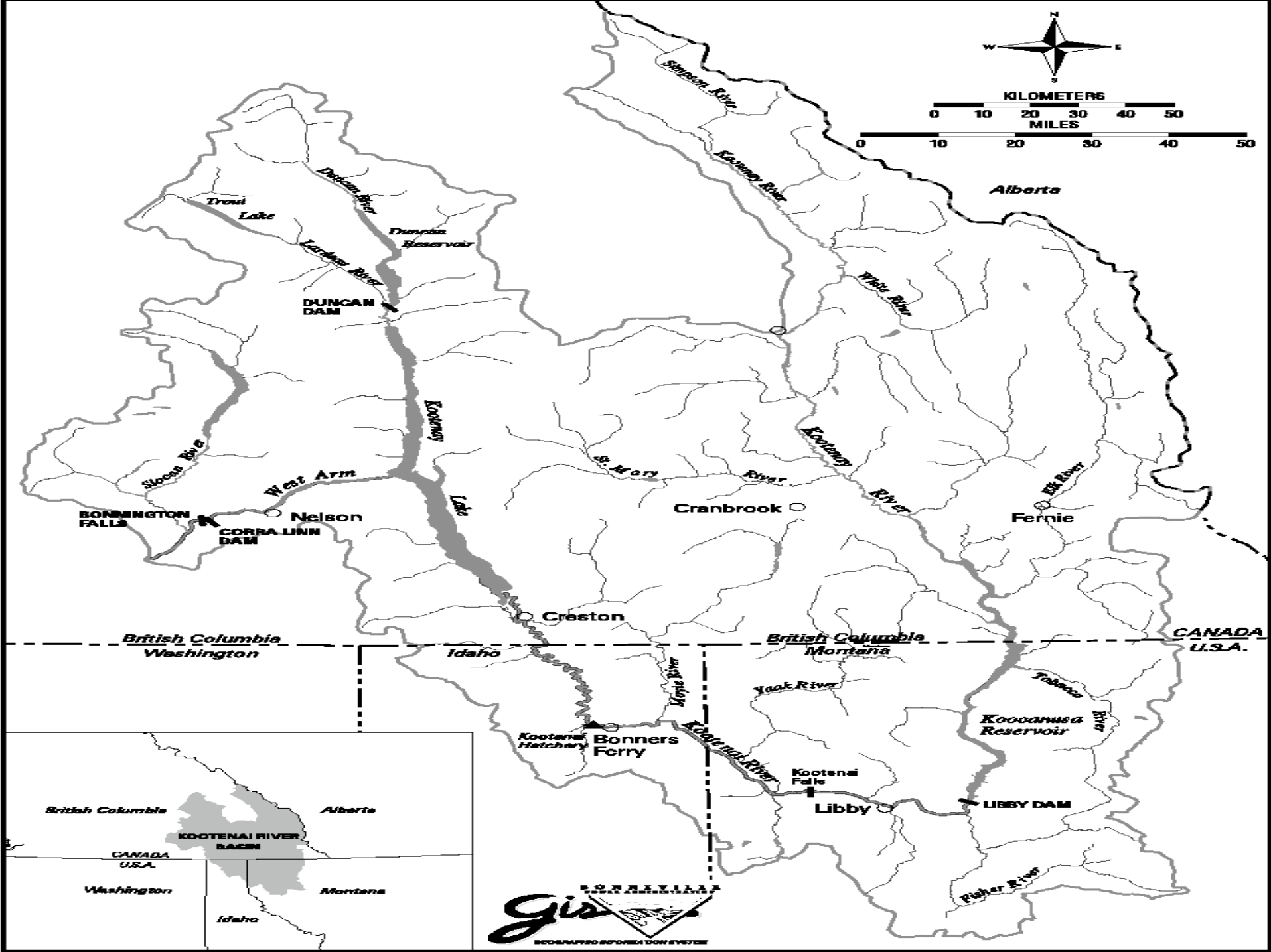
Effects of Whole-River Fertilization on Benthic Macroinvertebrates: Feeding a Starving River.

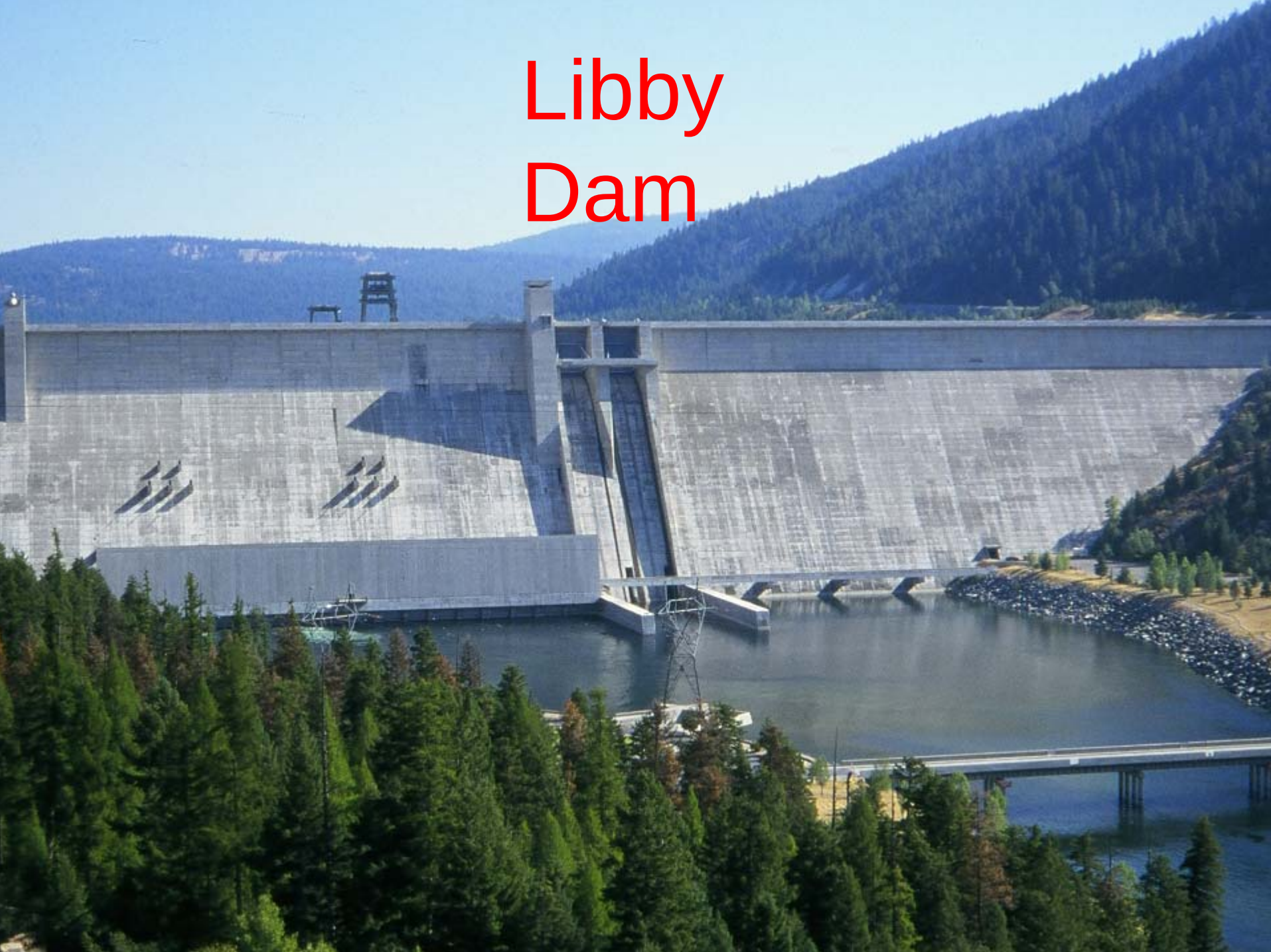
Gary Lester, EcoAnalysts, Inc.
Charlie Holderman, Kootenai Tribe of Idaho, Project Lead

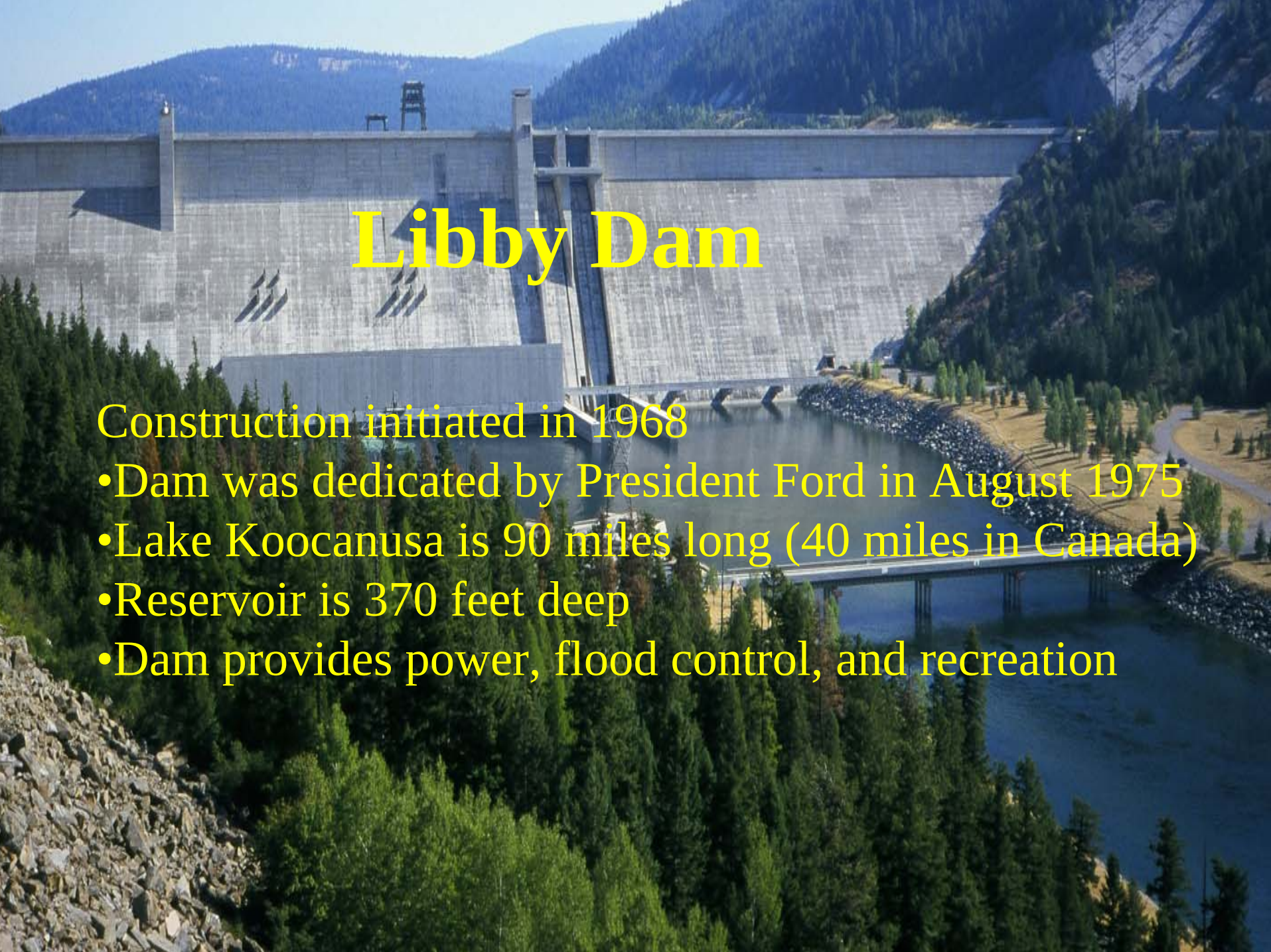
NEAEB 2008
Bartlett, New Hampshire

Overview of Presentation

- Background regarding Kootenai River
- Nutrient enhancement experiment on the river
- Preliminary responses to fertilization


KILOMETERS
0 10 20 30 40 50
MILES
0 10 20 30 40 50
Slimpson River
Kootenay River
Alberta
Trout Lake
Duncan River
Duncan Reservoir
Lardeau River
DUNCAN DAM
White River
Kootenay Lake
Slocan River
West Arm
BONNINGTON FALLS
CORRA LINN DAM
Nelson
St Mary River
Cranbrook
Kootenay River
Elk River
Fernie
Creston
British Columbia
Washington
Idaho
British Columbia
Montana
CANADA
U.S.A.
Yaak River
Kootenai Hatchery
Bonners Ferry
Kootenai River
Tobacco River
Koocanusa Reservoir
Kootenai Falls
Libby
LIBBY DAM
Fisher River
British Columbia
Alberta
KOOTENAI RIVER BASIN
CANADA
U.S.A.
Washington
Montana
Idaho


Libby
Dam



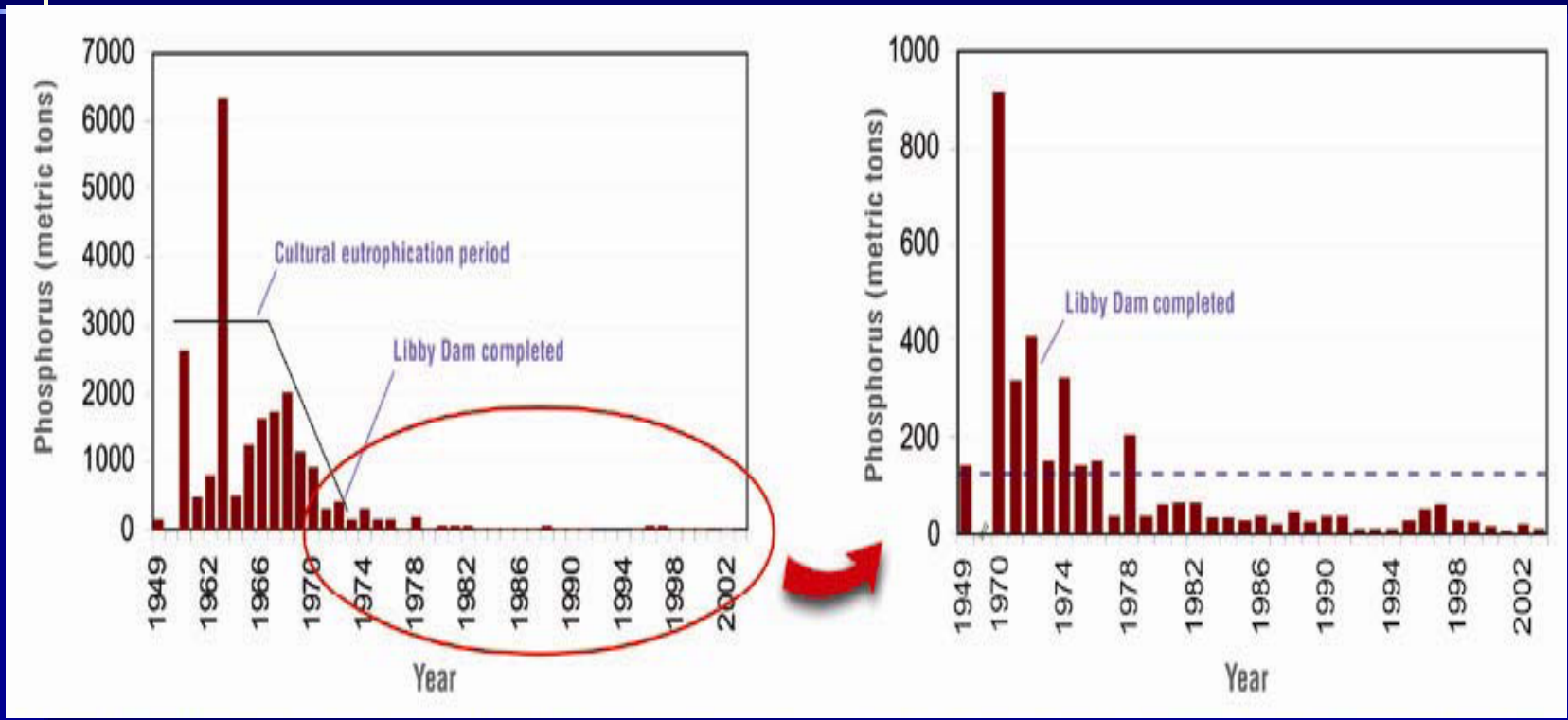
Libby Dam

Construction initiated in 1968

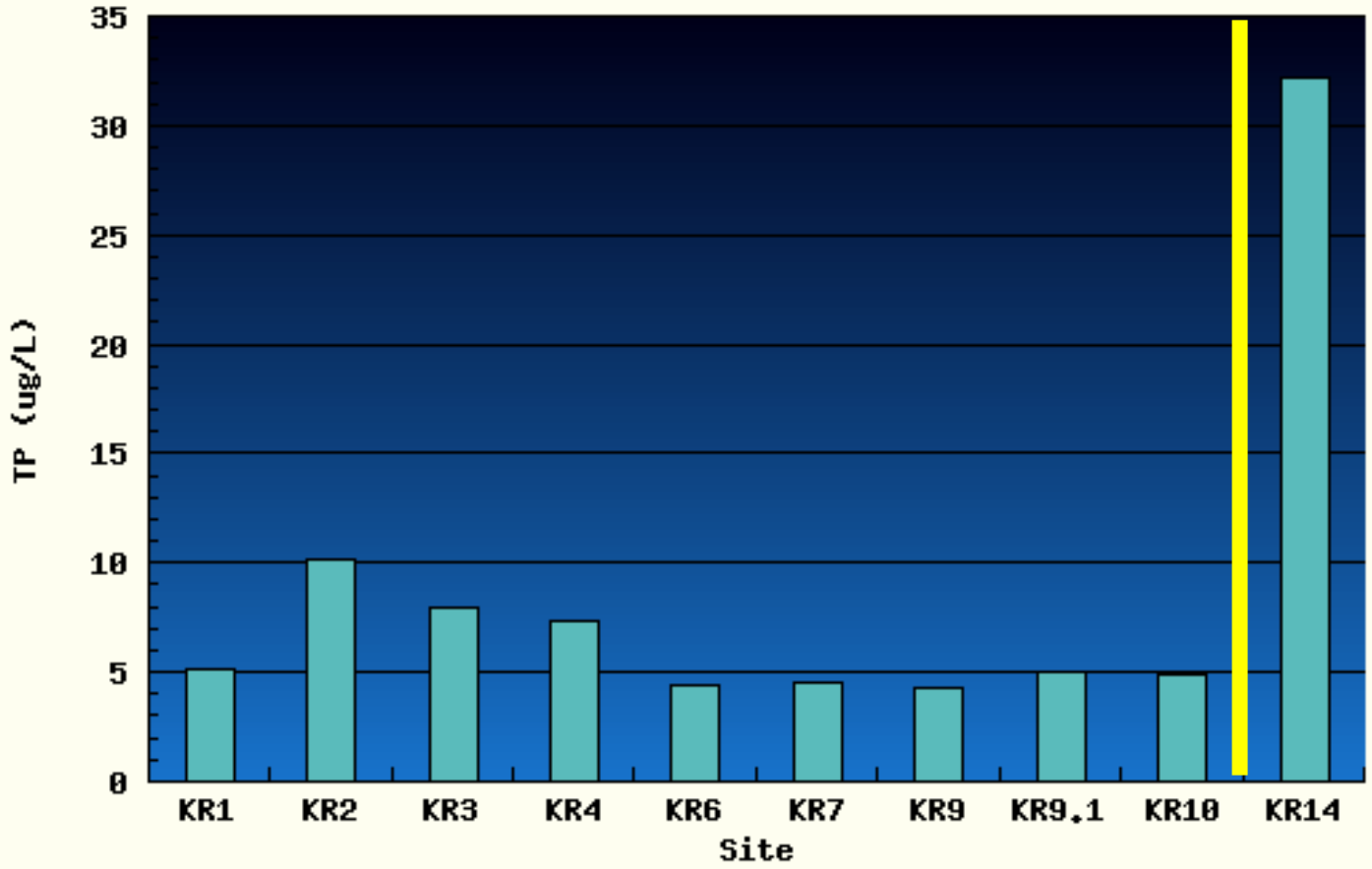
- Dam was dedicated by President Ford in August 1975
- Lake Koocanusa is 90 miles long (40 miles in Canada)
- Reservoir is 370 feet deep
- Dam provides power, flood control, and recreation


•Dam acts as a sediment transport barrier
•Reservoir acts as a nutrient sink
•Dam operations result in an unnatural hydrograph
•Floodplain wetlands disconnected by dikes and flood control

THE PHOSPHORUS STORY



Total Phosphorus - 2003

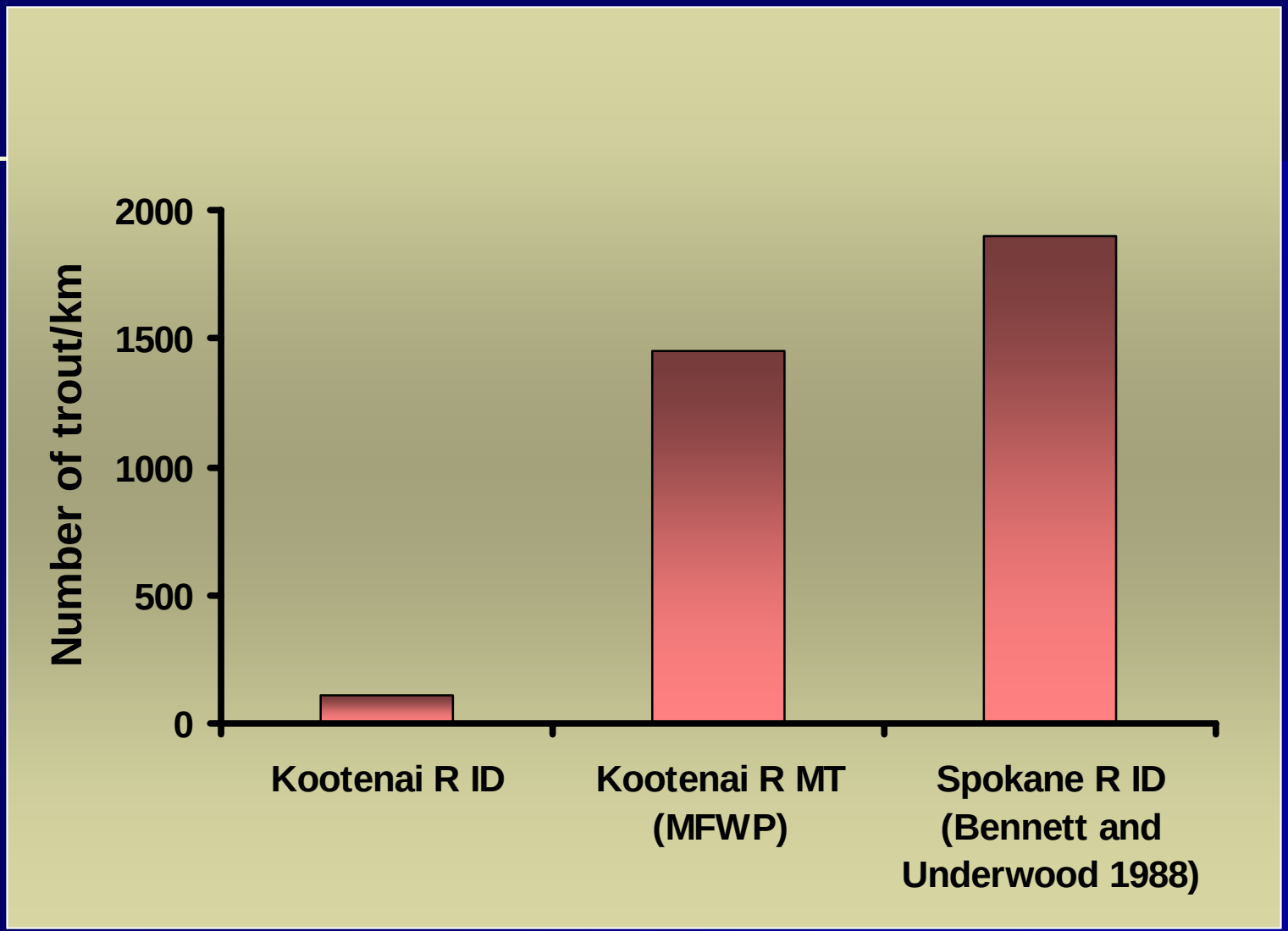


RESULT:
Trophic collapse due to "cultural oligotrophication"

Collapse of native fish populations including:

- Kootenai River white sturgeon (endangered)
- Burbot
- Westlope cutthroat trout
- Rainbow trout
- Kokanee

Trout Comparisons



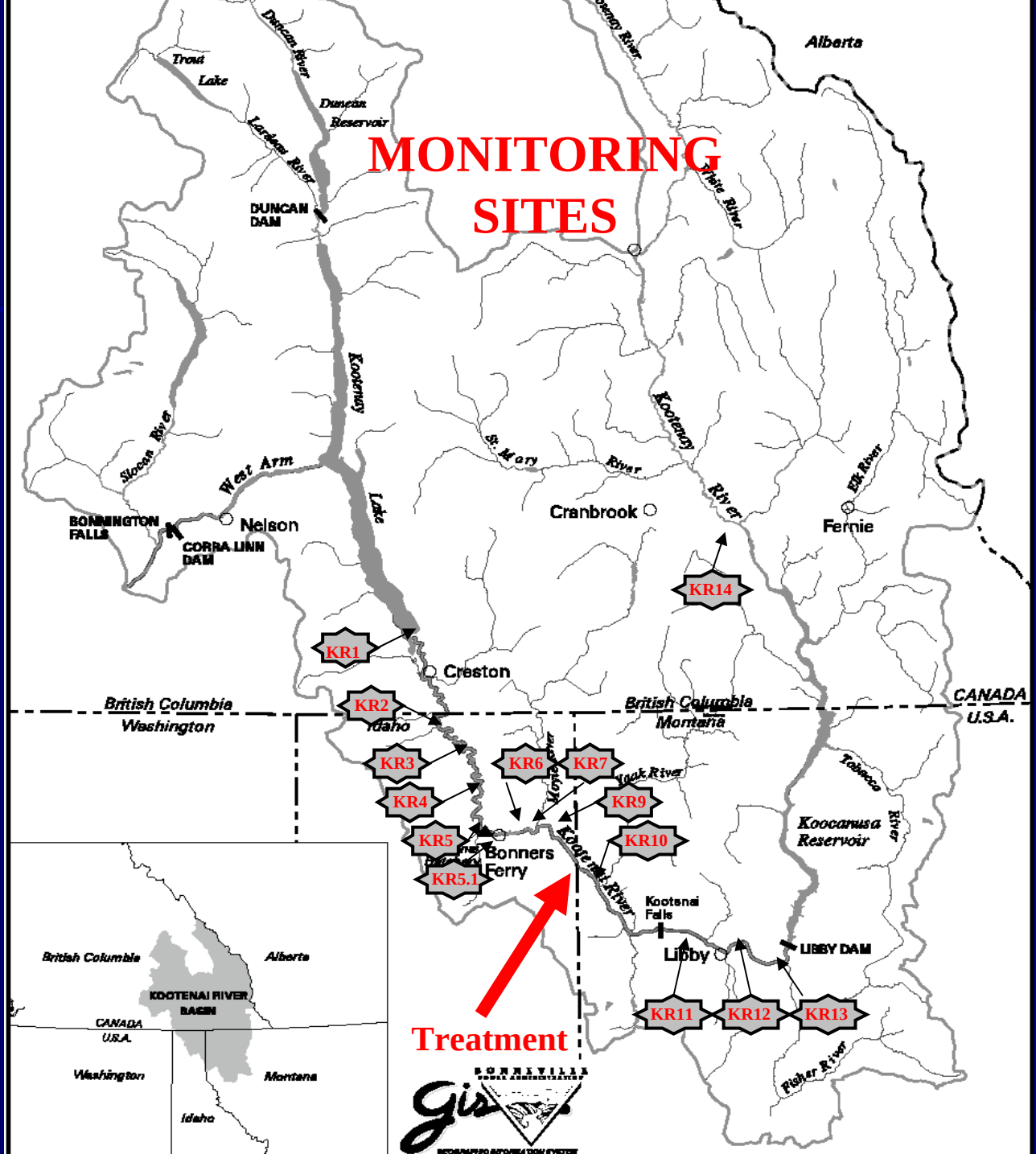
The Study

A large-scale, controlled nutrient enhancement experiment is underway to stimulate productivity in the Kootenai River.

Cooperators - IKERT

International Kootenai Ecosystem Restoration Team

- Kootenai Tribe of Idaho
- Idaho Fish and Game
- Bonneville Power Administration
- BC Ministry of Environment
- Montana Fish Wildlife and Parks
- Academics and consultants
- USACE


MONITORING SITES
Alberta
Trout Lake
Duncan River
Duncan Reservoir
Lardeau River
DUNCAN DAM
Kootenay River
Slocan River
West Arm
BONNINGTON FALLS
CORRA LINN DAM
Nelson
Lake
St. Mary River
Kootenay River
Cranbrook
Elk River
Fernie
KR14
KR1
Creston
British Columbia
Washington
KR2
Idaho
British Columbia
Montana
CANADA
U.S.A.
KR3
KR6
KR7
KR4
KR9
KR5
KR10
Bonners Ferry
KR5.1
Moyie River
Yaak River
Tobacco River
Koocanusa Reservoir
Kootenai River
Kootenai Falls
Libby
LIBBY DAM
KR11
KR12
KR13
Fisher River
Treatment
British Columbia
Alberta
KOOTENAI RIVER BASIN
CANADA
U.S.A.
Washington
Montana
Idaho

Monitoring Parameters

- Nutrients
  - TDP, SRP, TN, NH_4, NO_2+NO_3
- Primary Productivity
  - ChlA, Periphyton and phytoplankton community structure
- Secondary Productivity
  - Invertebrate abundance, biomass, community structure
- Tertiary Productivity
  - Fish abundance/biomass, community structure, condition

Study Design

- Monthly sample for water quality, periphyton and invertebrates from April – October
- Replicates (1-6) collected at each site for various parameters
- Fish population work once per year
- Five years of pre-treatment data (completed)
- Five years of post-treatment data (started 2005)

Nutrient Augmentation

- Addition of P ($NH_4P_2O_5$) toward a target level of 1.5ug/L in river in 2005, 3.0 in 2006/2007/2008
- Target 20:1 N/P ratio in the river
- Summer 2005 flow rate of 0.31L/min
- Flow rate is dependent upon river discharge
- 2km mixing zone

Sampling Methods - Periphyton

- Artificial substrates (30 day colonization times) for ChlA
- Scrape and filter known area
- Samples monthly at most sites
- One composite sample from natural substrate (3 cobble scrape) for taxonomy


Control – KR10
Test – KR 9.1

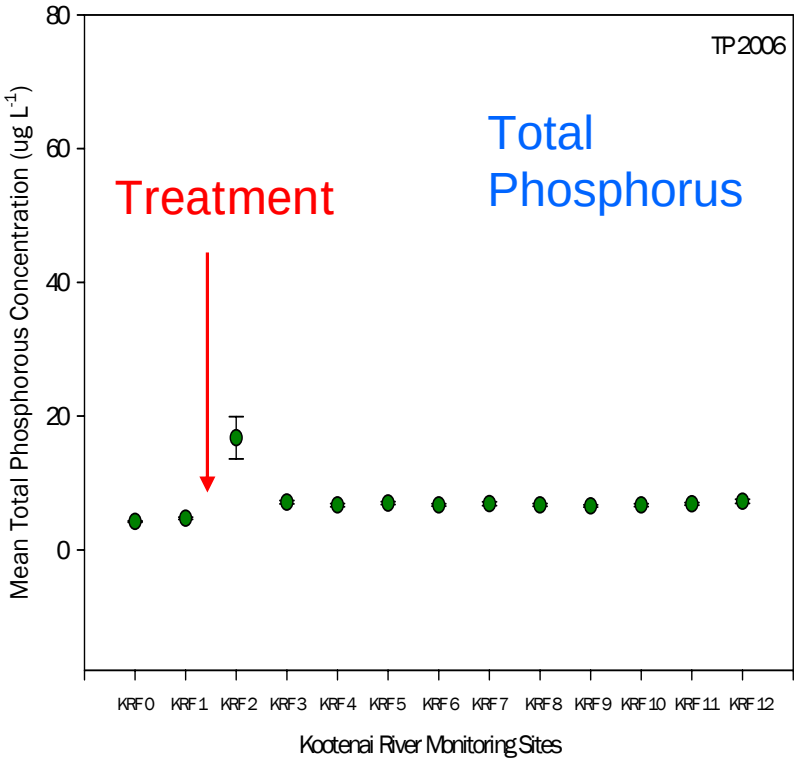
Sampling Methods – Invertebrates

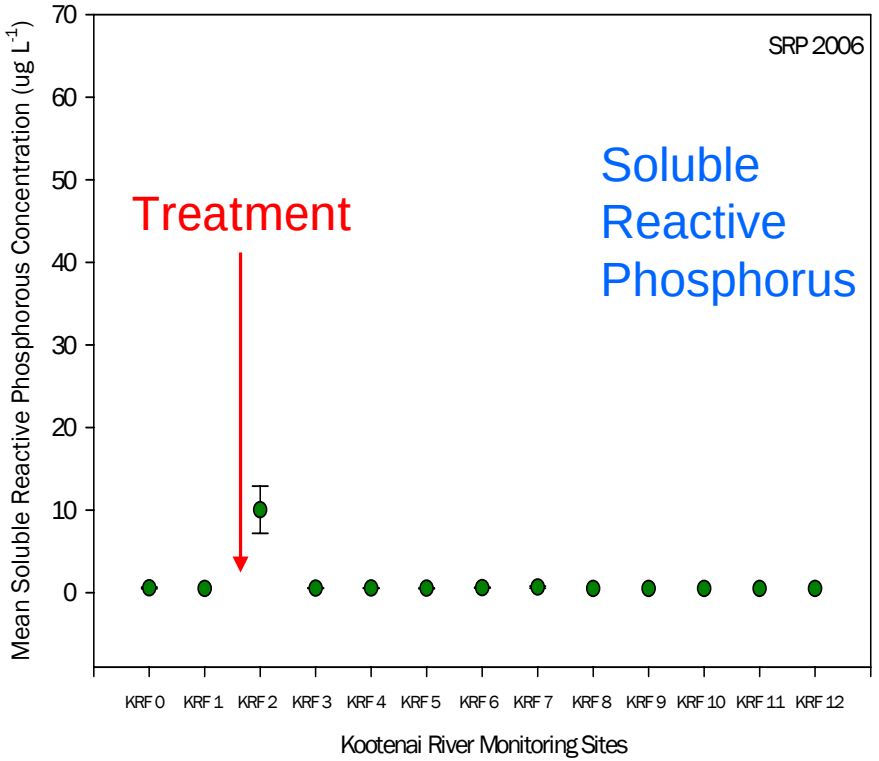
- Quantitative benthic samples using a modified slack sampler, 0.25m^2 area
- Sample events in spring, summer and fall (when flows allow)
- Six replicates per site
- Full sorts by KTOI staff using 3x lens
- ID to genus/species, worms to class, by EcoAnalysts
- Whole-sample dry weight and dry weight by order (Eco)


•Modified slack sampler
•Dimensions = .5m x.5m
•500 micron mesh net
•Allows sampling of large substrates

RESULTS

Effect of P Additions on TP, SRP Concentration (Hoyle 2006)

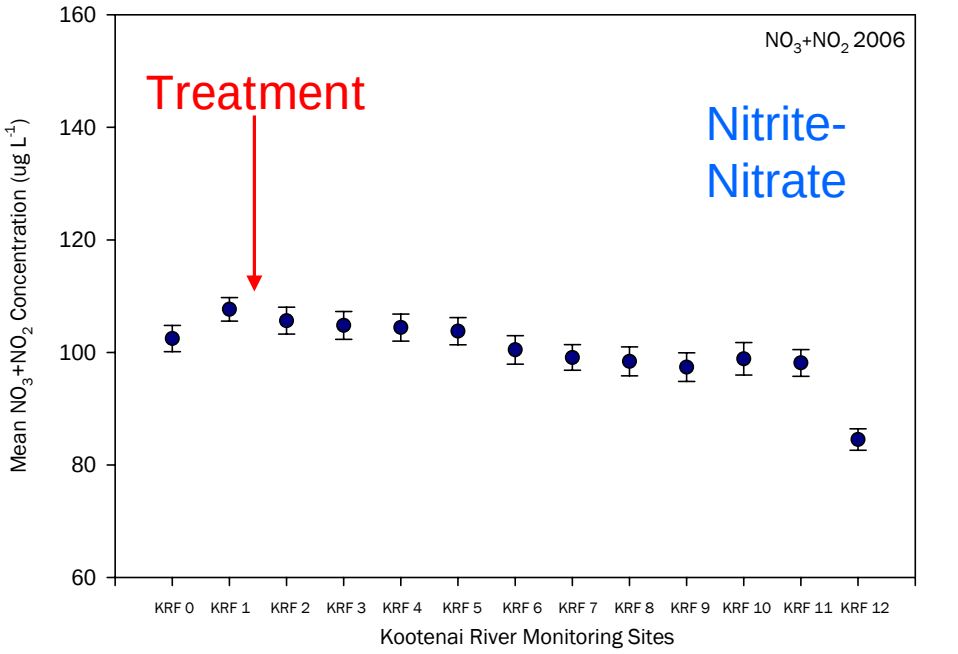


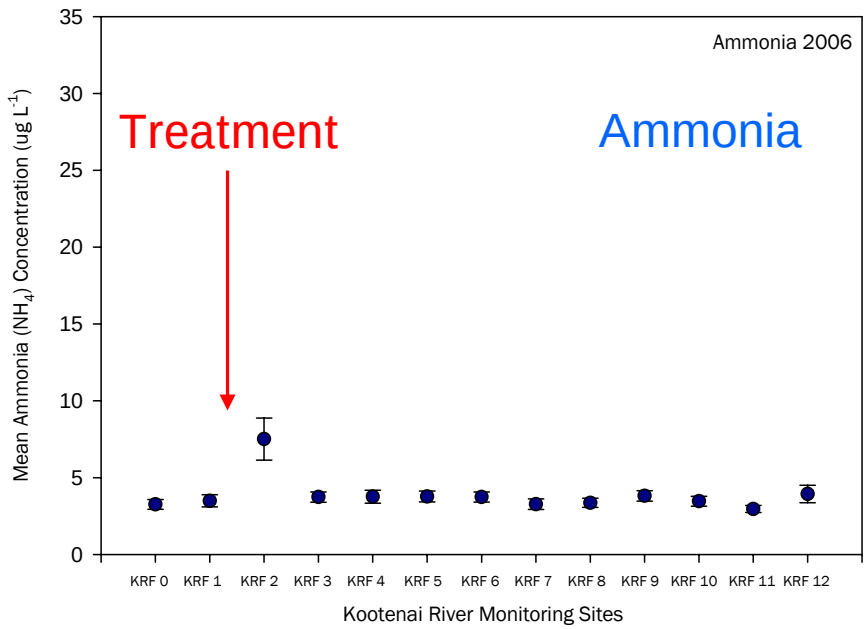


Sites are 1km apart.

Nitrate & Ammonia Concentrations

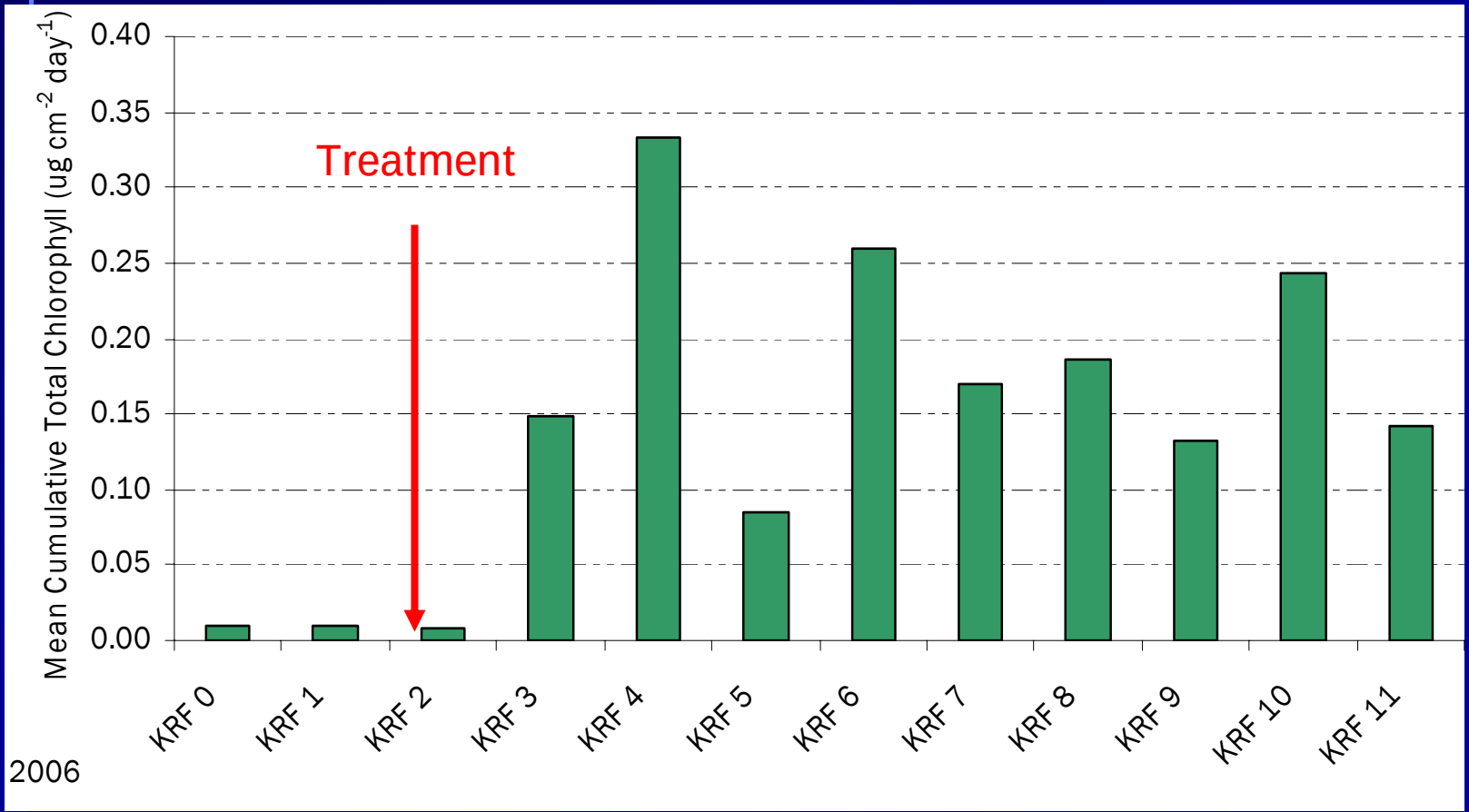
(Hoyle, 2006)



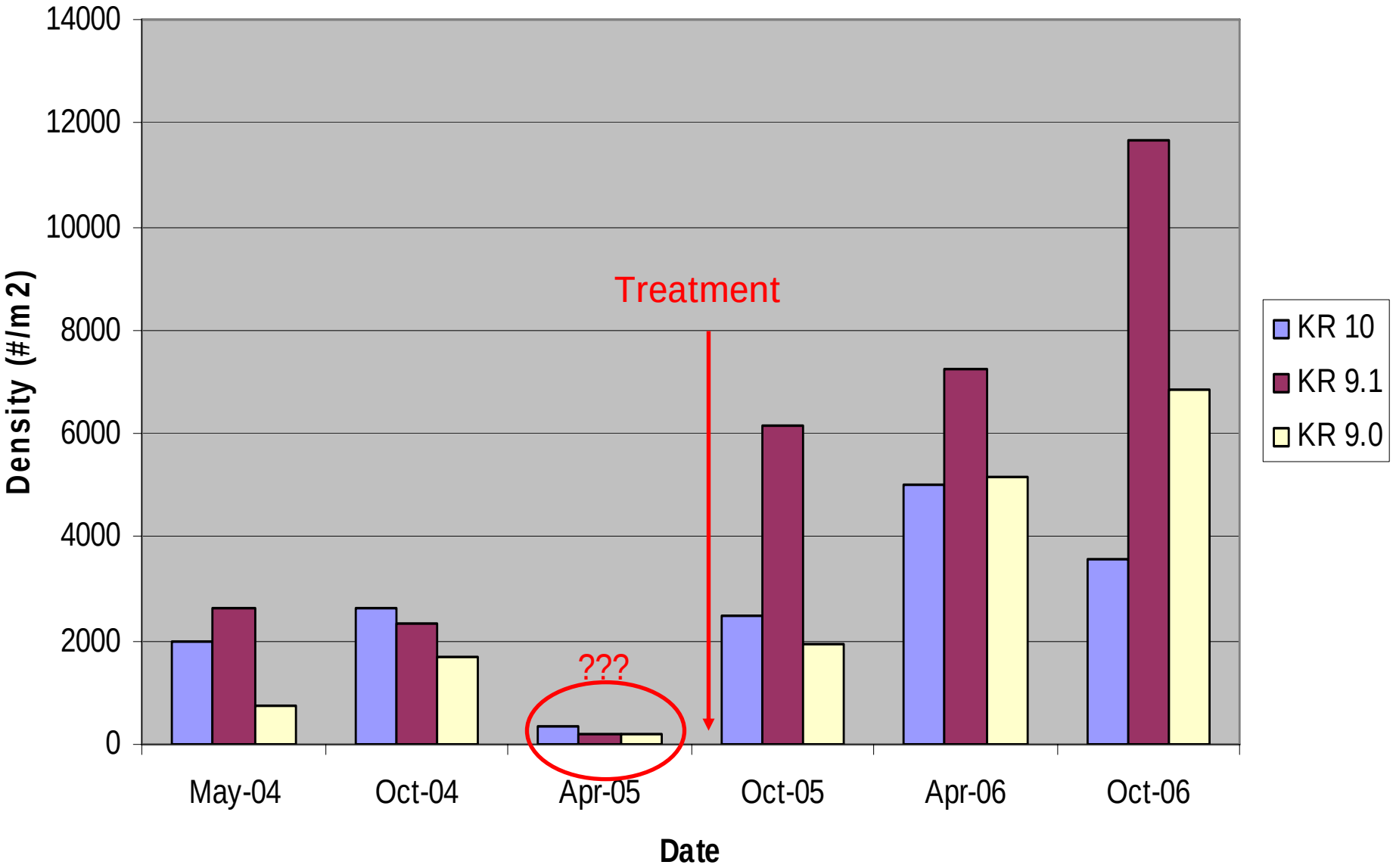


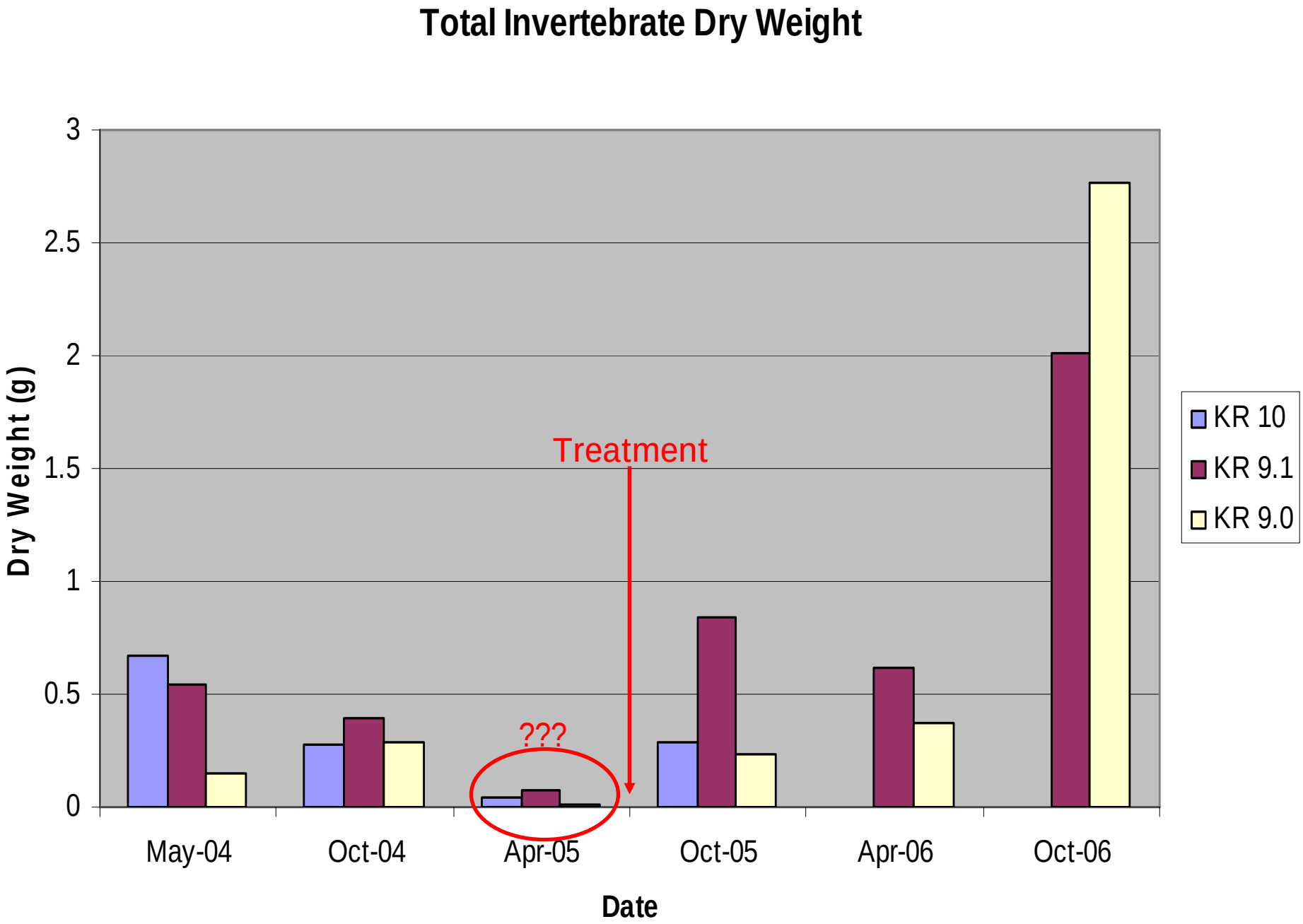
Chlorophyll Response, Kootenai River

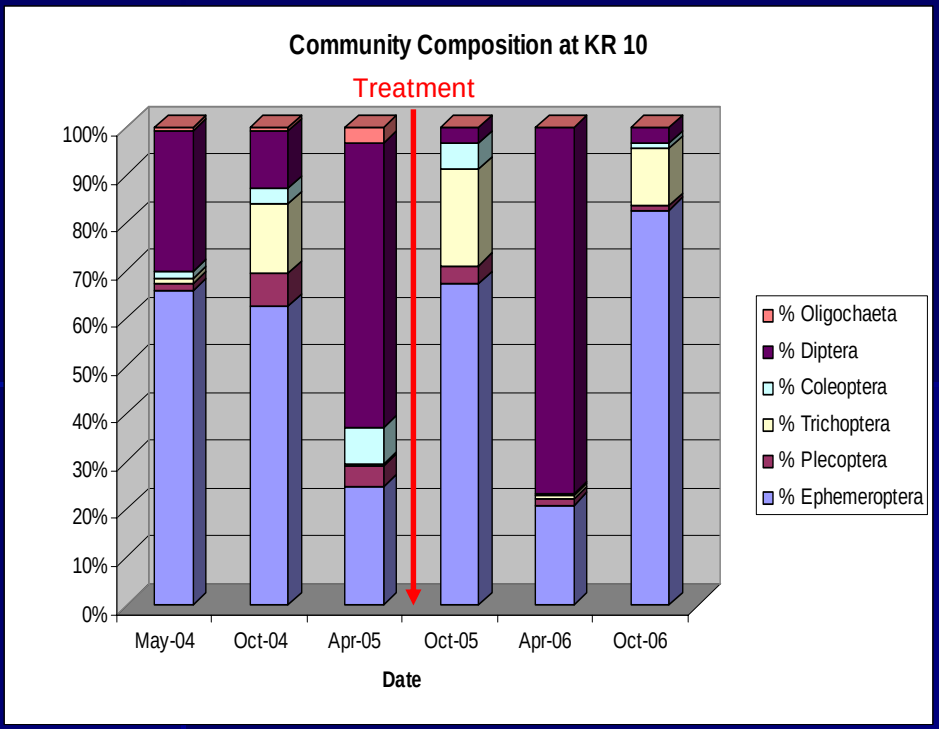
(Hoyle 2006)

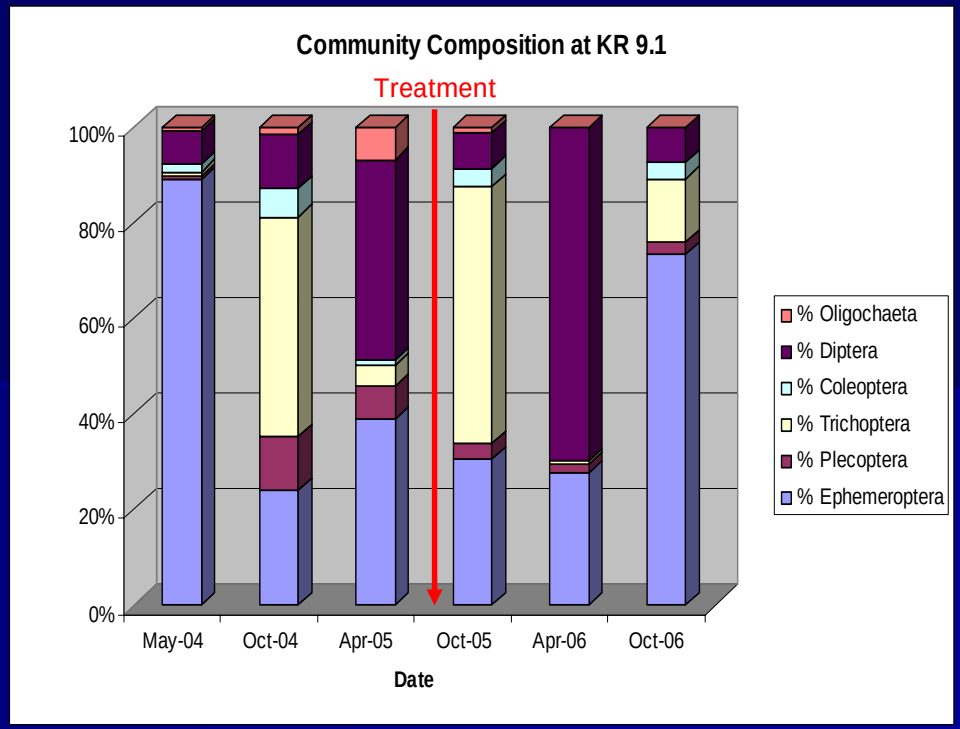


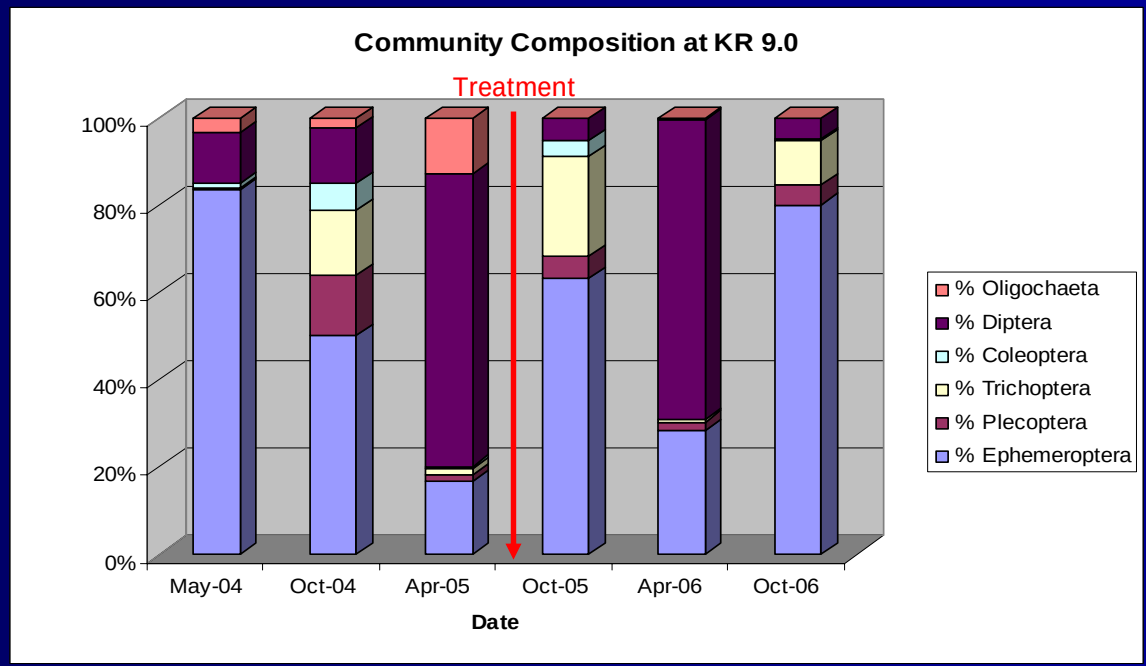
Macroinvertebrate Density

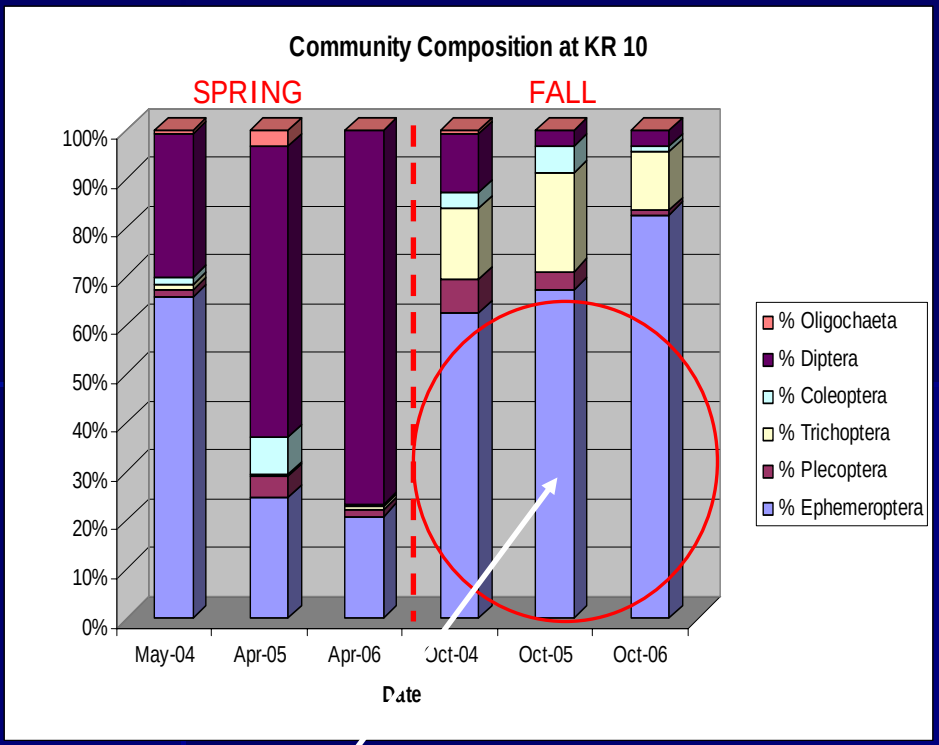


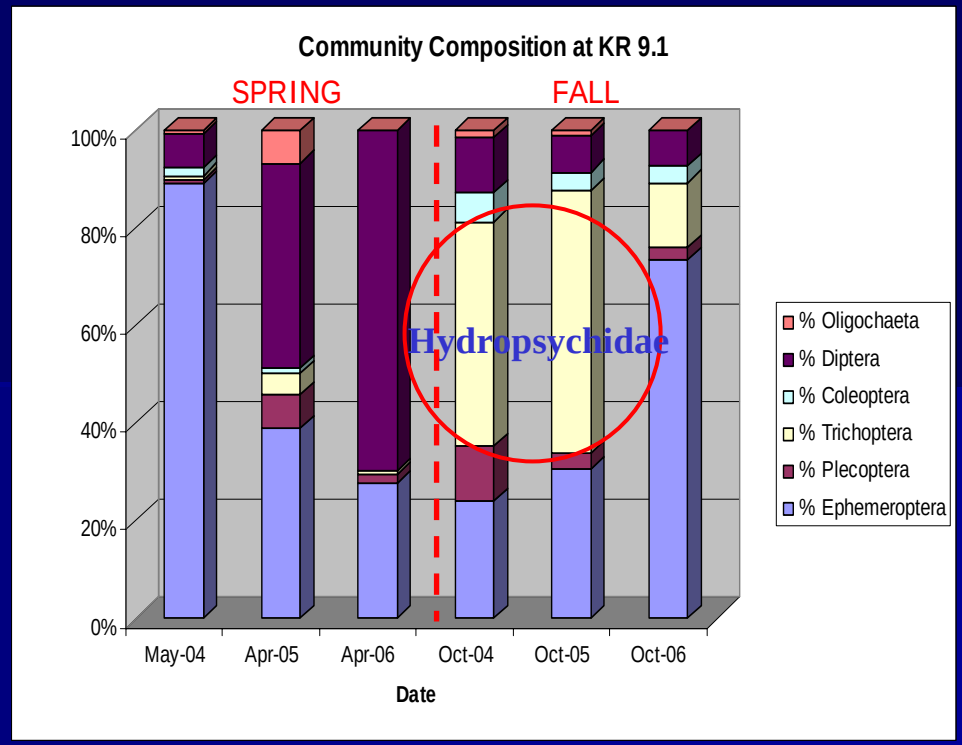

Total Invertebrate Dry Weight
Dry Weight (g)
3
2.5
2
1.5
1
0.5
0
Treatment
???
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
KR 10
KR 9.1
KR 9.0


Community Composition at KR 10
Treatment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Oligochaeta
% Diptera
% Coleoptera
% Trichoptera
% Plecoptera
% Ephemeroptera


Community Composition at KR 9.1
Treatment
100%
80%
60%
40%
20%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Oligochaeta
% Diptera
% Coleoptera
% Trichoptera
% Plecoptera
% Ephemeroptera


Community Composition at KR 9.0
Treatment
100%
80%
60%
40%
20%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Oligochaeta
% Diptera
% Coleoptera
% Trichoptera
% Plecoptera
% Ephemeroptera

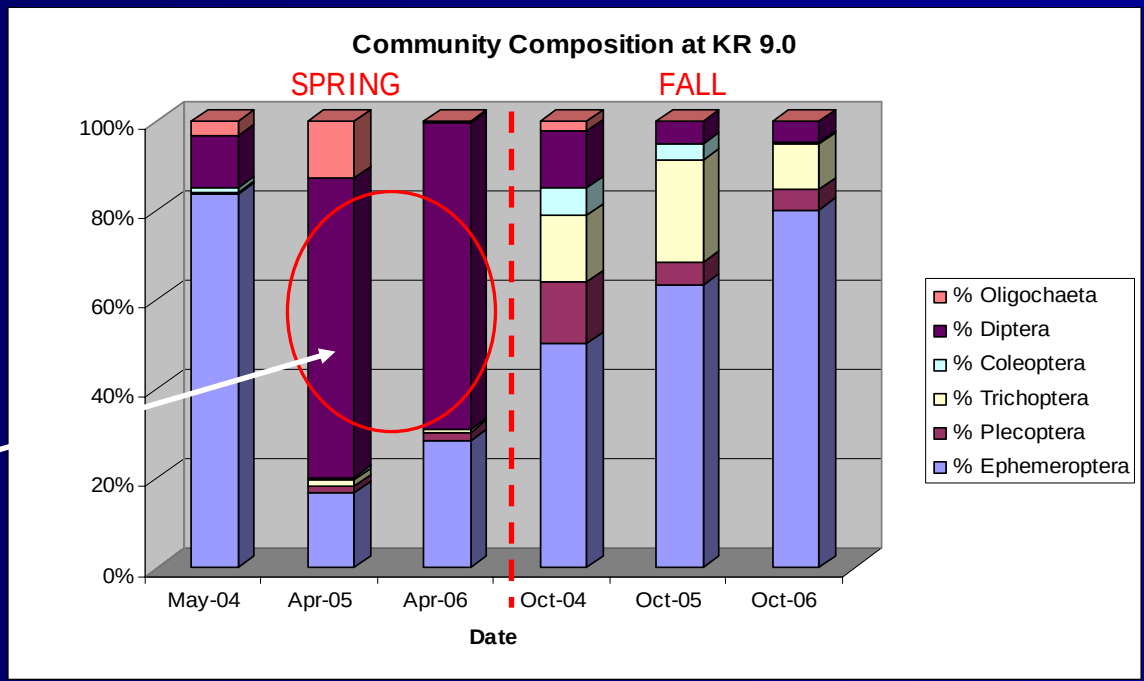


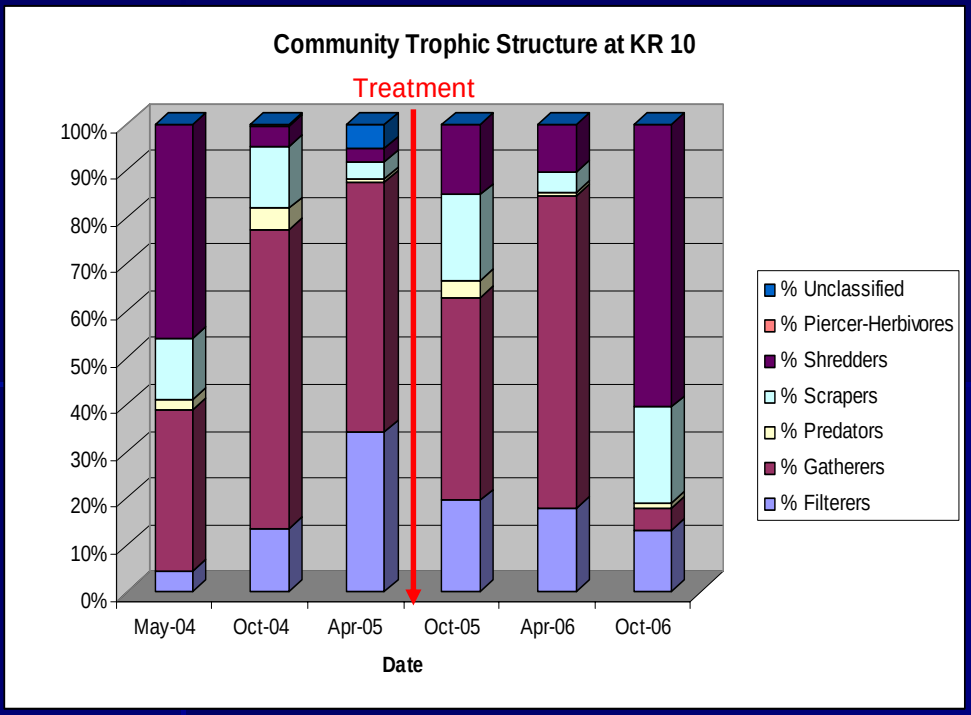


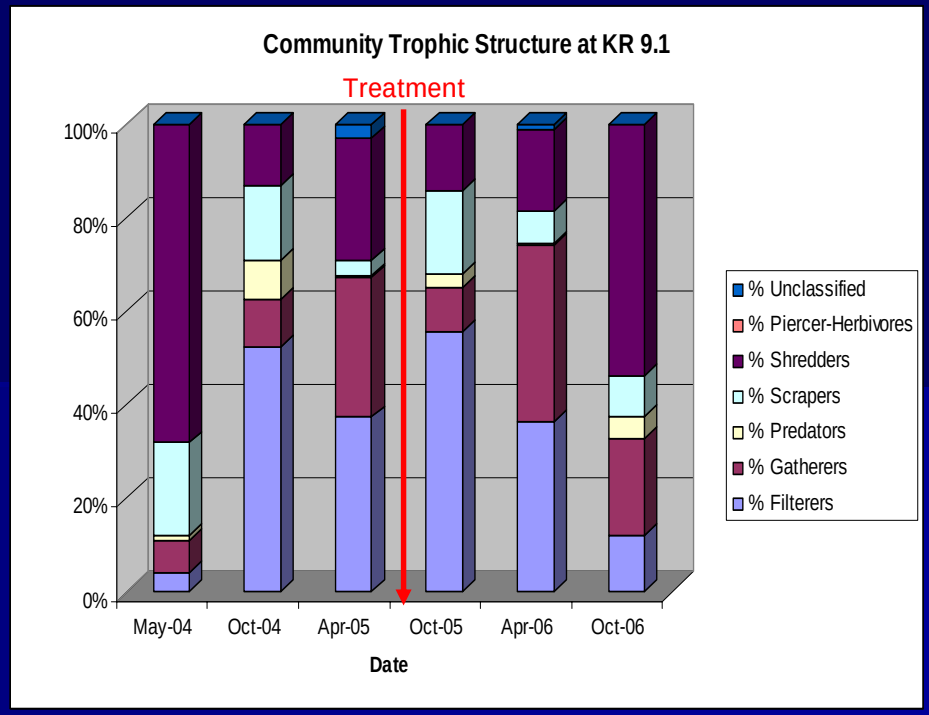
Ephemerella inermis/infrequens

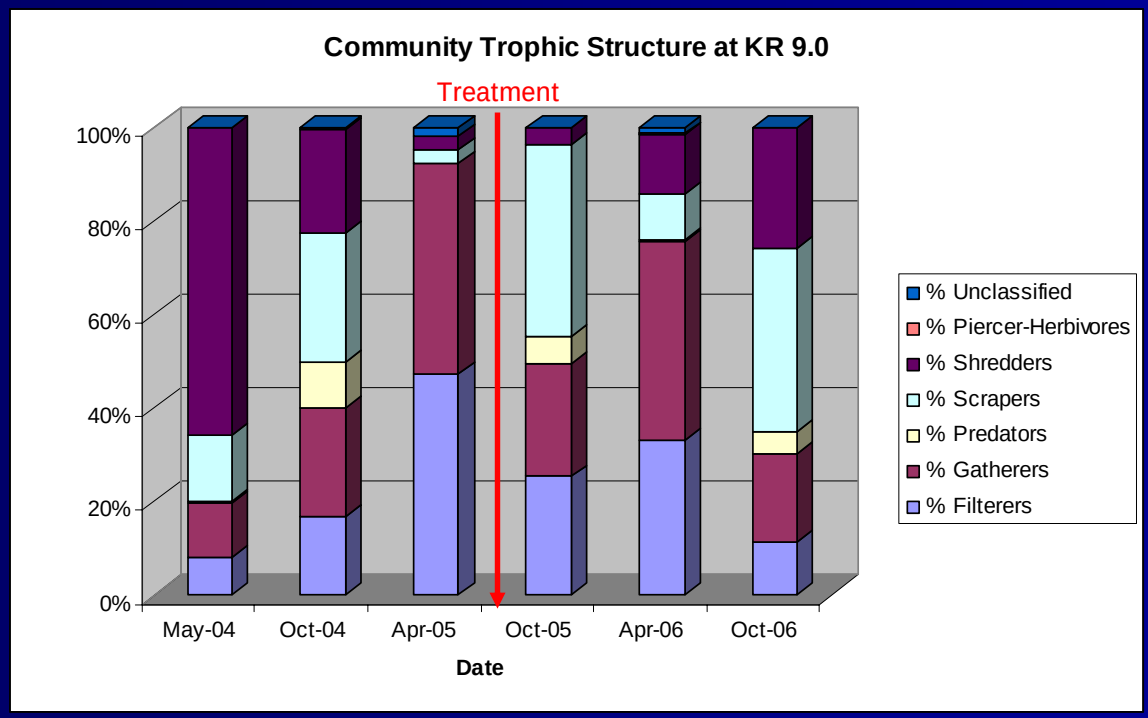
Orthocladius sp.

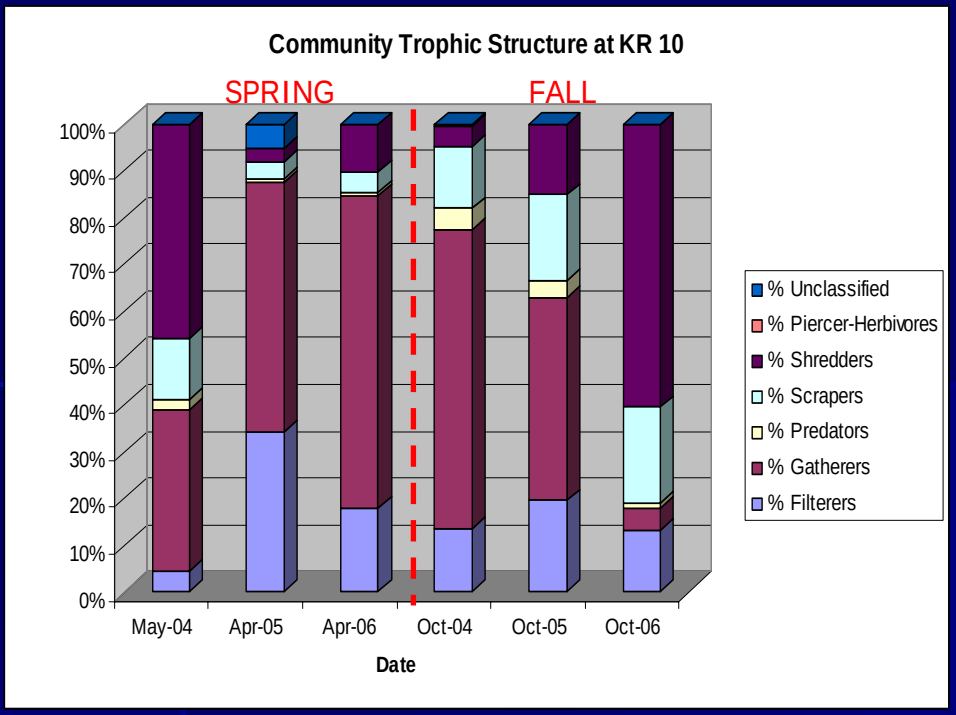
Simulium sp.

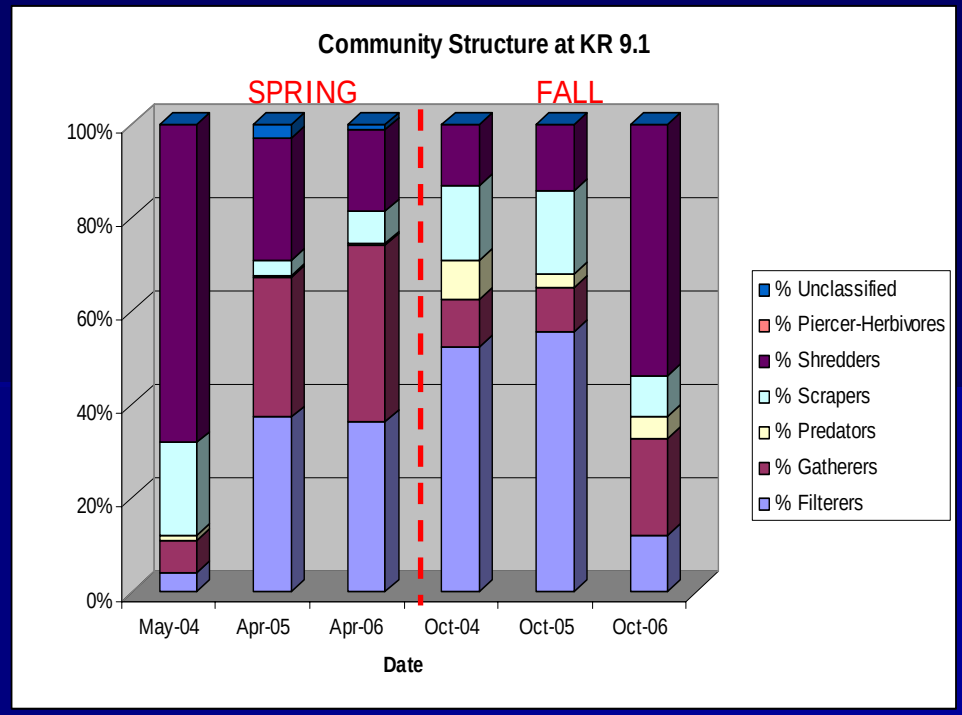



Community Trophic Structure at KR 10
Treatment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
% Scrapers
% Predators
% Gatherers
% Filterers


Community Trophic Structure at KR 9.1
Treatment
100%
80%
60%
40%
20%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
% Scrapers
% Predators
% Gatherers
% Filterers


Community Trophic Structure at KR 9.0
Treatment
100%
80%
60%
40%
20%
0%
May-04
Oct-04
Apr-05
Oct-05
Apr-06
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
% Scrapers
% Predators
% Gatherers
% Filterers


Community Trophic Structure at KR 10
SPRING
FALL
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-04
Apr-05
Apr-06
Oct-04
Oct-05
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
% Scrapers
% Predators
% Gatherers
% Filterers


Community Structure at KR 9.1
SPRING
FALL
100%
80%
60%
40%
20%
0%
May-04
Apr-05
Apr-06
Oct-04
Oct-05
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
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% Predators
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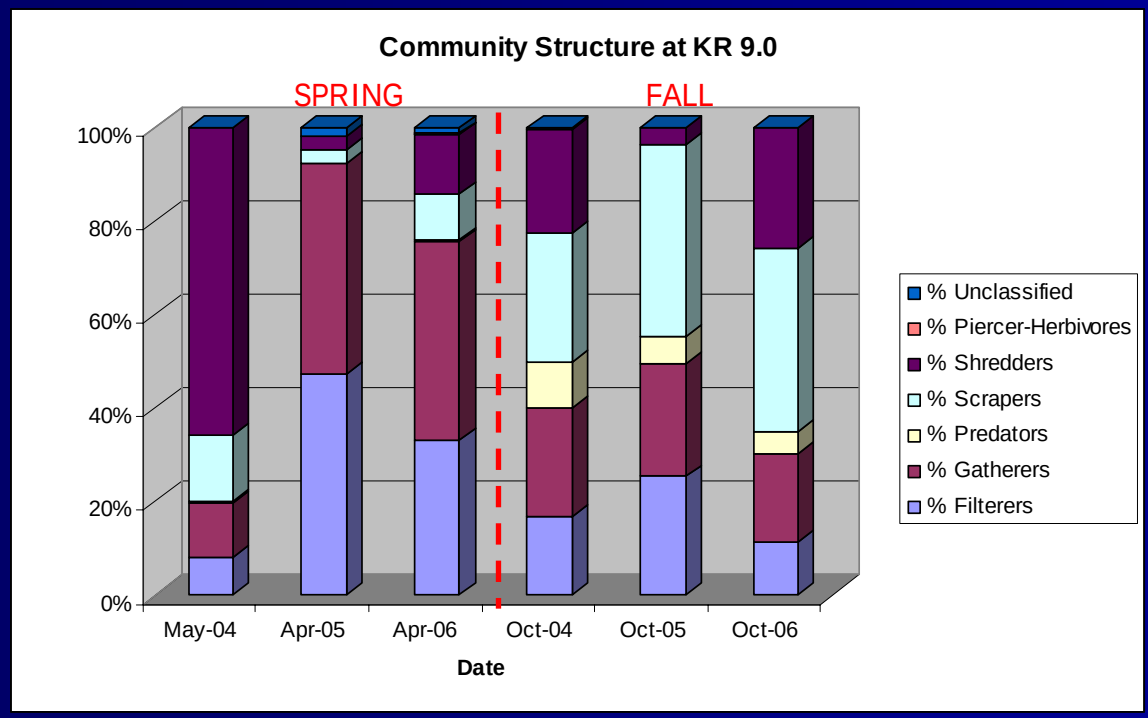
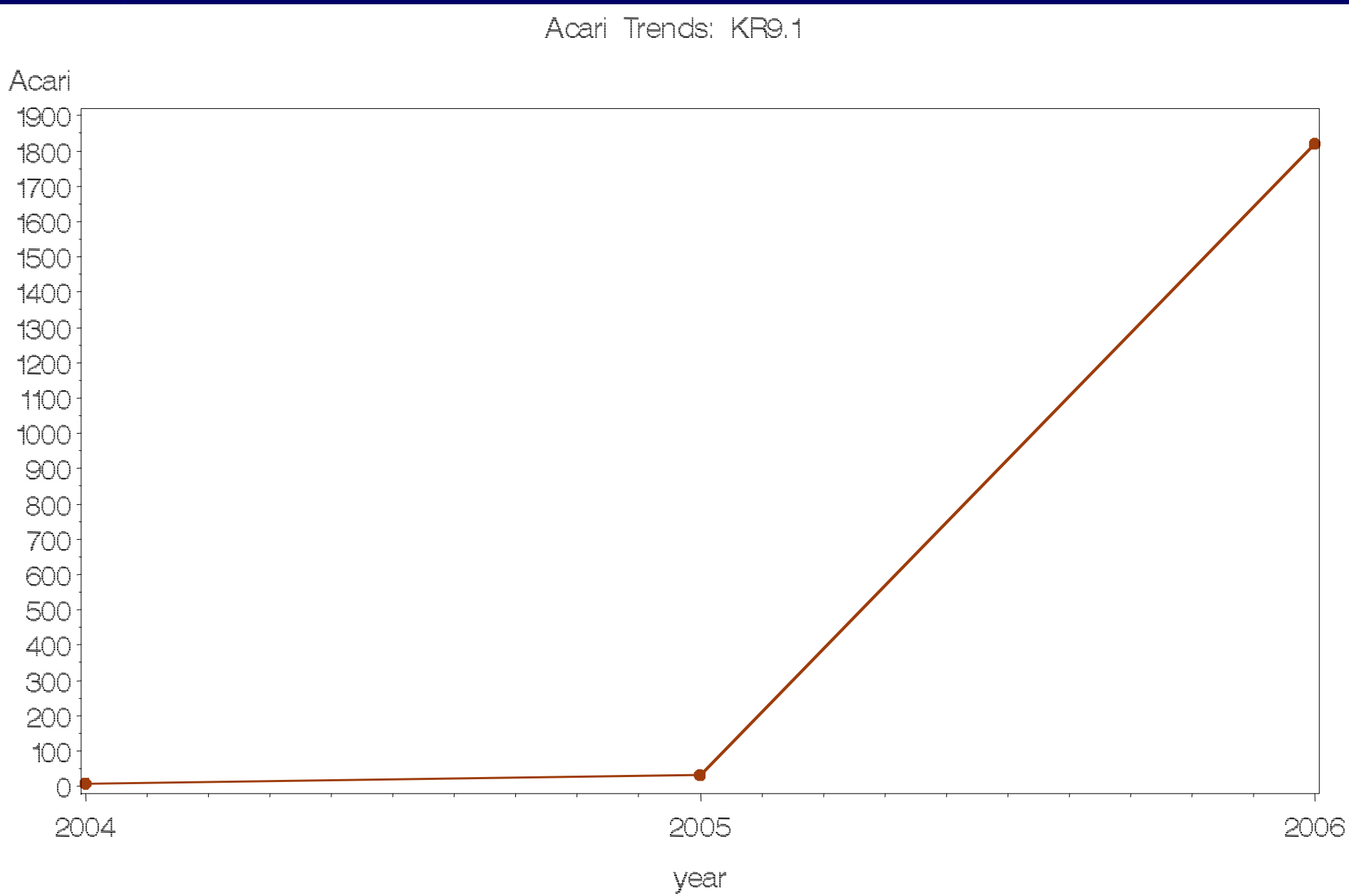
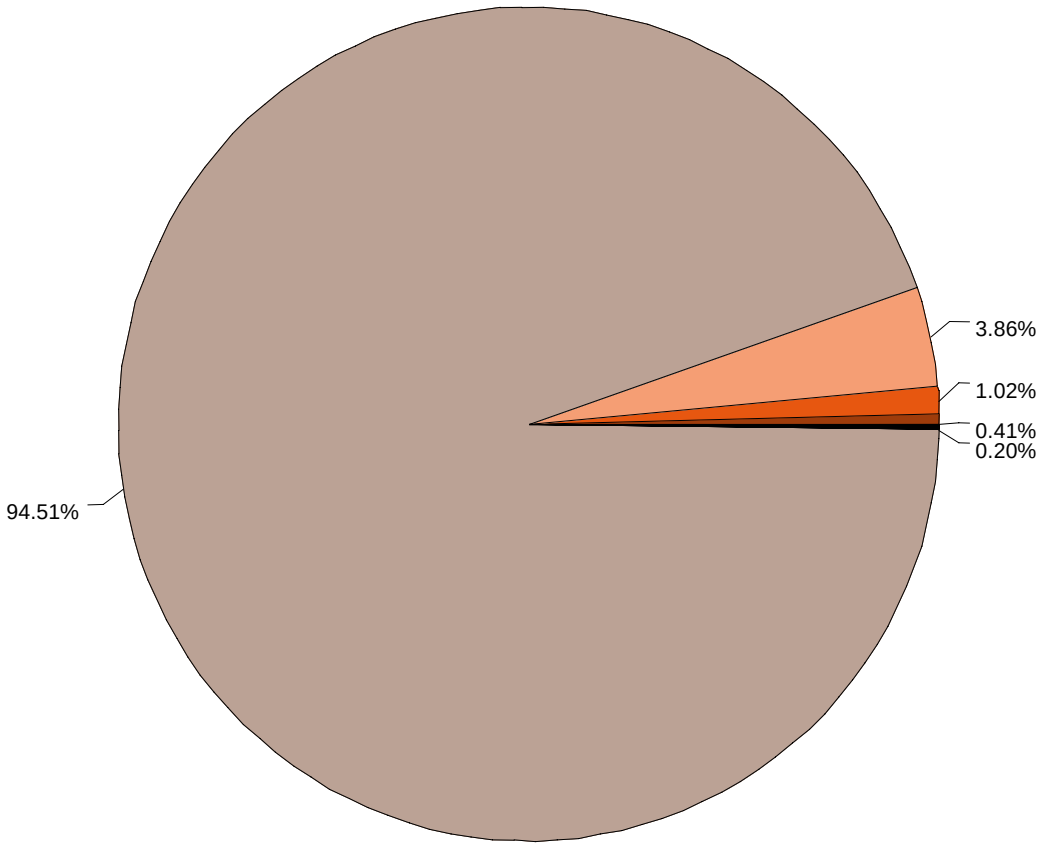
% Filterers

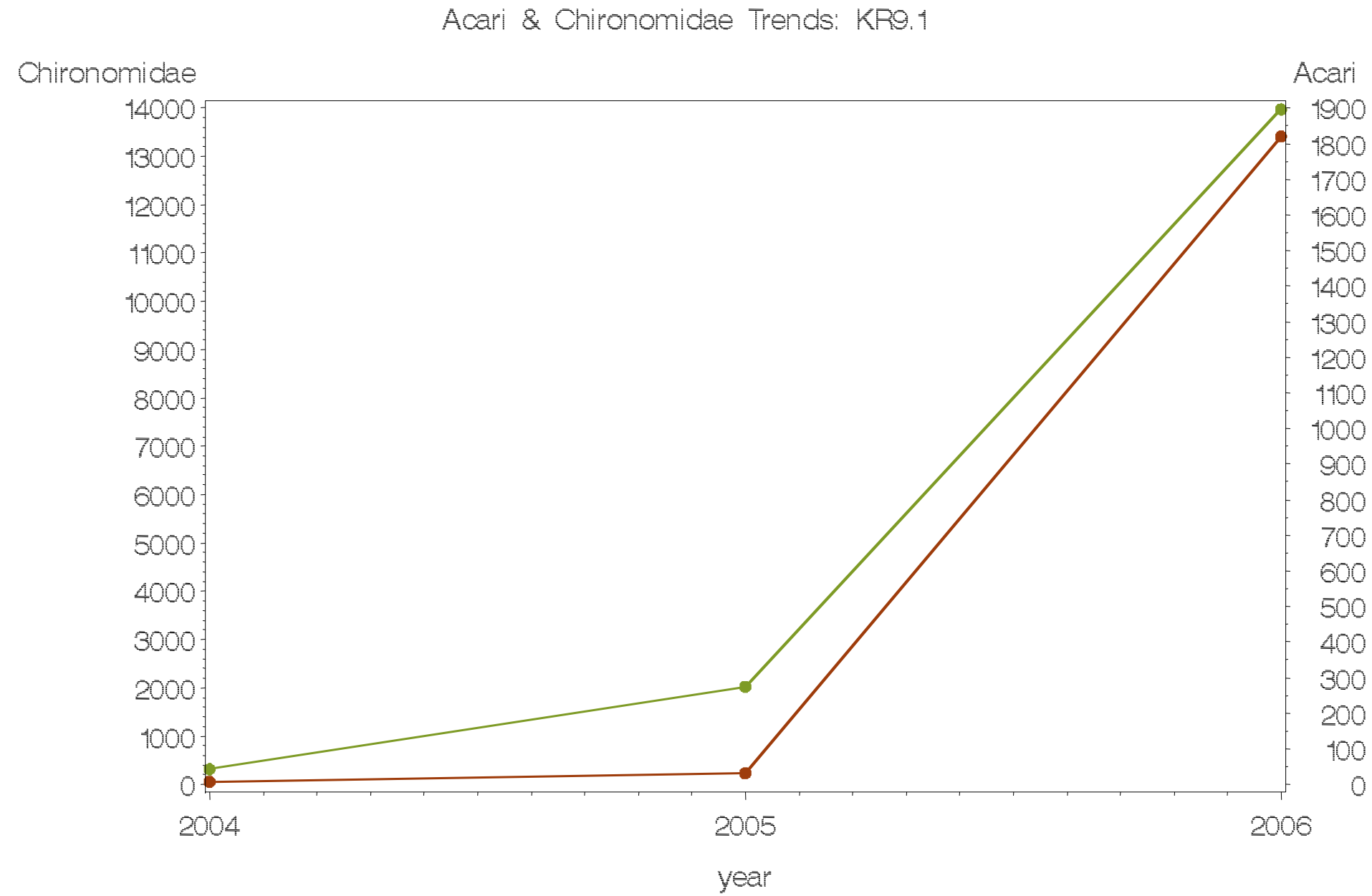

Community Structure at KR 9.0
SPRING
FALL
100%
80%
60%
40%
20%
0%
May-04
Apr-05
Apr-06
Oct-04
Oct-05
Oct-06
Date
% Unclassified
% Piercer-Herbivores
% Shredders
% Scrapers
% Predators
% Gatherers
% Filterers

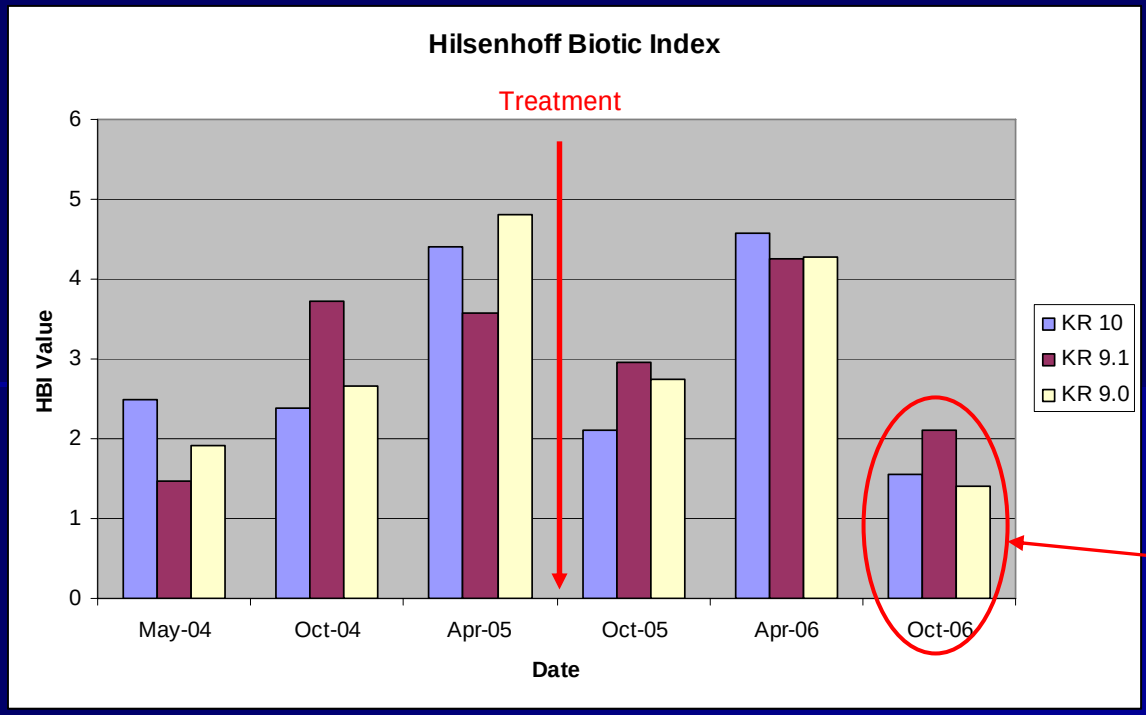

Acari Trends: KR9.1
Acari
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2004
2005
2006
year

Acari Species Composition

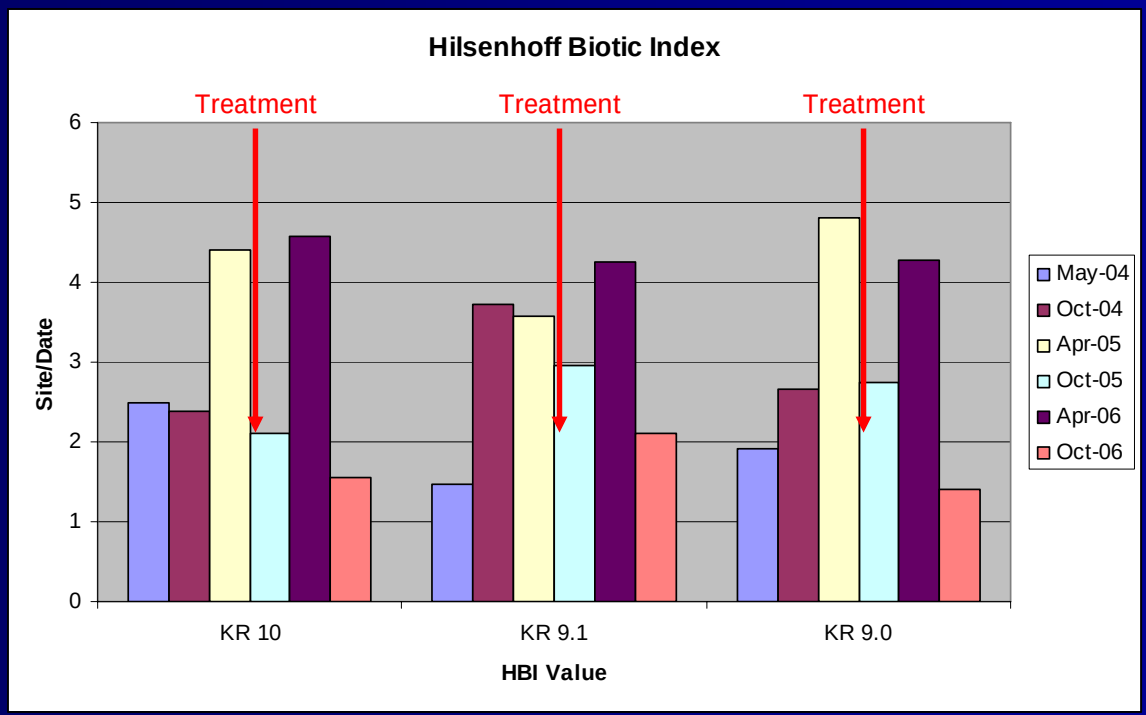
SUM of Frequency Count by species



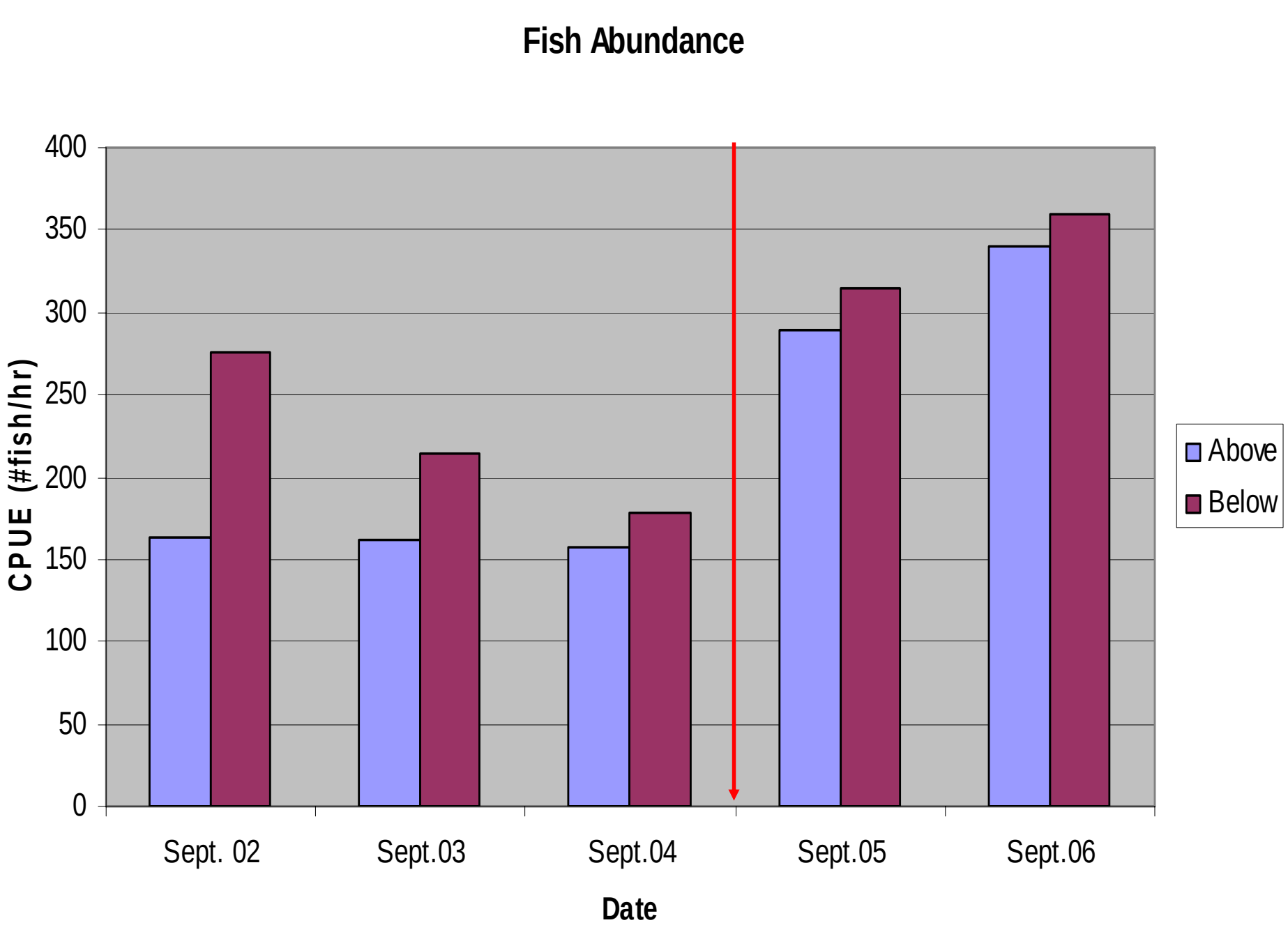

Acari & Chironomidae Trends: KR9.1
Chironomidae
Acari
14000
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
2004
2005
2006
year

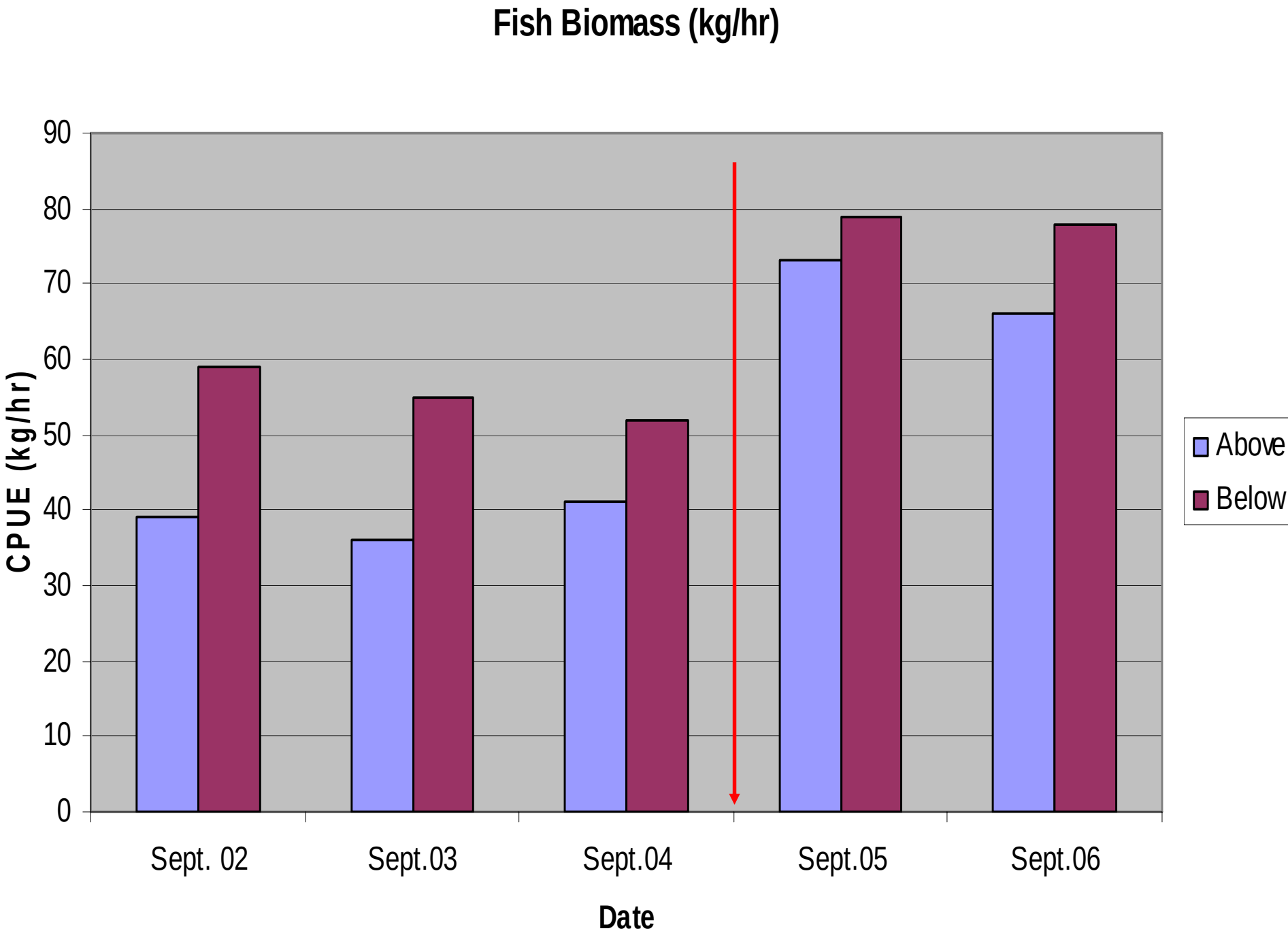


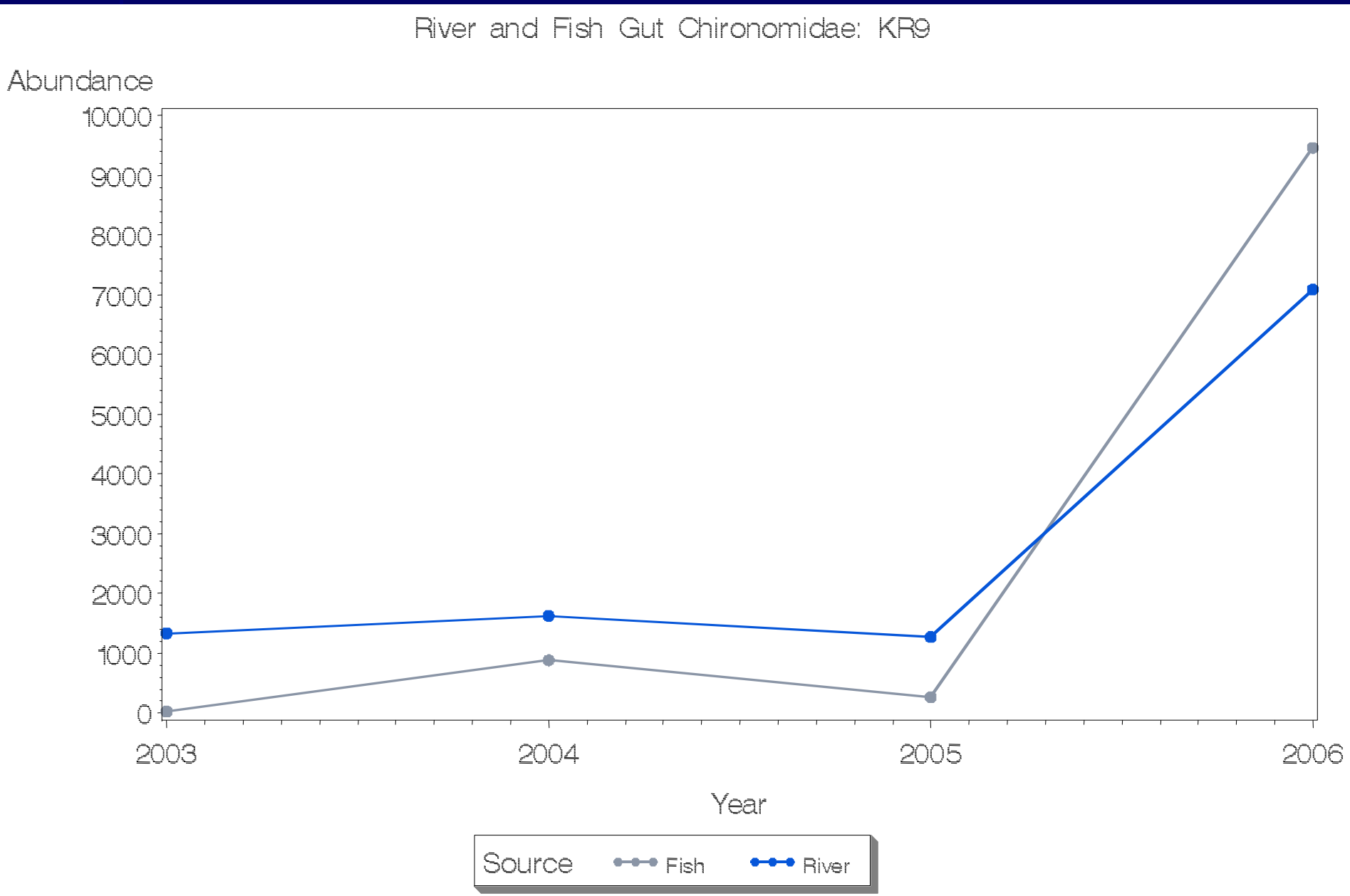
E. inermis/infrequens highly dominant




Fisheries


Fish Abundance
400
350
300
250
200
150
100
50
0
CPUE (#fish/hr)
Sept. 02
Sept.03
Sept.04
Sept.05
Sept.06
Date
Above
Below


Fish Biomass (kg/hr)
CPUE (kg/hr)
90
80
70
60
50
40
30
20
10
0
Sept. 02
Sept.03
Sept.04
Sept.05
Sept.06
Date
Above
Below


River and Fish Gut Chironomidae: KR9
Abundance
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
2003
2004
2005
2006
Year
Source
Fish
River

SUMMARY

- Saw immediate increase in primary productivity (ChlA) to 30km downstream
- Increase in macoinvertebrate density and biomass immediately below treatment; lesser response further downstream
- No significant alteration of macroinvertebrate community structure – getting more of the same bugs
- Starting to see response in fish diet– expecting (hoping) to see increase condition factor/numbers soon

Acknowledgements

- Charles Holderman, KTOI
- Ryan Hardy, IDFG
- BPA - funding