Conservation Challenges for the Freshwater Pearl Mussel in Europe

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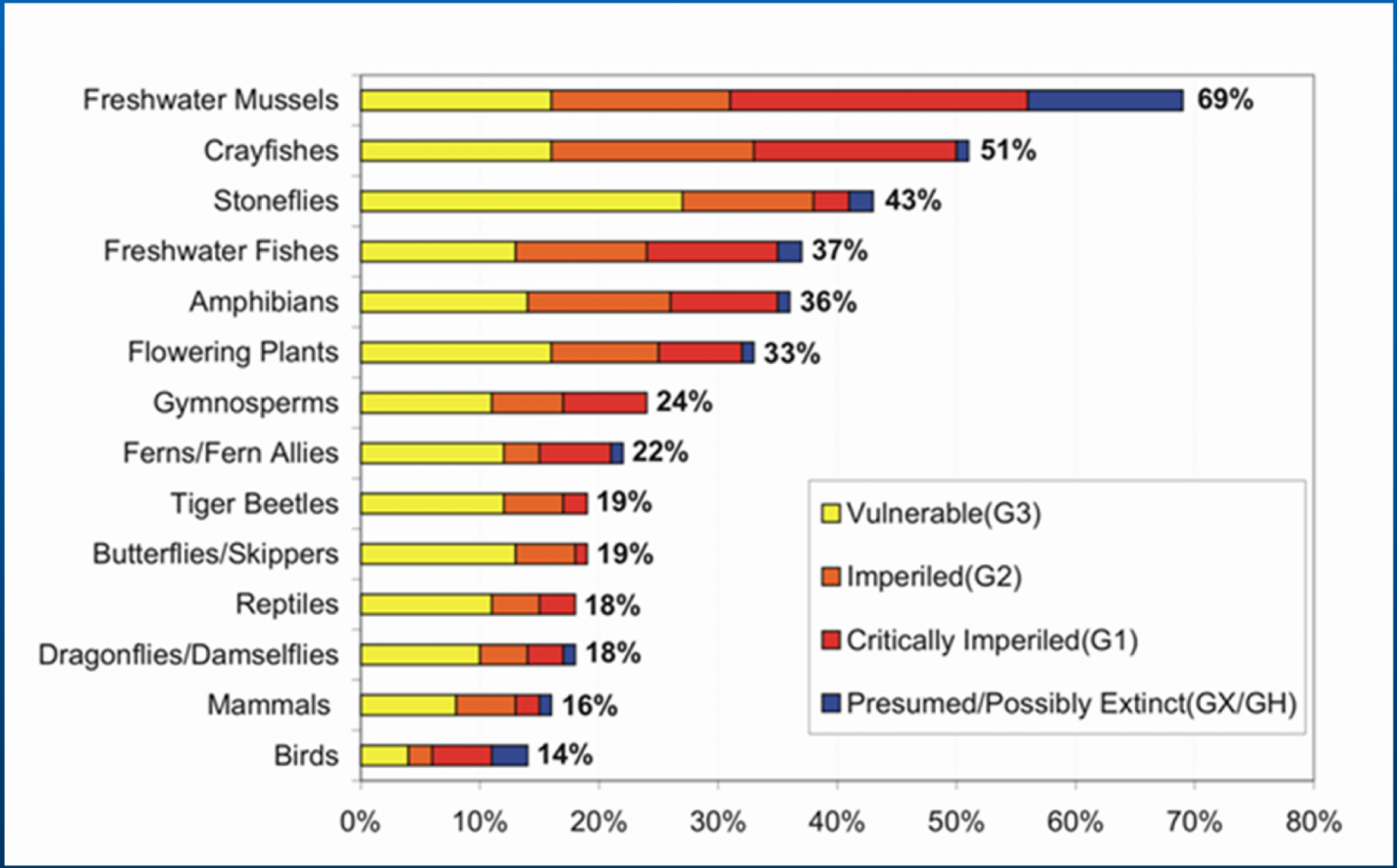
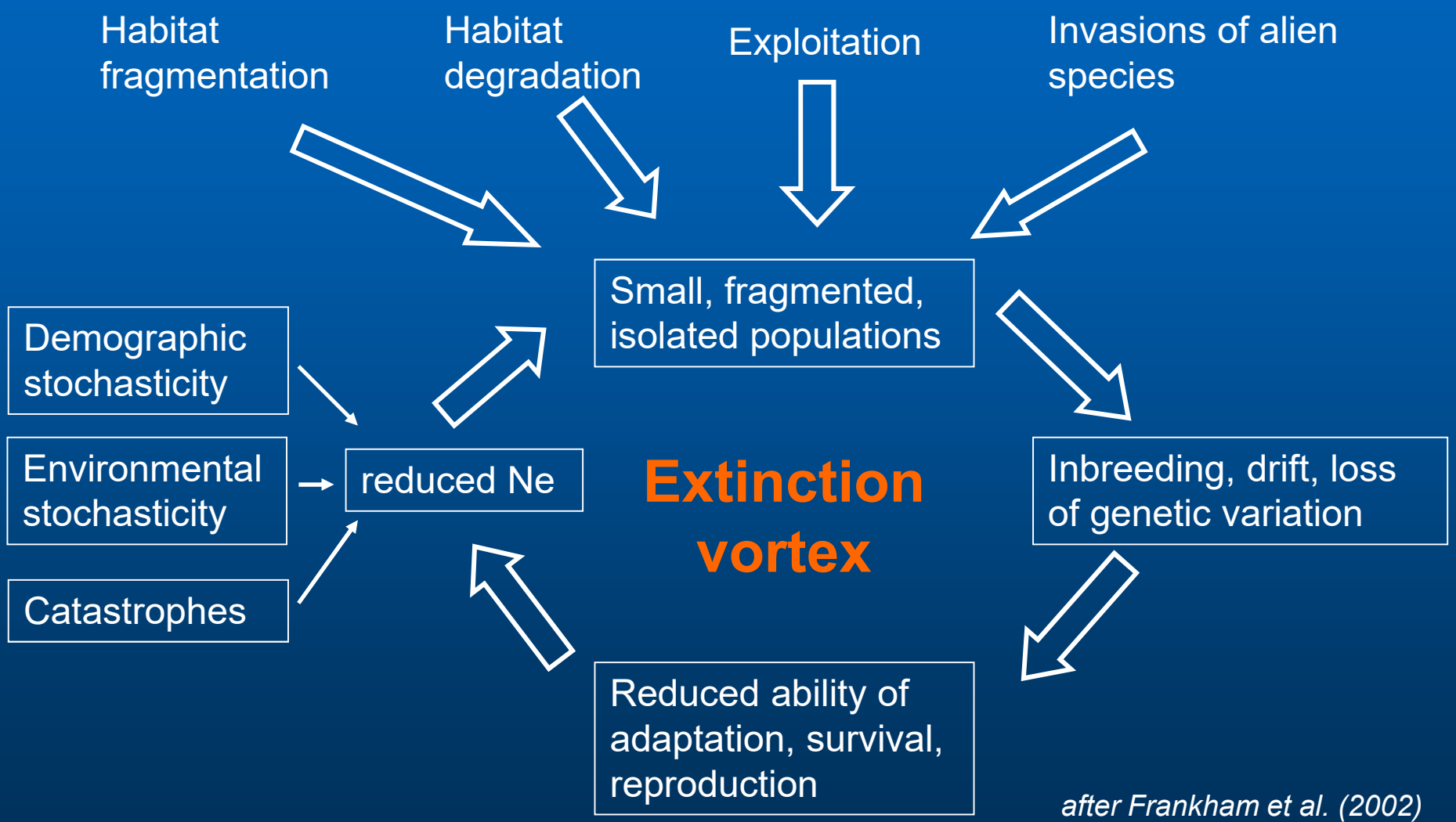
TECHNISCHE UNIVERSITÄT MÜNCHEN

Freshwater Mussels in Peril



Redrawn from „The Nature Conservancy and NatureServe“



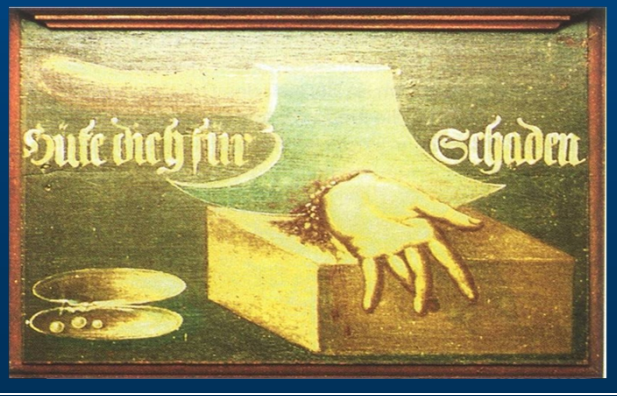
after Frankham et al. (2002)

The Freshwater Pearl Mussel: Target Species for Conservation

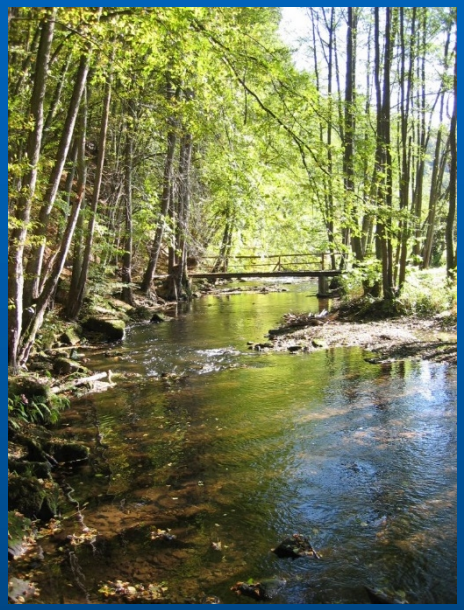
- Indicator species
- Keystone species
- Umbrella species
- Flagship species

- Core problem: recruitment

Geist (2010) Hydrobiologia



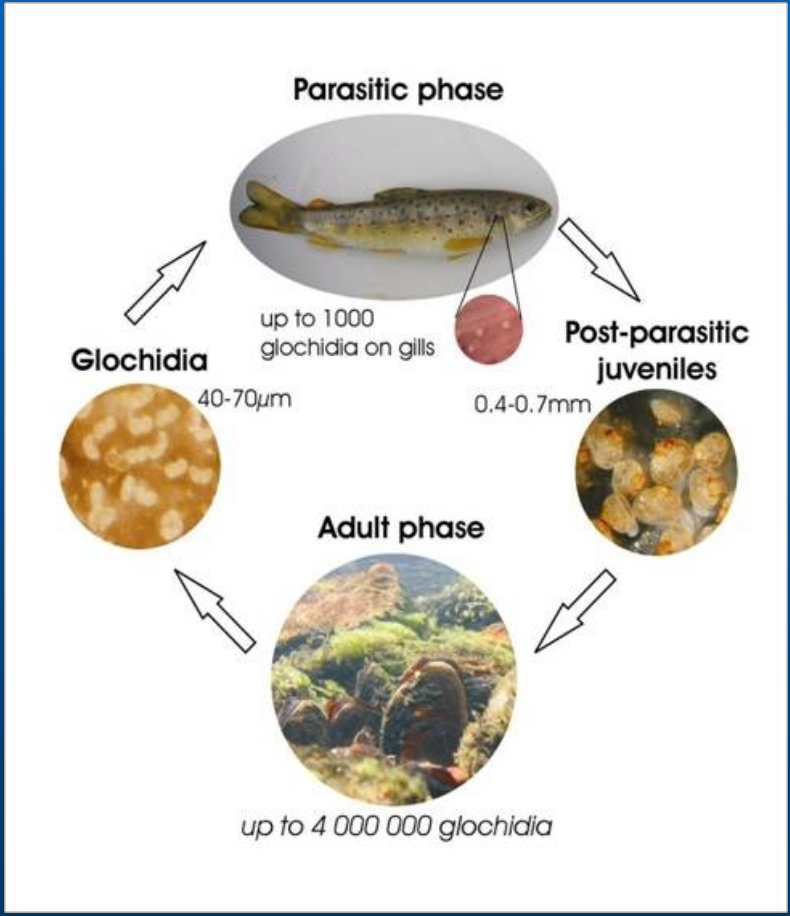
Diversity of Pearl Mussel Streams




Life Cycle

Status of host fish stocks?



Habitat for juveniles / substratum?

+ Genetics?

+ Environmental change?

Fertility / Gravidity?

Geist (2010) Hydrobiologia

The First Step: Gravidity of Populations

- Normal levels of gravidity in most streams
- No decrease of gravidity with age
- High reproductive potential
- Induced release of glochidia

The Parasitic Phase on the Host Fish

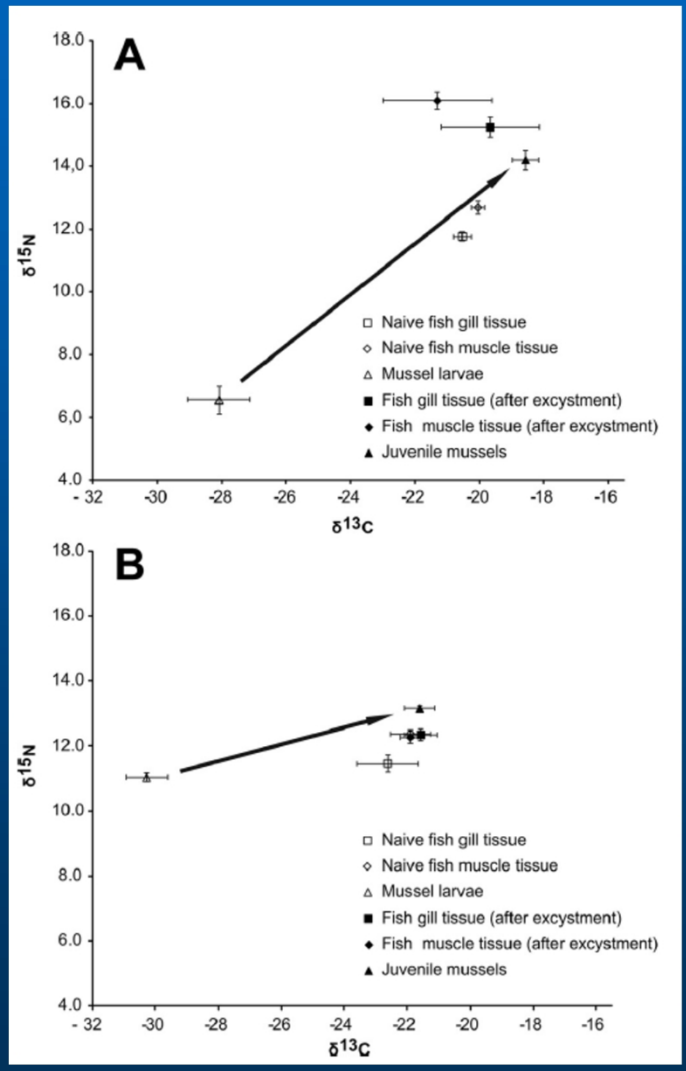
Salmo trutta

Gill of *S. trutta* with encysted glochidia

The host fish – mussel relationship

- Nutrient transfer from host to glochidium
- Adverse effects on the host at high infestation densities
- Differences in host suitabilities
  - Between fish species
  - Within fish species
  - Depending on holding conditions (e.g., Temp.)

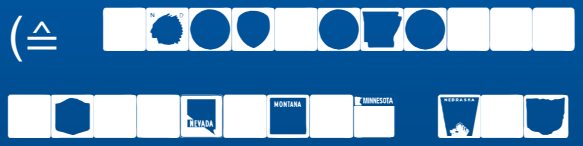
Denic, Taeubert & Geist (2015) Invertebrate Biol.



Optimum Infestation Densities of *Salmo trutta* with glochidia of *M. margaritifera*

Stocking of glochidia-infested fishes:

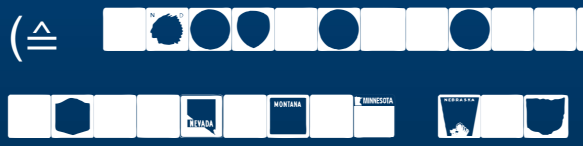
Up to 100 glochidia per g fish weight

(≙ 

~18 cm fish)

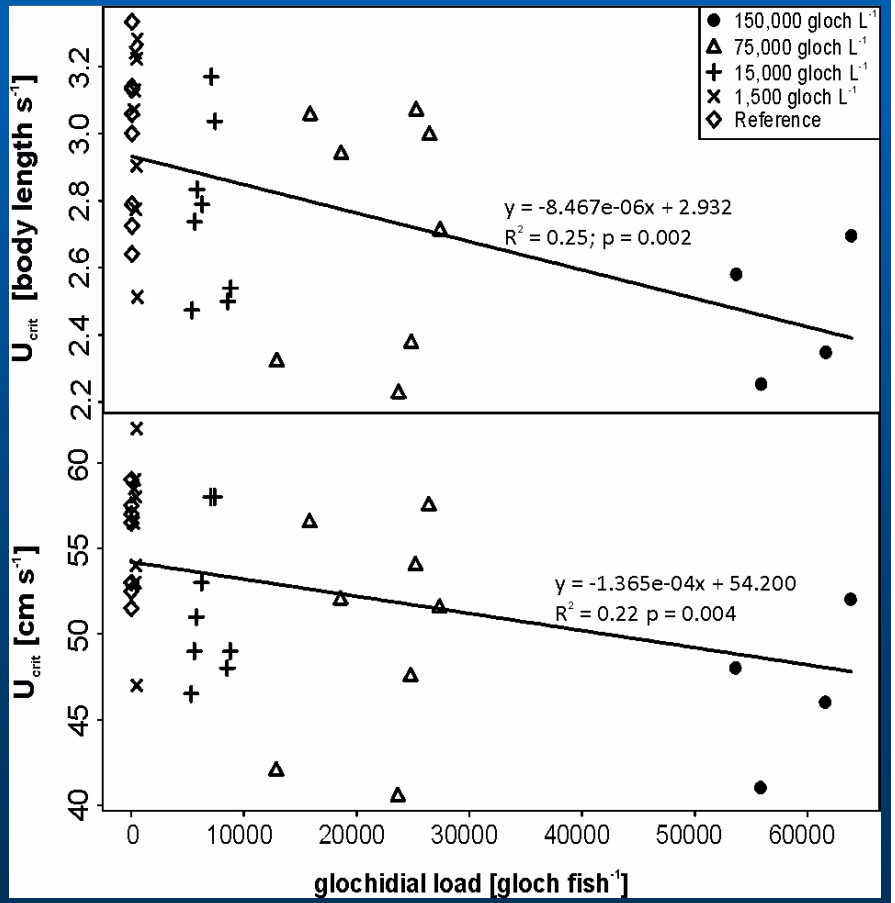
Captive breeding of mussels:

Up to 300 glochidia per g fish weight

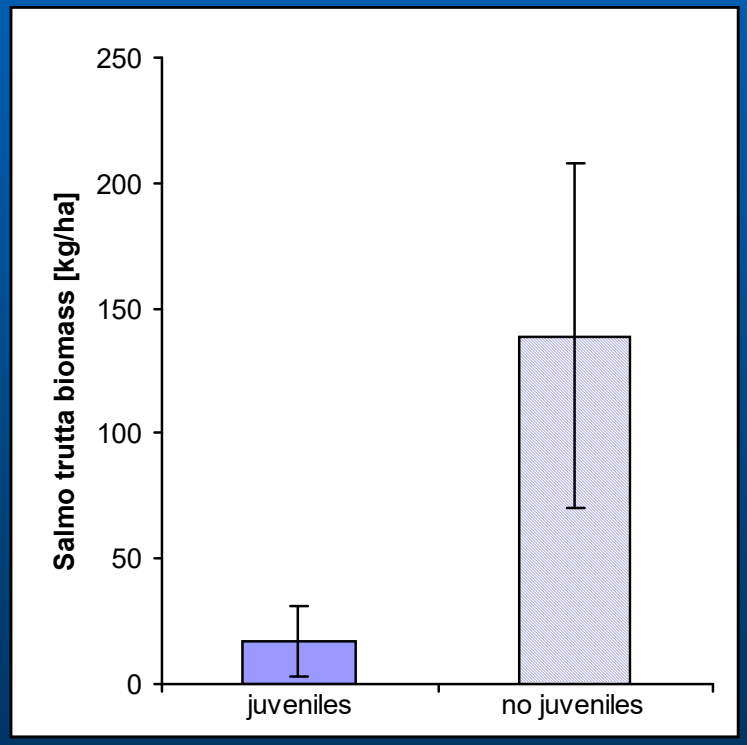
(≙ 

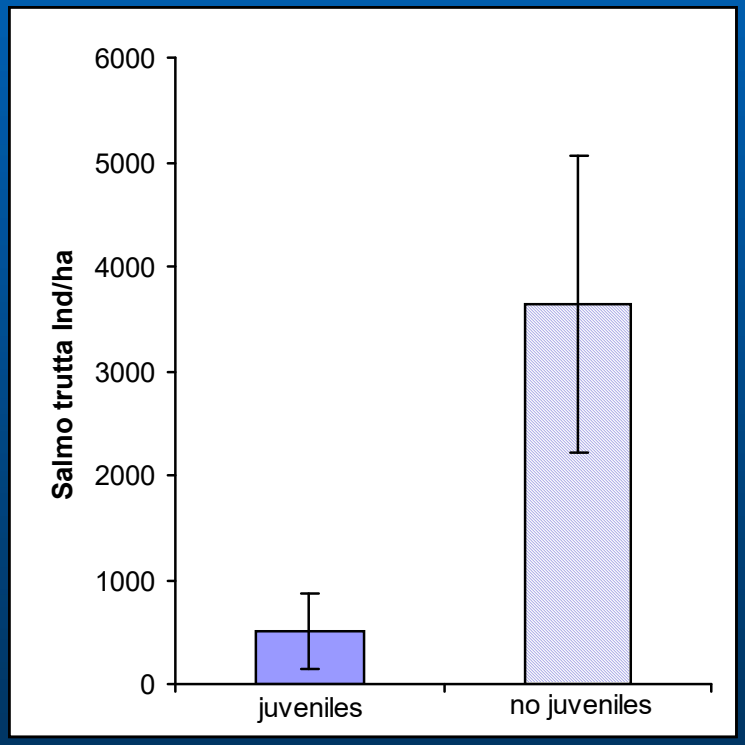
~18 cm fish)

Taeubert & Geist (2013) Parasitology Research

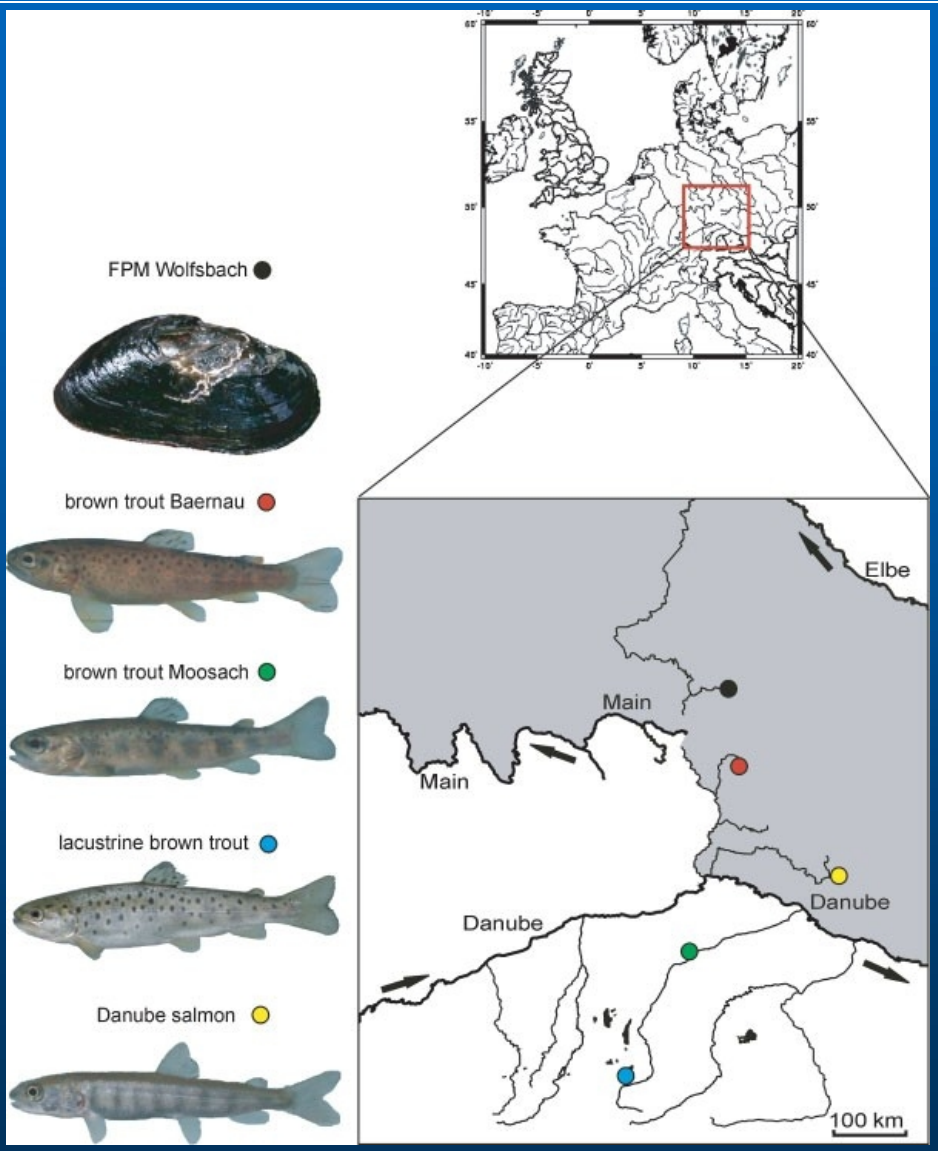


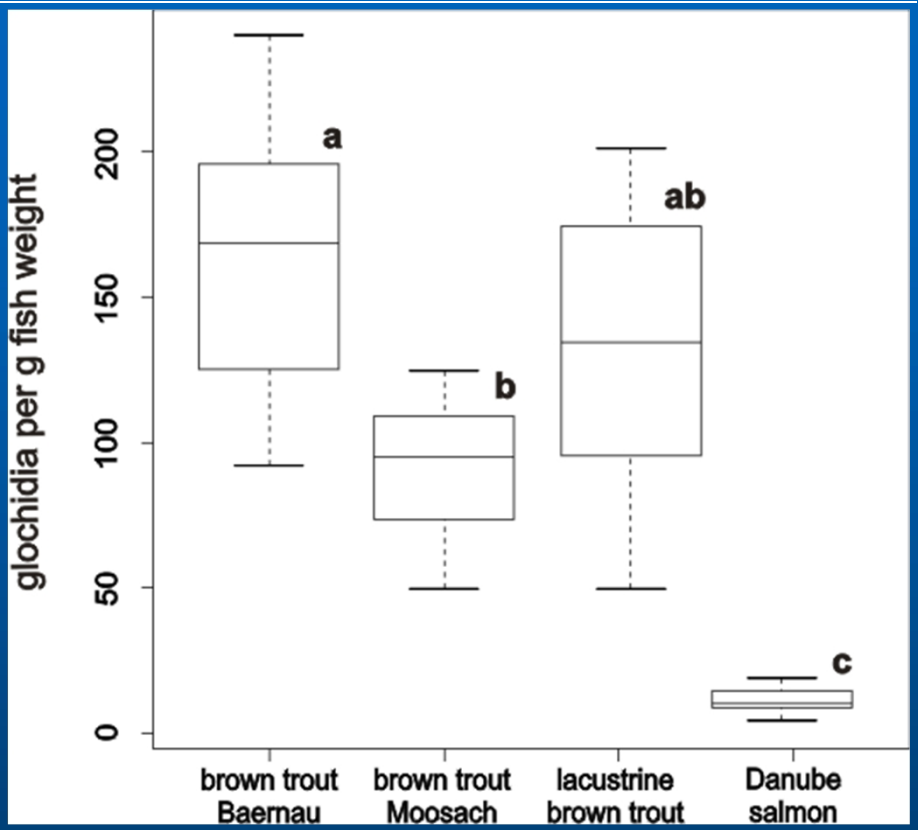
Host Fish Densities in Functional and Non-Functional Pearl Mussel Populations





Geist et al. (2006) Aquatic Conserv.



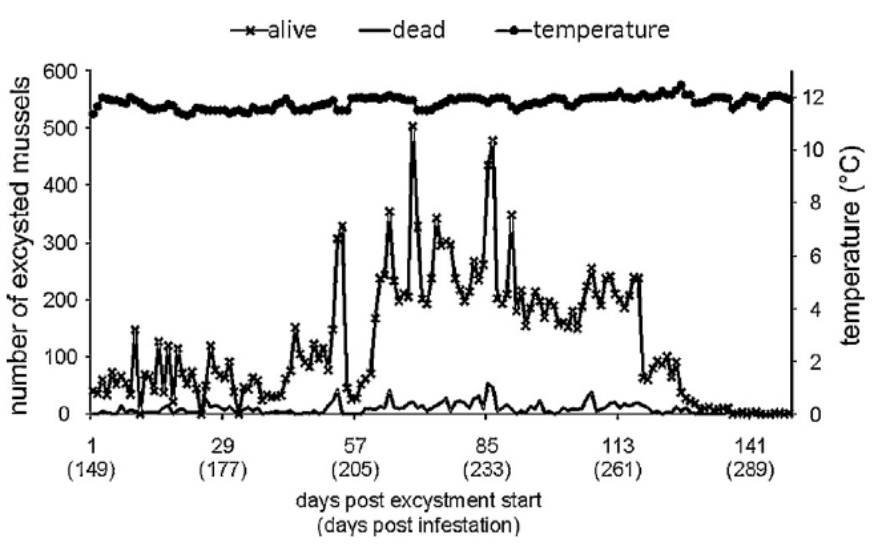


Taeubert et al. (2010) Aquatic Conserv.

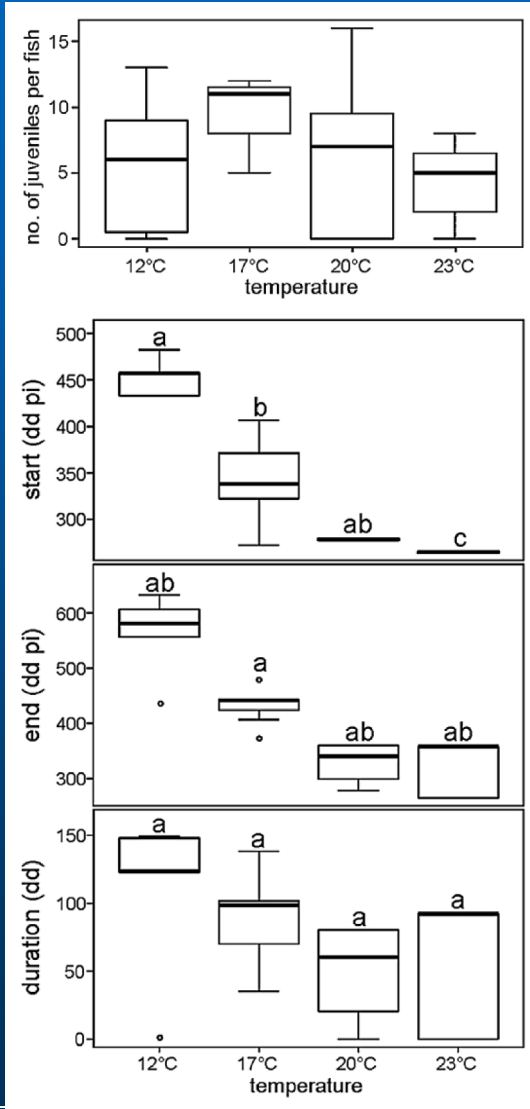
Ieshko et al. (2016) Knowl Manag Aquat Ecosyst

Temperature-Dependence of Metamorphosis

M. margaritifera



U. crassus



Taeubert, Gum & Geist (2013) Limnologica

Taeubert, El-Nobi & Geist (2014) Aquatic Conserv.

Stream Bed:
The Core Problem for Juvenile Recruitment

Texture

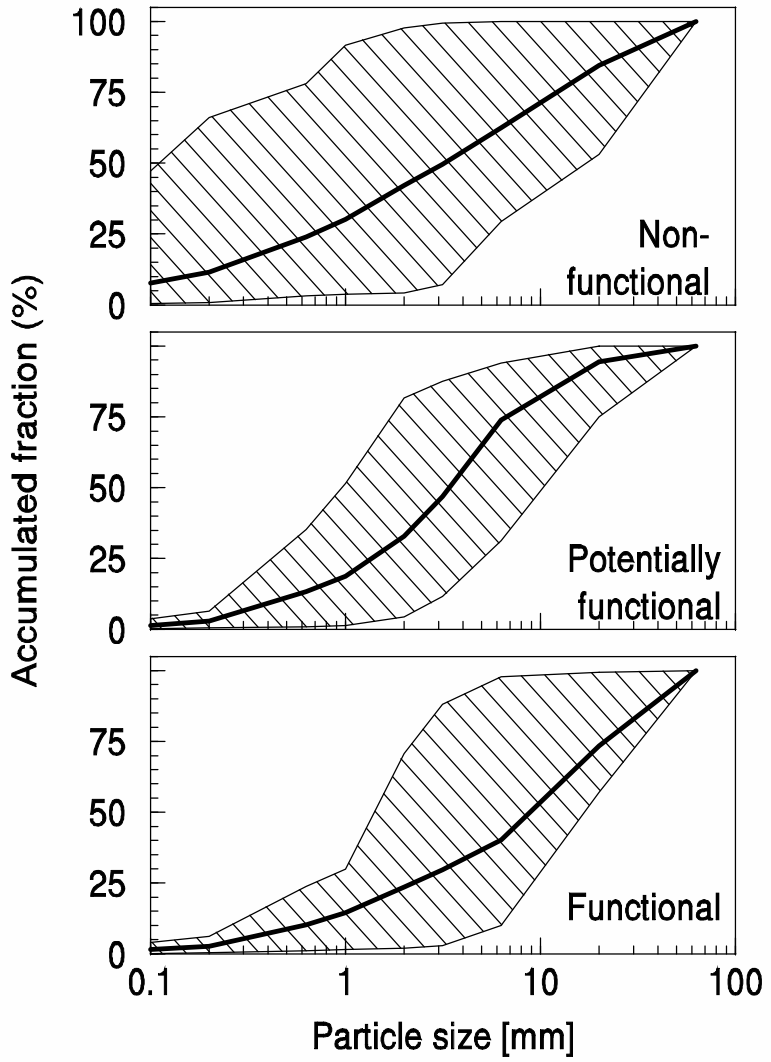
Functional populations:

- Well-sorted gravel
- Low percentage of fines

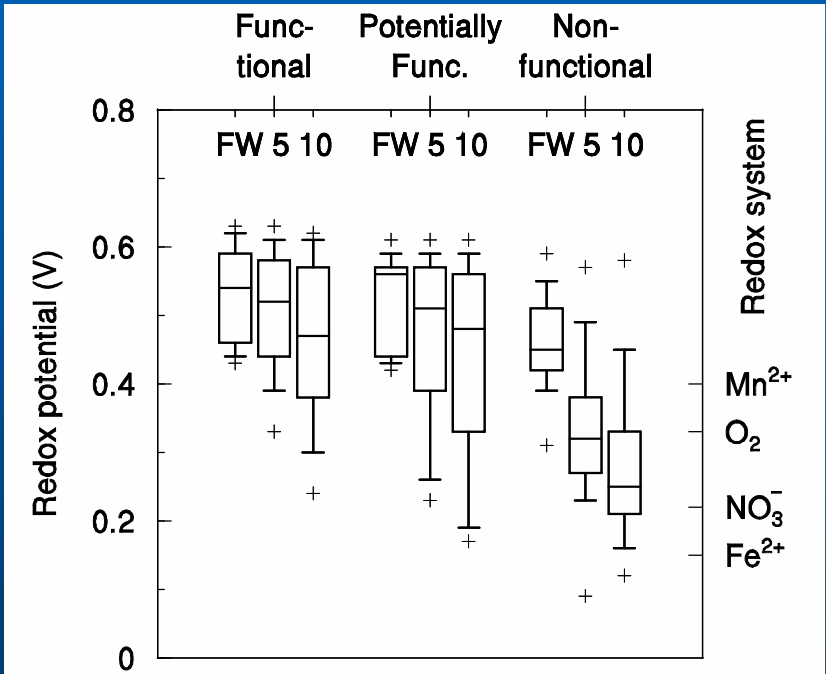
Non-functional populations:

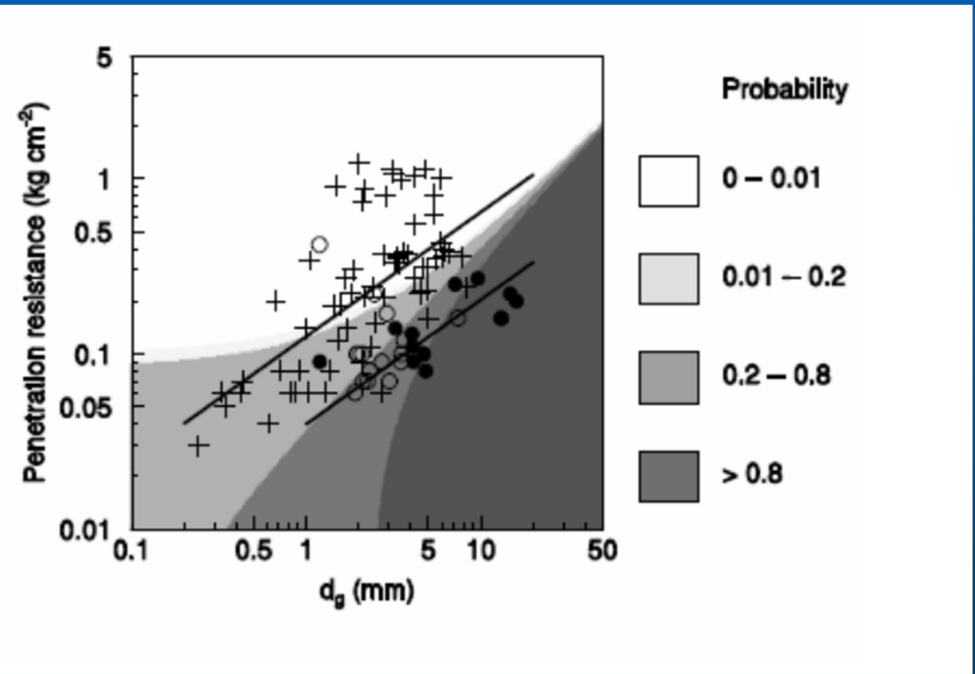
- Mixed texture
- High percentage of fines

Geist & Auerswald (2007) Freshw. Biol.



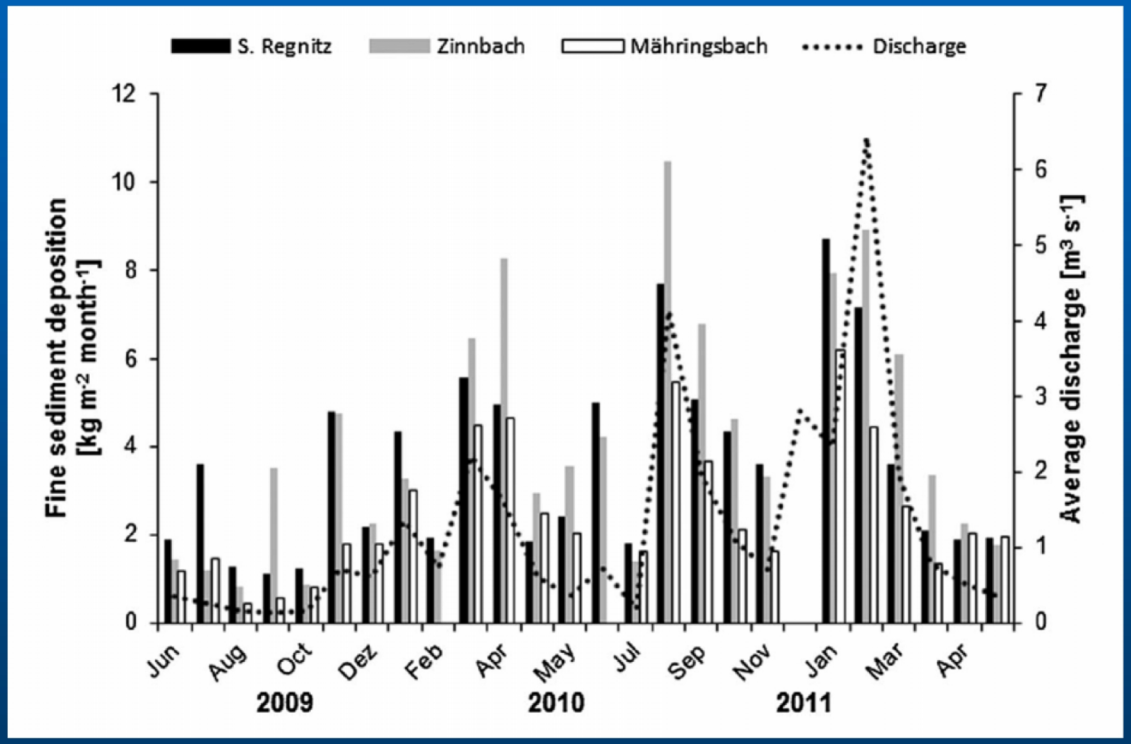
Determining Functional Substrate Conditions





Geist & Auerswald (2007) Freshw. Biol.

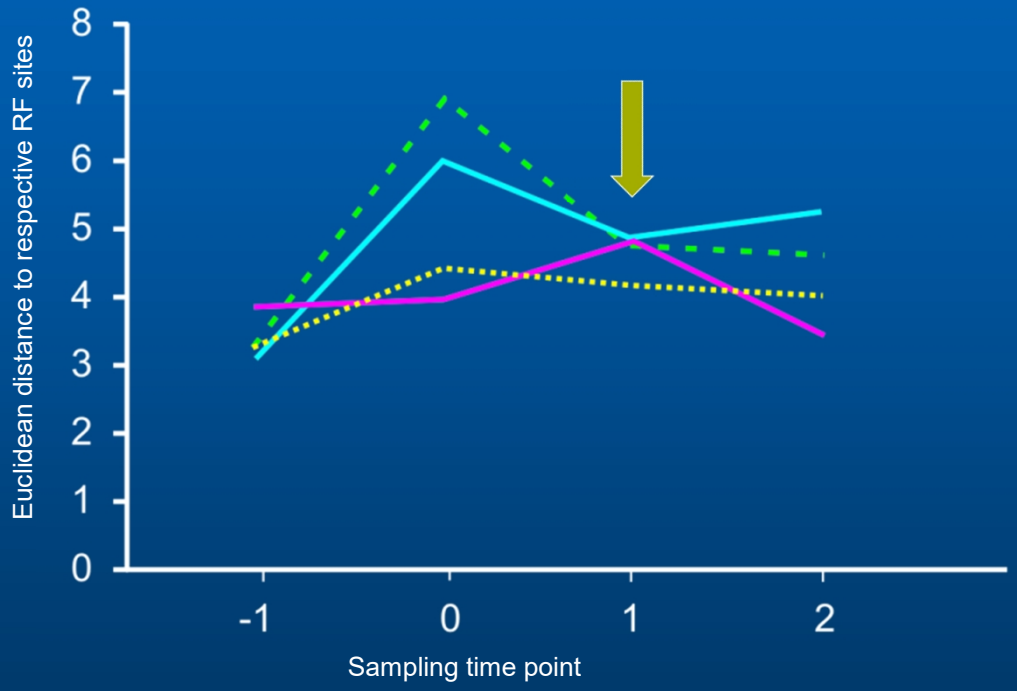
Monitoring of Siltation



Denic & Geist (2015) River Research and Applications

Comparisons of Different Stream Substratum Restoration Measures

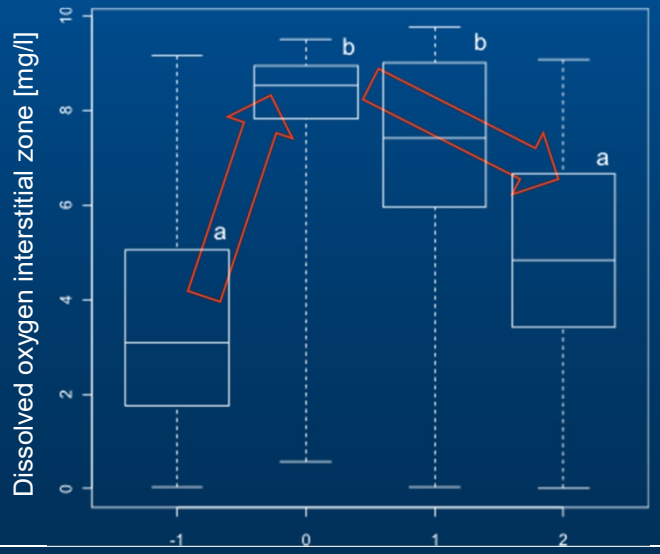
Changes of Physicochemical Habitat Characteristics



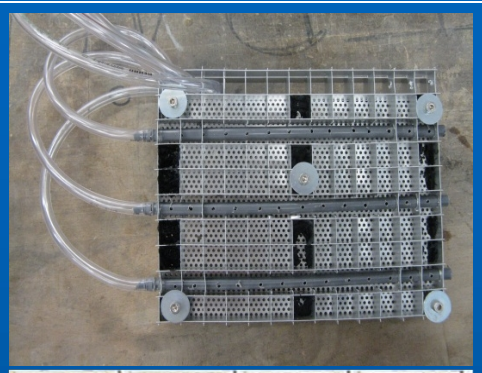
Pander, Mueller & Geist (2014) River Res. Appl.

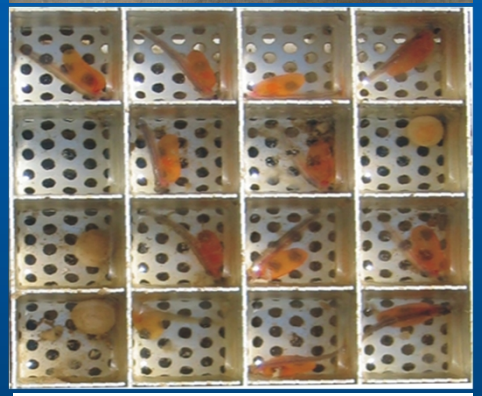
Mueller, Pander & Geist (2014) Ecolog. Engineering

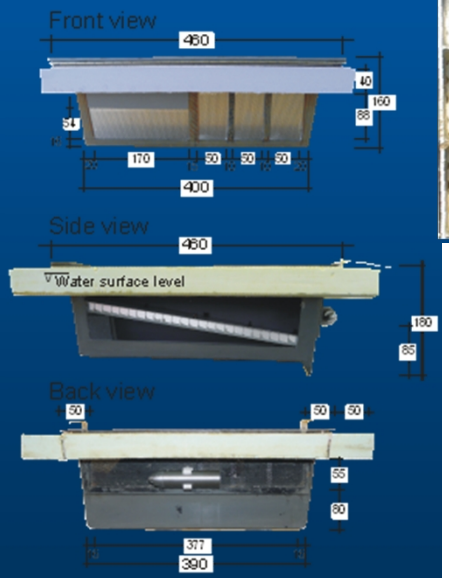
Dissolved oxygen at 16/32 sites

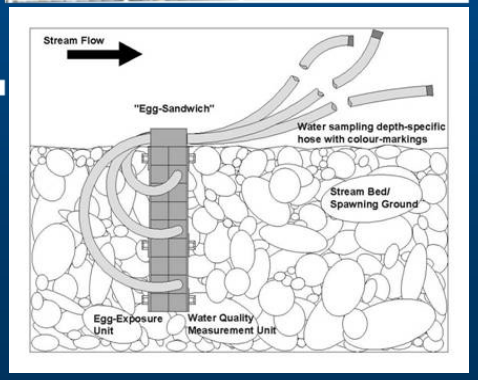


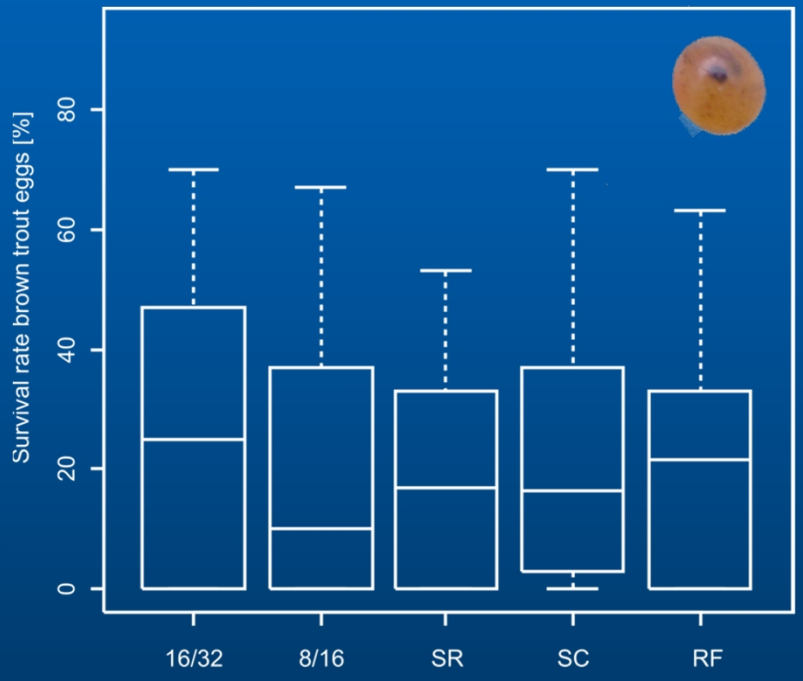
Kruskal-Wallis-ANOVA: $p < 0.001$, pairwise Mann-Whitney-U-Test: $p < 0.05$









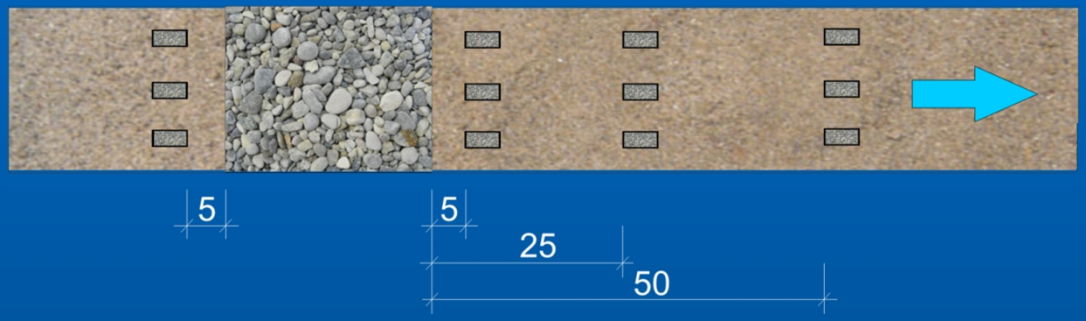


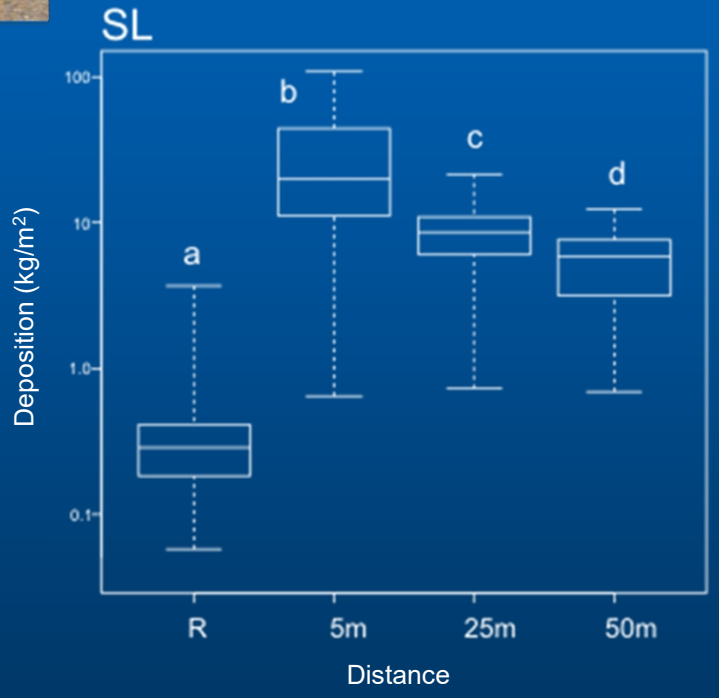
Pander, Schnell, Sternecker & Geist (2009) *J. Fish Biol.*

Pander & Geist (2010) *J. Fish Biol.*

Sternecker, Cowley & Geist (2013) *Ecol. Freshw. Fish*

Restoration can also have negative effects!



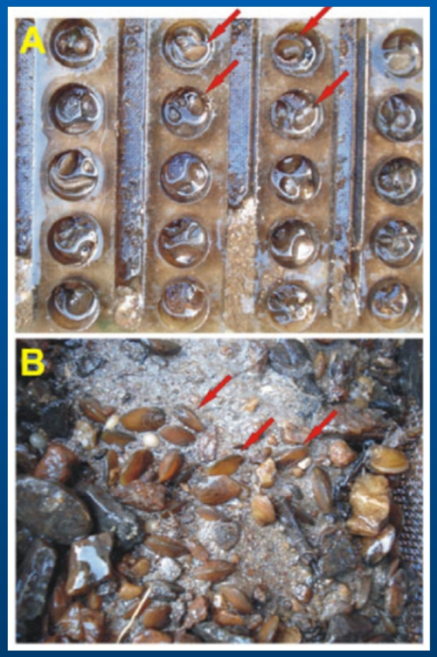


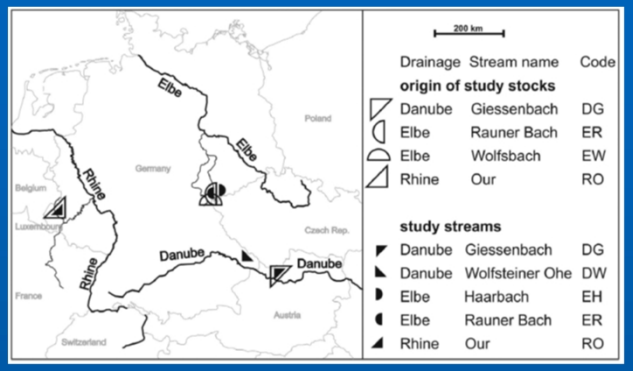
Mueller, Pander & Geist (2014) Ecol. Engineering

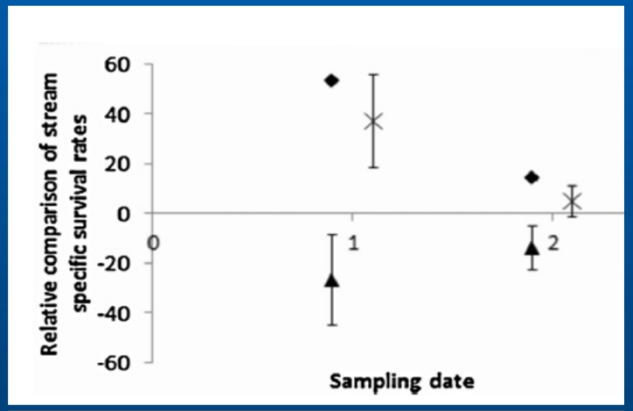
Pander, Mueller & Geist (2014) Riv. Res. Appl.

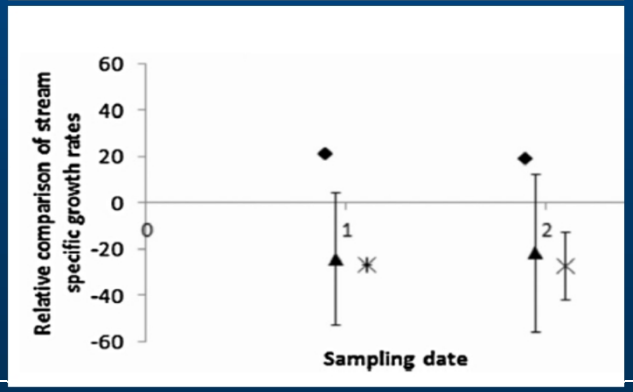
Ark projects and captive breeding

Local habitat adaptation







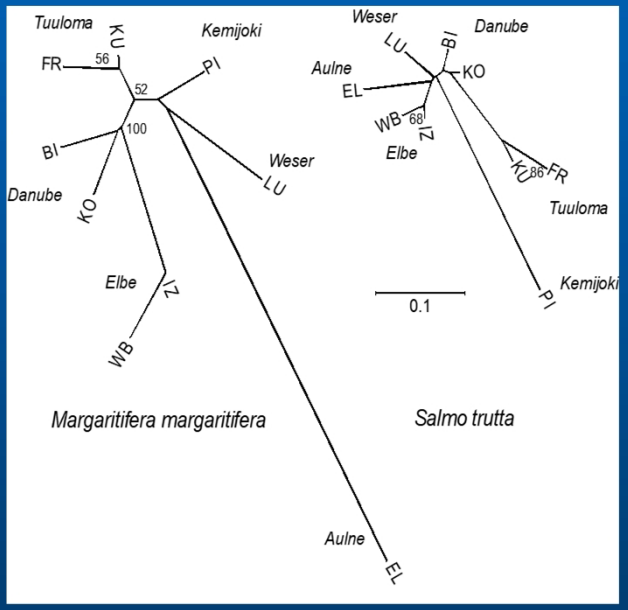


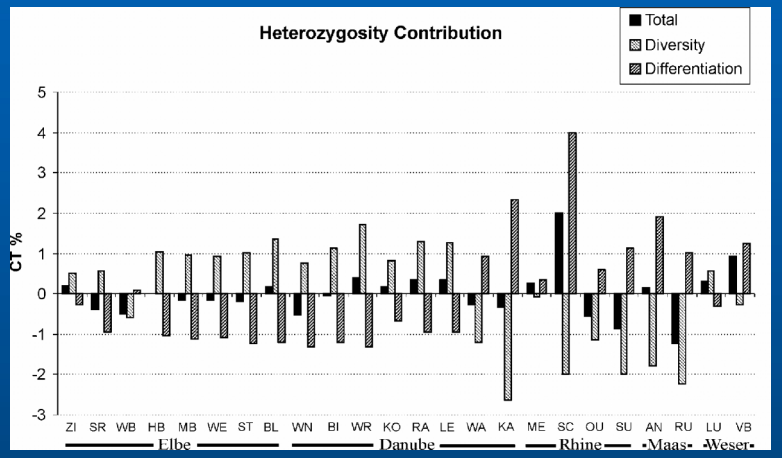
Gum, Lange, Geist (2011) *Aquat. Conserv.*

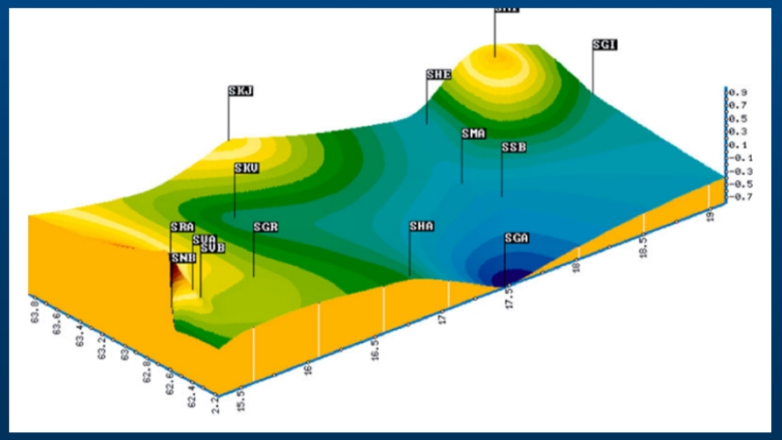
Denic et al. (2015) *Limnologica*

Geist (2015) *Aquat. Conserv.*

Decisions on Priority Populations



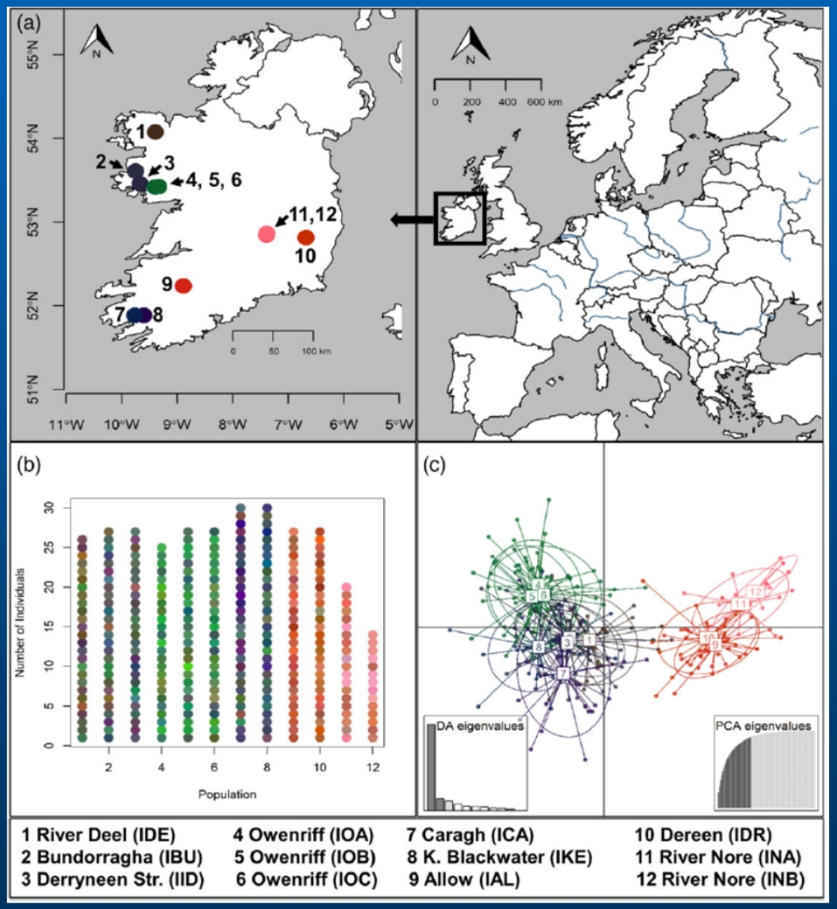




Geist et al. (2003) Mol. Ecol. Res.
Geist & Kuehn (2005) *Mol. Ecol.*
Geist & Kuehn (2008) *Mol. Ecol.*
Geist et al. (2010) *Conserv. Genetics*
Stoeckle et al. (2017) *Conserv. Gen.*
Zanatta et al. (2018) *Biol. J. Linn. Soc.*
Feind, Kuehn & Geist (2018) *Hydrobiol.*

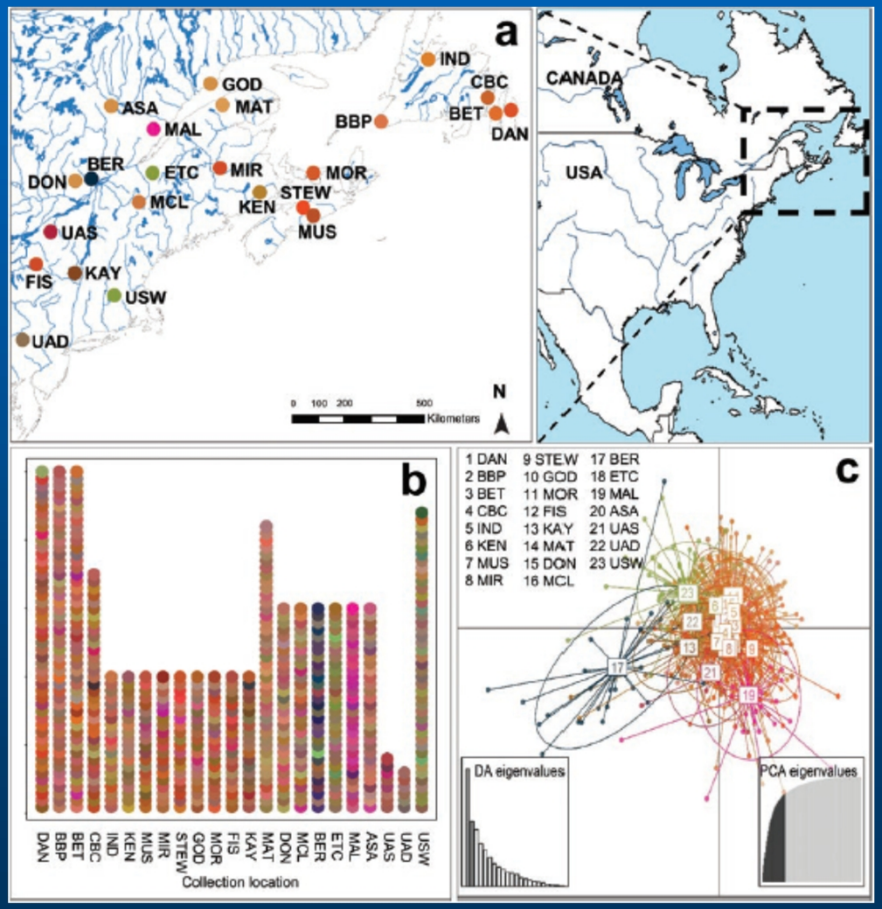
Considering genetic diversity is important

Ireland



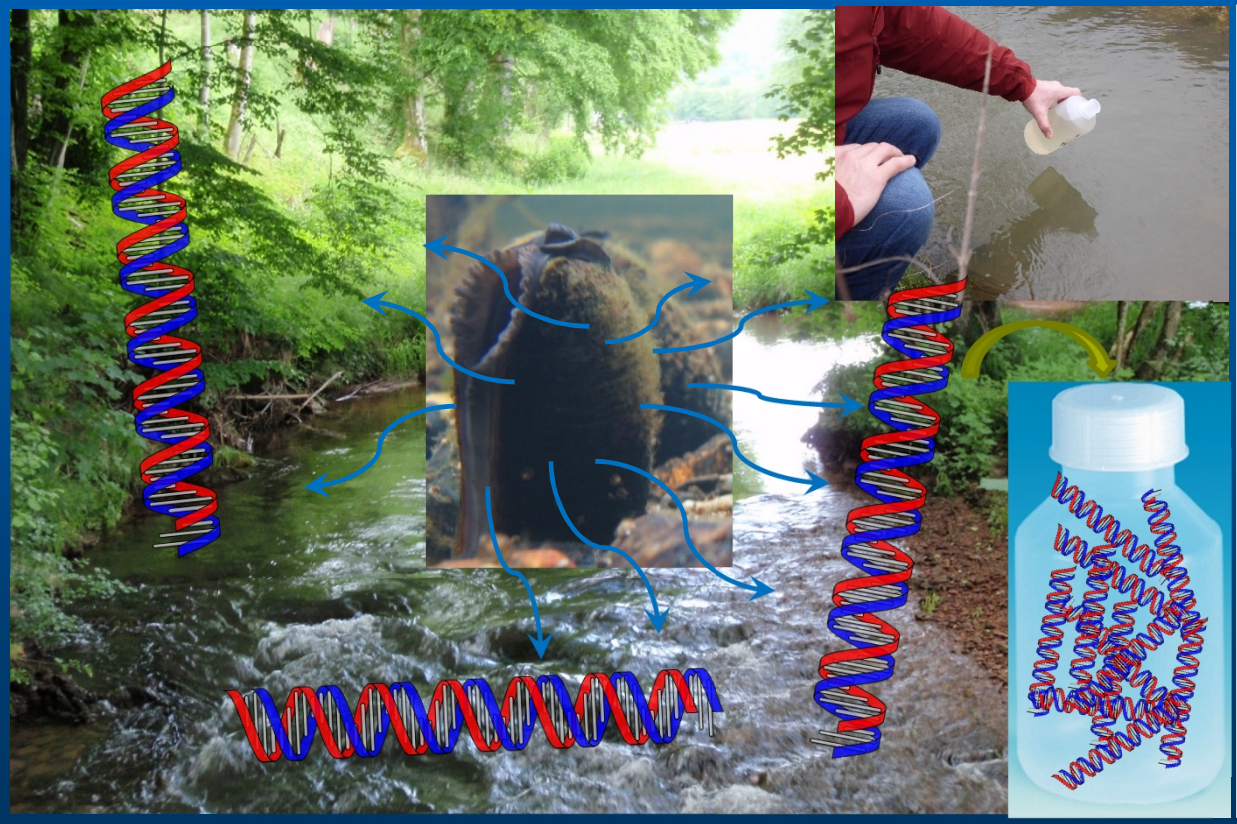
Geist et al (2018) *Aquatic Conservation*

North America



Zanatta et al (2018) *Biol. J Linn. Soc.*

Environmental DNA (eDNA)



AQUATIC CONSERVATION: MARINE AND FRESHWATER ECOSYSTEMS
Aquatic Conserv: Mar. Freshw. Ecosyst. (2015)
Published online in Wiley Online Library
(wileyonlinelibrary.com). DOI: 10.1002/aqc.2611

Environmental DNA as a monitoring tool for the endangered freshwater pearl mussel* (Margaritifera margaritifera L.): *a substitute for classical monitoring approaches?

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[b]*Unit of Molecular Zoology, Chair of Zoology, Department of Ecology and Ecosystem Management, Technische Universitaet Muenchen, Freising, Germany*
[c]*Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Las Cruces, NM, USA*

ABSTRACT

1. Knowledge of species distribution is of utmost importance for conservation and management of endangered freshwater mussels. Conventional monitoring approaches are often time consuming and costly. The use of environmental DNA (eDNA) is a relatively new approach and considered as an effective tool to detect the presence of target species in aquatic environments. The aim of this study was to establish a nested PCR system to detect eDNA of *Margaritifera margaritifera* and to discuss the advantages and disadvantages of eDNA in mussel surveys compared with classical monitoring.
2. DNA of *M. margaritifera* was detected in 2 L water samples collected directly downstream (25 m) from pearl mussel populations (population size from 800–20 000), with an internal-nested PCR approach greatly increasing the detection sensitivity (down to 10 fg target DNA). eDNA detection at greater distances downstream (500 and 1 000 m) of these populations failed, possibly due to DNA degradation or dilution processes. eDNA was also detected downstream of an extinct population, most likely resulting from overlooked mussels or the release of DNA from dead shells.
3. The eDNA approach proposed herein may be helpful in initial screening of streams that are otherwise difficult to monitor, or in the detection of buried juvenile mussels without disturbing their habitat. However, it cannot replace monitoring of population demography, and of other important information for conservation, and should thus only be seen as a supplementary tool.

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KEY WORDS: bivalves; eDNA; conservation; contamination; nested PCR; survey; distribution

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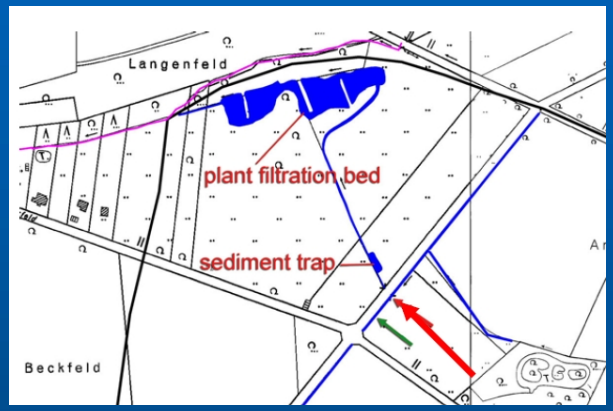
Stoeckl, Kuehn & Geist (2016) Aquatic Conserv.

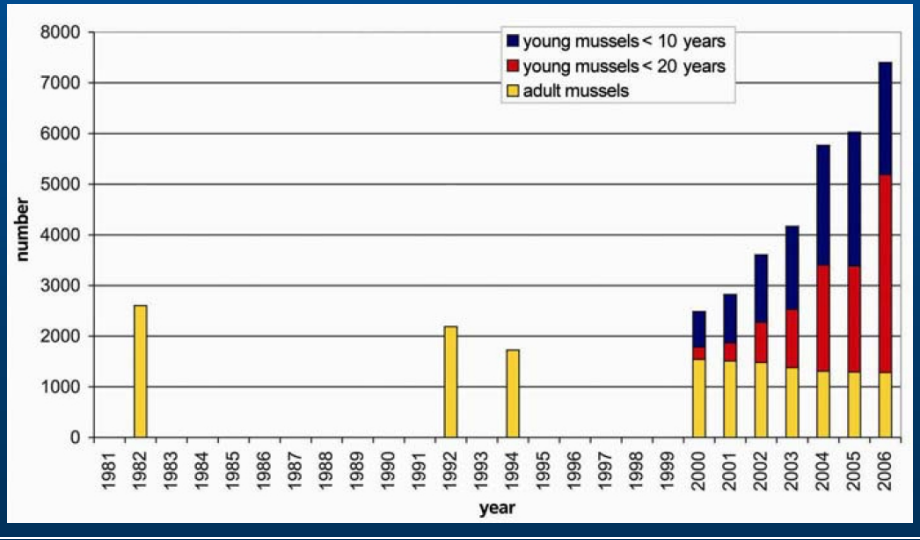
Examples of Currently Applied "Conservation" Approaches and their Problems

Approach	Problem
Infestation and release of host fishes from hatcheries into natural populations	Does often not address the bottleneck Low persistence of allochthonous fishes Possible gene swamping, disease
Release of early post-parasitic juveniles into wild populations	Trial and error based Poor monitoring possibilities
Population surveys / counts of mussels, Water quality control	Only a monitoring tool No conservation action
Gradivity monitoring of adult mussels	Not a powerful indicator No conservation action

Successful Examples of Restoring Freshwater Mussel Populations



Dr. Reinhard Altmüller
and the Lutter Project



Altmüller & Dettmer (2006)

Effective Conservation Management: A Stepwise Approach

Step 1: Decisions on conservation objectives

Step 2: Determination of status quo

Step 3: Identification of bottlenecks and problems

Step 4: Decisions on conservation action with stakeholders and sponsors

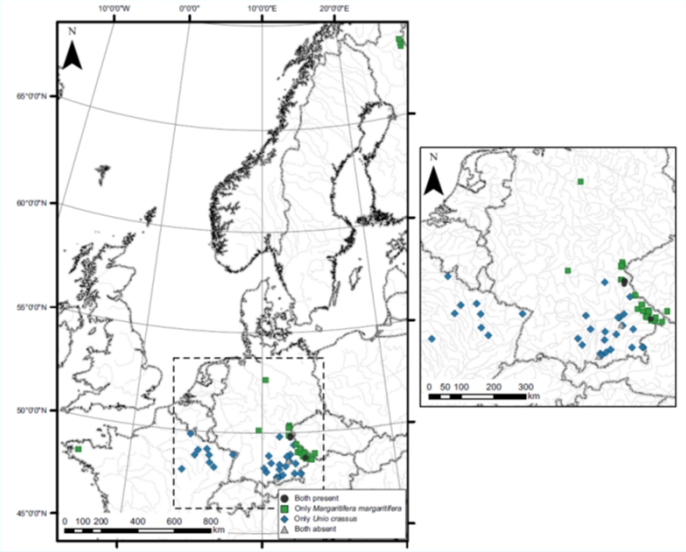
Step 5: Conservation action

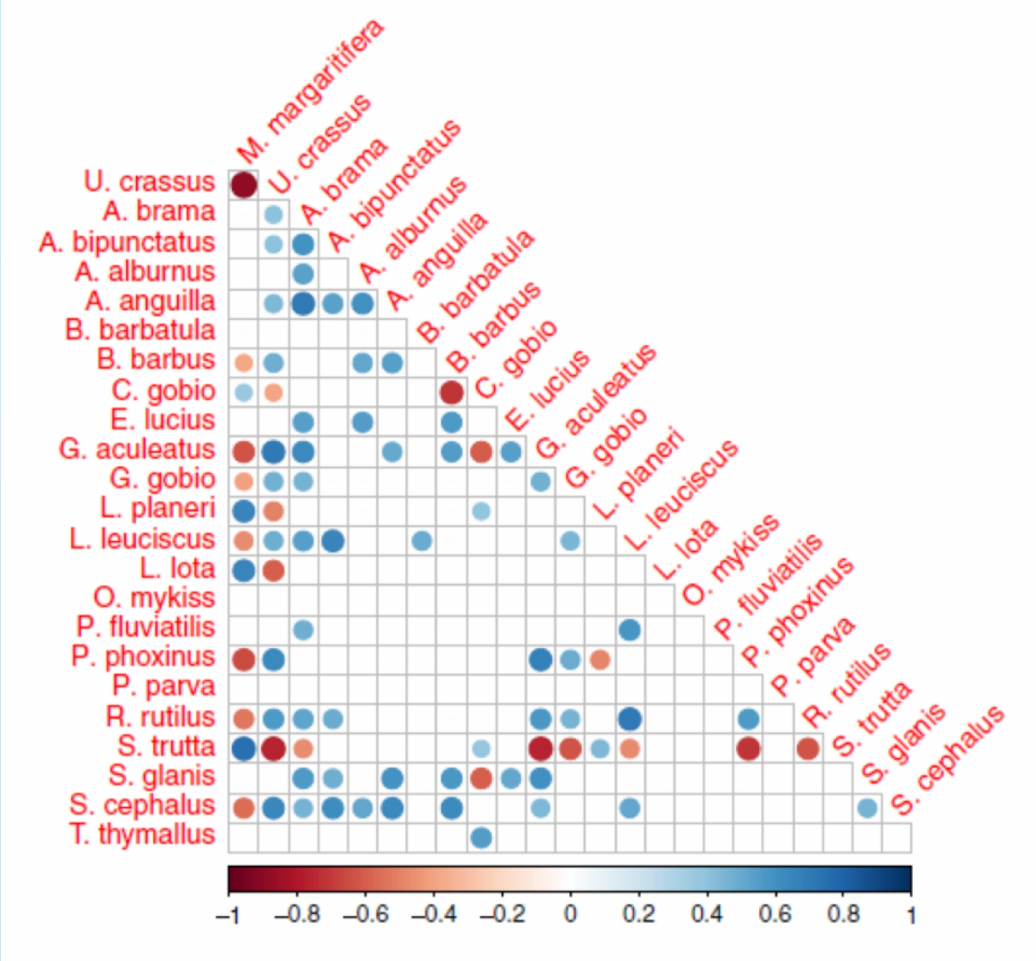
Step 6: Evaluation and adaptive management

Step 7: Publication of results

Geist (2015) Aquatic Conservation: Marine and Freshwater Ecosystems

Systematic conservation planning





Inoue, Stoeckl, Geist (2017)
Diversity & Distributions

Conservation of Functionally Intact Populations (Kola peninsula)






Conservation of Functionally Intact Populations (North America)

Public Awareness and Communication

Motto of the Freshwater Mollusk Conservation Society Meeting 2009

in Baltimore, USA

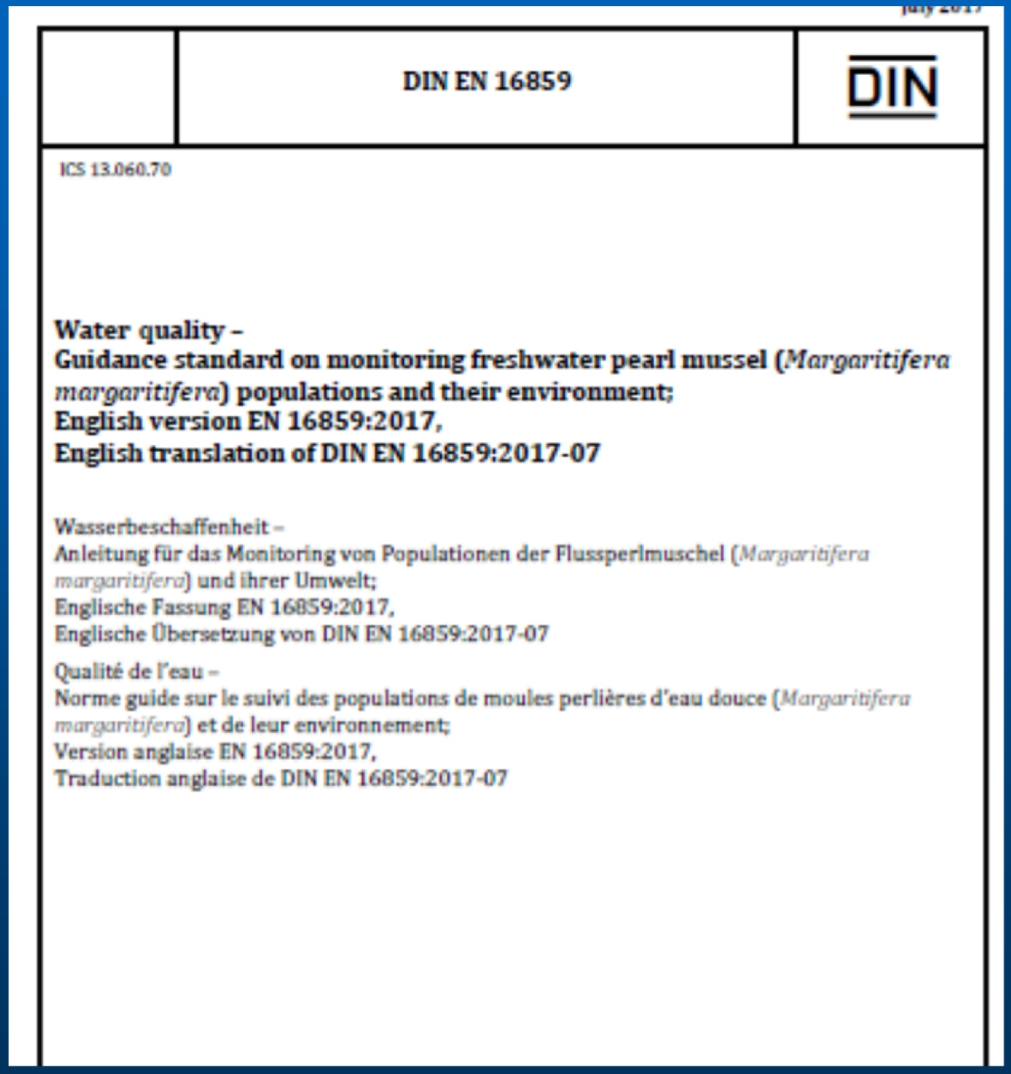
Harmonization and Collaboration

New CEN standard

Identification of key variables on population characterization and habitat assessment

See also review paper

Boon, Cooksley, Geist, Killeen, Moorkens & Sime (in press) Aquatic Conservation



DIN EN 16859

DIN

ICS 13.060.70

Water quality –
Guidance standard on monitoring freshwater pearl mussel (*Margaritifera margaritifera*) populations and their environment;
English version EN 16859:2017,
English translation of DIN EN 16859:2017-07

Wasserbeschaffenheit –
Anleitung für das Monitoring von Populationen der Flussperlmuschel (*Margaritifera margaritifera*) und ihrer Umwelt;
Englische Fassung EN 16859:2017,
Englische Übersetzung von DIN EN 16859:2017-07

Qualité de l'eau –
Norme guide sur le suivi des populations de moules perlières d'eau douce (*Margaritifera margaritifera*) et de leur environnement;
Version anglaise EN 16859:2017,
Traduction anglaise de DIN EN 16859:2017-07

Non-static conservation needs to consider climate change

Conclusions

- Freshwater pearl mussel populations continue to be in trouble, despite of knowledge on the limiting factors for recruitment
- Prioritization of populations / areas of conservation based on ecological and genetic data is important
- Catchment conservation in functionally intact populations should have highest priority
- Combination of short-term remediation (culturing) with long-term objectives (catchment restoration) is essential
- Conservation needs to be more systematic and requires evaluation plus publication of positive and negative results

Thank you for your attention!

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