Pôle Karst / Journée d'Échanges Techniques

« Pollutions des hydrosystèmes karstiques : Où? Quand? Comment? »

Approches isotopiques sur la Loue

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Collaborateurs

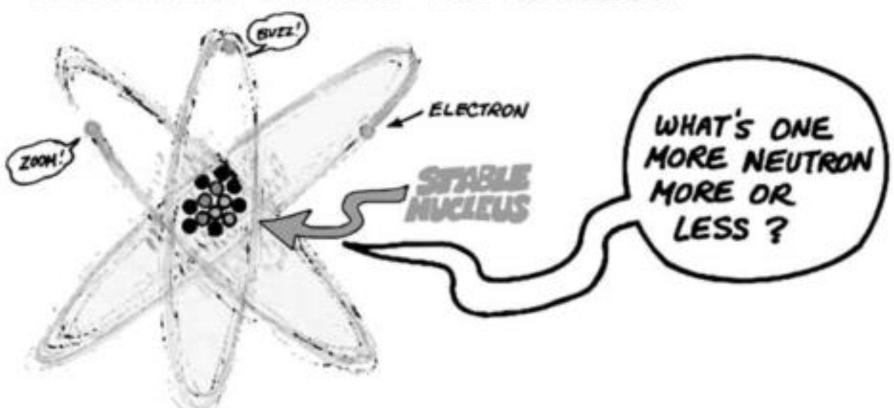
Financeurs

Isotope principles

Element	Isotope Abundance Low Mass		Isotope Abundance High Mass		Mass Difference[b] (Relative)	Range in δ[c] (‰)
Hydrogen[d]	^{1}H	99.984	^{2}H	0.016	2.00	700
Carbon	^{12}C	98.89	^{13}C	1.11	1.08	110
Nitrogen	^{14}N	99.64	^{15}N	0.36	1.07	90
Oxygen	^{16}O	99.76	^{18}O	0.20	1.13	100
Sulfur	^{32}S	95.02	^{34}S	4.21	1.06	150

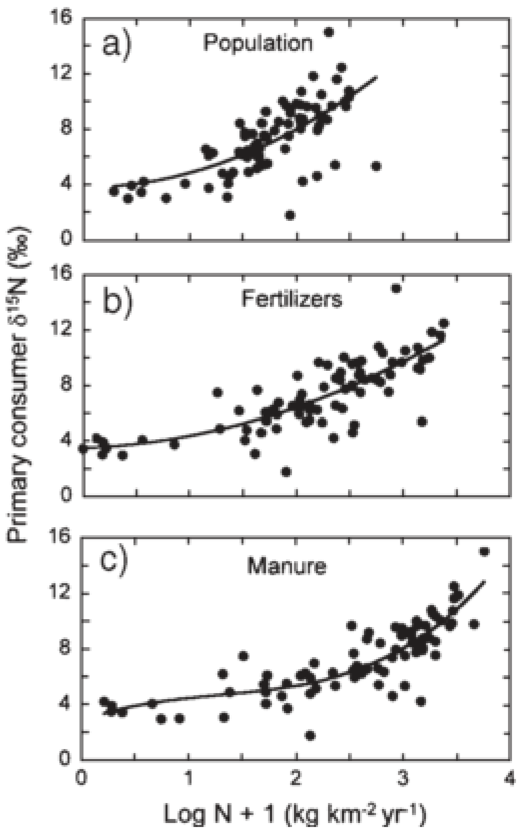
^{13}CARBON HAS ONE MORE NEUTRON THAN ^{12}CARBON IN ITS NUCLEUS.

IN MOST CASES ^{12}CARBON AND ^{13}CARBON BEHAVE THE SAME BECAUSE EXTRA NEUTRONS DON'T CHANGE THE REACTIVE SPHERE OF ELECTRONS AROUND THE NUCLEUS.

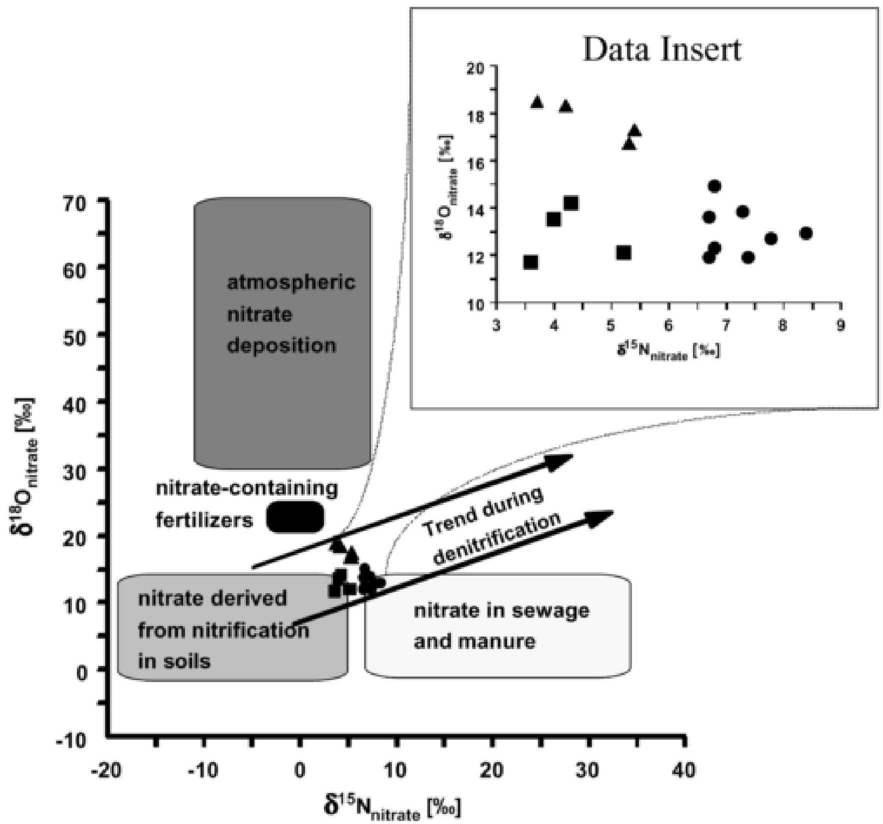


Isotope principles

Nitrogen isotopes → proxy of nitrogen sources
→ nitrogen cycle (coupled with nitrogen concentration)



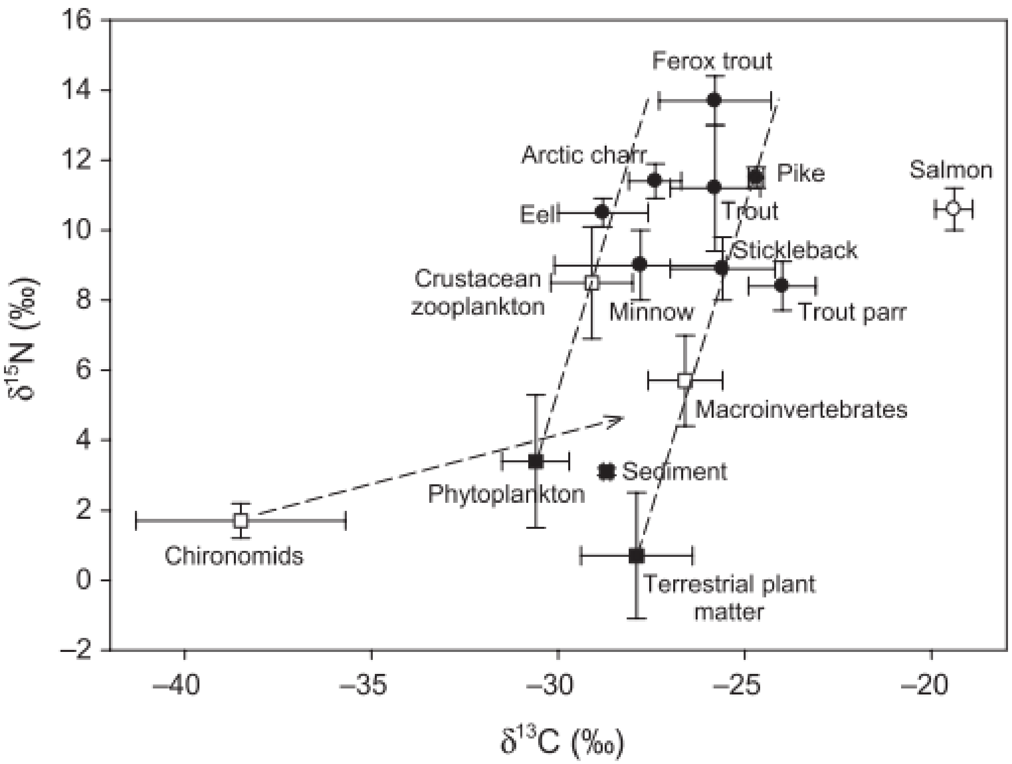
Anderson et Cabana 2006



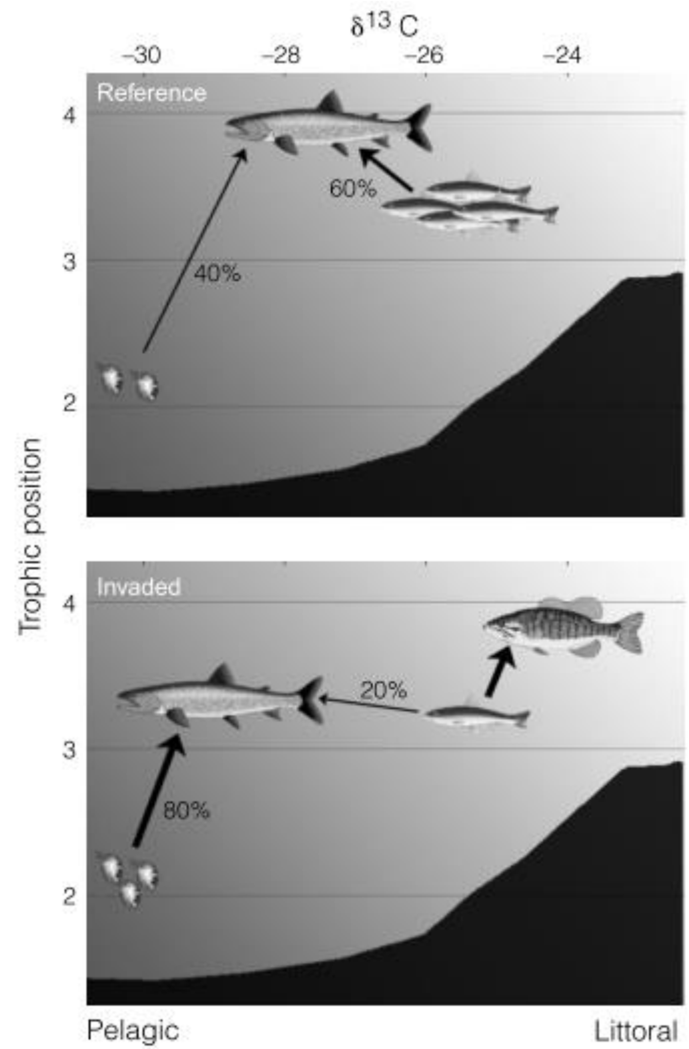
Mayer et al. 2002

Isotope principles

Isotope space → proxy of foodweb structure → ecological proxies (TP and ressoure use)



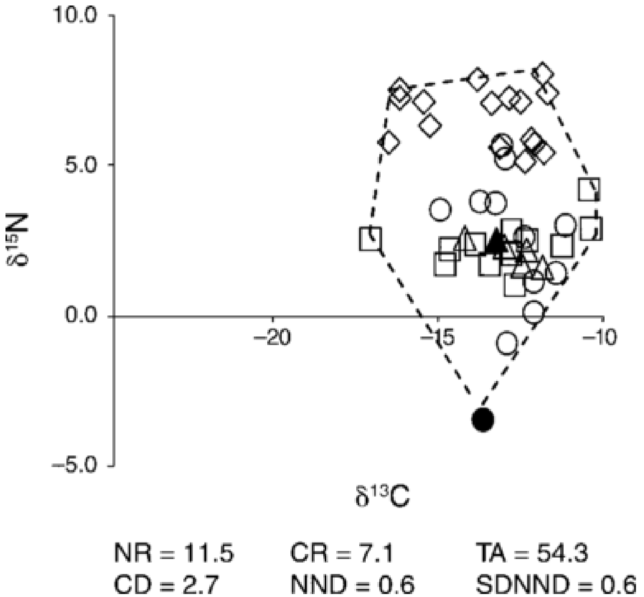
Grey and Jones 2011



Vander Zanden and Cabana 1999

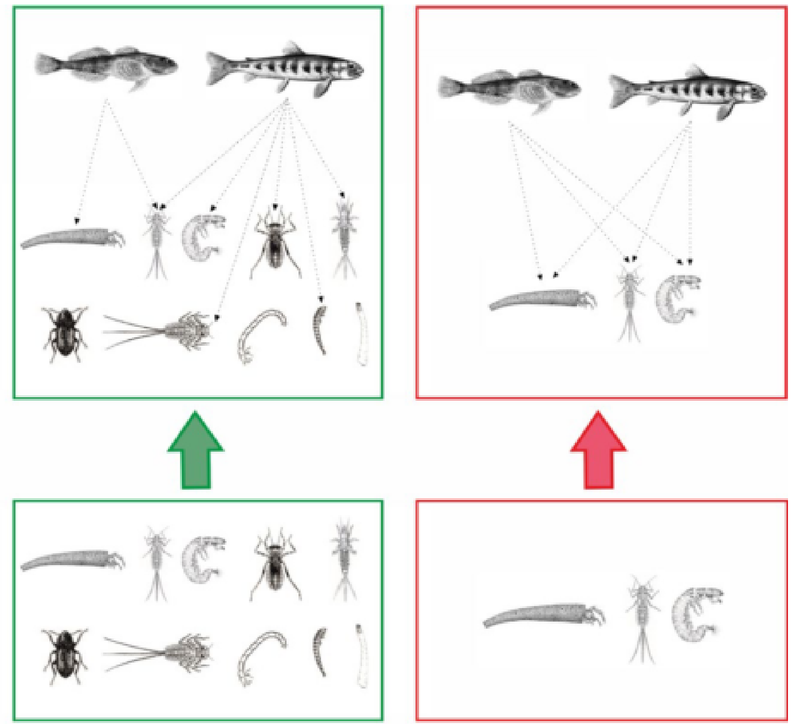
Isotope principles

Foodweb derived-metrics from isotope space



Layman et al. 2007

Space / time comparisons of foodweb structures

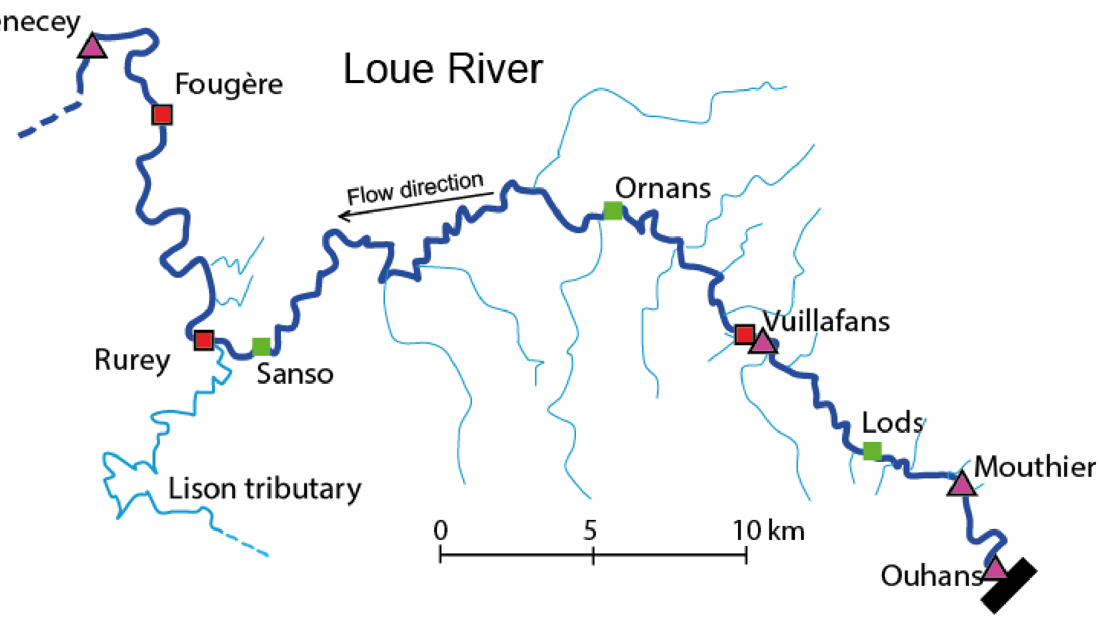


Sanchez-Hernandez et al. 2016

Nitrogen imprint in the Loue River

Nitrate data

- Besançon city : Chenecey 2004 to 2016 (n = 3549)
- Karst network multisite survey : 2016 (n = 1082)



Isotope data

Invertebrate (n = 300)

Collectors		Predators			Scrapers	Shredders	Filterers
Trichoptera	Goeridae (12)	Plecoptera	Perlidae	Dinocras (18)	Ancylidae (16)	Gammaridae (27)	Simulidae (24)
	Brachycentridae (24)			Perla (4)	Limnae (20)		
	Glossosomatidae (4)			Perlodes (4)			
	Limnephilidae (13)		Nemouridae (4)				
	Odontoceridae (9)	Hirudinea	Glossiphoniidae (1)				
	Hydropsychidae (9)		Erpobdellidae (1)				
	Leptoceridae (3)	Trichoptera	Ryacophilidae (4)				
Ephemeroptera	Ephemerellidae (14)	Diptera	Atericidae (3)				
	Ephemeridae (13)						
	Baetidae (8)						
	Caenidae (1)						
	Heptageniidae (5)						
Diptera	Chironomidae (12)						
Coleoptera	Elmidae (3)						
Oligochaeta (13)							

Macroalgae (n = 69) : *Vaucheria* sp. and *Cladophora* sp.

Objectives

Characterize spatial and temporal nitrogen isotope patterns?

Identify possible origins?

Assess whether nitrogen export from a karst watershed

may impact the river biota?

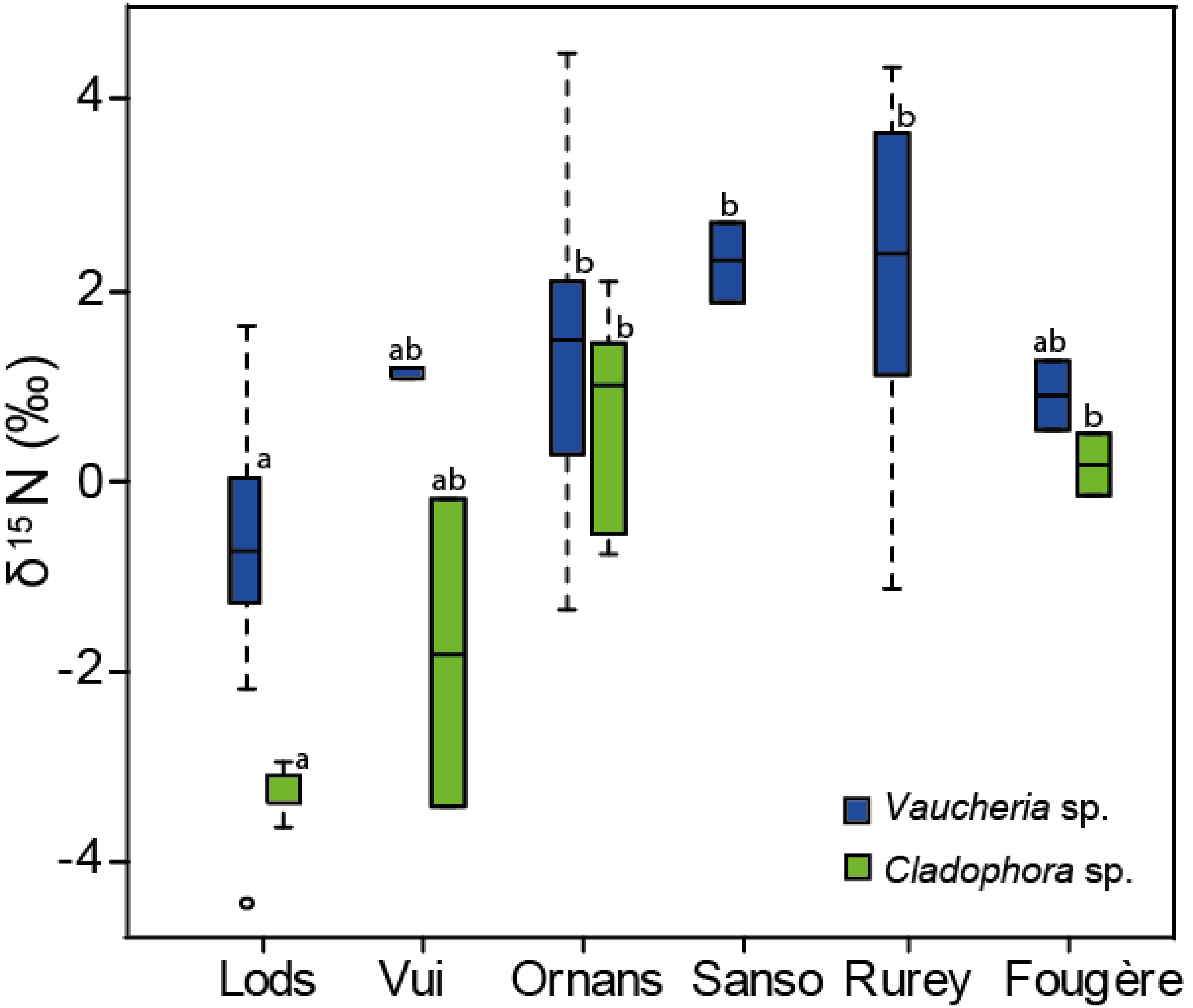
Spatial pattern of nitrogen isotope

- Macroalgae

Upstream : nitrogen originating from organic particles or mineral forms from soil /litter?

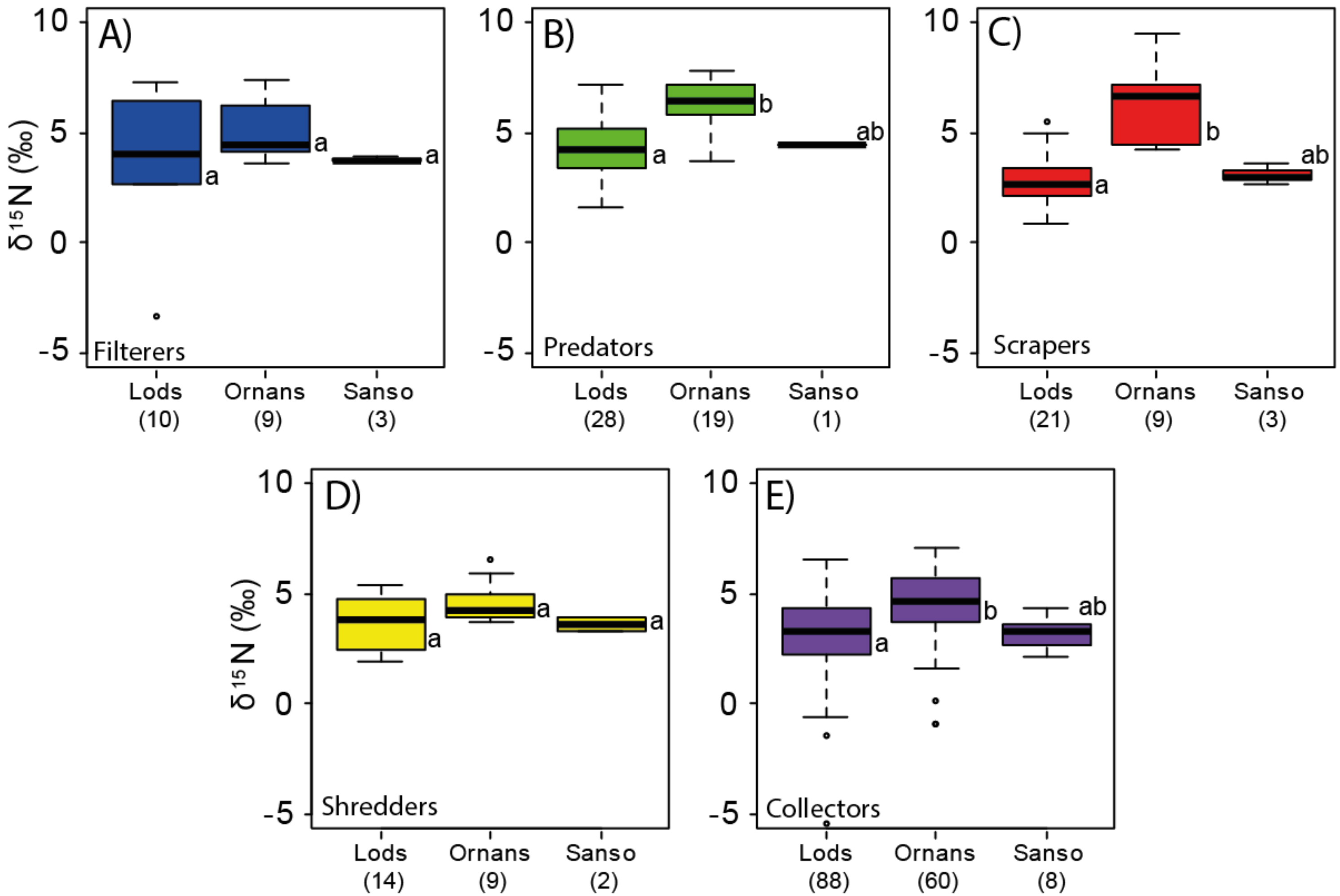
Downstream: Increase of organic source

Most-downstream: Changes of nitrogen source (fertilizers)?



Spatial pattern of nitrogen isotope

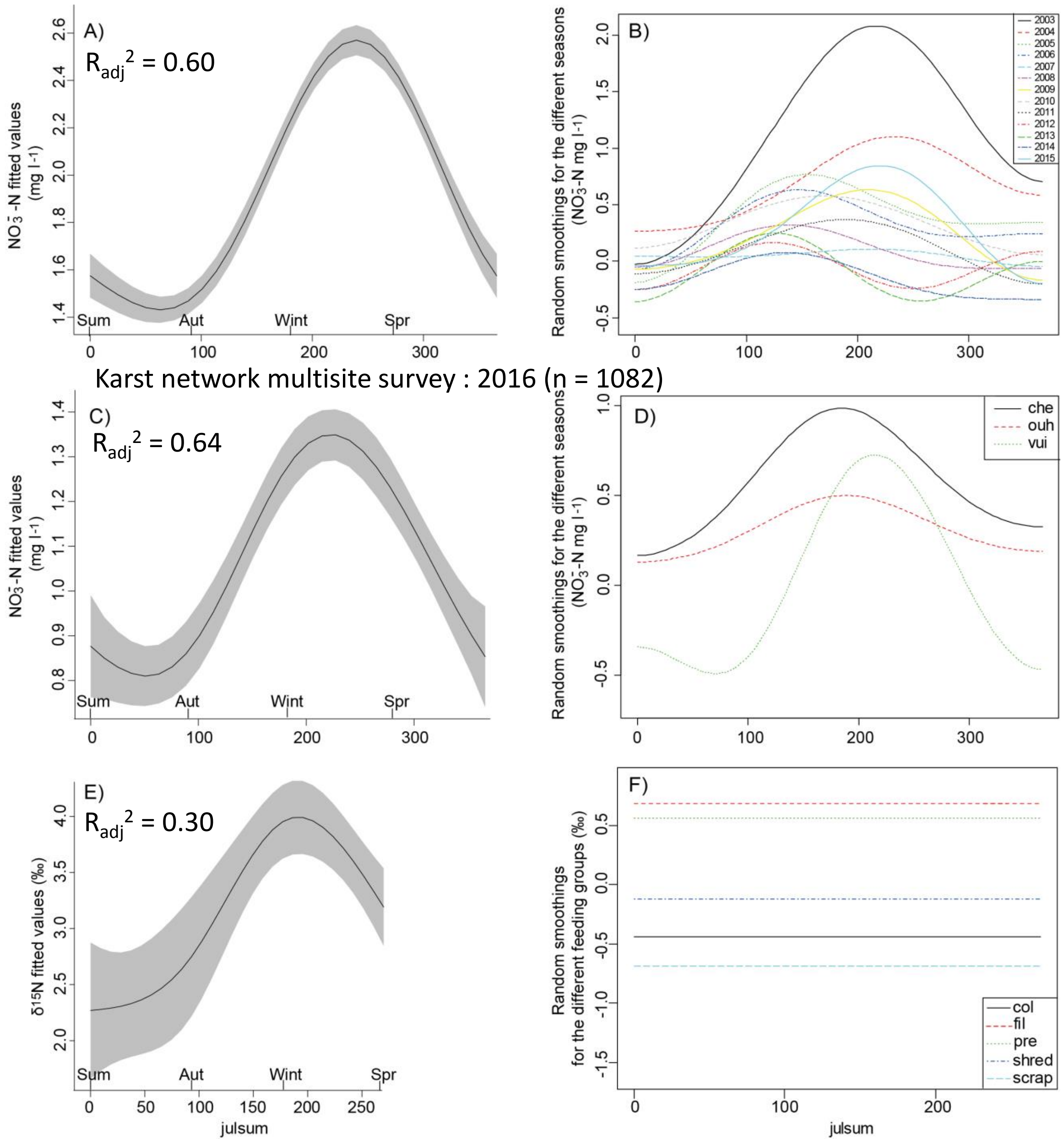
- Invertebrate



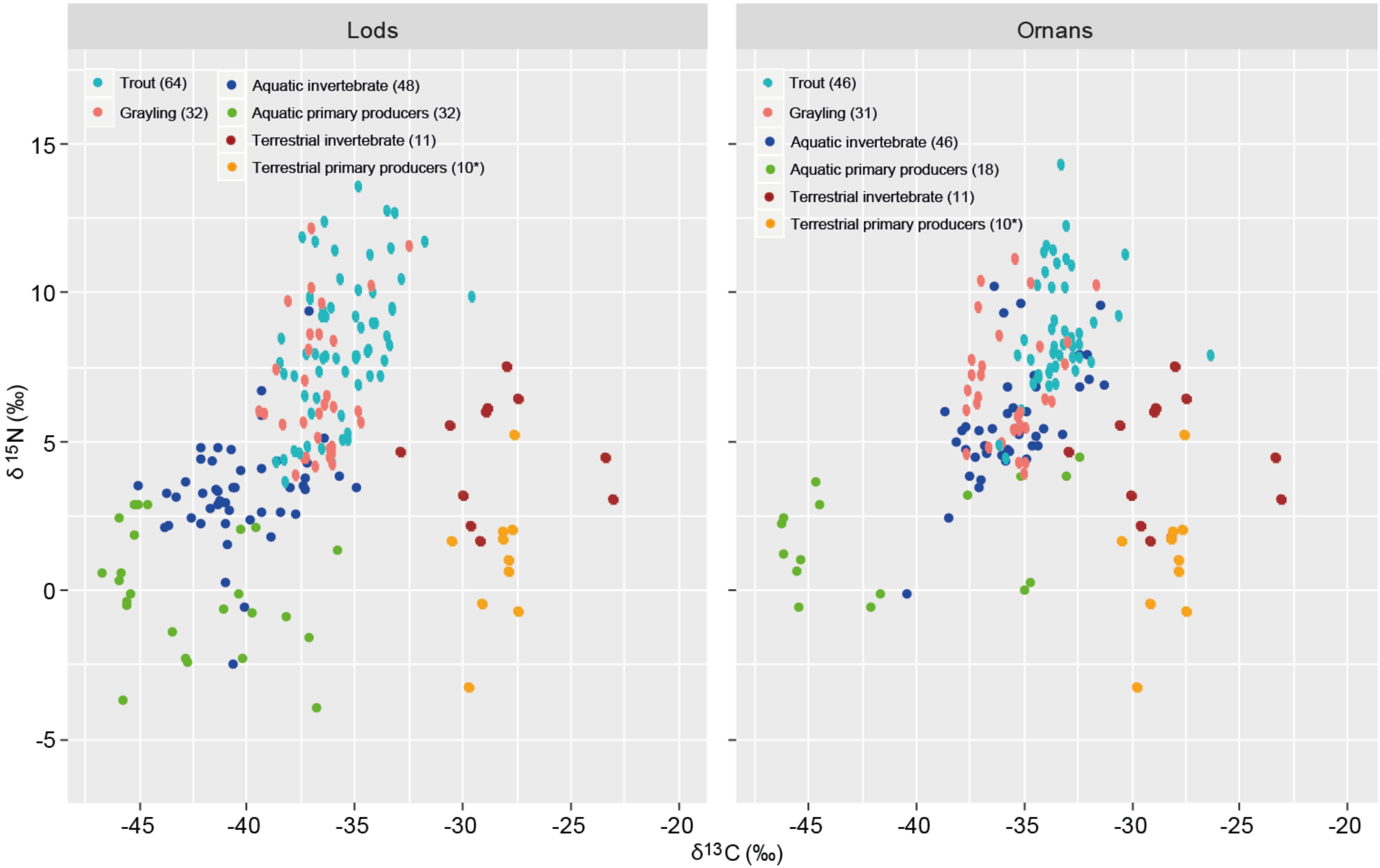
Similar patterns as compared to macroalgae

Annual patterns of nitrogen concentrations and isotopes

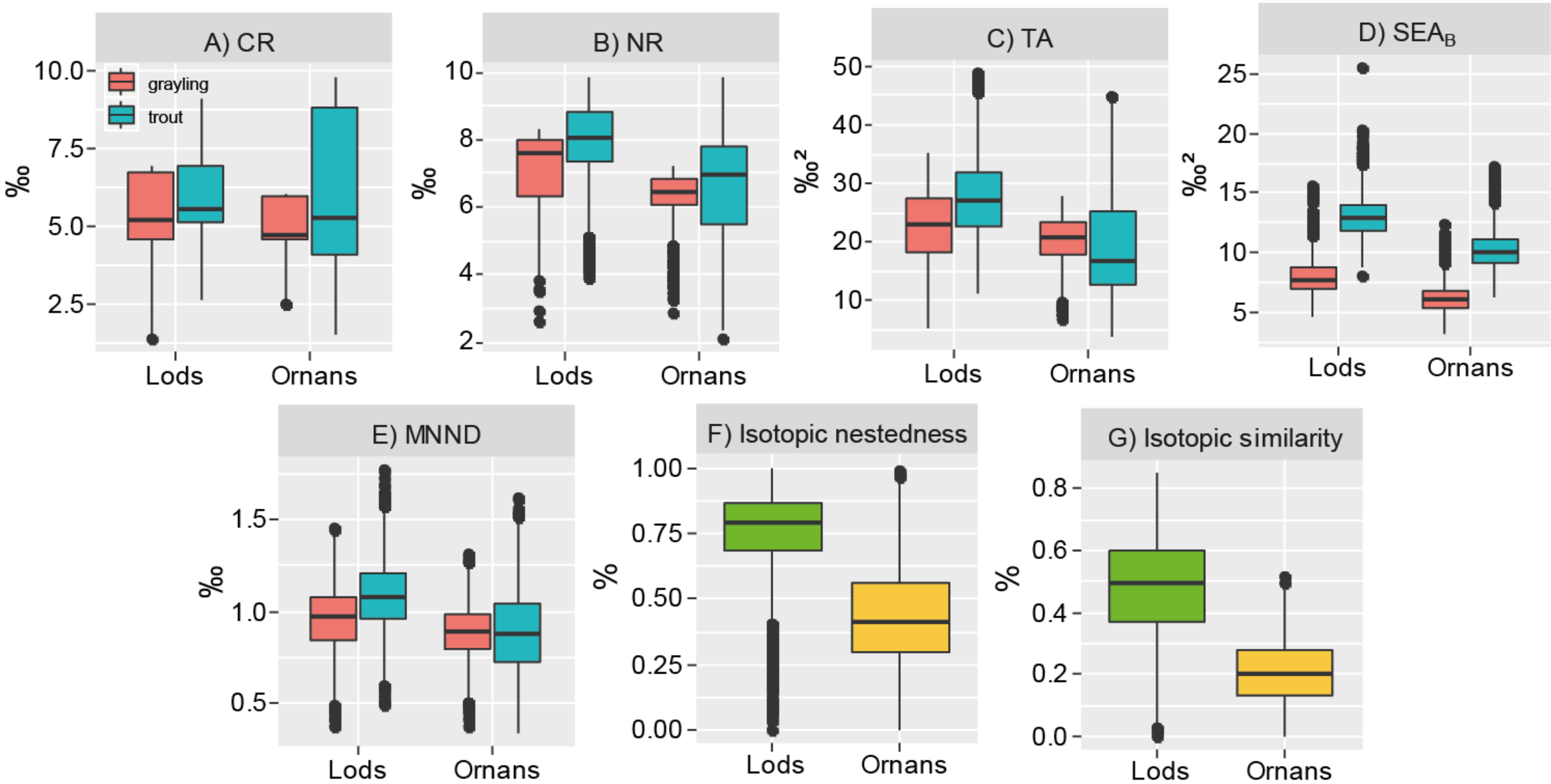
Besançon city (Chenecey) 2003 to 2015 (n = 3549)



Isotope insights on salmonids and food webs



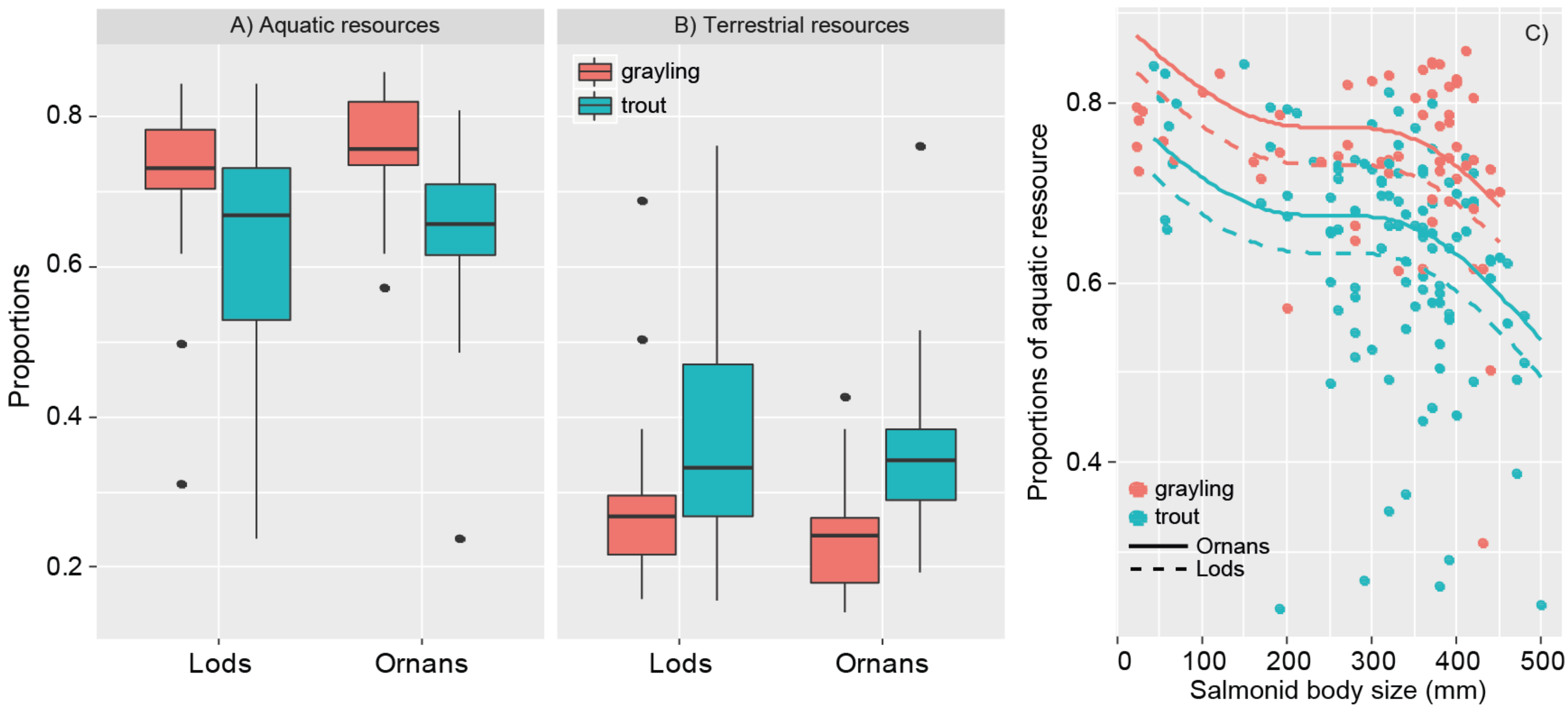
Isotope food web metrics / isotope overlap



Higher salmonid isotope space upstream than downstream → Difference in foodweb complexity
Wider sitope niche for trout than grayling

Higher isotope overlap upstream than downstream → Difference in ressource partitioning

Ressource used by salmonids

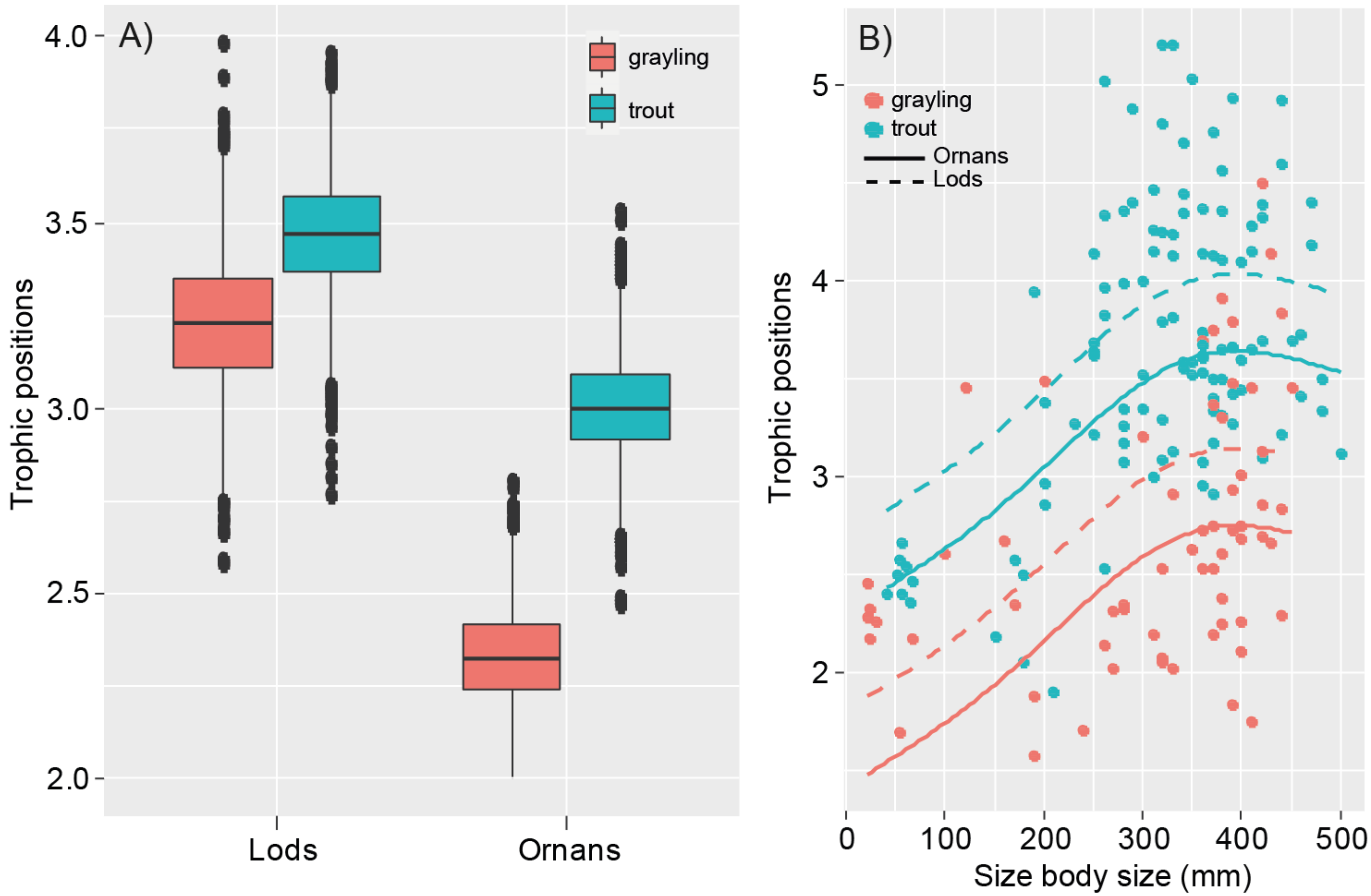


Major reliance on aquatic resources → high dependence on aquatic secondary production

Trout significantly more fuelled by terrestrial subsidies than grayling
(36 ± 13% against 26 ± 9%)

The decrease in aquatic resource with size → ontogenetic changes in food resources (habitat use?)

Trophic positions of salmonids



Grayling had consistently lower TP than trout

TP increase wit size → ontogenetic diet changes

Higher TP upstream than downstream → shorter foodweb length / alteration of invertebrate community downstream?

Insights and limits

Pros :

- Time integrative ecological information
- Diverse ecological insights at multiple organisational scales

  (ressource use, TP, food chain length, isotope diversity)
- Limited cost (10-15€ / sample)
- Limited mass needed (~1mg)

Cons :

- Multiple ecological / physiological / metabolic processes can affect isotope compositions
- Use complementary isotopes (S, H, O) / practical and methodological complications

Stable isotopes can be powerful tool for ecologists and managers

When accounting for - careful sampling

- data treatement

- combined with complementary proxies

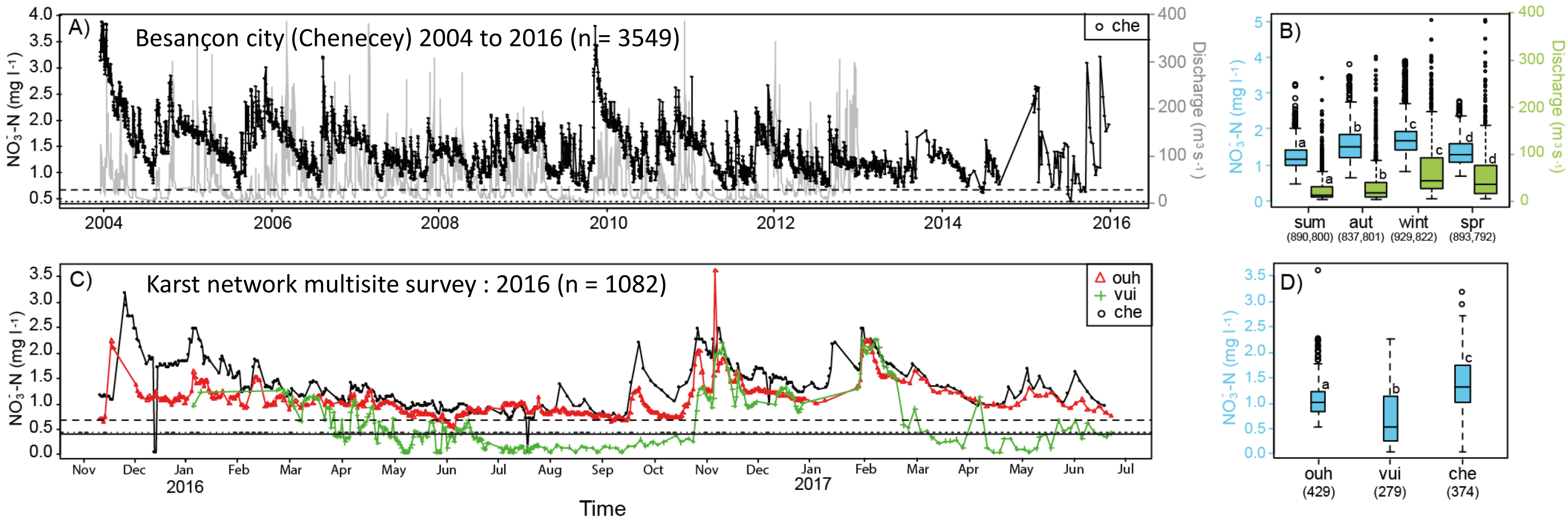
Related papers

- Frossard, V., Aleya, L., Vallet, A., Henry, P. & Charlier, J.-B. (2020). Impacts of nitrogen loads on the water and biota in a karst river (Loue River, France). *Hydrobiologia*, 2433–2448

- Frossard, V., Vagnon, C., Rossignon, C. & Caudron, A. (2021). Variability of isotopic partitioning between sympatric brown trout (Salmo trutta) and European grayling (Thymallus thymallus) in the Loue River (France). *Ecology of Freshwater Fish*, DOI: 10.1111/eff.12583.

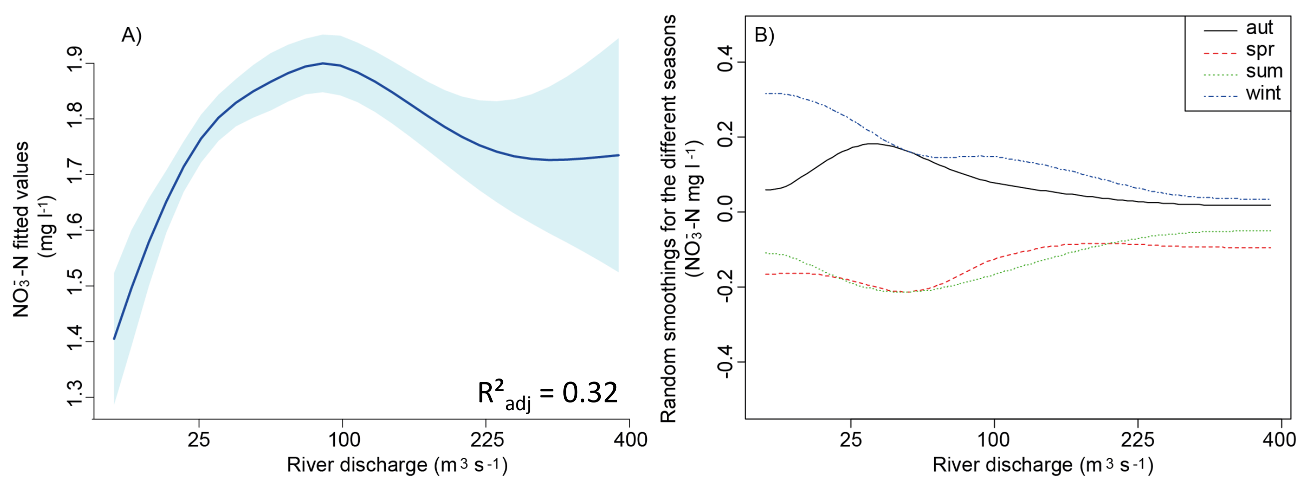

Merci pour votre attention!

Appendix



Low nitrate at Vuillafans during spring and summer: macroalgae nitrogen uptake / limited lateral inflows

Floods of limited extent may provide the most suitable context for the transfer of nitrogen to the river?

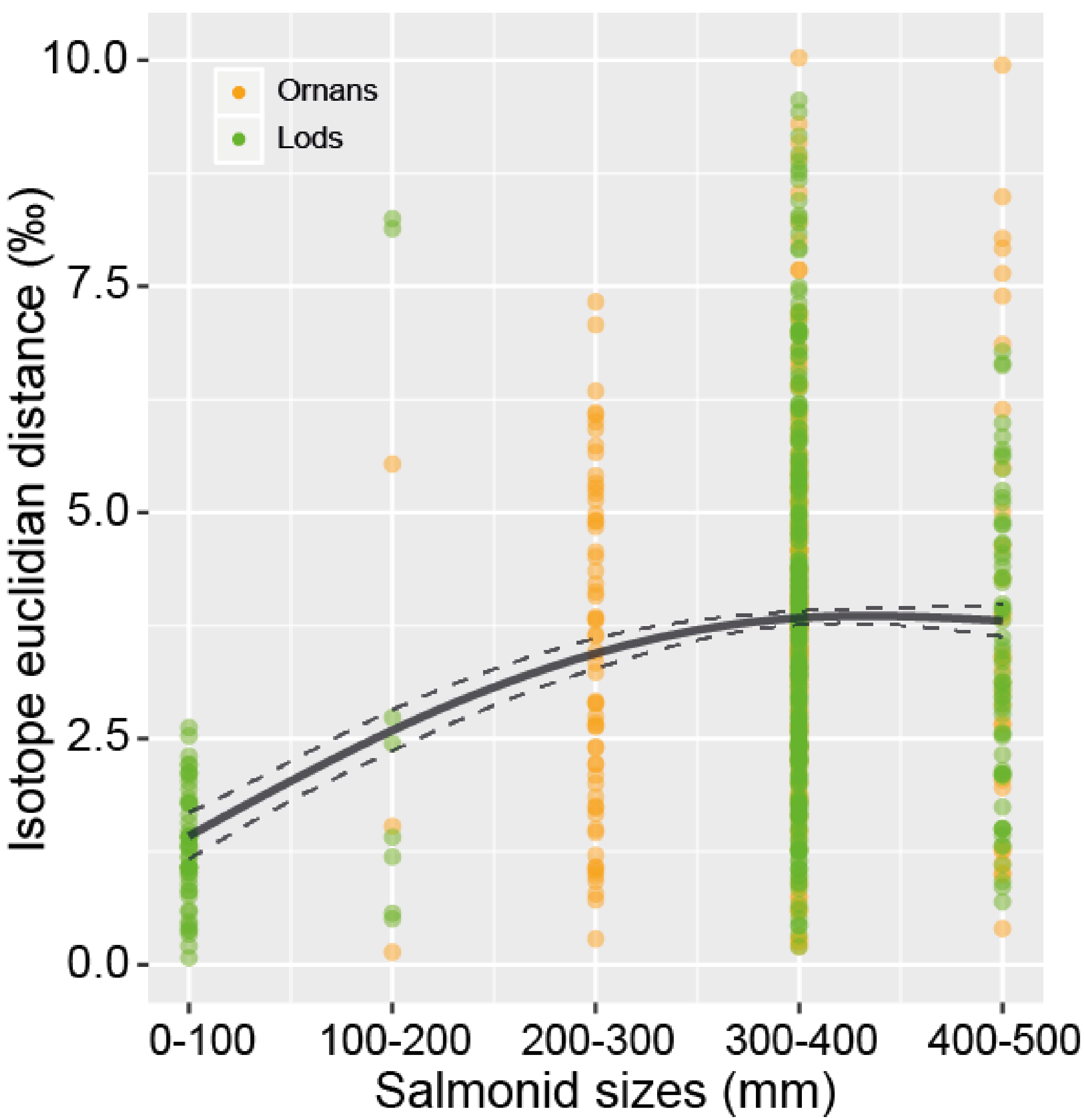


Appendix

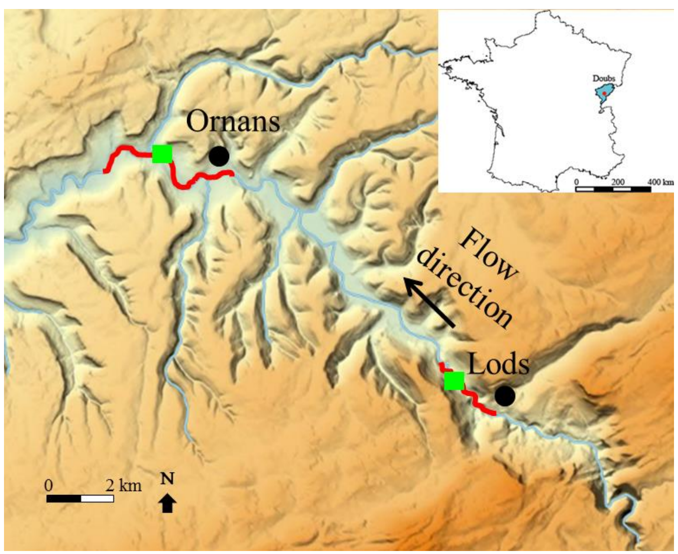
Appendix

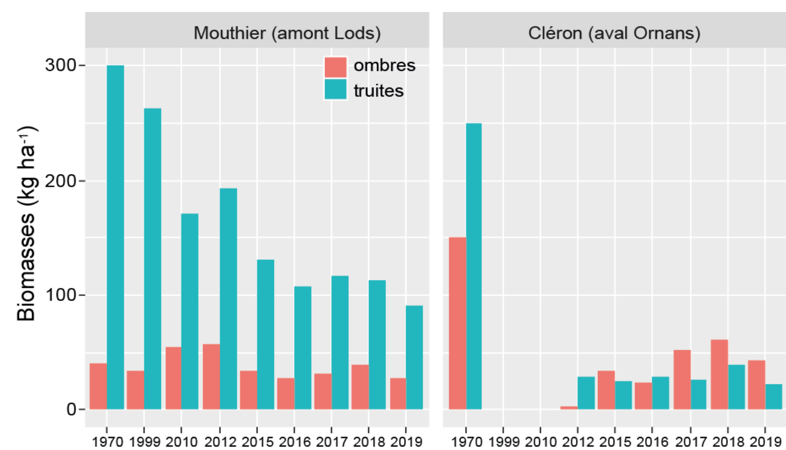
Increasing isotope distances with salmonid size → isotopic niche partitioning increase with ontogeny.

Similar habitat requirements for 0 +, adults tend to exploit more distinct river habitats and prey items.



Appendix


Ornans
Flow direction
Lods
Doubs
0 200 400 km
0 2 km
N


Mouthier (amont Lods)
Cléron (aval Ornans)
ombres
truites
Biomasses (kg ha-1)
0
100
200
300
1970 1999 2010 2012 2015 2016 2017 2018 2019
1970 1999 2010 2012 2015 2016 2017 2018 2019