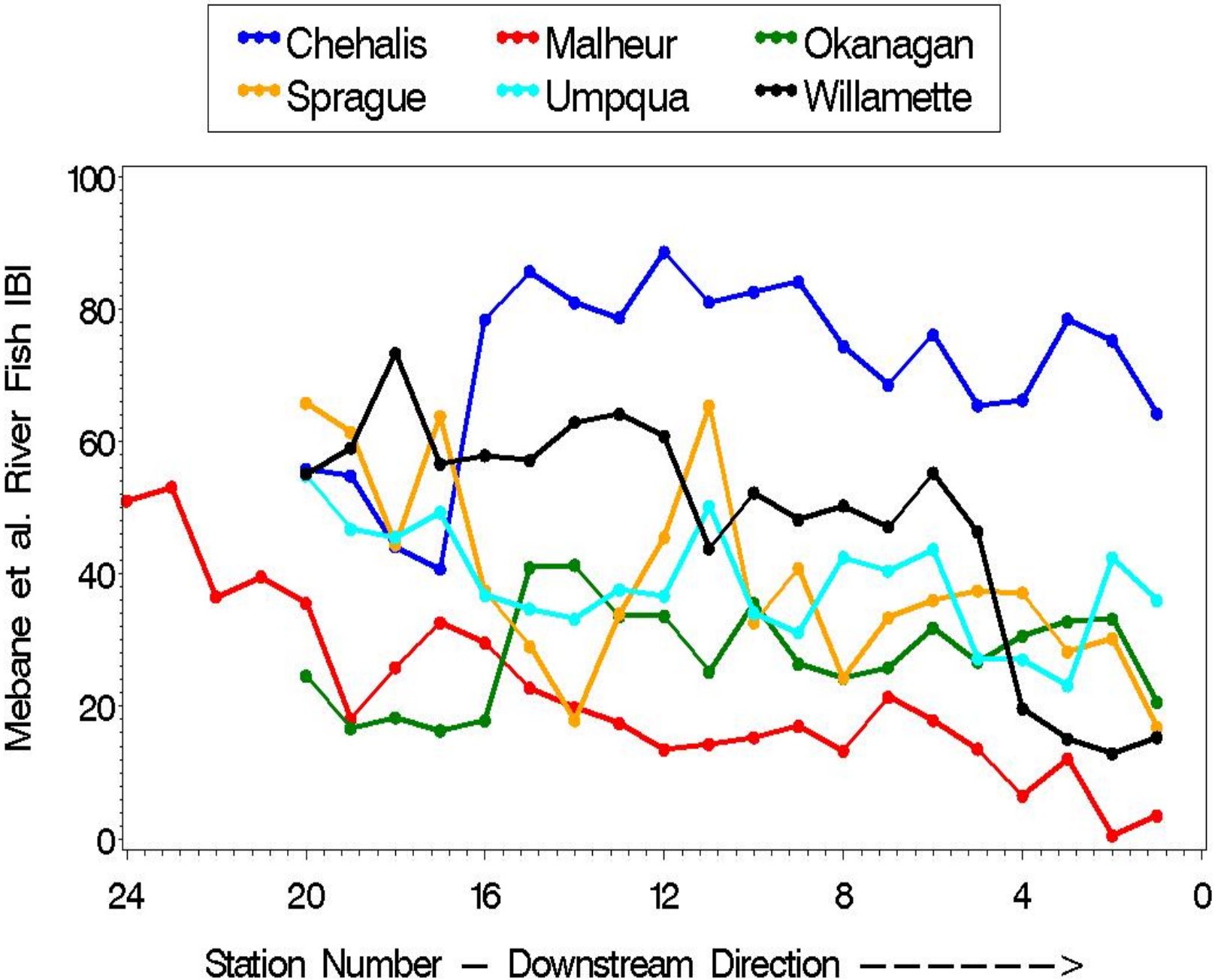

RIVMAP Water Chemistry – Summer 2006/2007
Chehalis
Malheur
Okanogan
Sprague
Umpqua
Willamette
1000.0
100.0
10.0
1.0
0.1
Nitrate (ueq/L)
100
80
60
40
20
0
Relative River Distance (%) – Downstream --->

Fish

Umpqua River Subreach


Total Fish Species Richness
25
20
15
10
5
0
100
80
60
40
20
0
Relative River Distance (%) — Downstream ——>
Malheur
Okanogan
Willamette


Malheur
Okanogan
Willamette
Exotic Fish Species Richness
10
8
6
4
2
0
100
80
60
40
20
0


Chehalis
Malheur
Okanagan
Sprague
Umpqua
Willamette
Mebane et al. River Fish IBI
100
80
60
40
20
0
24
20
16
12
8
4
0
Station Number — Downstream Direction ------->

Changes in Alien Fish Species Extent Since 1944 – Willamette

- LaVigne at al., in press. Northwest Sci.
- Range Expansions
  - Smallmouth Bass
  - Banded Killifish
  - Walleye
- Failed Introductions
  - Tench
  - Black Bullhead
  - White Catfish
  - Pacu

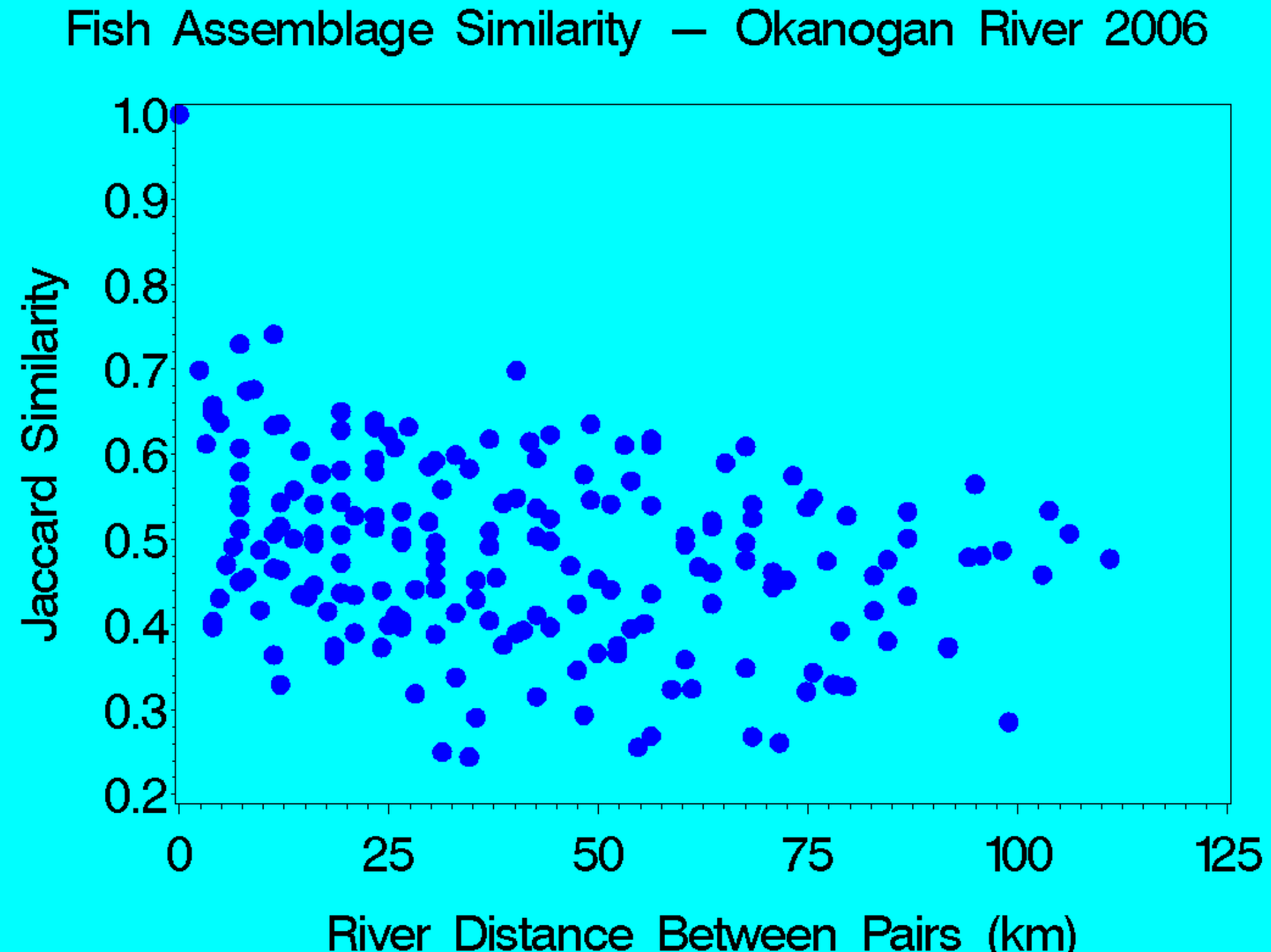
Willamette River Grass Carp

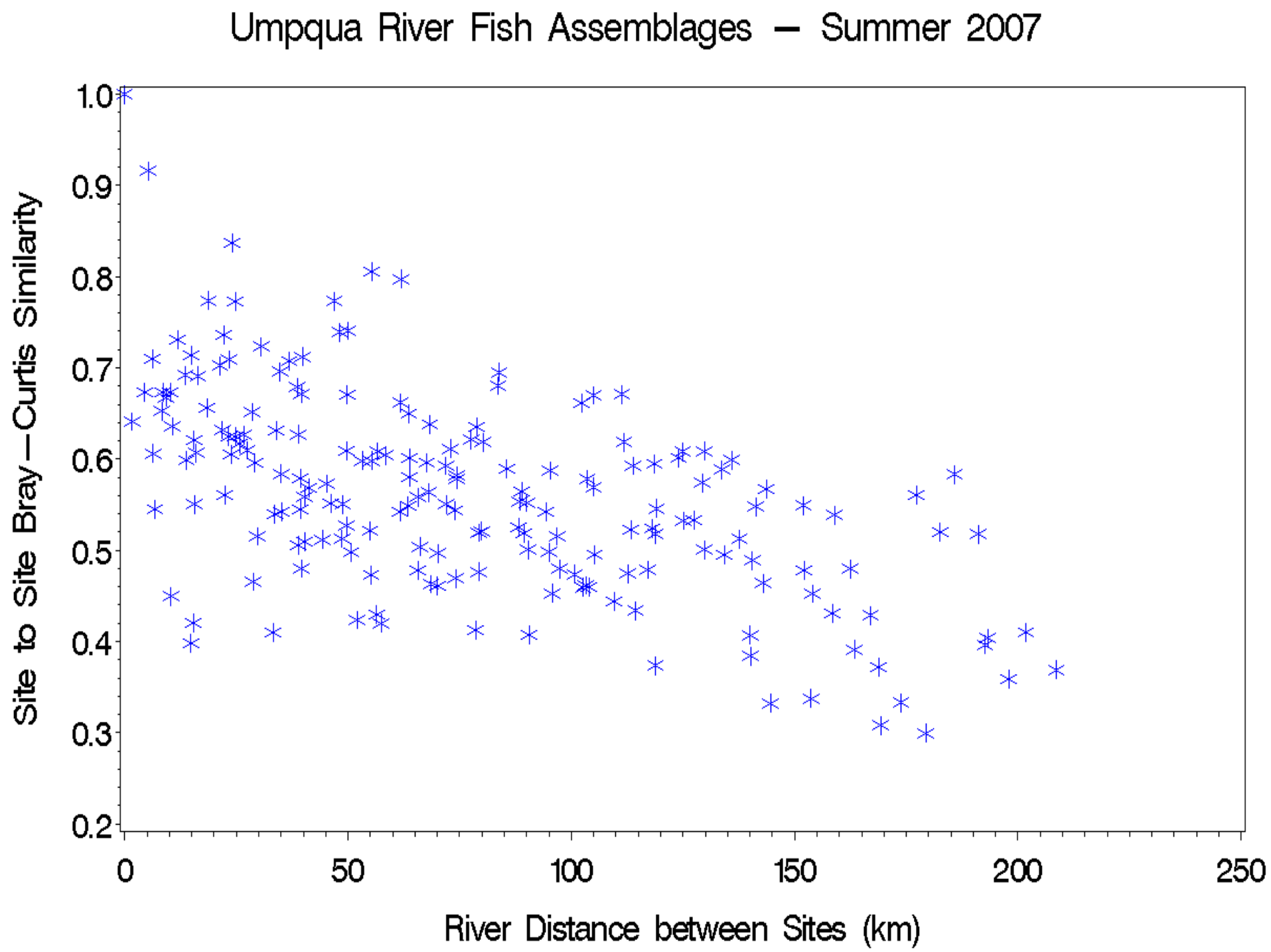
Malheur River

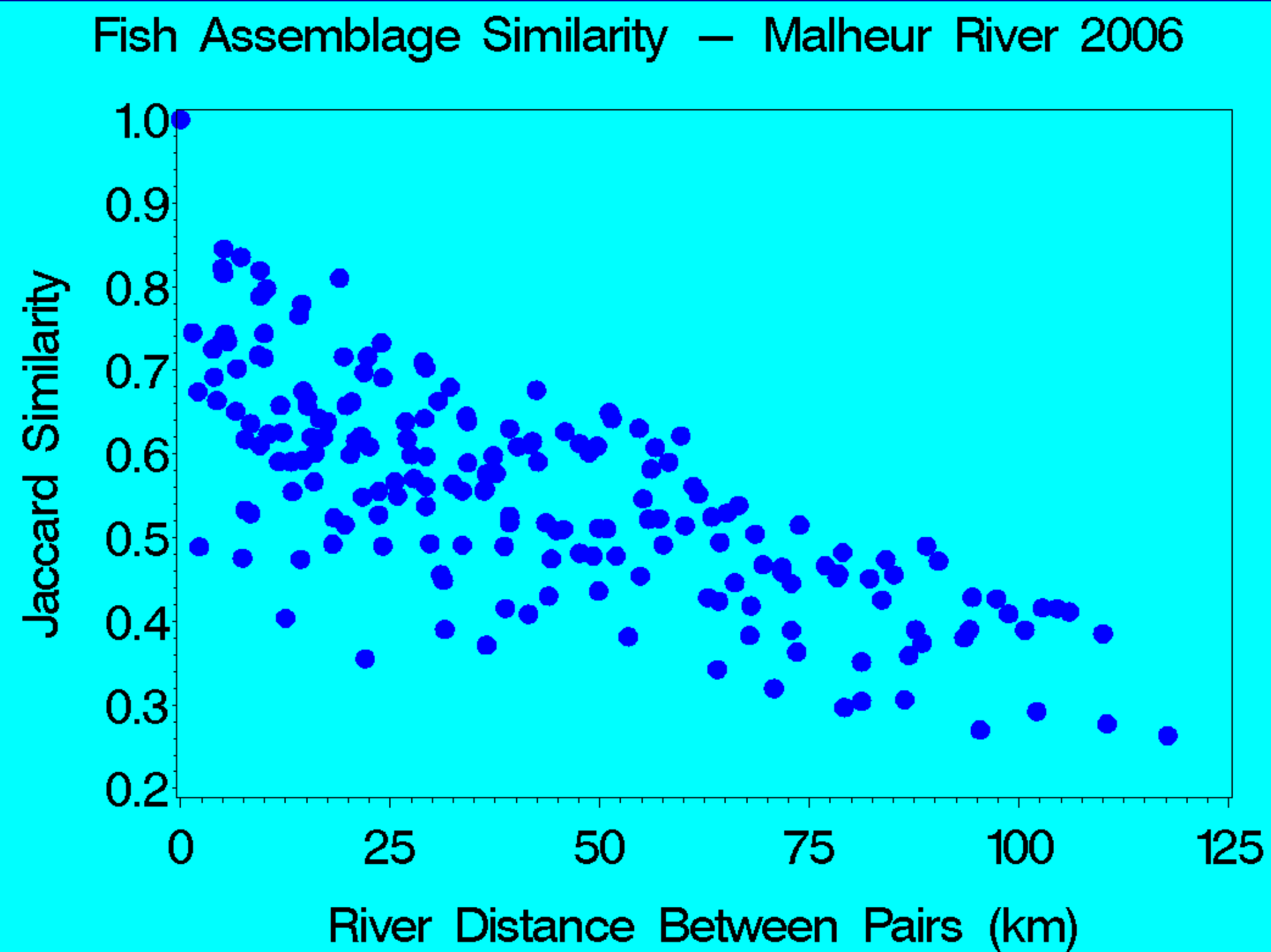
- Absence of Mountain Whitefish
- Presence of Endemic Mountain Sucker
- Presence of Alien
  - Tadpole Madtom
  - Black Bullhead
  - Flathead Catfish
  - Pumpkinseed
- Range Extensions
  - Largemouth Bass
  - Yellow Perch

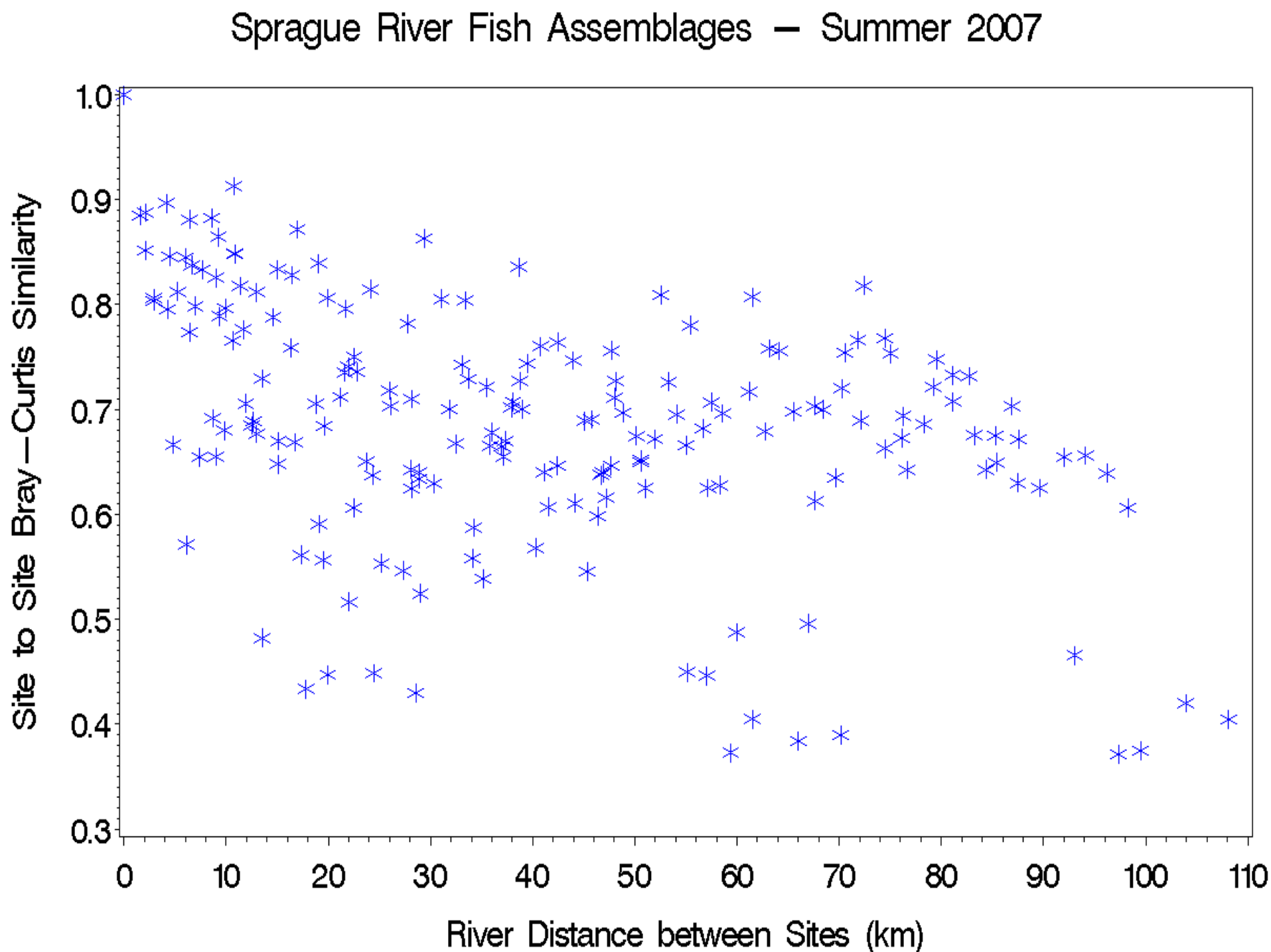
Among-Site Fish Assemblage Similarity by Distance

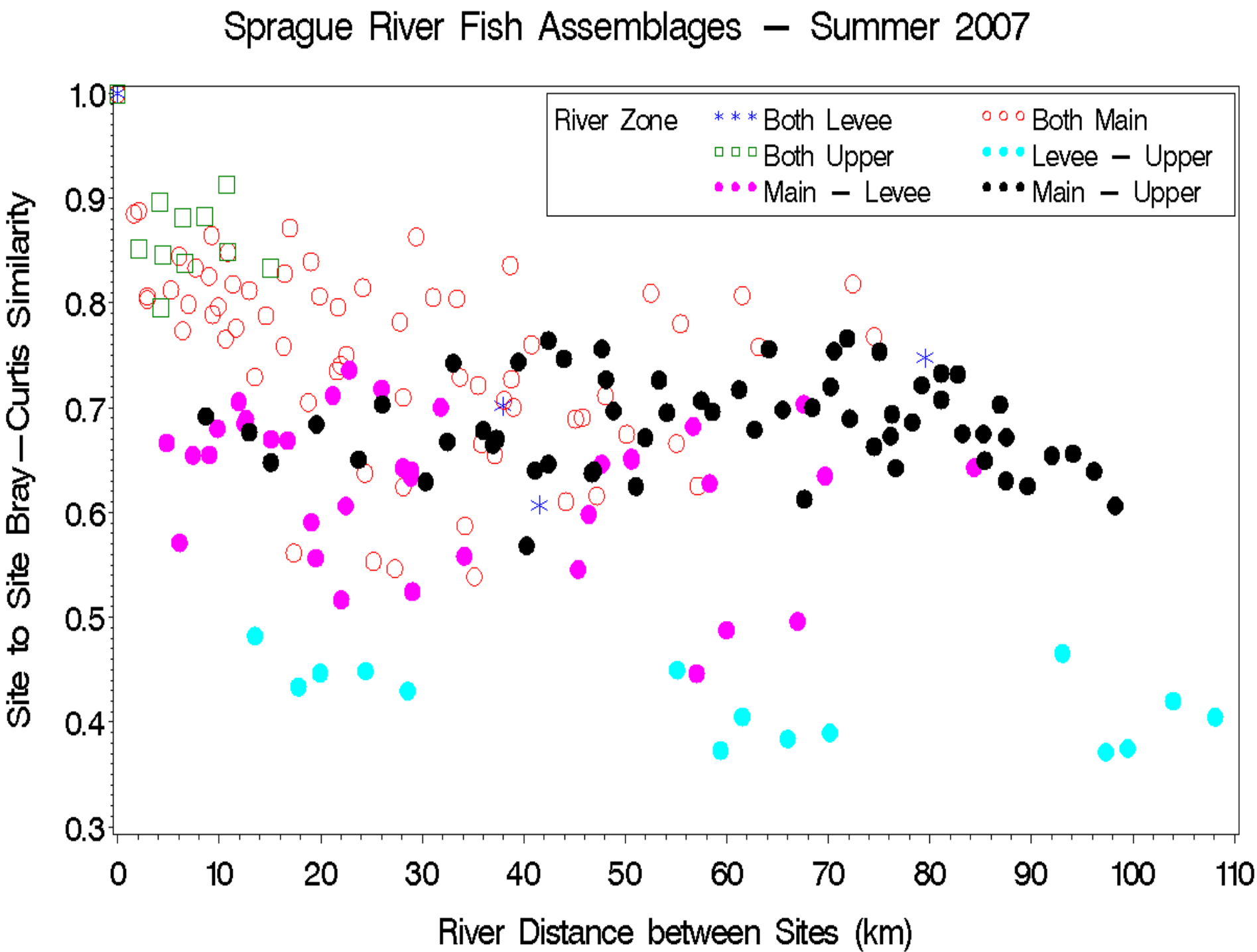
- For each river, calculated Jaccard similarity between all pairs of sites
- 190 pairs for 20 sites
- Calculated river distance between each pair

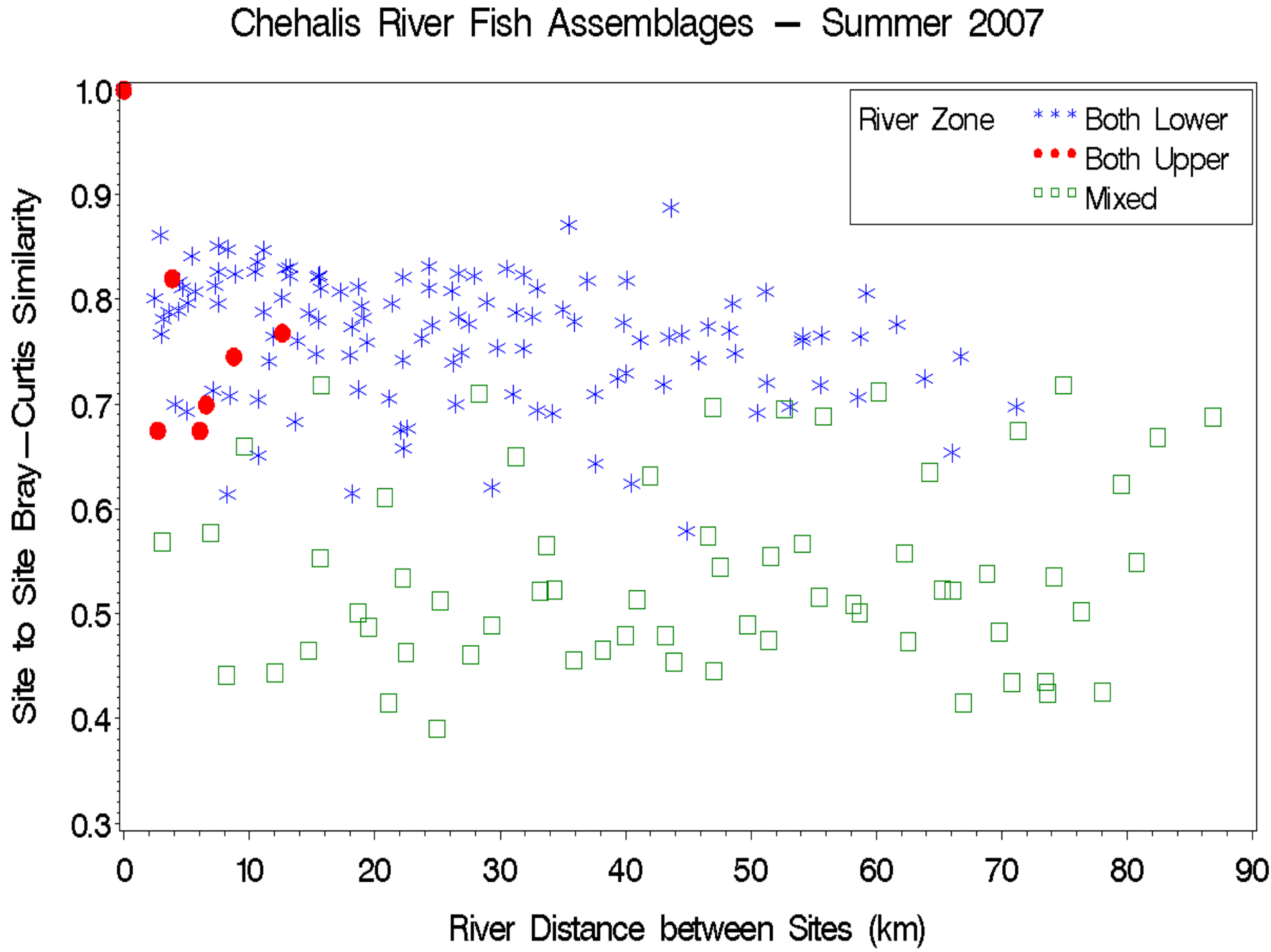

Fish Assemblage Similarity — Okanogan River 2006
Jaccard Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
25
50
75
100
125
River Distance Between Pairs (km)

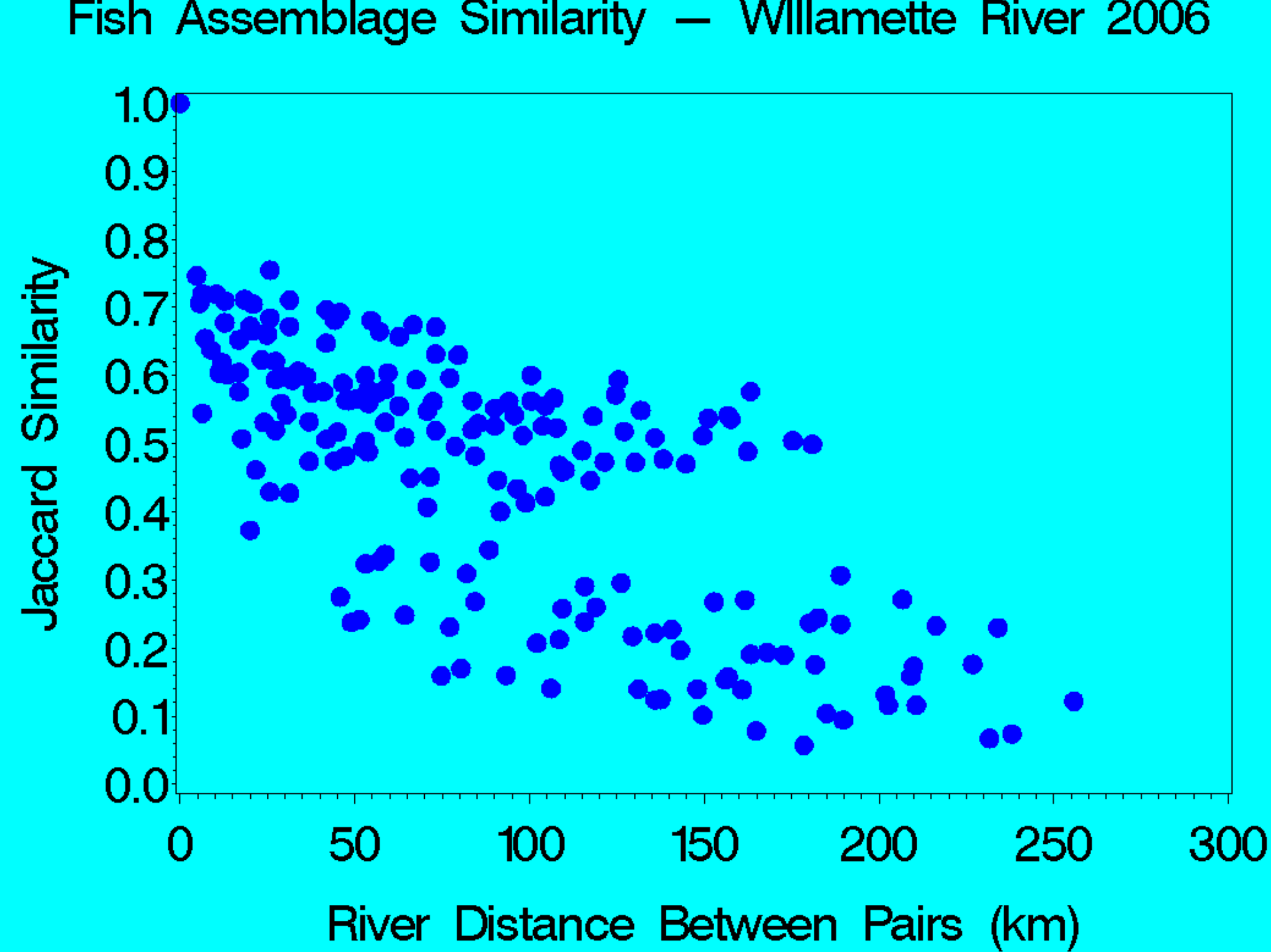

Umpqua River Fish Assemblages — Summer 2007
Site to Site Bray—Curtis Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
50
100
150
200
250
River Distance between Sites (km)

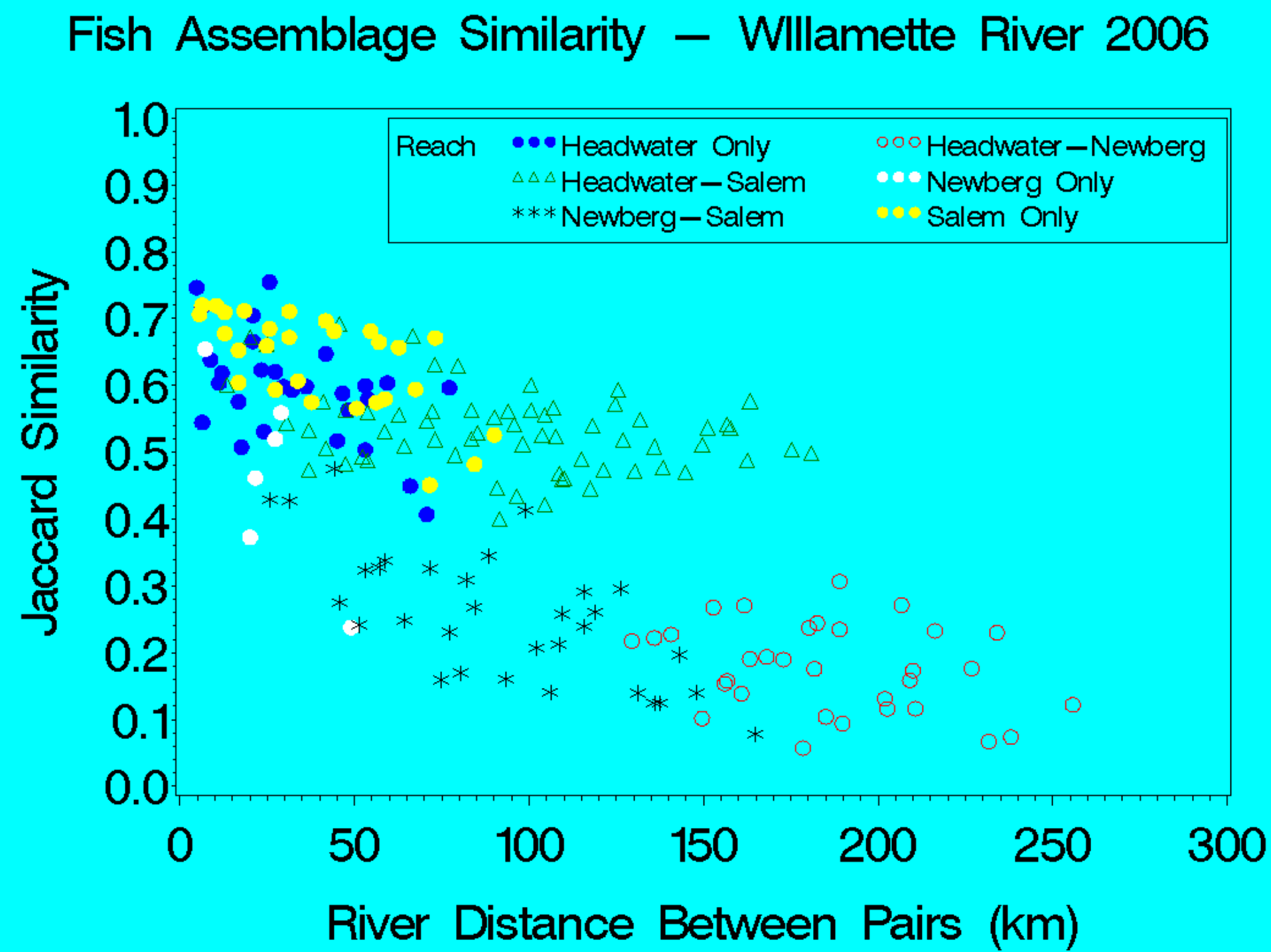

Fish Assemblage Similarity — Malheur River 2006
Jaccard Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
25
50
75
100
125
River Distance Between Pairs (km)


Sprague River Fish Assemblages — Summer 2007
Site to Site Bray—Curtis Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50
60
70
80
90
100
110
River Distance between Sites (km)


Sprague River Fish Assemblages – Summer 2007
River Zone
Both Levee
Both Main
Both Upper
Levee – Upper
Main – Levee
Main – Upper
Site to Site Bray–Curtis Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50
60
70
80
90
100
110
River Distance between Sites (km)


Chehalis River Fish Assemblages — Summer 2007
River Zone
Both Lower
Both Upper
Mixed
Site to Site Bray—Curtis Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
10
20
30
40
50
60
70
80
90
River Distance between Sites (km)


Fish Assemblage Similarity — Willamette River 2006
Jaccard 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)


Fish Assemblage Similarity — Willamette River 2006
Reach
Headwater Only
Headwater—Newberg
Headwater—Salem
Newberg Only
Newberg—Salem
Salem Only
Jaccard 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)

Summary

- Little longitudinal change in chemical and physical habitat in most rivers
- Surveys provide useful information documenting species extent
- Spatial patterns in fish assemblages differ among the six study rivers