Impacts of pumped storage hydropower on the ecosystem of reservoirs

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Outline

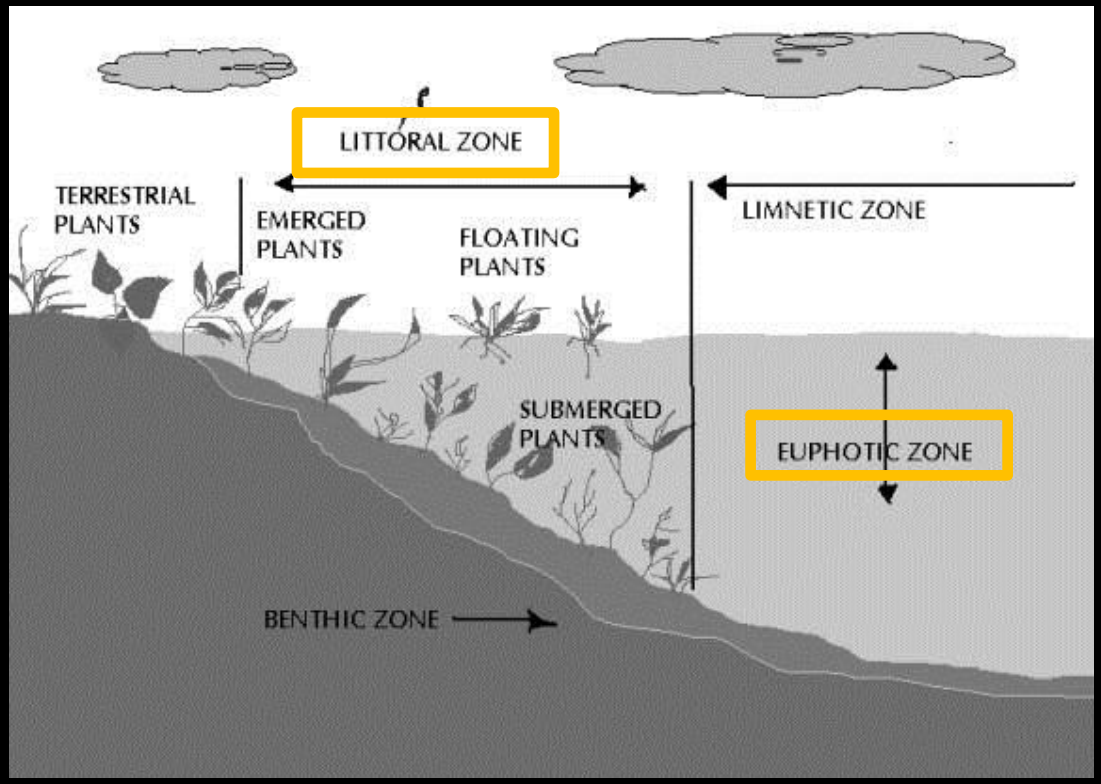
- Environmental effects of pumped storage hydropower
- Biological production in lakes
- Examples of known biological effects of hydropower
- Research needs

Physical impacts in reservoirs

- Increased erosion
- Increased frequency of draining and filling of reservoir
  - Less predictable water level
- Changed circulation pattern, may effect thermal stratification
- Changes in water temperature and ice formation
- Lower temperatures in downstream reservoirs

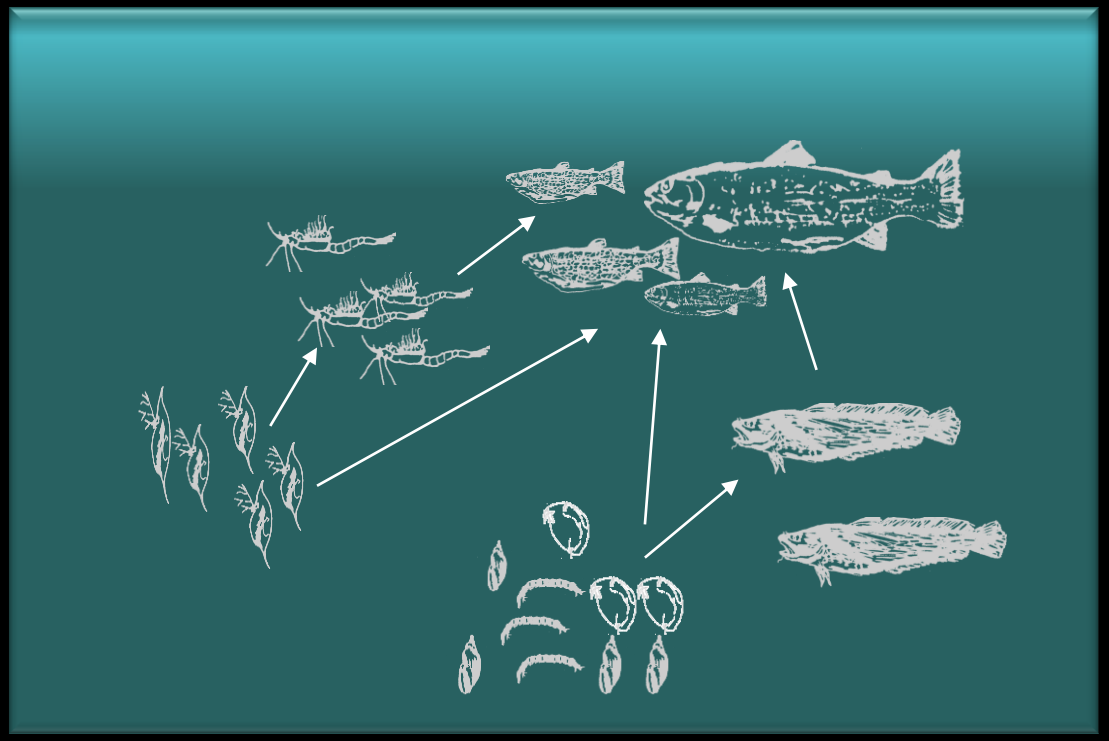
E. Solvang, A. Hartby & Å. Killingtveit (2012) Rapport

Productivity in lakes



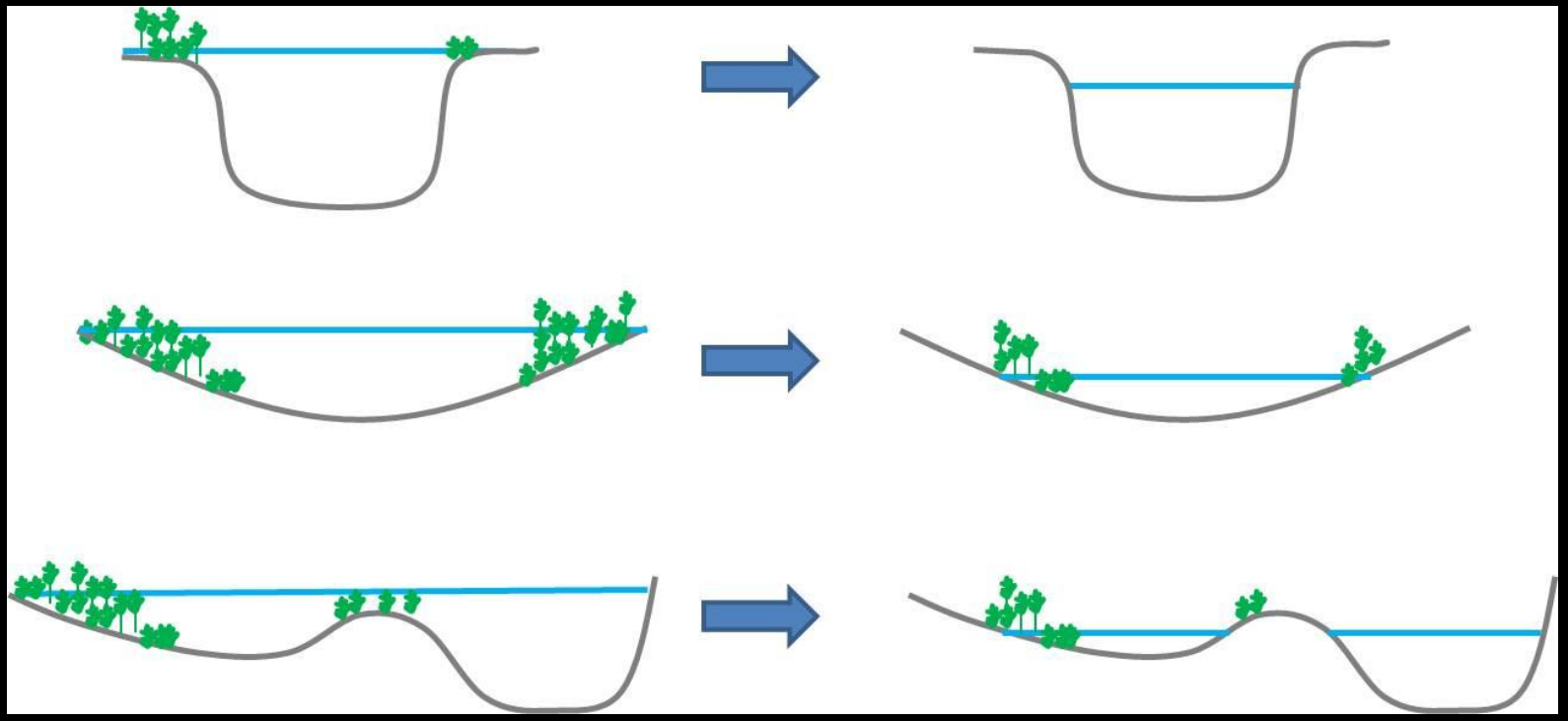
- The impact of regulation depends on how much of the production areas are influenced

Aquatic food web



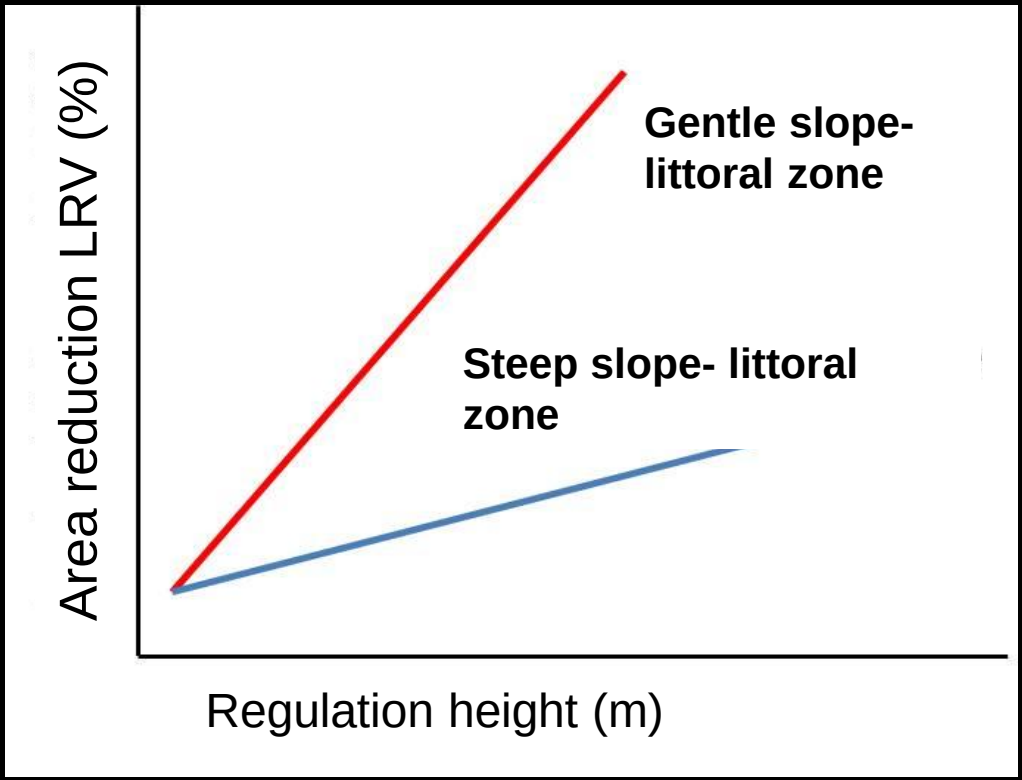
- Production in the littoral zone is vital for the food web in the lake
- Trout and charr are flexible and can make switches from one prey to another quickly.
- Other fish species such as the whitefish (sik) is more specialized and may suffer more from changes in the food web
- In some cases reservoirs can be modified without effecting the fish population → lake morphology

Lake morphology



Shape of reservoir s determines the biological impact when the waterlevel is reduced. The plants illustrates the littoral zone.

Lake morphology and area reduction



Examples of known biological effects of hydropower

Physical impact:
Water level less predictable

Timing and season

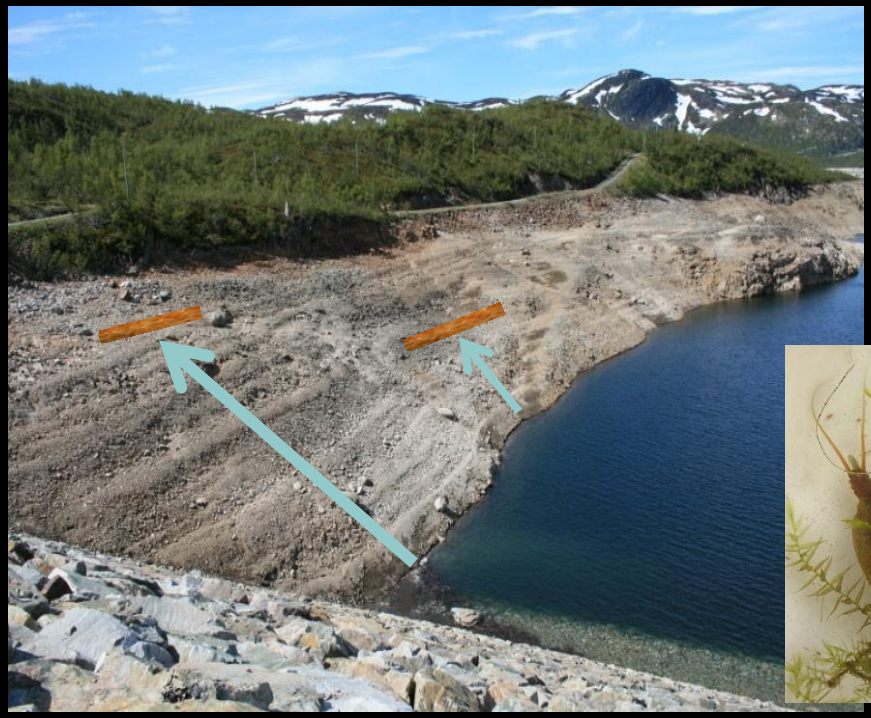
- Brown trout in reservoirs need access to spawning streams
  - Too low water level may prevent access to spawning streams- reduced production of brown trout
- Older juveniles need access to the lake


Photo: E.B. Thorstad

(Jonsson & Jonsson 2011)

Timing and season
Tadpole shrimp and waterlevel

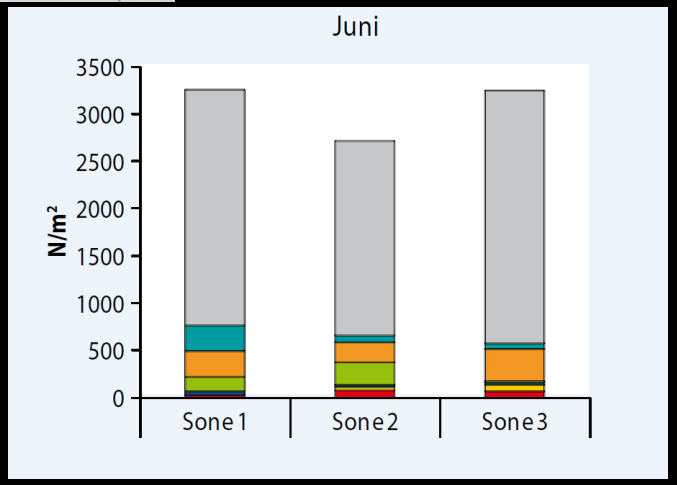
Physical impact:
Water level less predictable

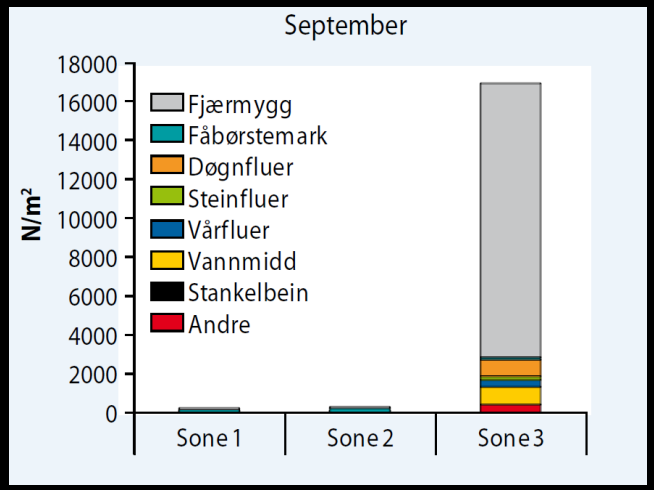


Discrepancy from HRWL during egglaying determines abundance of tadpole shrimp the following summer.

Physical impact:
Frequent fluctuations in water level

Hydropeaking and benthic invertebrates



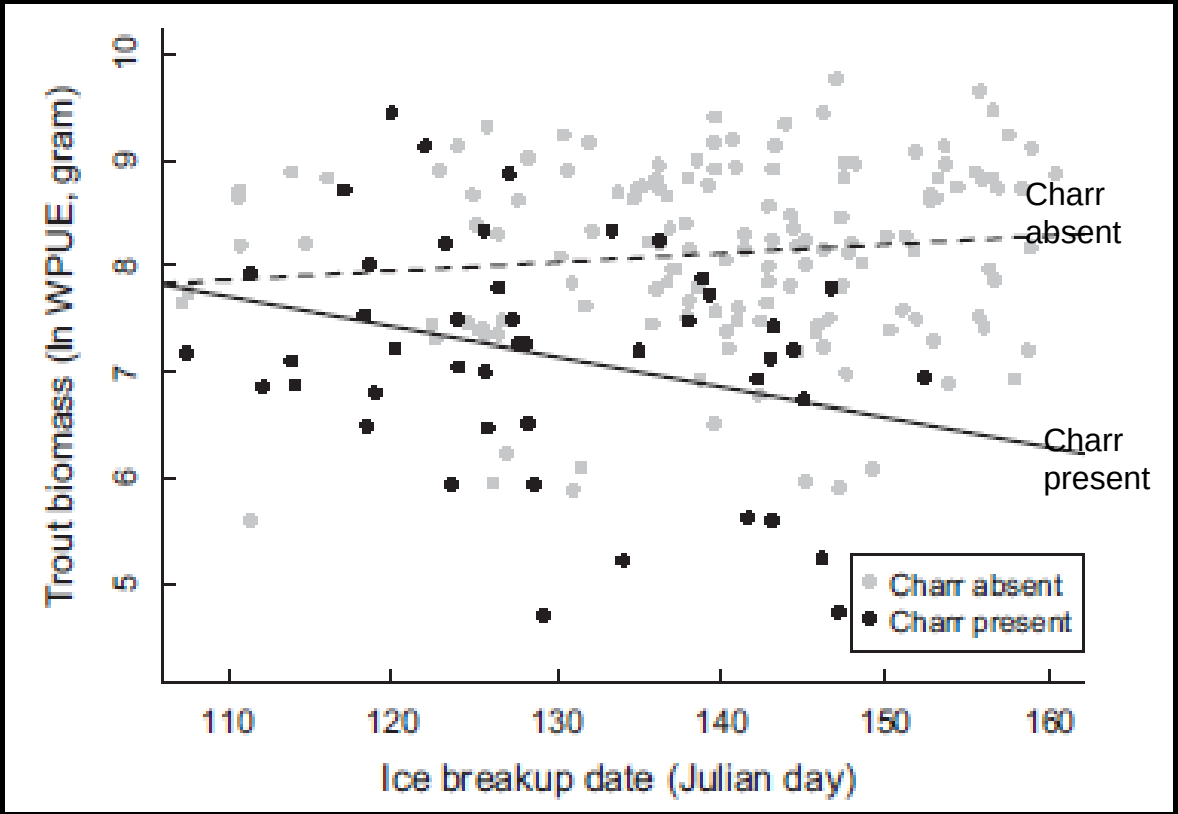


- Negative relationship between number of «dry episodes» and abundance of benthic invertebrates
- Benthic fauna only returnes several months following normal water level

Johnsen (red), B. O., m.fl. 2010. Effekter av vassdragsregulering på villaks. - Kunnskapsserien for laks og vannmiljø 3.

Physical impact:
Less stable ice cover

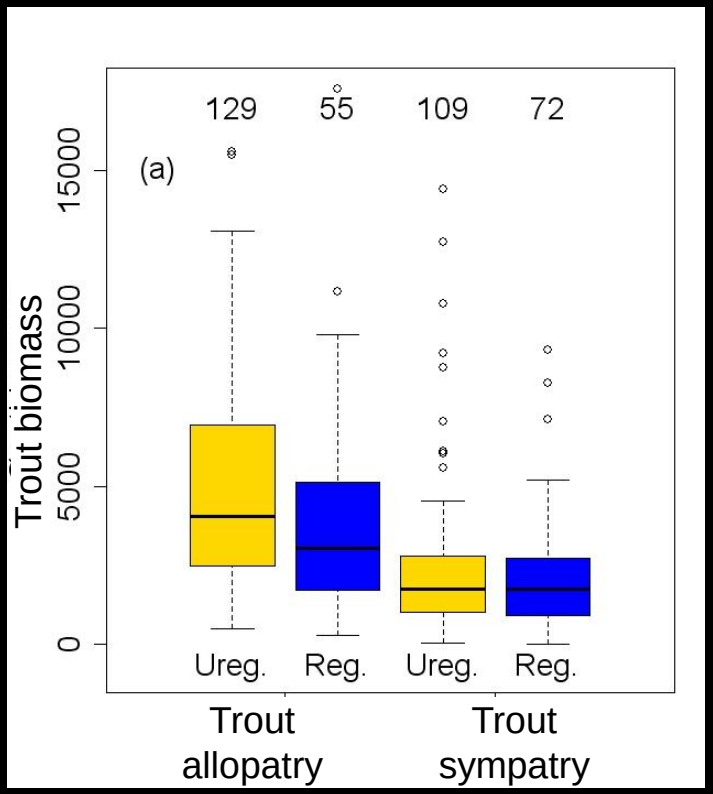
Ice cover- population dynamics

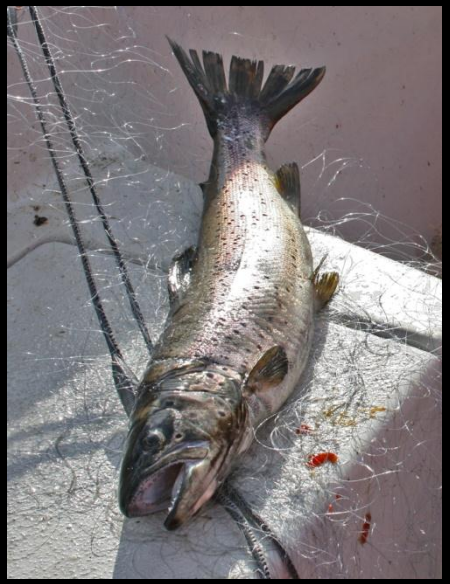


Helland, I., A. G. Finstad, T. Forseth, T. Hesthagen, & O. Ugedal,. 2011. J. Anim. Ecol. 80, 539-547.

Physical impact:
Less stable ice cover

Brown trout in reservoirs; competition





Presence of other fish species has a larger impact on biomass than regulation

Helland, I.P., mfl. 2010. Standardiserte ørretfangster som hjelpemiddel for å vurdere økologiske effekter av vannstandsreguleringer i innsjøer - NINA Rapport 560

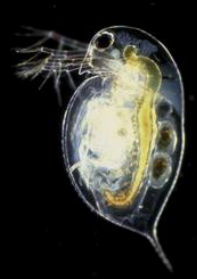
Physical impact:
Transfer of water

Increased levels of nutrients

Increased level of nutrients: whole lake experiments

Canada; 20 lakes fertilized over two decades

- Increase phytoplankton biomass (50-60%)
- Two-fold increase in zooplankton biomass
- Increased biomass and size of fish population



versus

Stockner& Macisaac(1996) Reg. Riv. Res. Manag.,12, 547-561

Physical impact:
Transfer of water

Invasive species

- Common minnow (*Phoxinus phoxinus*)-
  from harmless species to pest
- Naturally distributed in low altitude localities
- Spread in mountain areas during 1900s; due to use of live bait
- Successful in harsh habitats


Photo: biopix

J. Museth, T. Hesthagen, O.T. Sandlund, E. B. Thorstad & O. Ugedal (2007) J. Fish. Biol. 71, 184-195.

Summary

- Complex relationship between different environmental factors
- Different demands for different
  - Habitats
  - Species
  - Season
  - Lifestages
- We have a conceptual understanding, but need more data due to complex interactions

Research needs

- We need to collect data across relevant gradients to enable quantitative models
  - Climate gradients
  - Species composition gradient
  - Lake type gradients (size/depth/shape)
- Changes in the food web need to be studied together with changes in the regulation pattern
- We need to know the pre-regulation state of the food web.










Thank you!

Cooperation and expertise

for a sustainable future