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The importance of healthy fish stocks for the ecological quality of rivers

Carola Winkelmann

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Importance of fish

Species conservation
(Habitats Directive)

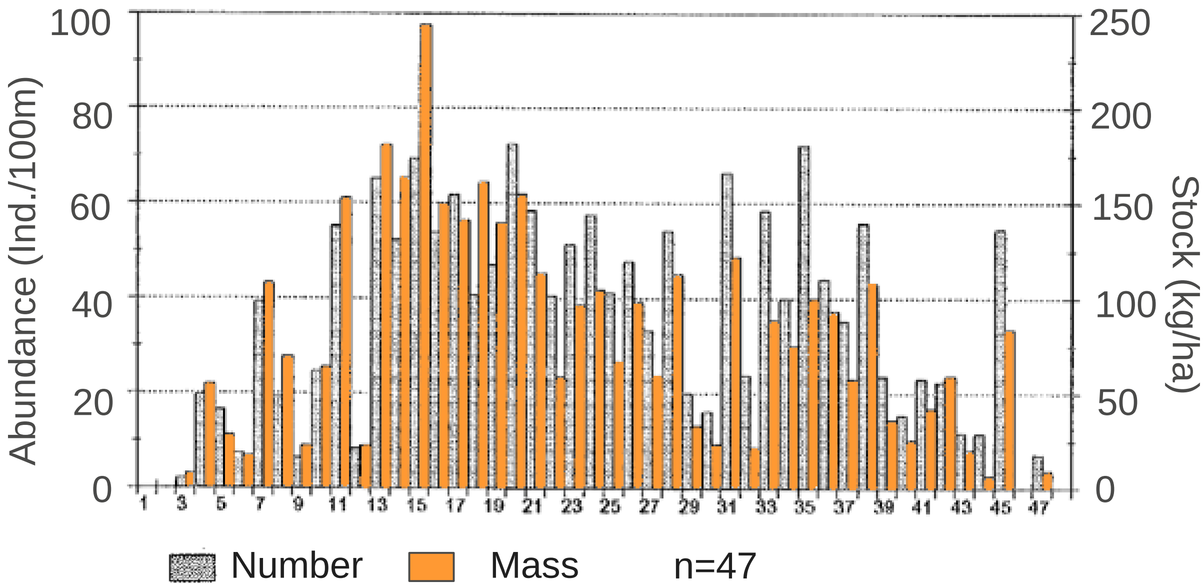
Ecological status
(WFD assessment)

Pristine habitats

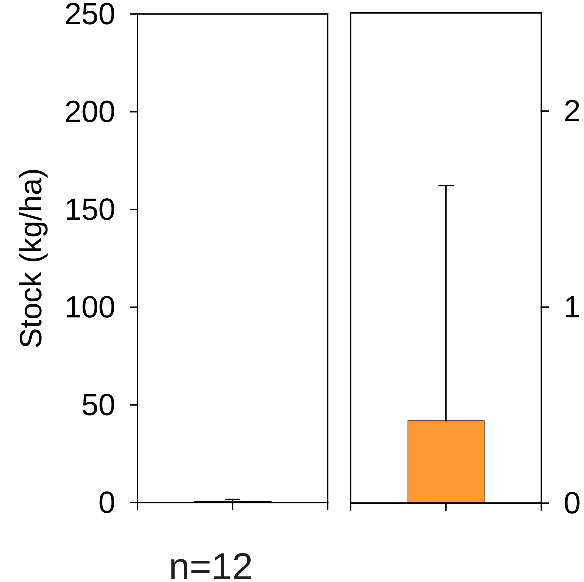
High biodiversity
Ecosystem services
(benthic invertebrates, fish)

Conservation status grayling: Kyll

1994

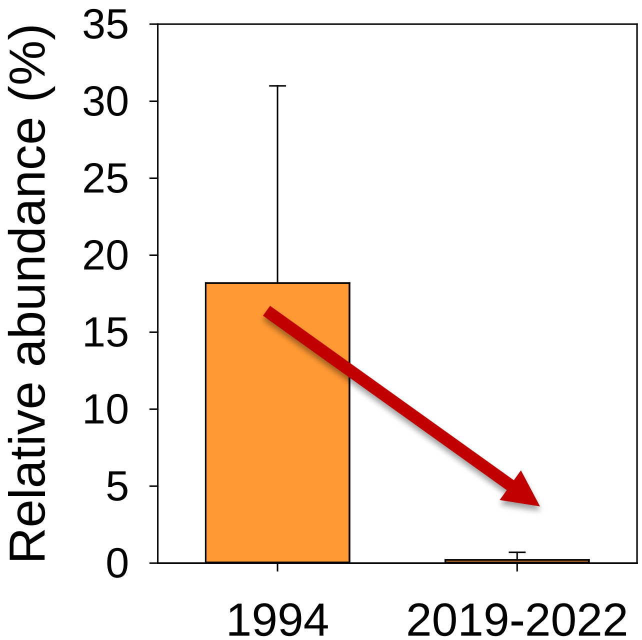


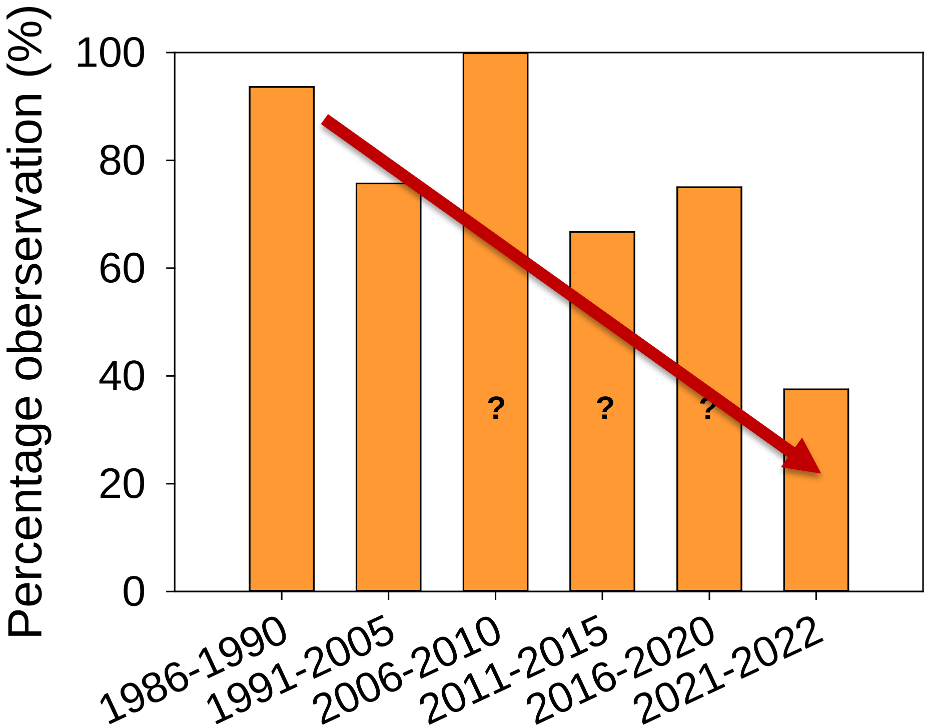
2019-2022



Dramatic reduction in grayling stock, in spite of good habitat quality
(benthic invertebrates: “good”, hydro-morphology: “moderately affected”)

Conservation status grayling: Kyll





Grayling: from a dominant to a rare species within 30 years.

Data: Roland Mauden, Fish and Fishery Agency Rhineland-Palatine (Germany), Relative abundance of grayling in 1994 (n=47), 2019-2022 (n=12), Percentage of sampling sites where grayling was detected (%), bar: n ≥ 7, bar with “?”: n < 7.

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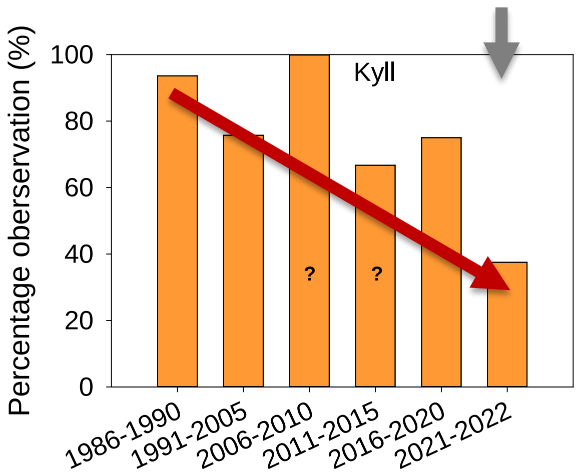
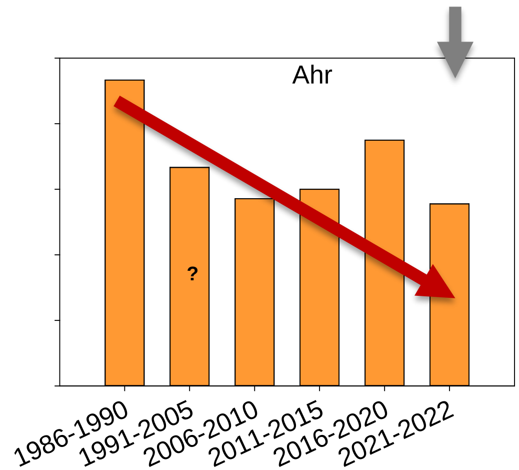
Conservation status grayling

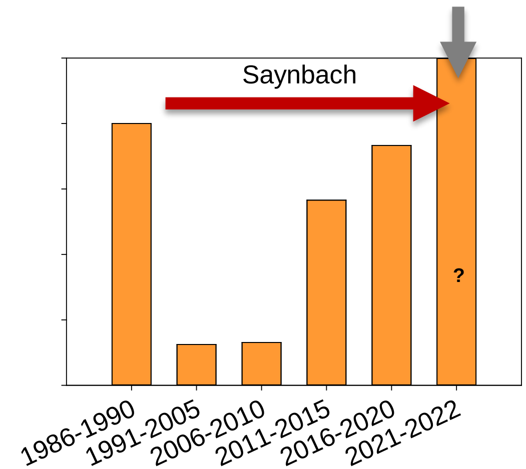
0,4 ±1,2 kg/ha



1,7 ±3,4 kg/ha



10 ±12 kg/ha



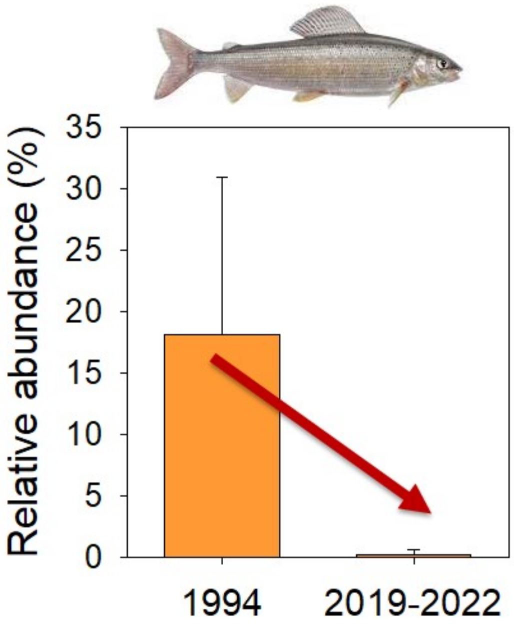
30% adjoining street

60% adjoining street

~100% adjoining street
canopy cover

Data: Roland Mauden, Fish and Fishery Agency Rhineland-Palatine (Germany), Percentage of sampling sites where grayling was detected (%), bar: n ≥ 7, bar with “?”: n < 7, pictures: Wikipedia.org (CC BY-SA 3.0)

Conservation status grayling



Dramatic decline of grayling populations:

- General reduction of mean stock
- Disappearing at several sampling sites
- Apparently less decline in heavily disturbed areas or closed canopy (cormorant?)

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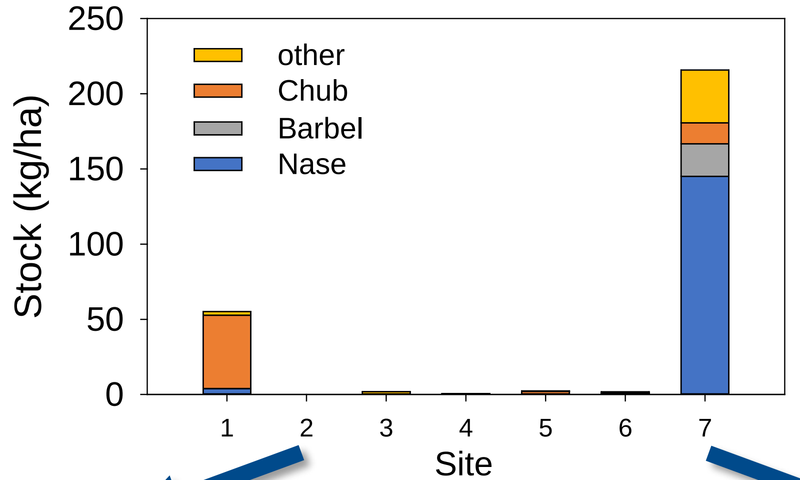
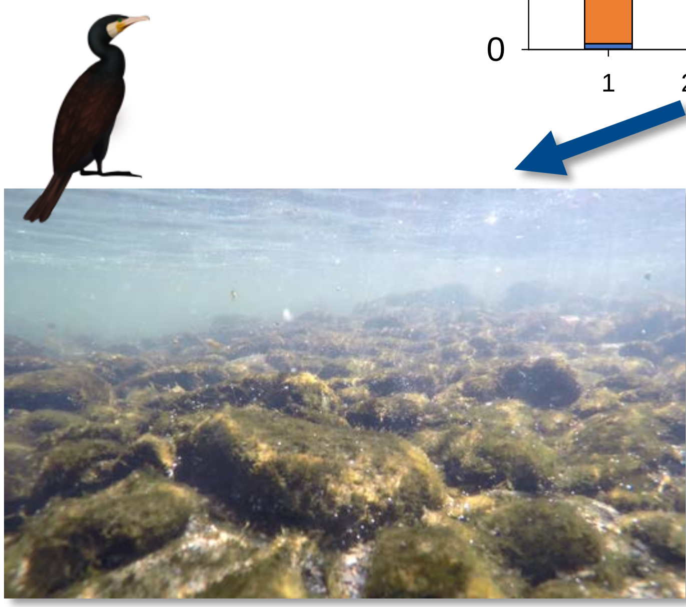
Ecosystem effects of nase





Increased eutrophication

Pictures:13.4.2019 River Nister (Germany) in Helmeroth (left: no cormorant hunting) und Stein-Wingert (right: cormorant hunting)

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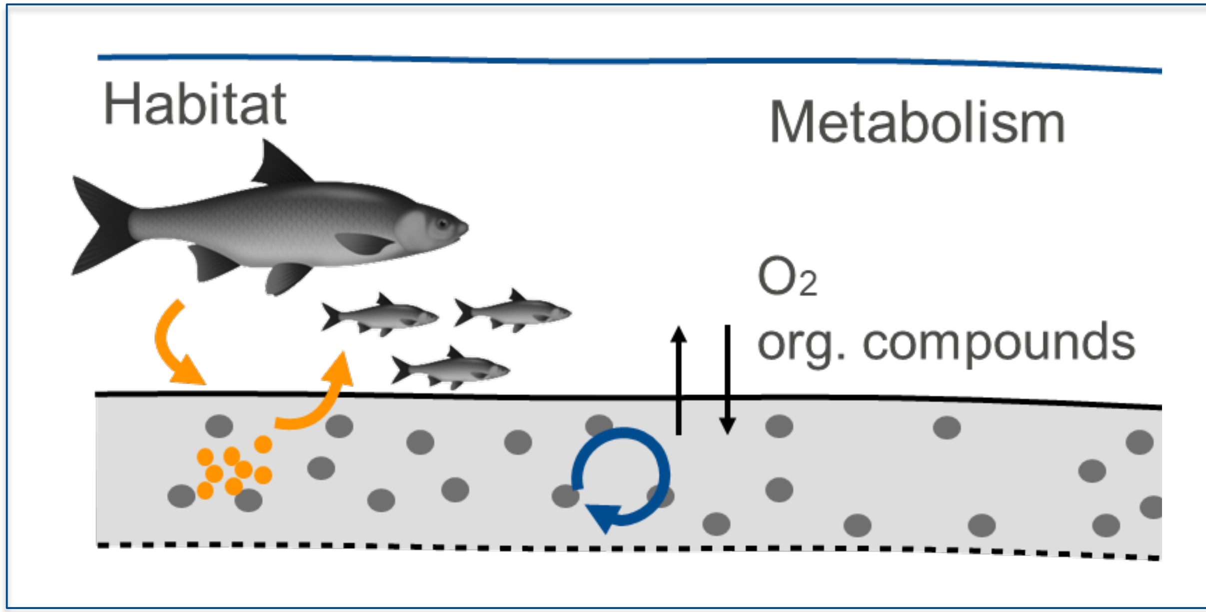
Eutrophication effects



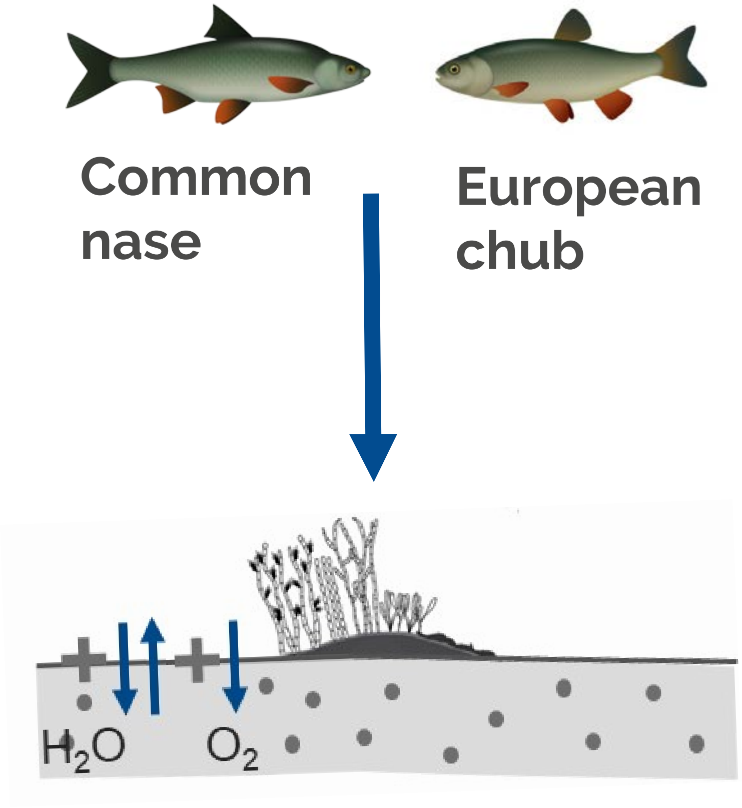
- Lack of oxygen
- Death of fish larvae or benthic invertebrates
- Reduction of stream biodiversity
- Reduction of ecosystem services

Eutrophication control

Can trophic interactions be used to control eutrophication effects in streams and rivers?

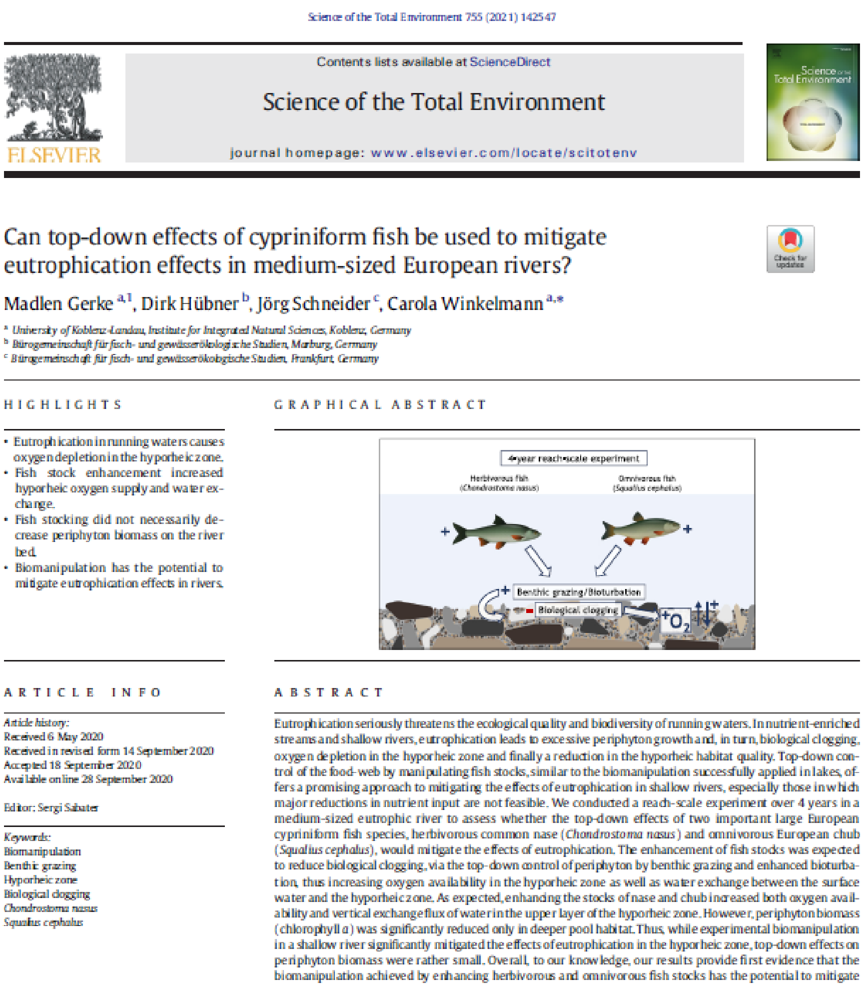
Stocking with herbivorous and omnivorous cyprinid fish

- reduces algae biomass,
- reduces biological clogging
- consequently increases oxygen concentrations



Gerke et al. (2021) Can top-down effects of cypriniform fish be used to mitigate eutrophication effects in medium-sized European rivers? Science of the total Environment 755: 142547

Eutrophication control



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Can top-down effects of cypriniform fish be used to mitigate eutrophication effects in medium-sized European rivers?

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HIGHLIGHTS

- Eutrophication in running waters causes oxygen depletion in the hyporheic zone.
- Fish stock enhancement increased hyporheic oxygen supply and water exchange.
- Fish stocking did not necessarily decrease periphyton biomass on the river bed.
- Biomanipulation has the potential to mitigate eutrophication effects in rivers.

GRAPHICAL ABSTRACT

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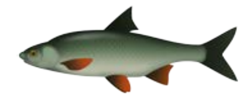
ABSTRACT

Eutrophication seriously threatens the ecological quality and biodiversity of running waters. In nutrient-enriched streams and shallow rivers, eutrophication leads to excessive periphyton growth and, in turn, biological clogging, oxygen depletion in the hyporheic zone and finally a reduction in the hyporheic habitat quality. Top-down control of the food-web by manipulating fish stocks, similar to the biomanipulation successfully applied in lakes, offers a promising approach to mitigating the effects of eutrophication in shallow rivers, especially those in which major reductions in nutrient input are not feasible. We conducted a reach-scale experiment over 4 years in a medium-sized eutrophic river to assess whether the top-down effects of two important large European cypriniform fish species, herbivorous common nase (*Chondrostoma nasus*) and omnivorous European chub (*Squalius cephalus*), would mitigate the effects of eutrophication. The enhancement of fish stocks was expected to reduce biological clogging, via the top-down control of periphyton by benthic grazing and enhanced bioturbation, thus increasing oxygen availability in the hyporheic zone as well as water exchange between the surface water and the hyporheic zone. As expected, enhancing the stocks of nase and chub increased both oxygen availability and vertical exchange flux of water in the upper layer of the hyporheic zone. However, periphyton biomass (chlorophyll *a*) was significantly reduced only in deeper pool habitat. Thus, while experimental biomanipulation in a shallow river significantly mitigated the effects of eutrophication in the hyporheic zone, top-down effects on periphyton biomass were rather small. Overall, to our knowledge, our results provide first evidence that the biomanipulation achieved by enhancing herbivorous and omnivorous fish stocks has the potential to mitigate



Oxygen hyporheic zone

Water exchange with hyporheic zone

Algae biomass

Healthy fish stocks (nase, chub) can increase habitat quality of hyporheic zone.

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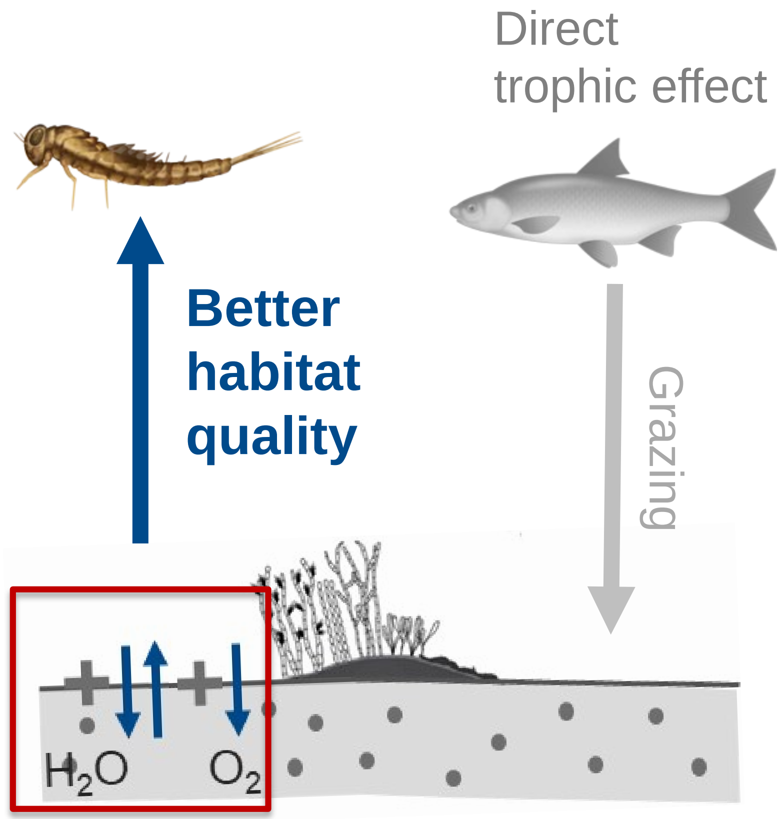
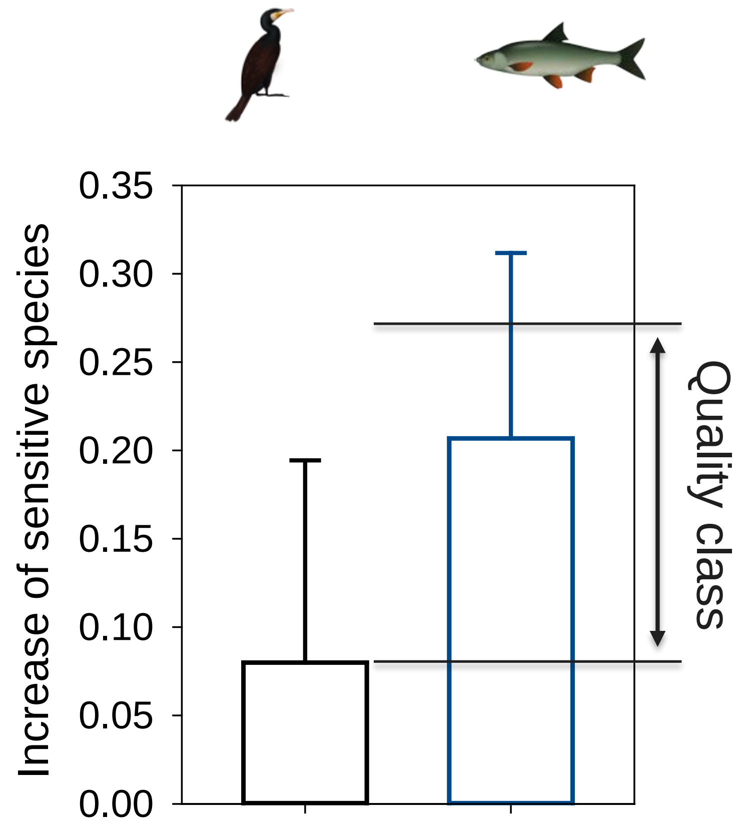
Ecological quality





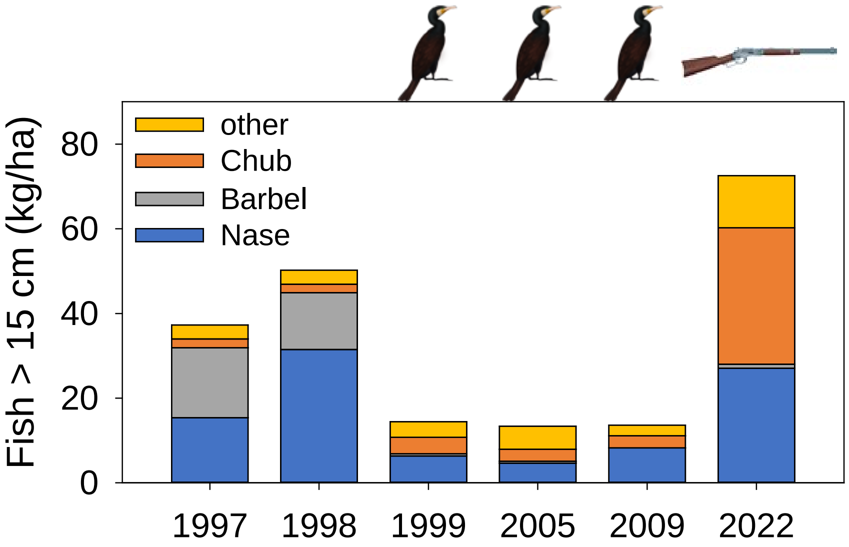
Increase in sensitive species
WFD relevant

Healthy fish stocks (nase, chub) can increase ecological quality of rivers.

Sensitive Species: relative abundance EPT (%) in pools, depicted as score of WFD-assessment,
$p= 0.044$, t-test, $n=6$

Cormorant predation

Cormorant predation affects stock of large cyprinids (River Nister)



Cormorant predation in **one** large fish wintering habitat uses fish production of 20-30% of the whole cyprinid region of the river!

Cormorant predation during winter 2021/22: 180-275 kg → Mean fish stock: 80 kg/ha → 5-8 km stretch when using 30% of fish stock (representing sustainable withdrawal)

Cormorant & eutrophication

- **Healthy fish stock (nase, chub) can increase habitat quality of hyporheic zone and increase ecological quality of rivers.**
- **Cormorant and other piscivorous birds can prevent the development of healthy fish stocks.**
- **Thereby they can impair ecological river quality and indirectly reduce aquatic biodiversity.**

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Take home message

- Astonishingly weak data base for assessment of grayling development due to cormorant predation: **monitoring needed.**
- Healthy fish stocks are important for ecological quality of rivers.
- Cormorant predation can therefor impair not only fish biodiversity directly but also ecological status of rivers.