Multiple Spatial Scale Fisheries Research on the Missouri River

Multiple Spatial Scale Fisheries Research on the Missouri River

Objectives:

- Review principles of scale in ecological assessments
- Illustrate using Missouri River benthic fishes study

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Ecological Assessments need to be Scale Dependent

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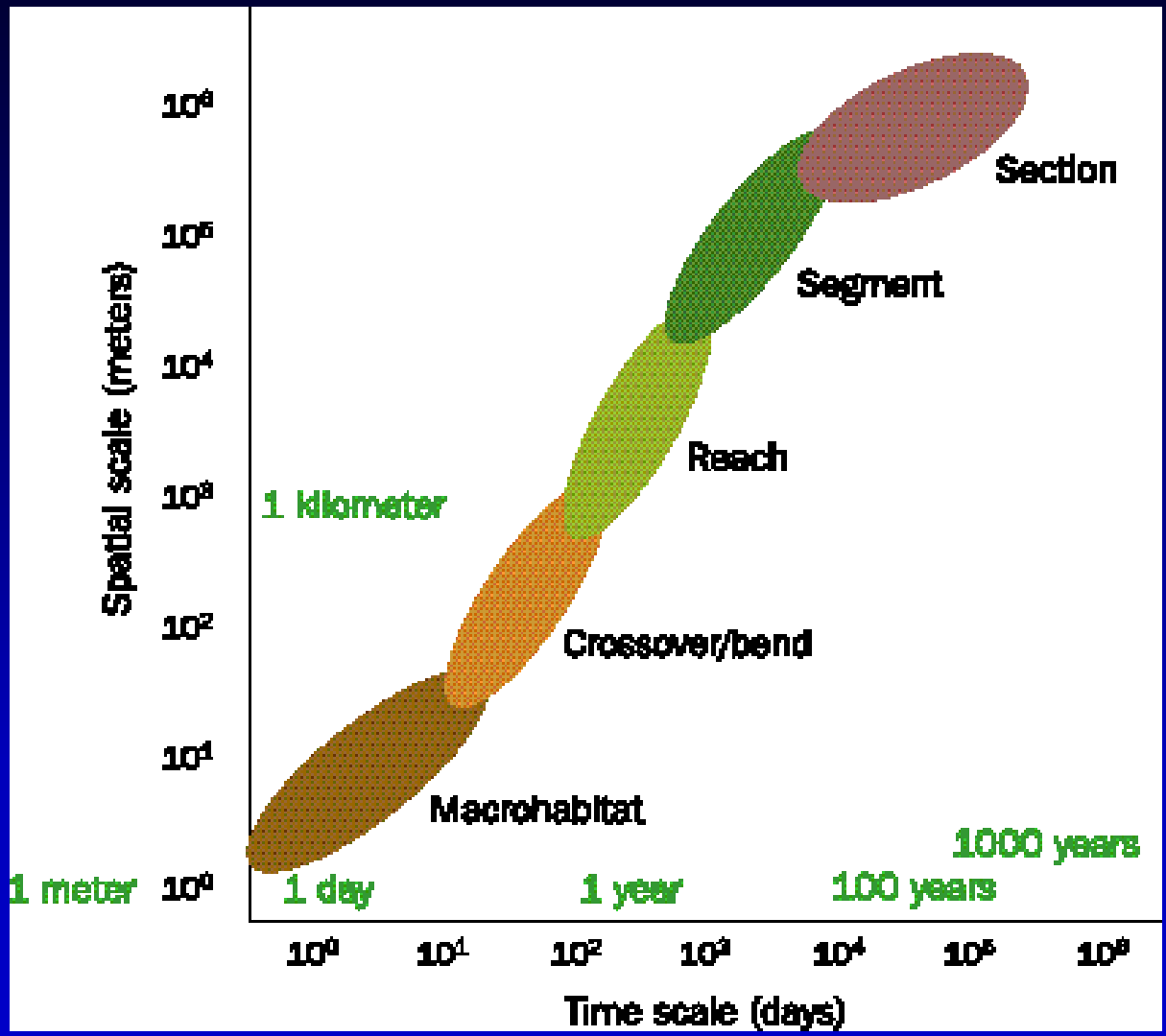
Spatial-temporal Scales



Source:
M. Laustrup

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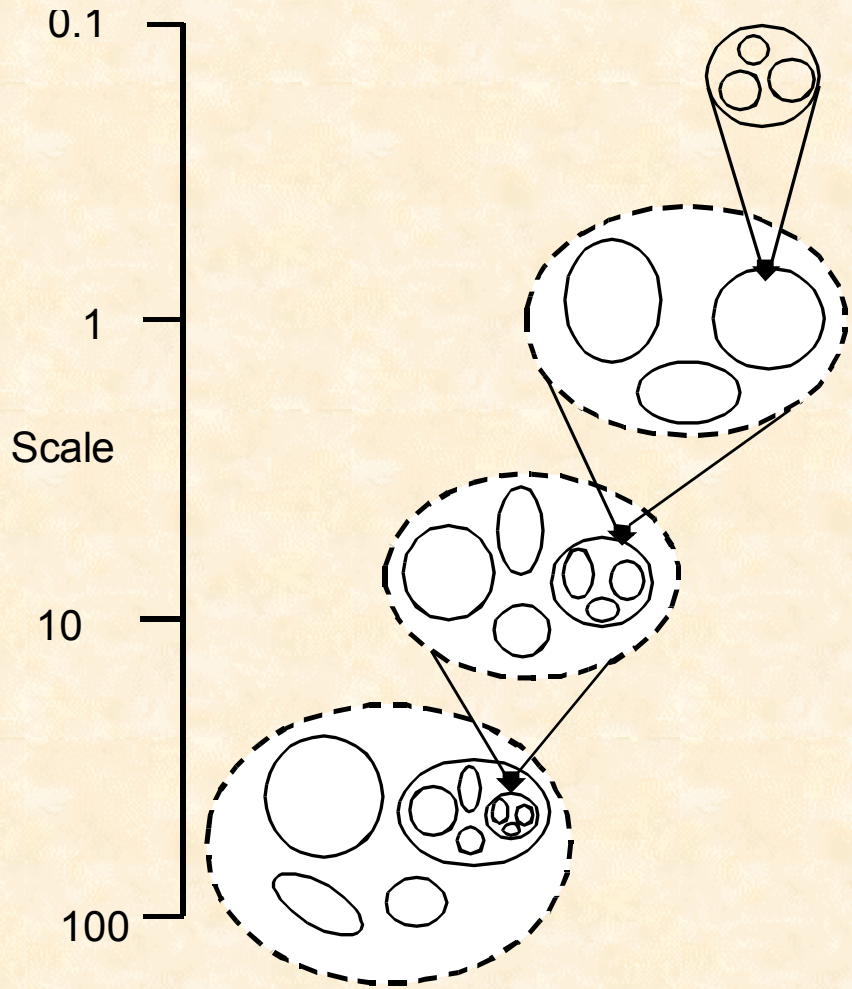
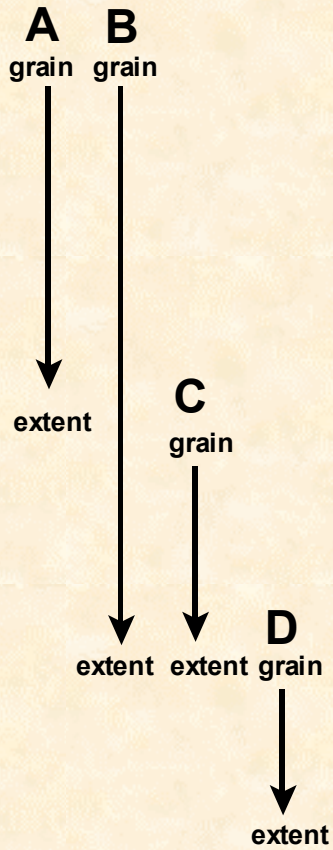
Ecological Grain & Extent



Patch Structure



Ranges of Grain -Extent

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Spatial
Scales of Ecological Assessments

Local Regional Basin

USGS

Spatial, Temporal Scales of Ecological Assessments

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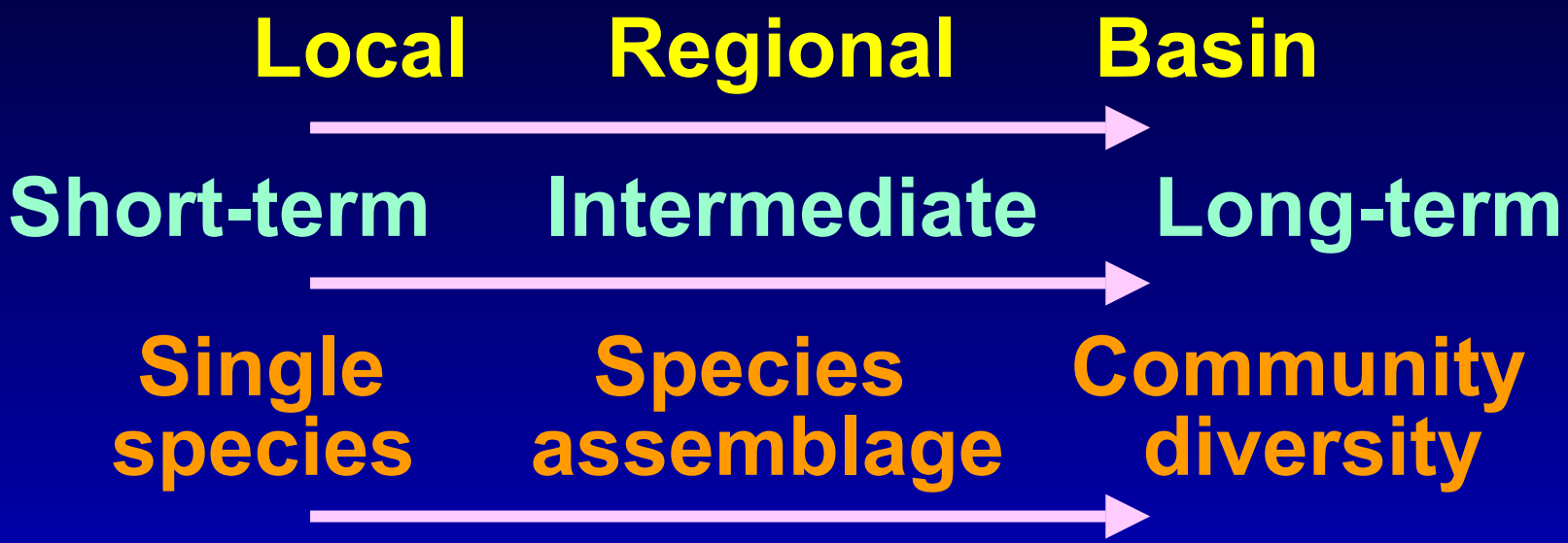
Spatial, Temporal & Taxonomic Scales of Ecological Assessments



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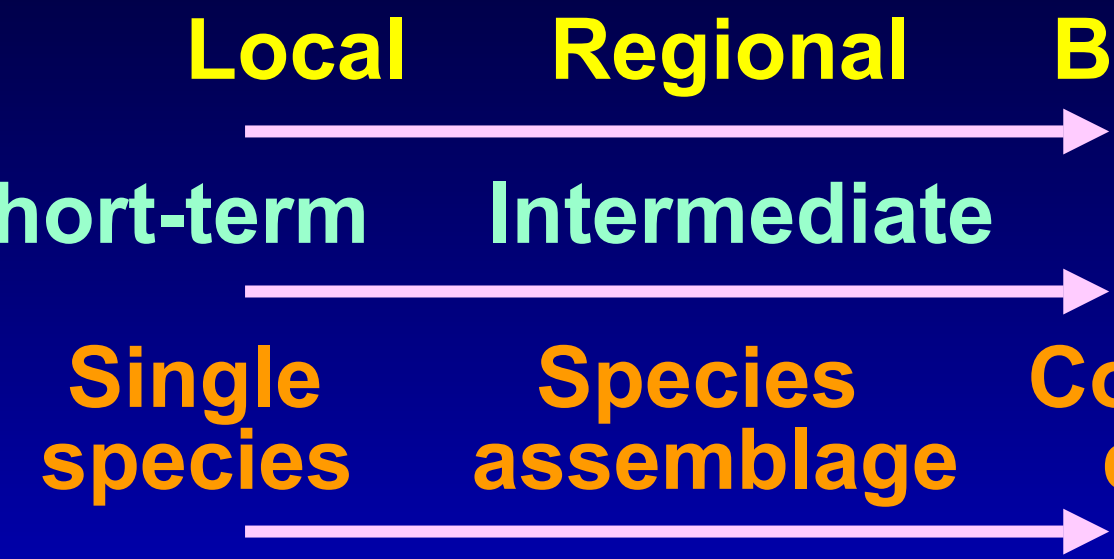
Spatial, Temporal & Taxonomic Scales of Ecological Assessments



Increasing

- Funding
- Coordination
- Constraints
- Administrative commitment

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Biotic Hierarchy & Common Metrics to Ecological Assessments

Taxonomic Hierarchy

	Individual
Examples of Metrics	Identity Health Growth Fecundity Movement

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Biotic Hierarchy & Common Metrics to Ecological Assessments

	Taxonomic Hierarchy	
	Individual	Population/ Meta-population
Examples of Metrics	Identity Health Growth Fecundity Movement	Recruitment Habitat occupation Age structure Tolerance/ intolerance Genetic diversity

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Biotic Hierarchy & Common Metrics to Ecological Assessments

	Taxonomic Hierarchy		
	Individual	Population/ Meta-population	Species
Examples of Metrics	Identity Health Growth Fecundity Movement	Recruitment Habitat occupation Age structure Tolerance/ intolerance Genetic diversity	Relative abundance Richness/ diversity Trophic status Tolerance/ intolerance

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Biotic Hierarchy & Common Metrics to Ecological Assessments

	Taxonomic Hierarchy			
	Individual	Population/ Meta-population	Species	Guild/ Assemblage
Examples of Metrics	Identity Health Growth Fecundity Movement	Recruitment Habitat occupation Age structure Tolerance/ intolerance Genetic diversity	Relative abundance Richness/ diversity Trophic status Tolerance/ intolerance	Presence/ absence Number of guilds Composition Relative abundance

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Missouri River

A Global 'Great River'

Basin

- 1/6 US Area
- 4 Physiographic Provinces
- 10 states, 2 Canadian Provinces, 25 Native American Reservations

River

- Longest river in NA
- 7 States
- 10^{o} Latitude
- 1,000 m Altitude
- Largest volume & area reservoir system in US
- 10.2 M Mwh/yr power 750 M$/yr
- >1,600 Water intakes

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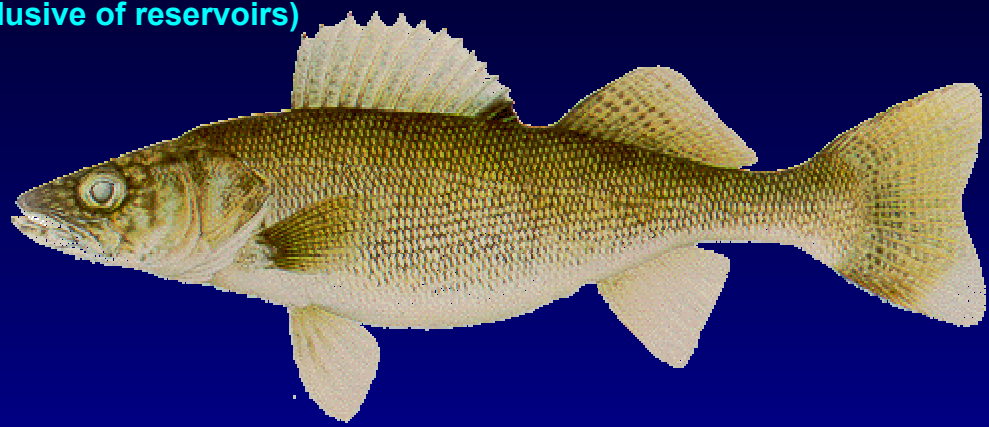
Missouri River Benthic Fishes Study

Evaluate population structure and habitat use of bottom-dwelling fishes along the main-stem, warm-water Missouri and lower Yellowstone rivers (exclusive of reservoirs)



- **Benthic Fishes**
  - Describe & evaluate composition, relative abundance, distribution, recruitment, growth, mortality, size structure, & body condition
- **Habitat**
  - Characterize physical variables in dominate habitats where fishes are collected
- **Habitat Use**
  - Describe use of dominant habitats by benthic fishes

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Missouri River Benthic Fishes Consortium

Cooperative Research Units at:

Montana State University

University of Idaho

South Dakota State University

Iowa State University

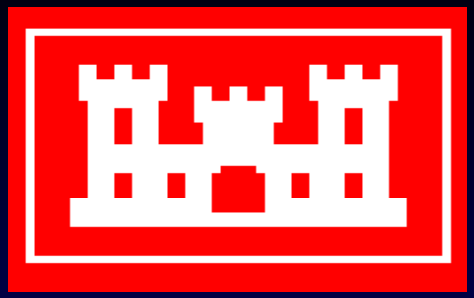
Kansas State University

University of Missouri

Montana Department of Fish, Wildlife and Parks

USGS, Columbia Environmental Research Center

USGS



U. S. Army Corps
of Engineers

Funding Provided By:

U. S. Army Corps of Engineers - Missouri River District

Biological Resources Division, U. S. Geological Survey

U. S. Bureau of Reclamation

U.S. Environmental Protection Agency

U.S. Fish and Wildlife Service

North Dakota, Iowa, Kansas, Missouri

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Spatial Scales

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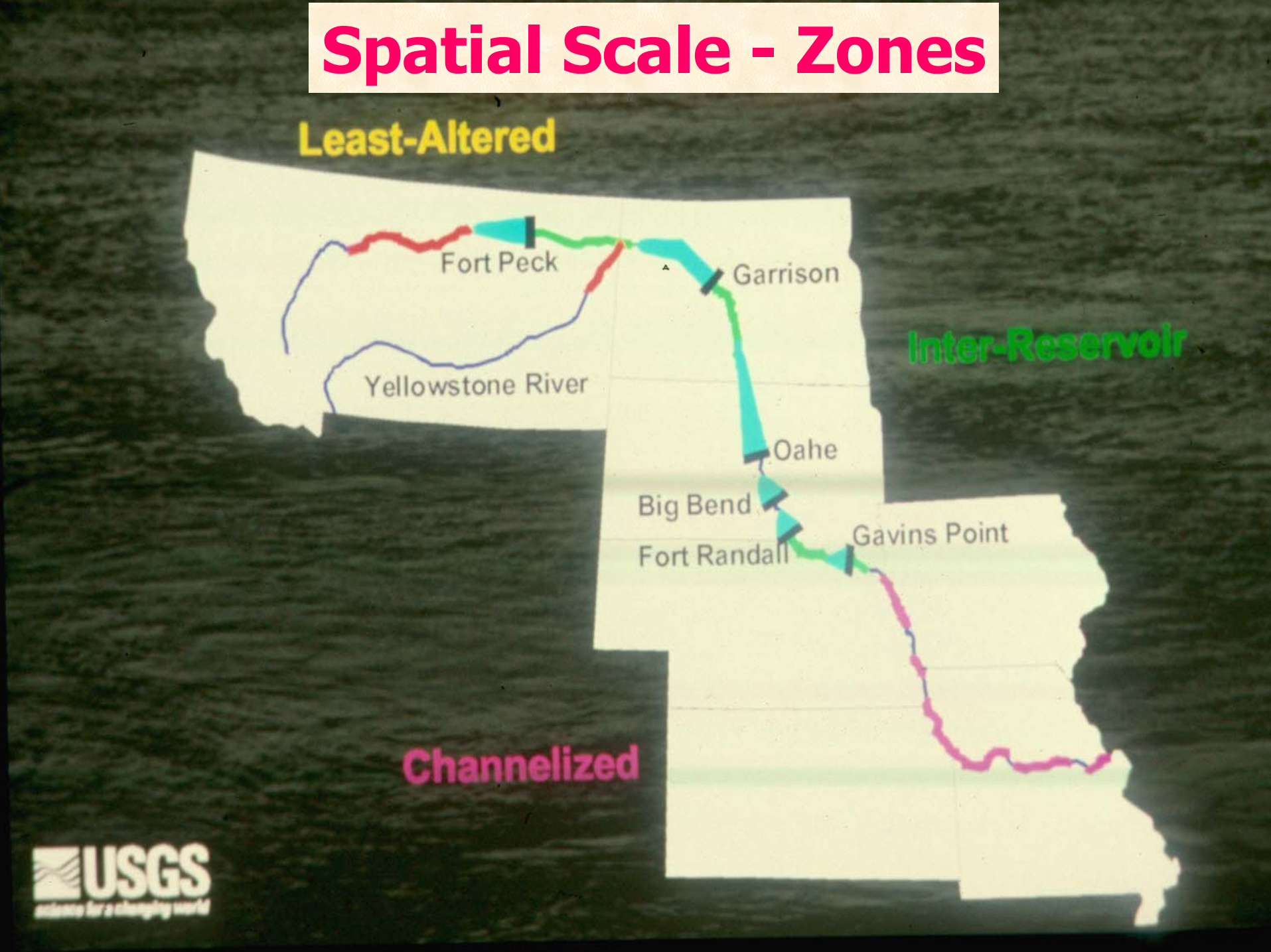
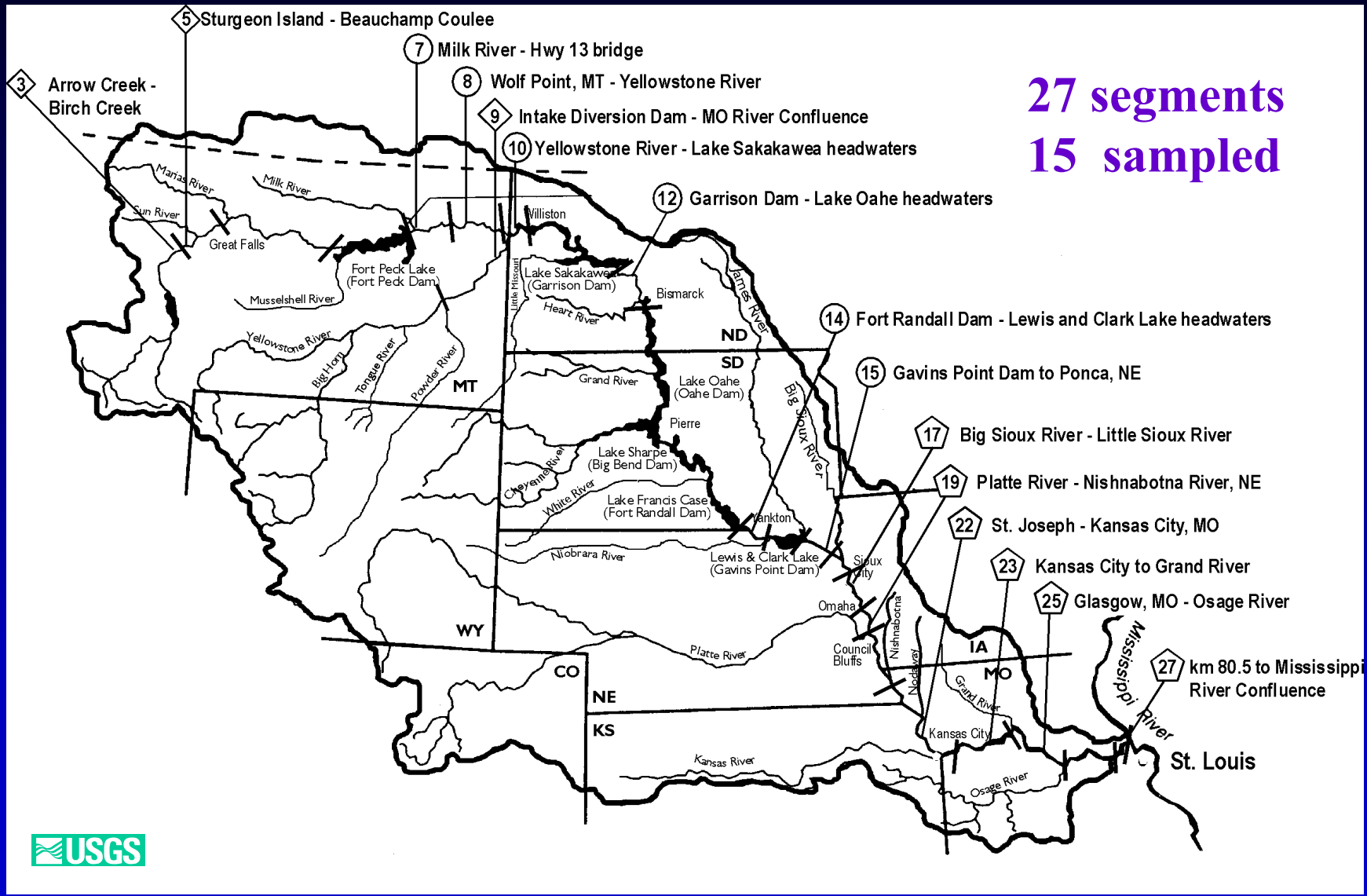
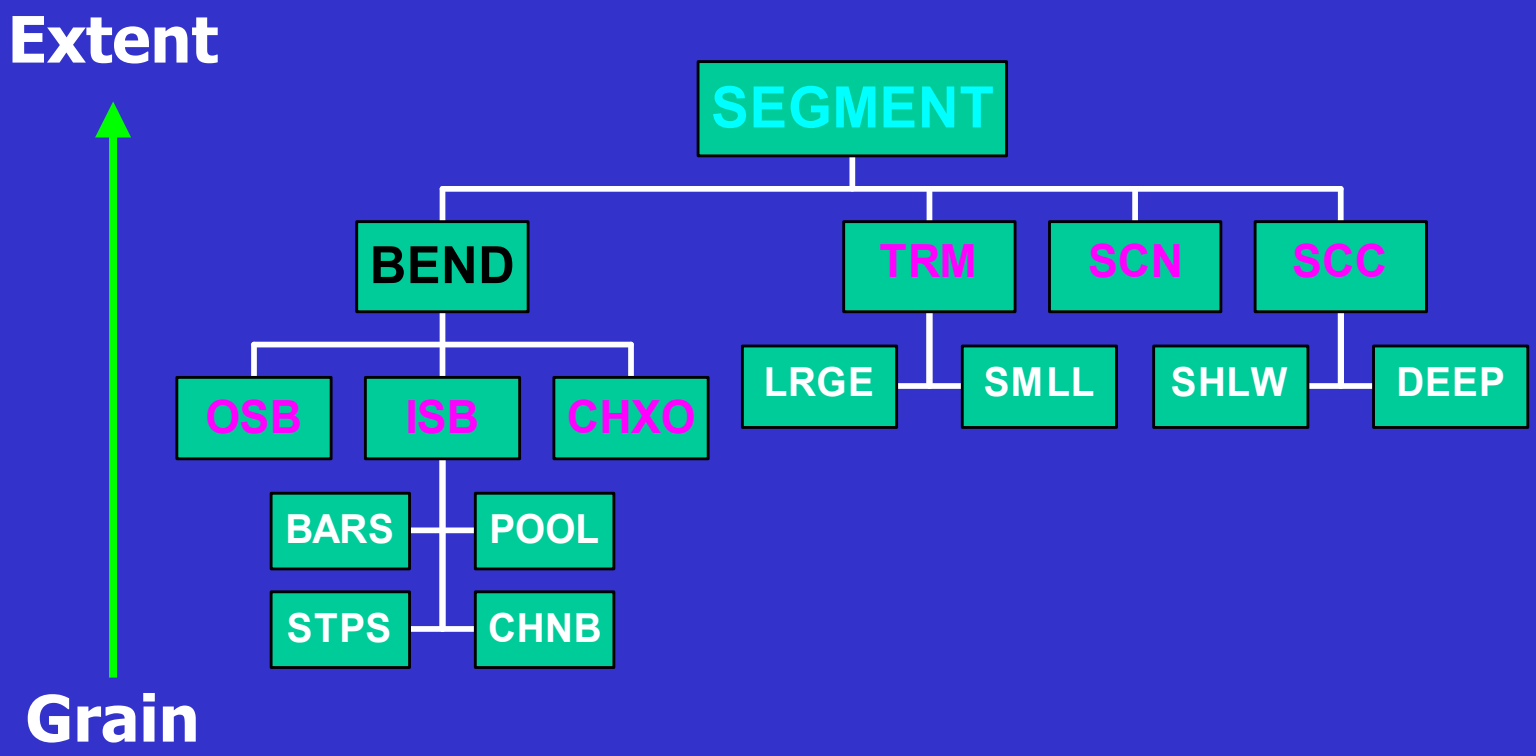
Spatial Scale - Zones



Spatial Scale - Segments



Spatial sampling hierarchy for each segment within 3 zones; 6 macrohabitats per segment, 3 within each BEND. Mesohabitats were sampled within complex macrohabitats.



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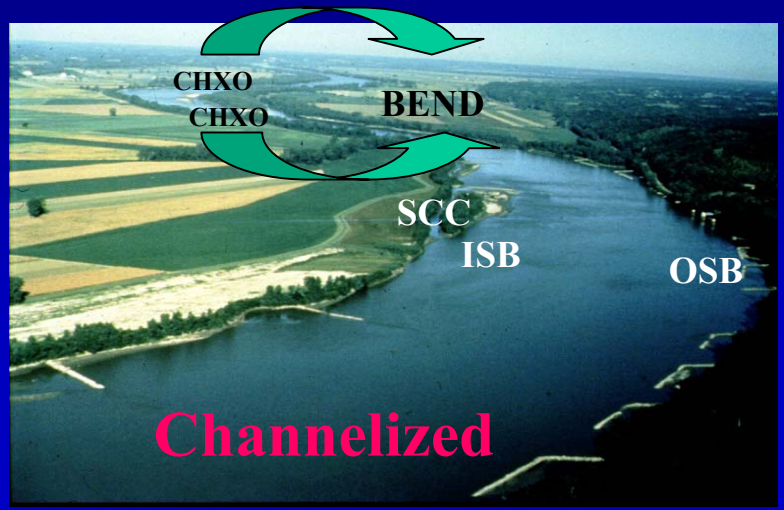
Macrohabitats within Zones



BEND = river bend
CHXO = channel cross-over
ISB = inside bend
OSB = outside bend
SCC = secondary channel not-connected
SCN = secondary channel connected
TRM = tributary mouth

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Temporal Scale

Objective:

Reduce temporal variability by sampling over relatively short time.

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Temporal Scale

July - October, 1996-1998

- River Flow Low and Stable
- Most Macrohabitats Present
- Fishes Active
- Age-0 Fishes Recruited to Gear

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Define Hierarchy of Scales Based on Goals & Objectives of Assessment

Missouri River Benthic Fishes Study

Evaluate population structure and habitat use of bottom-dwelling fishes along the main-stem, warm-water Missouri and lower Yellowstone rivers, exclusive of reservoirs

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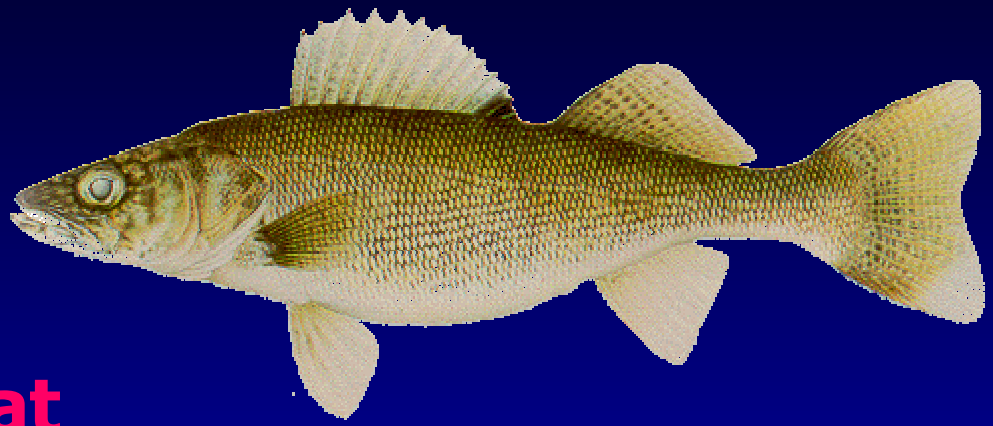
Missouri River Benthic Fishes Study



- **Habitat**
  - Characterize physical variables in dominate habitats where fishes are collected

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Statistical Analyses

3- Way ANOVA:

Year, Segment, Macrohabitat, Interactions

Zone, Segment, Macrohabitat, BEND contrasts

Variance Decomposition

Multivariate Ordination:

Principal Components Analysis (PCA)

Cluster Analysis

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Variance Decomposition

Identify which spatial scales most important in explaining overall variance in physical variables.

Proportion of total model sum-of-squares contributed by Type III partial sum-of-squares for each main effect and interaction

Ecological significance:
≥10% of total model variance for main effects
≥ 2% for planned contrasts

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Variance decomposition with main effects of year, segment, and macrohabitat (BEND, SCC, SCN, TRM) summarized as percent of total sum of squares for physical habitat variables. Effects contributing ≥10.0% of total variance are in bold.

Physical habitat variable	Year	Segment	Macrohabitat
Depth	0.3	4.7	**33.5**
Velocity (m/s)	<0.1	2.4	**50.2**
Temperature (C)	1.2	**44.6**	0.3
Turbidity (NTU)	1.3	**29.3**	0.8
Conductivity (uS/cm)	0.1	**25.3**	0.9
Gravel (%)	<0.1	**10.7**	**11.9**
Sand (%)	0.2	4.8	**35.2**
Silt (%)	0.1	2.0	**41.5**
Geometric mean	0.0	1.9	**42.9**

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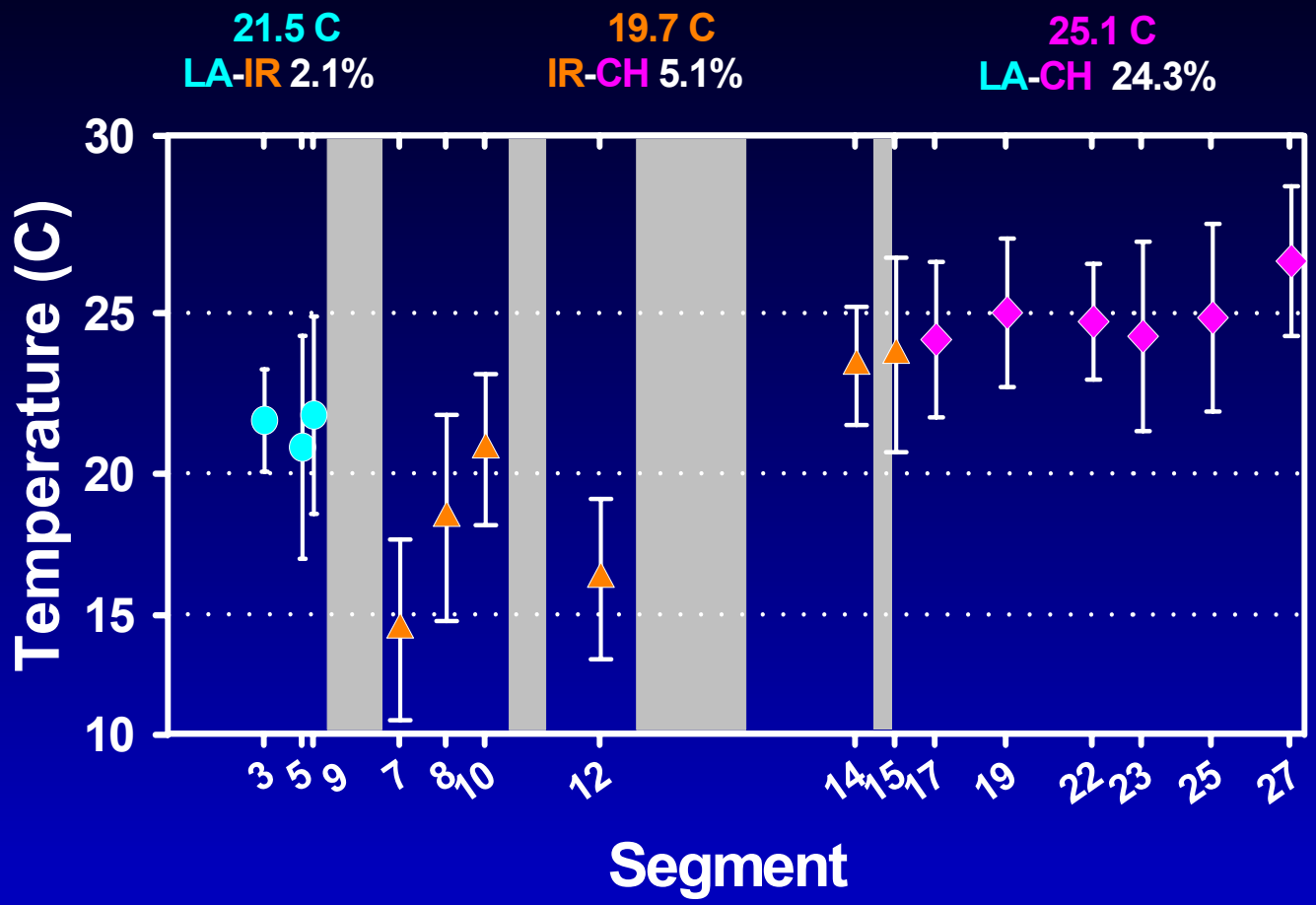
Segment Scale - Temperature



Mean (± SD) water temperature of macrohabitats combined at segments of Missouri and lower Yellowstone rivers, 1996-1998. Least-altered (LA), inter-reservoir (IR), reservoirs, channelized (CH).

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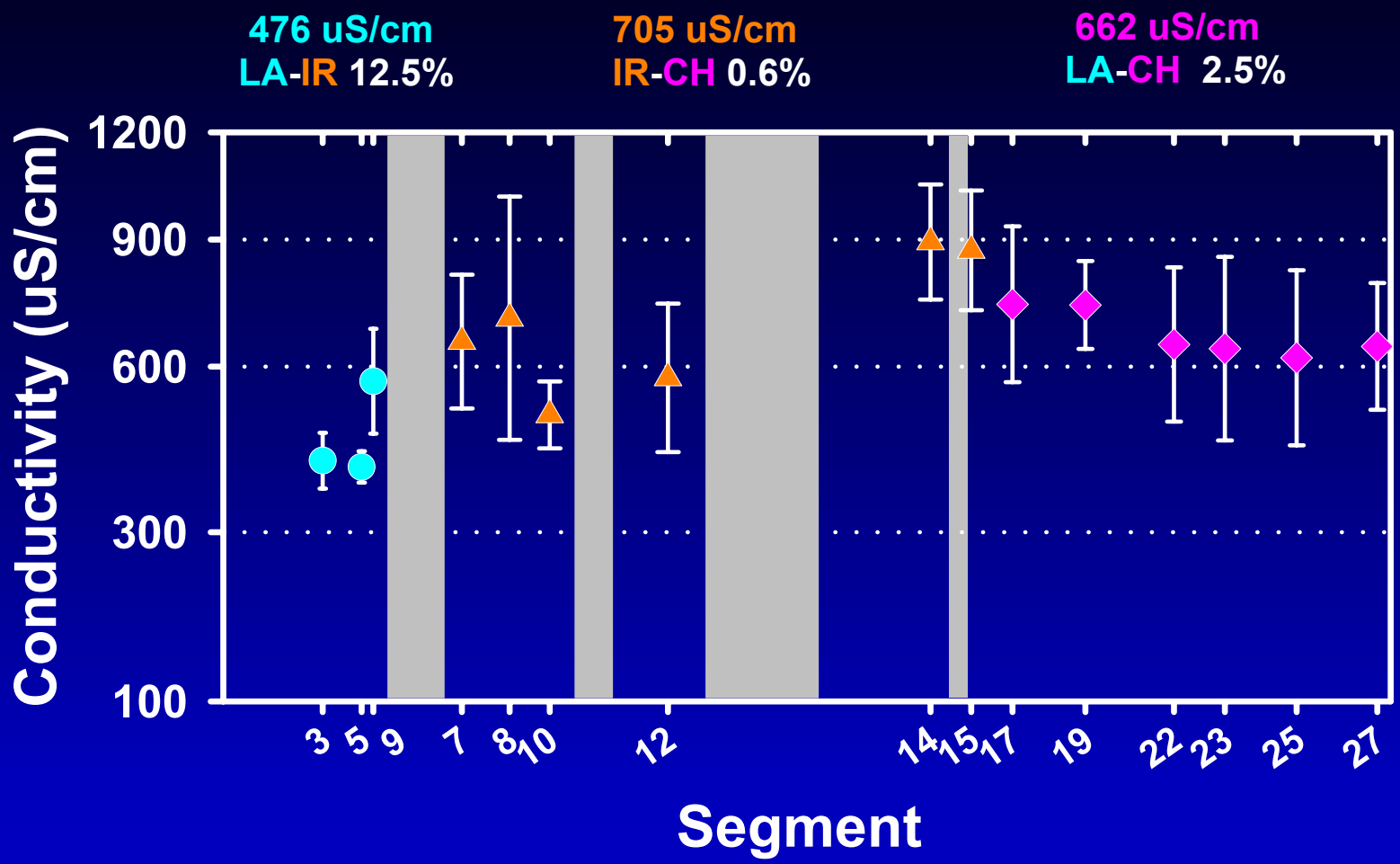
COND_MEAN_SLD

Segment Scale - Conductivity



Mean (± SD) conductivity of macrohabitats combined at segments of Missouri and lower Yellowstone rivers, 1996-1998. Least-altered (LA), inter-reservoir (IR), reservoirs, channelized (CH).

USGS

Variance decomposition with main effects of year, segment, and macrohabitat (BEND, SCC, SCN, TRM) summarized as percent of total sum of squares for physical habitat variables. Effects contributing ≥10.0% of total variance are in bold.

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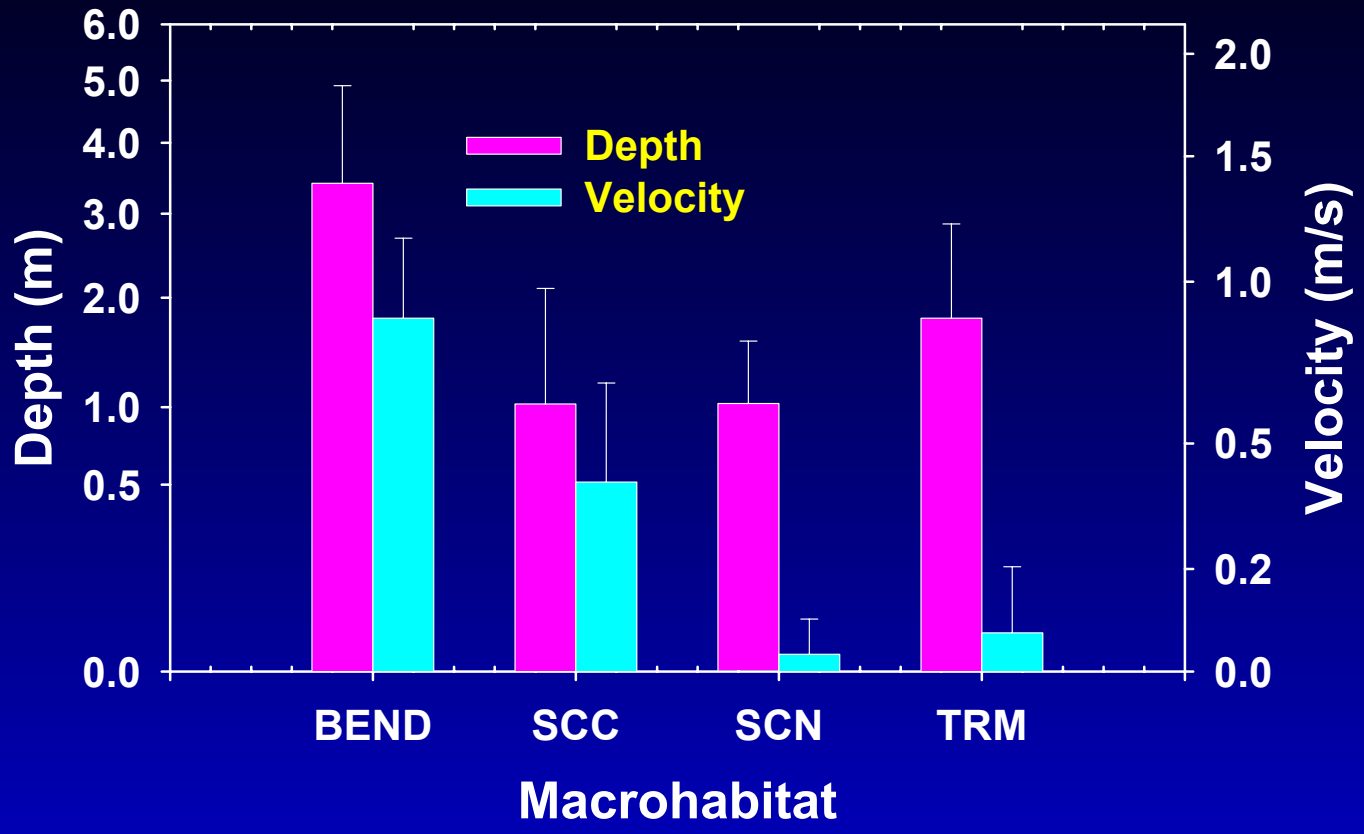
Macrohabitat Scale – Depth/Velocity



Mean (± 1SD) depth and velocity in macrohabitats over all segments of Missouri and lower Yellowstone rivers. BEND: bend, SCC: secondary channel connected, SCN: secondary channel not-connected, TRM: tributary mouth.

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Spatial Scale & Physical Habitat
Zone/Segment

Variable	Controlling Factors
Temperature	Dams (2- 6 C ↓) Longitudinal (~ 4 C ↑)
Turbidity	Dams (>100 NTU ↓) Longitudinal (~ 40 NTU ↑)
Conductivity	Tributaries ↕ Evaporation ↑

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Spatial Scale & Physical Habitat
Macrohabitat

Variable	Controlling Factors
Depth (~ 5 m)	Channelization ↑ Geomorphology ↕
Velocity (~ 3 m/s)	Channelization ↑ Geomorphology ↕

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Implications for River Restoration at a Landscape Scale

Spatial scale may differentially influence physical habitat variables.

Missouri River:

temperature, turbidity, conductivity - Segment (10^1-10^2 km)

depth, velocity - Macrohabitat ($\leq 10^0$ km)

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Missouri River Benthic Fishes Study

- **Benthic Fishes**
  - Describe & evaluate composition, relative abundance, distribution, recruitment, growth, mortality, size structure, & body condition
- **Habitat Use**
  - Describe use of dominant habitats by benthic fishes

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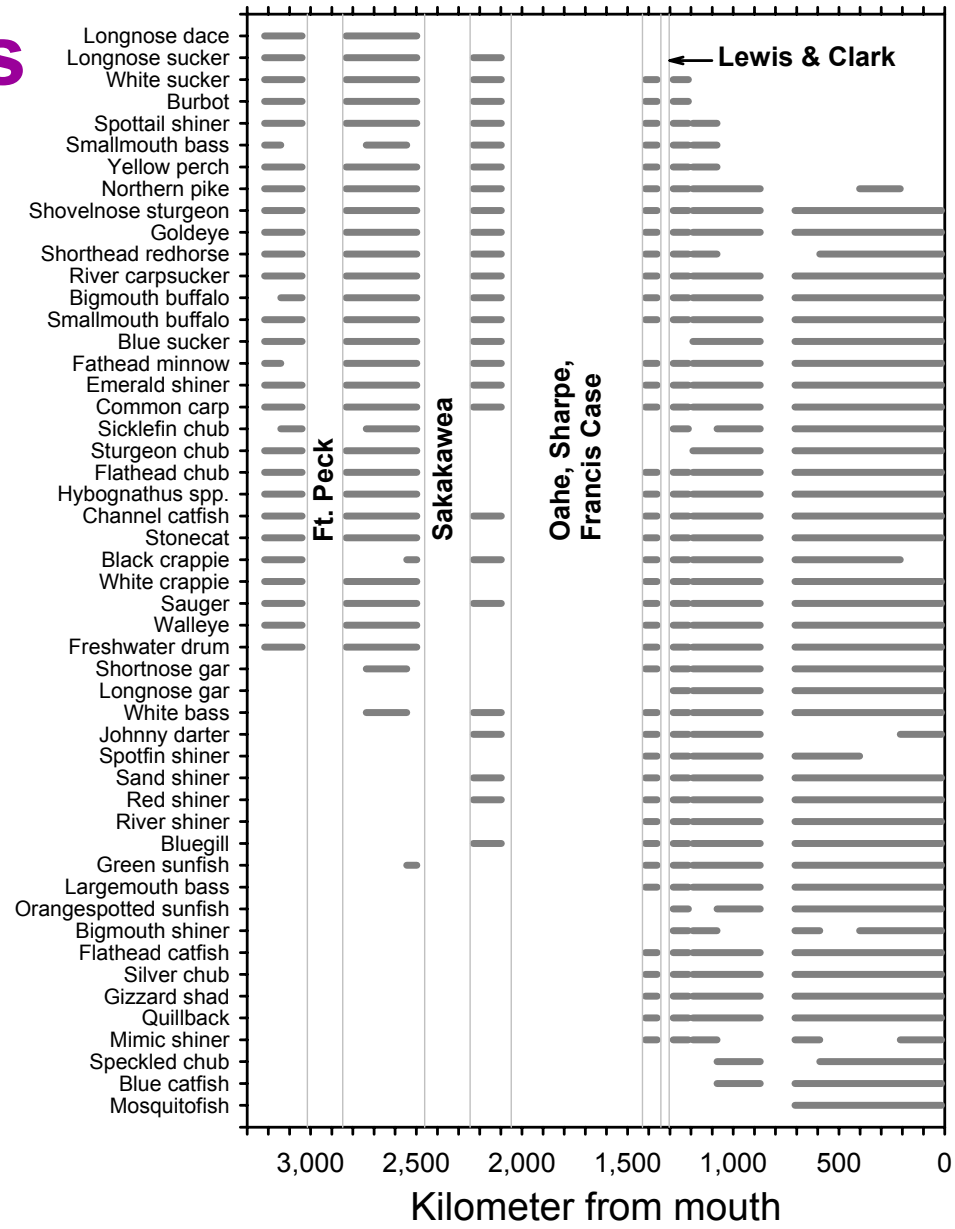
River/Zone – Assemblage Scales

Longitudinal distribution of major (≥100 collected) Missouri River fishes based on standardized sampling between July and October 1996-1998, from main-channel habitats exclusive of reservoirs.

- 4 taxa restricted to LA & IR zones
- 21 taxa restricted to CH zone
- 36% of taxa absent below reservoirs



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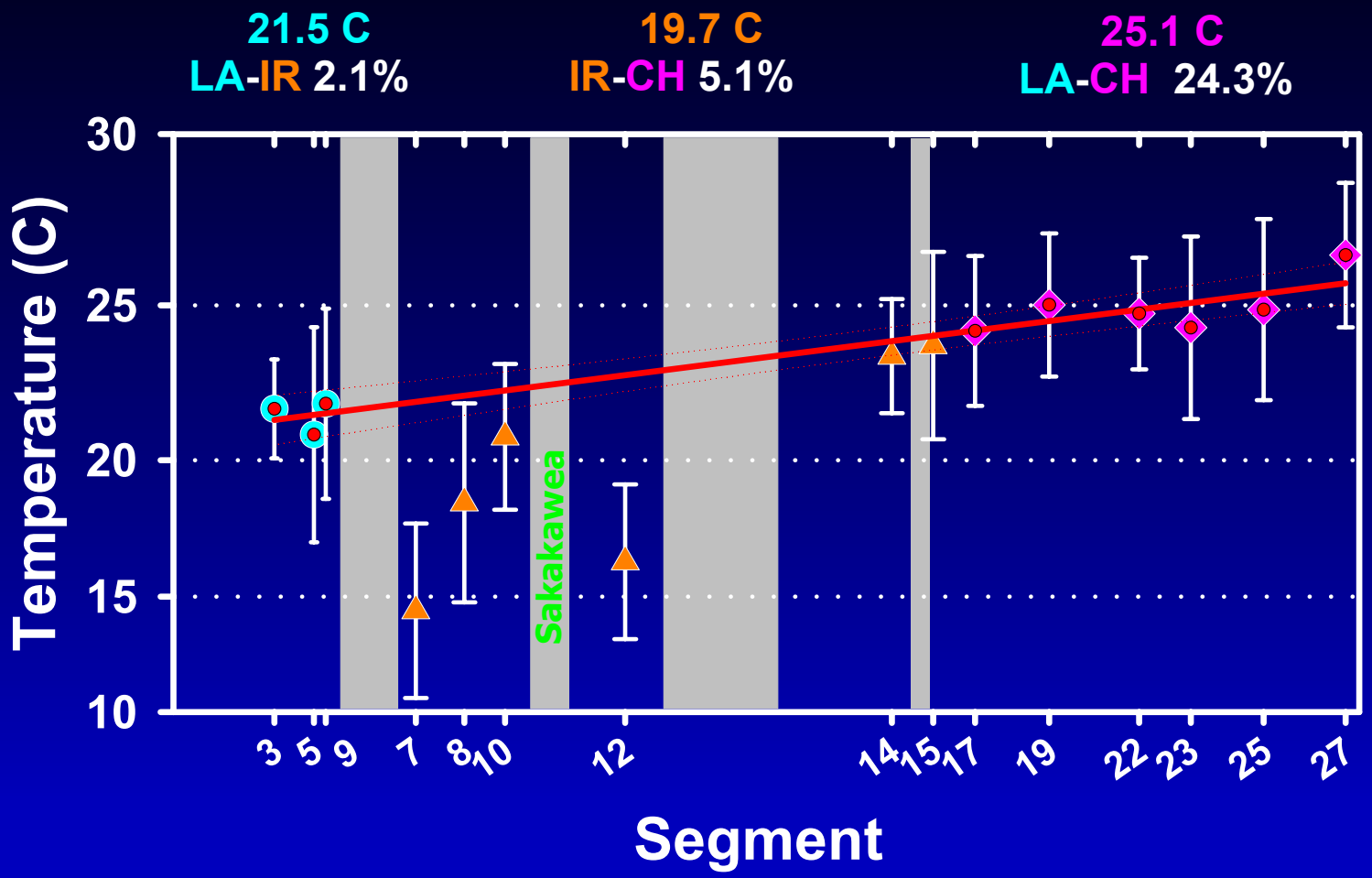
Physical Variables and Fishes – Segment Scale



Mean (± SD) water temperature of macrohabitats combined at segments of Missouri and lower Yellowstone rivers, 1996-1998. Least-altered (LA), inter-reservoir (IR), reservoirs, channelized (CH).

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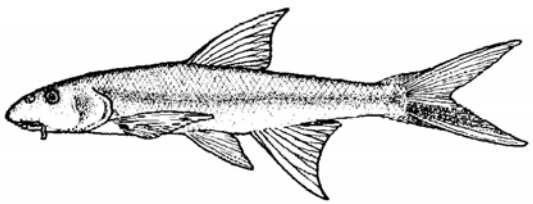
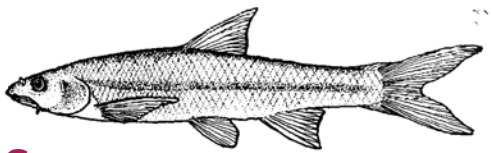
Physical Variables and Fishes – Segment Scale

Longitudinal distribution of Missouri River fishes based on standardized sampling 1996-1998, exclusive of reservoirs.

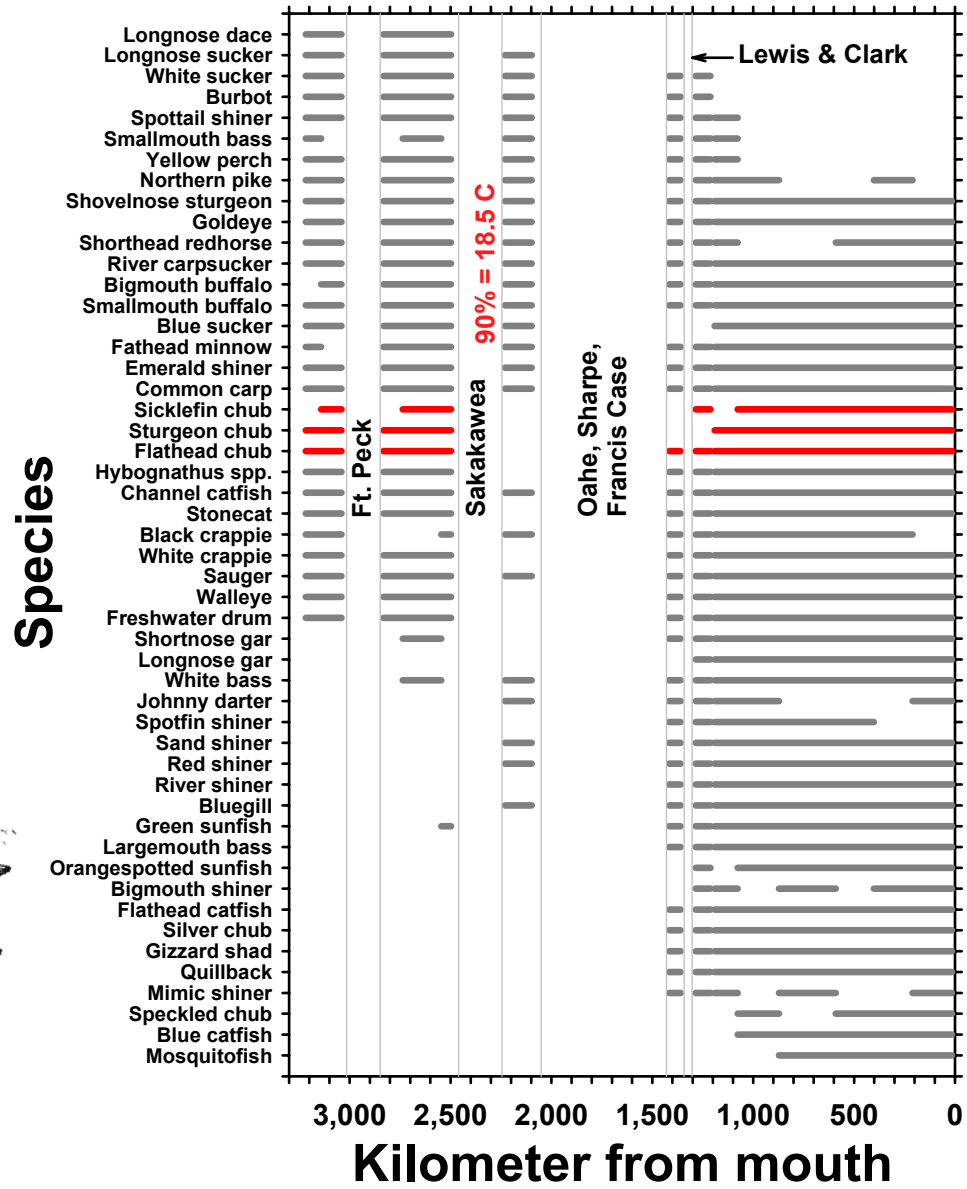


Sicklefin chub, C
Macrhybopsis meeki
20 C



Sturgeon chub, C
Macrhybopsis gelida
23 C

Flathead chub, S1
Platygobio gracilis
25 C



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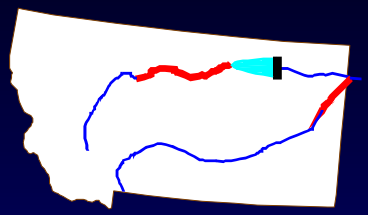
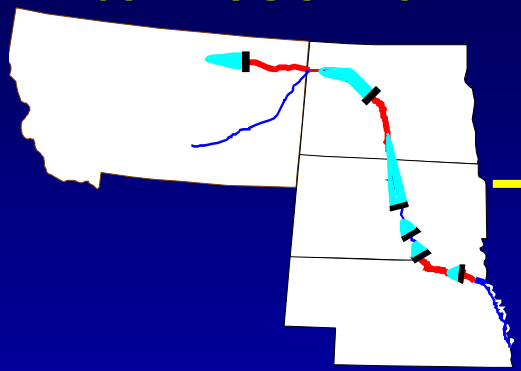
Shovelnose Sturgeon

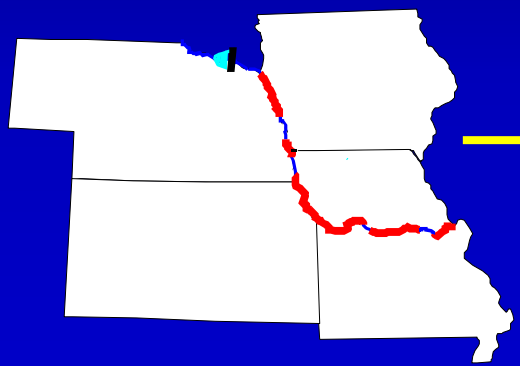
Least-Altered

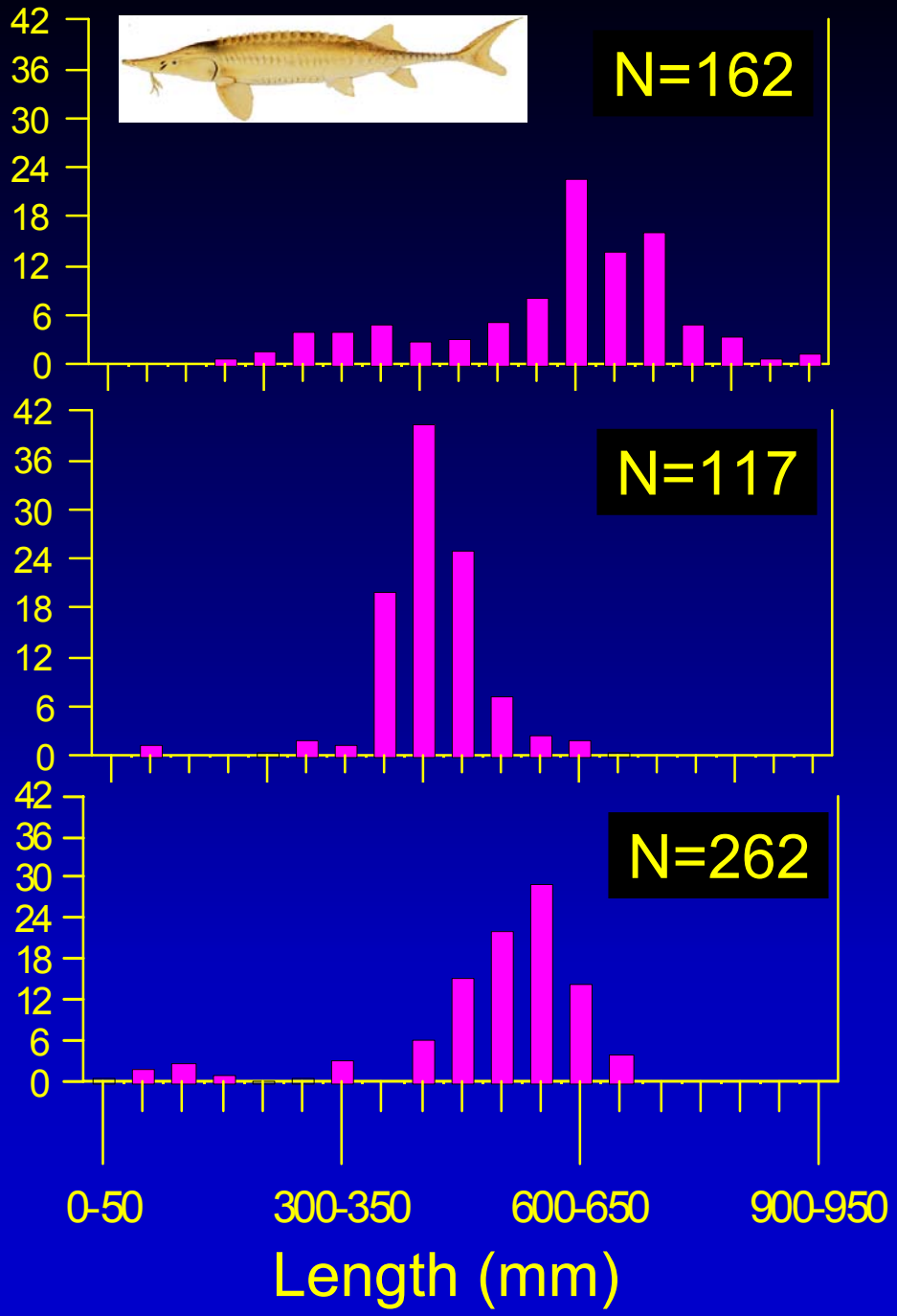


Inter-reservoir



Channelized





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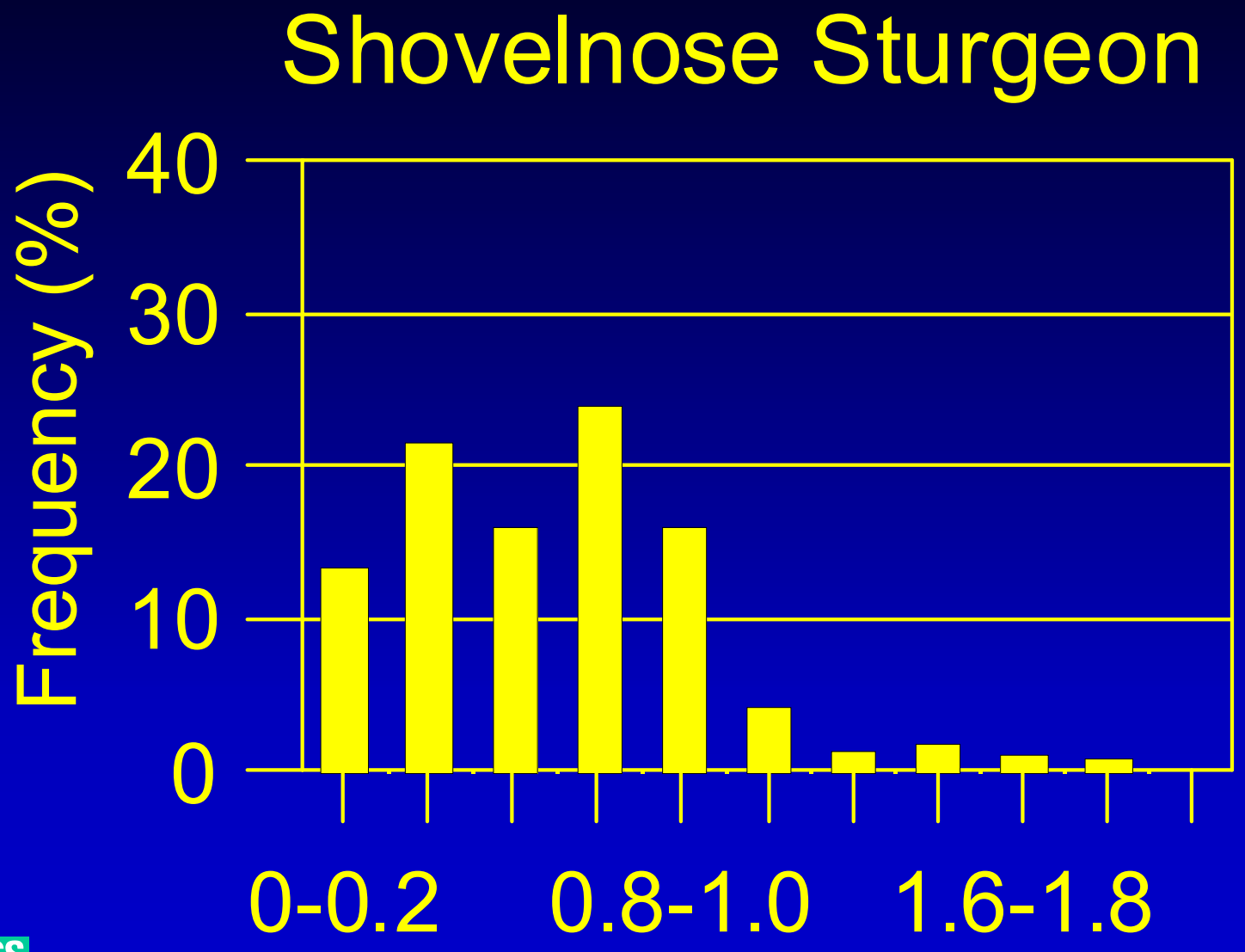
Macrohabitat Scale - Velocity



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Implications for River Assessments at a Landscape Scale

Necessary to distinguish anthropogenic effects from natural sources of habitat and species variability and manage accordingly.

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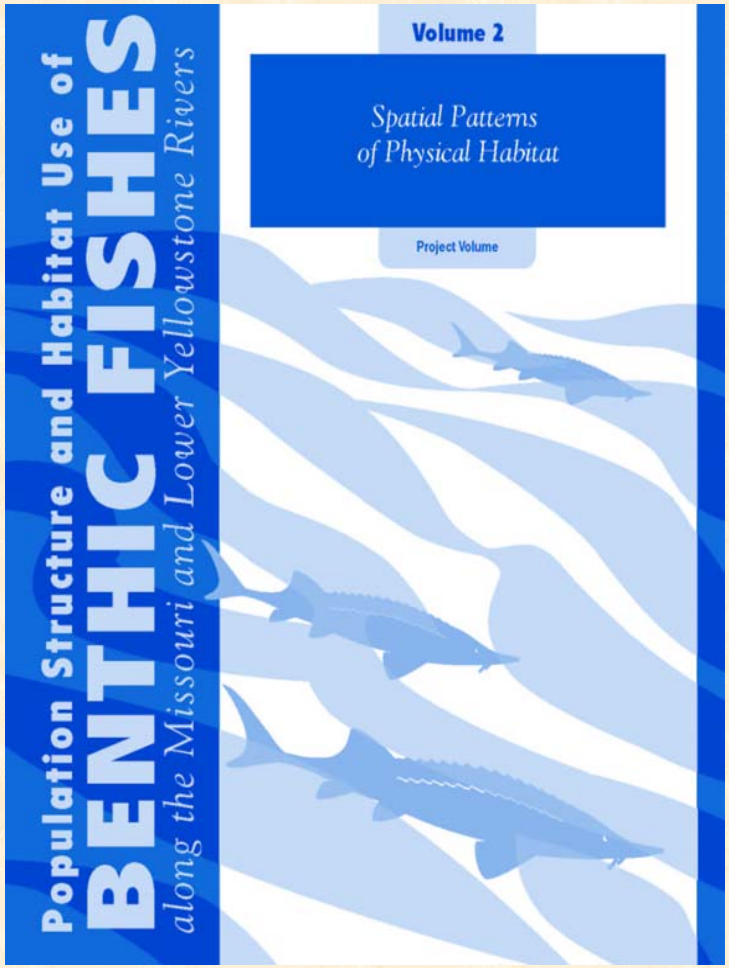
Recommendation

Define spatial, temporal, and taxonomic scales of ecological assessments and state results and implications accordingly.

USGS

http://infolink.cr.usgs.gov/science/benthicfish

http://www.nwo.usace.army.mil/html/pd-e/planning.html



Communication of Research

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