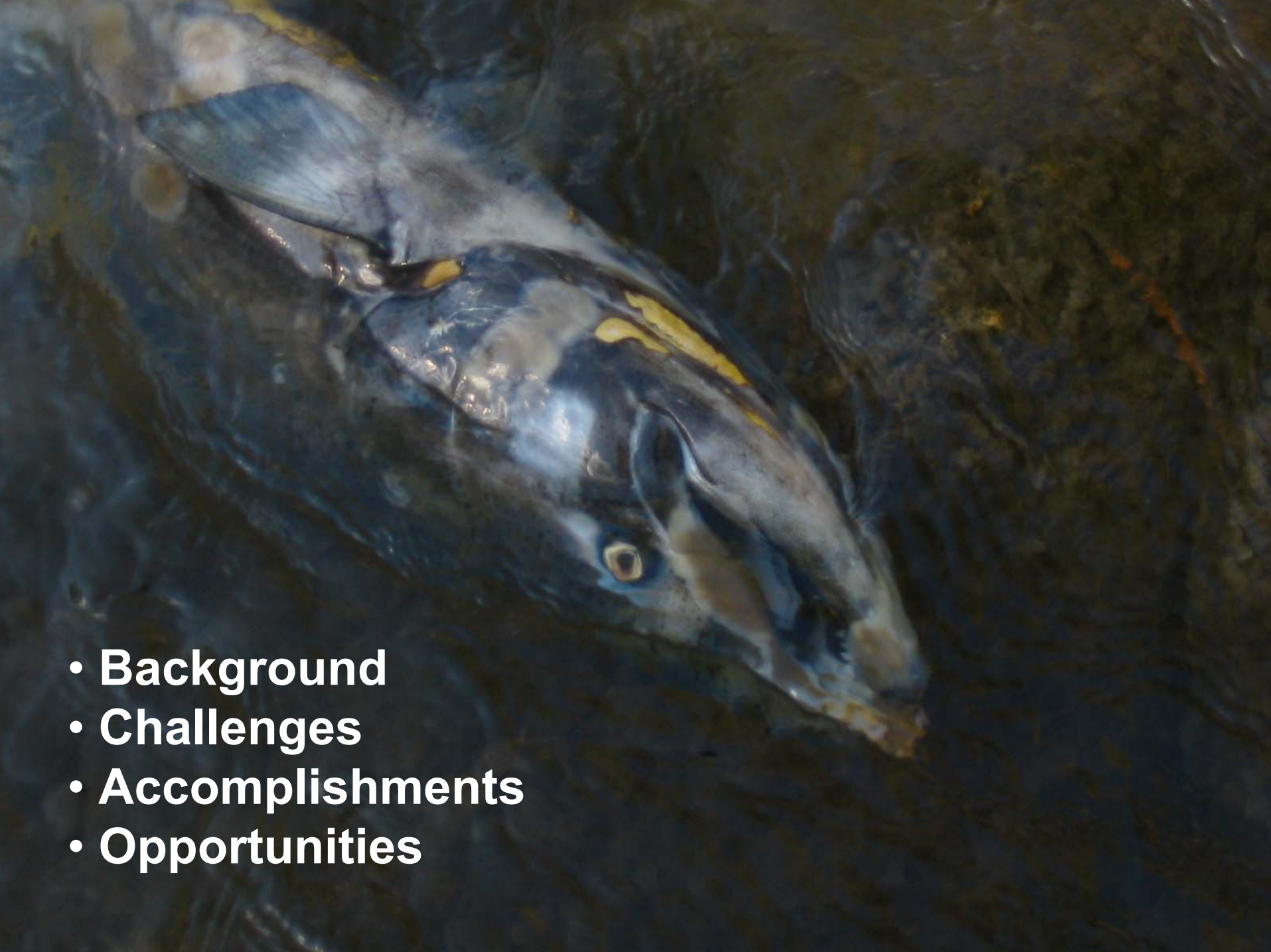


- Background
- Challenges
- Accomplishments
- Opportunities

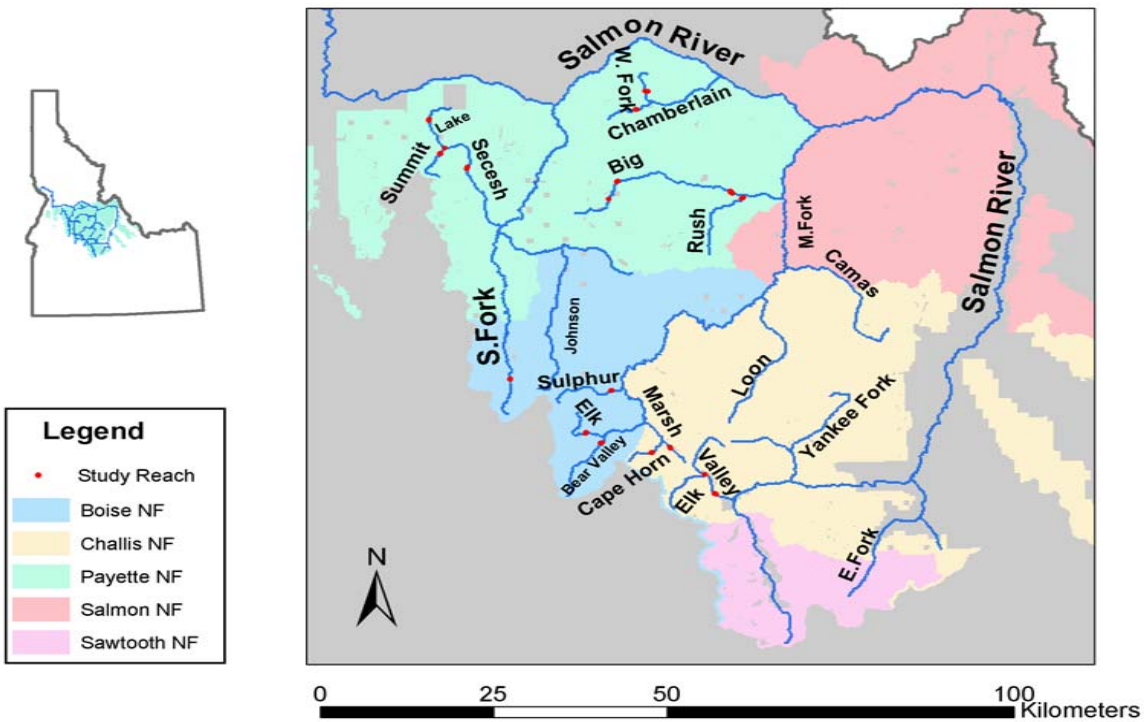
Question

- Can enhancing stream nutrients positively affect juvenile salmon?

- If so,
  - What is the best way to add nutrients?
  - Which streams might benefit most?

Multiple approaches

1. Comparative Study (17 streams)
2. Behavioral Studies
3. Experimental Studies

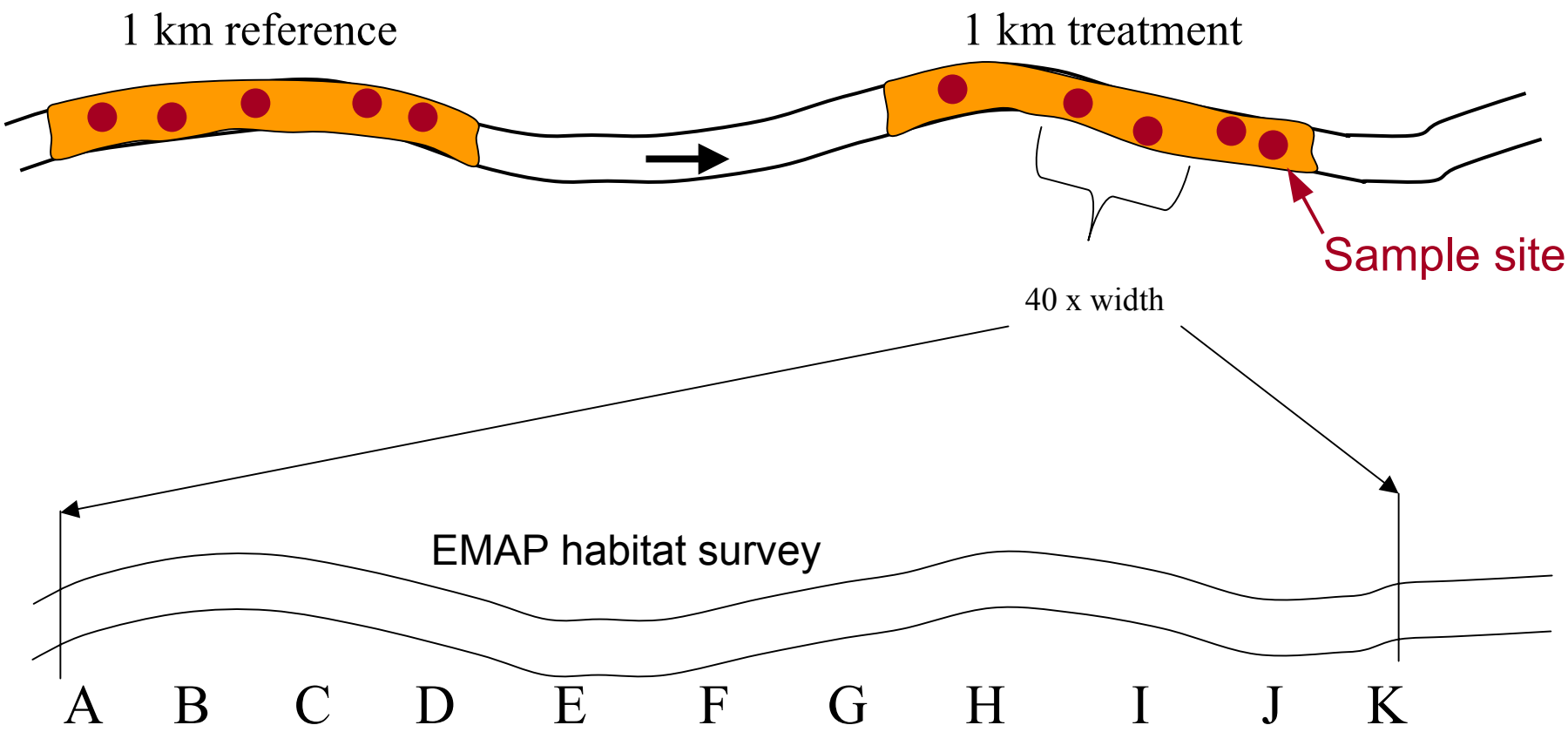


Comparative Study

- Chemical & physical habitat
- Nutrient limitation of periphyton
- Algal production
- Invertebrate biomass and drift
- Survey of whole fish community
- Juvenile fish size and survival
- Stable isotopes of food web

		REACH 1 Upstream	REACH 2 Downstream
Water Chemistry	[TN, TP] [PO4, Si(OH)4, NO3, NO2, NH3] Nutrient Limitation DOC Dissolved Oxygen Turbidity	3 riffles 3 riffles NO July and Sept, 3 riffles NO June and Aug, 3 riffles	3 riffles 3 riffles Yes, pre & post spawners July and Sept, 3 riffles NO June and Aug, 3 riffles
Primary Producer Community	Algal biomass (AFDM) (tiles and rocks) Chlorophyll a (tiles and rocks) Isotope Composition	5 riffles (Tiles only) 5 riffles (Tiles only) 3 riffles	5 riffles 5 riffles 3 riffles
Invertebrate Community	Community biomass / density Species composition Drift Isotope Composition – grazers, predators	NO	5 riffles 5 riffles July and Sept, 3 riffles 3 riffles
Decomposition	Leaf litter decomposition	NO	4 removal dates: between July and Sept
Fish: Community	Species composition Abundance/Density/Biomass Size and age structure (length and weight)	Snorkel survey Snorkel survey NO	Snorkel survey Snorkel survey NO
Individual	Length/weight/growth rate/condition Survival Salmonid diets Isotope Composition (2 dominant / 1 resident)	NO Achord NO Yes	NO Achord NO Yes
Physical-Hydrologic stream parameters	Temperature (PVC + caps) Discharge/Flow rates	Tidbits (1/stream) Flow meter and tennis ball methods	Tidbits (1/stream) NO
Predator Survey	Aquatic and terrestrial predators	Bird surveys	Bird surveys
Habitat Characterization	EMAP Habitat survey	Done – 2002 Except Loon/Camas/Marsh	August 2003

Stream Sampling Design



Behavioral Study

- feeding behavior

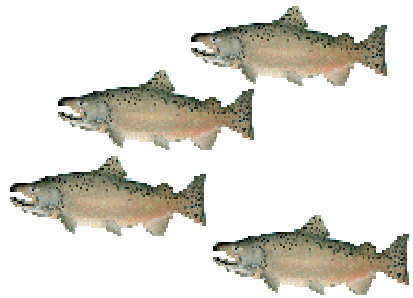
- habitat use

- interactions with other fish

Experimental Studies

Whole Ecosystem Experiment

Treatment	Number of Replicates
Analog	2
Carcass	2
Inorganic Pellets	2
Control	2



Nutrients

Juvenile salmonids

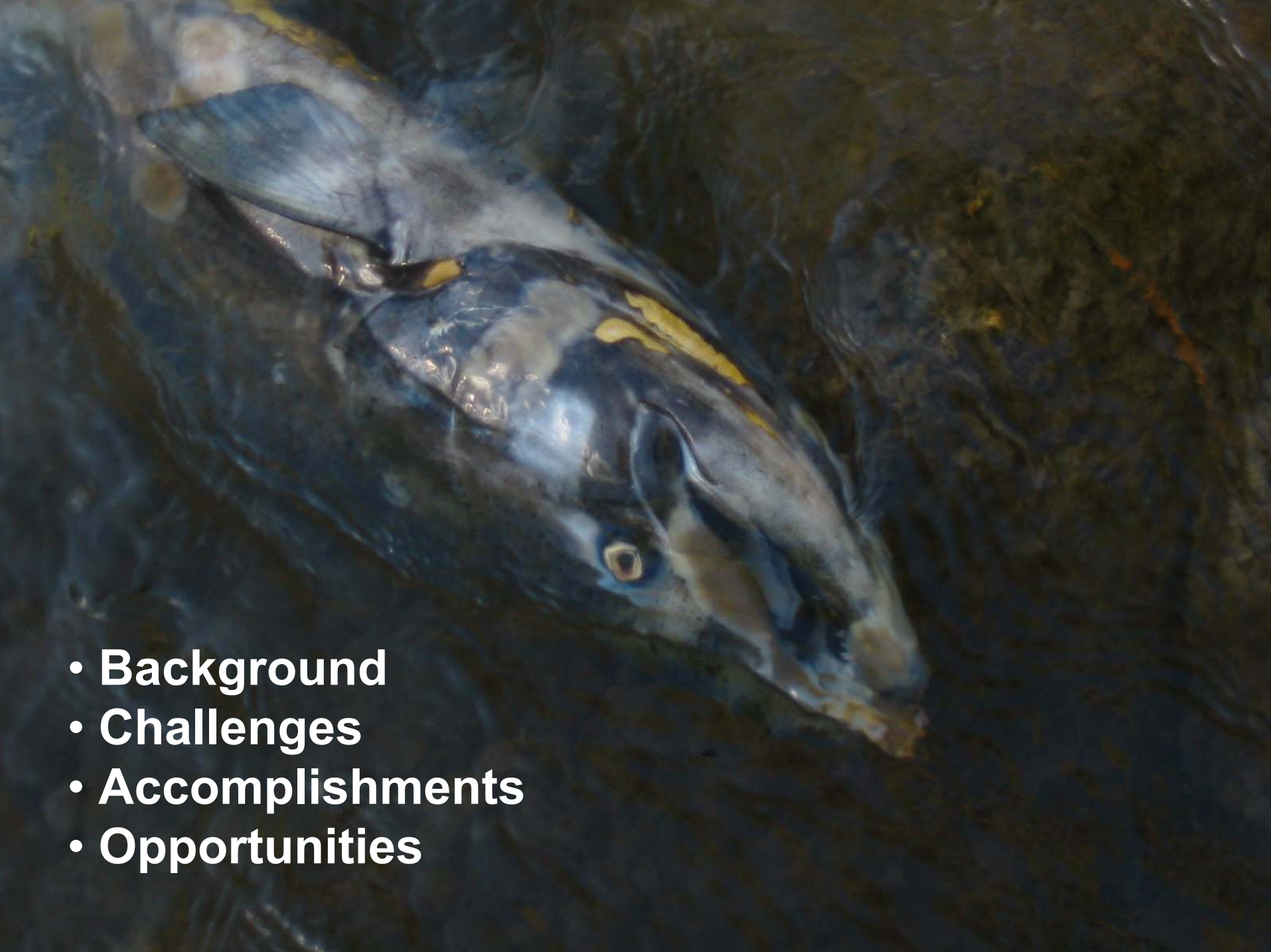
Riparian species

Periphyton

Invertebrates

Native trout and non-native species

Habitat



- Background
- Challenges
- Accomplishments
- Opportunities

Study timeline

	2001	2002	2003	2004
Baseline monitoring	Before	Before	During	After
Stream enclosure/channel experiments				
Ecosystem nutrient enrichment experiment				

Plan A

Proposal submitted in 2000
Coordination among WDFW, ShoBans, Yakama and NOAA in 2001
Contract in legal dispute and awarded in spring 2002

Permits 2004

USFS National Forest Permits (requests submitted for modifications to existing permits)
- Boise (Level 1 meeting, June 2004)
- Payette
- Salmon-Challis
- Sawtooth National Recreation Area

IDFG Permit (fish sampling)
ESA (modification to permit requested)
Department of Environmental Quality
USFW (Bull Trout)
NEPA

Permits 2003

USFS National Forest Permits
- Boise (received)
- Payette (received)
- Salmon-Challis (received)
- Sawtooth National Recreation Area (received)
- Boise National Forest Biological Assessment of Invertebrate Sampling and Stream Enclosure Experiments (Level 1 meeting 4/30/03)

ESA Permit Section 10 (Salmon and Steelhead: #1402)
ESA Permit Section 7 (Bull Trout; permit # 1-7-00-F-336, Study 2 request under review)
IDFG Permit Request
USFW (Bull Trout)
NEPA

Permits 2002

USFS National Forest Permits
- Boise (ID#BOI003601, issued8/1/02, no invertebrate sampling permitted)
- Payette (ID#MCC033, issued 8/09/02)
- Salmon-Challis (Yankee Fork sites approved; Middle Fork sites were not)
- Sawtooth National Recreation Area (File Code 2700, issued 8/22/02)

ESA Permit (#1056, Study 3)
USFW (Bull Trout)
IDFG Permit Request (Not Approved)
NEPA

Permits 2005

Department of Environmental Quality
IDFG
NEPA

27 months of people time

Permit-related meetings with state, tribal and federal entities

Date	NOAA Staff	Organization	Attending
June 2001	Sanderson, Kiffney, Hockersmith	Ellensburg, WA (Shoshone Bannock, WDGW, Yakama Nation, Weyerhaeuser)	Todd Pearsons, Doug Taki, Mike Haddix, Bill Sharp, Bob Bilby
March 2002	Sanderson, Kiffney, Coe	Idaho State of Fish and Game, Shoshone Bannock	Steve Yundt, Mike Haddix
May 2002	Sanderson, Coe	United States Forest Service, Idaho State of Fish and Game, Nez-Perce Tribe, Bonneville Power Administration	Dave Burns, Jane Cropp, Quinn Carver, Jason Dunham, Russ Thurow, Dan Issak, Virgil Moore, Charlie Petrosky, Jeff Lutch, Steve Yundt, Felix McGowan, Peter Lofy
June 2002	Sanderson, Amerson	NMFS (Boise), United States Forest Service (Payette, Boise, Salmon-Challis, Sawtooth NRA), Bonneville Power Administration, Nez-Perce Tribe	Gary Rule, David Fornander, Jane Cropp, Kathy Nash, Dave Burns, Roger Nelson, Cam Meyer, Paul Bryant, Michael Kellett, Joseph Vacirca, Mark Moulton, Felix McGowen, Peter Lofy, Shannon Stewart
Feb 2003	Sanderson, Coe, Kiffney, Macneale, Tran	Weyerhaeuser, British Columbia Ministry of Water, Land and Air Protection	Bob Bilby, Ken Ashley
Feb 2003	Sanderson, Coe, Tran	United States Forest Service - Payette National Forest	Dave Burns, Kathy Nash, Jane Cropp, Jenni Blake
	Sanderson, Coe, Tran	United States Forest Service - Boise National Forest	Paul Bryant, Michael Kellett
	Sanderson, Coe, Tran	United States Forest Service - Rocky Mountain Research Station	Russ Thurow
March 2003	Sanderson, Kiffney, Tran	United States Forest Service - Rocky Mountain Research Station	Jason Dunham, Amanda Rosenburg
	Sanderson, Kiffney, Tran	Idaho State of Fish and Game	Steve Yundt, Bill Horton, Jeff Lutch, Peter Lofy
	Sanderson, Kiffney, Tran	United States Forest Service - Boise National Forest	Mike Kellett
	Sanderson, Tran	United States Forest Service – Sawtooth National Recreational Area	Scott Loos
	Sanderson, Tran	United States Forest Service – Salmon-Challis National Forest	Patty Bates, Joey Vacirca, Russ Camper
April 2003	Sanderson	United States Forest Service - Boise National Forest	Michael Kellett, Lisa Nutt, Jim Nutt, Edna Vizgirdas, Allyson Turner, Debbie Artimez
March 2004	Sanderson, Tran, Drake	Idaho State of Fish and Game	Keith Johnson, Kim Apperson, Dale Allen, Jeff Lutch, Bill Horton, Gene McPherson
	Sanderson, Tran, Drake	United States Forest Service - Payette National Forest	Dave Burns, Kathy Nash, Jane Cropp
April 2004	Sanderson, Coe, Drake	Idaho State of Fish and Game	Jeff Lutch, Sam Sharr, Kim Apperson, Jerry Lockhart, Bill Horton, Sharon Kiefer
	Sanderson, Coe, Drake	United States Forest Service - Rocky Mountain Research Station	Bruce Rieman, Jason Dunham
	Sanderson, Coe, Drake	United States Forest Service - Boise National Forest	Michael Kellett, Laurie Fink
June 2004	Macneale, Tran	United States Forest Service - Boise National Forest	Michael Kellett, Lisa Nutt, Jim Nutt, Edna Vizgirdas, Allyson Turner, Debbie Artimez

Study timeline

	2001	2002	2003	2004
Baseline monitoring	Before	Before	During	After
Stream enclosure/channel experiments				
Ecosystem nutrient enrichment experiment				

	2001	2002	2003	2004
Baseline monitoring	Partial	Partial	Complete	Complete
Stream enclosure/channel experiments			Complete	
Ecosystem nutrient enrichment experiment				

Plan B

Table 3. Streams included in baseline monitoring efforts of the nutrient enhancement study.

	Forest	Sho-Ban or Wilderness	ISS	Other – Carcasses in SF drainage only	Nutrient Enhancement
Bear Valley	Boise		C		Analog
Elk	Boise				Inorganic
South Fork	Boise		T		Carcass
Lower Big	Payette				
Rush	Payette				
Chamberlain	Payette				
WF Chamberlain	Payette			Permitted reach outside of anadromous zone	
Lake	Payette		C		
Secesh	Payette		C	Permitted reach insufficient	
Summit	Payette				
Camas	Salmon-Challis			Access, border wilderness	
Cape Horn	Salmon-Challis	Analog			
Loon	Salmon-Challis			Access, border wilderness	
Marsh	Salmon-Challis	Control	C		
Sulphur	Salmon-Challis			Access, border wilderness	Analog
Elk Creek Trib	Sawtooth	Analog			
Valley	Sawtooth	Control	C		

Study timeline

	2001	2002	2003	2004
Baseline monitoring	Before	Before	During	After
Stream enclosure/channel experiments				
Ecosystem nutrient enrichment experiment				

	2001	2002	2003	2004	2005 ?
Baseline monitoring	Partial	Partial	Complete	Complete	
Stream enclosure/channel experiments			Complete		
Ecosystem nutrient enrichment experiment					

Plan C ?

Our specific goal for summer 2004 is to select and monitor sites that will be acceptable by all parties for nutrient enhancement in 2005.

The streams: What have we learned from baseline monitoring?

Response Variables

i. Fish

ii. Chemistry

iii. Periphyton & Invertebrates

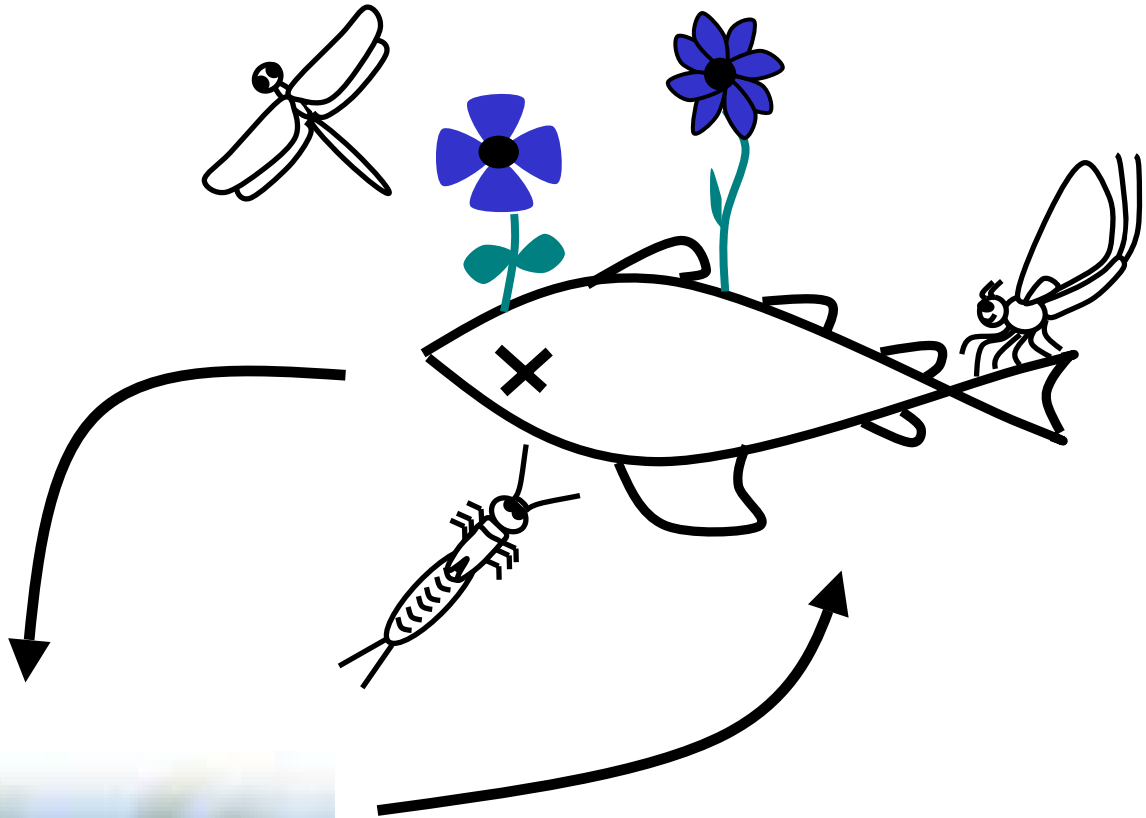
iv. Isotopes

v. Non-native species

- Background
- Challenges
- Accomplishments
- Opportunities

Baseline Parameters Monitored
Summer 2003/2004

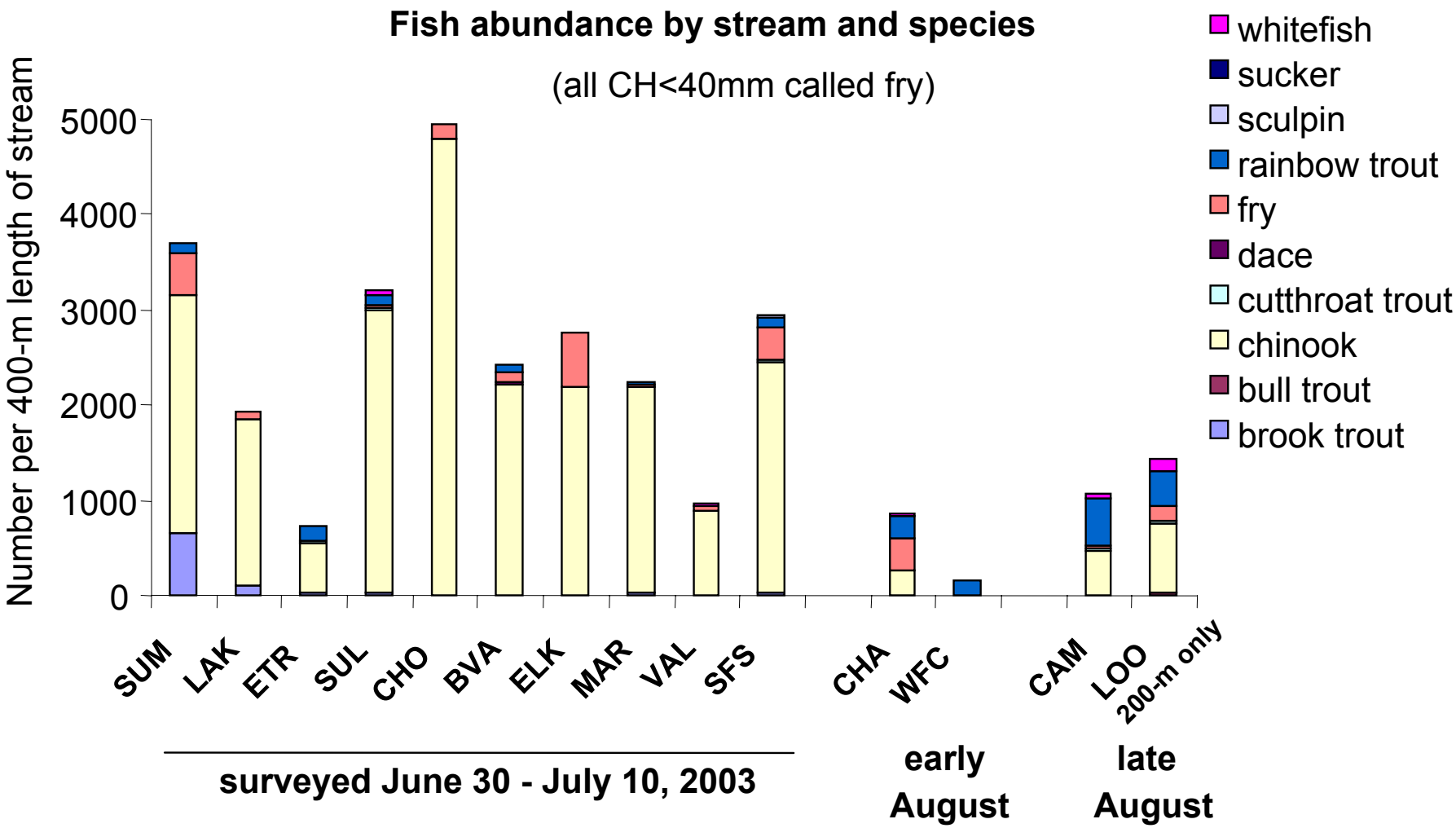
Water Chemistry	Primary Productivity	Invertebrate Community	Temperature Discharge	Physical Characterization	Fish Community	Fish Stable Isotopes
Water collection Nutrient limitation	Biomass (rocks and tiles) Decomposition rates Stable isotopes	Hess sampling Drift sampling Stable Isotopes	Tidbits Measure flow	Habitat survey	Snorkeling survey	Fish collections
3-4 sampling events	3-4 sampling events	2-3 sampling events	Measured over 3-4 months	1 sampling event	1 sampling event	2 sampling events



Fish through space and time:

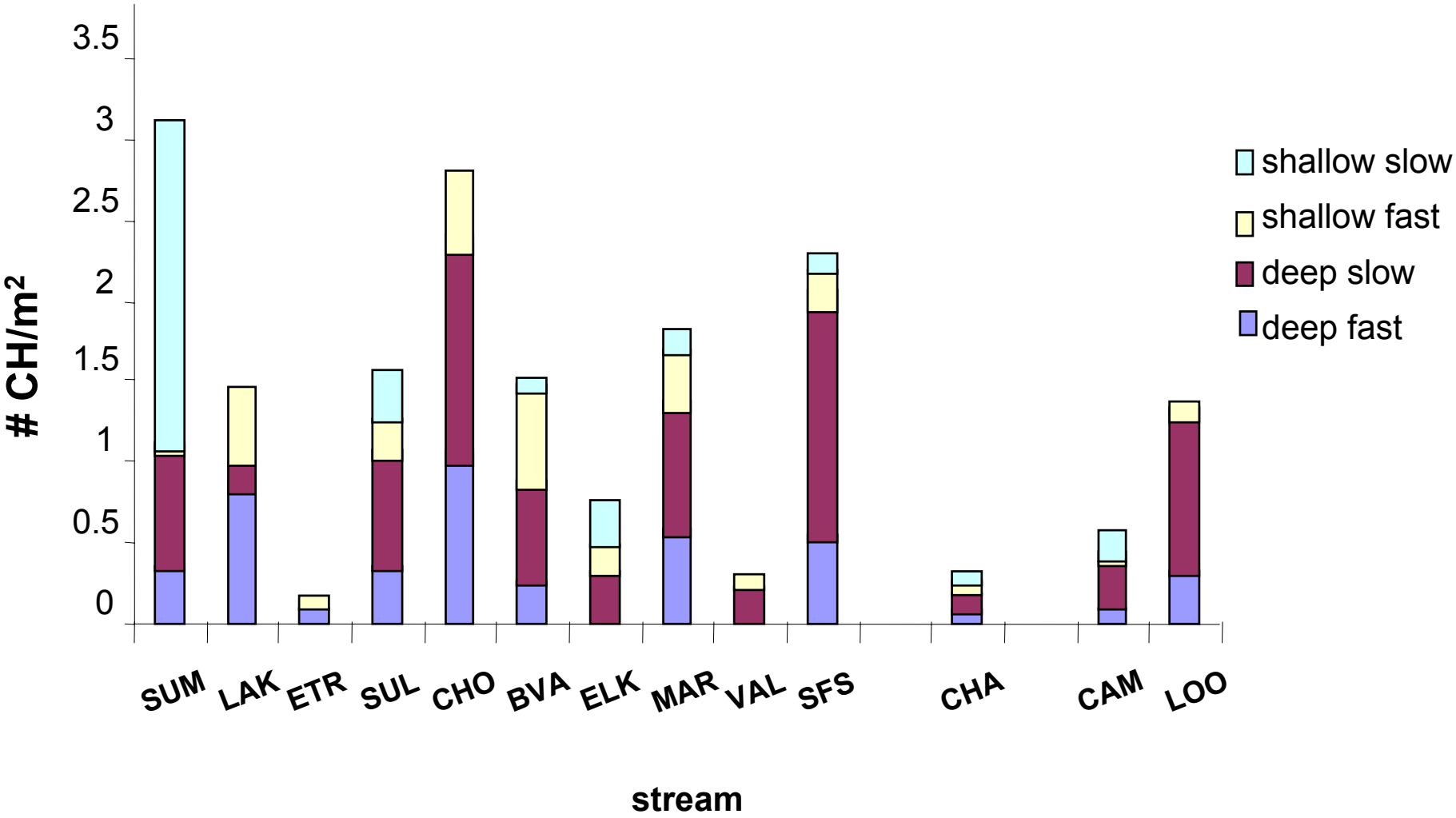
- species composition and distribution

- chinook survival, abundance and size

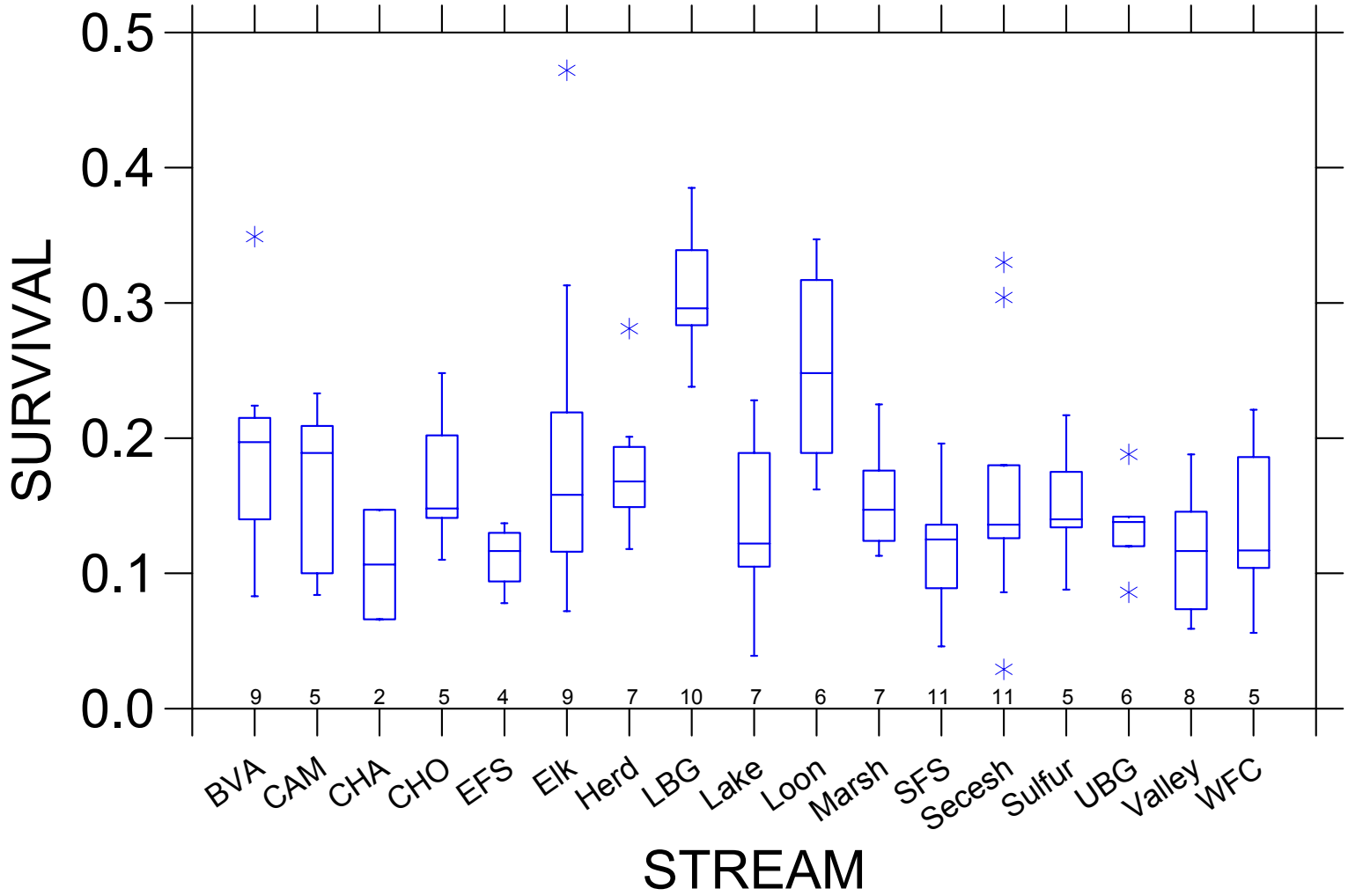


snorkel survey 2003

Chinook by stream and habitat

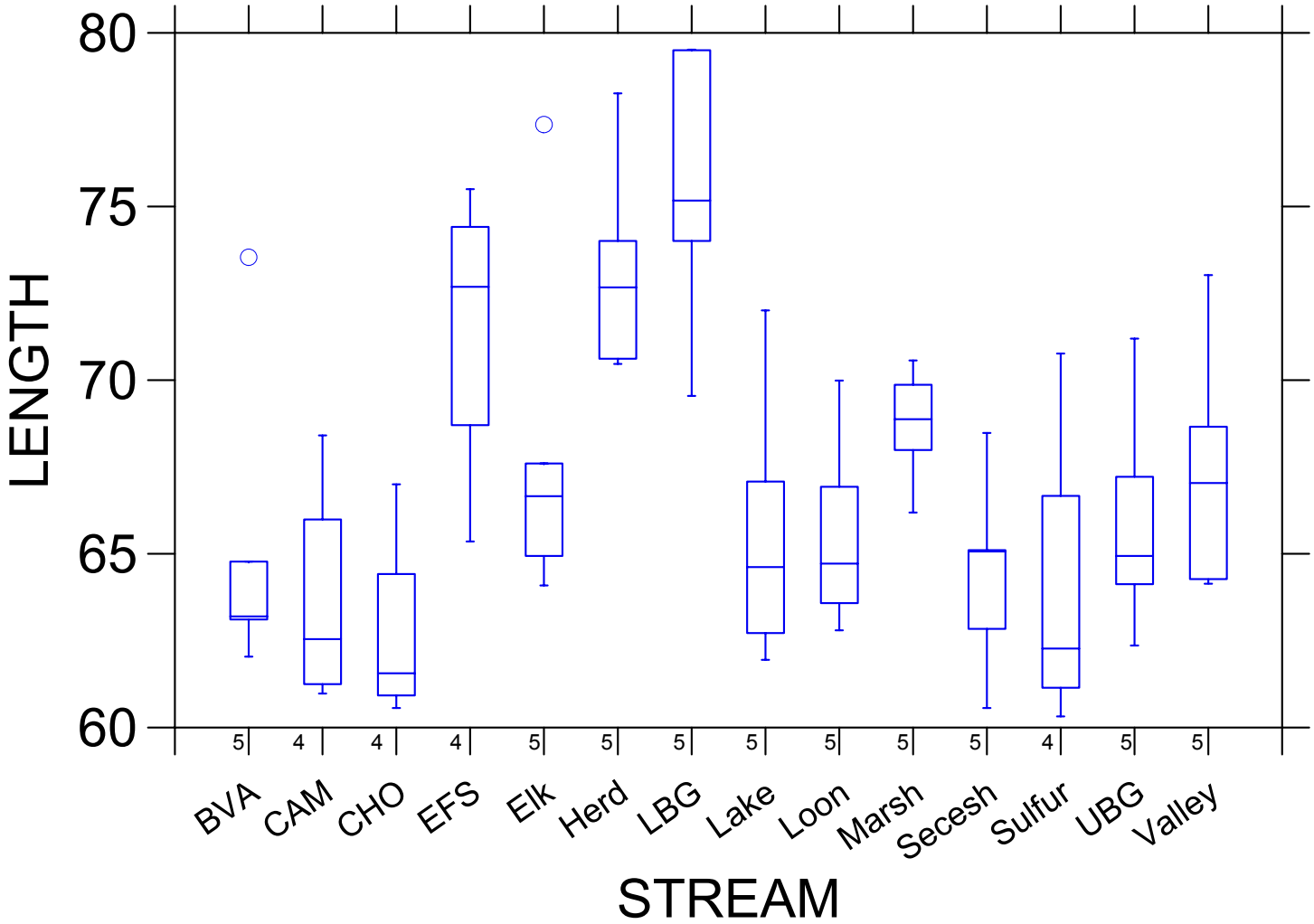


snorkel survey 2003



Zabel & Achord

1992-2002

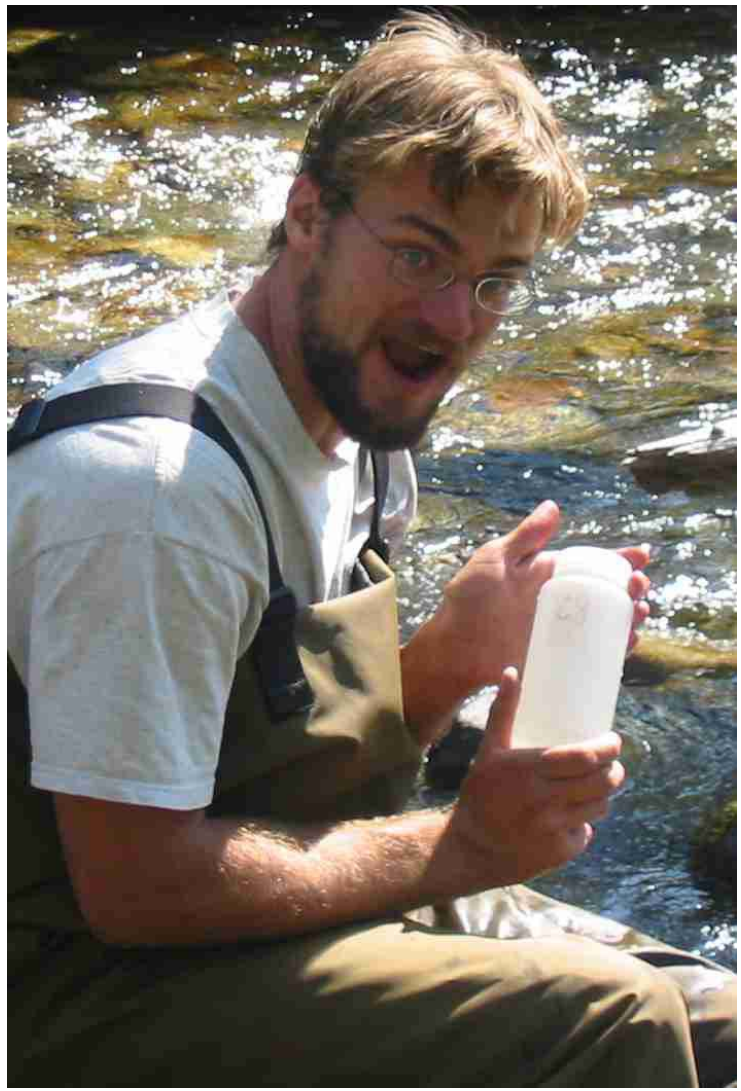


Zabel & Achord

1992-1994, 1998-1999

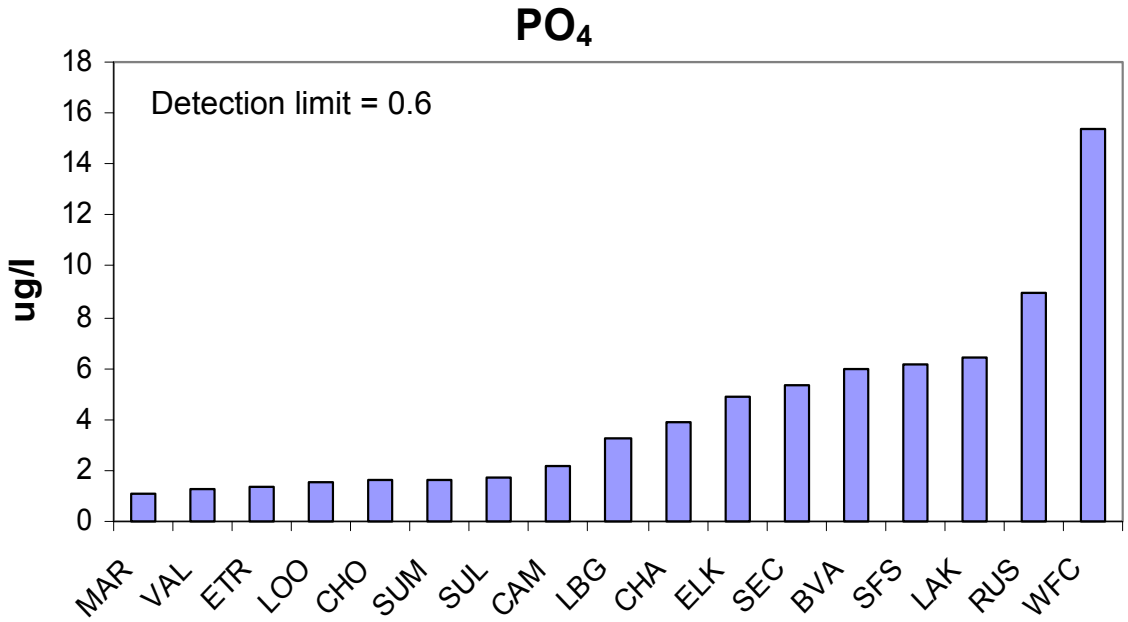
Chemistry

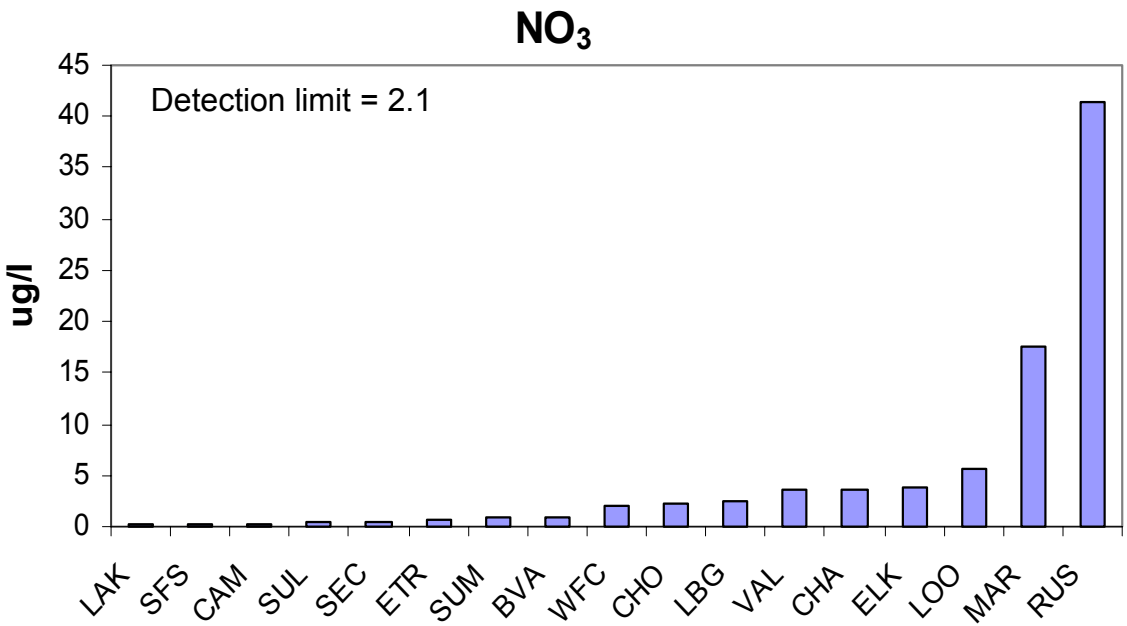
1) What are concentrations?
2) How do they vary?
   a) Time
   b) Space
3) Are nutrients limiting?



Average concentrations

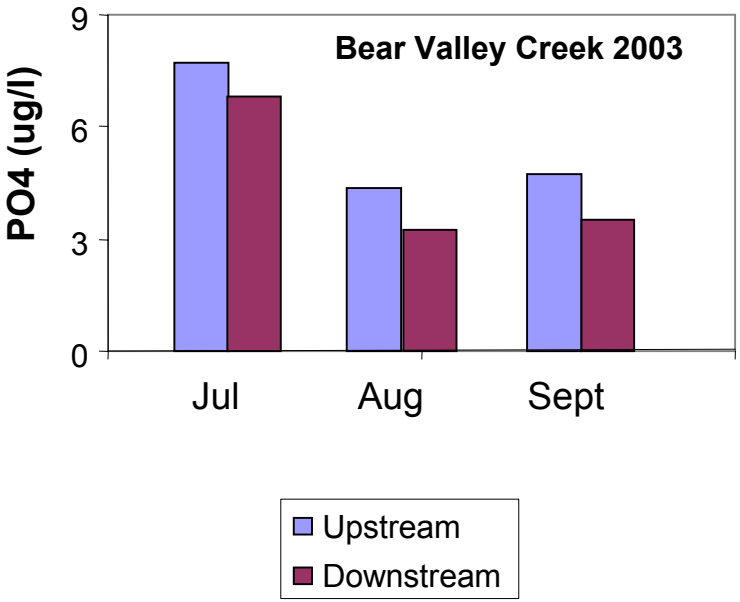
June-September 2003





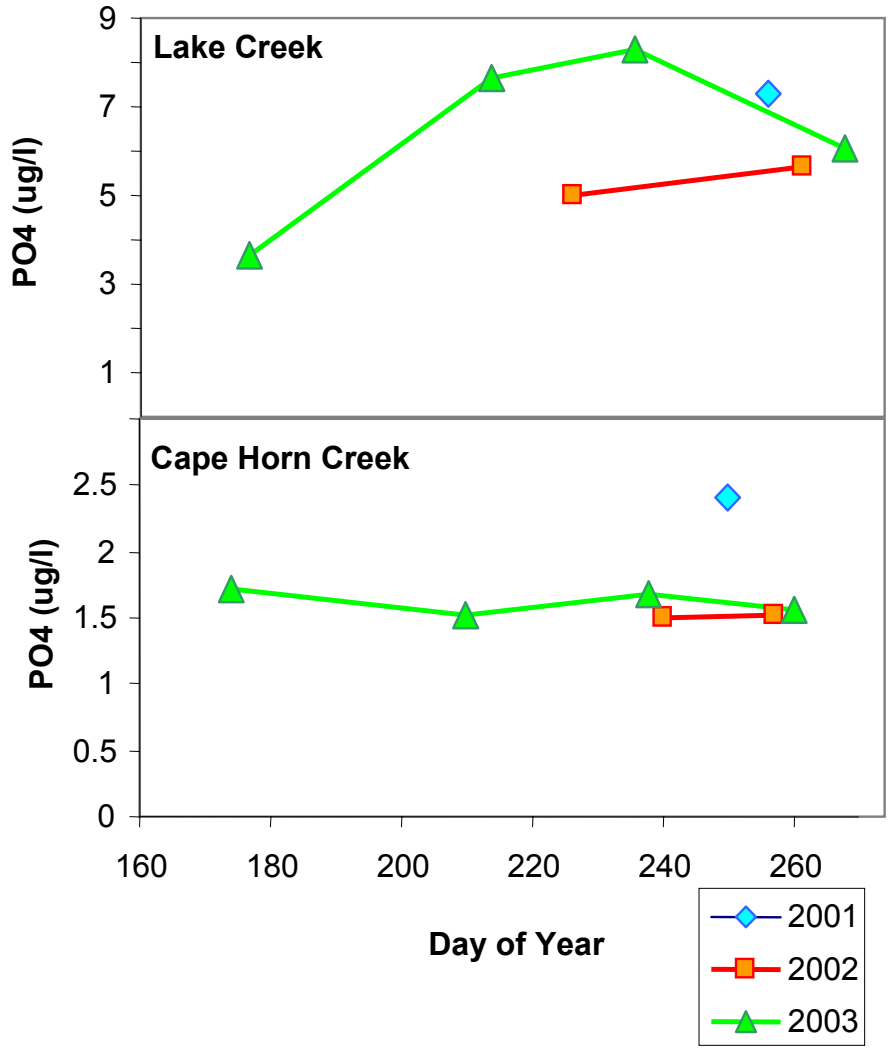
Space

- upstream vs. downstream

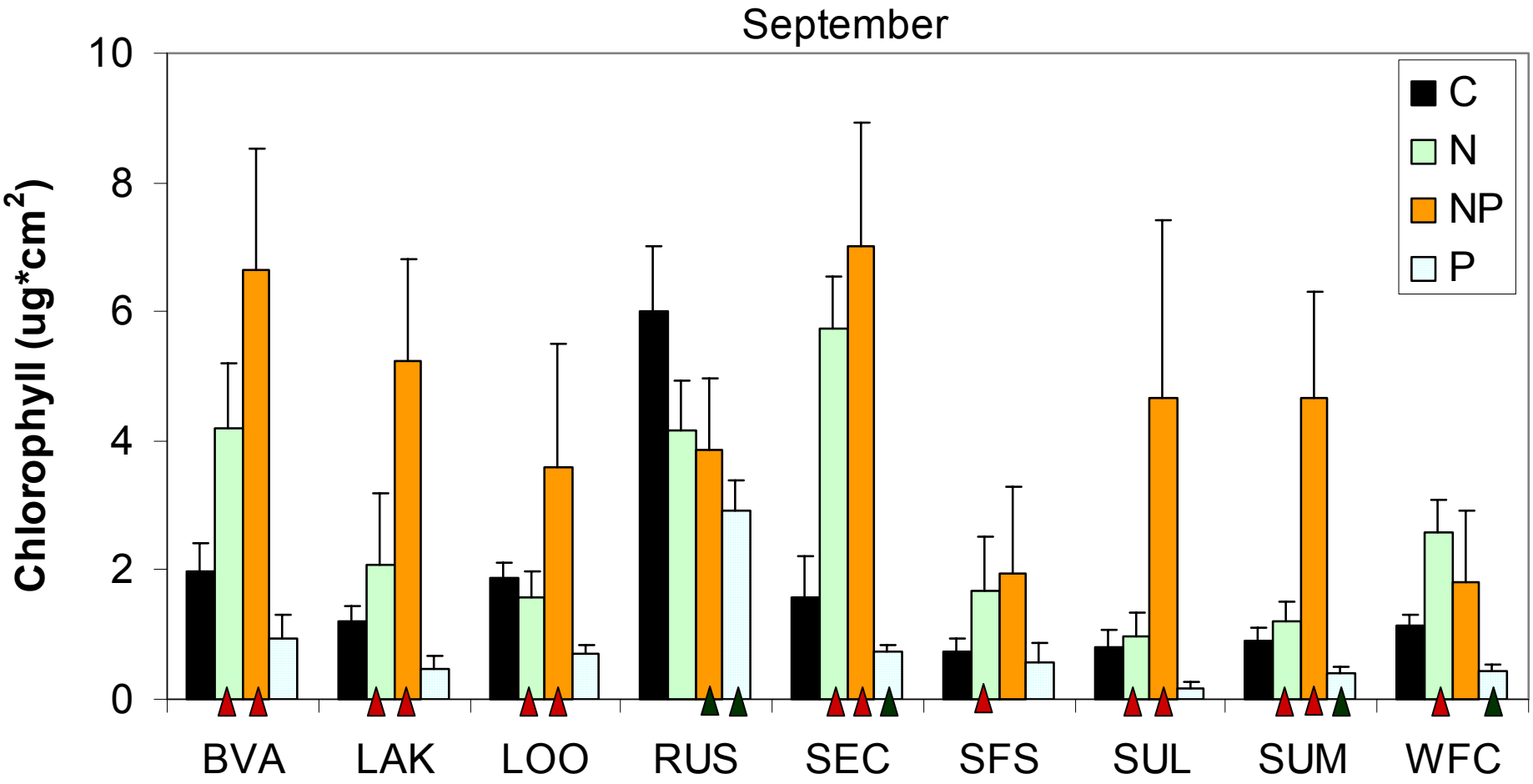


Time

- within year
- across years



Nutrient Limitation Assessment



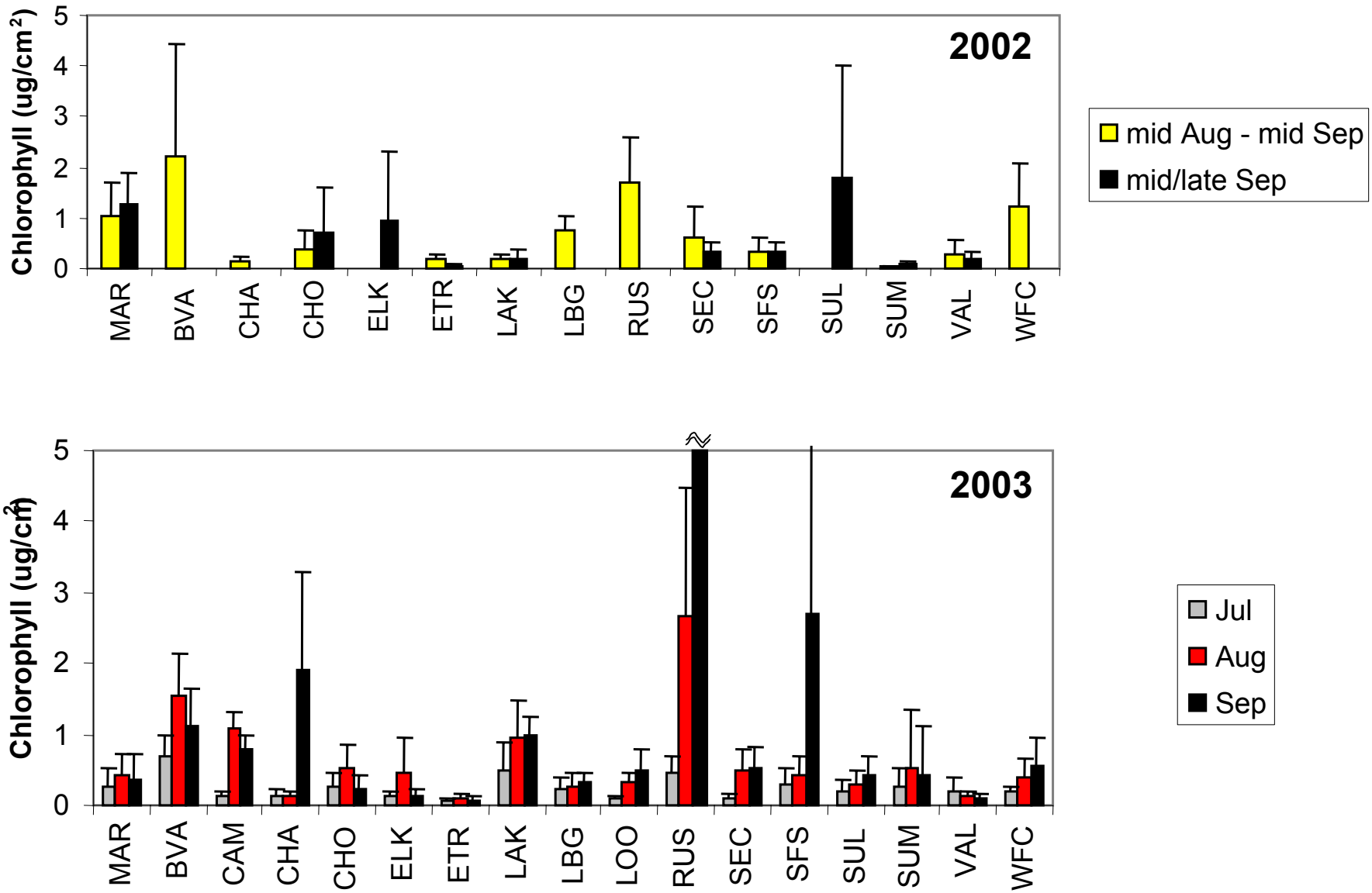
- N-limited (except RUS and LOO?)
- Co-limited (except RUS, SFS, WFC)

Significant p<0.05

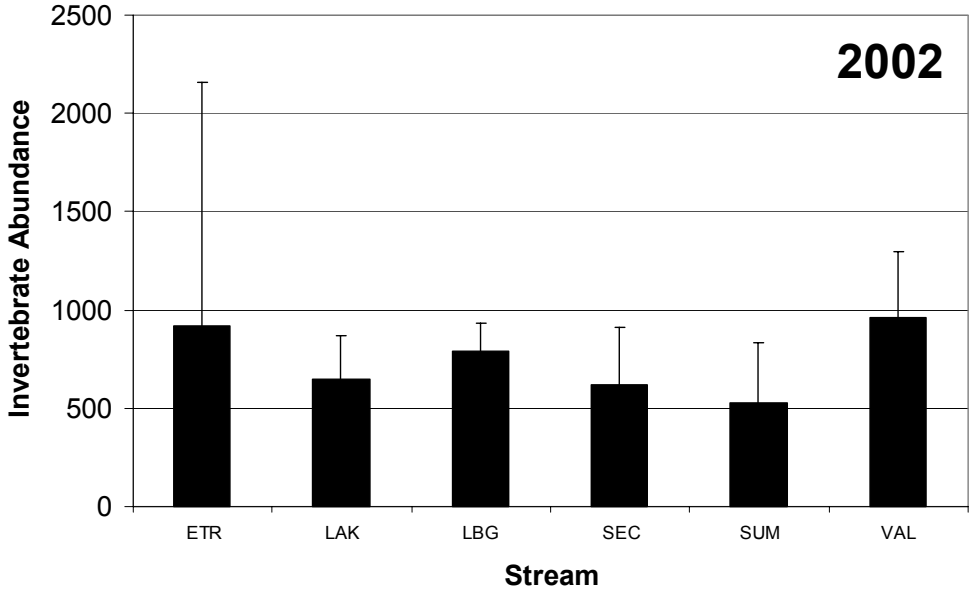
Sig. lower

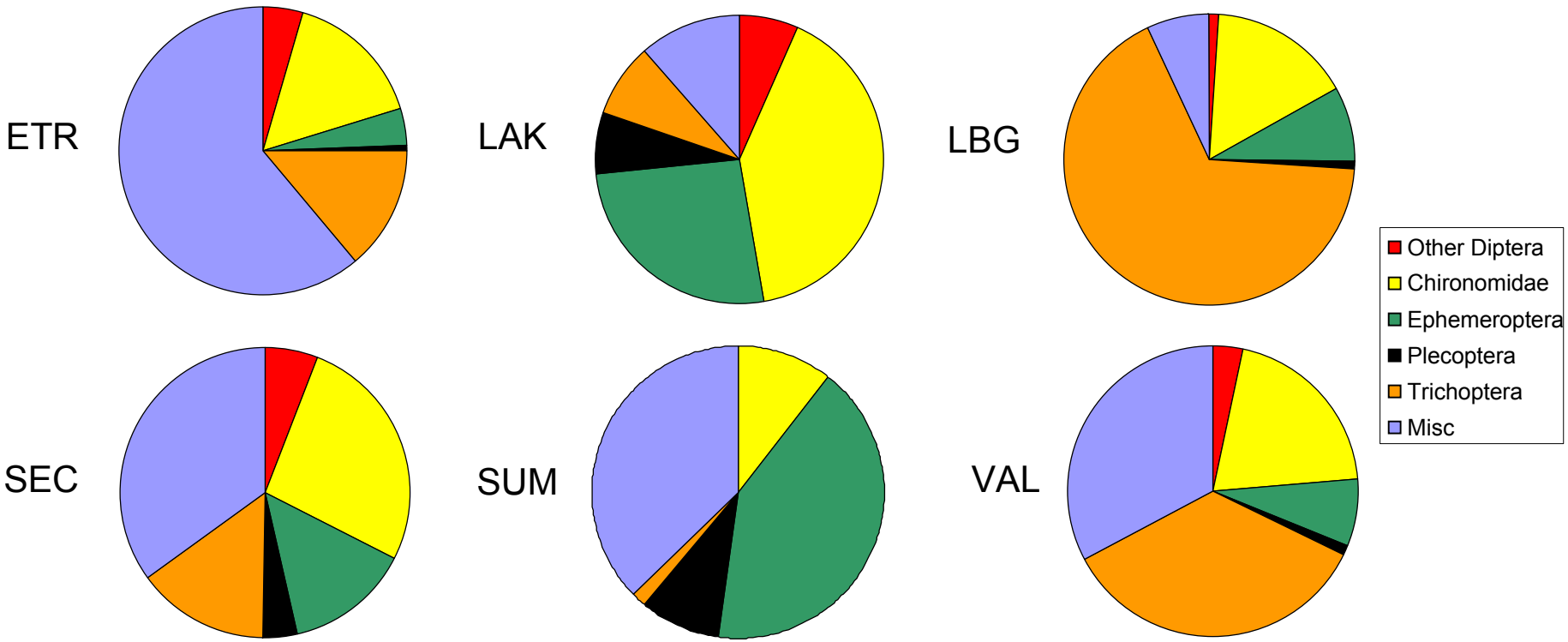
Will we be able to link marine derived nutrients to benthic production (a.k.a. fish food)?

Chlorophyll

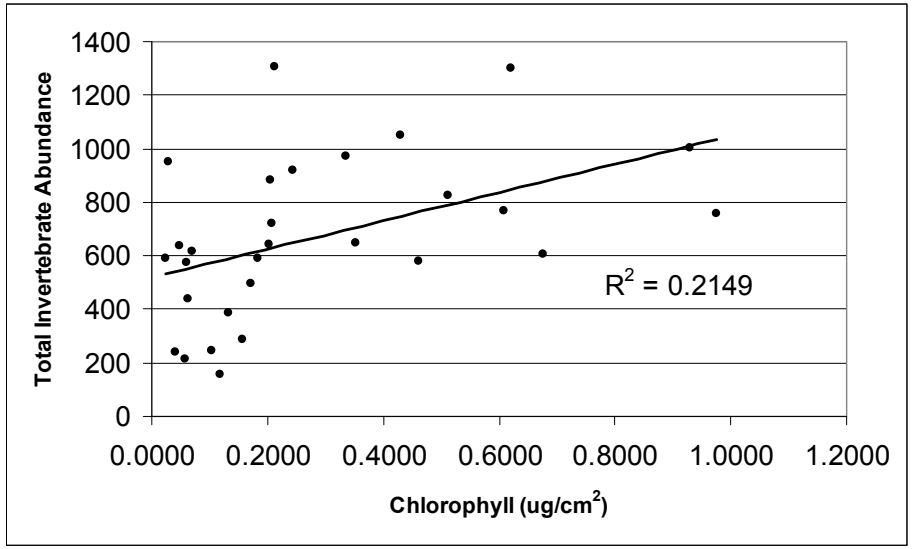


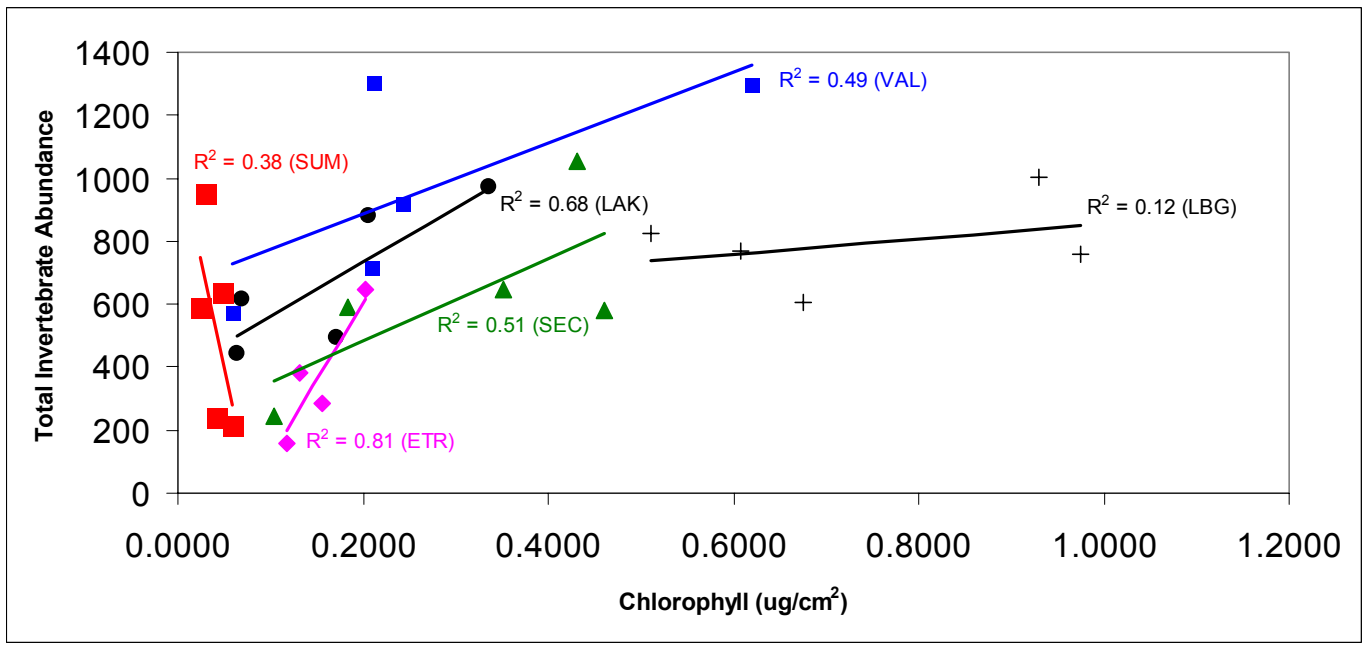
Invertebrates



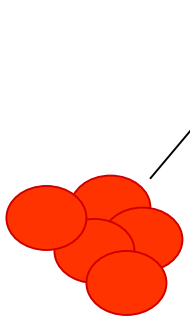


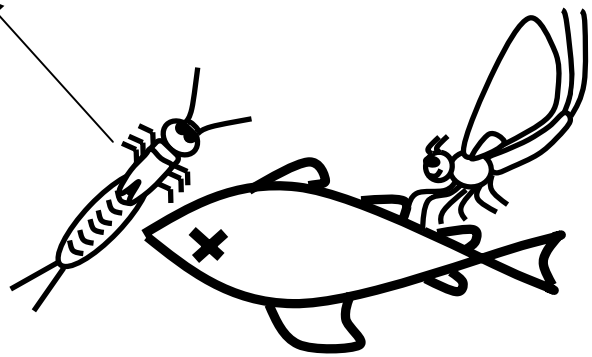
Relationship between chlorophyll concentration & total invertebrate abundance 2002



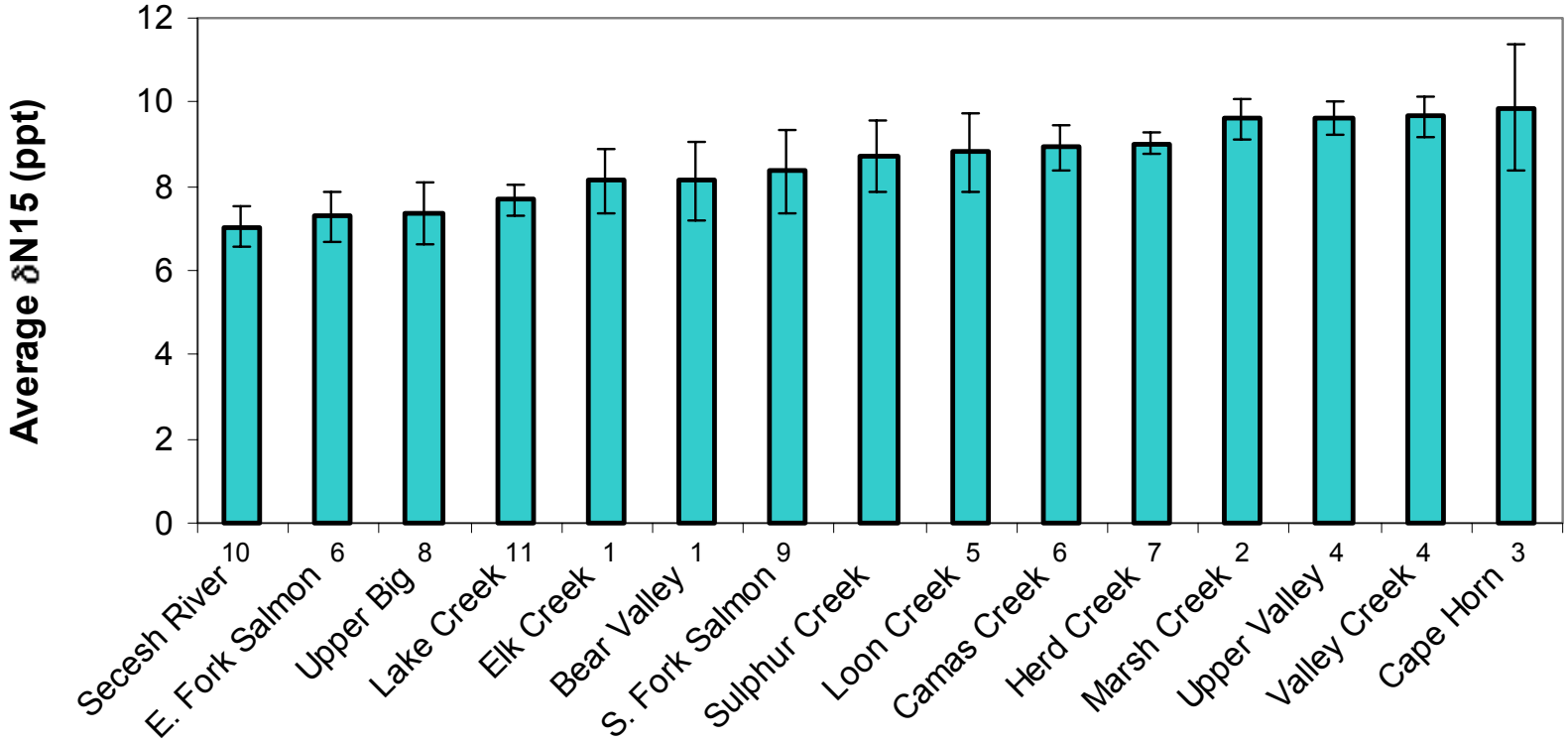


$\delta^{15}N$





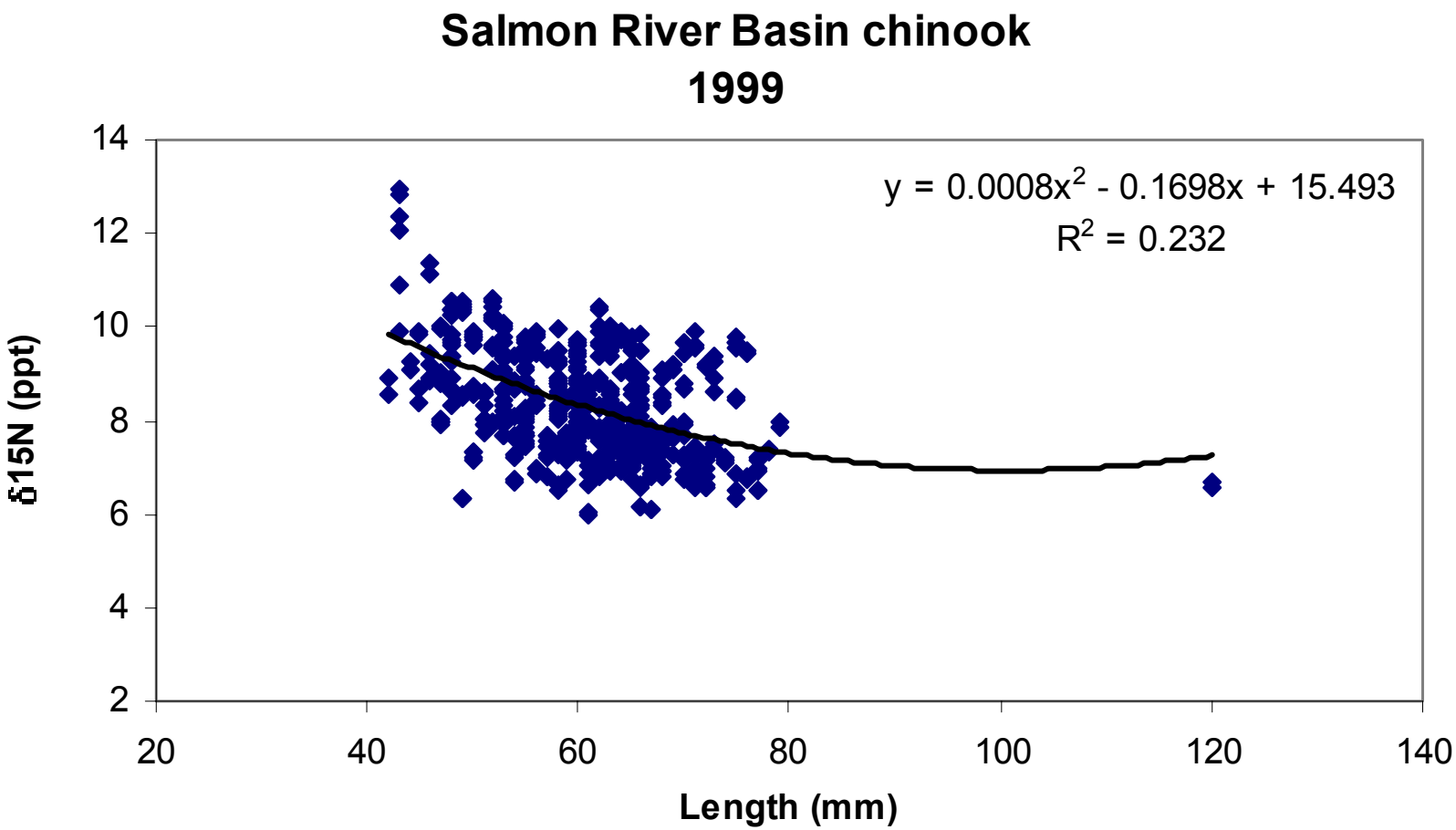
Juvenile Chinook 1999 δ15N Signatures



Sanderson et al. 2003 isotope samples for chinook, steelhead and trout are being processed

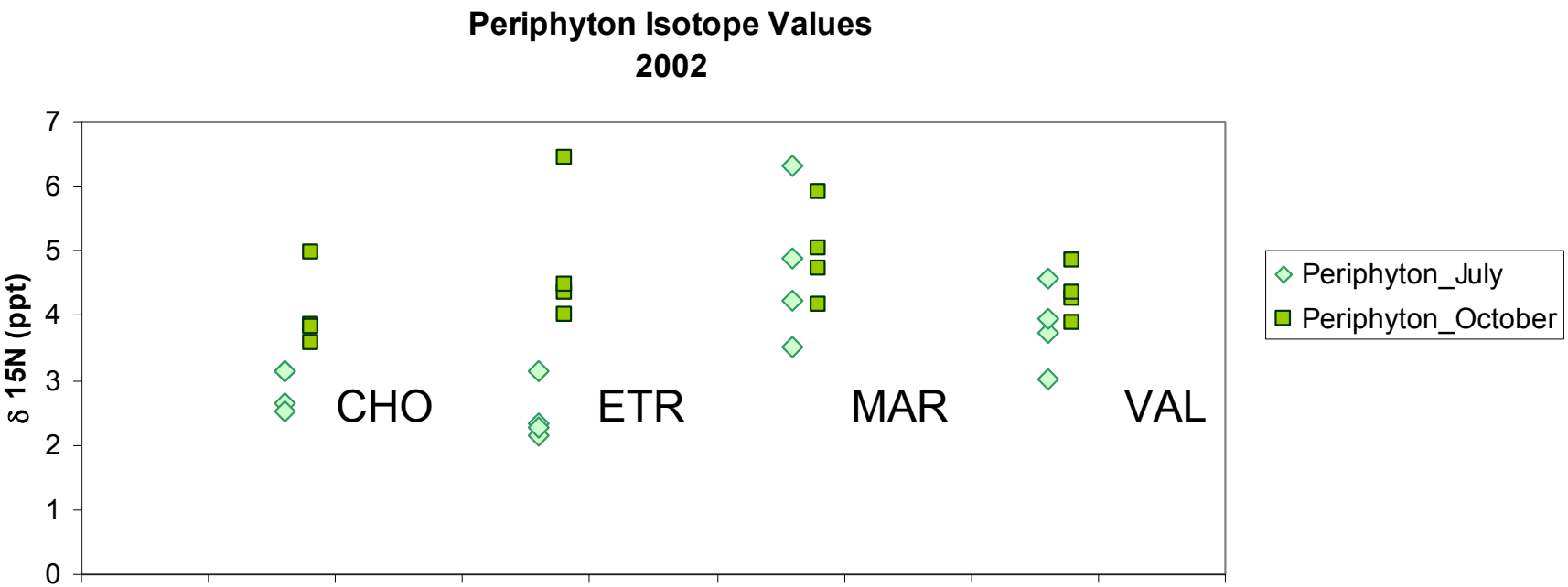
Number indicates order in which streams were sampled over a 1-month period.

Data from Bilby, Bennett, Roni

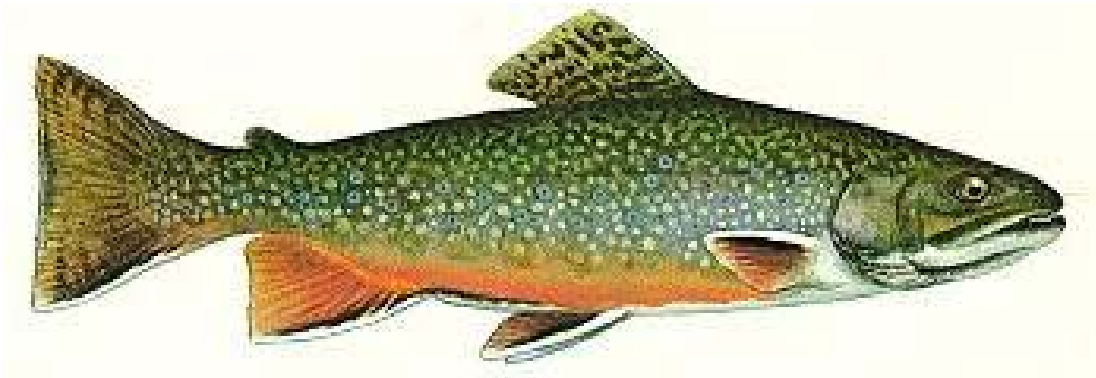


Data from Bilby, Bennett, Roni

Salmon nutrients are detected in periphyton shortly after spawning



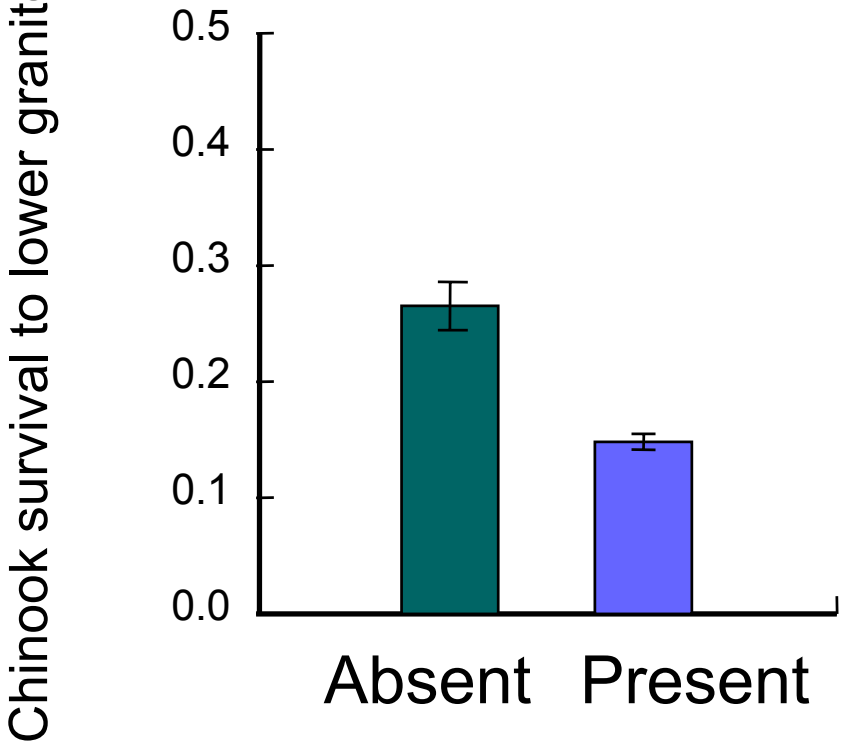
Data from Shoshone Bannock Tribe



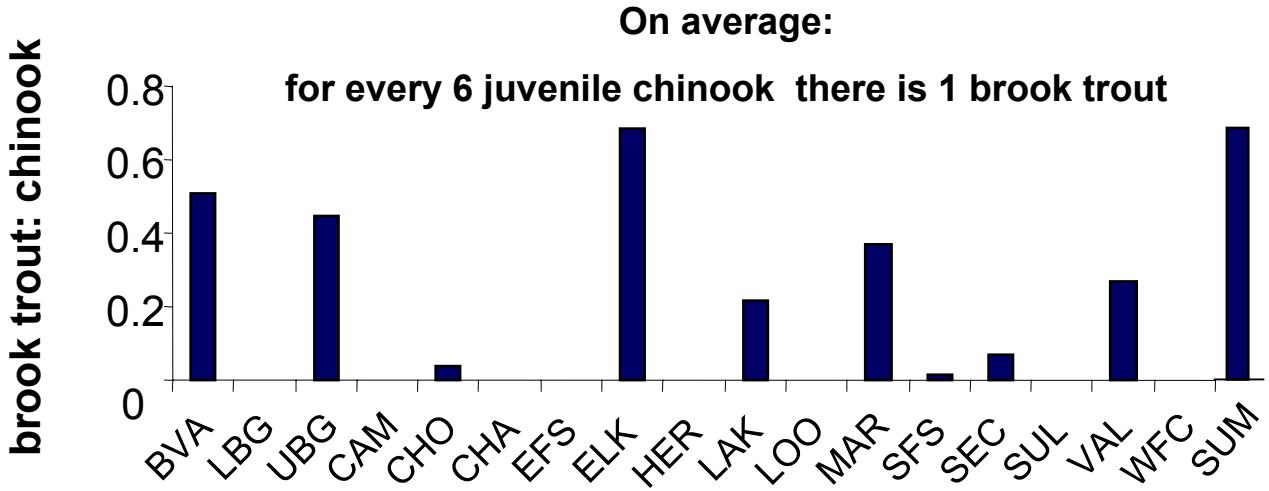
How will non-native brook trout respond to nutrient enhancement?

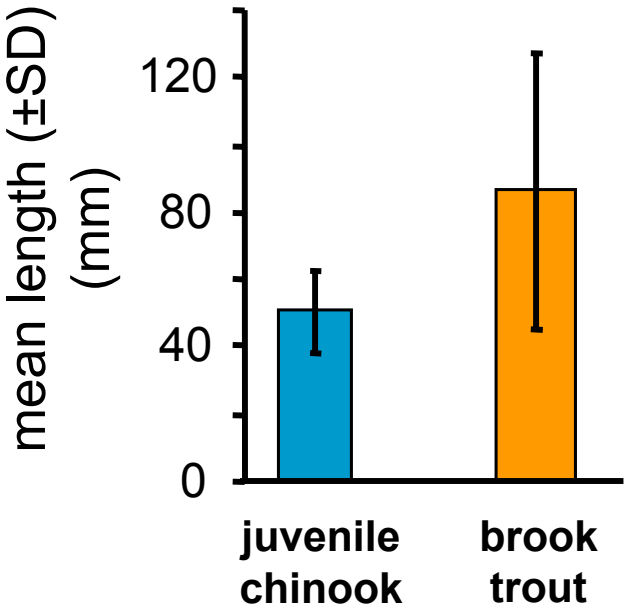
Will brook trout interfere with potential benefits?

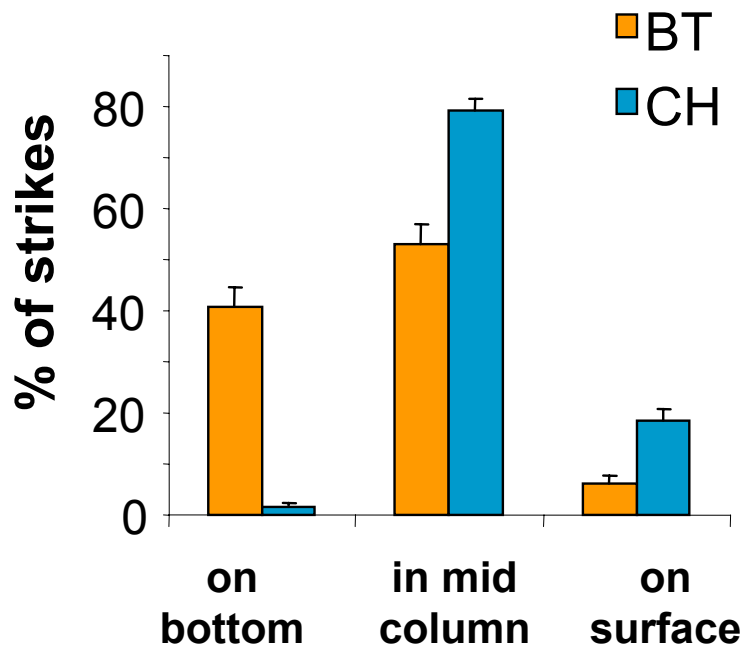
Brook Trout….competition? predation??



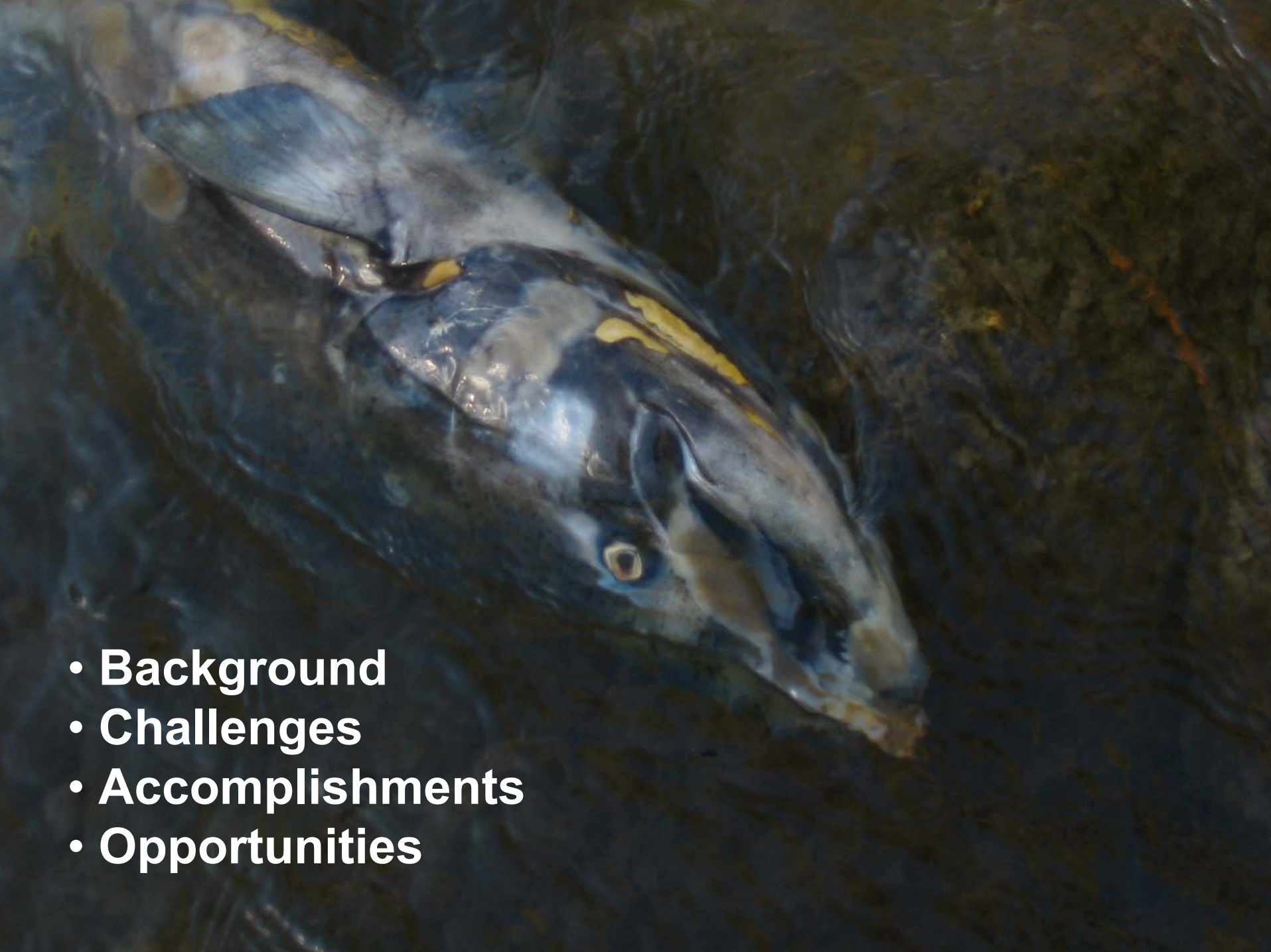
Levin et al. 2002







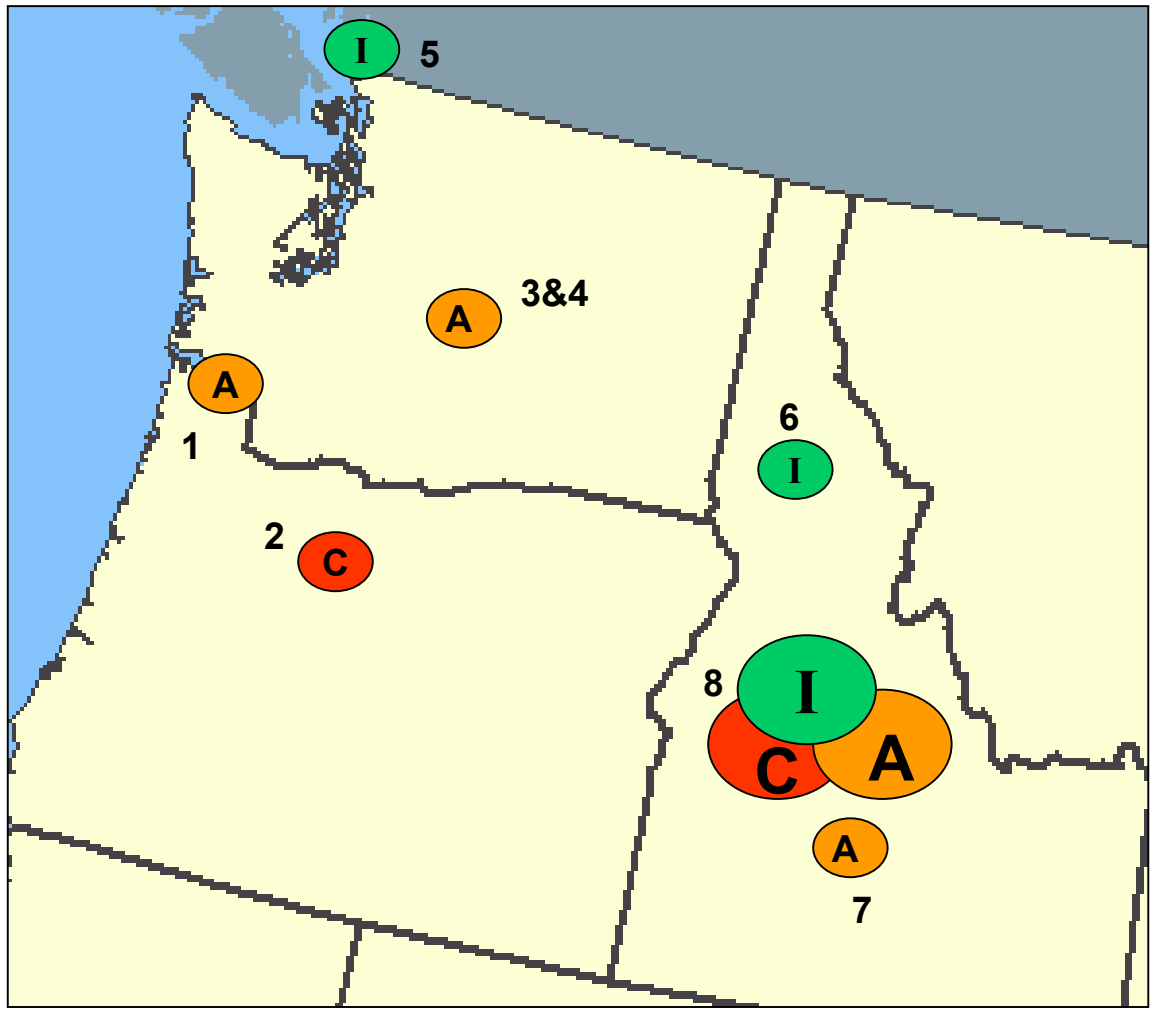
Data from Sanderson, Achord, Macneale



- Background
- Challenges
- Accomplishments
- Opportunities

Ecosystem Scale Nutrient Enhancement Studies completed or in progress

1. Matt Mesa, USGS
2. Dan Shively, USFS
3. Todd Pearsons, WDFW
4. Bill Sharp, Yakama Nation
5. Ken Ashley, BC
6. Kootenai + IDFG
7. Shoshone Bannock
8. Beth Sanderson, NOAA



C Carcass

A Analog

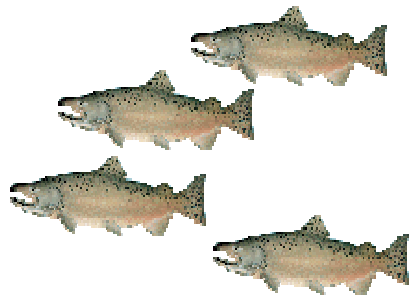
I Inorganic

Experimental Design

Ecosystem nutrient addition experiment (2005)

Treatment	Number of Streams	Streams
Analog	2	Bear Valley Sulphur
Carcass	2	South Fork TBD
Inorganic Nutrients	2	Elk TBD
Control	2	Marsh Valley
TOTAL	8	

Our specific goal for summer 2004 is to select and monitor sites that will be acceptable by all parties for nutrient enhancement in 2005.



Nutrients

Juvenile salmonids

Riparian species

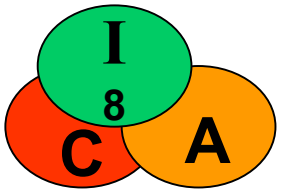
Periphyton

Invertebrates

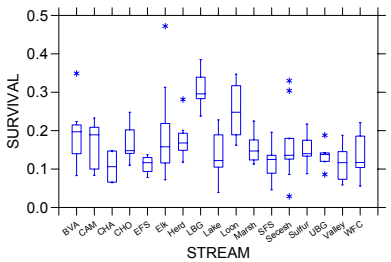
Habitat

Native trout and non-native species

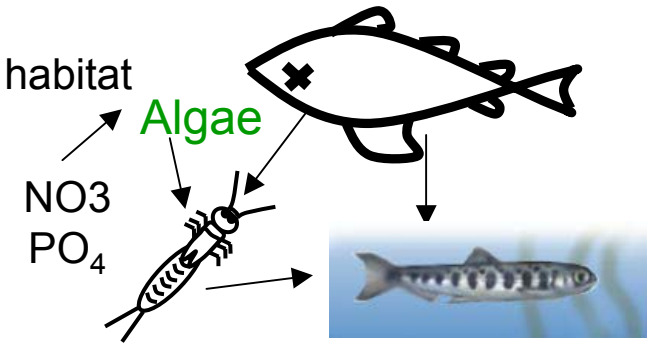
Why is this project novel and important ?



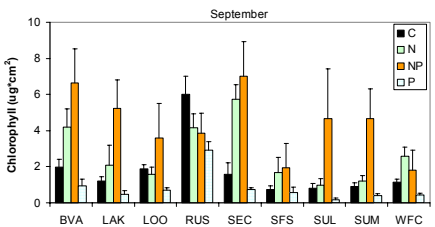
Compare three approaches simultaneously



Measure growth and survival of fish in treated reaches

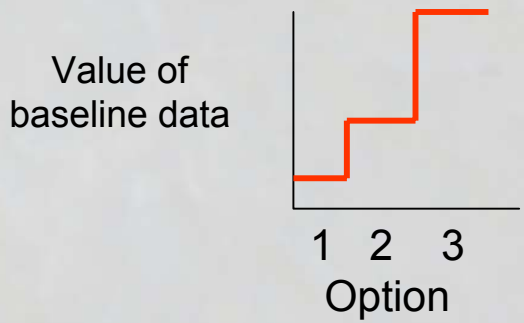


Monitor responses in food web and role of habitat



These streams have **low** concentrations of nutrients and are **Nitrogen-Limited,** unlike streams where most other research has been conducted

	Options	Products	Ecological Insight	Management Insight	Total Costs
1	No new funding	Monitoring data and comparative studies ending 2004, publications in peer reviewed journals	moderate	low	0-70K
2	1-year nutrient experiment (2005)	Option 1 and short-term comparison of nutrient additions on stream productivity and juvenile growth and survival	high	moderate	300-400K
3	Long-term nutrient experiment (1 + generations)	Option 2 and Long-term comparison of 3 types of nutrient additions, responses for multiple cohorts of fishes, and retention of nutrients across years	high	high	To be determined



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