Development of metrics relating flow alteration impacts to river/reservoir food web dynamic

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How to measure productive capacity of fish habitat ?

- Habitat based methods
- Fish methods
- Lower trophic methods
- Ecosystem level methods

RESERVOIRS FEATURES

Reservoirs are flooded rivers and terrestrial vegetation

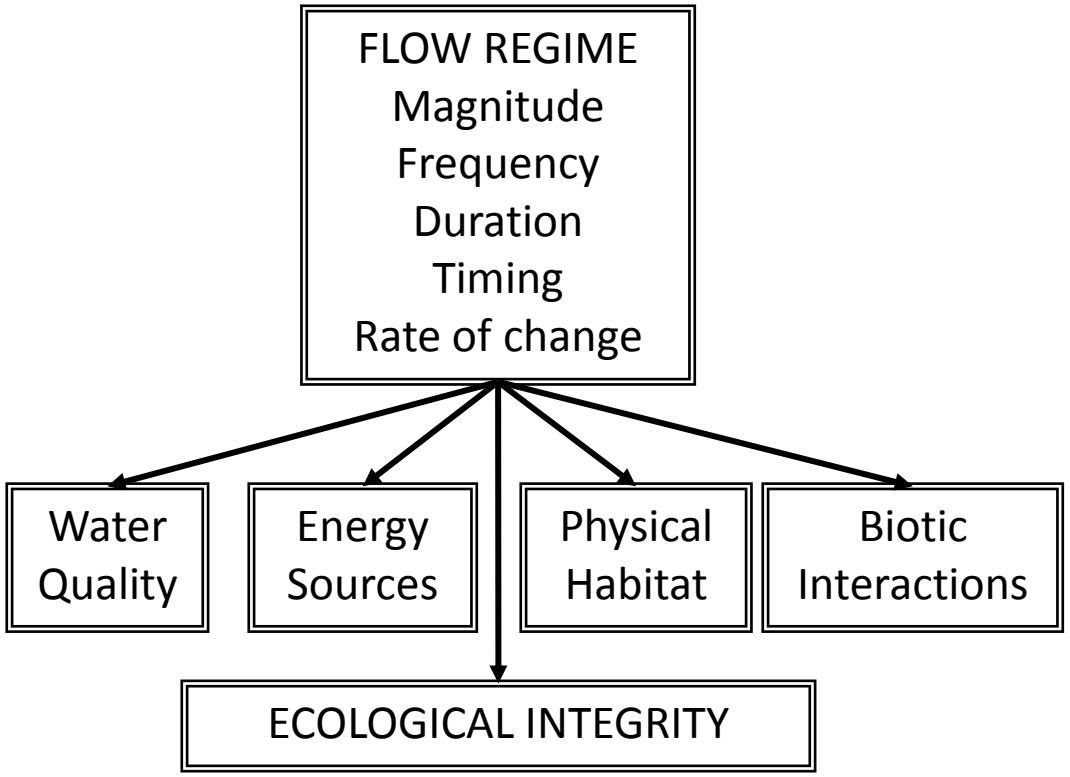
- Shift from benthic to pelagic food webs.
- Reservoir production is higher after flooding.
- They receive higher terrestrial C than lakes.
- They are known to support a productive fish community.

“ Reservoirs are disable lakes. The lack of a littoral zone because of unnatural fluctuations in water level results in a sterile shoreline, sometimes dry, sometimes flooded, but with no predictable pattern to which organisms could adjust.” (Moss- 2008).

WHAT IS THE ENERGY FLOW SUPPORTING FISH PRODUCTION IN RESERVOIRS ?

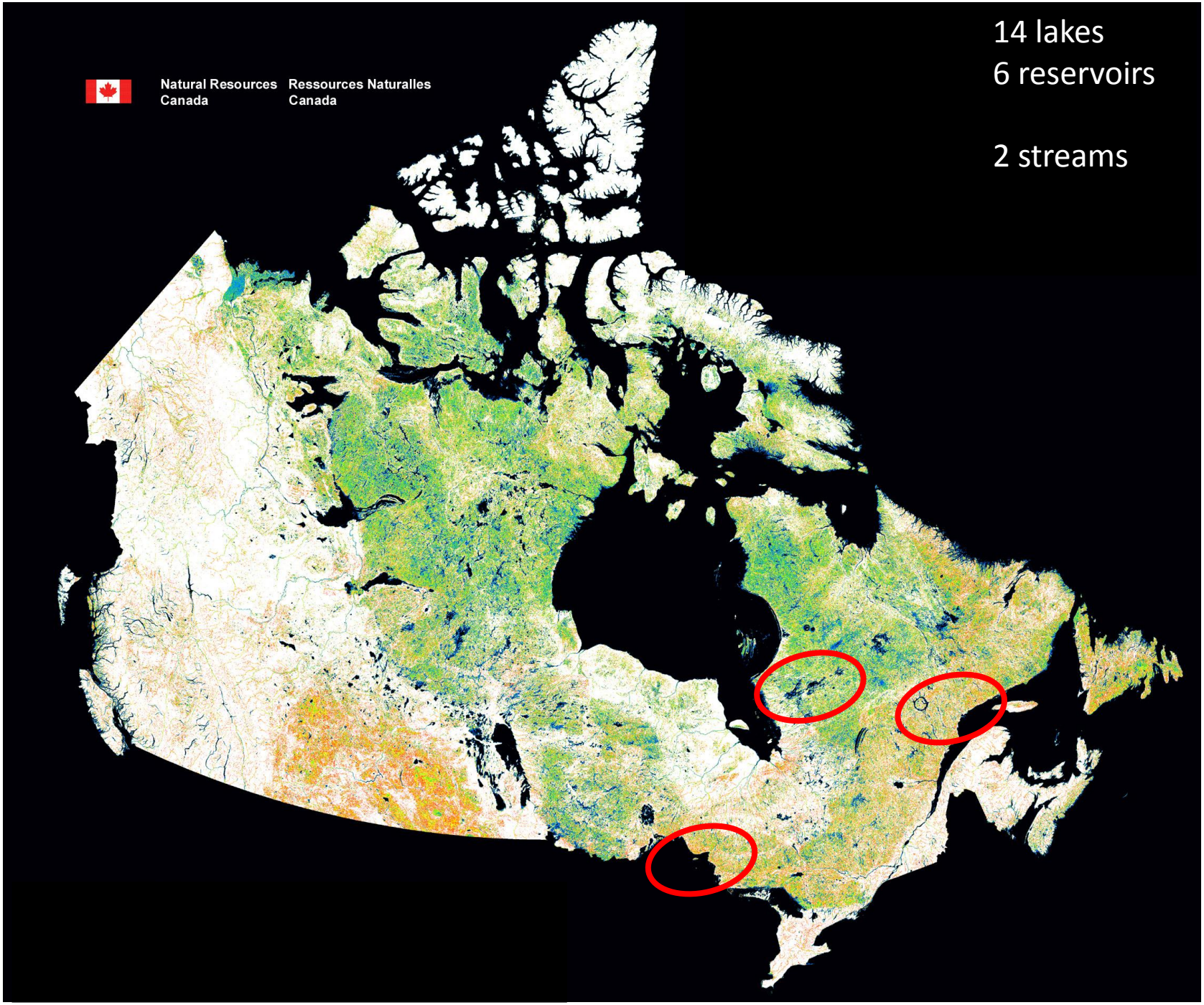
REGULATED RIVER FEATURES

Below dams, lentic food webs are influenced by many variables (cold water release, reservoir production, flow alteration)

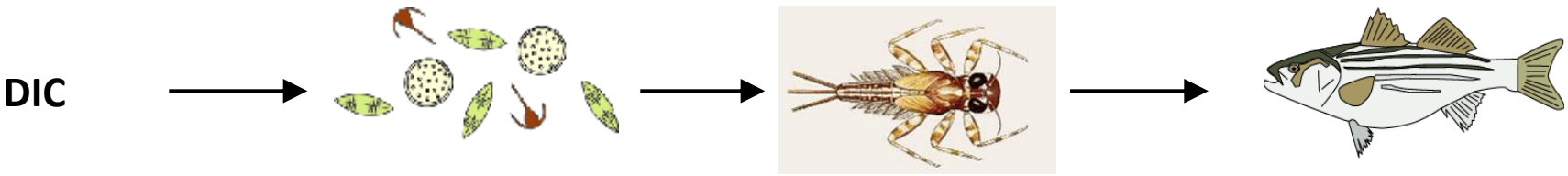


WHAT IS THE RESPONSE OF RIVER FOOD WEBS TO RAMPING ?

Sabater- 2008


Natural Resources Canada
Ressources Naturalles Canada
14 lakes
6 reservoirs
2 streams

$\delta^{13}C$ and ecosystem functions

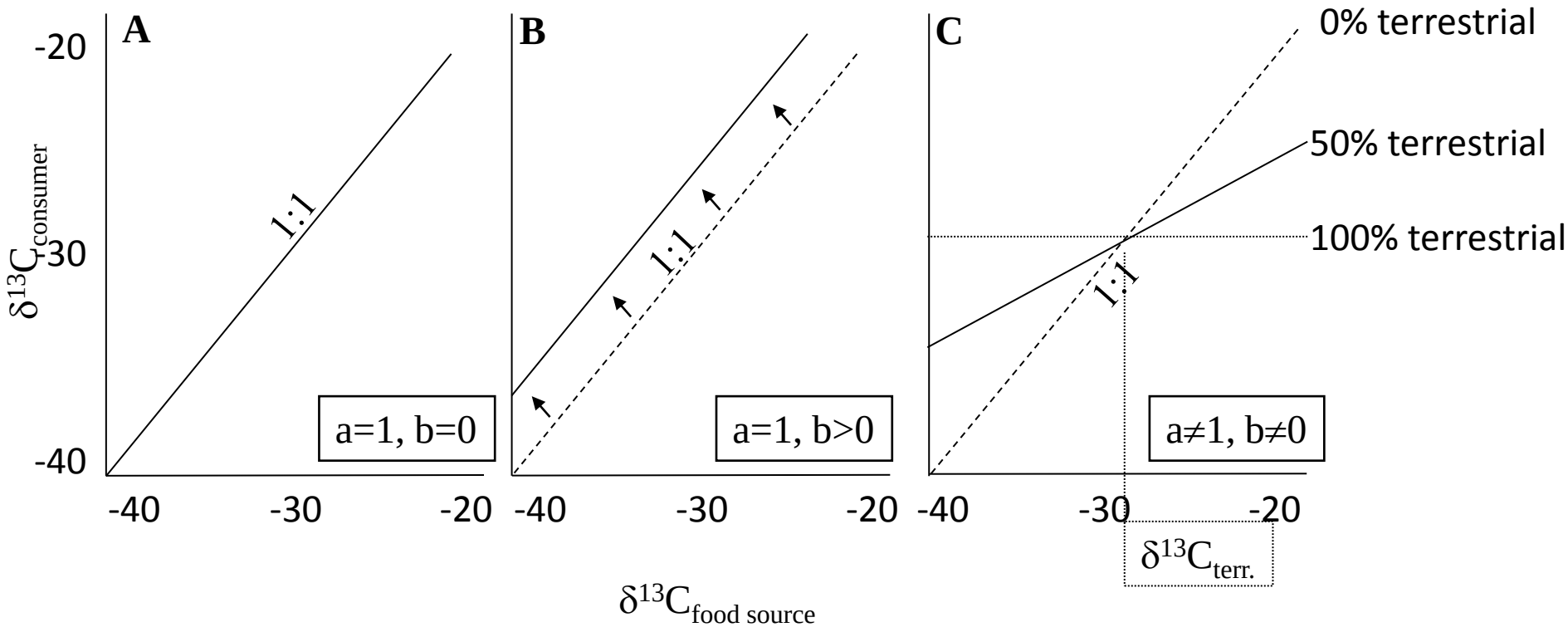


In aquatic systems: **- algal $\delta^{13}C$ is variable (function of CO2, μ, flow velocity)**
- terrestrial $\delta^{13}C$ is homogenous (-28 ‰)

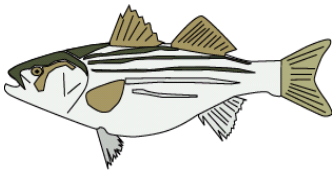
Carbon isotope signatures applications:

- food sources (terrestrial versus aquatic)
- carbon cycling indication (respiration, methanogene)

$\delta^{13}C$ and ecosystem functions



$\delta^{15}N$ and ecosystem structure

Nutrients →  →  → 

F~ 3.4‰ F~ 3.4‰ F~ 3.4‰

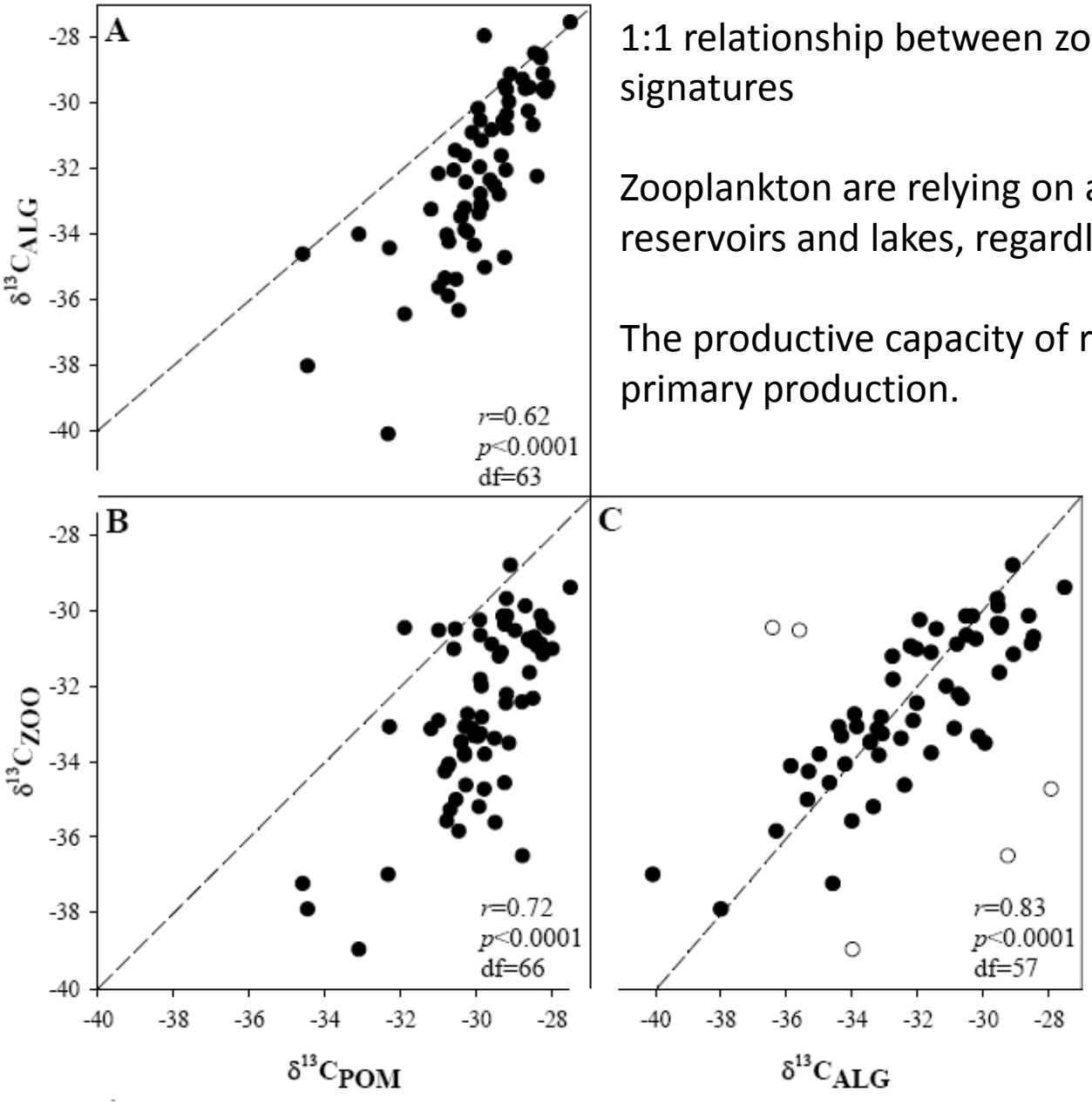
Trophic position	1	2	3

T.P. = [(fish $\delta^{15}N$ – primary consumer $\delta^{15}N$)/3.4] + 2

Food-web length

$FWL = \delta^{15}N_{max} - \delta^{15}N_{min}$

C sources in reservoirs



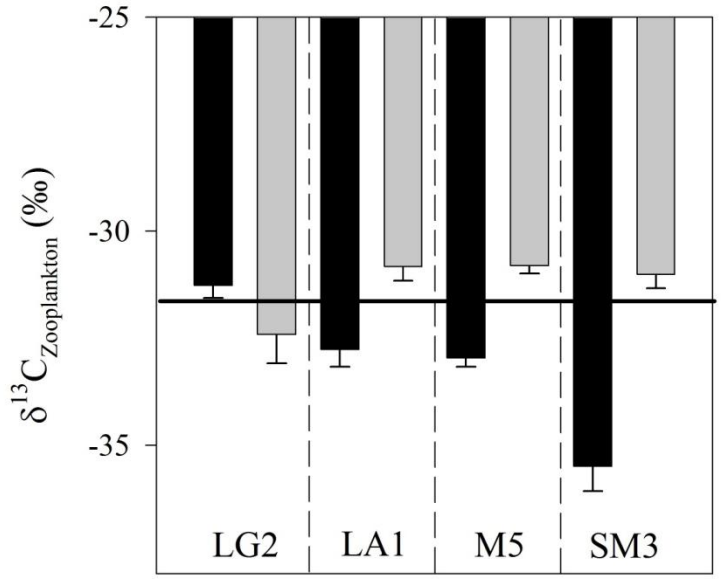
1:1 relationship between zooplankton and algal signatures

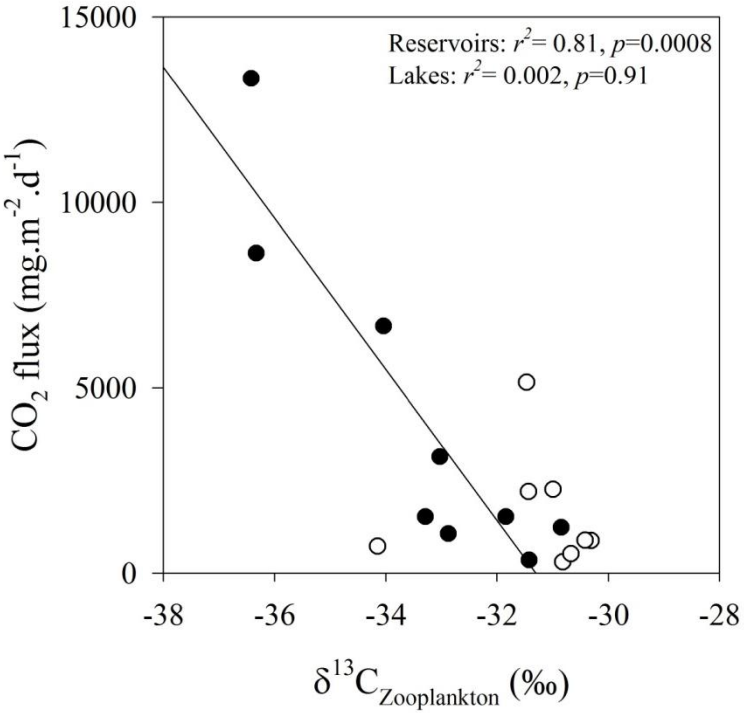
Zooplankton are relying on algal production in reservoirs and lakes, regardless of terrestrial inputs.

The productive capacity of reservoirs depends on primary production.

Marty and Planas 2008, Marty et al. in prep

C sources in reservoirs



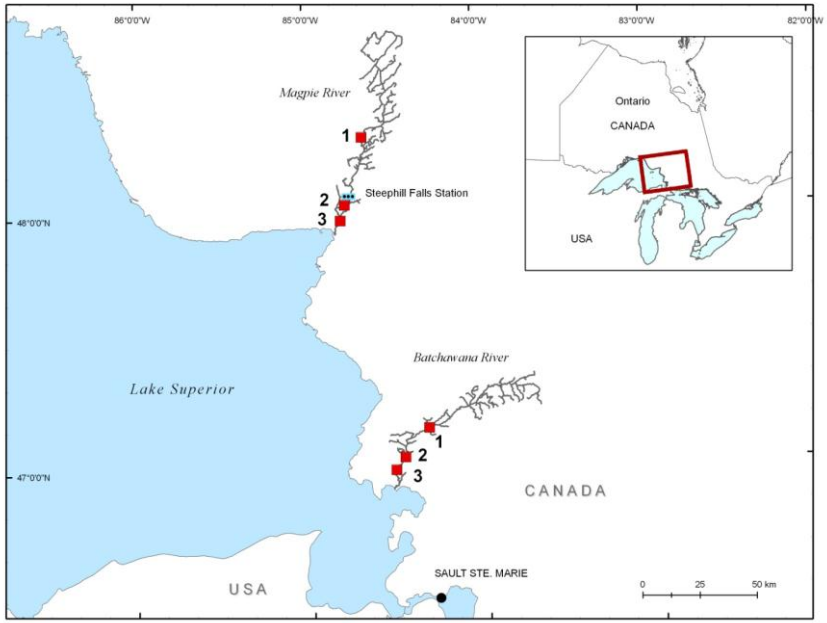


In reservoirs, lower d13C signatures are related higher recycling of organic matter via respiration, lowering DIC signatures and in turn algal signatures.

Relationship between d13C signatures and CO2 fluxes support the importance of respiration in reservoirs compared to lakes.

Tadonleke, Marty and Planas- submitted

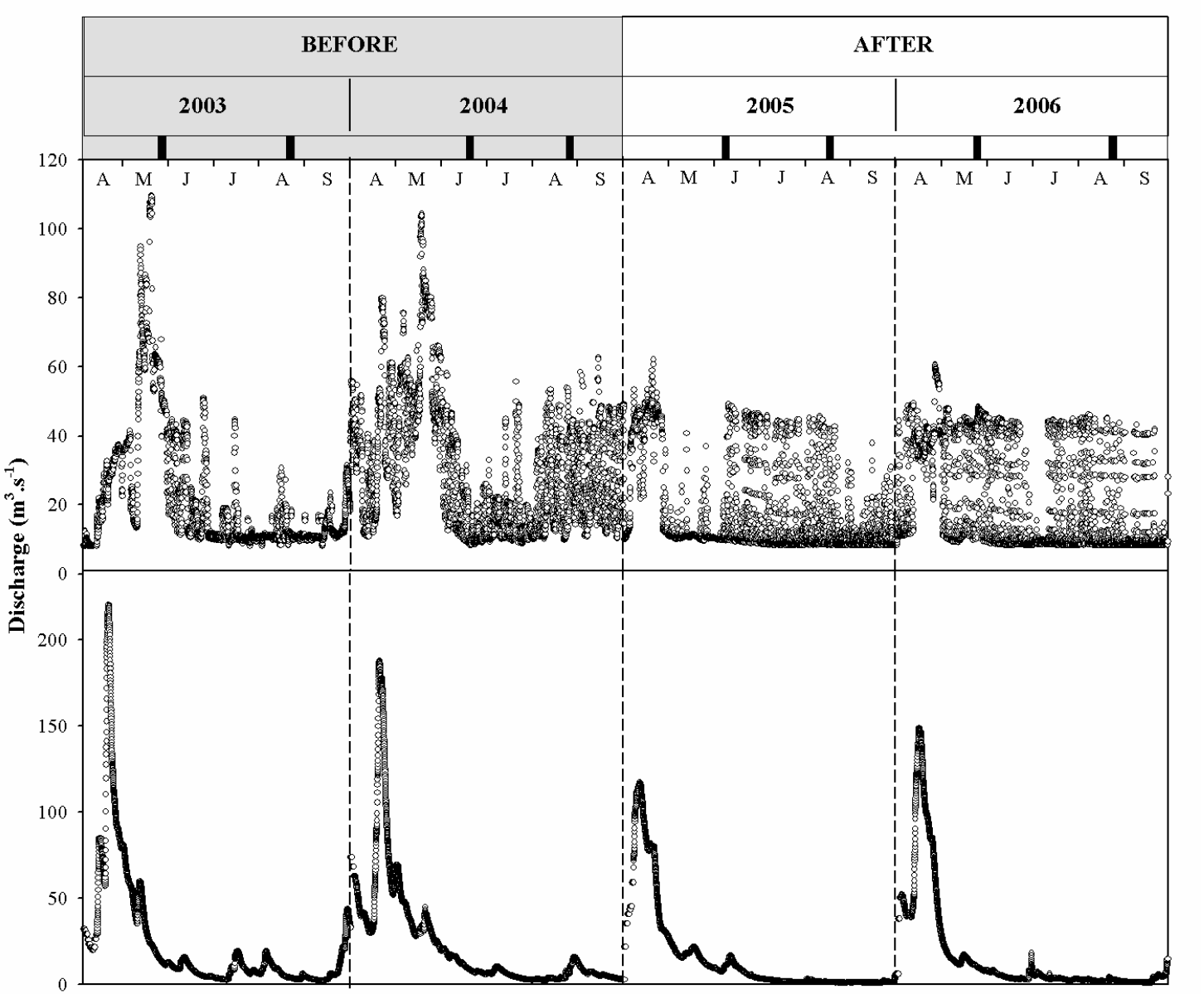
The Magpie project



Unregulated river: Batchawana
Regulated river: Magpie

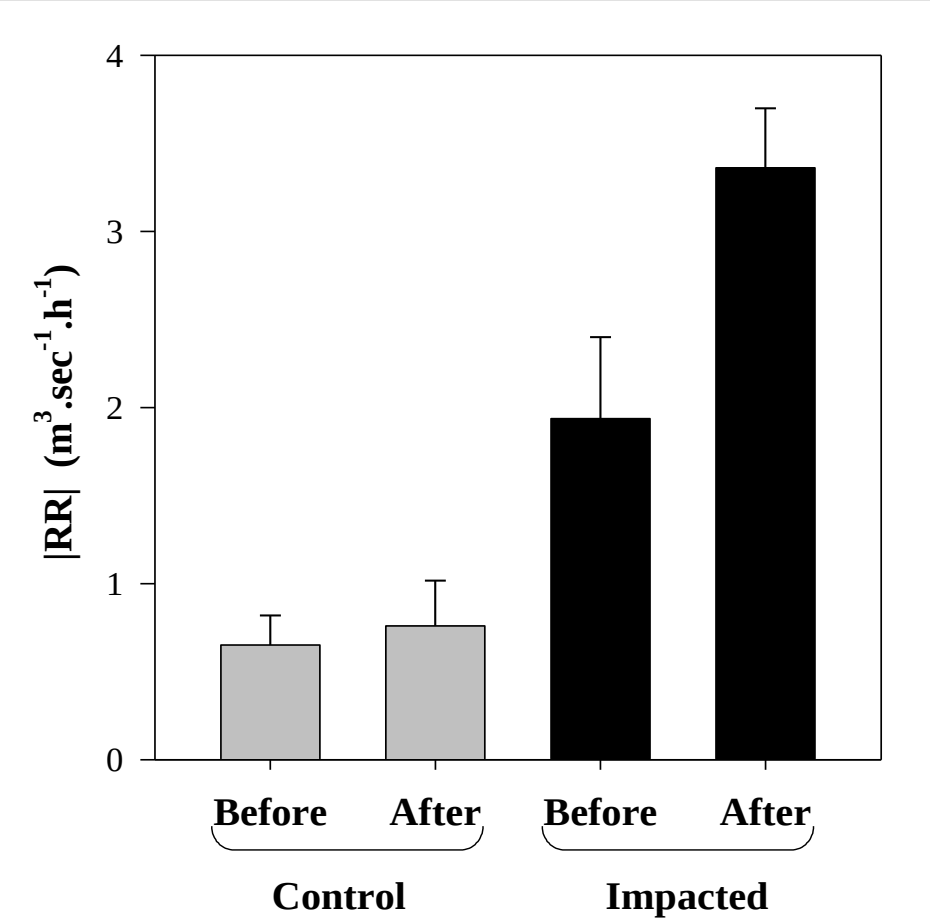
Regulated RR: 2003-2004
Unregulated RR: 2005-2006

Discharge

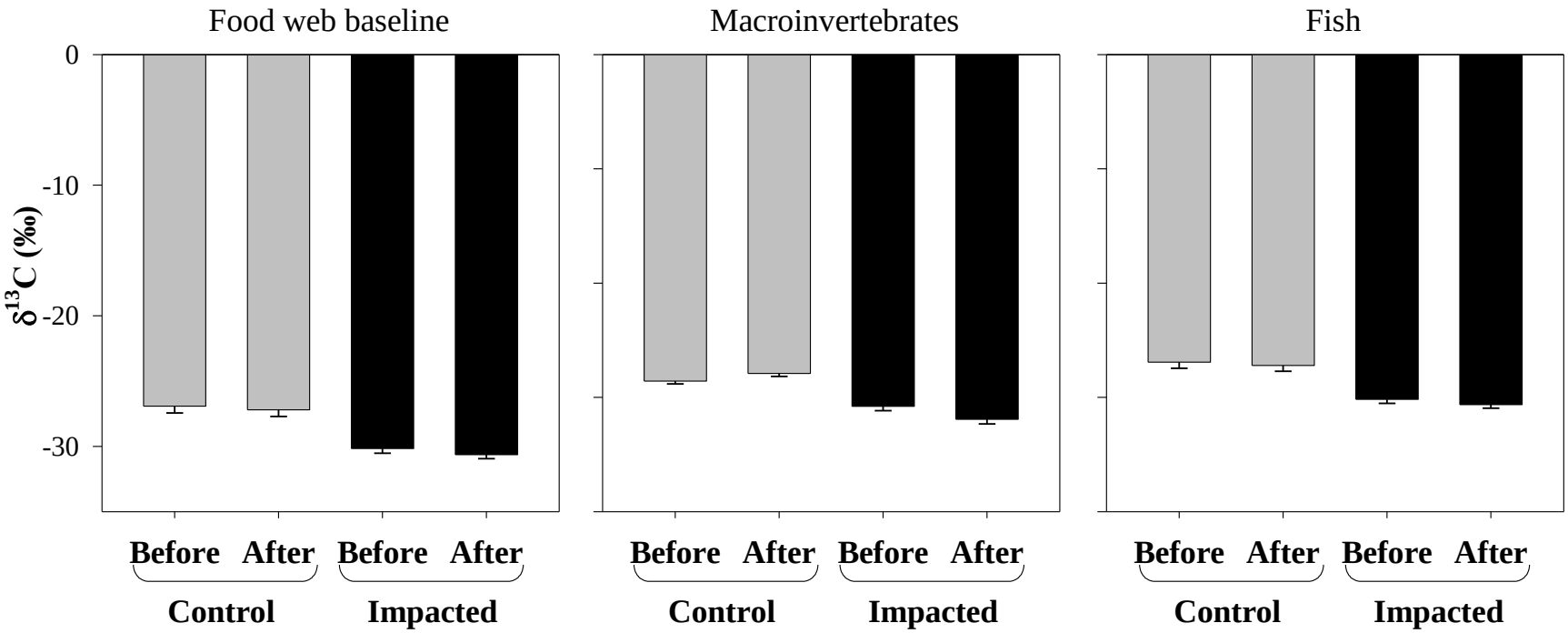


Before After Control Impact approach

Ramping rate values

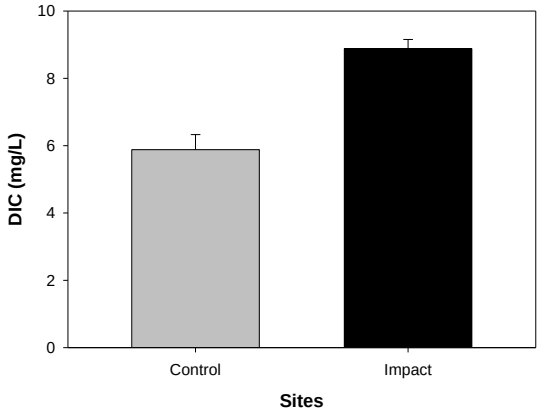


C sources in rivers



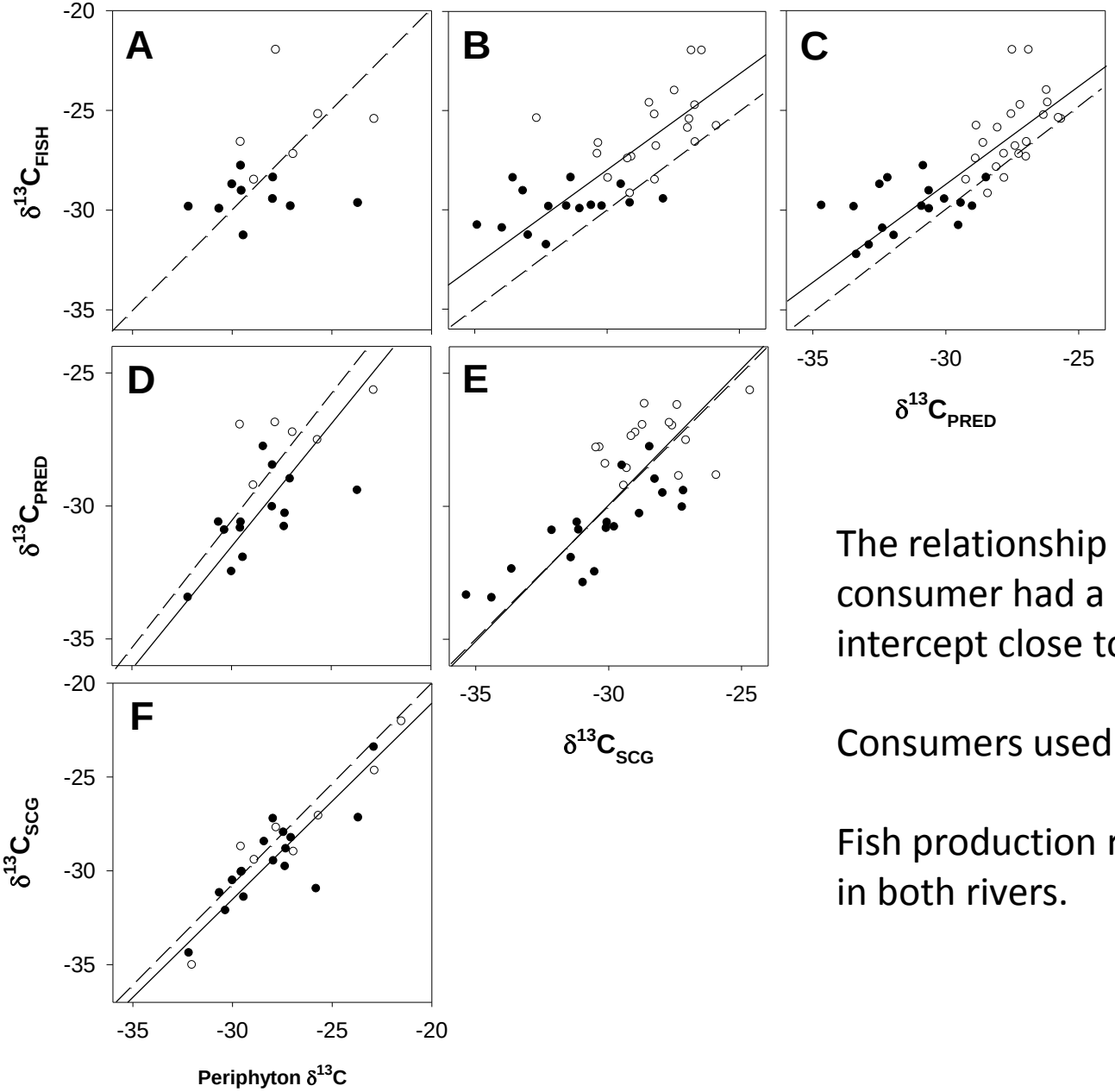
No differences in d13C before and after ramping in the Magpie: homogenous C sources.

Lower d13C below the dam may relate to higher recycling (and higher DIC).



Marty, Smokorowski and Power 2009

C sources in rivers



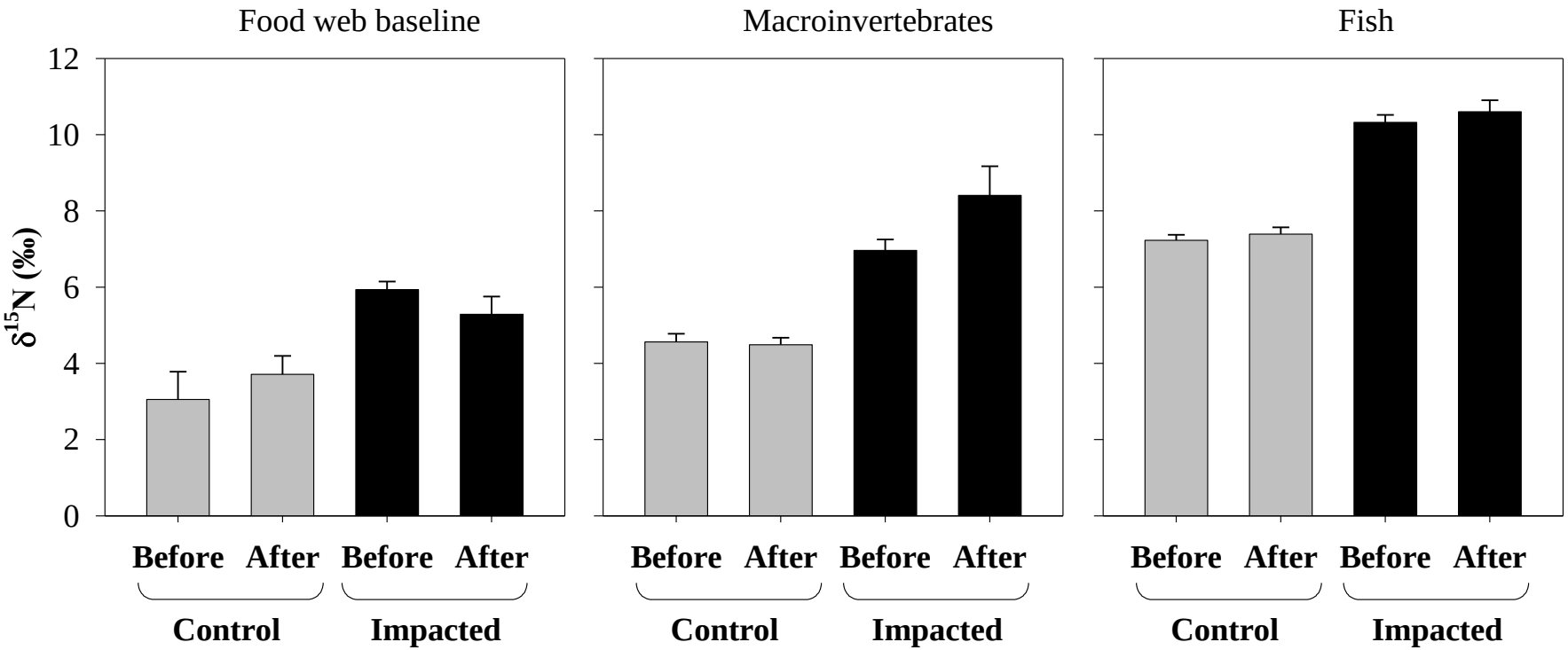
The relationship between periphyton and consumer had a slope of 1, with an intercept close to 0.

Consumers used little terrestrial C.

Fish production relies on algal production in both rivers.

Marty, Smokorowski and Power in prep.

Food web structure response



C/I : p>0.05
B/A: p<0.05
C/I x B/A: p>0.05

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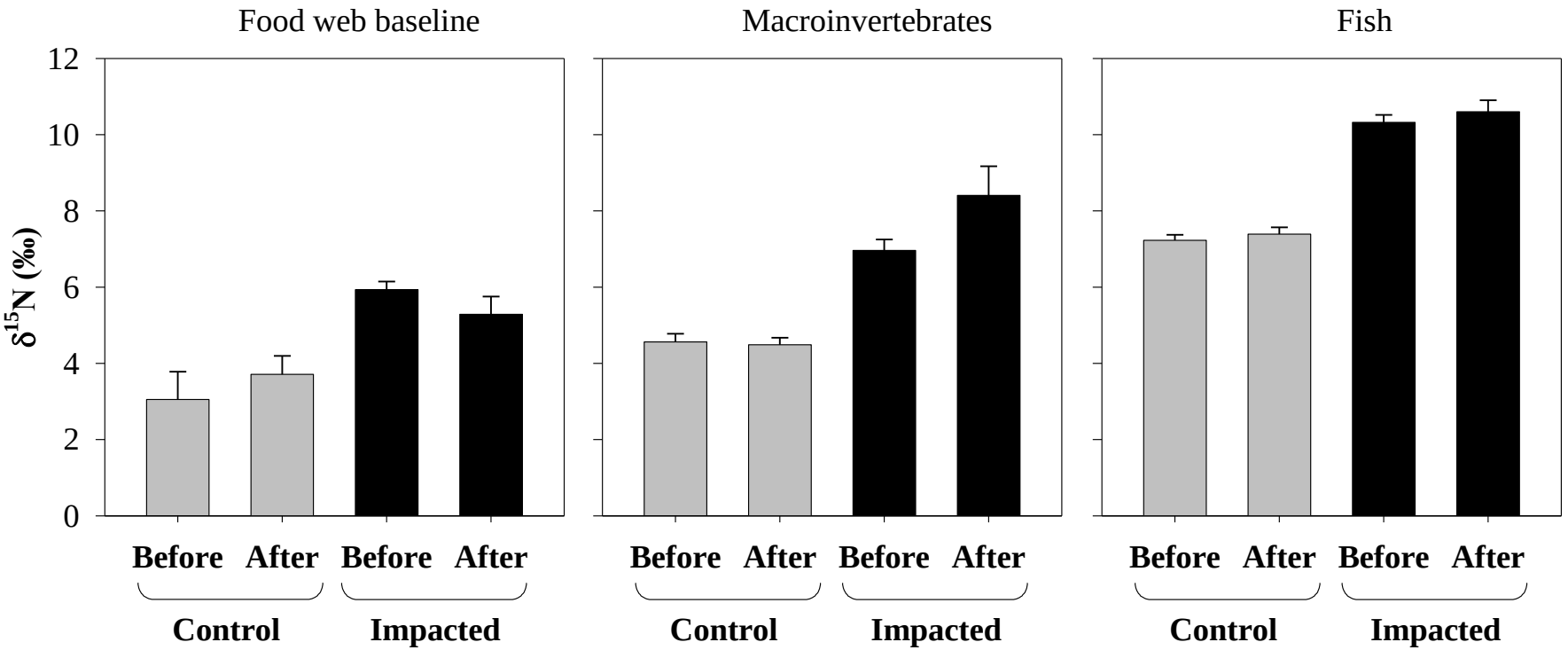
Marty, Smokorowski and Power 2009

Food web structure response



1- Significantly higher $\delta^{15}N$ values in impacted sites.

2- Unrestricted RR was responsible for higher $\delta^{15}N$ values for macroinvertebrates

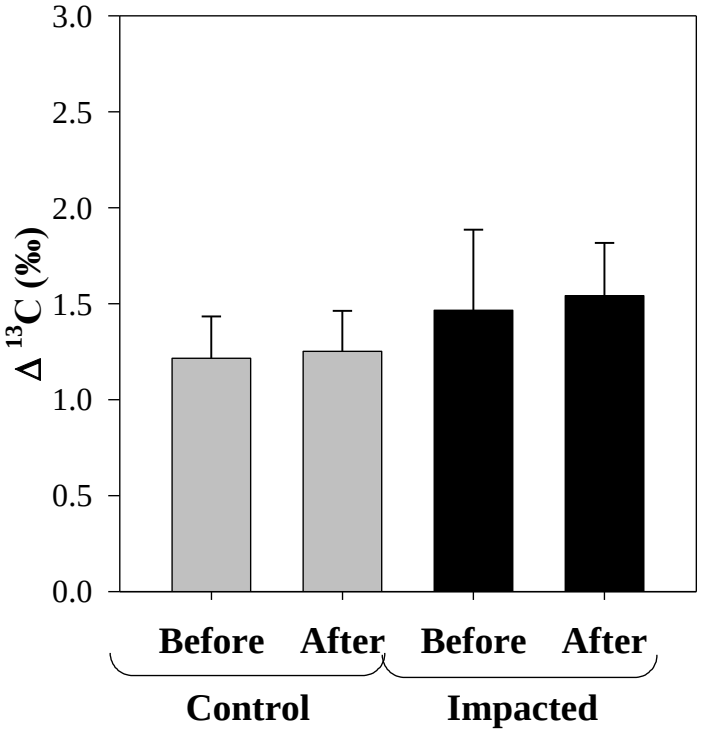
3- Macroinvertebrates trends were not transferred to fish.

Marty, Smokorowski and Power 2009

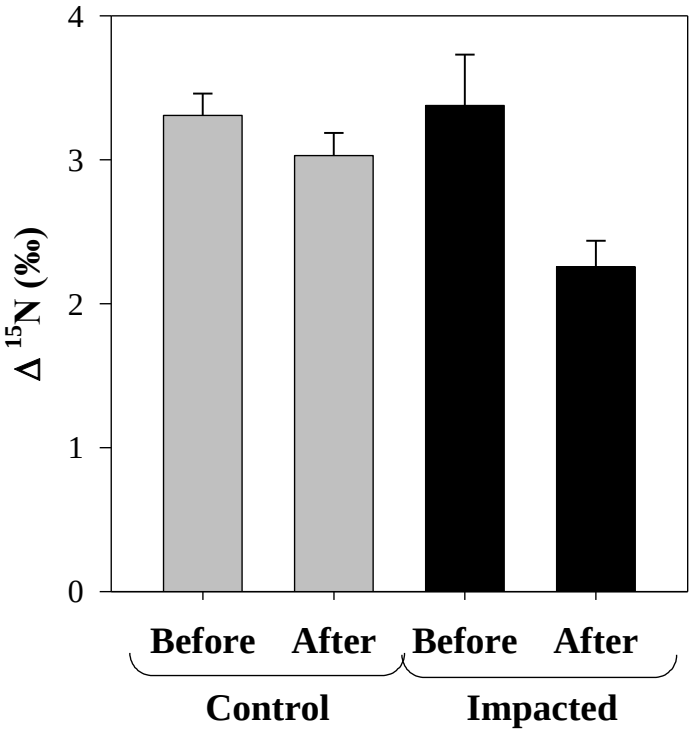
Food web structure response

Food web dynamic

$\Delta = |\delta_{INVERT} - \delta_{FISH}|$



Carbon source remains similar for all treatments, regardless of flow regime.



Food web length was shorter under unlimited RR

Summary

How to measure productive capacity of fish habitat ?

- Habitat based methods
- Fish methods
- Lower trophic methods
- Ecosystem level methods

Primary production supports aquatic food webs.
Flow alteration may alter the structure of the food web but not its function

Fish production capacity → Energy flows → Nutrient regime

Pelagic production ?	**Yes, in reservoirs**
Benthic production ?	**Yes, in rivers**
Terrestrial inputs ?	**Not as a food source but may provide nutrient when mineralized.**

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Marla Thibodeau (DFO)
Tobin Waterworth (U-Waterloo)
Rich Pyrce (OMNR)
uw-EILAB (U-Waterloo)

THANK YOU.

Ontario Ministry of Natural Resources
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Brookfield Power Ltd.
Ontario Centre of Excellence

St Lawrence River Institute
HydroNet (NSERC)