# Longitudinal and lateral migrations of riverine fish in rivers of Chile and New Zealand: implications for management

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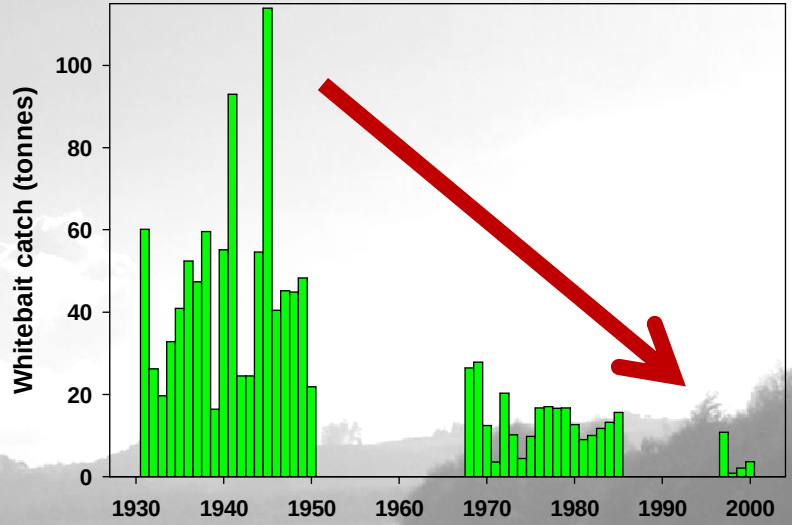
# Southern temperate rivers

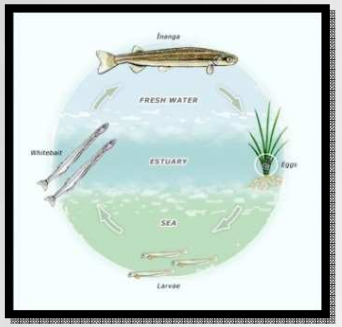
# Southern temperate riverine fish

# Southern temperate riverine fish

- Declining native fish populations

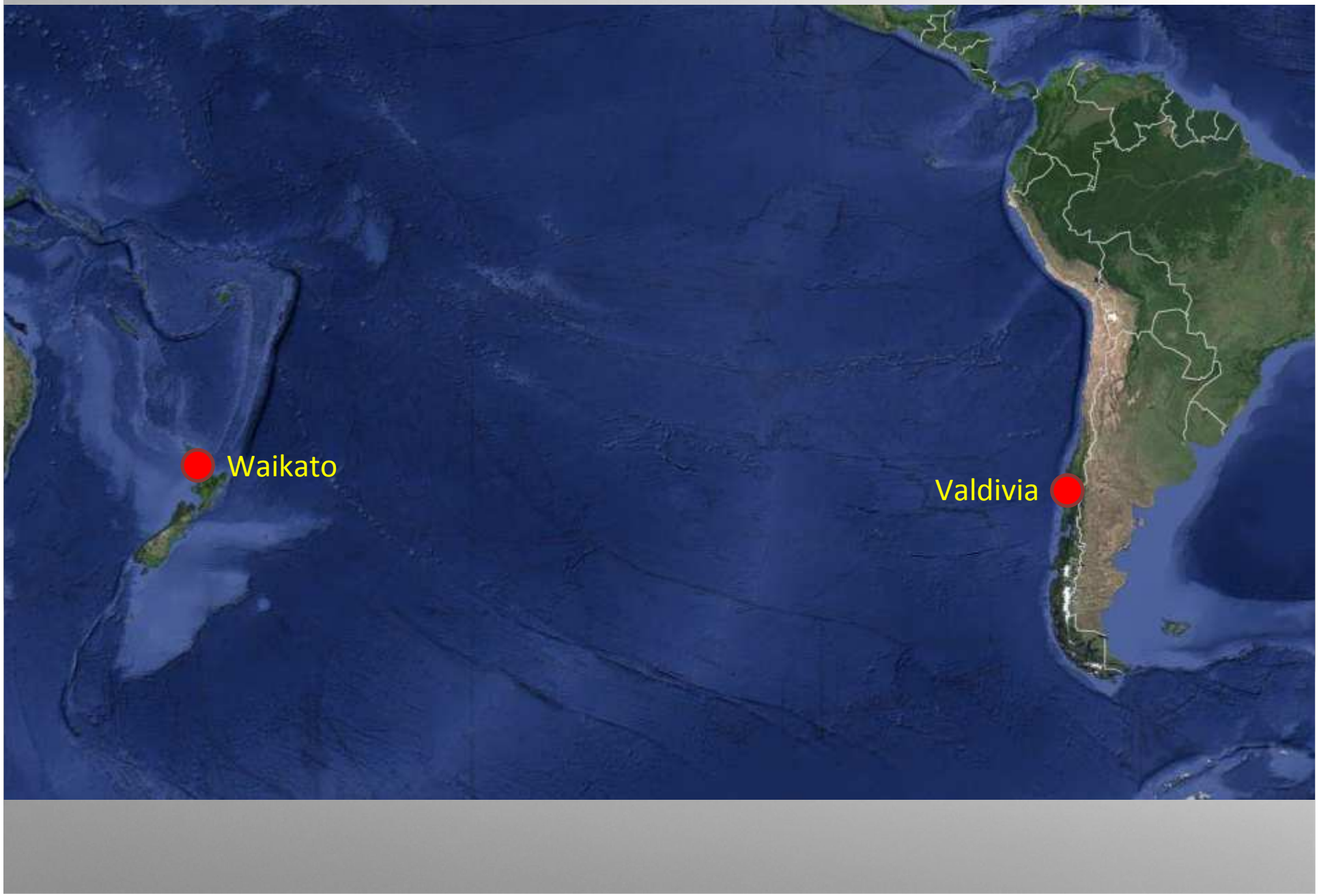



- Societal aims: Sustainable management / protection of native fish fauna (fisheries, conservation)
- **Knowledge gap:** Migration / recruitment strategies of these fish not understood

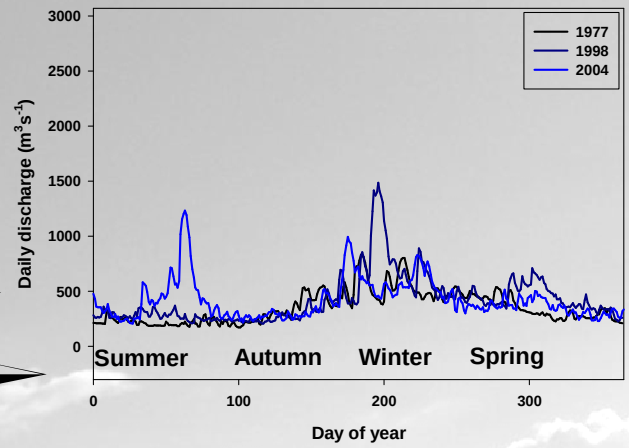


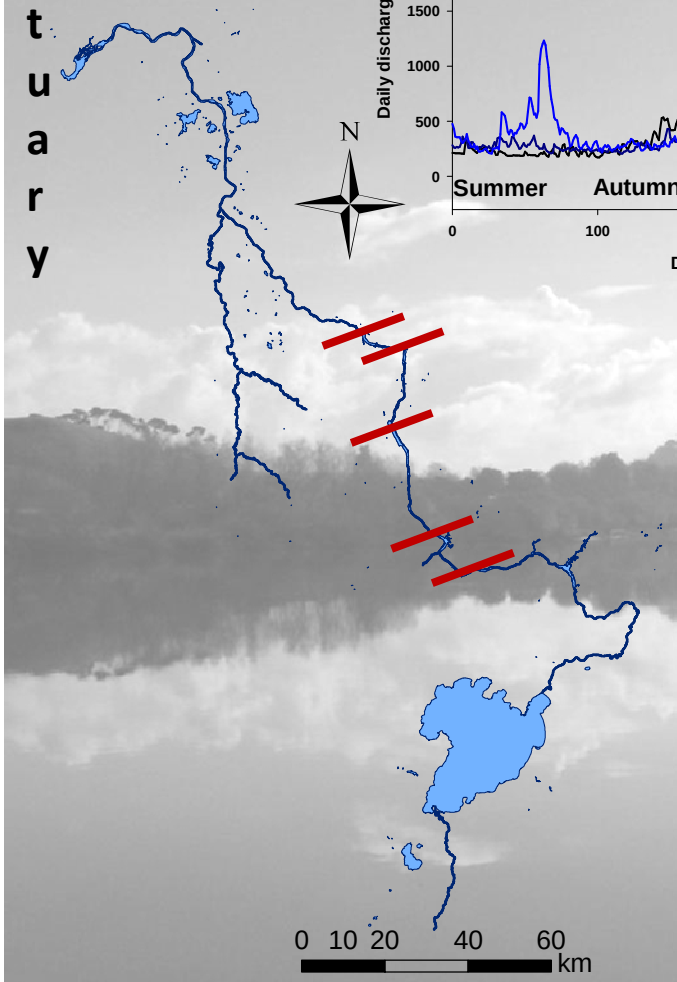

- **Detailed migration / habitat use patterns in the Valdivia River (Chile) and the Waikato River (New Zealand)**

- **Patterns of migration strategies across latitudes (Chile)**

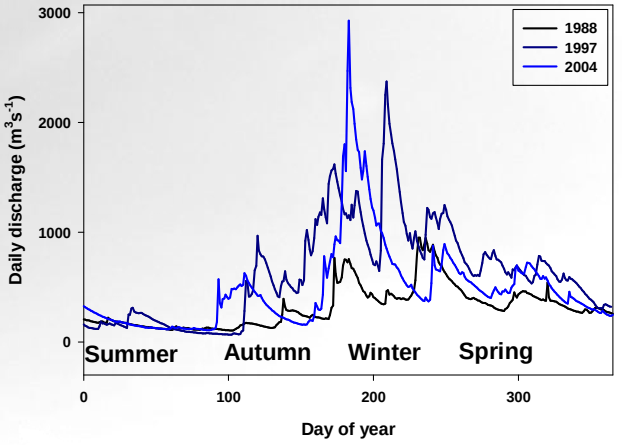

Waikato
Valdivia

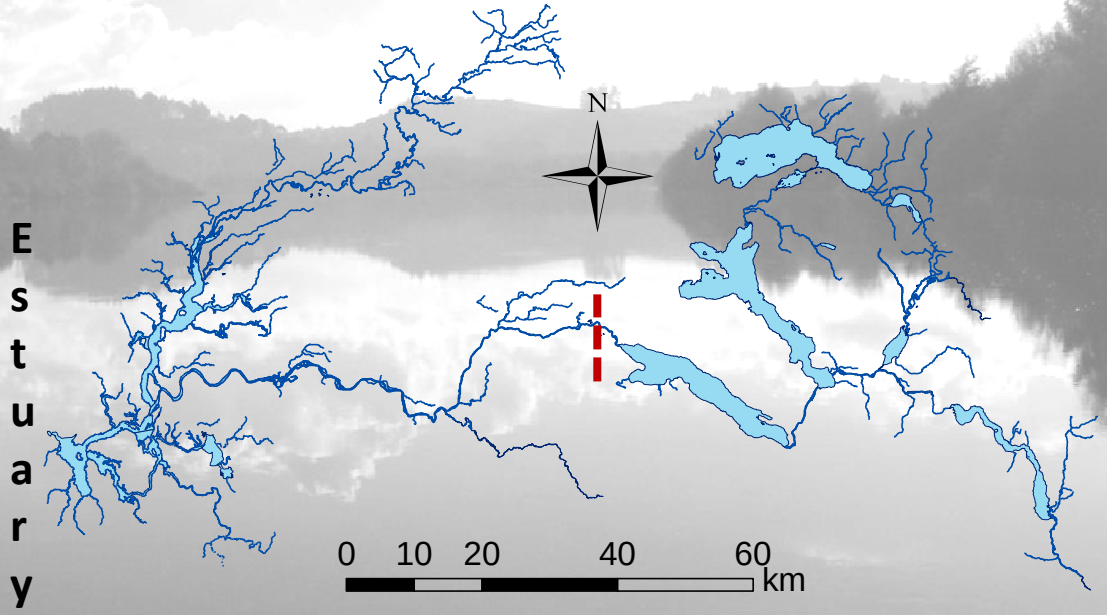
# Waikato



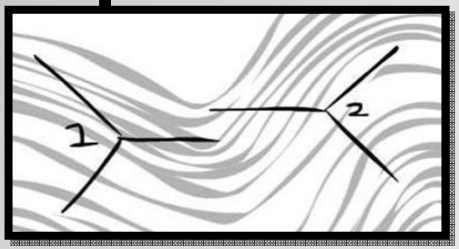




# Valdivia

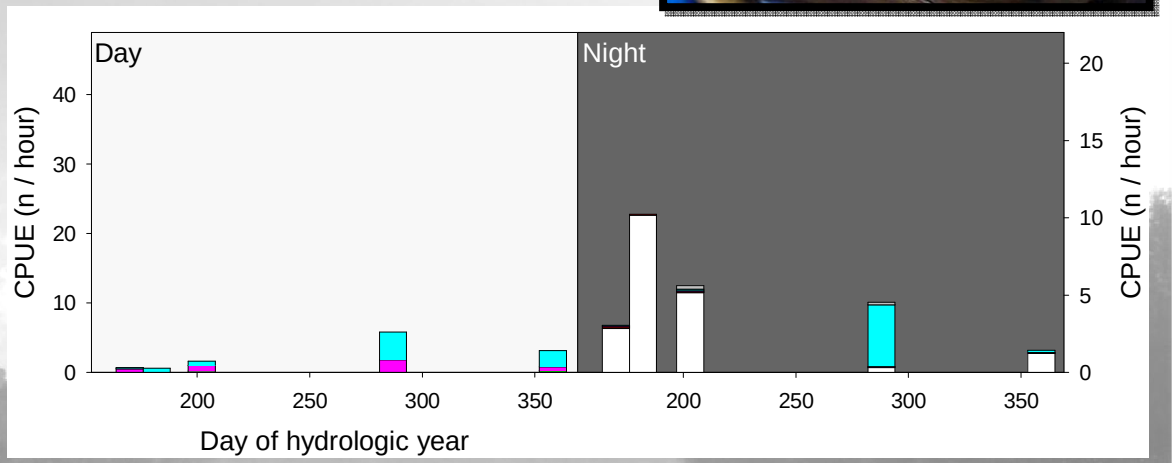


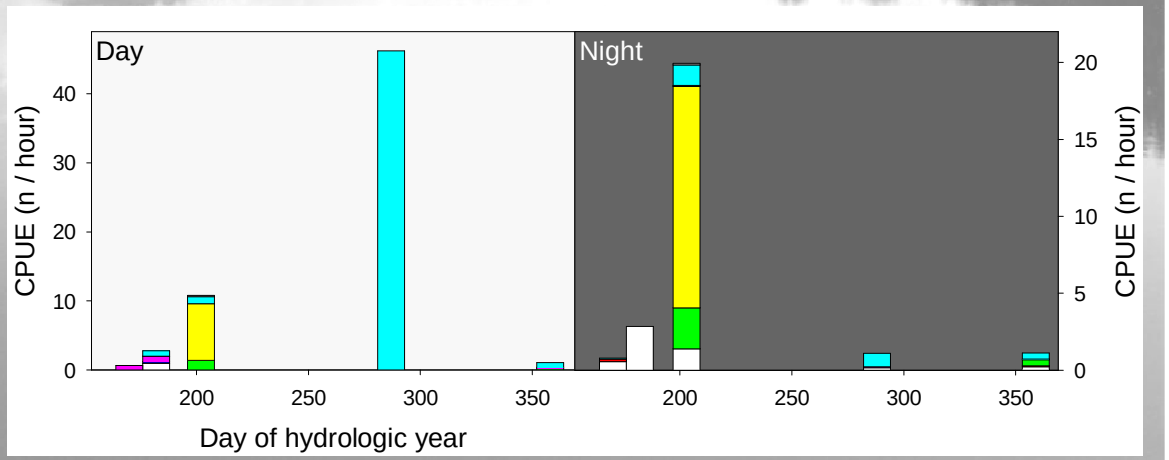
# Waikato – lateral floodplain habitat use




## Into the floodplain

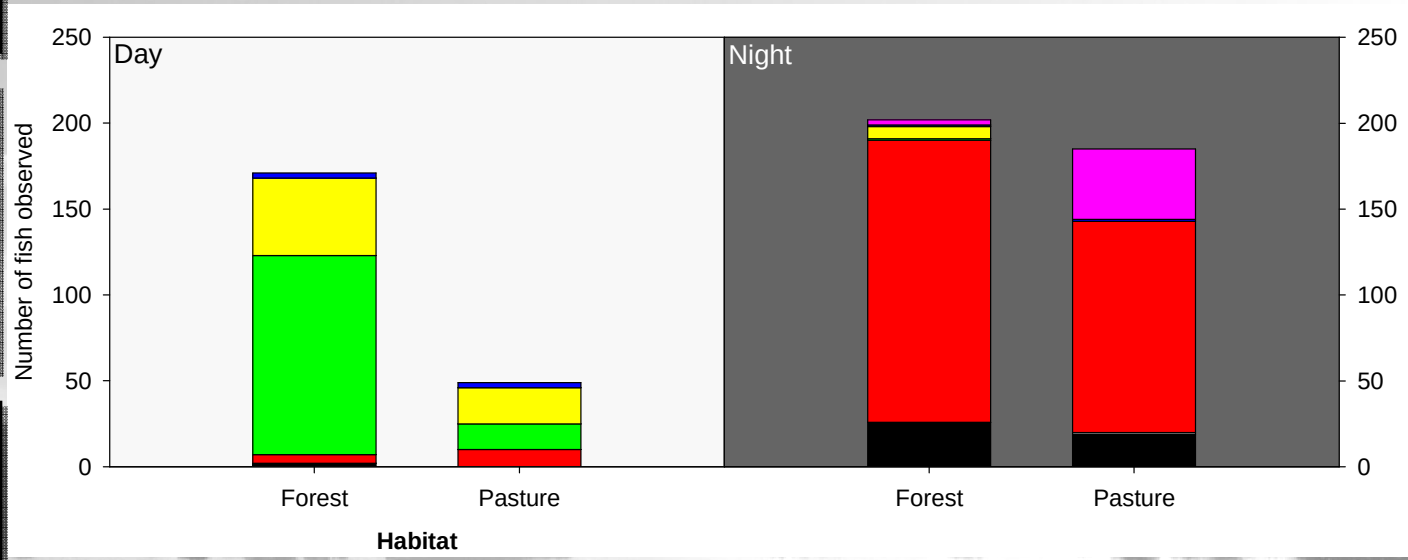


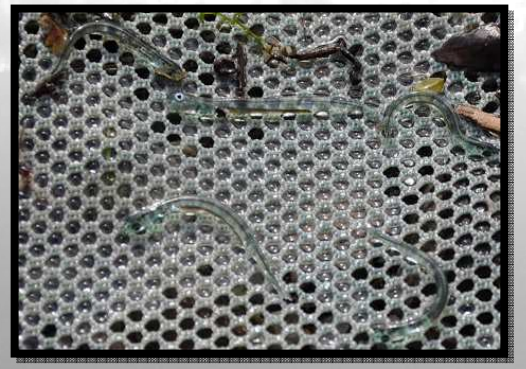

## Out of the floodplain




- Brown bullhead catfish (*Ameiurus nebulosus)*
- Shortfin eel (*Anguilla australis)*
- Longfin eel (*Anguilla dieffenbachii)*
- Goldfish (*Carassius gibelio)*
- Common carp (*Cyprinus carpio)*
- Gambusia (*Gambusia affinis)*
- Inanga (*Galaxias maculatus)*
- Common bully (*Gobiomorphus cotidianus)*
- Common smelt (*Retropinna retropinna)*

# Valdivia – lateral floodplain habitat use



- *Basilichthys australis*
- *Cheirodon australe*
- *Galaxias* spp juvenile
- *Galaxias maculatus*
- *Galaxias platei*
- *Percillia gillissi*
- *Percichthys trucha*

# Longitudinal habitat use: marine-freshwater

Drawing: Niky Wu

## Waikato

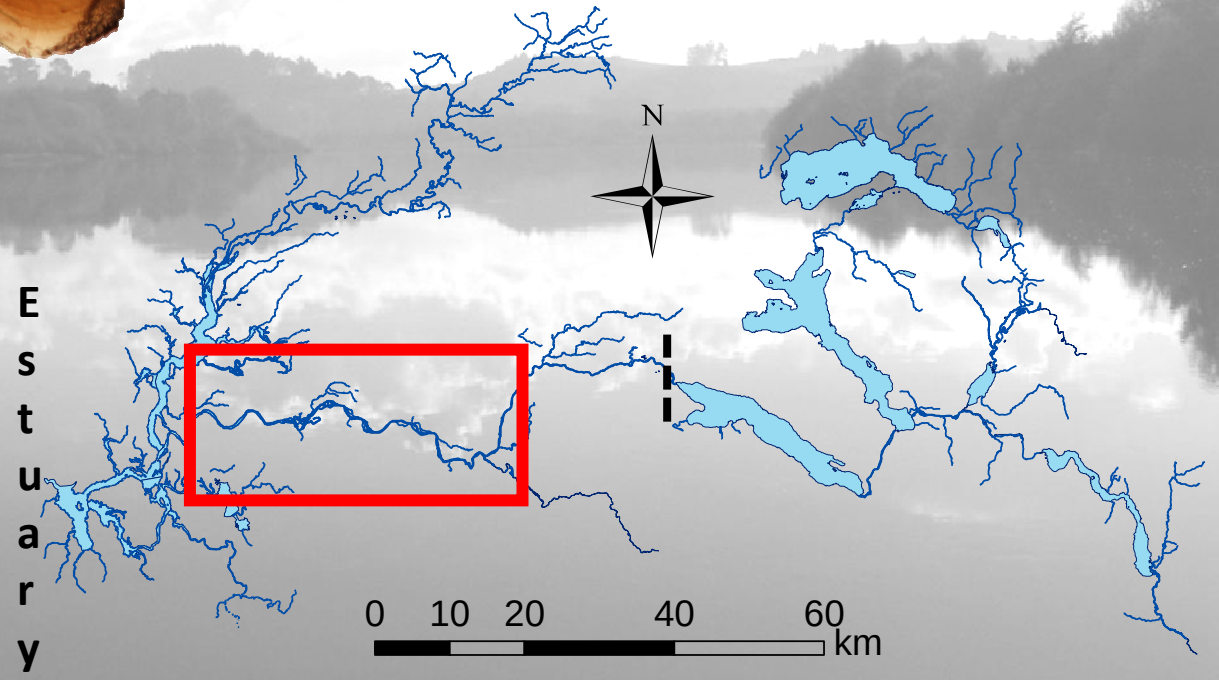
Estuary

**Ear-bones reflect water chemistry:**

High strontium (Sr) – marine

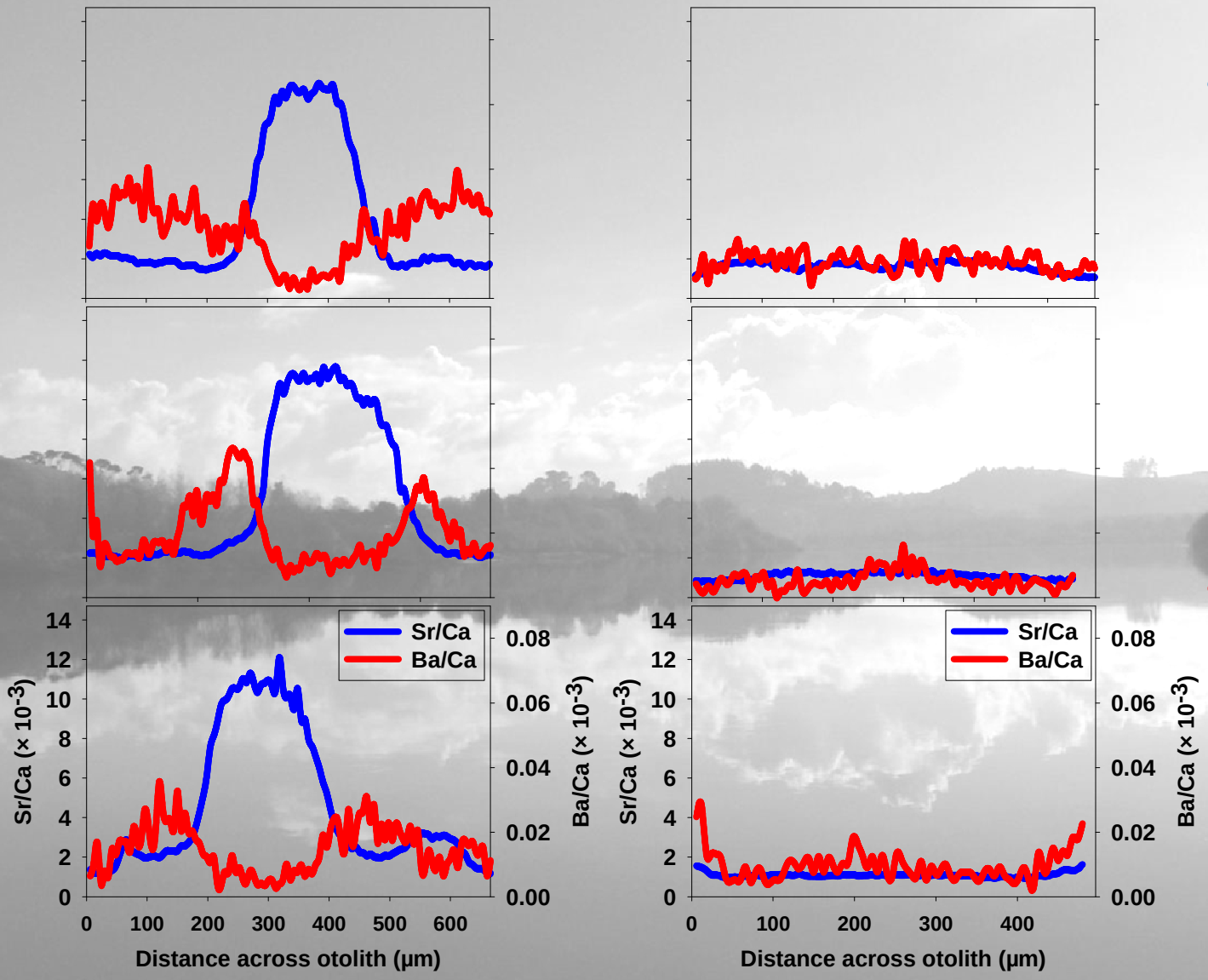
High barium (Ba) - freshwater


## Valdivia



# Waikato

# Valdivia




- Marine recruitment in the Waikato
- Freshwater recruitment in the Valdivia

Examples of temporal changes in otolith Sr/Ca and Ba/Ca ratios

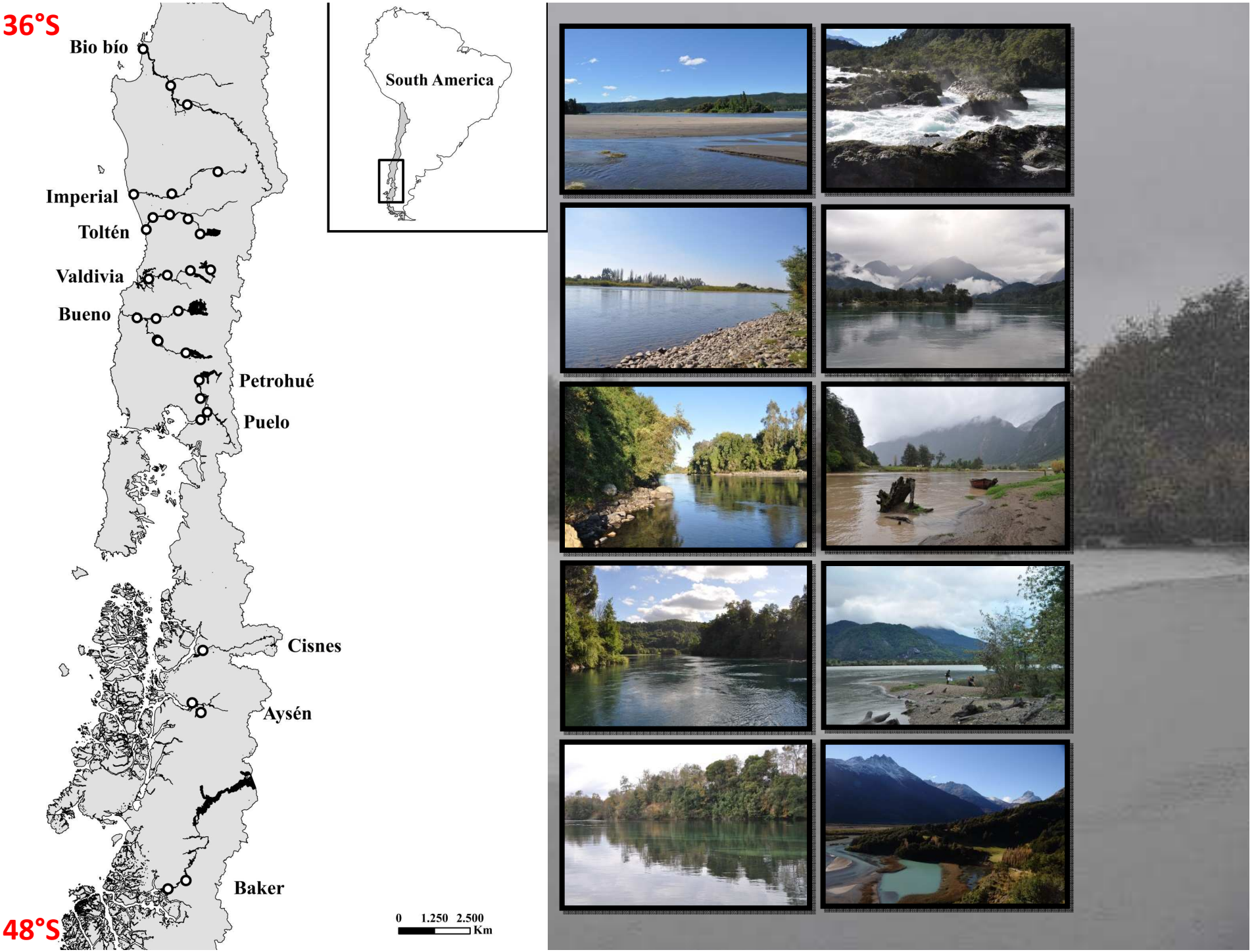
# Longitudinal movements across latitudes

- **Q: What is the propensity of marine recruitment of *Galaxias maculatus* in Chilean temperate rivers across latitudes (temperatures; flow regimes)?**

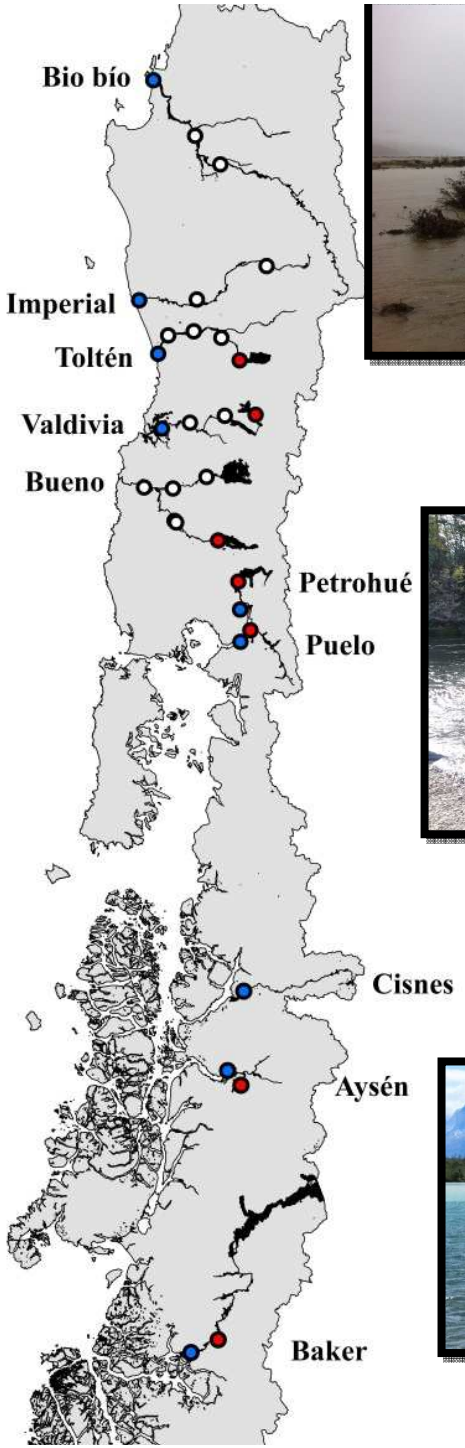
- **H:** ***Propensity of marine recruitment increases in rivers at higher latitudes (lower productivity of freshwater ecosystems)***

- Unique spatial distribution:
  flow E → W, parallel basins N → S

- Gradient of temperatures and flow conditions


36°S
Bio bío
Imperial
Toltén
Valdivia
Bueno
Petrohué
Puelo
Cisnes
Aysén
Baker
48°S
South America
0 1.250 2.500
Km

# Methods

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- Specimens collected using electrofishing and seining
- Fish sampled to cover broad range of habitats within each basin – headwater lakes, upstream channel, lowland large river, estuaries
- Fish bone tissue analysed for stable isotope composition (sulphur and nitrogen; ~20 ind.)

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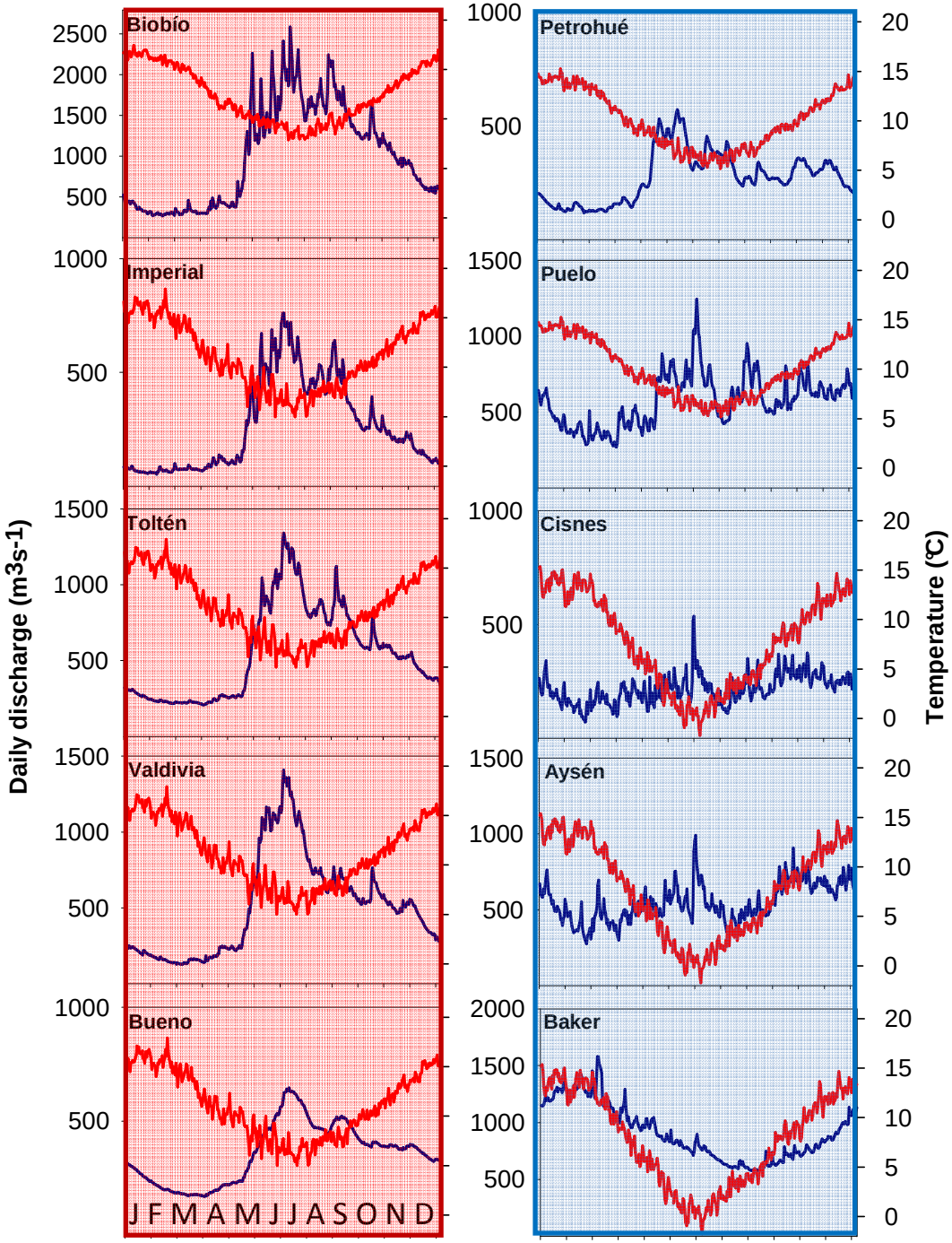
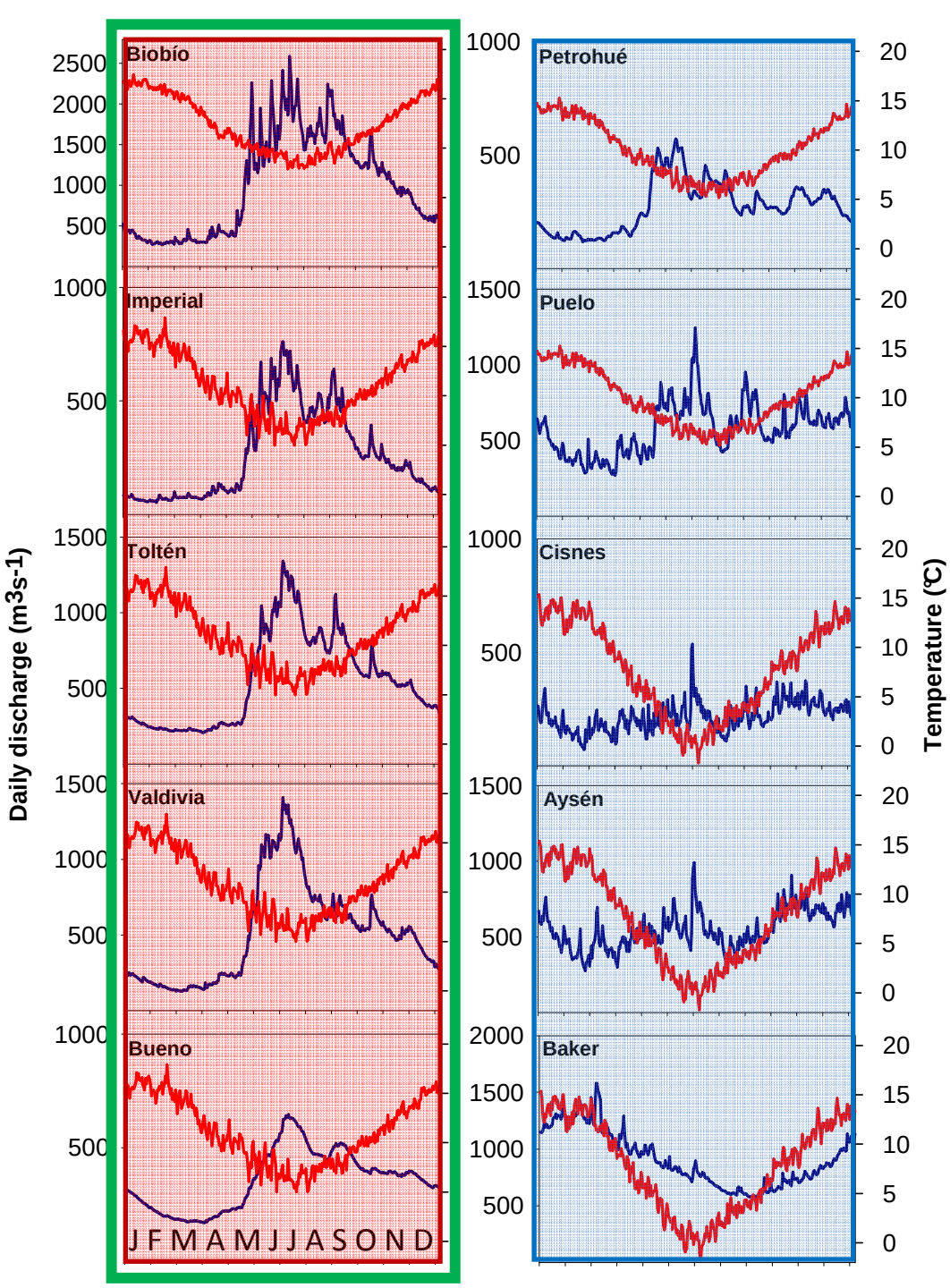


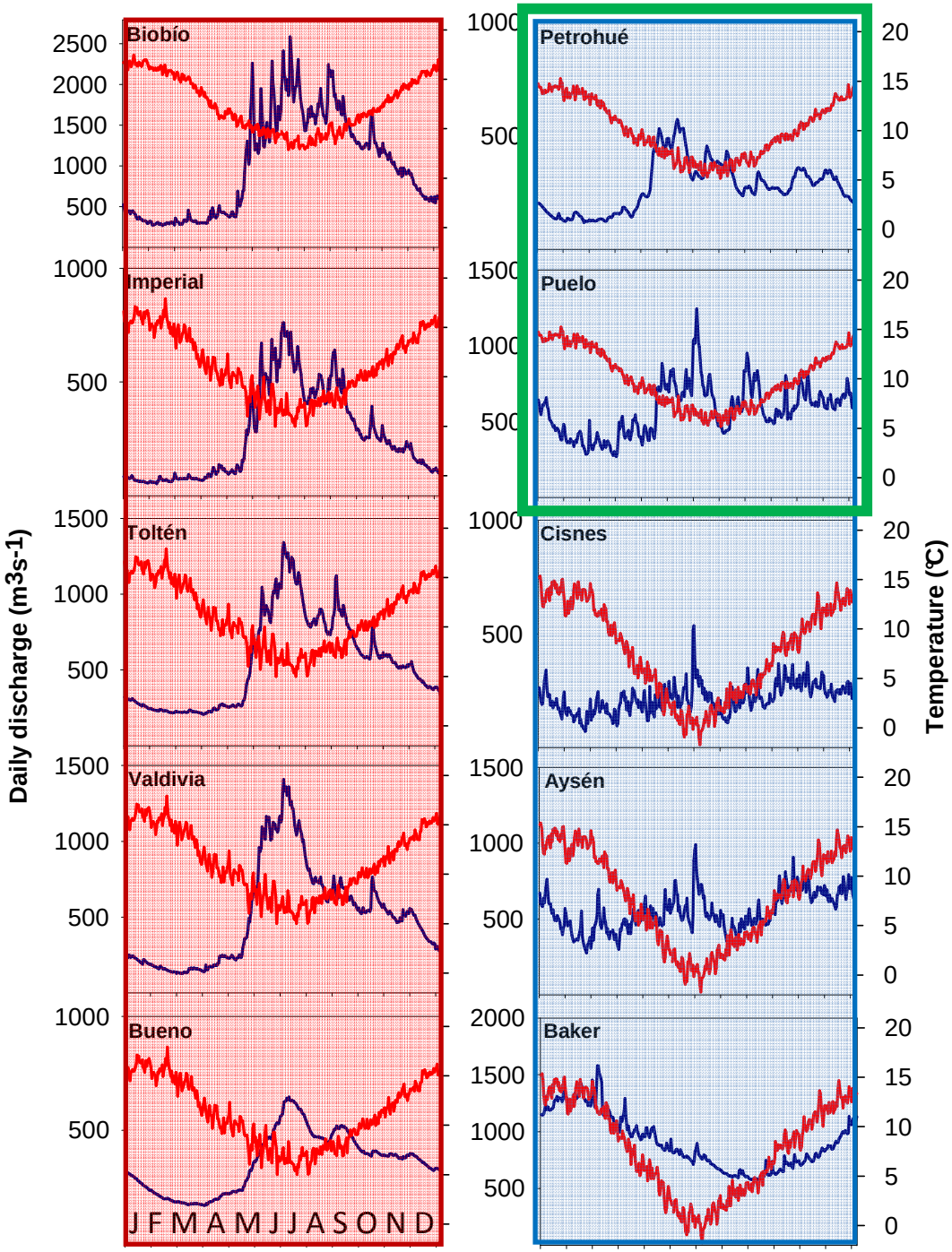

# Results: Temperature and flow

- *Mean daily temperature (1993-2013)*
  *red solid line*
- *Mean daily flow (2000-2013)*
  *blue solid line*



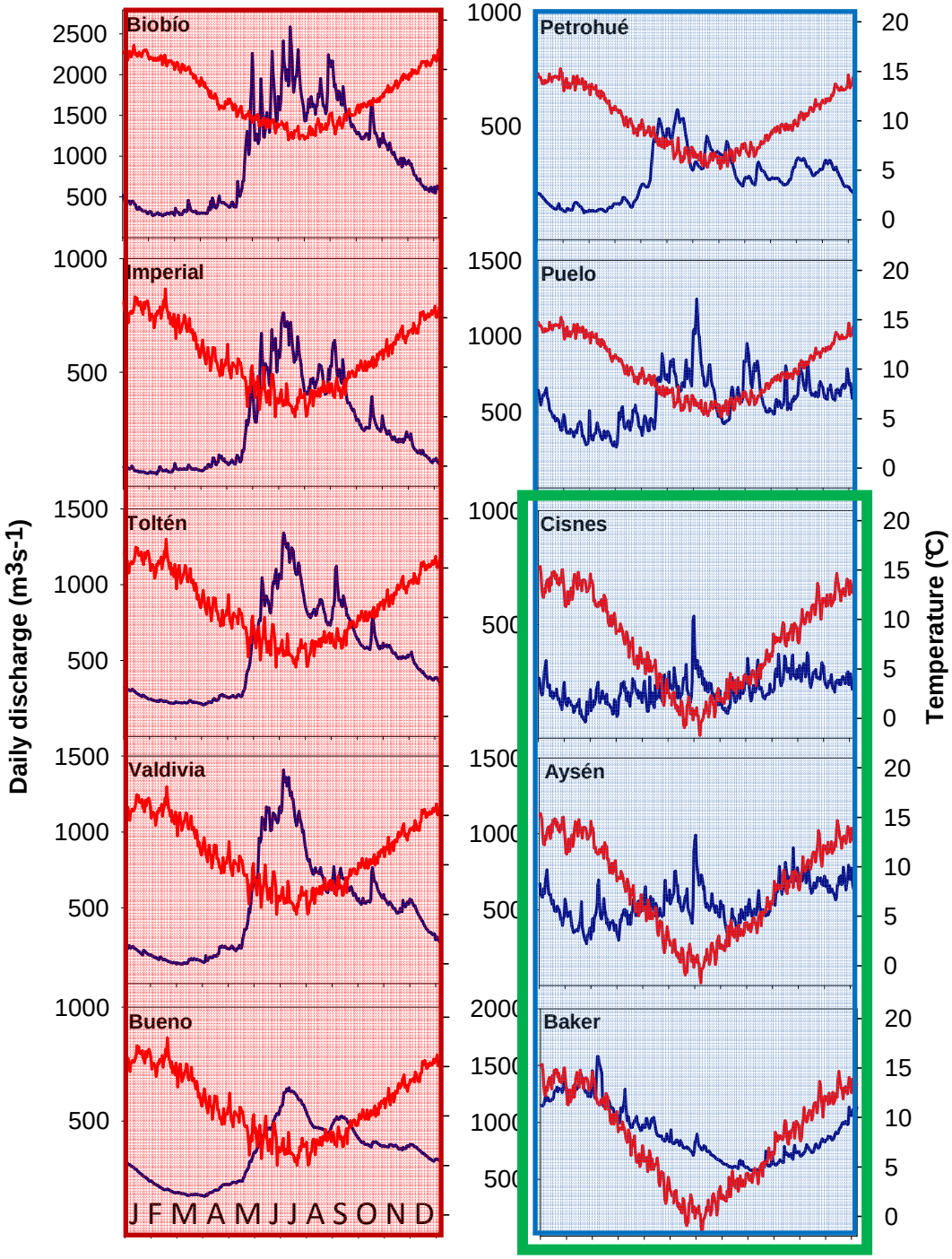

# Temperature and flow

- Daily temperature in the northern rivers **>15°C** in summer and **~10°C** in winter
- Number of days in a year with temperature above 12°C ~ **150 – 180**
- Seasonal flow patterns: **high winter-spring flows** – floodplain inundation
- **Low summer - autumn flows**



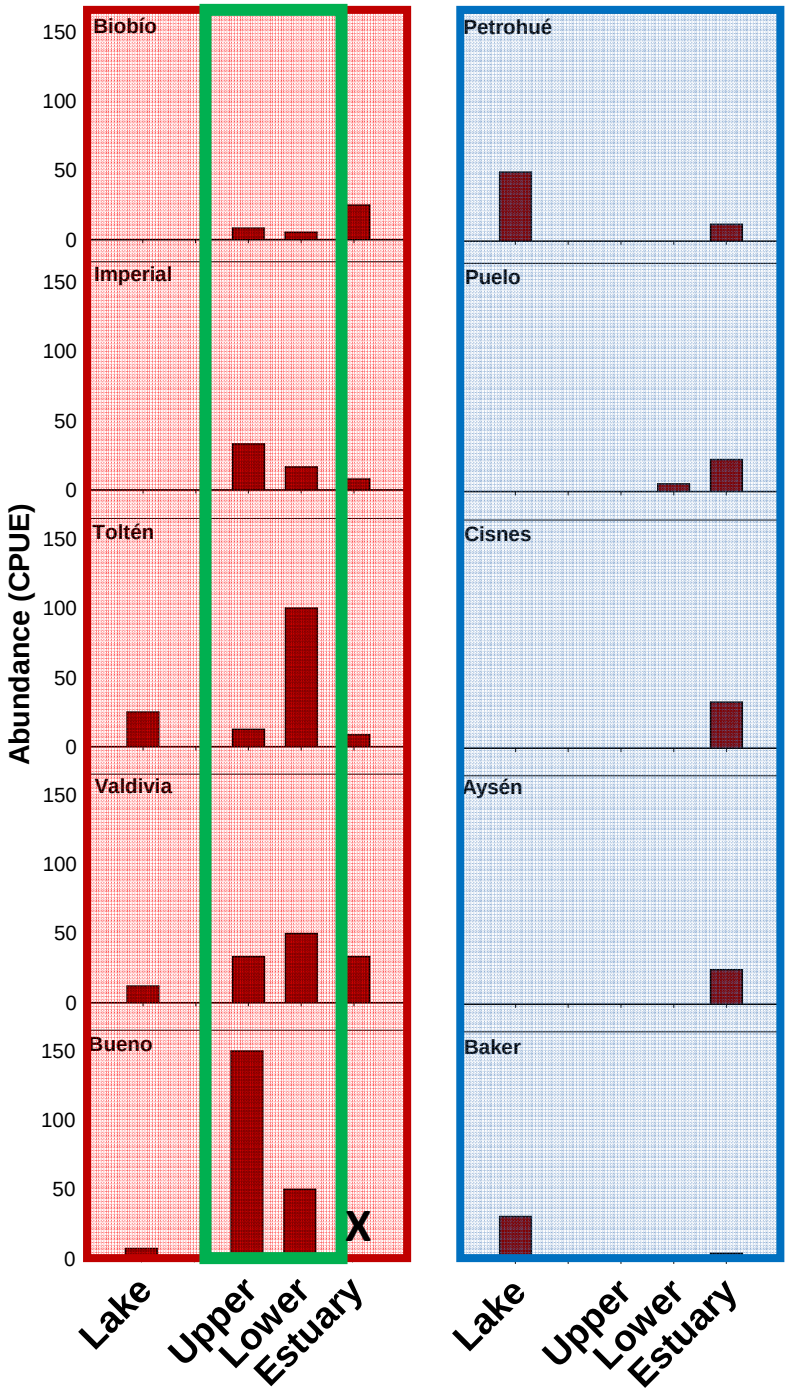

# Temperature and flow

- Intermediate latitude Petrohué and Puelo daily temperature in summer ~ **14°C** and **~6°C** in winter
- Number of days in a year with temperature above 12°C **~ 110**
- Higher short term **flow** variability and **less visible seasonal trend**



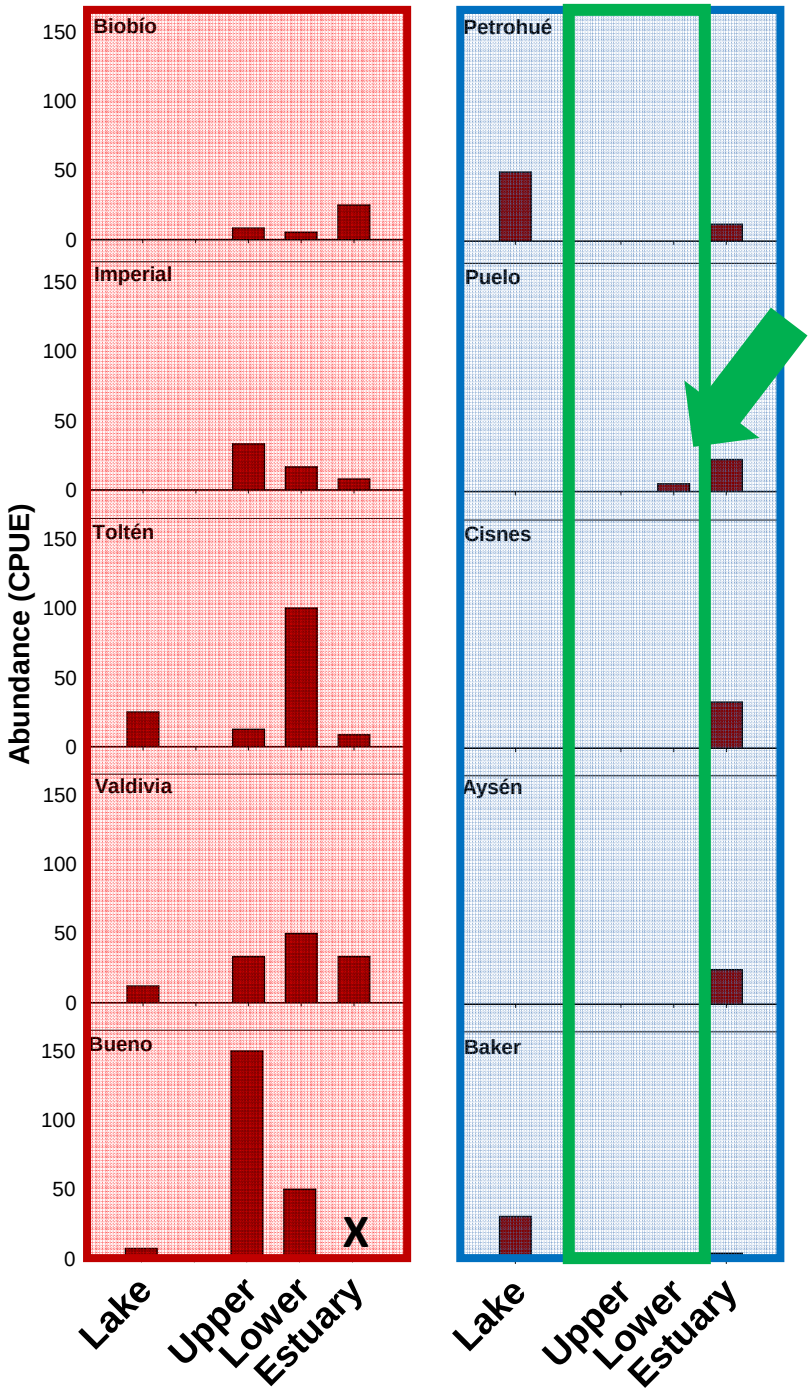

# Temperature and flow

- Daily temperature in the southern rivers ~**13°C** in summer and **~2°C** in winter
- Number of days in a year with temperature above 12°C **< 90**
- Higher short term **flow** variability and **no seasonal trend** for Cisnes and Aysén
- High summer flows for Baker (glacier melting)




# Fish abundance

- In the northern rivers highest abundances in the main channel samples




# Fish abundance

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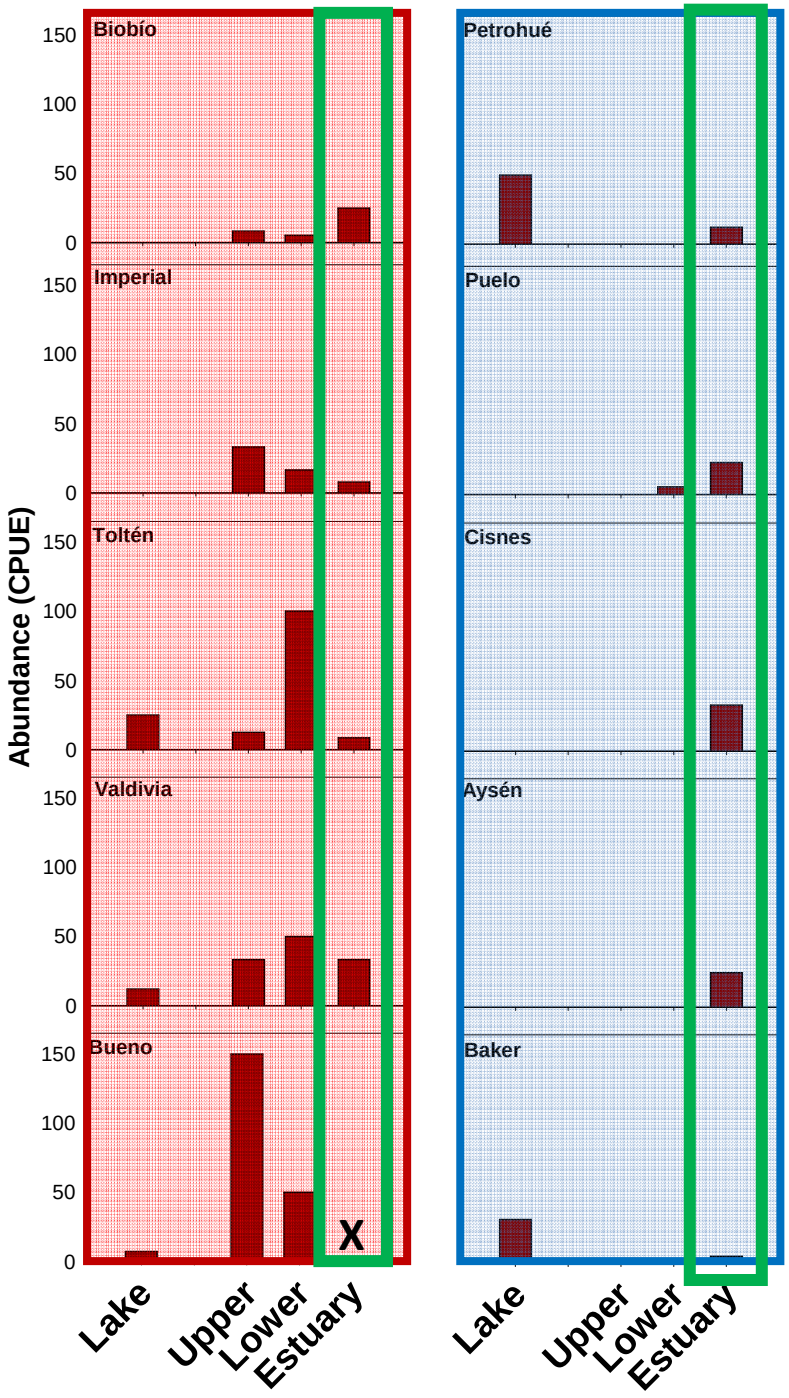
- In the southern rivers fish absent in the main channel with the exeption of lower Puelo

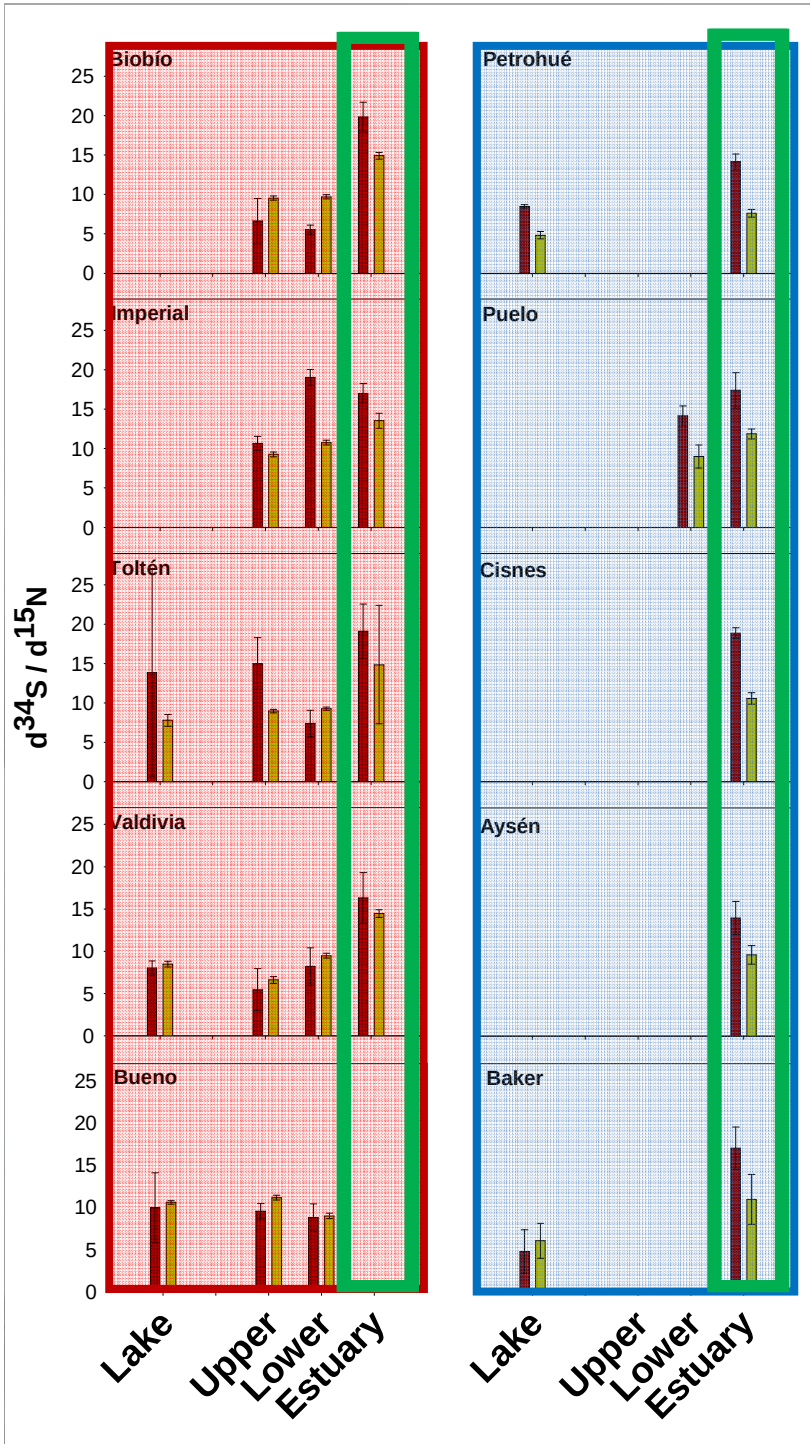



# Fish abundance

- In the northern rivers highest abundances in the main channel samples
- In the southern rivers fish absent in the main channel with the exeption of lower Puelo
- Fish always caught in estuaries, intermediate abundances in lakes

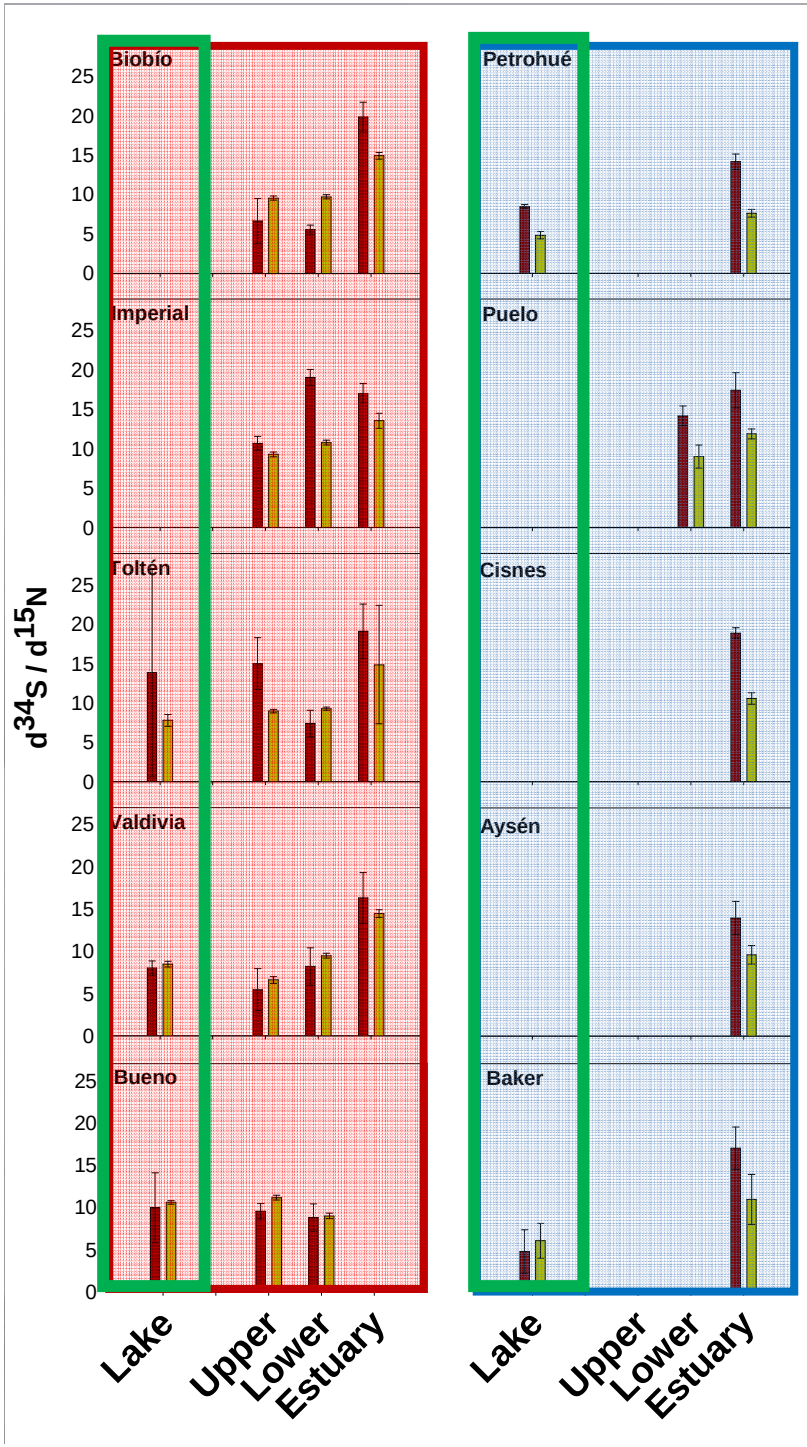
# Marine recruitment

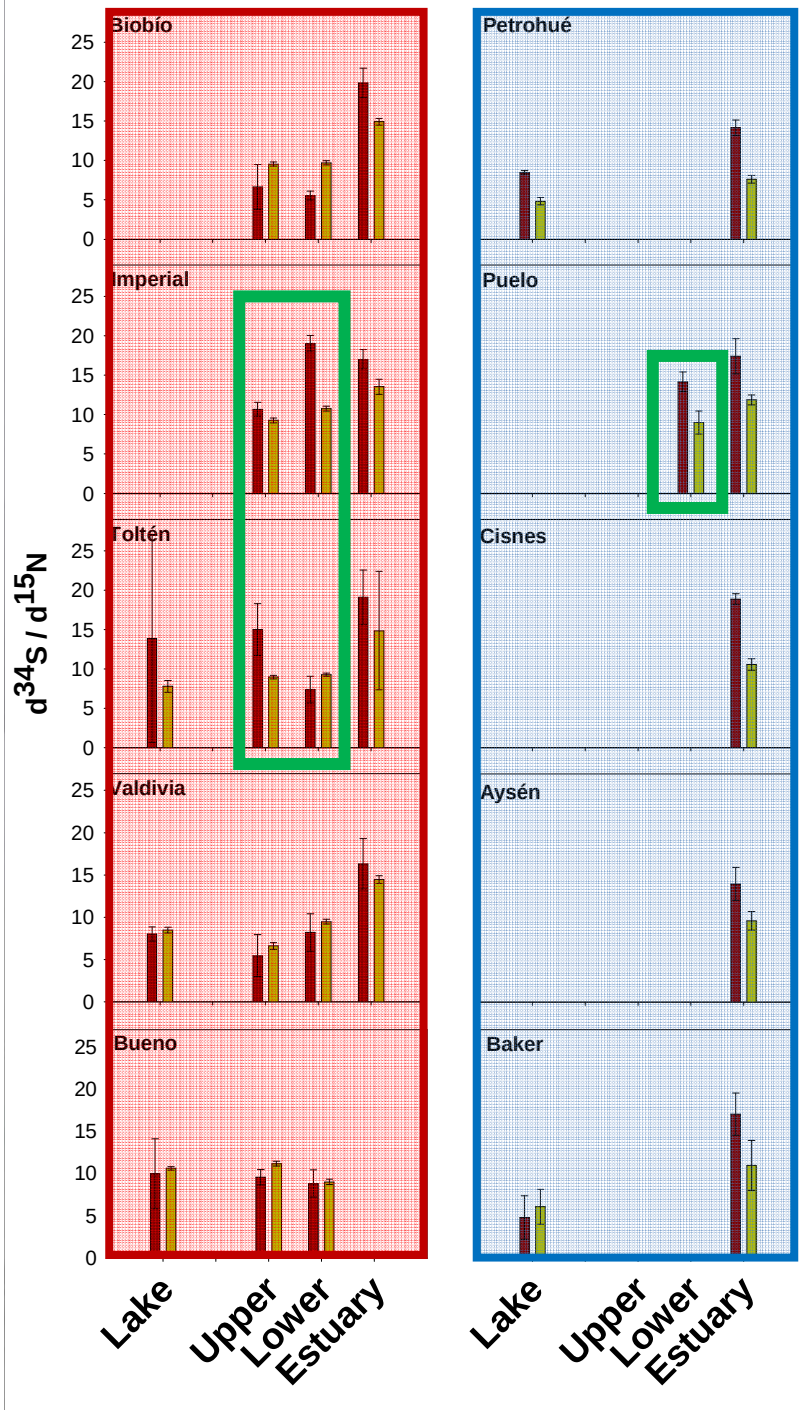
- Estuarine populations in all rivers - marine signatures (high d34S and d15N)



# Marine recruitment

- Estuarine populations in all rivers - marine signatures (high d34S and d15N)
- In lake populations depleted both sulphur and nitrogen



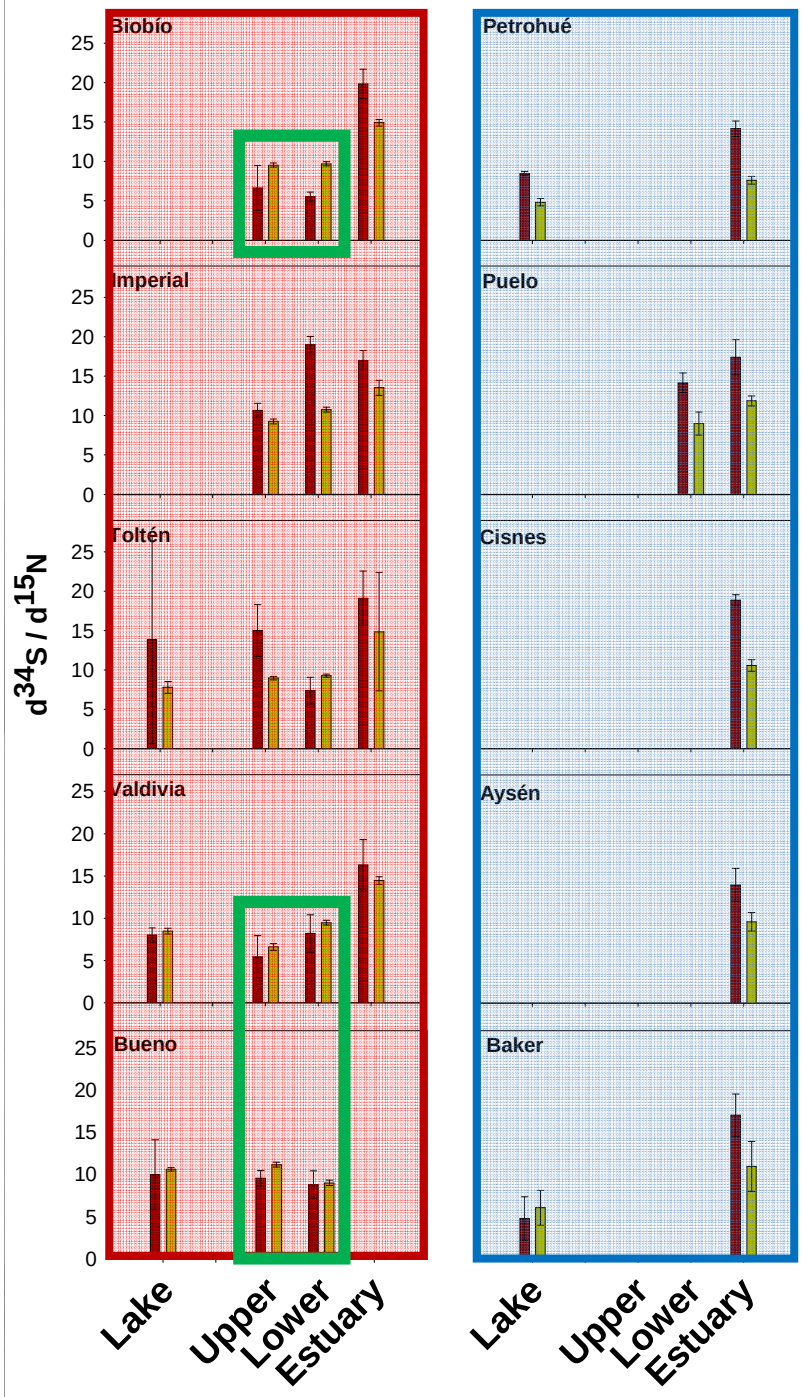



# Marine recruitment

- Estuarine populations in all rivers - marine signatures (high d34S and d15N)
- In lake populations depleted both sulphur and nitrogen
- River populations of northern smaller/less complex rivers Imperial and Toltén - higher d34S - potentially some marine recruitment
- Lower Puelo - marine recruitment

$d^{34}S$

$d^{15}N$




# Marine recruitment

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- In lake populations depleted both sulphur and nitrogen
- River populations of northern smaller/less complex rivers Imperial and Toltén - higher d34S - potentially some marine recruitment
- Lower Puelo - marine recruitment
- Large and complex northern basins – no marine recruitment

$d^{34}S$

$d^{15}N$

# Summary

- Lateral habitats are of high importance for fish as both juveniles and adults move into floodplain habitats during large and extended spring floods (Waikato and Valdivia)

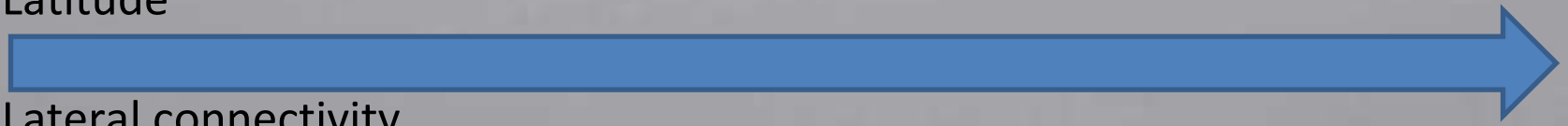
- Only river systems at lower latitudes and those with more predictable flow patterns (headwater lakes) accommodated non-migratory populations

- Management strategies that promote both lateral and longitudinal connectivity within riverine ecosystems are crucial to maximise habitat availability for native fish species

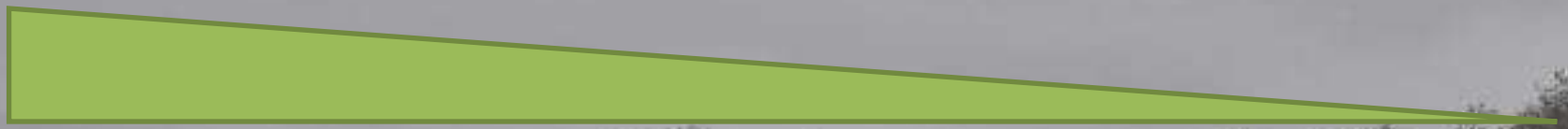
# Management/Restoration

**Southern temperate rivers:**

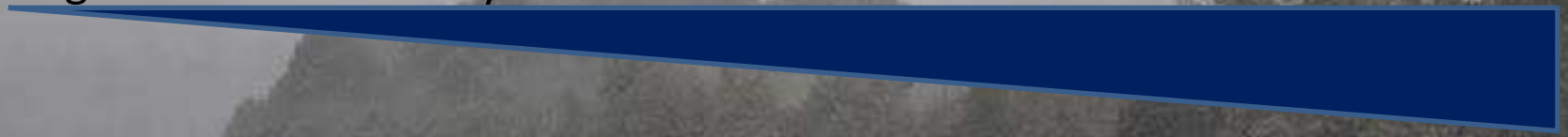
Latitude



Lateral connectivity



Longitudinal connectivity

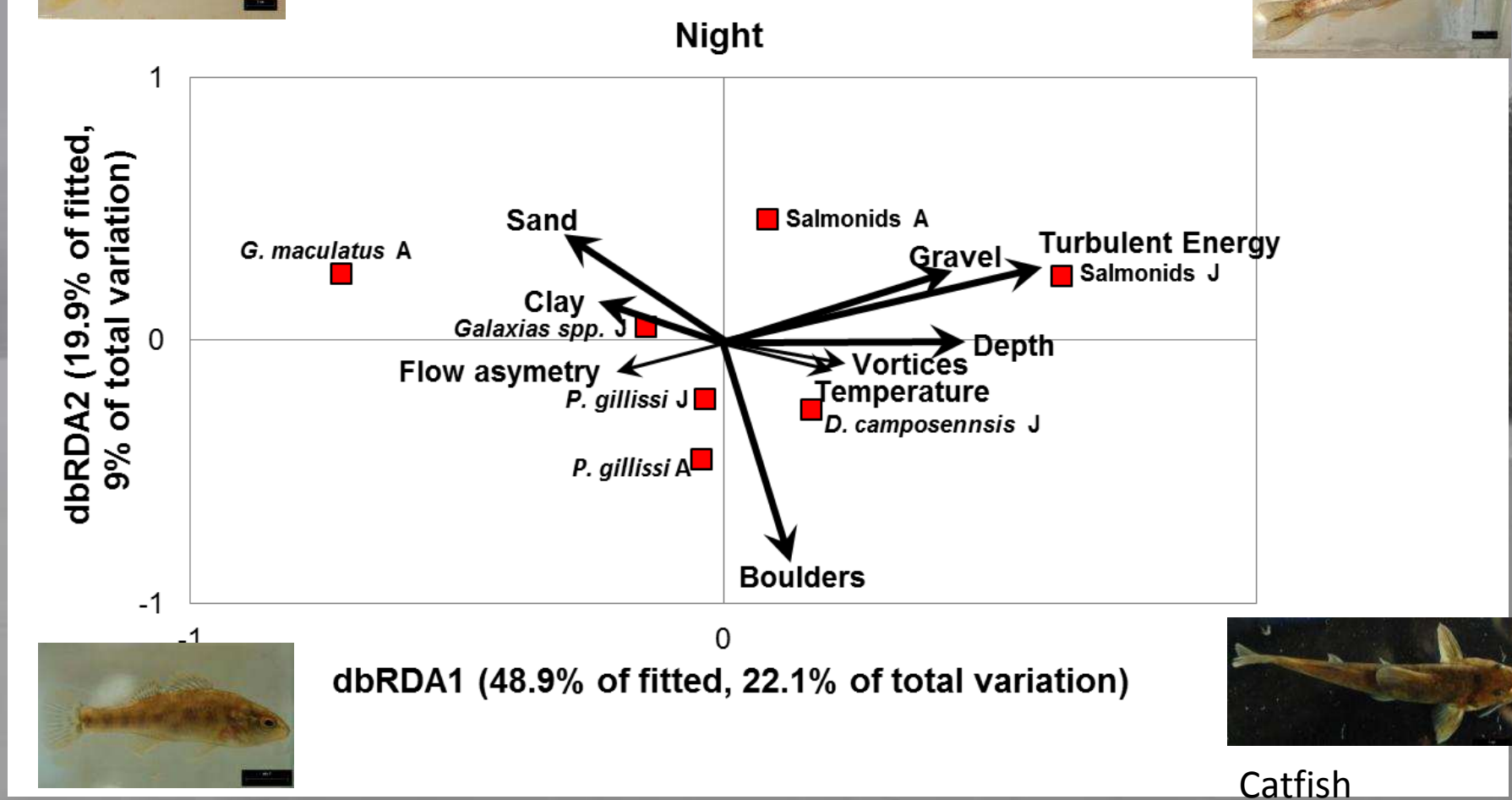


- **Differential impact depending on latitudinal location?**
- ***Limit benefits for invasive fish:***
- **Floodplain bottlenecks (fish size differences)**
- **Fish-pass designs for native fish - design as bottlenecks for invasives**

# Hydraulic habitat use

Galaxiids

Trout






Darters



Catfish


Thank you!

# Marine-Freshwater isotope difference

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- Sulfur isotope ratios - invariant in the ocean (d34S ~ 20) and consistently depleted in freshwater ecosystems (d34S < 10)
- Similarly nitrogen isotope ratio (d15N) are expected to be elevated in marine food sources relative to freshwater food sources

**If fish used marine resources during their lifespam – higher d34S and d15N expected**

(Thode, 1991; Zimmo et al., 2012)