Reintroduction and the importance of mussel-host fish interactions








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Freshwater – highly disturbed

- Habitat destruction
- Habitat degradation
- Habitat fragmentation
- Invasive species
- Global climate change

1. Rehabilitated rivers





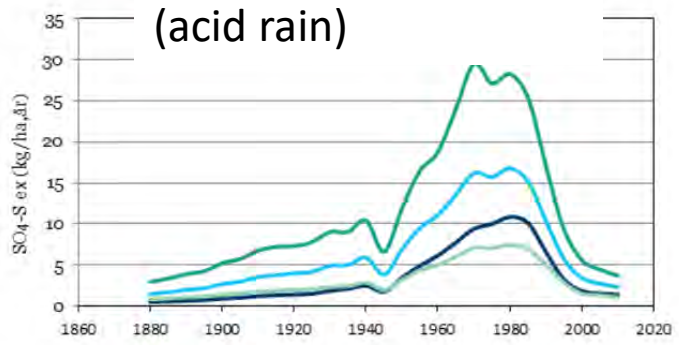



Habitat degradation





Acidfication
(acid rain)

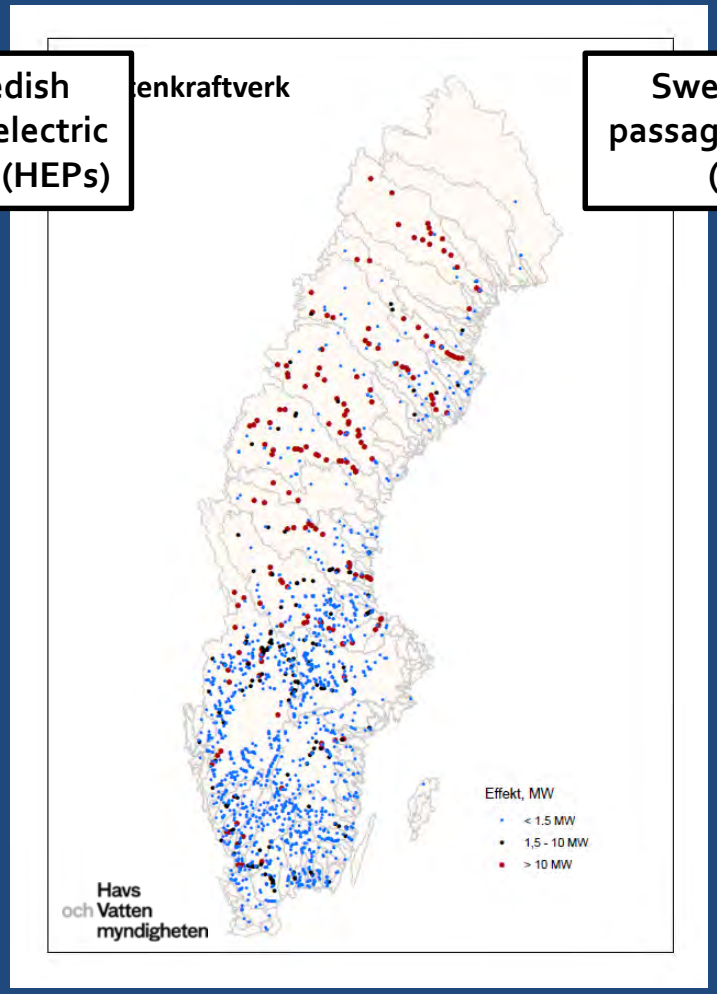


Svavelnedfallet har minskat kraftigt under de senaste 20 åren, framför allt i södra Sverige. Data kommer från EMEP.



Fish passage solutions

Swedish hydroelectric plants (HEPs)



Swedish fish passage solutions (FPS)







Dam removal



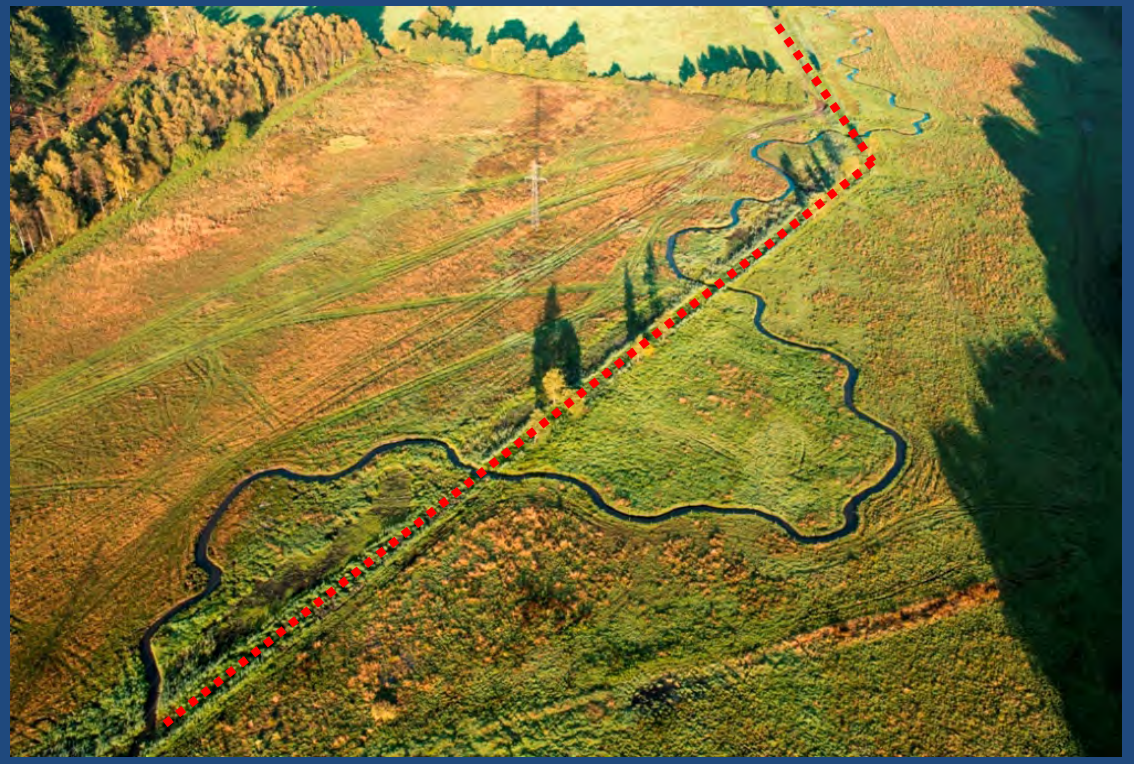






Re-meandering





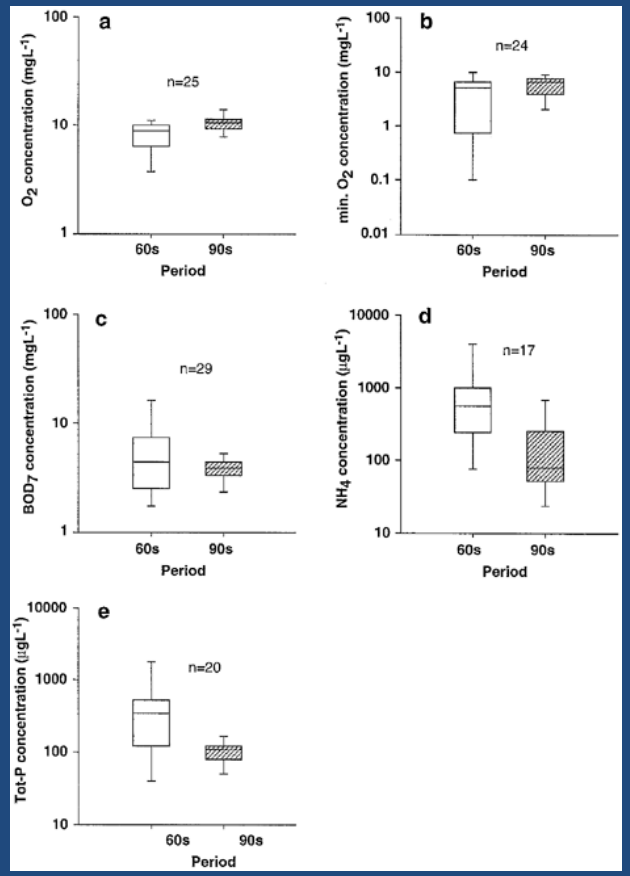
Habitat restoration

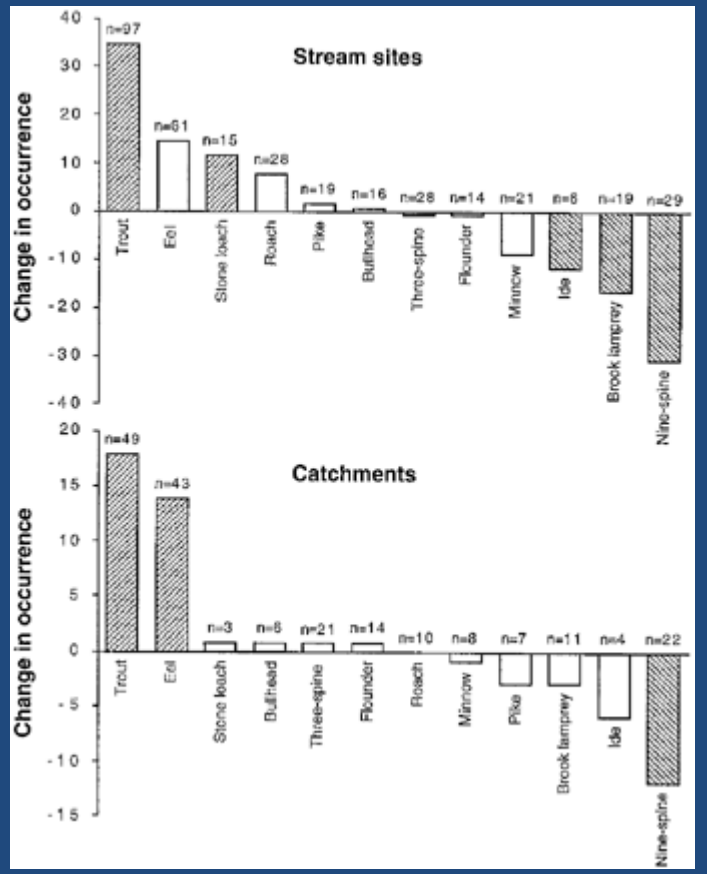




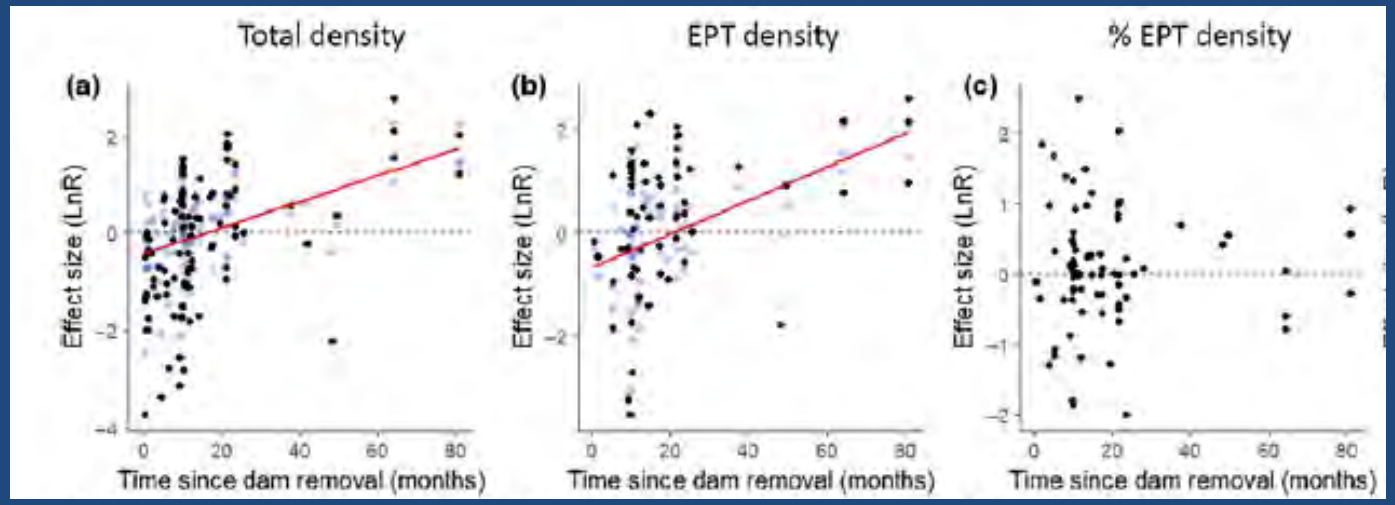
Improved water quality and fish







Dam removal


Total density
EPT density
% EPT density
(a)
(b)
(c)
Effect size (LnR)
Time since dam removal (months)
0
20
40
60
80
2
0
−2
−4
1
−1

2. Unionoid mussels








Threatened Unionoids

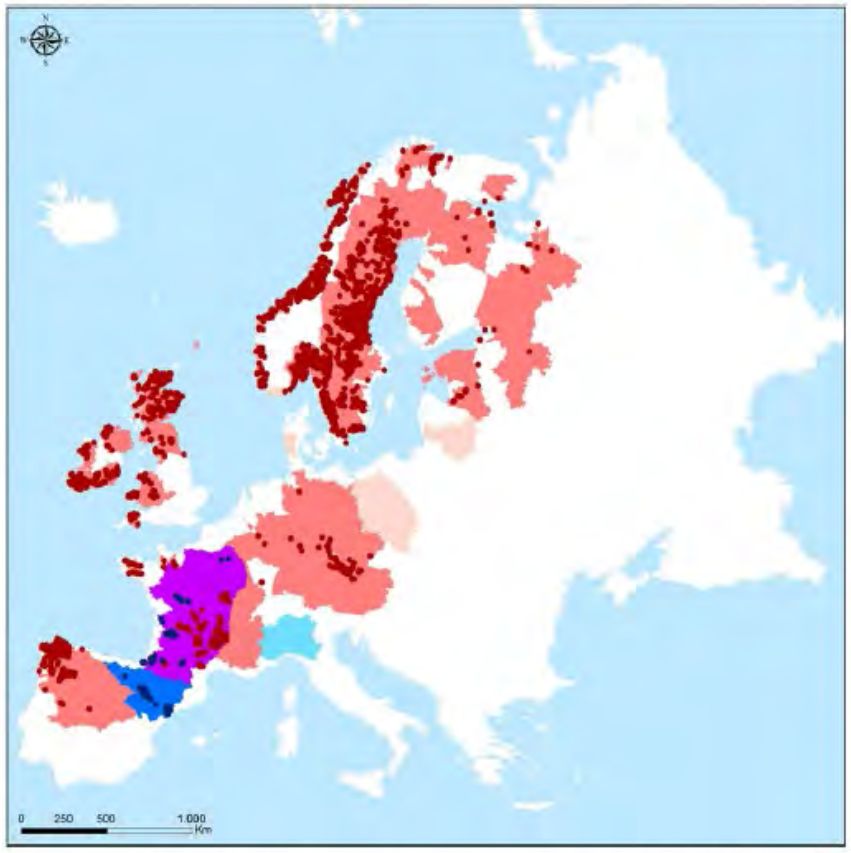


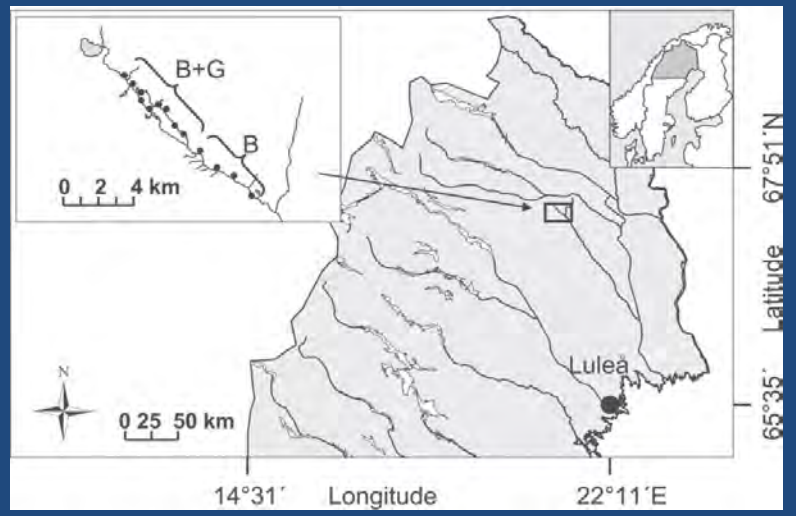
Fig. 3. Distribution of Margaritiferidae in Europe. Light shades correspond to historical distribution in hydrographical basins (prior to 1992), dark shades correspond to present distribution in hydrographical basins (after 1992) and dots represent present known populations (after 1992). Known distribution of *Margaritifera auricularia* (blue), *M. margaritifera* (red), and both (purple). Distribution data are based on recent surveys performed by the authors of this review and published distributions (see online Appendix S2).

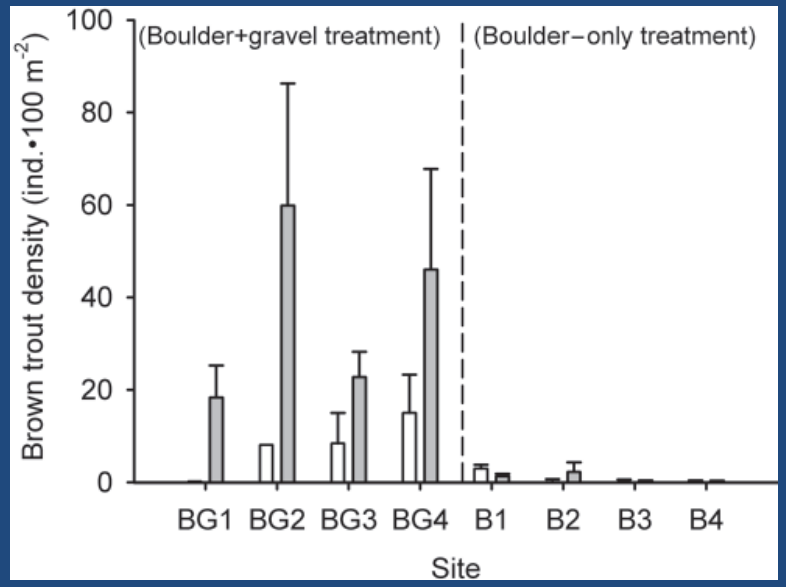
Lopes Lima et al (2016)

Habitat restoration and trout







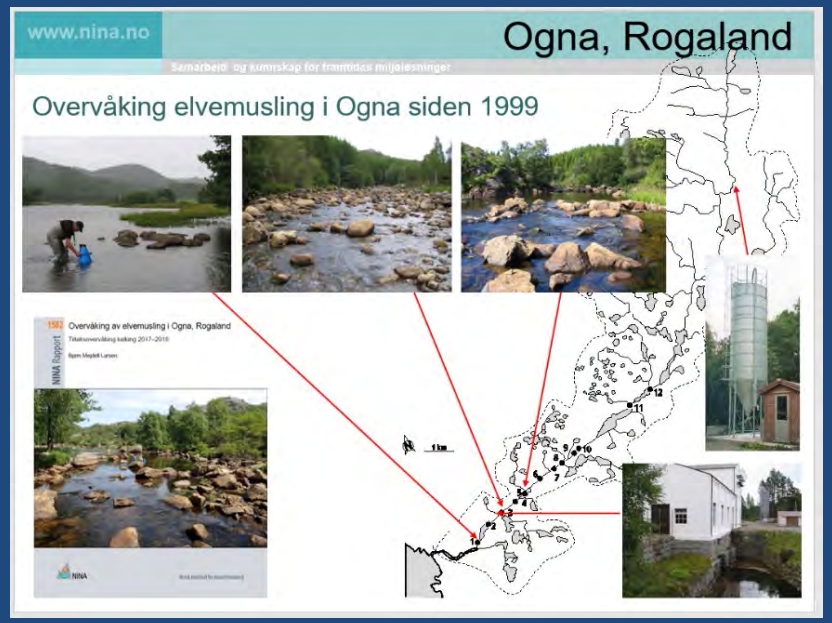


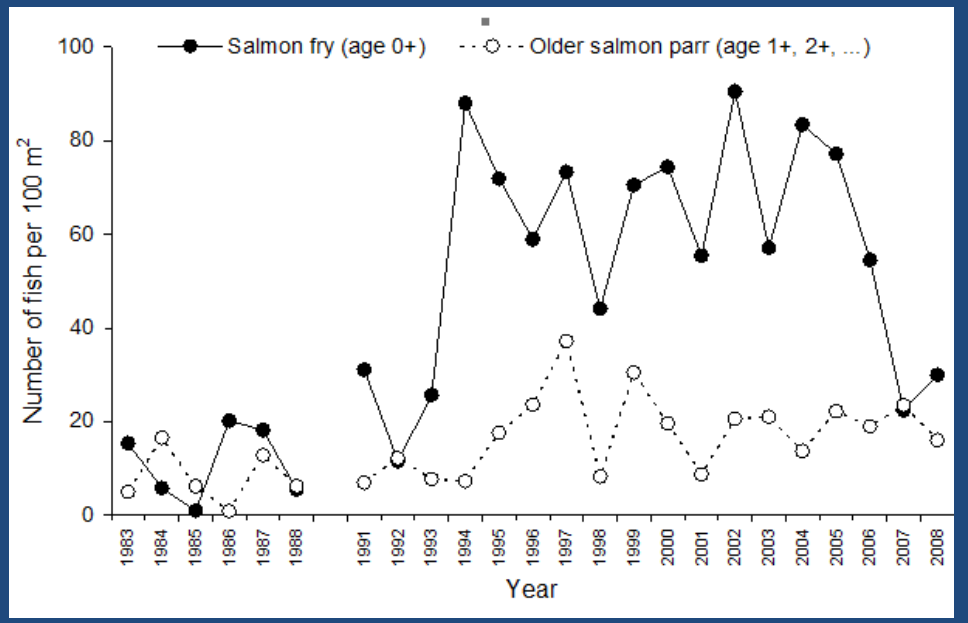
Palm et al. Can J Fish Aquat Sci (2007)

Fish passage – Sea trout / Atlantic salmon



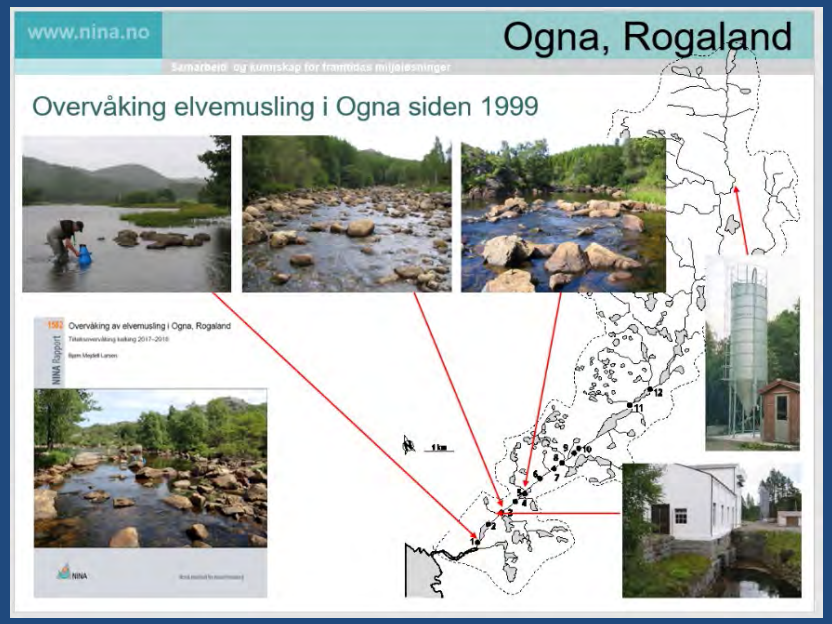
Acidification and Atlantic salmon

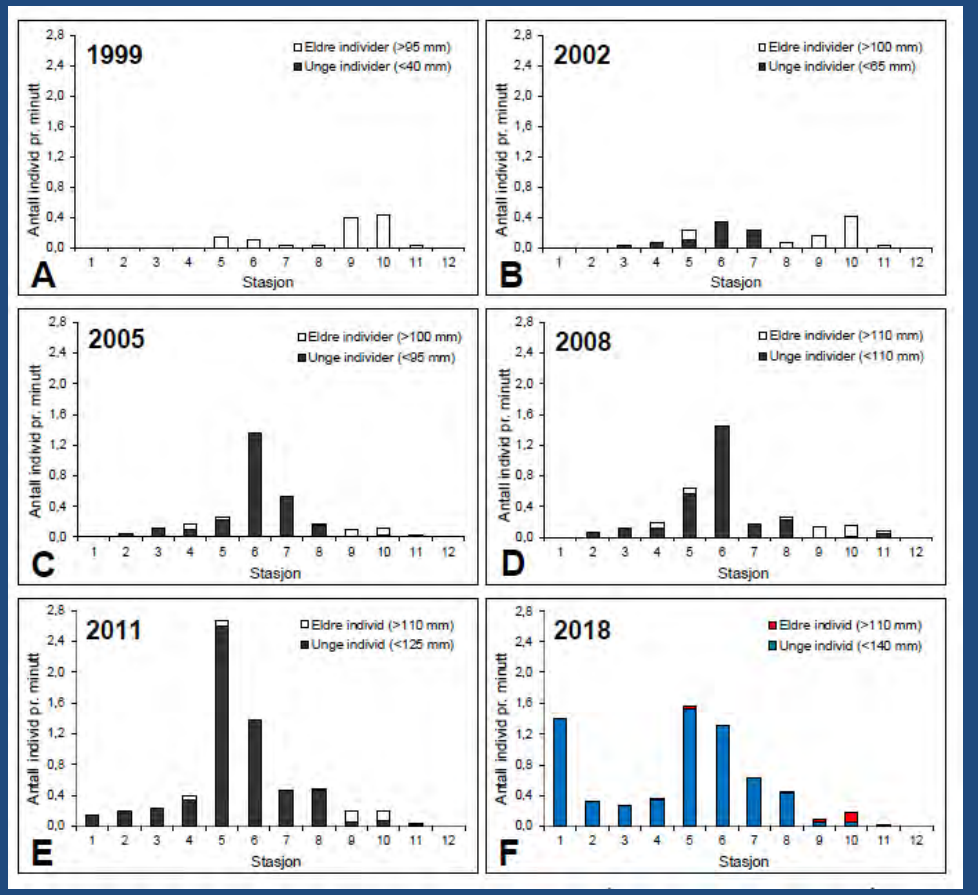




Larsen (2018)

Acidification and mussel recruitment

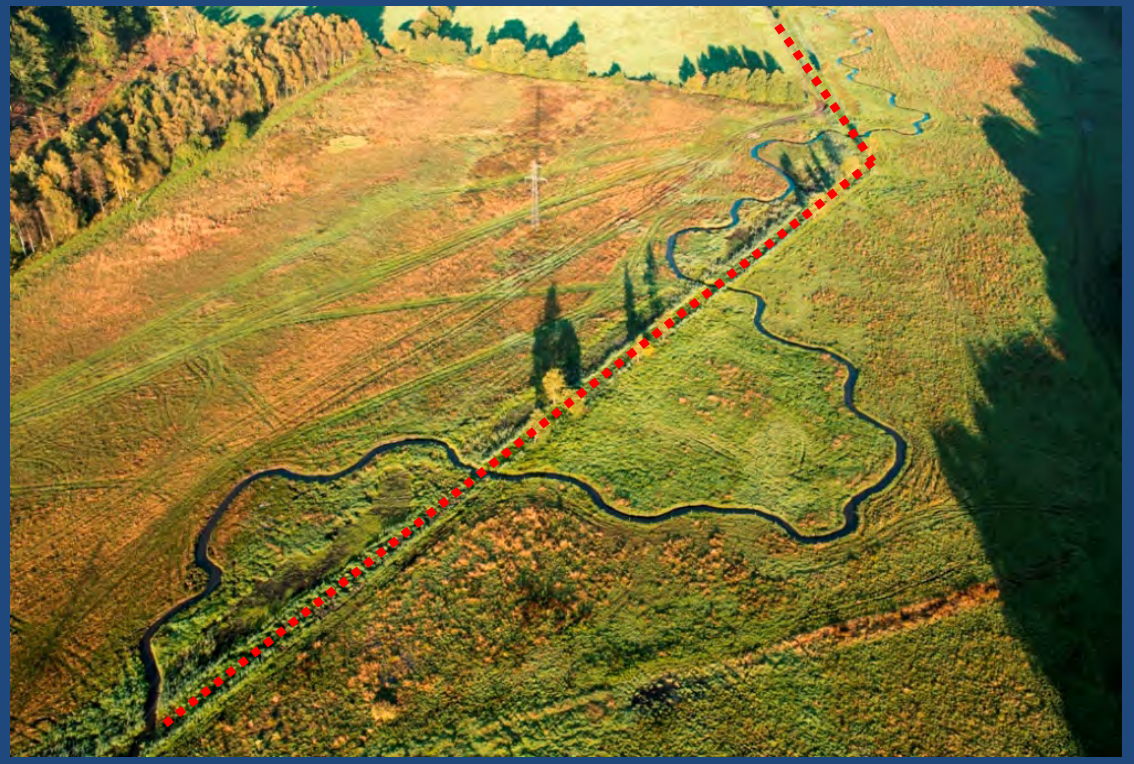




Larsen (2018)

Re-meandering, mussels and fish





Riparian forest and mussel recruitment



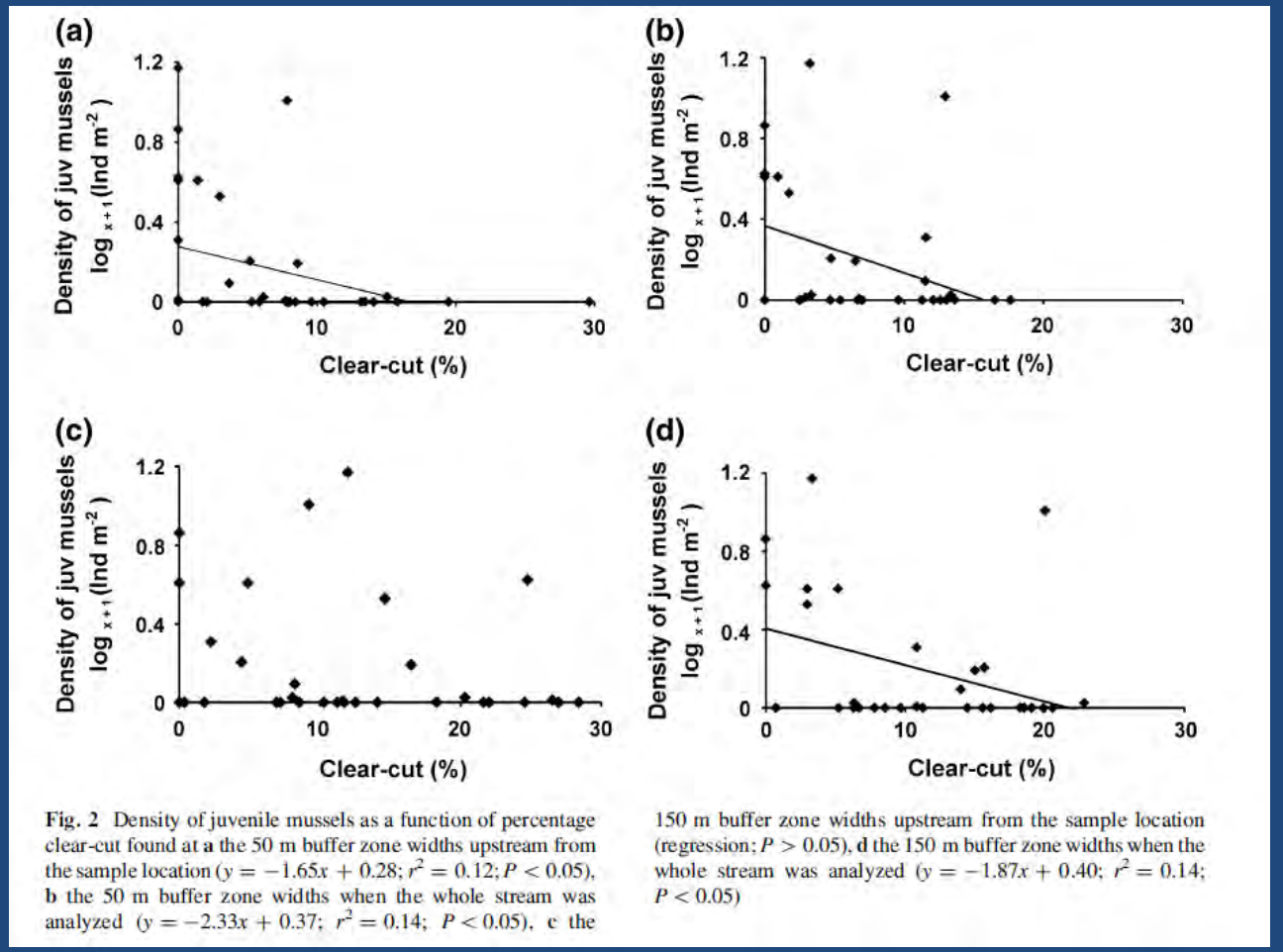


Fig. 2 Density of juvenile mussels as a function of percentage clear-cut found at **a** the 50 m buffer zone widths upstream from the sample location ($y = -1.65x + 0.28$; $r^2 = 0.12$; $P < 0.05$), **b** the 50 m buffer zone widths when the whole stream was analyzed ($y = -2.33x + 0.37$; $r^2 = 0.14$; $P < 0.05$), **c** the 150 m buffer zone widths upstream from the sample location (regression; $P > 0.05$), **d** the 150 m buffer zone widths when the whole stream was analyzed ($y = -1.87x + 0.40$; $r^2 = 0.14$; $P < 0.05$)

Rehabilitation – knowledge



Adult mussels
(reproduction in most cases)



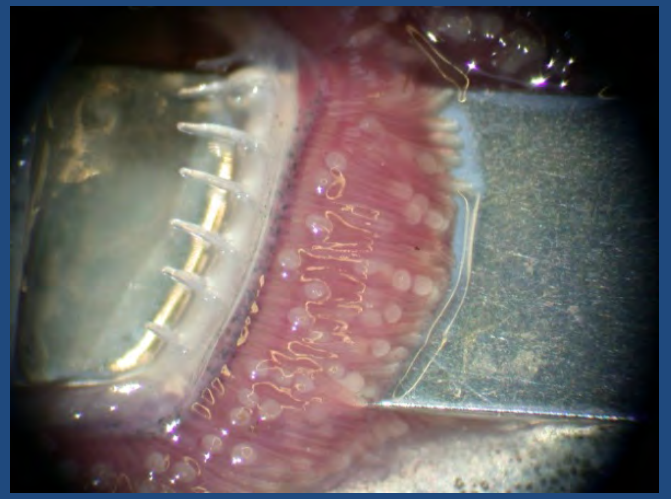
Host fish
(relatively tolerant)

+



Juvenile mussels

(sensitive, high knowledge of environmeltal requirements)



Mussel / host fish interactions?

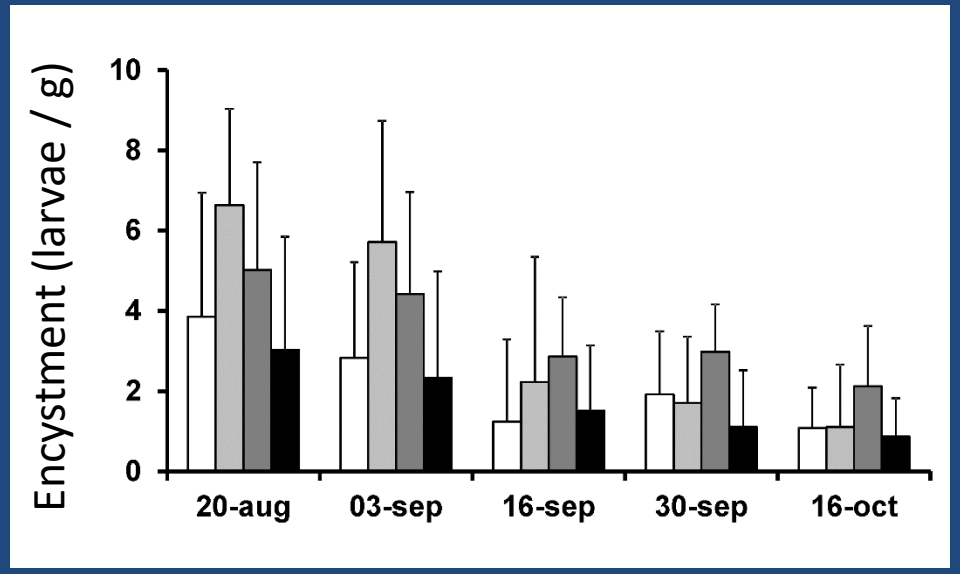
3. ”Suitability”

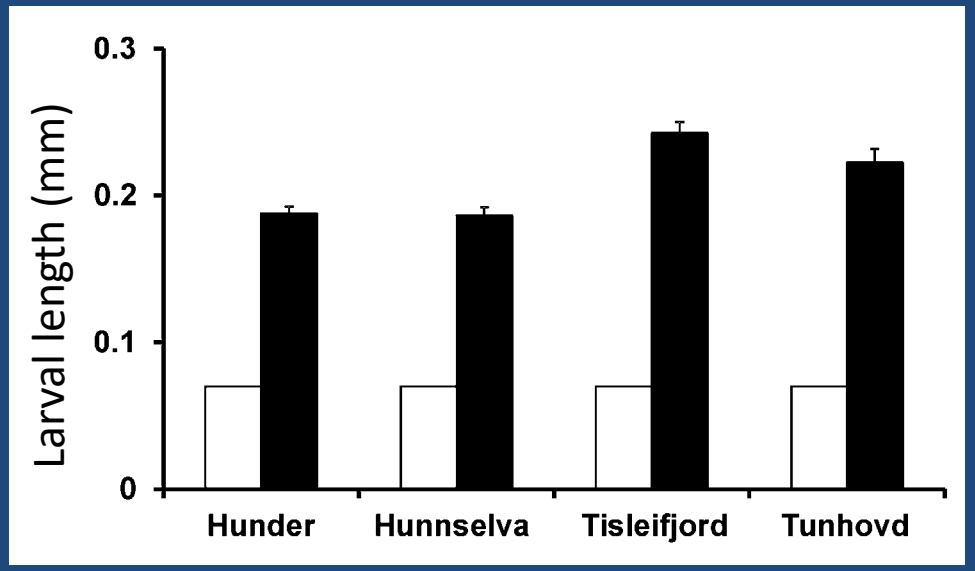






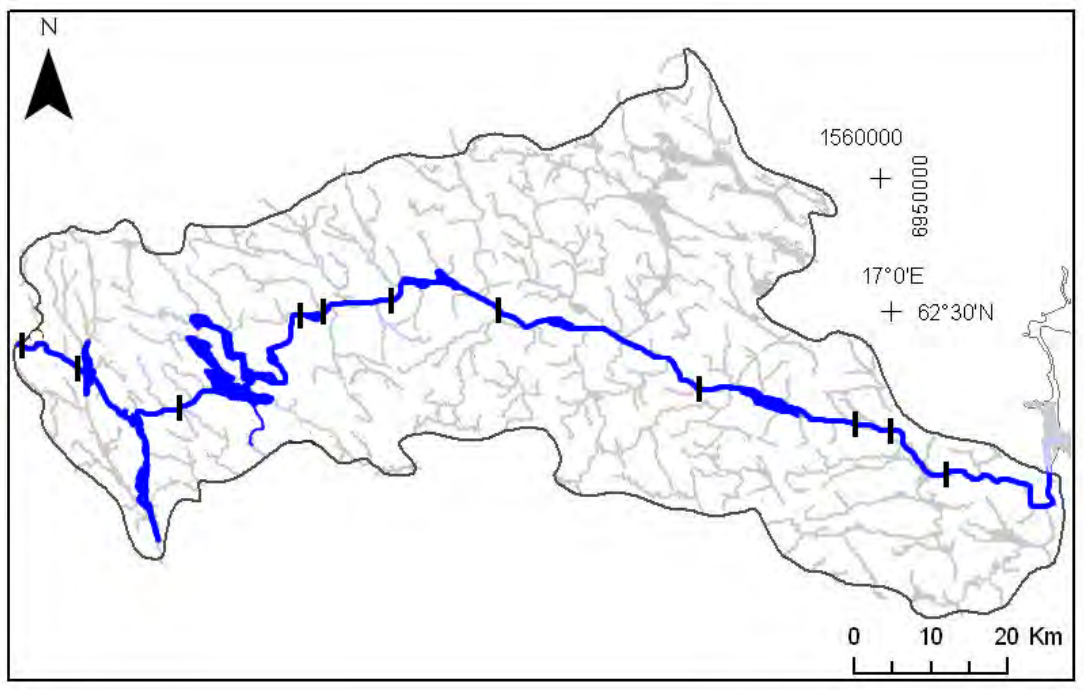

”Suitability”





Österling & Larsen (2013)
and see Taeubert et.al. (2010)

Suitability – wild and introduced strains



Suitability – fish age (Bratteforsån River)

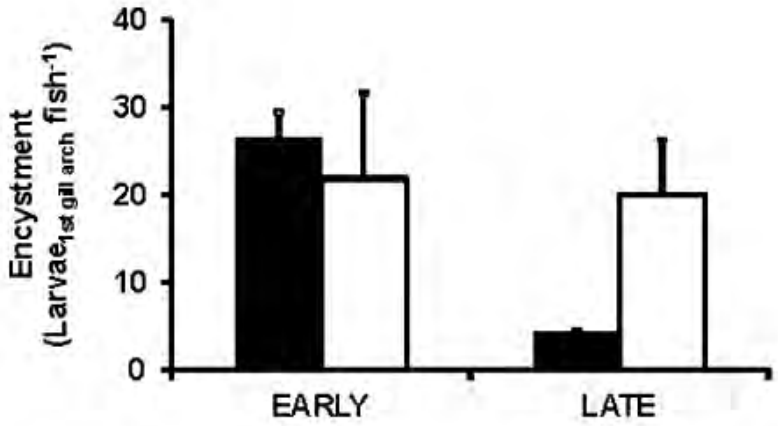


Fig. 2. Encystment abundance (Nrs larvae$_{1st\ gill\ arch}$ fish^{-1} ± 1SE) on the first (outer) gill arch on the left and the right side on one-year old trout (black bars) and YOY trout (white bars) from Brattefors River.

Suitability – age of fish (Lärjeån river)

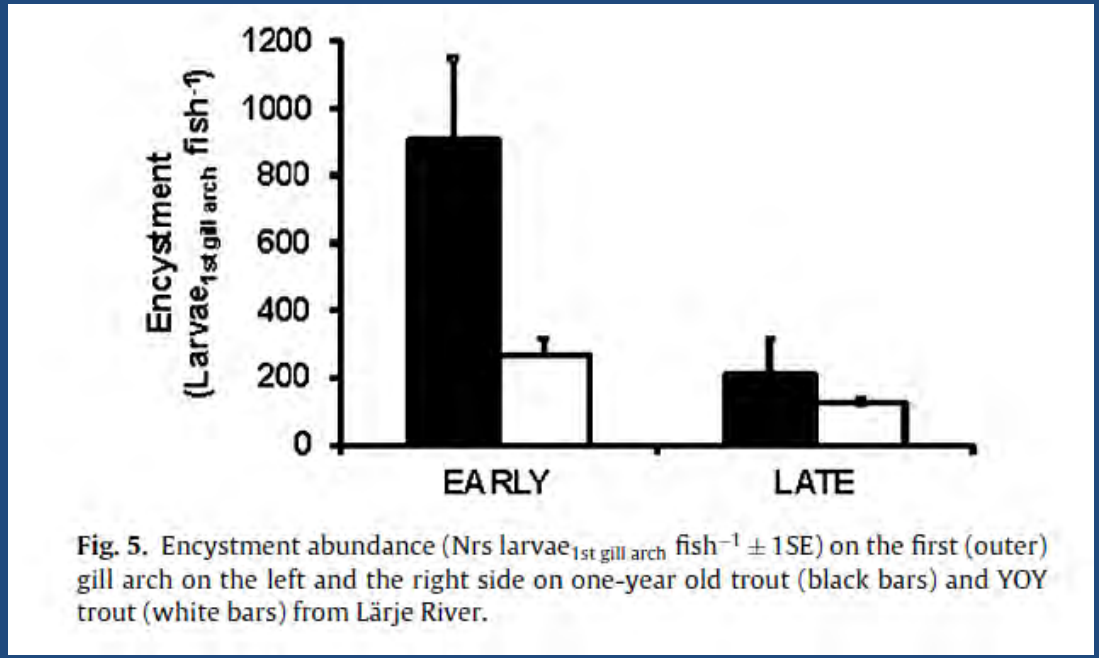
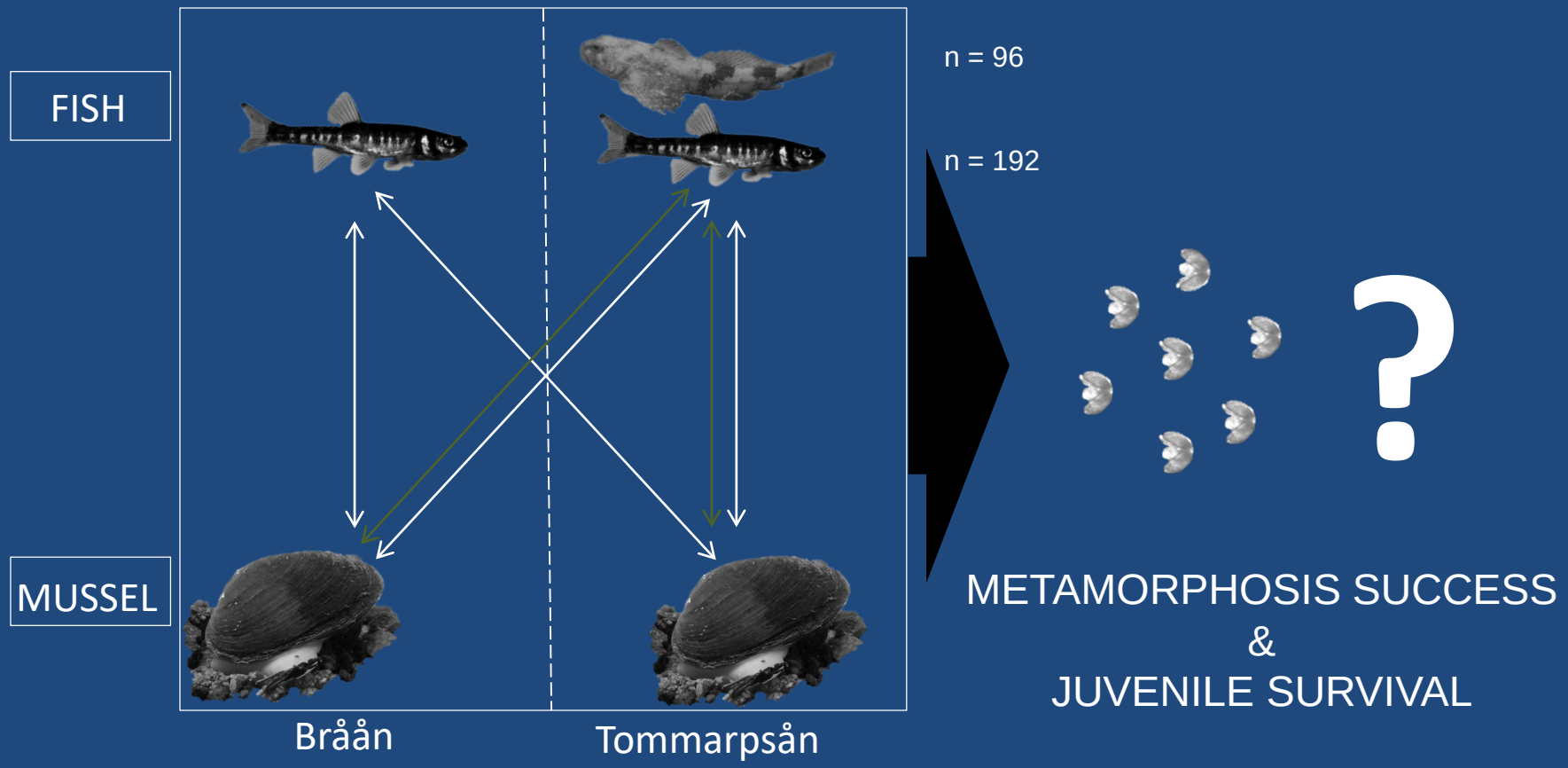


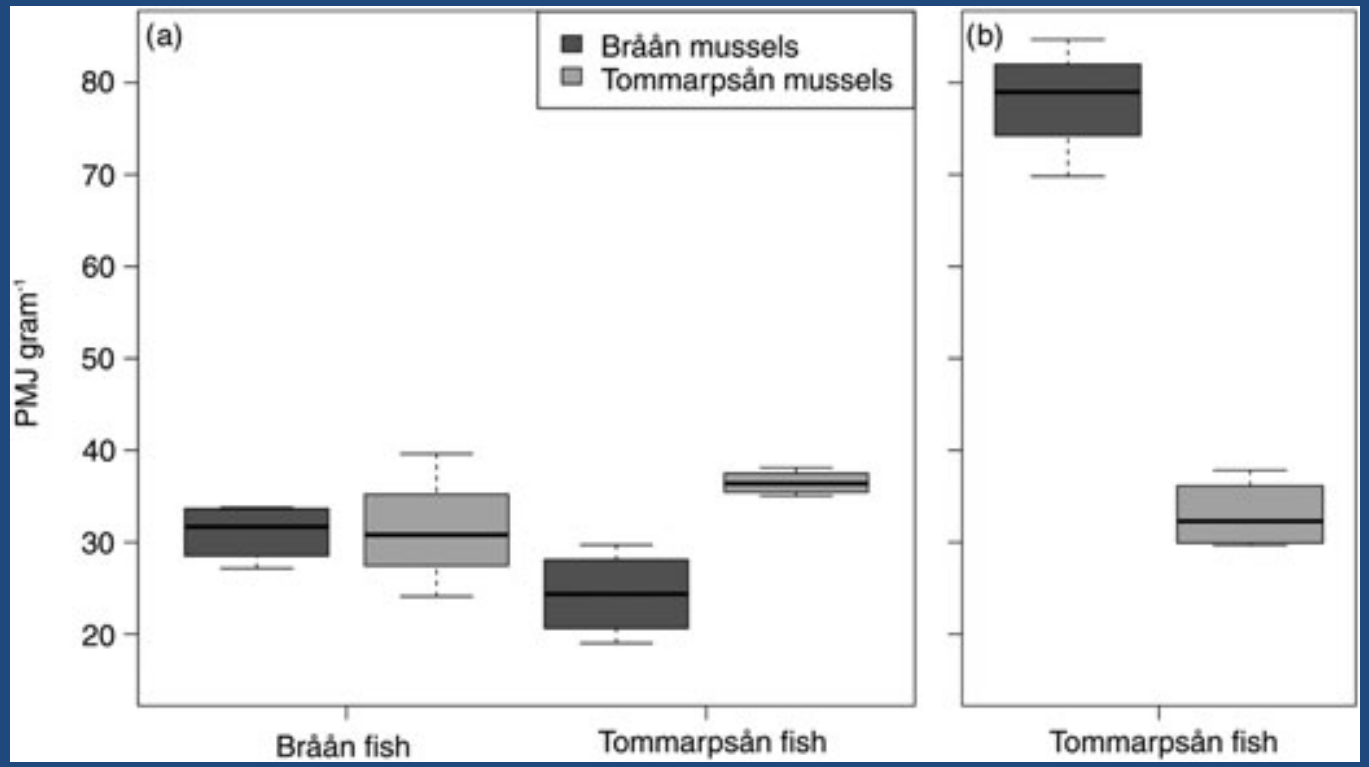
Fig. 5. Encystment abundance (Nrs $larvae_{1st\ gill\ arch}$ $fish^{-1} \pm 1SE$) on the first (outer) gill arch on the left and the right side on one-year old trout (black bars) and YOY trout (white bars) from Lärje River.

Local adaptation



Schneider et al (2016).

Local adaptation



Schneider et al (2016).

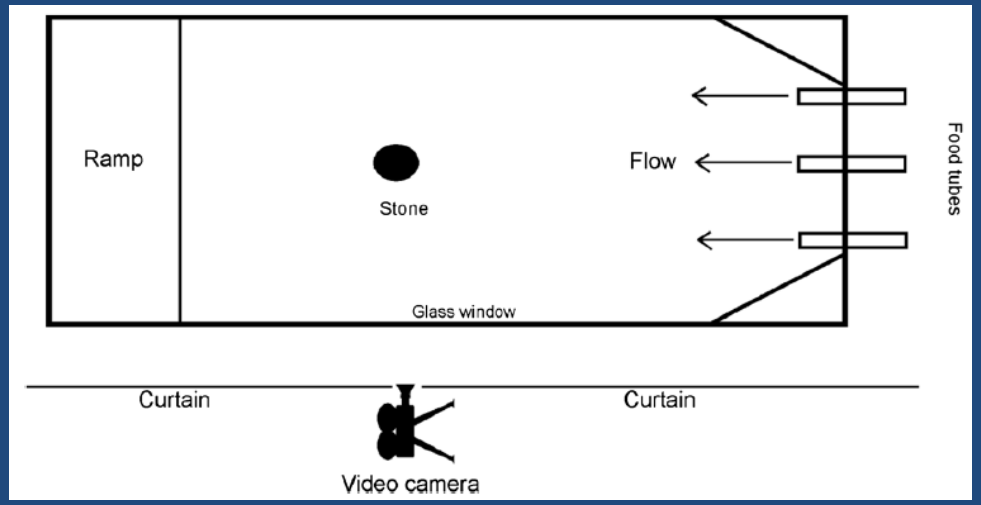
4. Effects on trout

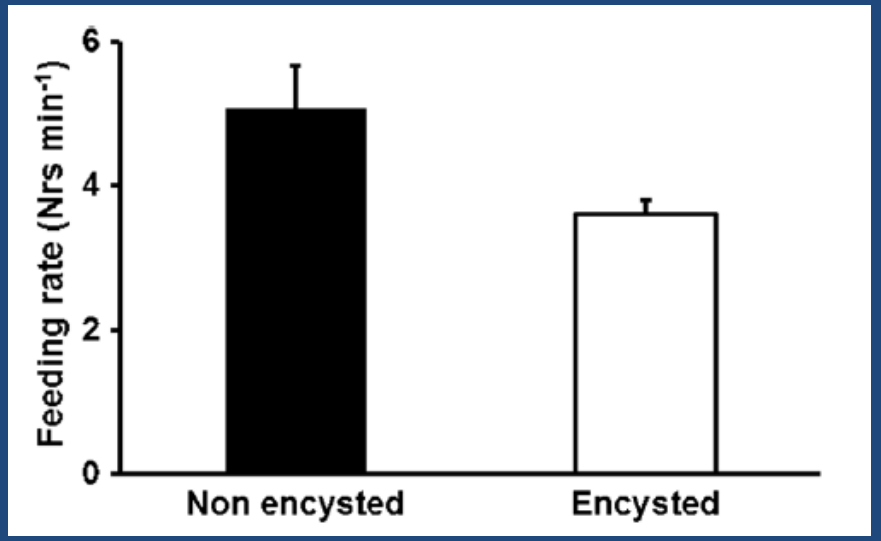


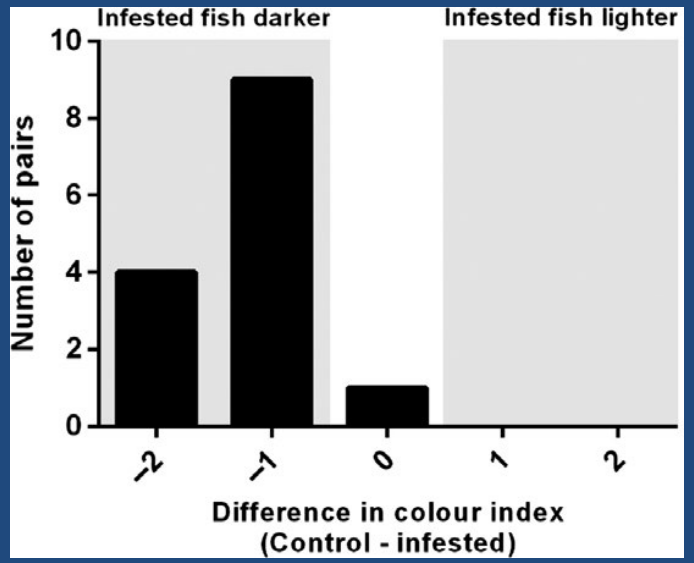


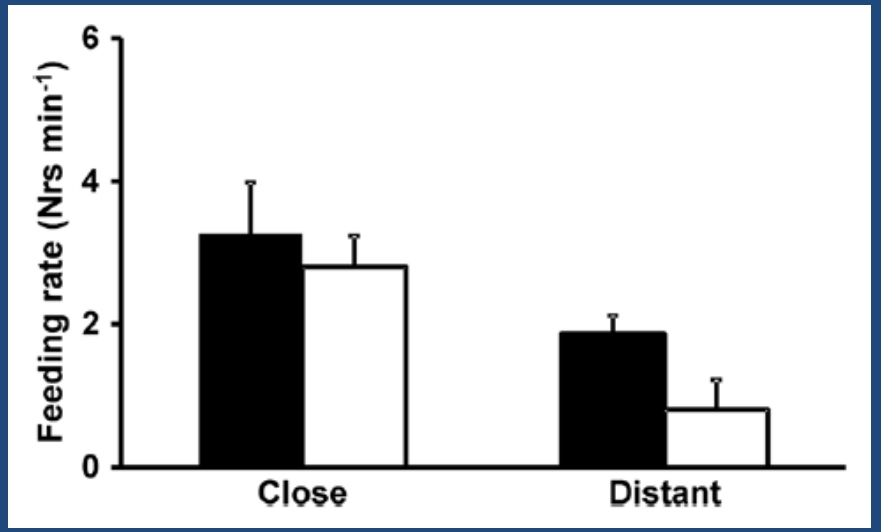



Effects on trout









Österling et al (2014)

Filipsson et al (2016)

See also Taeubert & Geist (2013)

5. Importance of density








Adult mussels



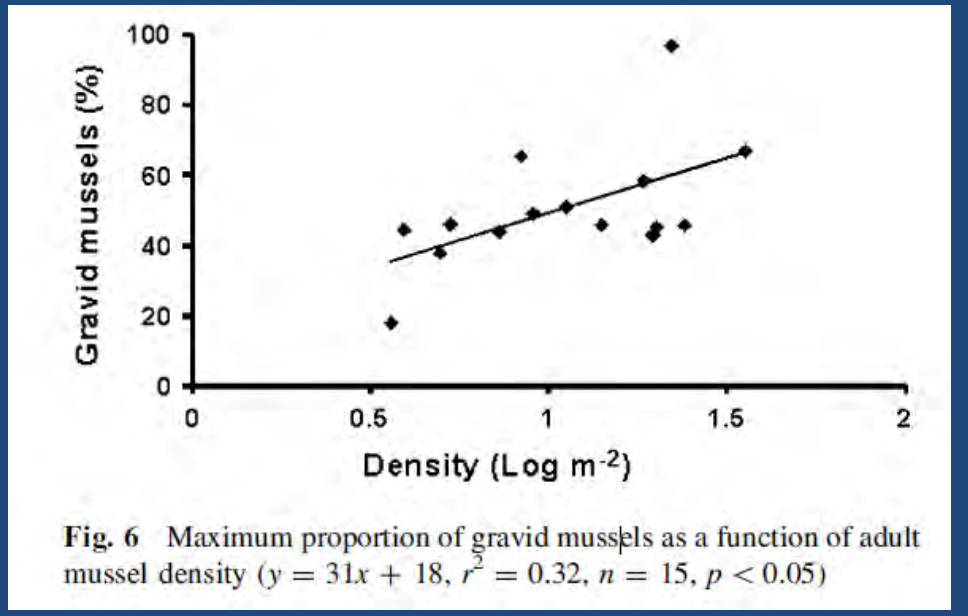
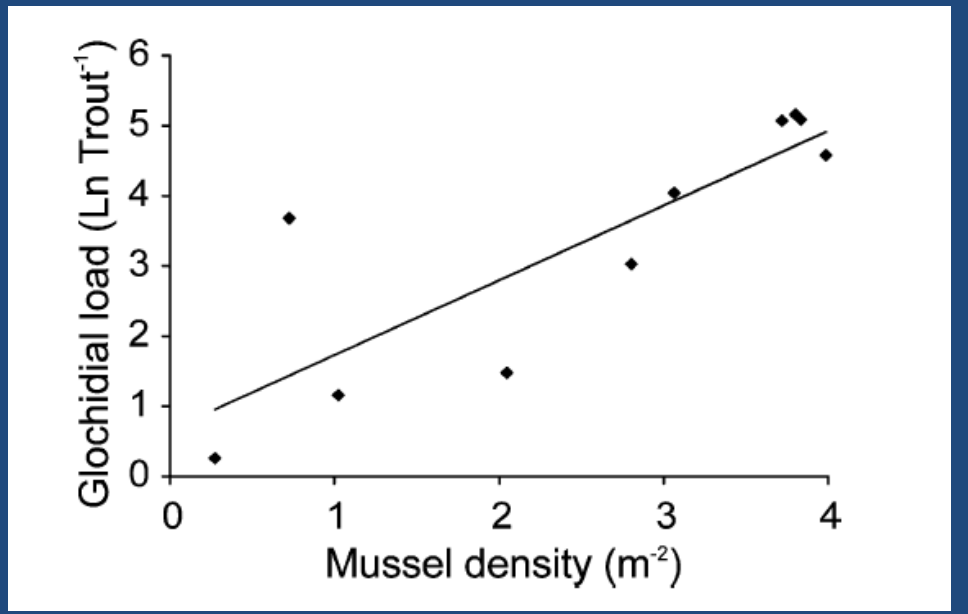


Fig. 6 Maximum proportion of gravid mussels as a function of adult mussel density ($y = 31x + 18$, $r^2 = 0.32$, $n = 15$, $p < 0.05$)



Österling et al (2008); Arvidsson, Karlsson & Österling (2012); Österling (2015)

Trout



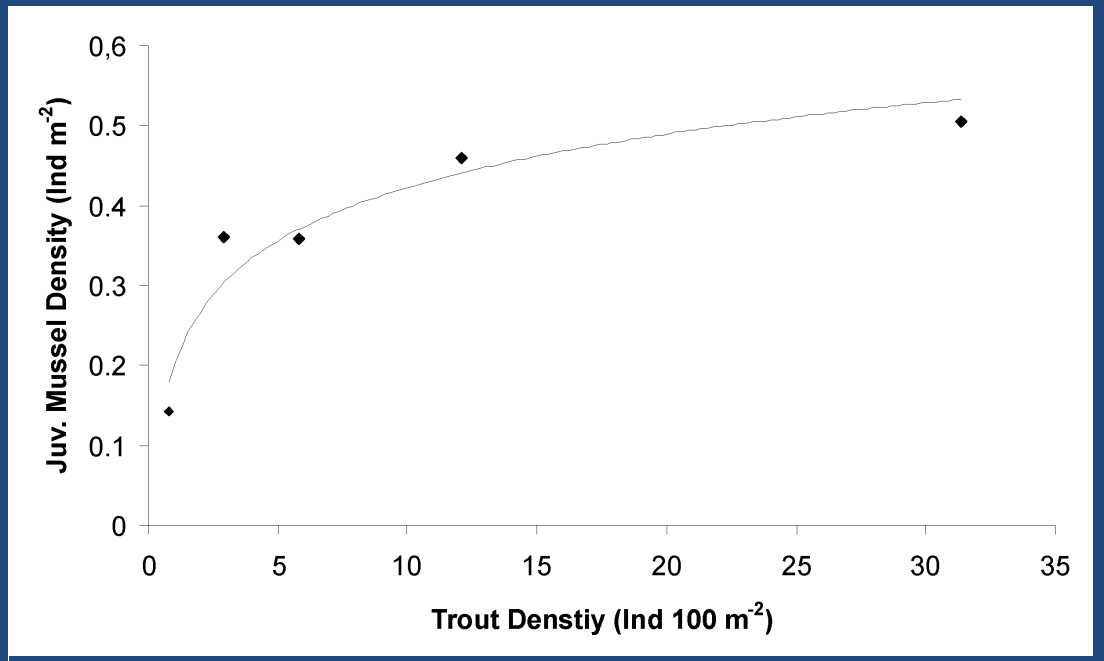
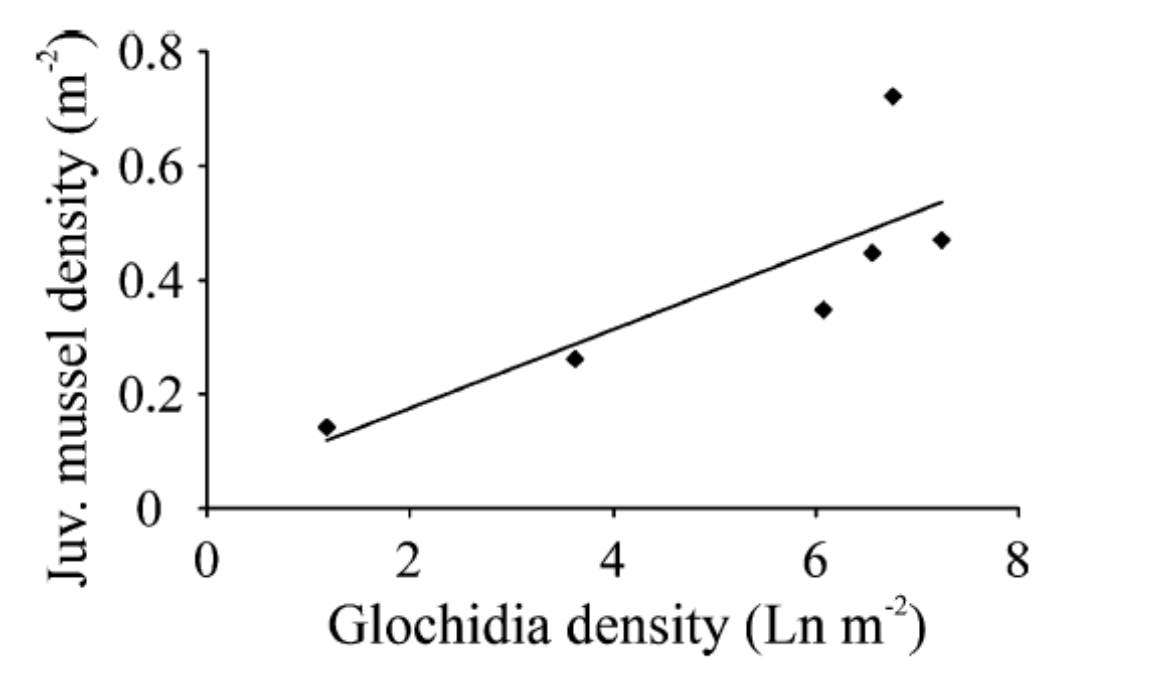


Fig. YOY trout

Arvidsson, Karlsson & Österling (2012)

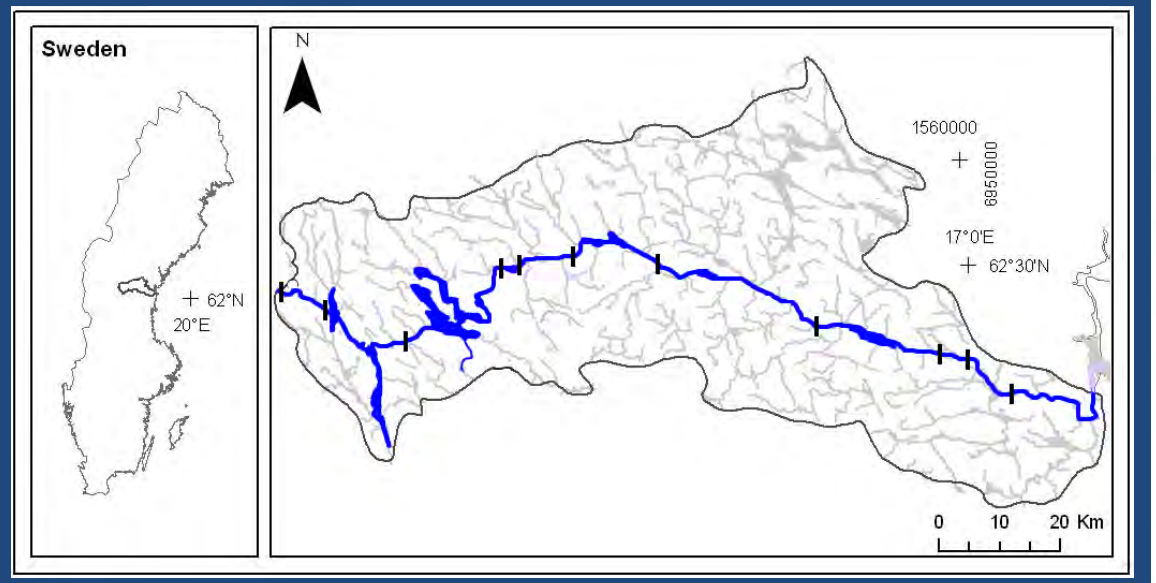
Recruitment potential (”Glochidia density”) - autumn



Österling et al (2008)

Recruitment potential and fragmentation





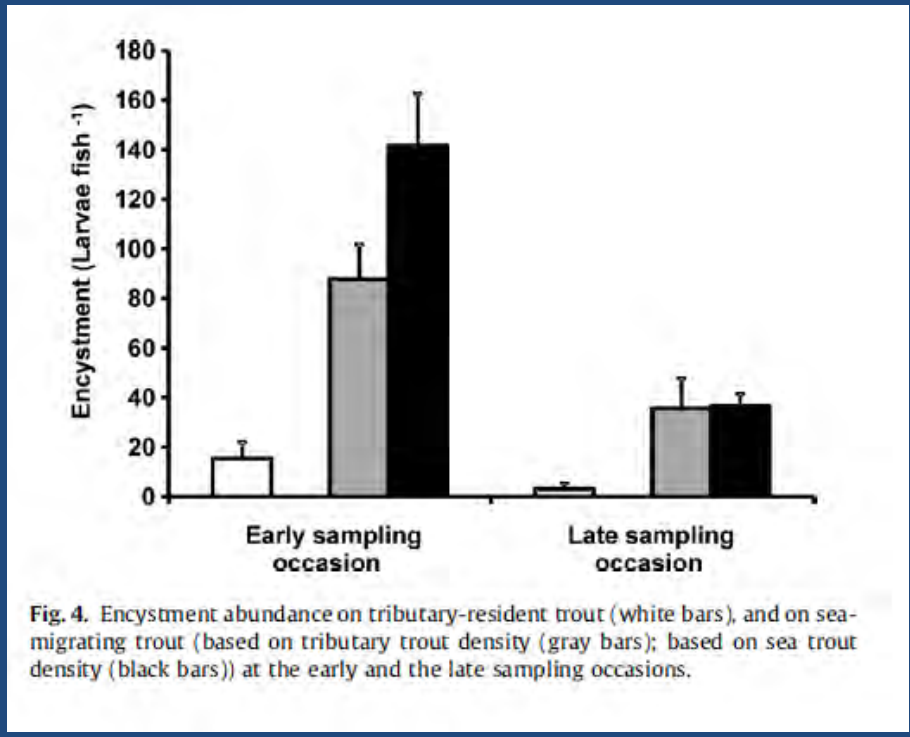


Fig. 4. Encystment abundance on tributary-resident trout (white bars), and on sea-migrating trout (based on tributary trout density (gray bars); based on sea trout density (black bars)) at the early and the late sampling occasions.

Österling & Söderberg, (2015)

Movement



6. Reintroduction





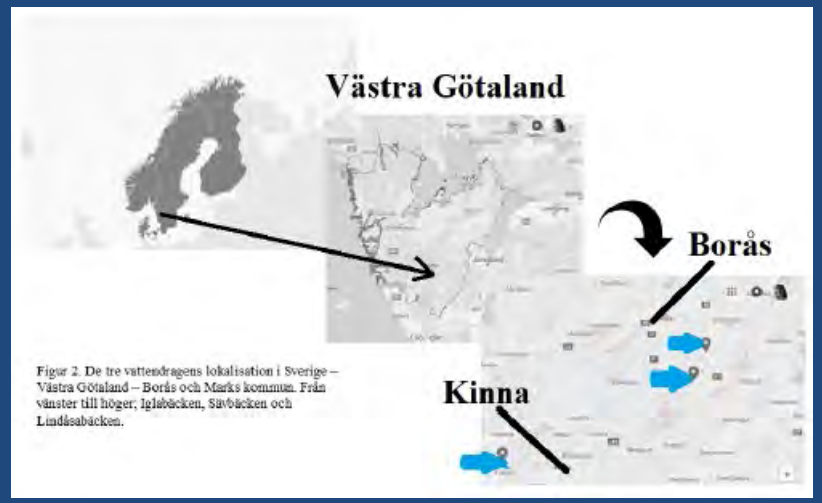



Reintroduction FPM (Sweden)



- Action program – FPM 2019!
  - ”Develop methodologies for artificial propagation”
  - ”Develop national re-introduction strategy”

Reintroduction / infested fish



Figur 2. De tre vattendragens lokalisation i Sverige – Västra Götaland – Borås och Marks kommun. Från vänster till höger; Igelsbäcken, Sävbäcken och Lindåsabäcken.





Reintroduction / survival of juveniles

7. Non-destructive methods





Electro







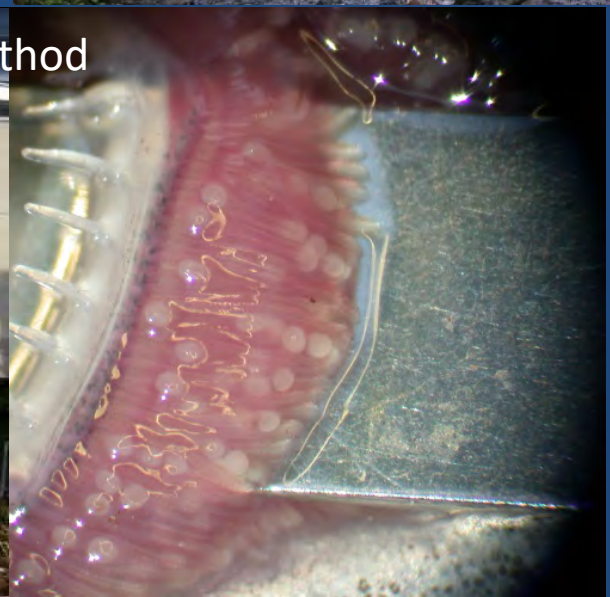
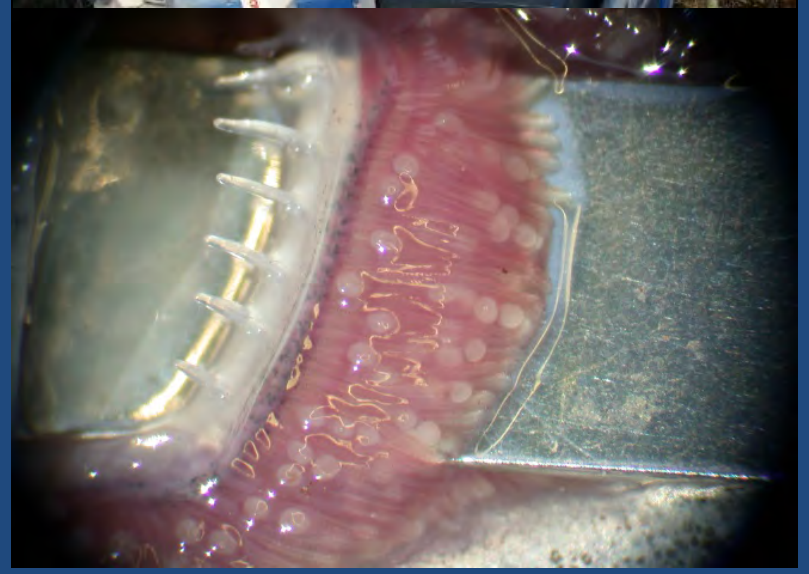
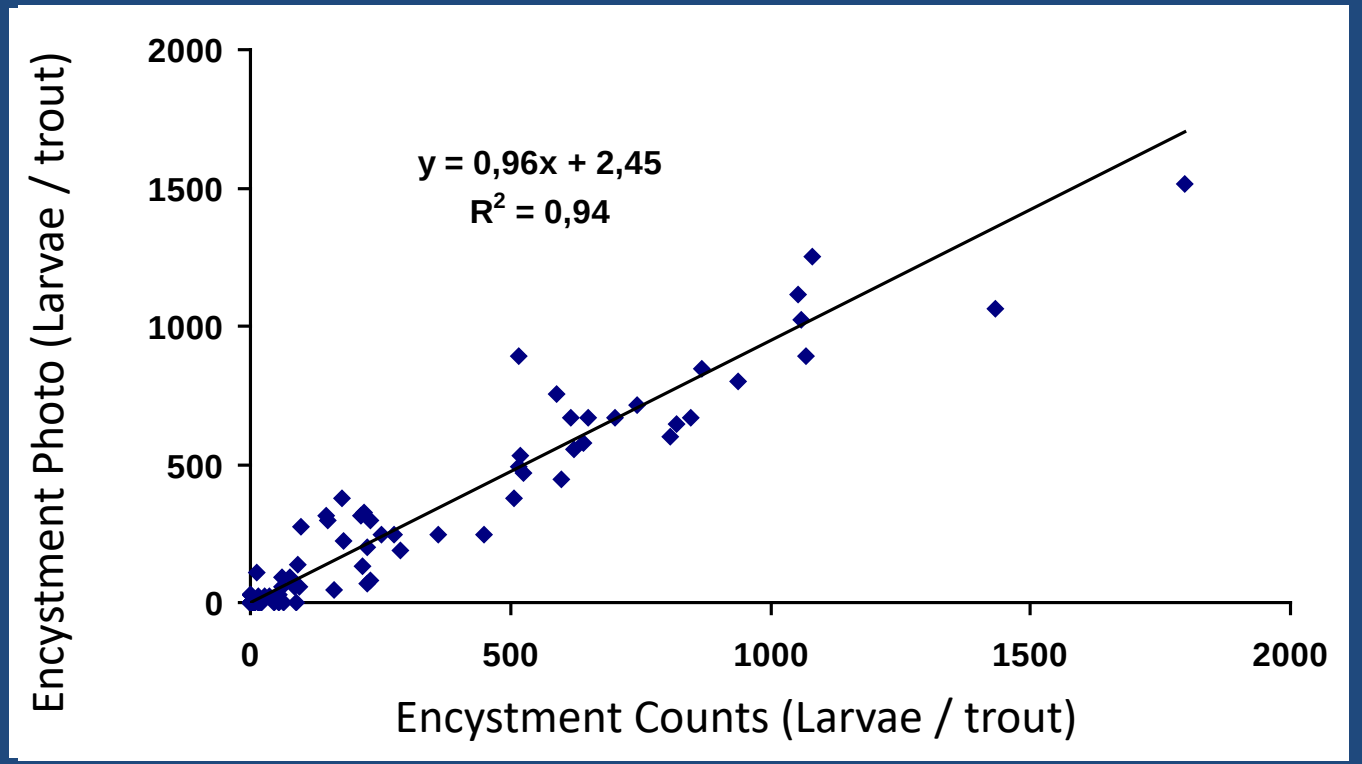


Photo-method







Thank you for your attention!



