Luke
NATURAL RESOURCES
INSTITUTE FINLAND

Monitoring the impacts of large-scale dam removals on boreal fish community

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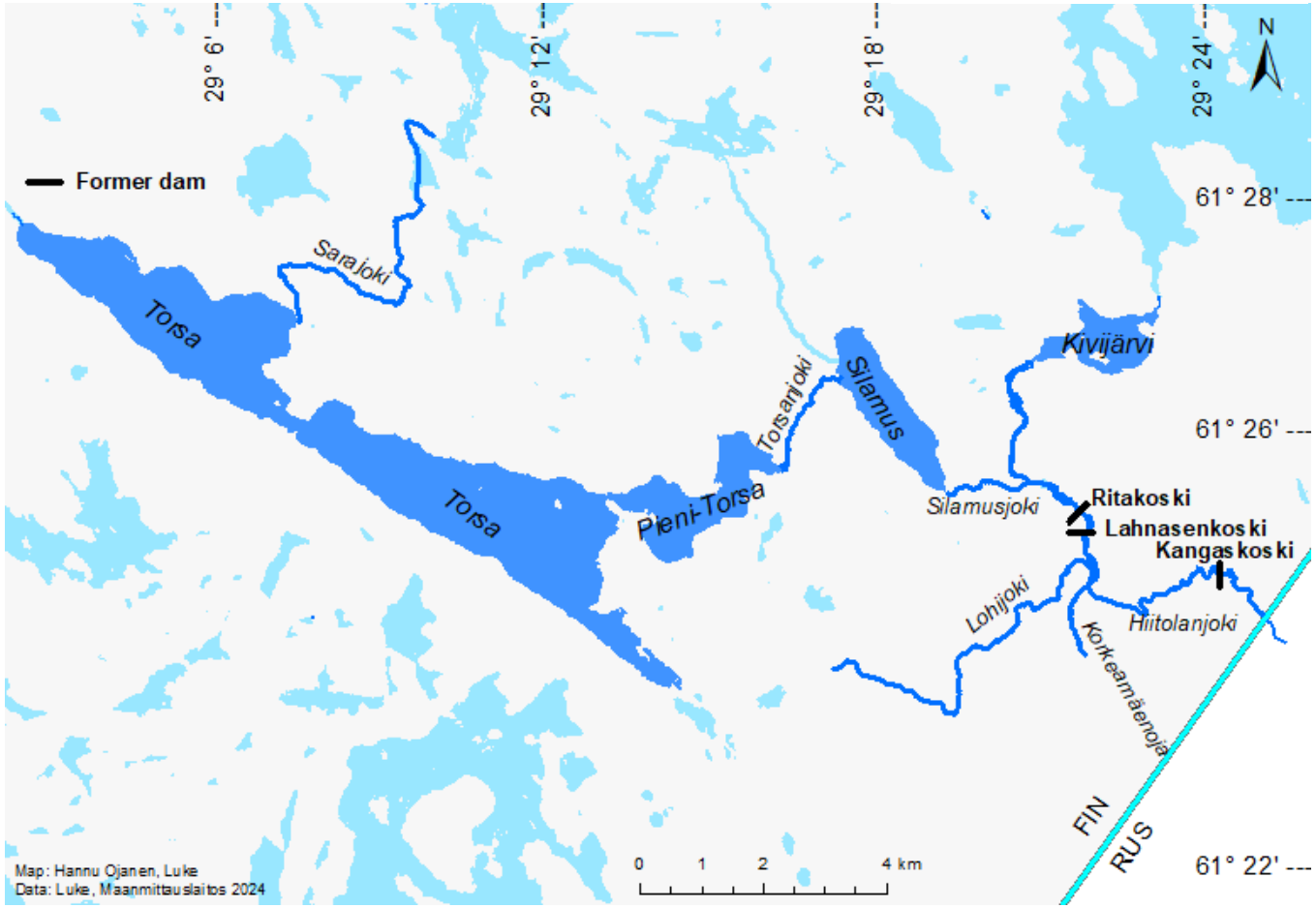
What is known about the impacts of dam removal on fish communities?

- Full dam removal and subsequent restoration actions can be viewed as the reversal of an im-pounded reach towards the original free-flowing state (Bednarek 2001)
    - Following the hydro-morphological processes and water quality changes, the river´s biota encompassing both flora and fauna, is expected to follow with the extent of alterations, thereby mitigating biodiversity loss (Bellmore et al. 2019)
- Species compositions usually start to change immediately, but might take >3 years to find balance
    - Especially abundance of migrating species increase (e.g. Catalano et al. 2007)
    - Salmon can spawn immediately and produce smolts if restored habitats are suitable
- Urgent need for long-term, multidisciplinary case studies to anticipate the effects of dam removal and inform future decision making (Bellmore et al. 2016)
    - E.g., <10 % have been scientifically evaluated in dam removals done in the U.S., and most of these studies were short in duration (<4 years) and had limited (1–2 years) or no pre-removal monitoring
- In Finland, the removal of dams has become more popular
    - There are over 5,500 dams in existence, of which ca. 220 are generating hydropower
    - Dam removals have been mostly done in small rivers with migratory fish, but with minimal impact on hydropower production

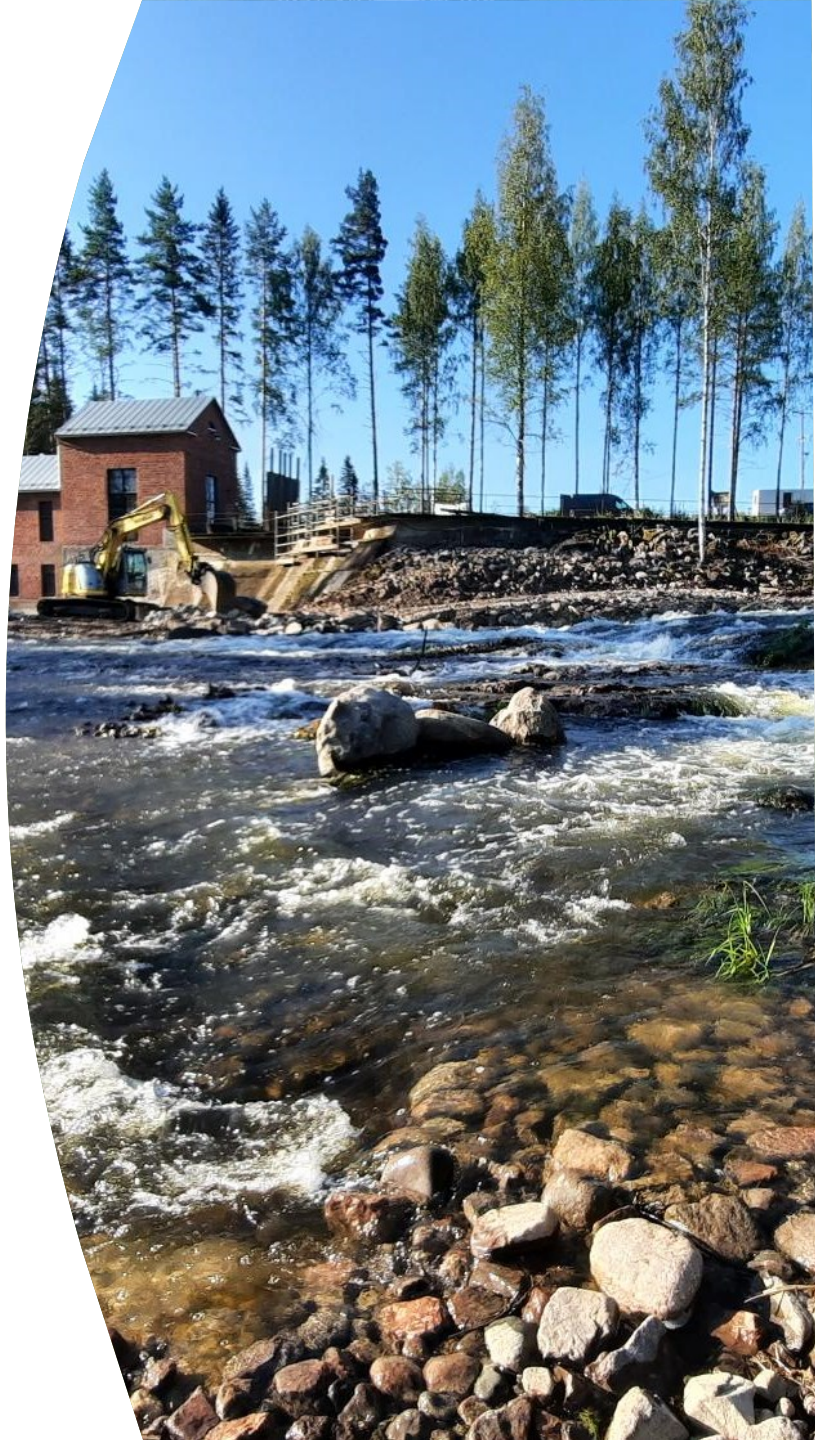
River Hiitolanjoki study case

- Flows from South-East Finland to Lake Ladoga
- Three consecutive dam removals in 8 km long river's main stem have sequentially taken place in years 2021–2023 and areas restored as reproduction areas suitable for salmonid fish
  - CR landlocked salmon
  - native brown trout



Extensive monitoring of impacts

- Monitoring of impacts on fish community started in ~2020 and continues until 2026
    - 1 year pre-removal, 3 years tempore-removal, 3 years post-removal
    - Juvenile habitat area
    - Fish community
    - Food web structure and food chain length
    - Upstream migrating fish starting in summer 2024
- Other monitoring
    - Greenhouse gas emissions in 2020–2021, 2024?
    - Area usage and importance to local citizens in 2021, 2025? (Artell et al. 2022)
    - Hydromorphology, sedimentation (ongoing by Aalto University)
- Extra data and co-operation with regional Ely-centre and local associations



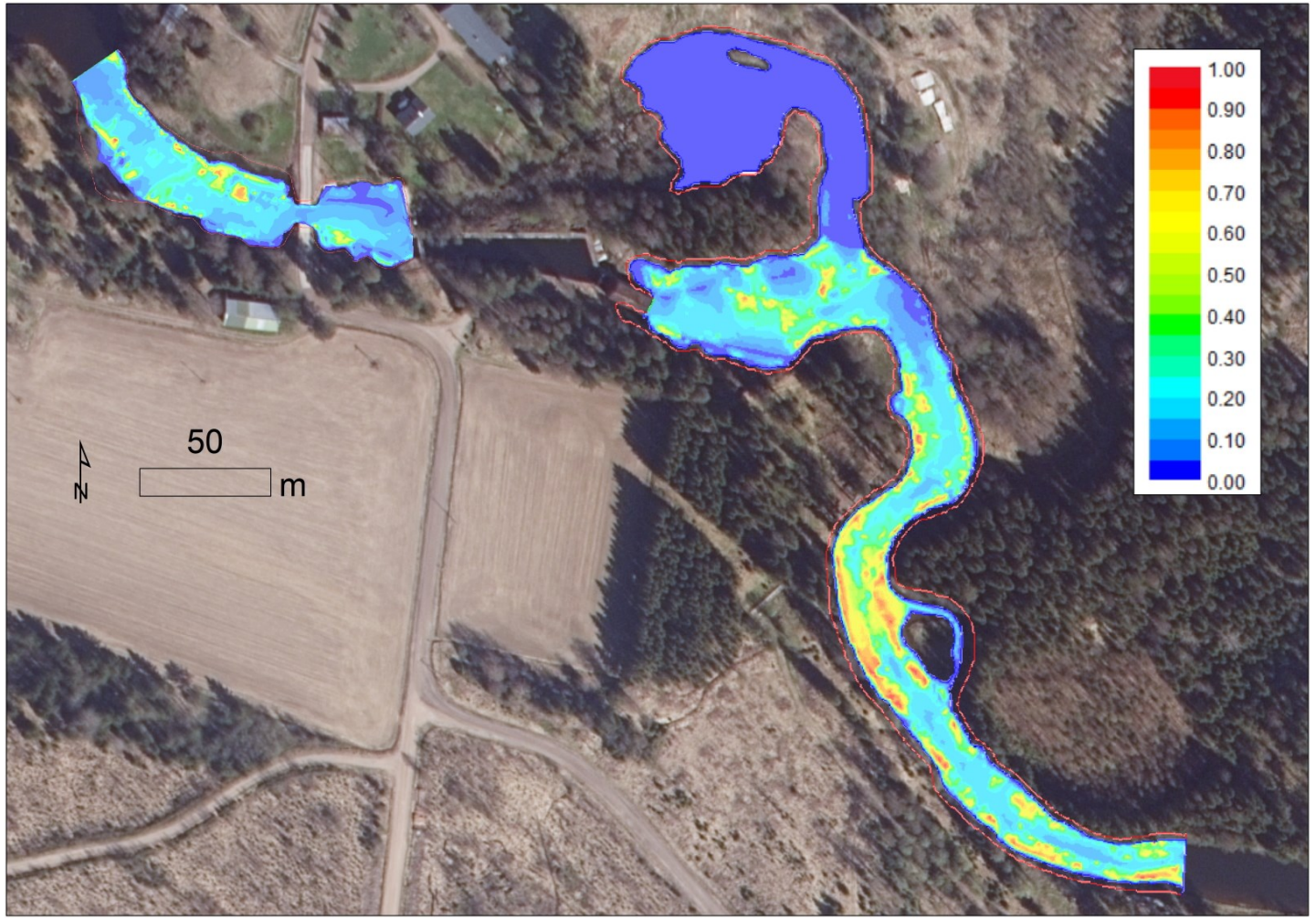
Main research questions

- What impact will the transition from impounded river sections to a free-flowing riverine waterbody have on the composition and stability of the riverine fish community over the course of a few years (short-term)?
- How do these modifications affect the structure of the aquatic food web?
- Will the critically endangered salmon make a natural comeback and establish a self-sustaining population?

Salmonid juvenile habitat

- Weighted Usable Area (WUA) for landlocked salmon juveniles and spawning
- River2D modelling
- Water current and depth, salmon habitat preferences from pre-existing data
- Example: Lowermost restored area in the river before the dam removal →

<10 cm juveniles, flow 5 m^3/s, WUA: 3225 / 20 224 m^2

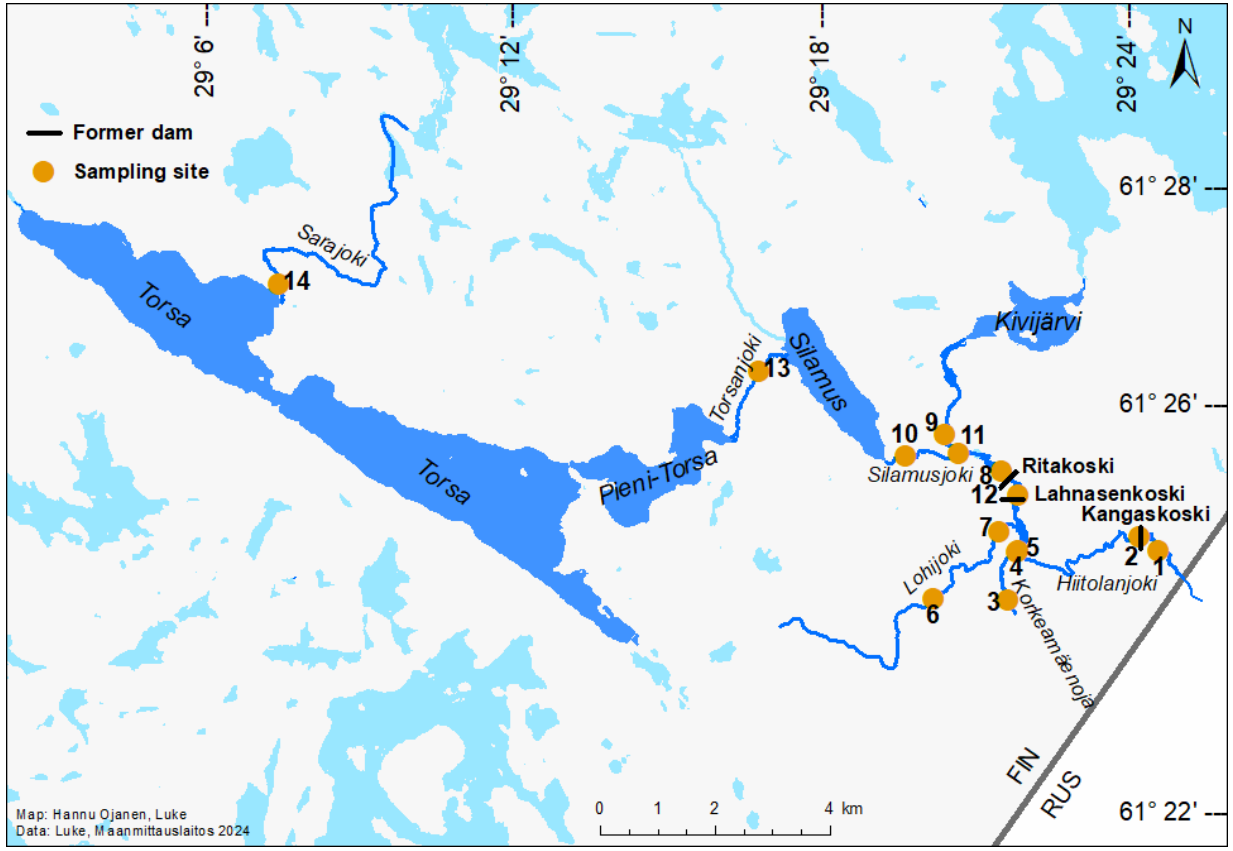


Fish species composition

- **Gill-netting the pool areas**
  - Typical lake fish species e.g., cyprinids and perch, some pikes
  - Not done anymore to prevent harm to salmon
- **Boat-based electrofishing in pools**
  - Only small changes in fish community, pools are still cyprinid-dominated
- **Electrofishing by wading in riffles**
  - Manifold increase in juvenile trout & salmon densities in the lowermost restored area (in total 78 ind./100 m^2 in first year)

Fish species composition – environmental DNA

- Potentially powerful tool for use in tracking the recolonization dynamics of fish populations (Duda et al. 2020)
- Monitoring the spreading of salmon and trout within the water system
  - When and where they migrate to
  - Do local fish communities change in response to the reintroduction of salmonids?
- Monitoring expanded from the impact area in main stem to side streams and upper reach areas of the river system



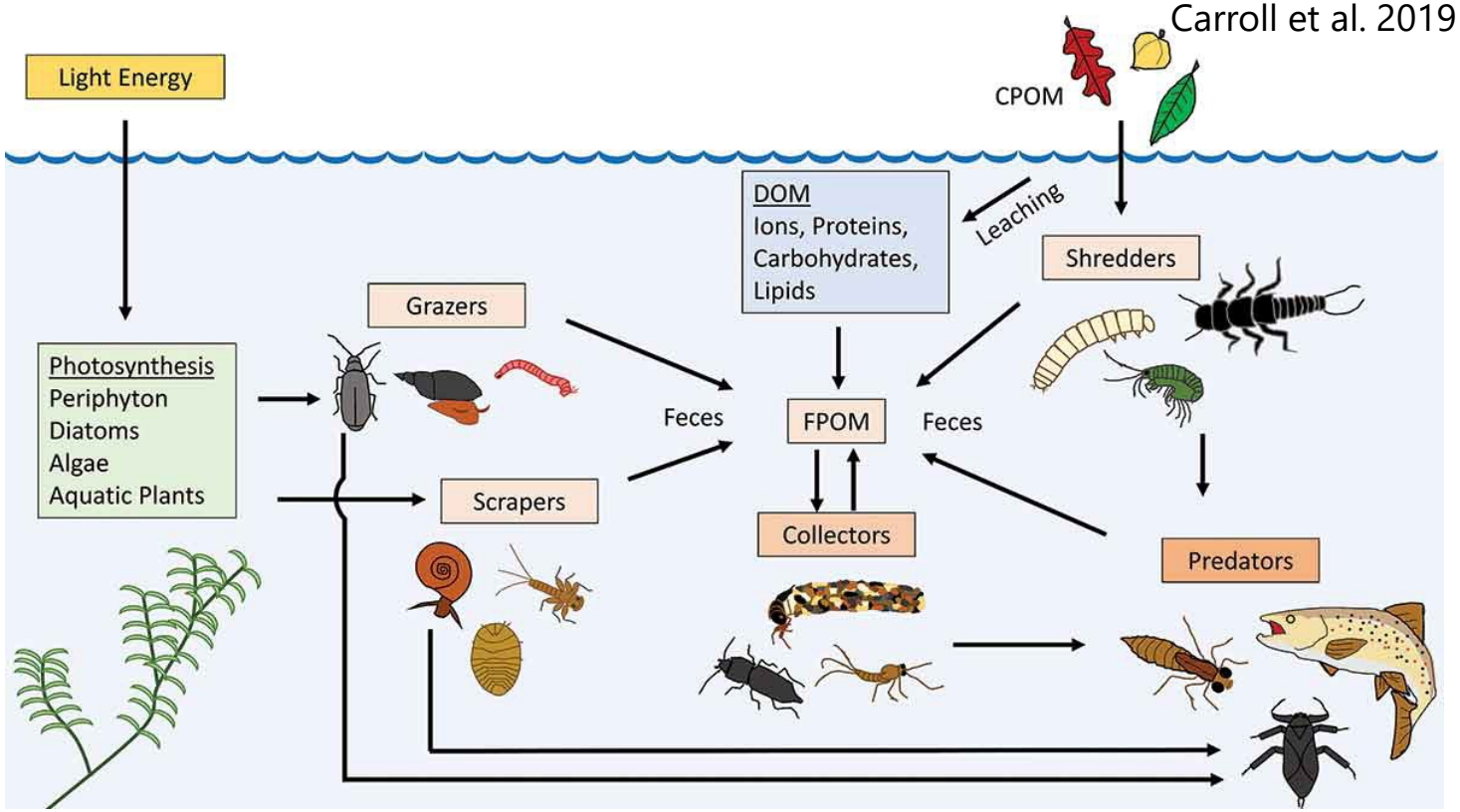
Food web structure

- ^{13}C and ^{12}C have relatively little variation in natural small aquatic ecosystems (Finlay et. al 2007)
  - could indicate a switch in main food source
  - ^{15}N enriches in food chain (Peterson & Fry 1987)
  - higher $\delta^{15}N$ values indicate higher position in food chain

→ Isotope ratios indicate food web structure and number of trophic levels

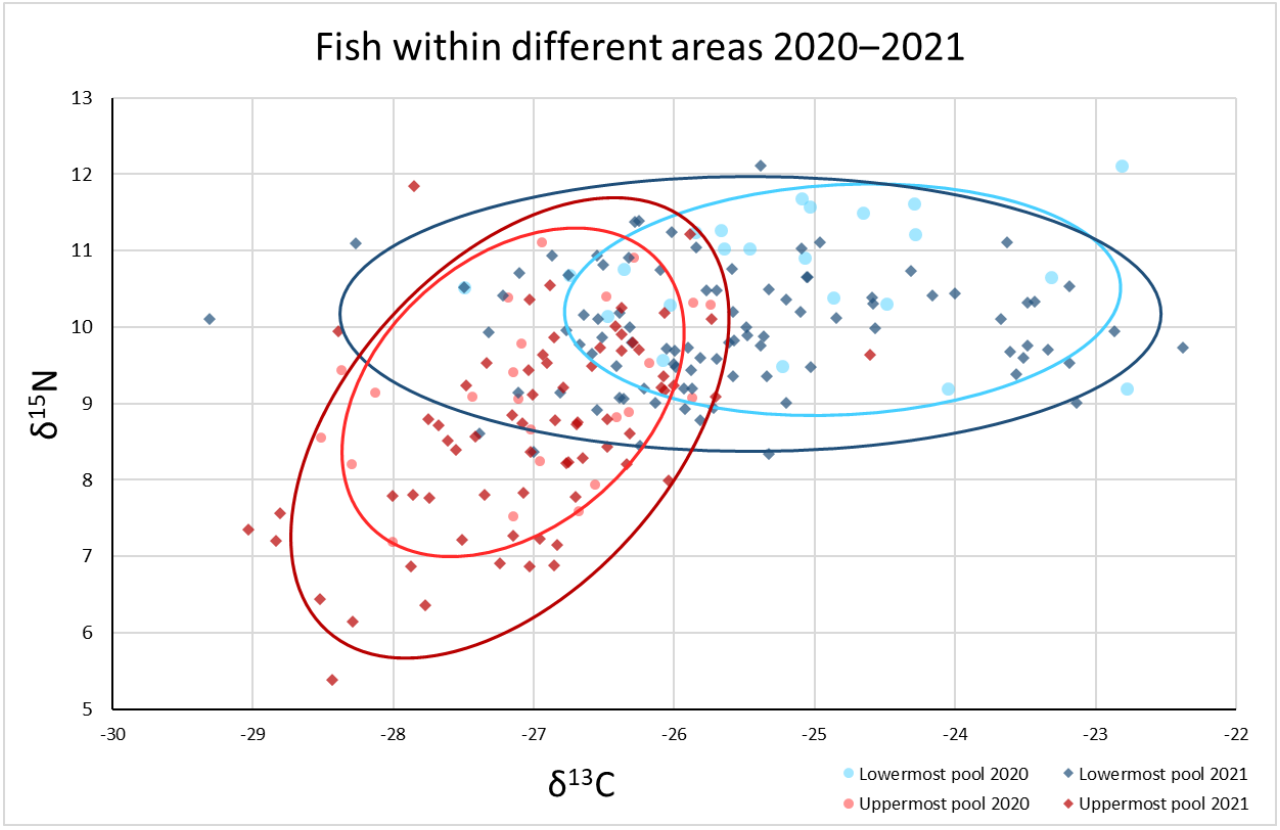
- We expect the food chain to shorten over time (lower $\delta^{15}N$ values, Vander Zanden & Fetzer 2007) and see a shift in $\delta^{13}C$ values (Vannote et al. 1980)

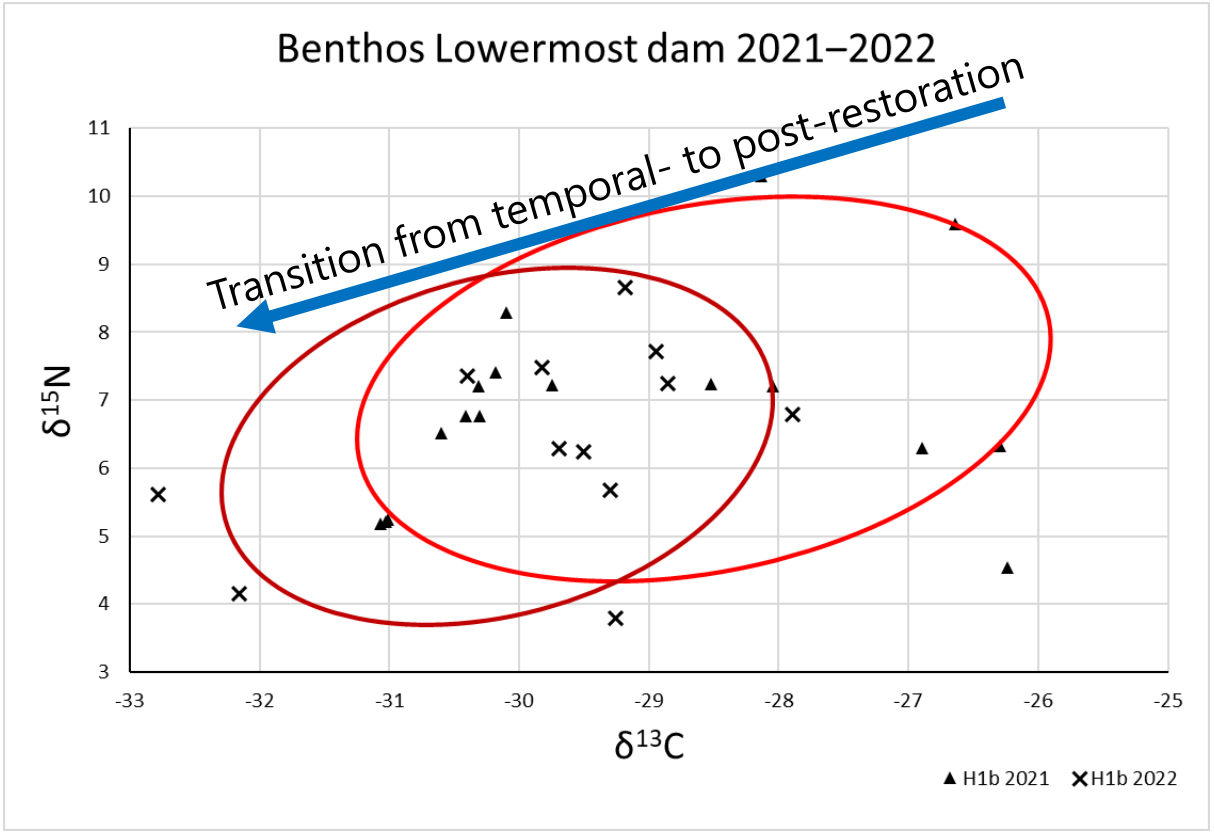
Carroll et al. 2019



Stable isotope analysis – preliminary results

- Results are only preliminary, but promising
- Fish show signs of initial disturbance (increased variance), balance is yet to be achieved
- Benthos show more apparent signs of reacting to habitat change





Thank you!

Luke
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