Fish growth changes in a nuclear power plant cooling reservoir show that not all fish know about the temperature size rule

Vytautas Rakauskas, Max Lindmark, Andrius Steponenas, Vytautas Kesminas & ***Asta Audzijonyte (presenting)***

Nature Research Centre, Lithuania

2014-2020 Operational Programme for the European Union Funds Investments in Lithuania

As climate warms, fish will become smaller. Or will they?

nature climate change

Altmetric: 311 Citations: 158 More detail »

Letter

Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems

William W. L. Cheung ✉, Jorge L. Sarmiento, John Dunne, Thomas L. Frölicher, Vicky W. Y. Lam, M. L. Deng Palomares, Reg Watson & Daniel Pauly

Opinion

Cell PRESS

Declining body size: a third universal response to warming?

Janet L. Gardner[1], Anne Peters[2,3], Michael R. Kearney[4], Leo Joseph[5] and Robert Heinsohn[1]

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Warming temperatures and smaller body sizes: synchronous changes in growth of North Sea fishes

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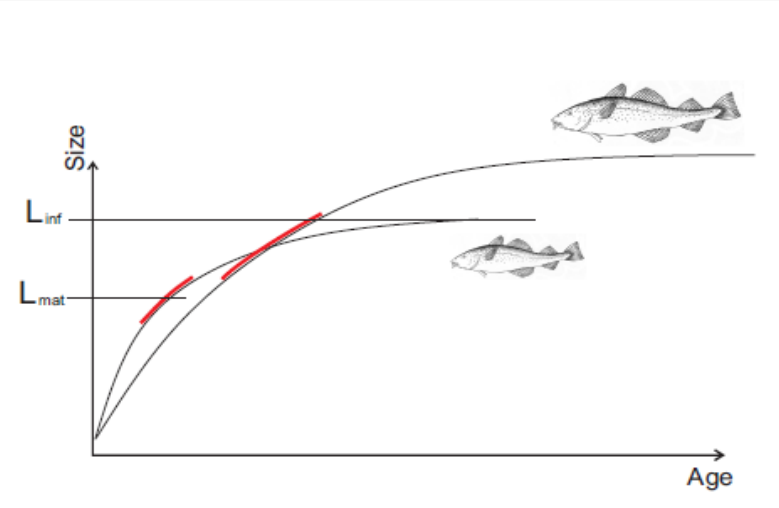
OPINION

WILEY Global Change Biology

Sound physiological knowledge and principles in modeling shrinking of fishes under climate change

Daniel Pauly | William W. L. Cheung

TSR is an experimental finding. Are these experimental results relevant?



- Controlled feeding
- No predation
- No environmental stochasticity
- Reduced competition?..

We need field data on climate change experiments!

To understand and predict natural ecosystem responses to temperature changes through time we need:

Long-term empirical observations that account for

a) Acclimation
b) Inter-generational plasticity or acclimation or adaptation
c) Ecosystem level temperature responses (changes in food availability, predation, etc)
d) Potentially different responses in different species

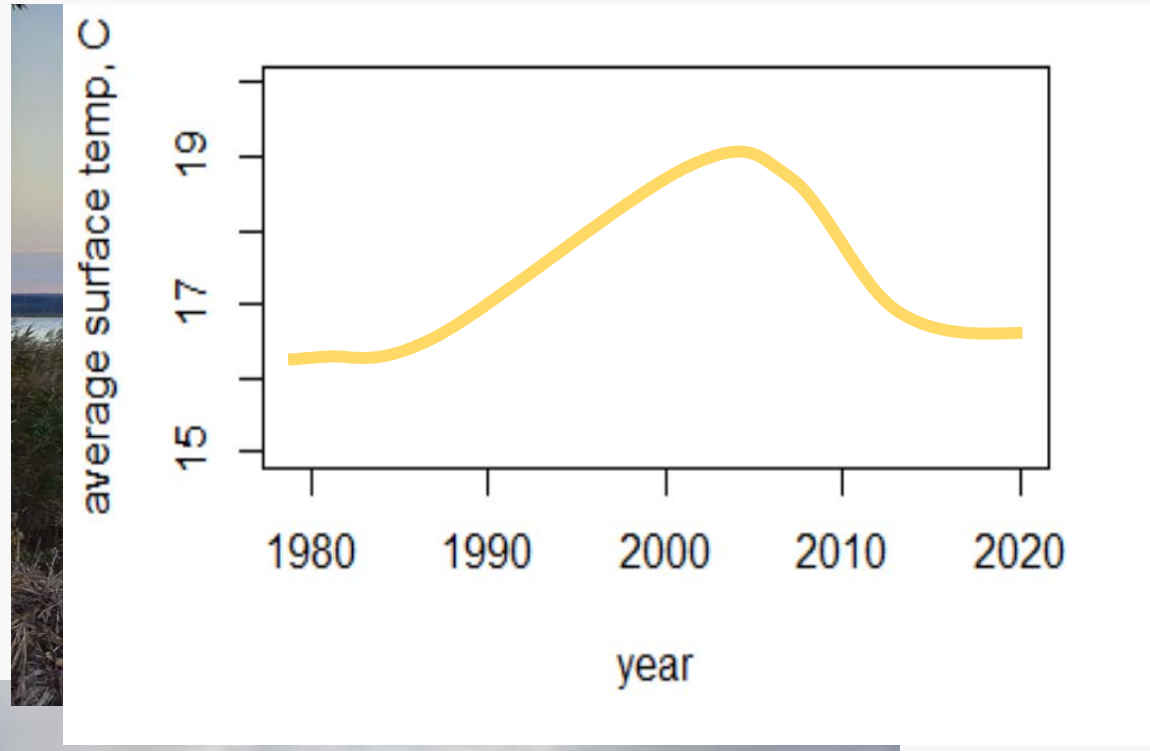
Finland
Helsinki
St Petersburg
Санкт-Петербург
Tallinn
Estonia
Baltic Sea
Riga
Latvia
Lithuania
Vilnius
Moscow
Москва
Minsk
Мінск
Belarus
Copenhagen
Denmark
Hamburg
Berlin
Poland
Warsaw
Amsterdam
Netherlands
Brussels
Belgium
Luxembourg
Germany
Prague
Czechia
Slovakia
Vienna
Munich
Kyiv
Київ
Kharkiv
Харків
Ukraine
Google

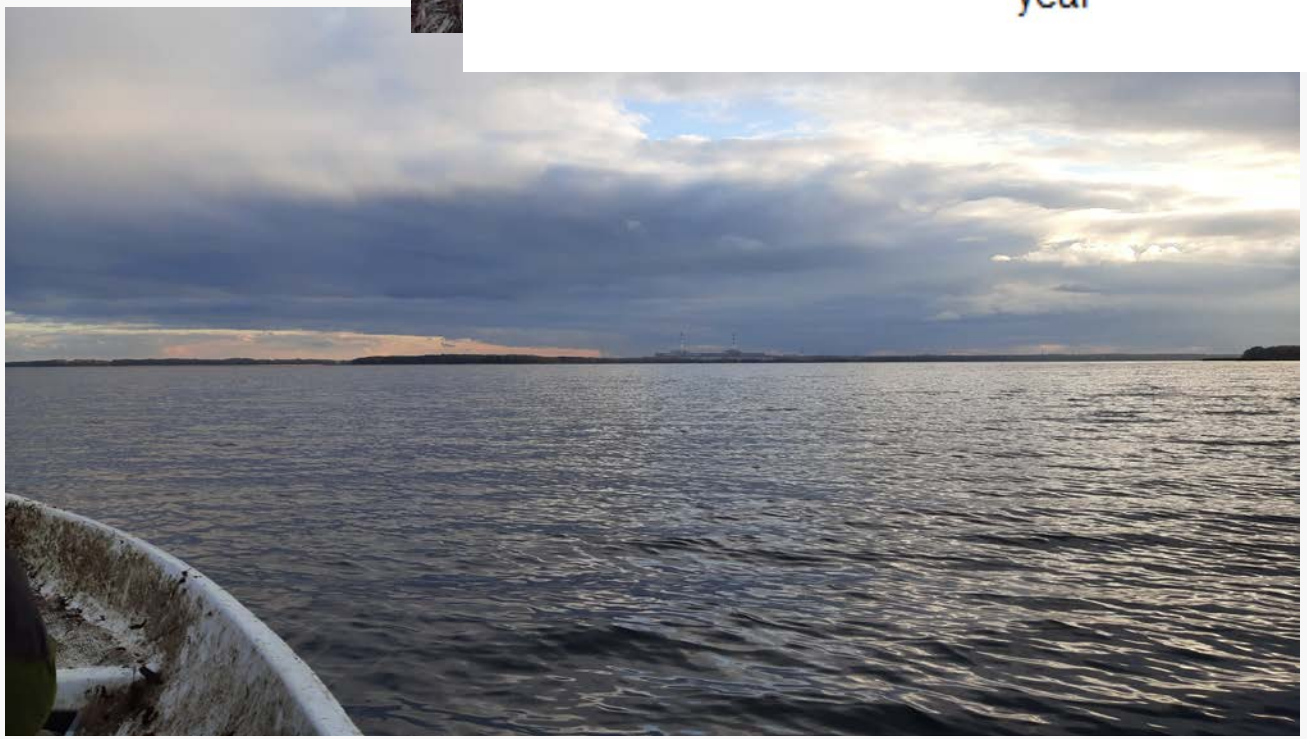
Druksiai Lake: a unique „experimental“ system

- large lake
- area of 45km^2
- maximum depth of 33 m
- oligotrophic

Nuclear power plant started in 1983

Year	*Temperature*
1983-1987	+0.6 C
1988-2004	**+2.5 C**
2004-2009	+1C
2009 onward	ambient





Data:

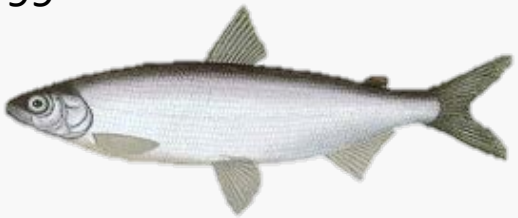
Regular gillnetting surveys: 1979-2020

Lots of digging into old journals…

Ageing based on scales
Species, total or standard length, age, year, month

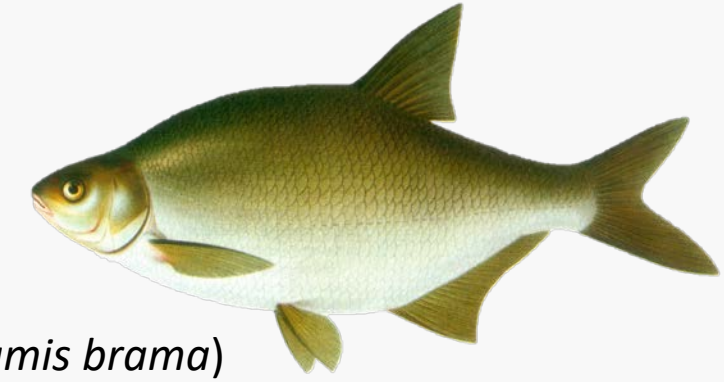
Length at age (at capture) in five common species

Vendace (*Coregonus albula*)
Max age – **5**
N - 799



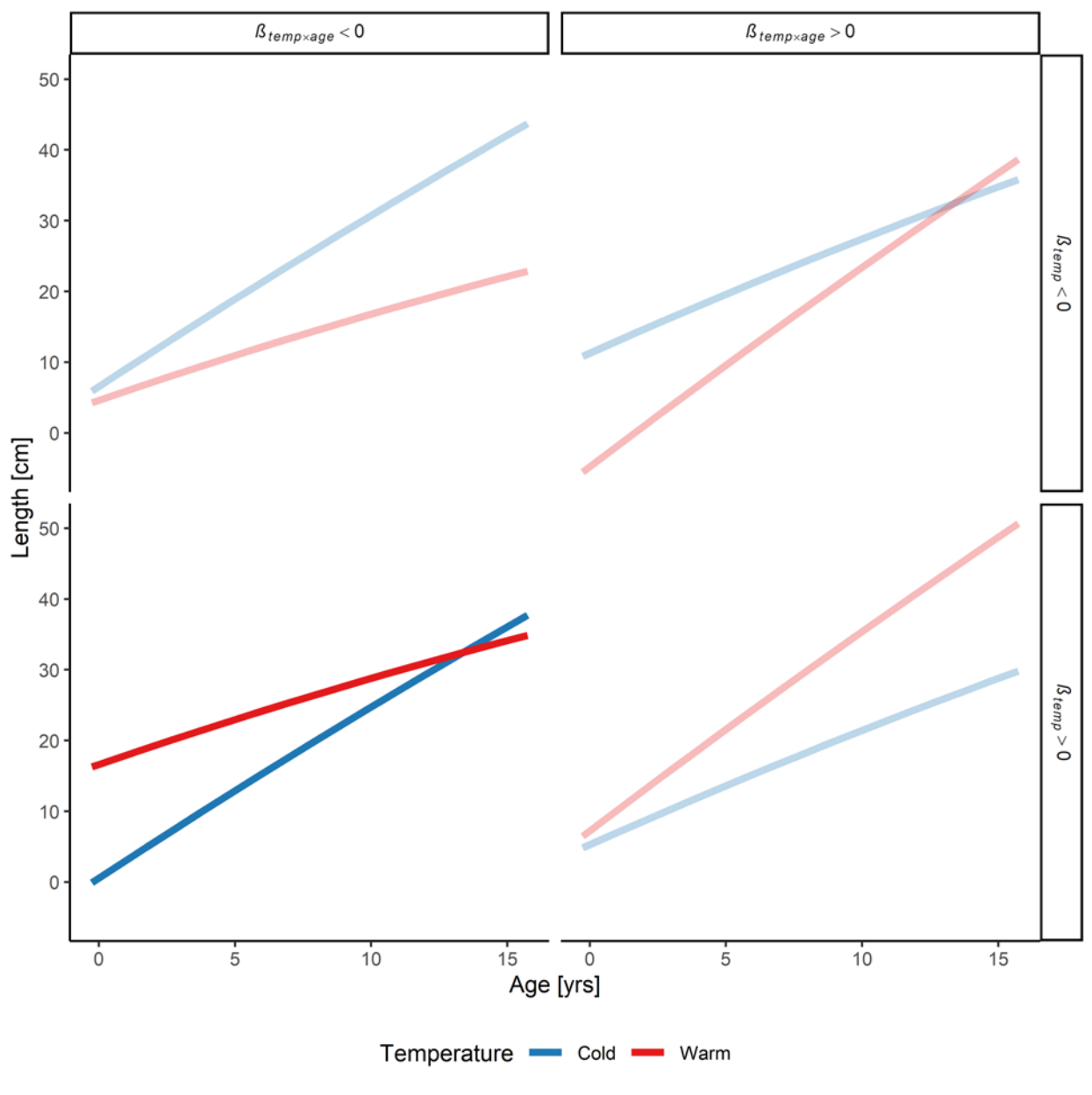
Roach (*Rutilus rutilus*)
Max age - **18**
N - 3874

Pike (*Esox lucius*)
Max age – **10**
N - 540



Bream (*Abramis brama*)
Max age – **17**
N - 2001

Perch (*Perca fluviatilis*)
Max age - **16**
N - 1179



$$L_a \sim \textbf{age*T} + age^2 + (1|month) + (1|year)$$

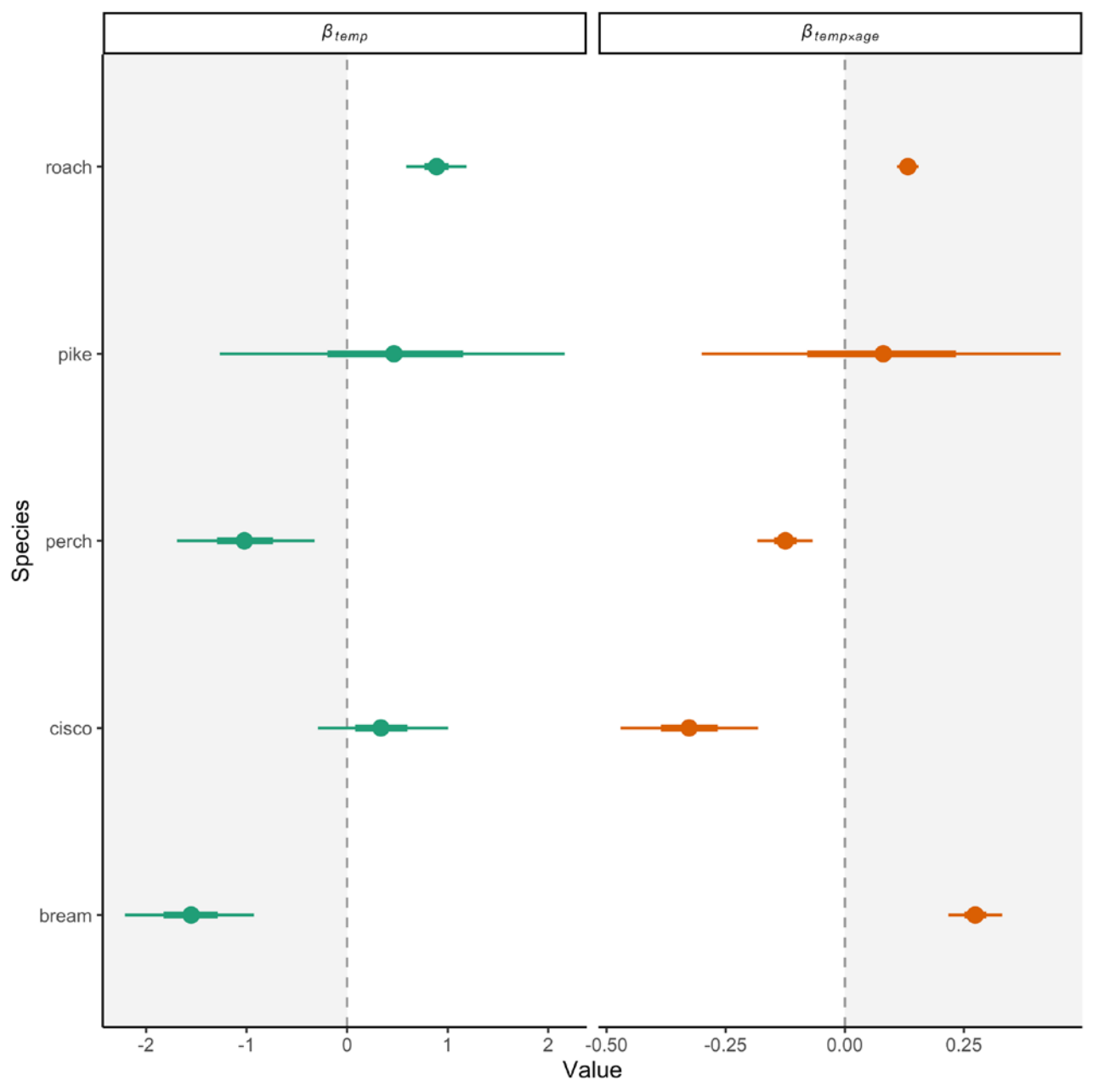
fixed effects *random effects*

Temperature size rule occurs when:

1) Intercept of temperature on age is positive (juveniles grow faster)
2) Temperature-age interaction is negative (adults are smaller)

Temperature intercept

Temperature-age slope

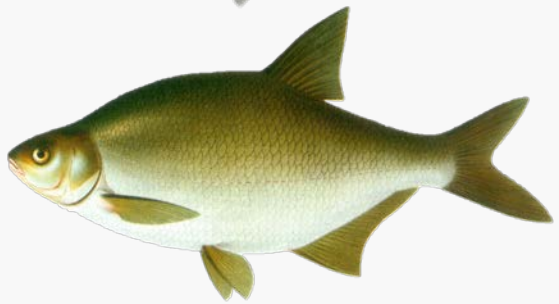


Roach

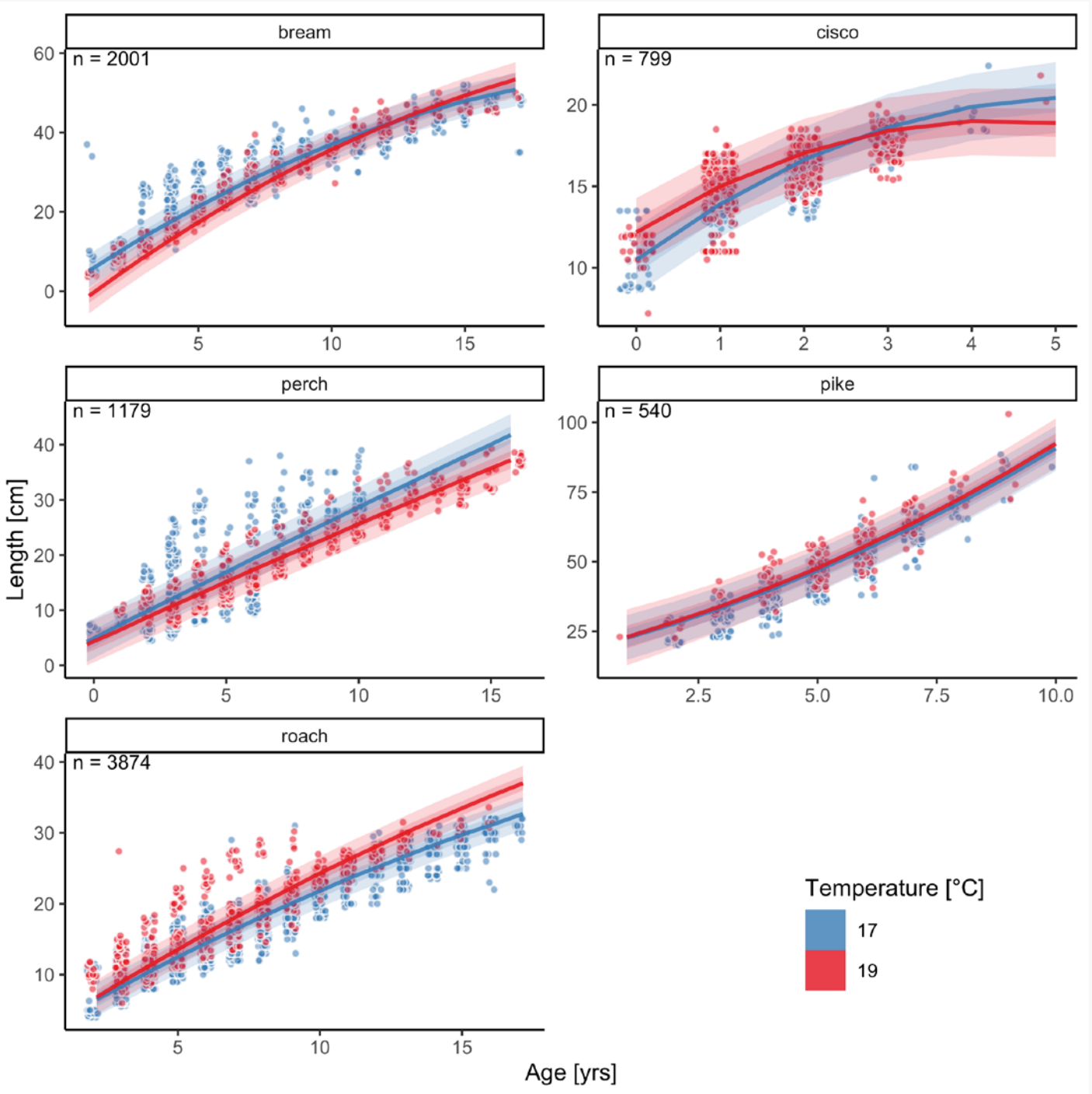
Pike

Perch

Vendace



Bream


bream
n = 2001
cisco
n = 799
perch
n = 1179
pike
n = 540
roach
n = 3874
Length [cm]
Age [yrs]
Temperature [°C]
17
19

Take home & significance

- Temperature affects fish growth and size
- In real ecosystems temperature affects many processes and we probably cannot expect temperature-size rule consistent growth changes
- Different temperature responses of different species may have profound food web consequences
- We need inter-generational long term empirical data
- Please keep all old records and journals safe. Someone will need them

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