Hydropower impacts on brown trout production in Norwegian reservoirs

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JYVÄSKYLÄ STUDIES IN BIOLOGICAL AND ENVIRONMENTAL SCIENCE
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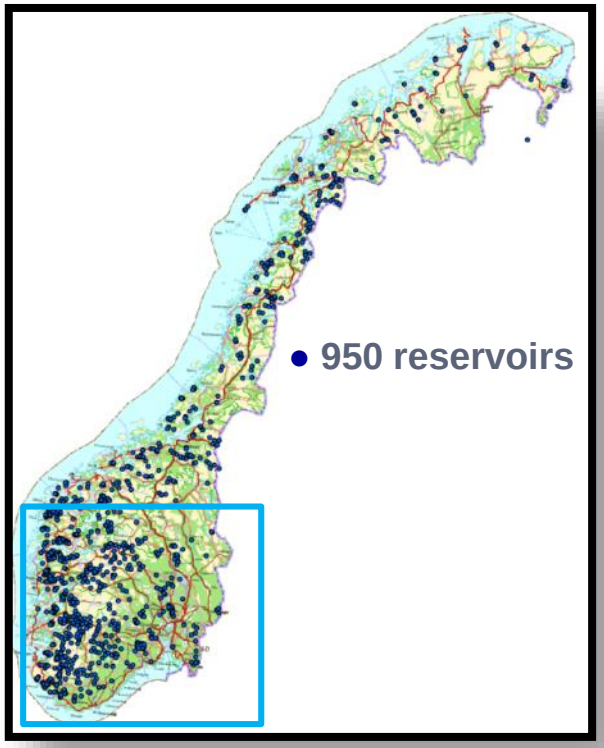
Antti Eloranta

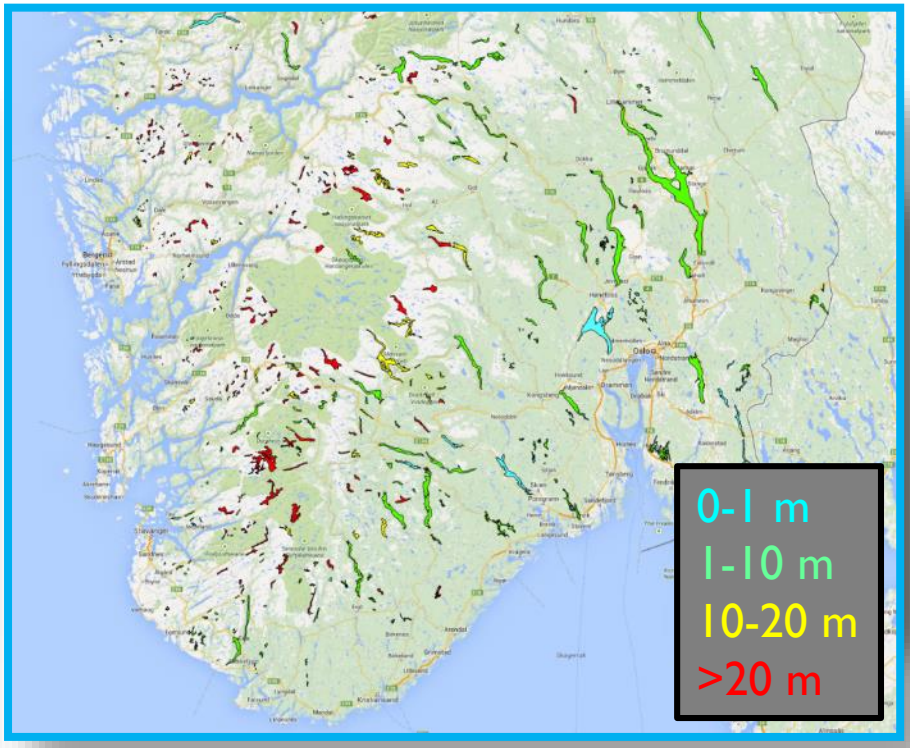
The Variable Position of Arctic Charr (*Salvelinus alpinus* (L.)) in Subarctic Lake Food Webs

JYVÄSKYLÄN YLIOPISTO

Hydropower in Norway

- 97 % (~143 TWh) of energy production in 2012
- 70 % of large watersheds are affected



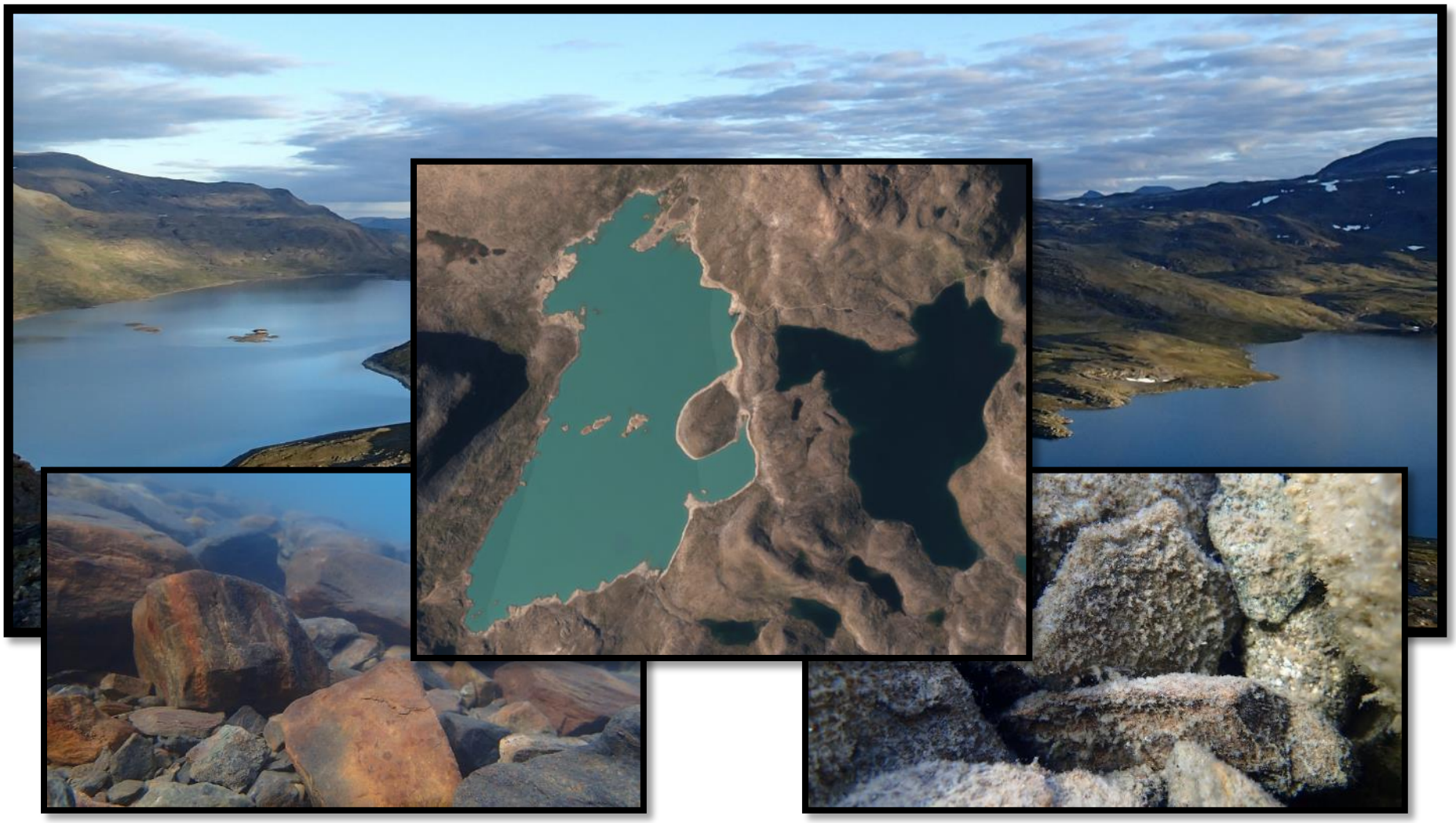


Norway as a study system

- Altitudinal and latitudinal gradients
- >450 000 lakes, >40 000 with fish
- Brown trout economically important and most common fish
- Most studies done in rivers, few in reservoirs

→ **HydroBalance** aims to fill this gap

"Eye-balling" lakes and reservoirs

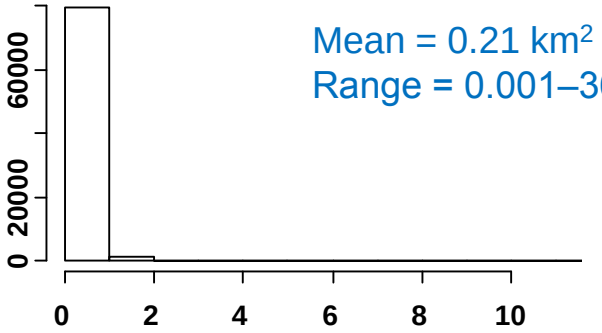


"Eye-balling" catches in reservoirs

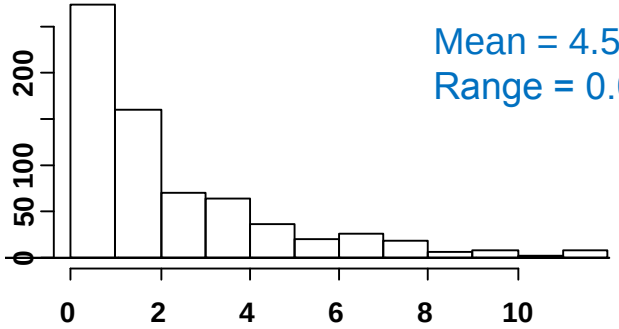
LAKES (n = 81 636)

RESERVOIRS (n = 757)

Area

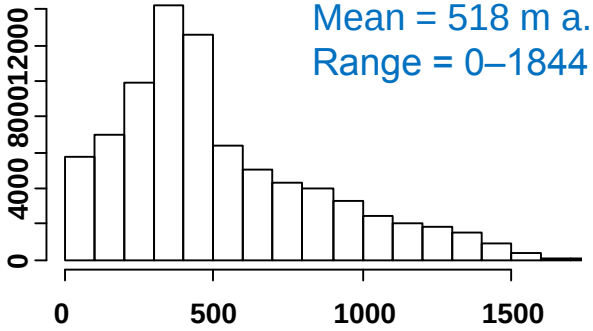


Mean = 0.21 km^2
Range = 0.001–369 km^2

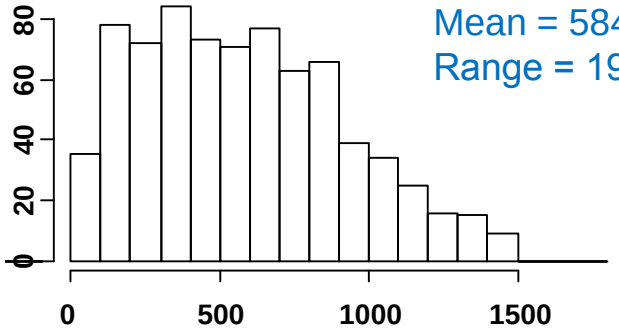


Mean = 4.51 km^2
Range = 0.018–122 km^2

Altitude

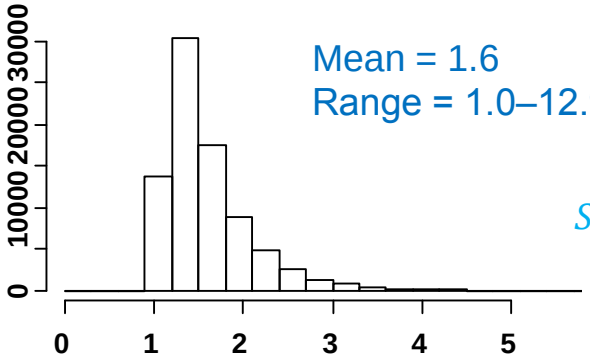


Mean = 518 m a.s.l.
Range = 0–1844 m a.s.l.



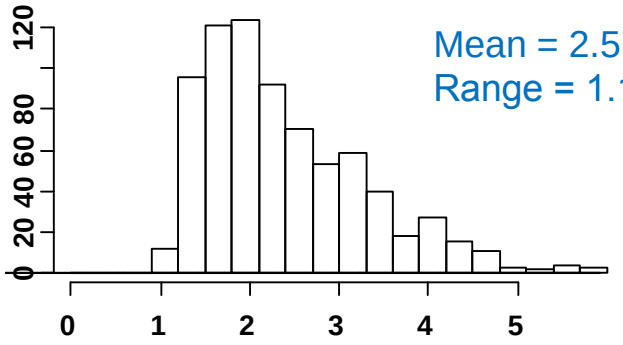
Mean = 584 m a.s.l.
Range = 19–1477 m a.s.l.

Shape



Mean = 1.6
Range = 1.0–12.9

$$Shape = \frac{L}{2\sqrt{\pi A}}$$



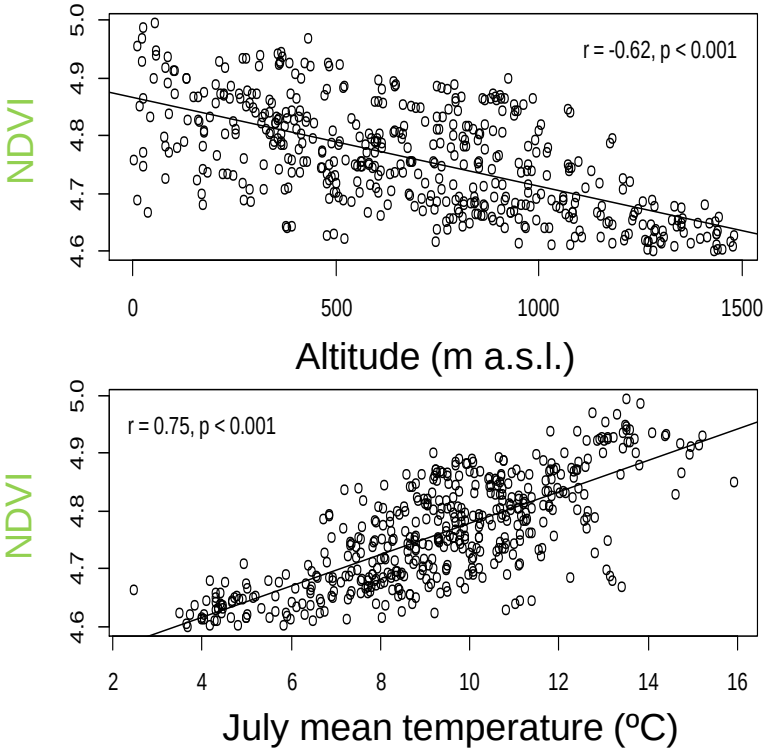
Mean = 2.5
Range = 1.1–10.5

Study question and method

- How lake characteristics and hydropower affect brown trout production?
  - Trout CPUE (g/100 m^2 net/night) data from test fishings and reports (**615 lakes**)
  - Other data from national and international authorities and GIS databases (**477 lakes**)
- Linear models in R 3.1.1
  - Generalized Least Squares
  - AIC for model selection (backward elimination)

Explanatory variables

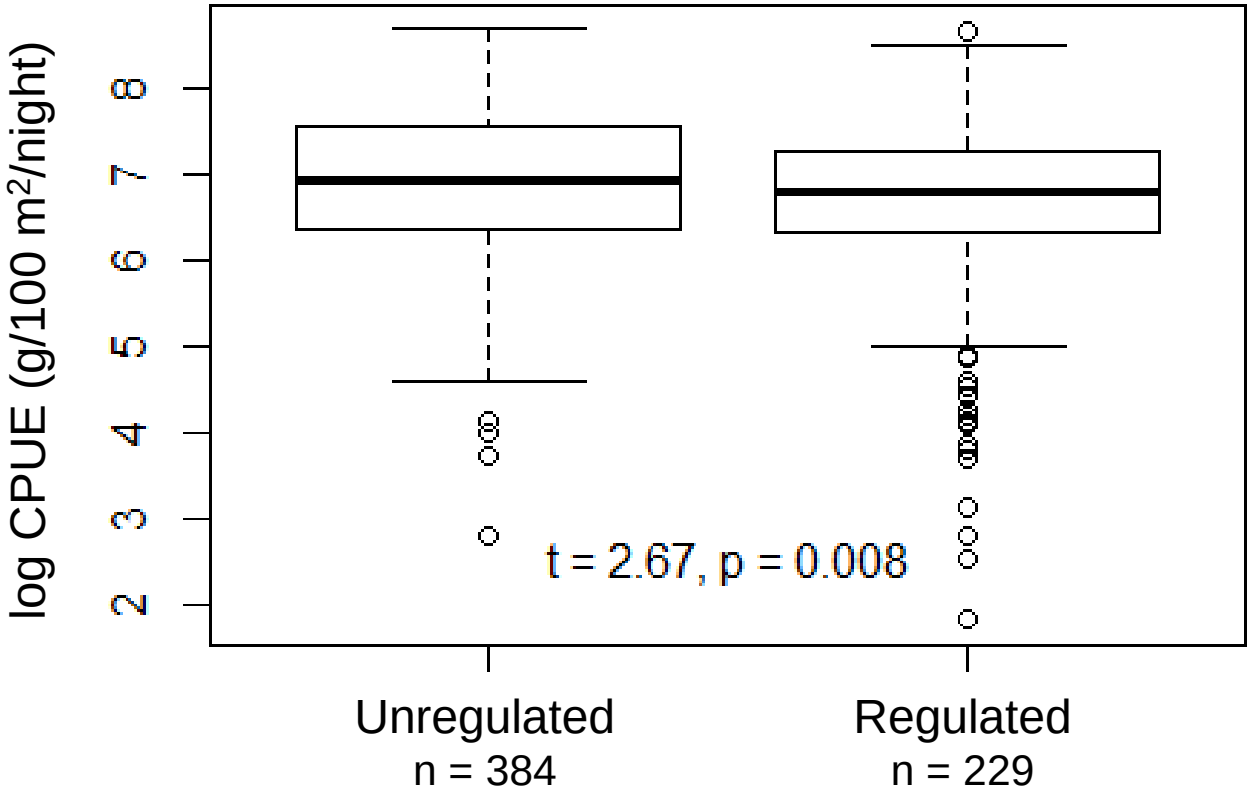
- Regulation (unregulated vs. regulated)
- Fish community (allopatric vs. sympatric)
- Lake surface area
- Catchment productivity: NDVI = "greenness index"
  - Correlates with climate and catchment properties
- Ice cover period
  - Based on annual mean air temperature



NDVI = Normalized Difference Vegetation Index

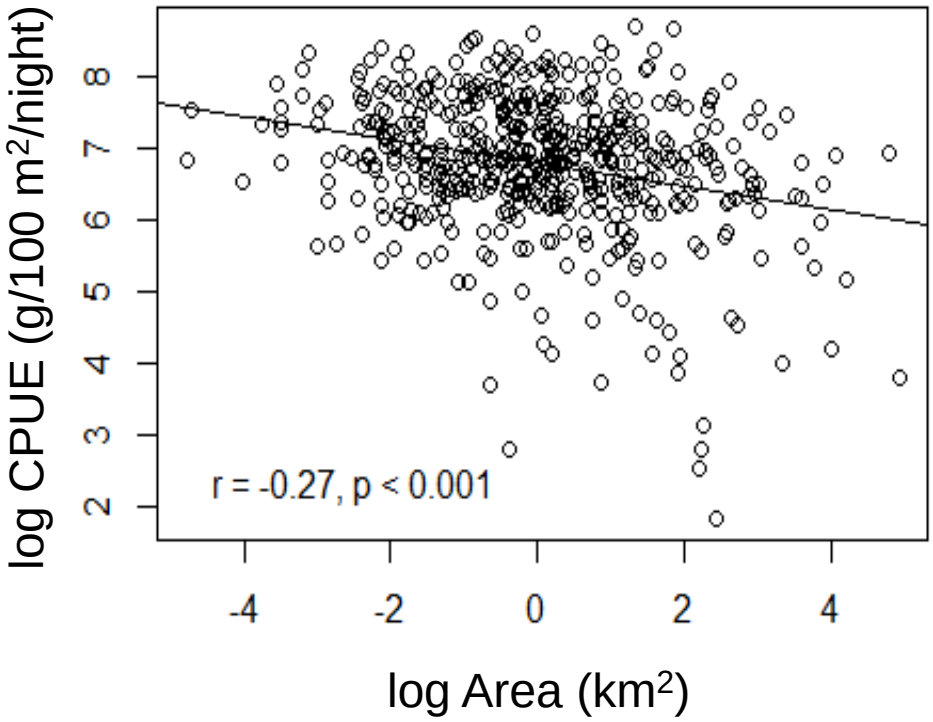
Results (615 lakes)

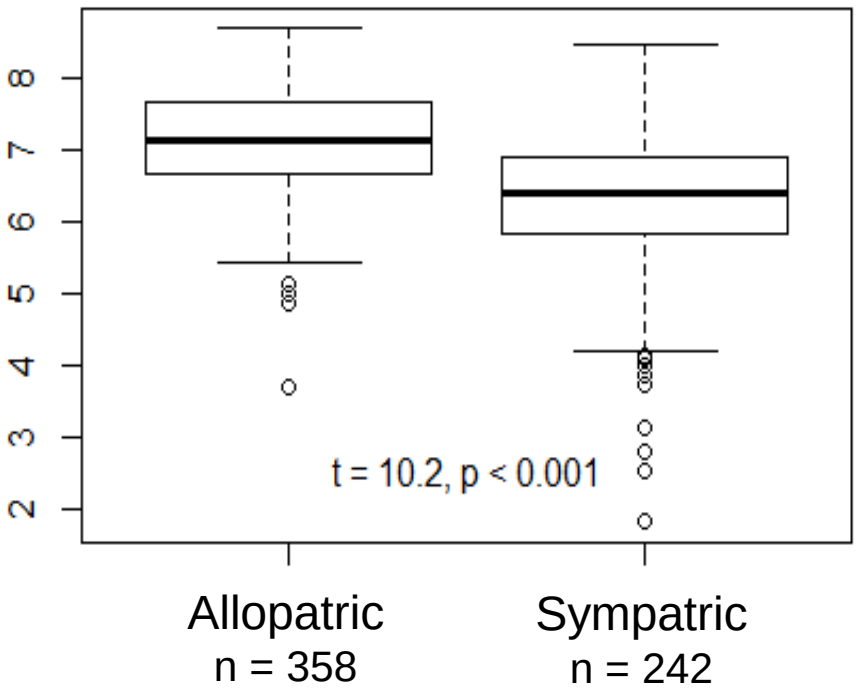
- Slightly lower trout biomass in regulated lakes



Results (615 lakes)

- Lower trout biomass in large lakes and in sympatric fish communities





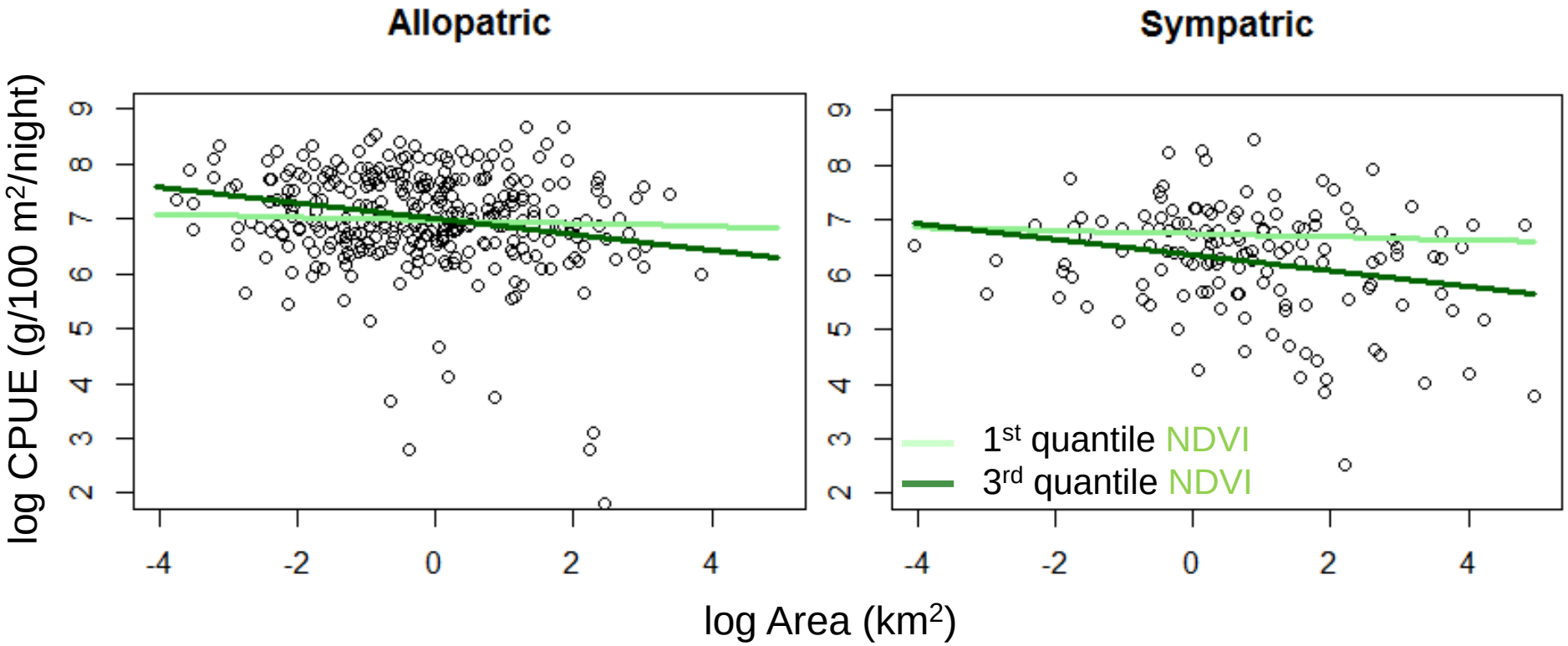
Modelling results (477 lakes)

- **Best model:**

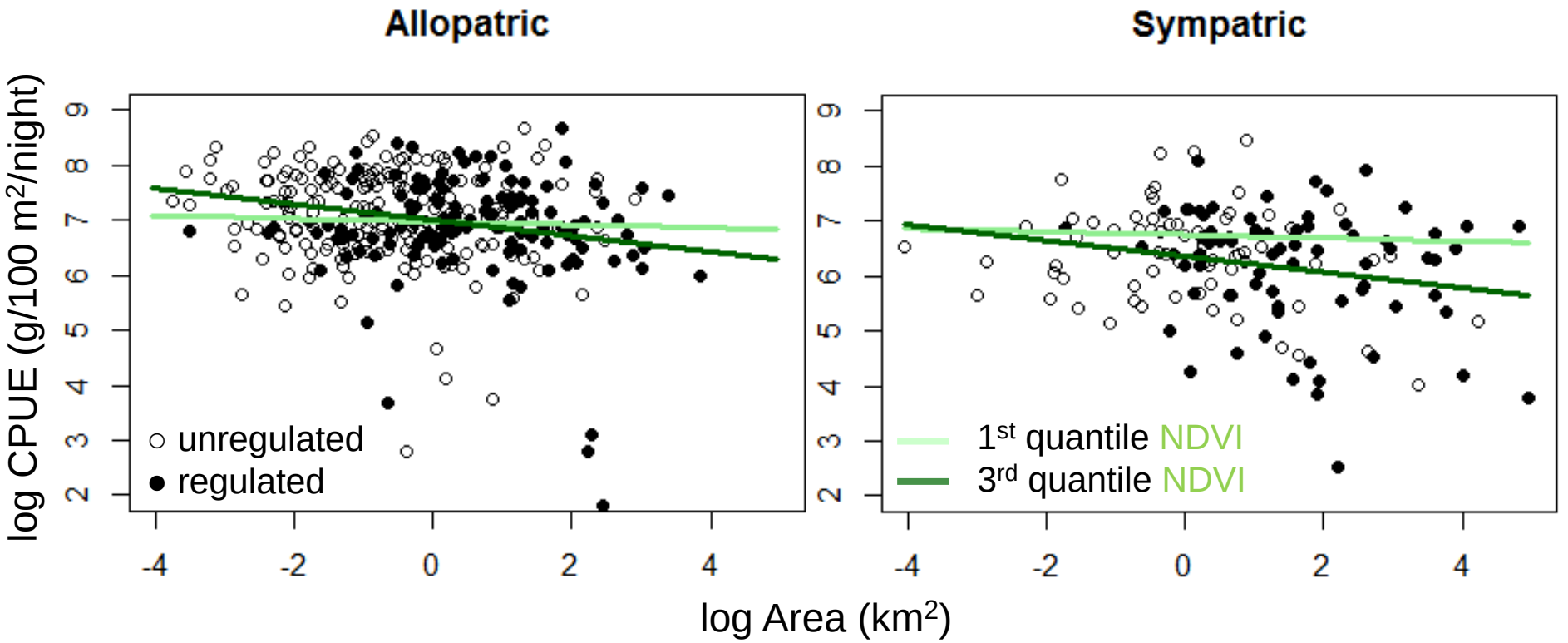
  log(CPUE) ~ log(Area) + (FishCom) + NDVI
  + log(Area):NDVI + FishCom:NDVI

Parameter	t	p
log(Area)	2.43	**0.015**
FishCom	2.11	**0.035**
NDVI	0.35	0.726
log(Area) : NDVI	-2.80	**0.005**
FishCom : NDVI	-2.66	**0.008**

Modelling results (477 lakes)



Modelling results (477 lakes)

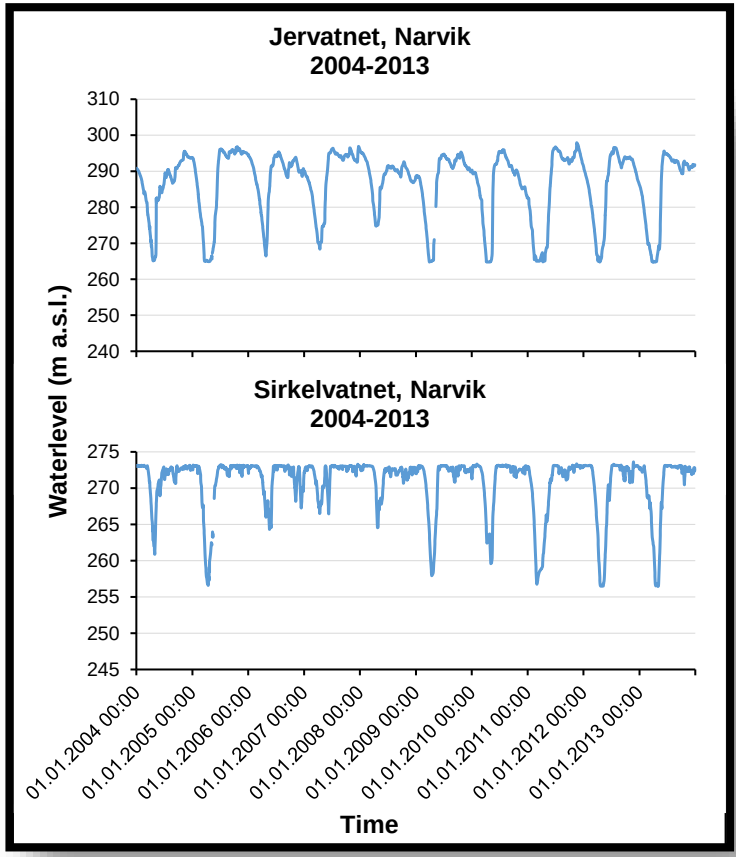


Conclusions

- Lake size and presence of other fish species have stronger impact on trout production than hydropower
  - Particularly evident in lakes with "greenest" catchments
- Compensatory trout stockings may partly mask hydropower impacts

Future plans

- More study lakes
- Studying realized regulation patterns prior to test fishing
- Food webs in unregulated, moderately and heavily regulated lakes
  - Stable isotope analyses
  - Parasites, heavy metals, fatty acids?



Thank you!


REGULERT VANN
-VARIABEL
VANNSTAND
Sirkelvatn
NORDKRAFT
Fare for dårlig is