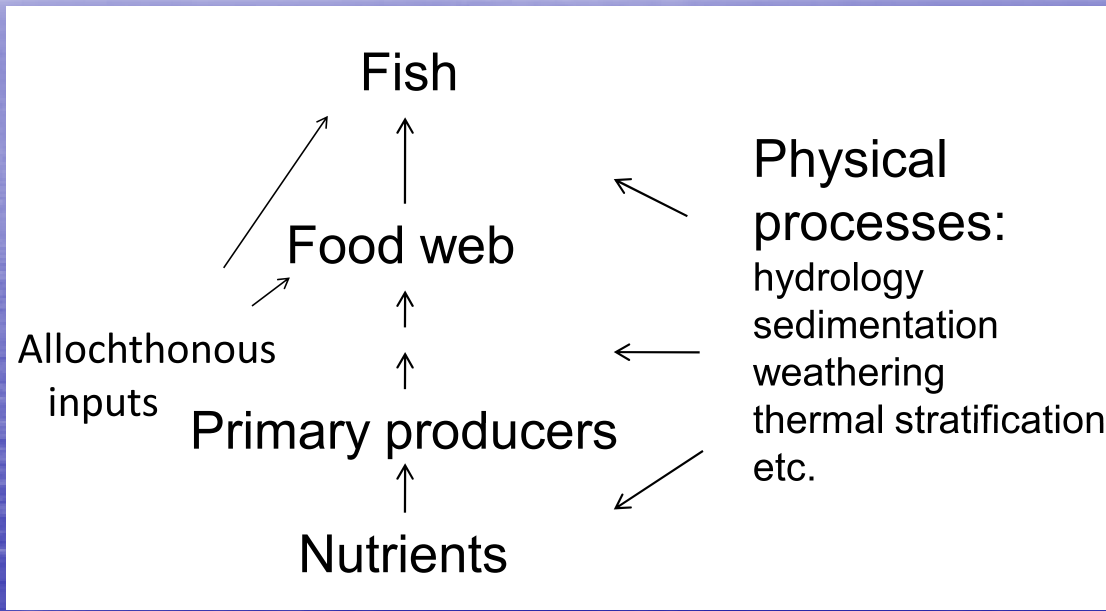
Chemical and biological drivers of fish productive capacity:

(Leader: Joseph Rasmussen, U of Lethbridge)



•**Premise:**
fish productive capacity can be viewed as the product of the system's "food base" which can be expressed in terms of "**energy flow**" (primary & secondary productivity) or at the level of its **nutrient** regime.

In Canada, fish and fisheries play a pivotal role in environmental regulation

- The Federal government has jurisdiction over Fisheries Resources, and have the mandate to “conserve and preserve fish and their habitat.”—*Fisheries Act*

- “No Net Loss” principle of productive capacity of habitats, as expressed in the DFO *Policy for the Management of Fish Habitat* reinforces this.

- A science-based definition of habitat productive capacity should reflect ecosystemic, community & population perspectives

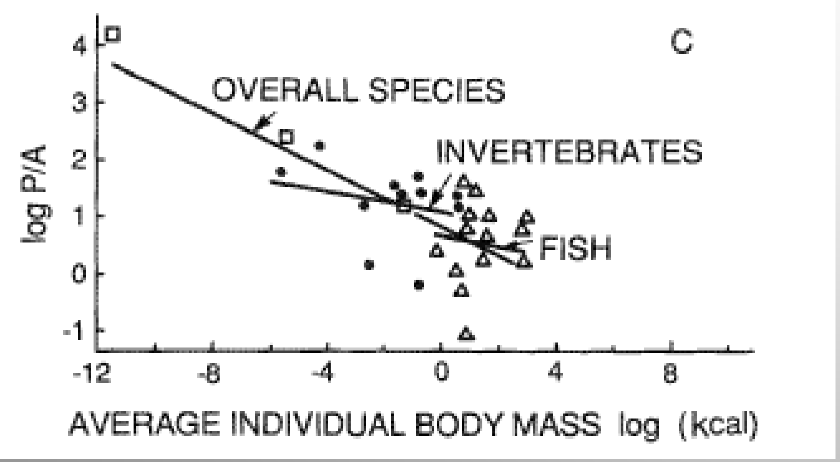
Boudreau & Dickie (1989) Fish production—the intrinsic capacity of a fishery/fish population to offset fishing mortality

•Mortality (natural –Including reproductive investment)+ fisheries) cannot exceed productivity or the resource collapses

Fish productivity Fish mortality

$$\frac{dB}{dt} = B \bullet [P/B] - (m_N + m_F) \bullet B,$$

rate of change of fish biomass *(B)*=fish productivity - (natural + fishing mortality)



•Increasing mortality through fishing pressure will lead to a reduction in average body size and an increase in conversion efficiency, which increases fish productivity

Productive capacity from the Consumer-Resource Perspective

Vito Volterra

≈1920

resource productivity — Avg consumer biomass

$$\frac{dR}{dt} = rR\left[1-\frac{R}{K}\right] - aRC, \quad C^* = \frac{r}{a}\left[1-\frac{R^*}{K}\right]$$

Nutrient regime
Habitat quality
Trophic diversity?

Rate of change of resources

=intrinisc growth rate - removal by consumers

consumer productivity — Avg resource biomass

$$\frac{dC}{dt} = caRC - mC, \quad R^* = \frac{m}{ca}$$

Fish size (mortality)
Temperature
Trophic diversity
Habitat quality

mortality
Trophic diversity

rate of change of Consumer population

= consumer growth (based on resource consumption) - death rate of consumer

Chemical Drivers of Fish production:

(Leader: Joseph Rasmussen, U of Lethbridge)

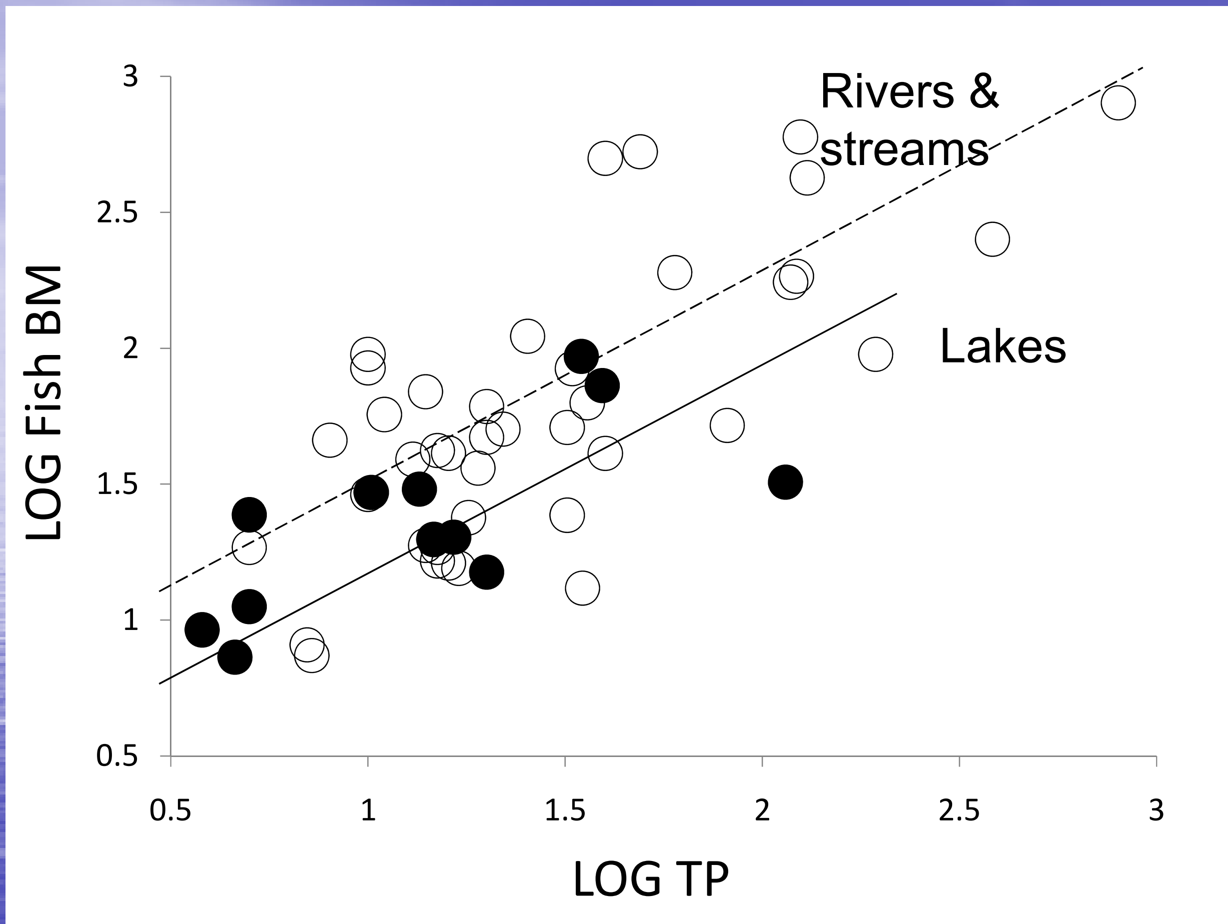
Objective: to establish a relationship between productive capacity for fish and the nutrient regime: TP (total phosphorus concentration in water), and TN (total Nitrogen concentration).

To provide a benchmark estimate of the potential fish productivity scaled to the level of system productivity.

Hypothesis:
We hypothesize that the total phosphorus concentration in the water (TP) will be the best overall predictor of fish productive capacity (Downing and Plante, 1993; Dillon and Rigler, 1974),

TN:TP ratio will also play a role in situations where the ratio is low (Smith, 1982).

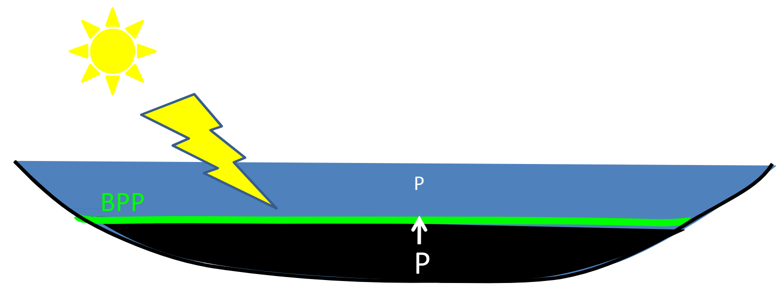
Chemical drivers of fish productive capacity:



While we expect that the relationship between fish community production and nutrient concentrations in water will differ between lakes, reservoirs, rivers etc. , it is possible that the nutrient regime will provide a unifying estimate of the potential fish productive capacity of an aquatic ecosystem.

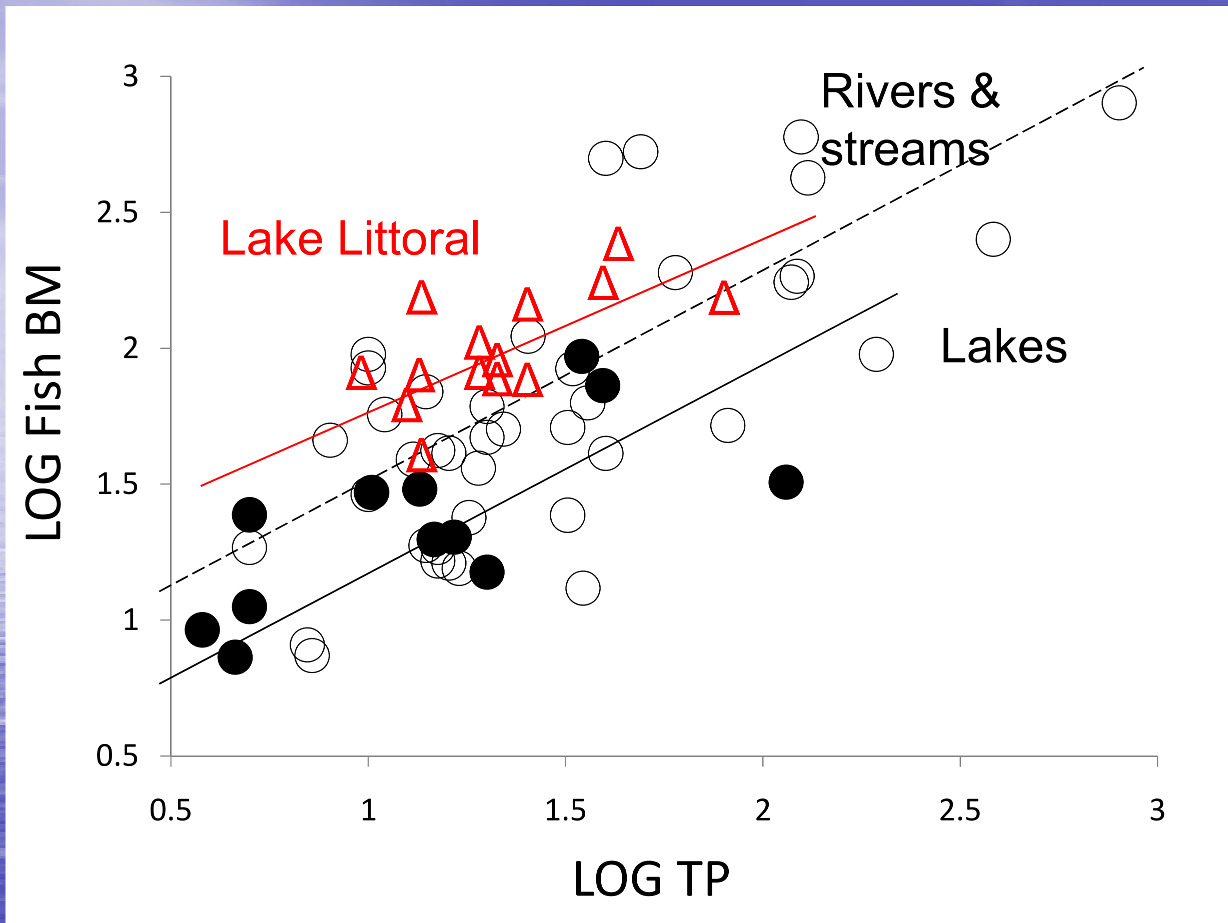
Why do rivers and streams produce more fish than lakes?

- Flow?
- Allochthonous organic input?
- Benthic primary productivity (BPP)?
- Species richness?



- Where light reaches the bottom →BPP
- Interstitial water in hyporheic zones, and sediments are much more nutrient rich than the overlying water
- BPP has access to more nutrients than phytoplankton
- Thus littoral zones in lakes should be as least as rich as rivers.

Are lake littoral fish communities as productive as rivers?



•Lake littoral fish communities are actually 2-fold richer than rivers and streams?
•Possibly the depositional regime made possible by macrophyte beds traps nutrients making the benthic 1º productivity relatively more important than in rivers
•Littoral lake slope slight < river slope-- benthic 1º productivity more important in oligotrophic lakes.

Chemical Drivers of Fish production:

Methods:

•sampling sites and schedule used will be the same as those used to estimate the productive capacity of fish habitats (PCFH).

•Total nitrogen (TN) = DIN (minus N2 gas) + DON + PON
•analyzed as an aggregate with an in-line digestion and oxidization method using ultraviolet light and heated alkaline persulfate.

•$NO_3^- \rightarrow NO_2^-$ by Cd column.
•nitrite measured colorimetrically as a diazonium ion (APHA 2004-4500-N).

Total phosphorus (TP) = ortho, poly, + organic PO_4 (diss + part).
Org- $PO_4 \rightarrow$ in-line to ortho- PO_4 (heat, ultraviolet and persulfate digestion) measured colorimetrically, ascorbic acid reduction (APHA 2004-4500-P).

Dissolved inorganic carbon (DIC) analyzed as an aggregate using a Shimadzu Model TOC-5000A carbon analyzer.

Analyses (TN, TP, DIC) by Biogeochemical Analytical Laboratory in the Department of Biological Sciences at the University of Alberta

Chemical Drivers of Fish production:

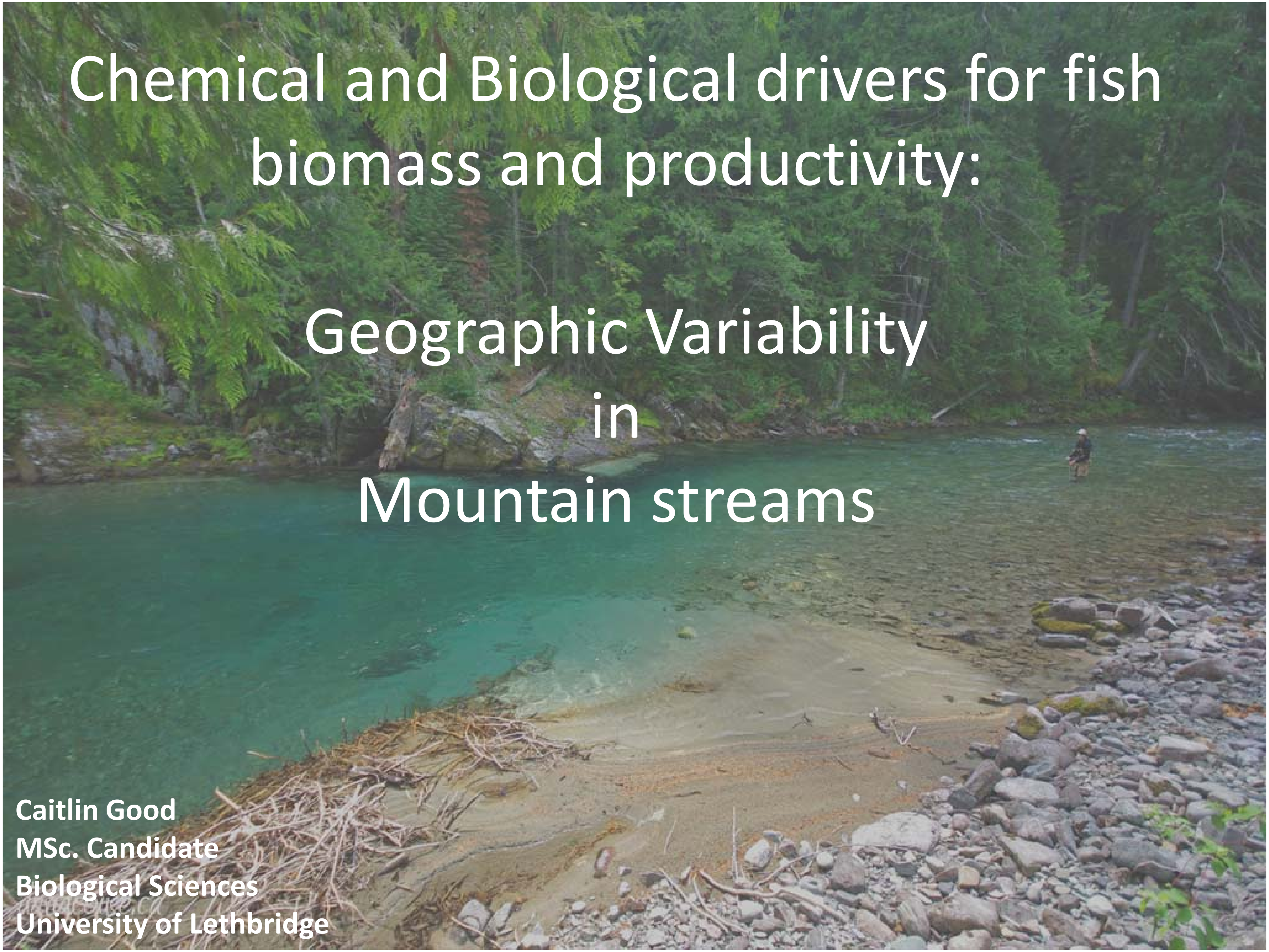
•**Fundamental/Scientific relevance**: Effect of nutrient trapping by lakes is not well known, and its delivery to downstream sections of rivers has been little studied. How these processes affect productivity at all levels in regulated rivers is poorly understood.

Benefits to Industry and Government:
relationship between nutrients and fish production, important for management

Nutrient regimes differ within and among regions and assessing the impact of environmental disturbances on fish productive capacity will depend on understanding the baseline productivity that can be expected from a given type of community.

More comparisons between the productive capacity of reservoirs, rivers (regulated and unregulated) and natural lakes are needed and we need to understand the different role of nutrients in these systems.

appropriate common "currency" (Randall and Minns 2000).


Chemical and Biological drivers for fish biomass and productivity:
Geographic Variability
in
Mountain streams
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OBJECTIVE

To establish the relationship between fish productivity/biomass and nutrient regimes when comparing regulated and unregulated rivers.

- Field study

  - 2 field seasons investigating high and low productivity at select sites (both regulated and unregulated)

- Data Compilation/analysis

  -(published and unpublished) of nutrient and fisheries data

Nutrient/Fish Data Sources

- Working with BC Hydro (contact: Alf Leake), DFO (contact: Mike Bradford)

- Cross linked information resources
  - -concurrent search of Eco Cat, MoF library, SIWE, BCSEE, EIRS
  - -ie: Lower Bridge River data set (comprehensive aquatic inventory)
  - -ie: Arrow Lakes Fertilization Project, Kinbasket/Revelstoke Ecological Productivity Monitoring
  - -Water Use Planning Reports

- Ministry of Environment Environmental Monitoring System (EMS WR)
  - -chemical, physical and biological data

- Others?

CLIR:http://www.env.gov.bc.ca/clir/
EMS WR: http://www.env.gov.bc.ca/emswr/

Project Location

- Southern Rocky Mountains (BC/ Alberta border)
- Geographic Variability

Mountain Environment

- Increase our understanding of nutrient relationship and fish in headwater streams
  - Used by different life stages, different species
- Understanding importance of connectivity for species richness
  - Access to habitat for all life stages

Sampling Parameters

- Fish Community
  - Fish sampling at base flows to determine relative abundance, biomass
- Habitat Assessment
  - Fish habitat assessment procedure (Johnston and Slaney, 1996)

Sampling Parameters

- Water Sampling

  -measure of total bioavailable phosphorus and nitrogen in mountain environment

  - influence of glacial (rock) flour

- Water Quality

  - temperature, pH, dissolved oxygen, specific conductance

Predictions/goals?

-Measure bioavailable phosphorus and examine its effect on fish populations in free flowing and regulated mountain rivers

-Trend in species richness based on connectivity

-Lentic systems studied will demonstrate ‘bottom up’ effect with nutrients as an indicator for fish productivity and biomass