Climate Change Induced Copper Toxicity in Two Key Arctic Copepod Groups

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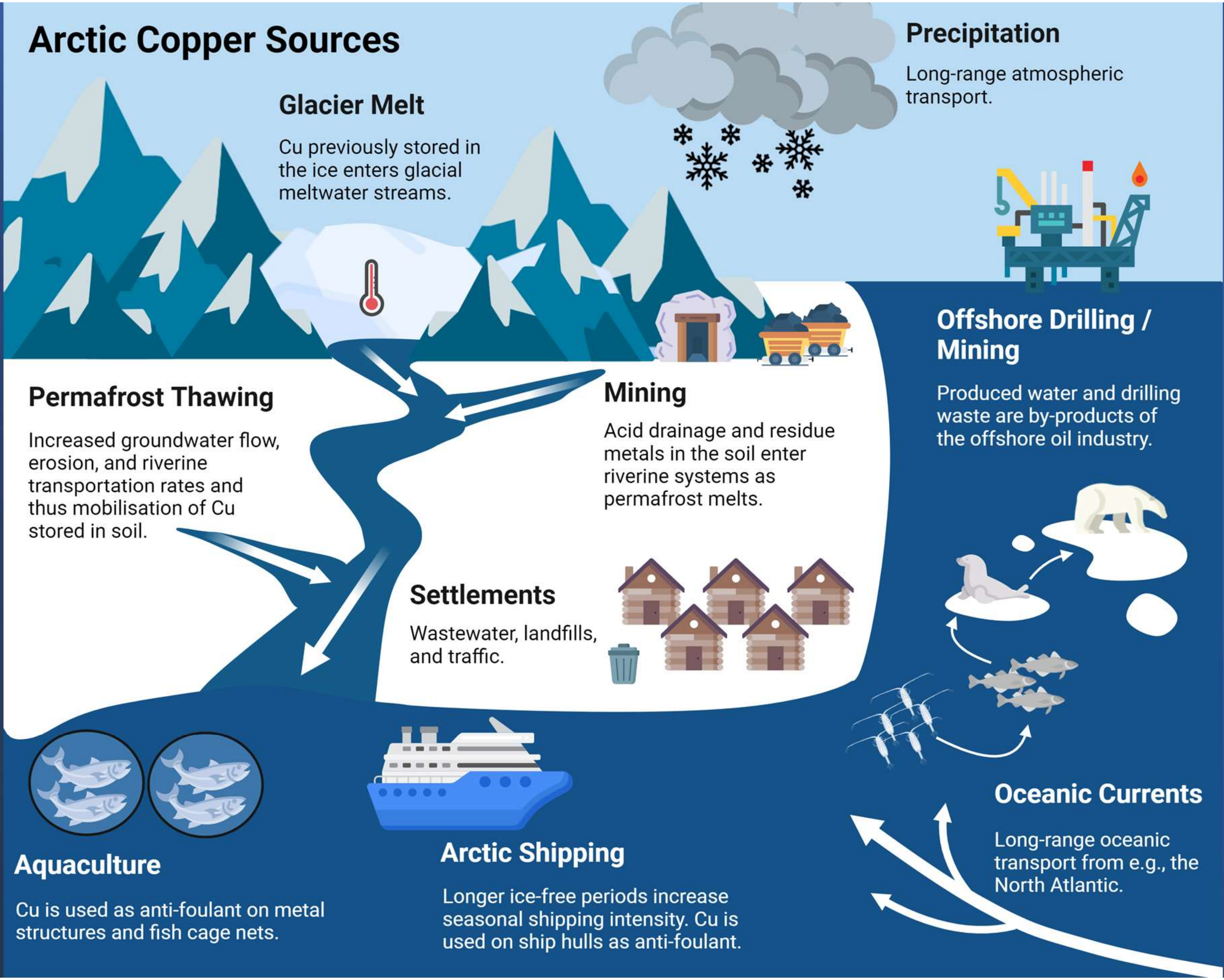


Arctic Copper Sources
Glacier Melt
Cu previously stored in the ice enters glacial meltwater streams.
Precipitation
Long-range atmospheric transport.
Offshore Drilling / Mining
Produced water and drilling waste are by-products of the offshore oil industry.
Permafrost Thawing
Increased groundwater flow, erosion, and riverine transportation rates and thus mobilisation of Cu stored in soil.
Mining
Acid drainage and residue metals in the soil enter riverine systems as permafrost melts.
Settlements
Wastewater, landfills, and traffic.
Oceanic Currents
Long-range oceanic transport from e.g., the North Atlantic.
Aquaculture
Cu is used as anti-foulant on metal structures and fish cage nets.
Arctic Shipping
Longer ice-free periods increase seasonal shipping intensity. Cu is used on ship hulls as anti-foulant.

Study Site in Norway Jun – Jul 2023

@Izabela Prates, 2015

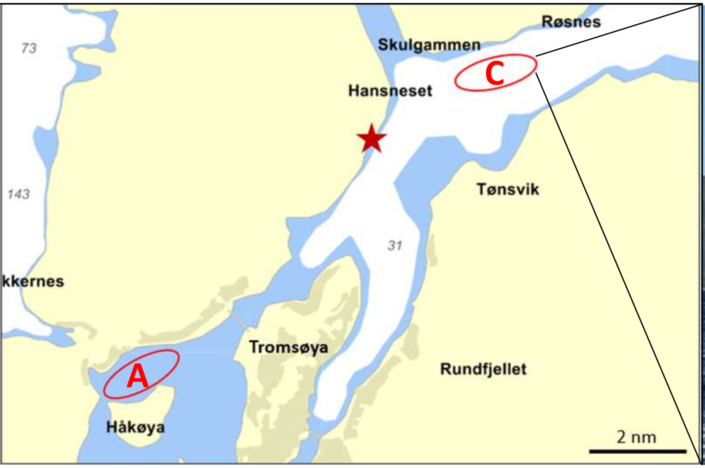
Calanoid copepods

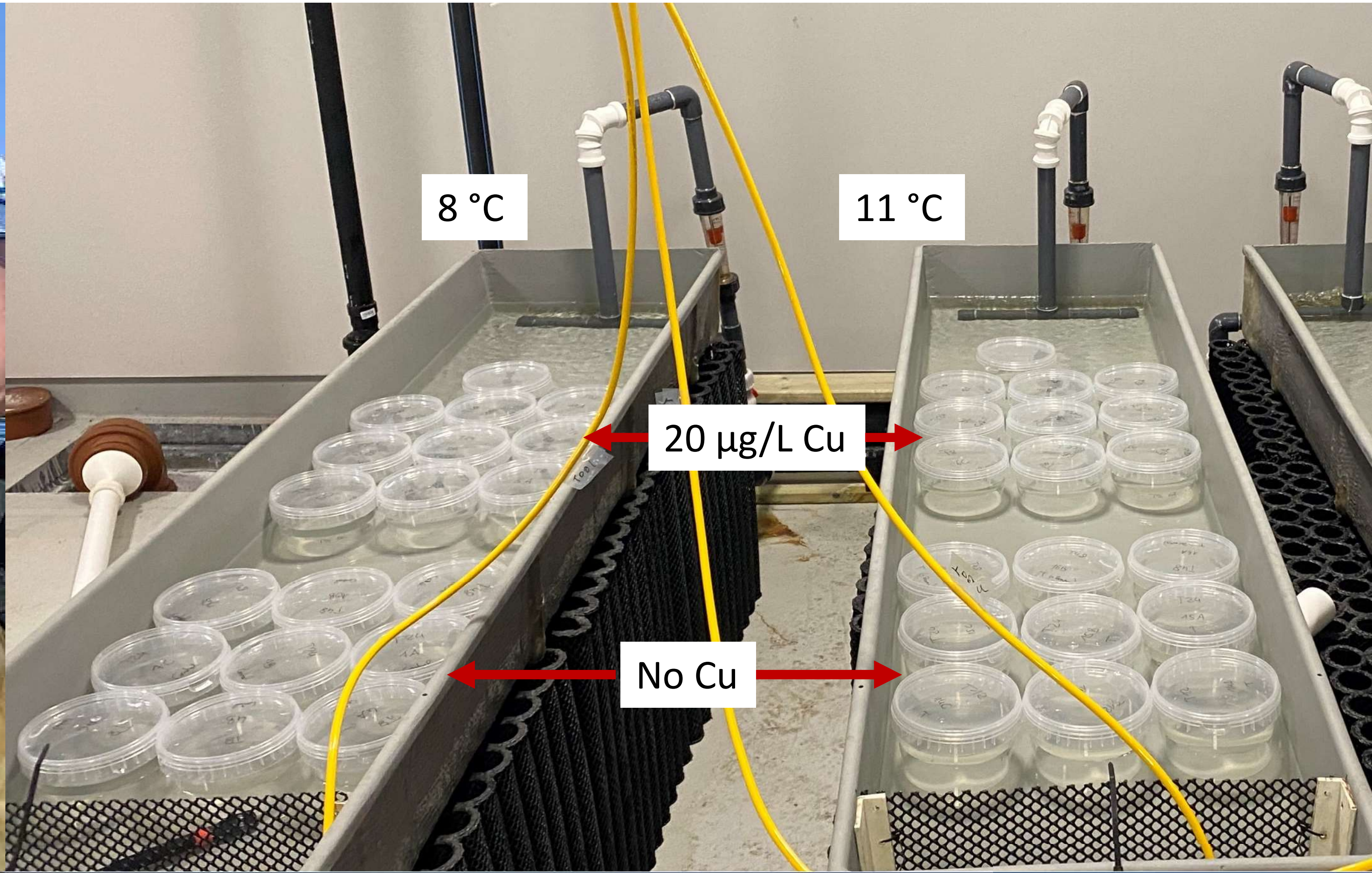
***Calanus* spp.**

- Fjord, deeper water
- Mixture of *C. finmarchicus* & *C. glacialis*
- Boreal - Arctic

Acartia longiremis

- Coastal, shallow water
- Arctic specialist





Methods

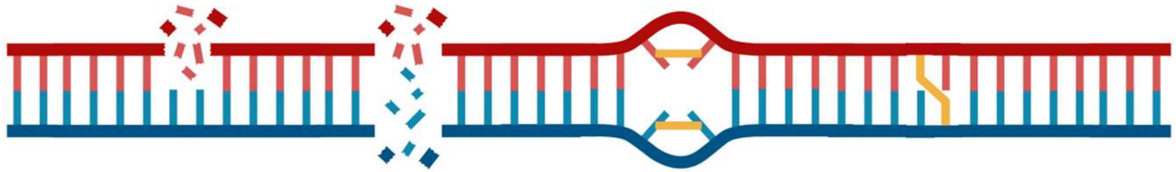
Net mesh size: 180 µm

10 *Calanus* spp. or 50 *Acartia longiremis* per beaker

Triplicate design

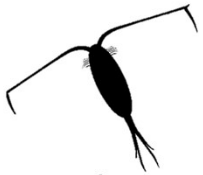
Impact Analysis

- Dose response modelling (LC50)
- *Calanus* sp. species ID
  - *G_150* DNA barcoding (Smolina *et al*., 2014; Mol. Ecol. Resour.)
- Targeted gene expression (qRT-PCR)
  - Oxidative stress genes
  - DNA repair genes
- DNA damage through fast micromethod assay (FMM) (Schröder *et al*., 2006; Methods Mol. Biol.)



Single- or double-strand breaks

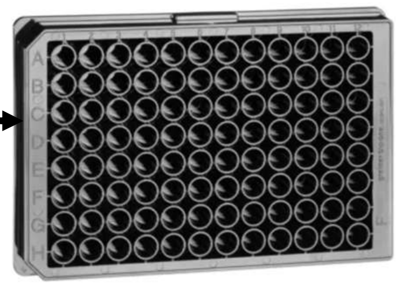
Intrastrand or interstrand crosslinks



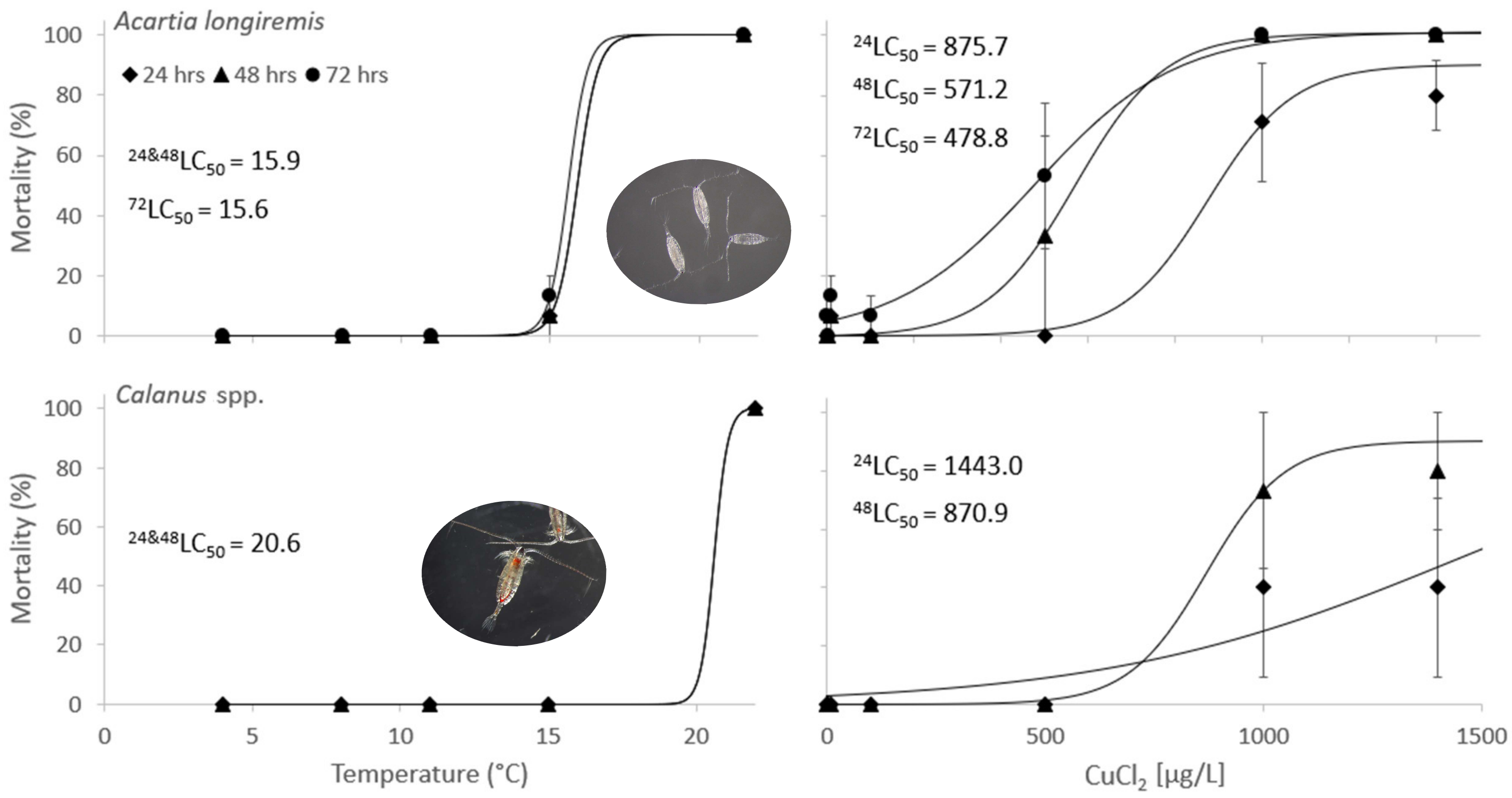
Speed of al unwinding corresponds to DNA strand breaks!

1 *Calanus* spp. / well

21 *Acartia longiremis* / well

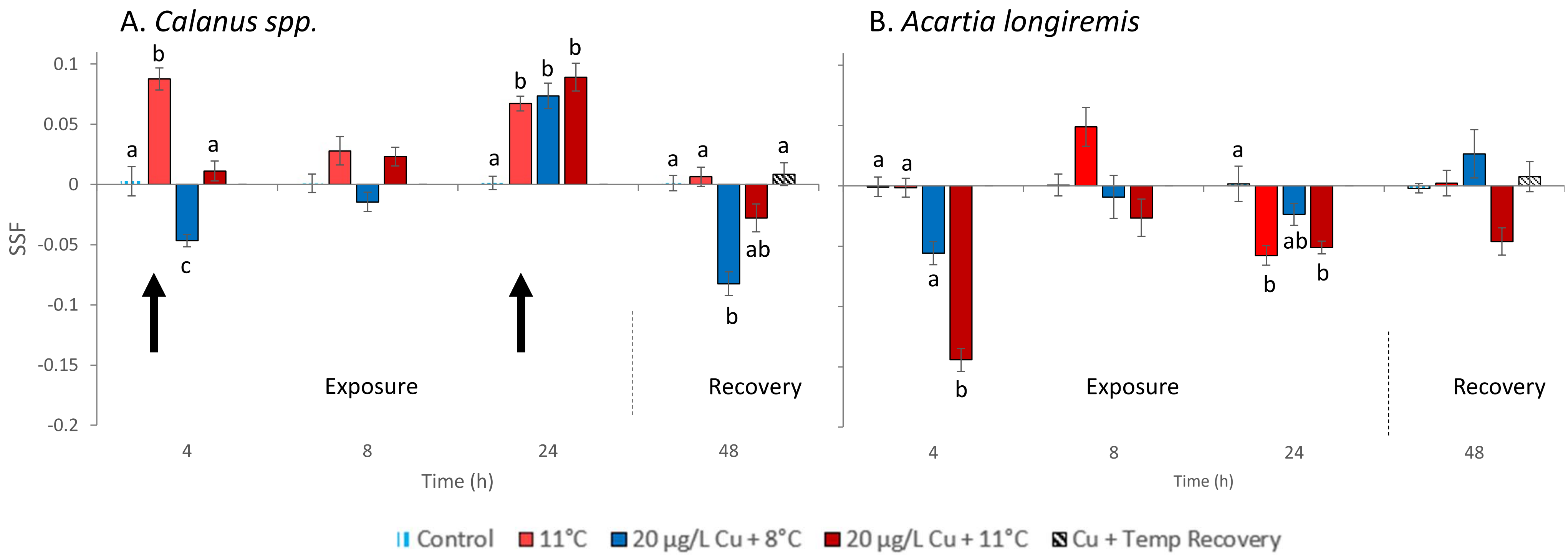


Mortality: *A. longiremis* more sensitive



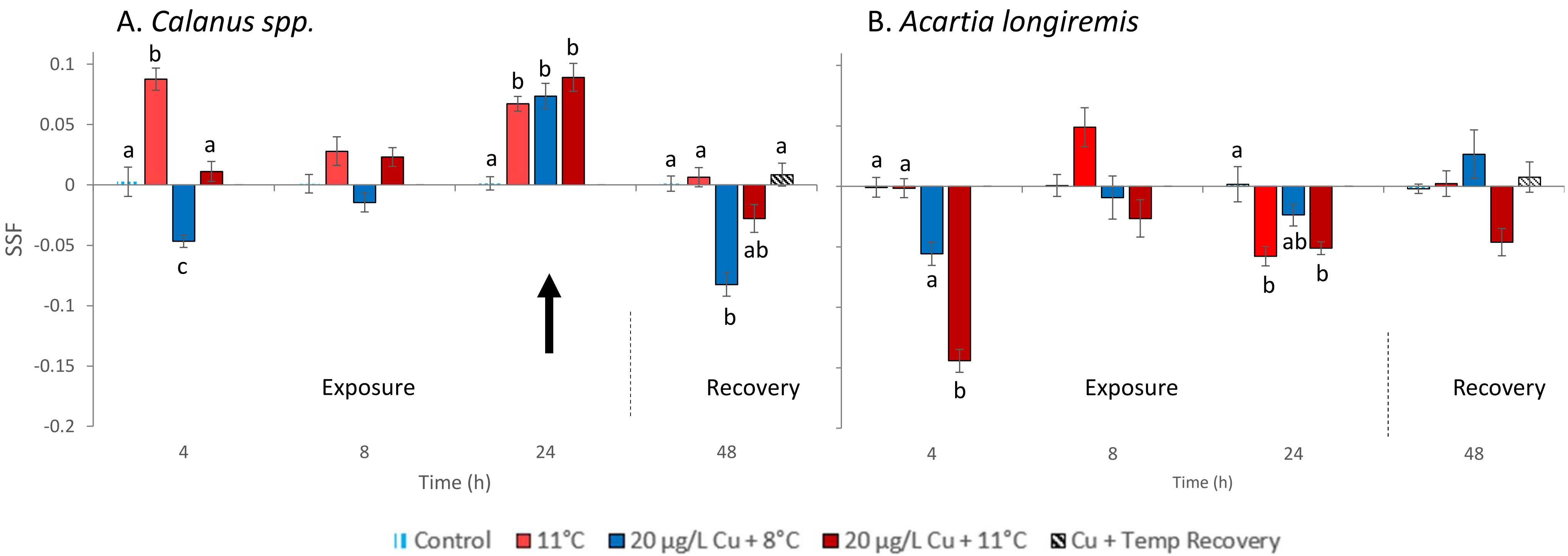
- *A. longiremis* died at lower levels in response to Cu and temperature as individual stressors compared to *Calanus* spp.

DNA damage: *Calanus* spp. more sensitive



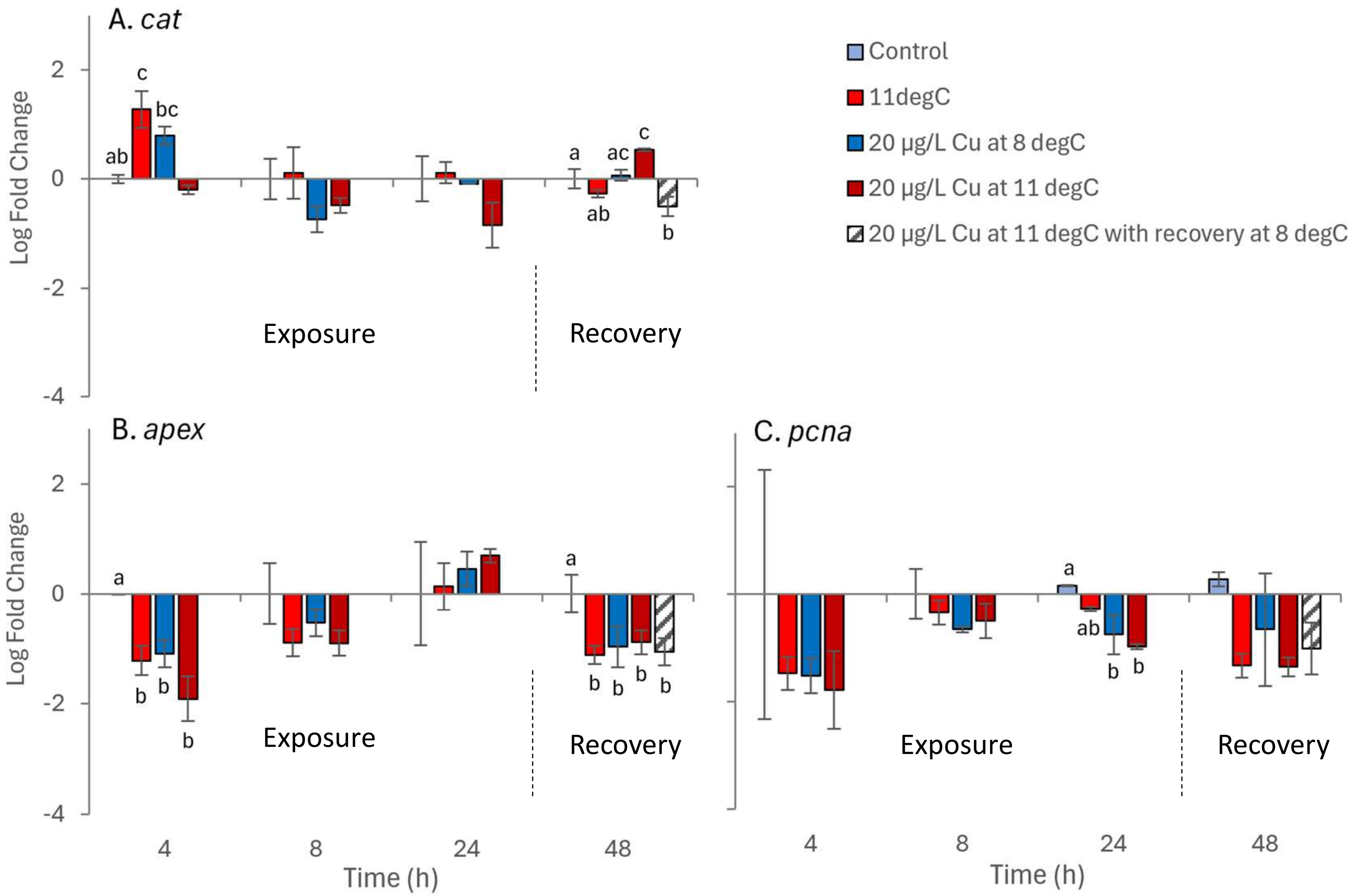
- Temperature significantly increased *Calanus* spp. DNA damage (GLM, $p < 0.05$)

DNA damage: *Calanus* spp. more sensitive



- Cu significantly increased *Calanus* spp. DNA damage (One-way ANOVA, $p < 0.05$)

Results – DNA repair gene expression



- Downregulation of DNA repair
  - Cu inhibits DNA repair
- High variation between individuals
  - plasticity?
- Temperature significantly induced oxidative stress gene *cat* expression (GLM, $p < 0.05$)
  - oxidative DNA damage

Conclusion

- Temperature causes reduction of genetic integrity of *Calanus* spp. but not *A. longiremis*
- Cu may induce crosslinks and suppress DNA damage repair mechanisms in both species
  - Impact of genetic instability on future populations?
- High intraspecific variability: **Resilience by Diversity?**
- Molecular mechanisms can uncover species differences in sensitivities to stress

Thank you for Listening!

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