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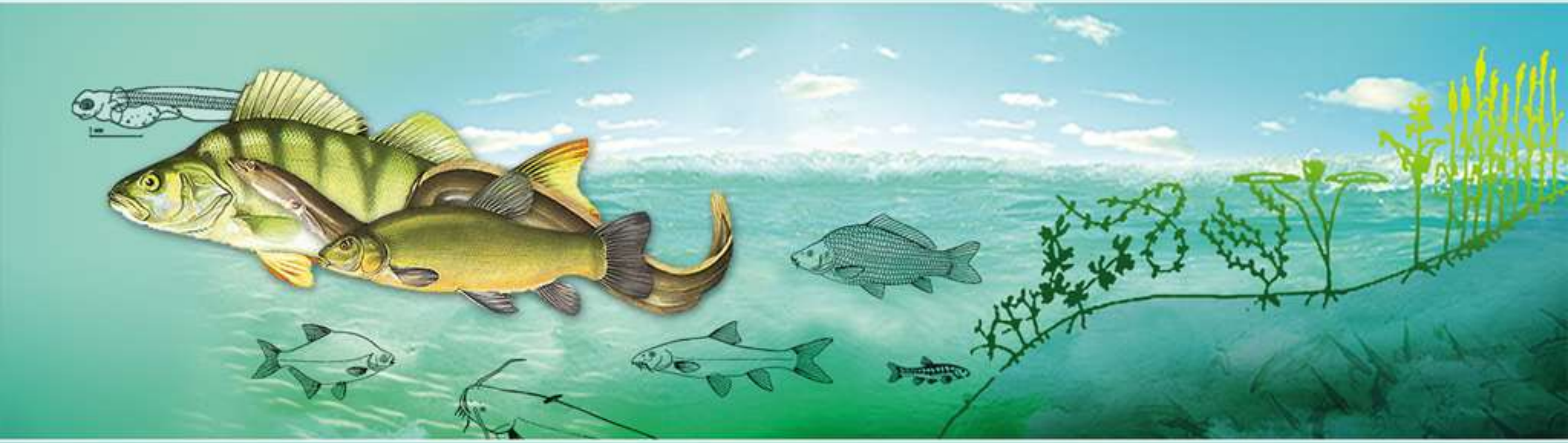

BIOTURBATION OF SEDIMENTS BY BENTHIC MACROINVERTEBRATES AND FISH AND THEIR IMPLICATIONS FOR POND WATER ECOSYSTEMS

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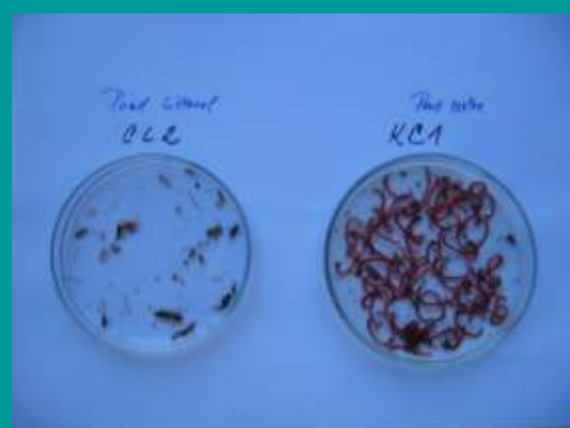
Bioturbation (bioperturbation)

- generally - disturbance of existing status by a biological element

- however – its perception in surface water bodies is reduced on the impact of macrozoobenthos and benthivorous fish upon the processes in bottom sediments

Macroinvertebrates

- macrozoobenthos - key component supporting heterogeneity of the sediment environment
- playing a crucial role in biogeochemical processes in water-sediment interface

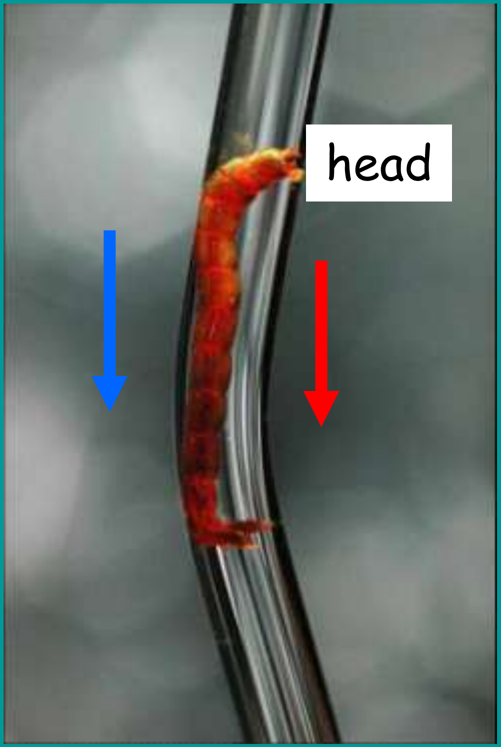




Compared with fish, the bioturbation performance of macroinvertebrates is more delicate but rather continuous and manifested preferably by organic matter translocation, ingestion, egestion (excretion) resulting in nutrient (upwards) & oxygen (downwards) transfer between pelagic and benthic environment

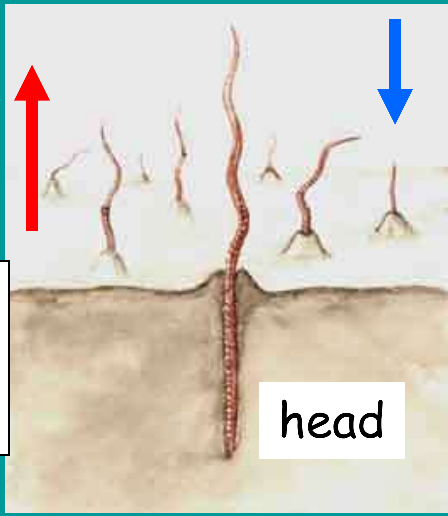
Macroinvertebrates

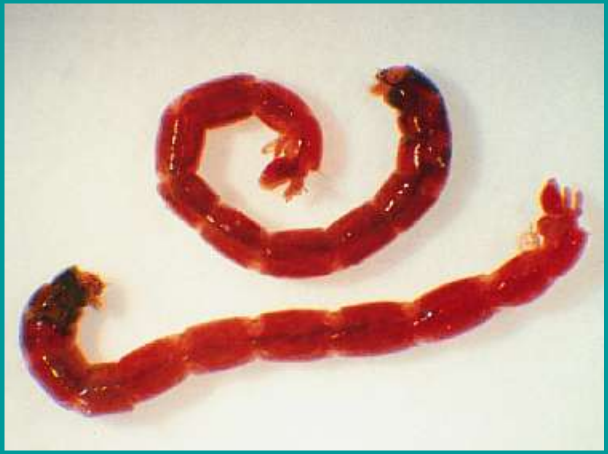
Key bioturbators are

- chironomid larvae
- tubicid worms

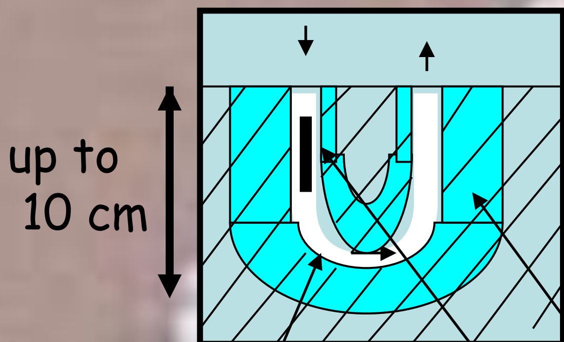


direction of nutrient flux via excretion and oxygen transfer via undulating breathing movements





Chironomid larvae
(midge fly larvae, Chironomidae)



food is brought by undulating movements or
collected from the surface as a „planktonic rain“

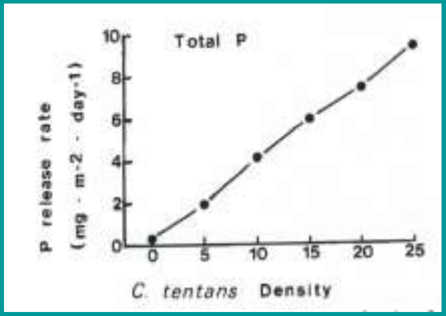
burrow of a chironomid larva is surrounded by oxygenated sediment, even if the sediment as a whole is depleted in oxygen

Consequencies of bioturbation by chironomid larvae for DO and nutrient flux through water-sediment interface

- **O2 penetration into sediments resulting in**

✓ raising mineralization processes in organic rich substrate
(e.g. Stief, de Beer 2006, Lagauzere et al. 2009, 2011)

✓ concentrations of phosphate, nitrate, iron(II) and ammonium ions significantly lower around ventilated burrows of *Chironomus plumosus*
(e.g. Lewandowski et al. 2007, Gunnars et al. 2002, Svensson 1998, Biswas et al. 2009 and others)



Gallepp 1979 ex Andersson et al. 1988

Nevertheless a positive relation between the rate of phosphate liberation from sediment cores and the amount of benthic macrofauna has been observed in several investigations (Holdren, Armstrong 1980, Wisniewski, Planter 1985, Starkel 1985).

Bioturbation and phosphorus – contradiction in terms of importance

Obviously, the attitudes on the impact
of bioturbation upon phosphorus cycling
are not unanimous

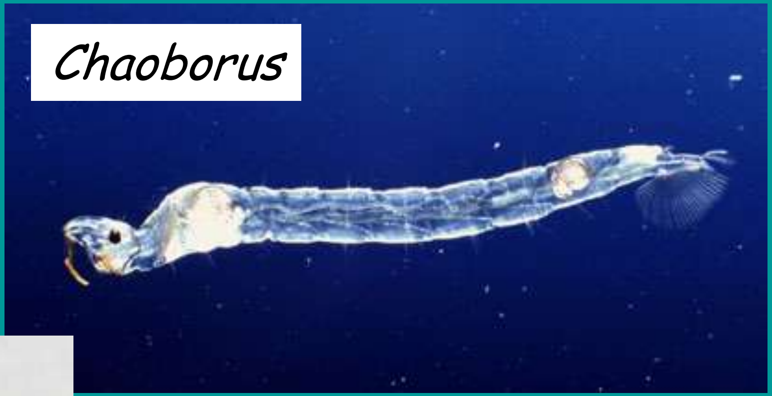
⇒

certainly bioturbation is an important process for the mineralization of sedimented particulate organic matter and for the subsequent return of dissolved substances to the water,
however
an increased release of phosphorus from sediment to water in the presence of macroinvertebrates is most likely mainly a physical mixing phenomenon
(Andersson et al. 1988)

Tubificids

- no alterations in DO flux through water sediment interface contrary to the impact of chironomid larvae (see above) (Zhang et al. 2009)
- markedly higher inhibition of SRP (soluble reactive phosphorus) release from sediments compared to chironomids (Mitraszewski & Uchmanski 1989, Stief & de Beer 2002, Zhang et al. 2009)
- considerable effect regarding nutrient transfer through sediment-water interface due to their excretion

Other invertebrates contributing to bioturbation are generally all those inhabiting muddy soft substrates like e.g. mussels (*Anodonta*, *Synanodonta*, *Unio*), phantom midge larvae (Chaoboridae), mayfly nymphs (*Caenis*), alder fly larvae (*Sialis*) and water louse (*Asellus aquaticus*) –
data missing or very scarce



Benthivorous fish

- important regulators of aquatic community structure via direct and indirect influence on water transparency and nutrient recycling ⇒ **all biocoenoses** (Northcote 1988)
- feeding habits of benthivorous fish affect the amount of sediment stirred and ingested ⇒ **amount of nutrients and resting stages liberated and released**
- stirring of sediments by benthivorous fish increases
  (1) diffusion rates across the sediment-water interface
  (2) aerobic decomposition by aerating anaerobic sediments

(Graneli 1979, Kadir et al. 2006, Phan-Van et al. 2008)



Common carp (Cyprinus carpio)

- adult carp forage predominantly on benthic macroinvertebrates and when doing so, they provide a severe bioturbation of pond bottom

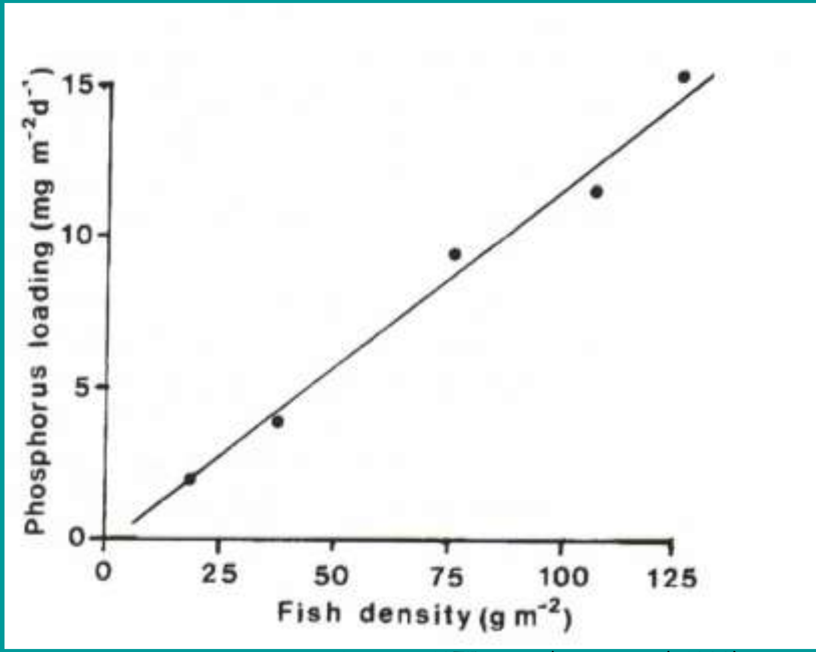
(Costa-Pierce and Pullin 1989)

- benthivorous carp expel large quantities of nutrients into the water column

(Kořínek et al. 1987, Andersson et al. 1988, Breukelaar et al. 1994, Matsuzaki et al. 2007)

- bioturbation-induced phosphorus release is of particular importance

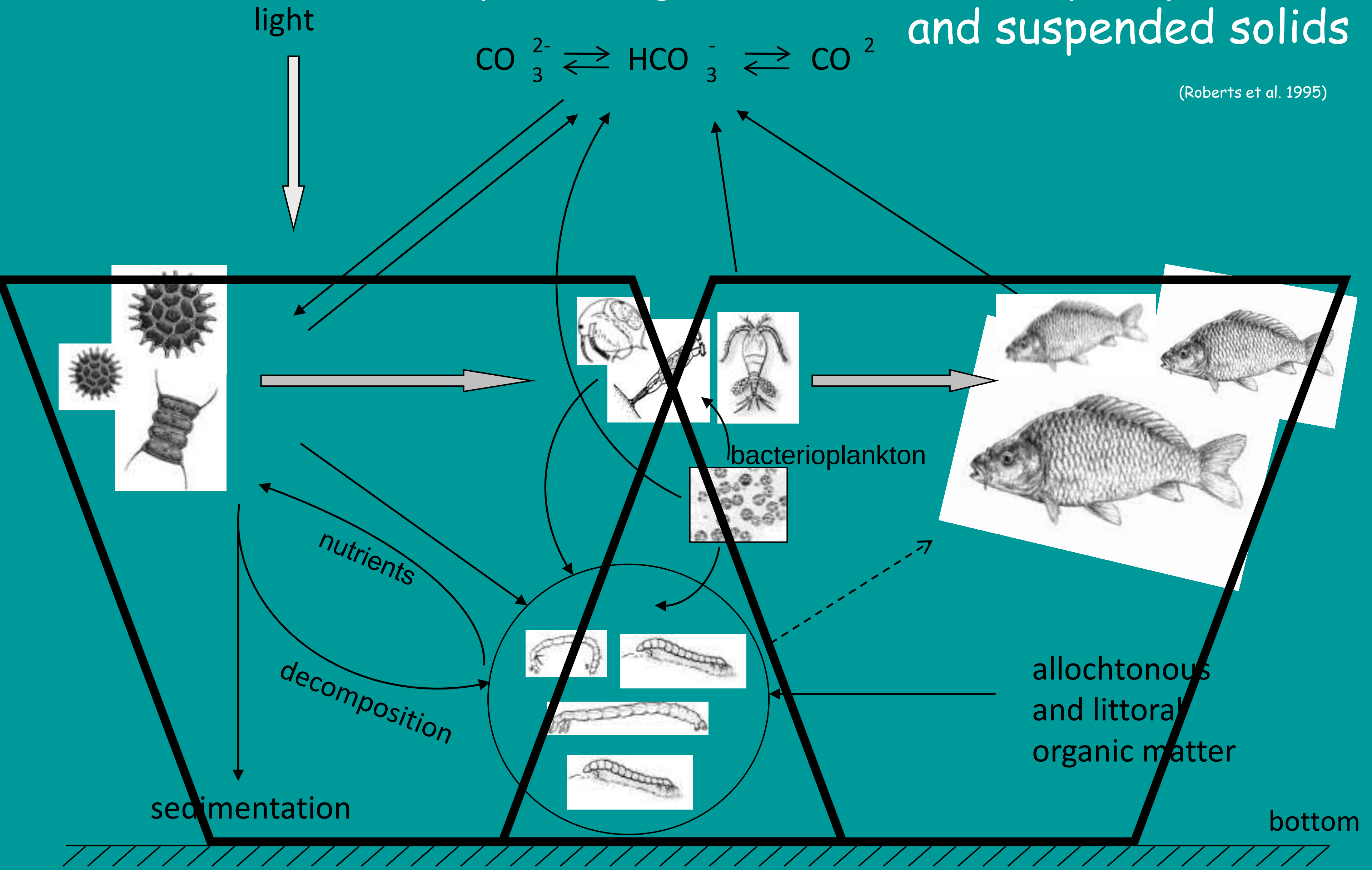
(Chakrabarty, Das 2007, Jana et al. 1992)



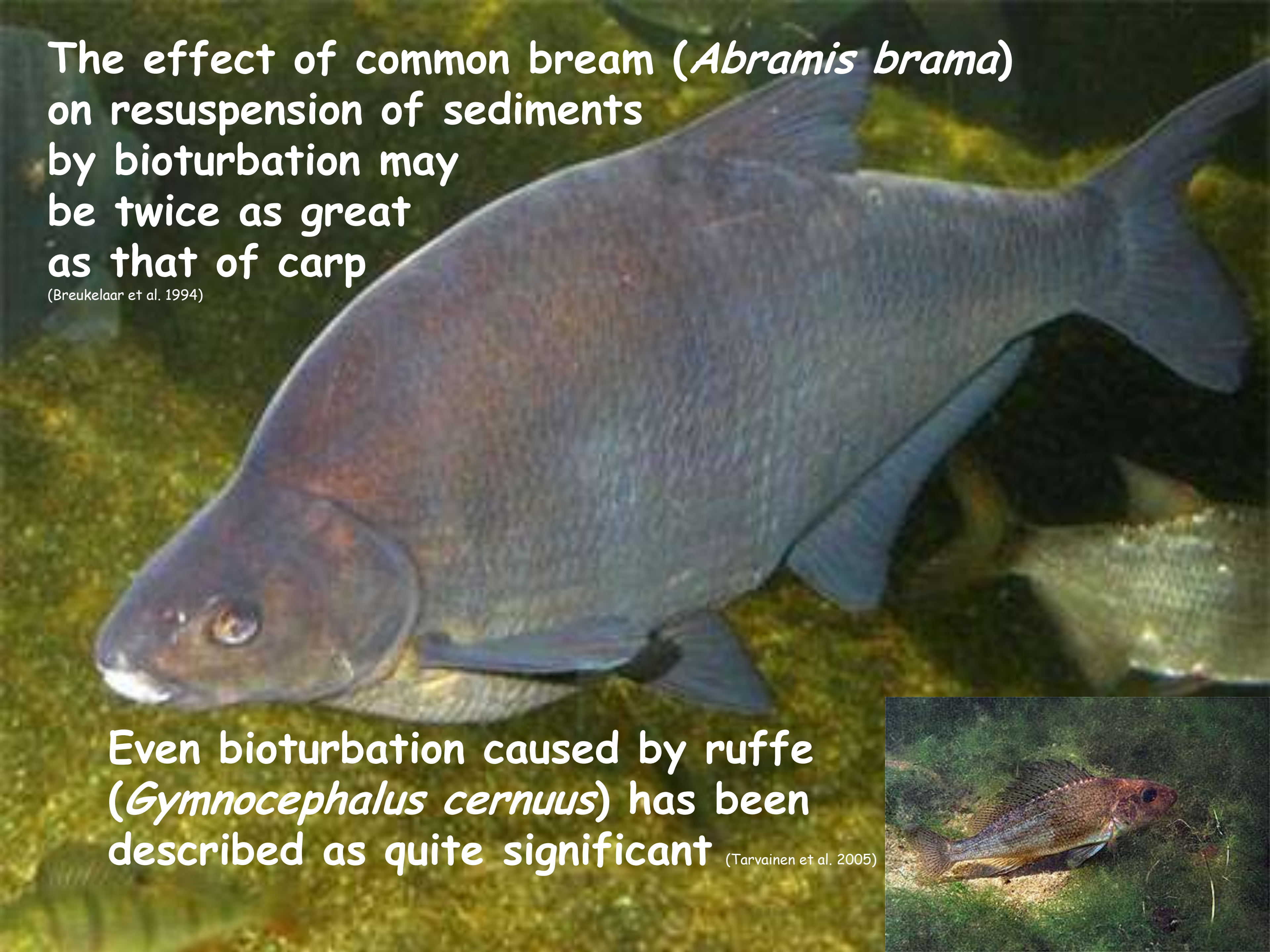
Lamarra 1975 ex Andersson et al. 1988)

Carp feeding activities ⇑ total phosphorus and suspended solids

(Roberts et al. 1995)



Adámek et al. 2010

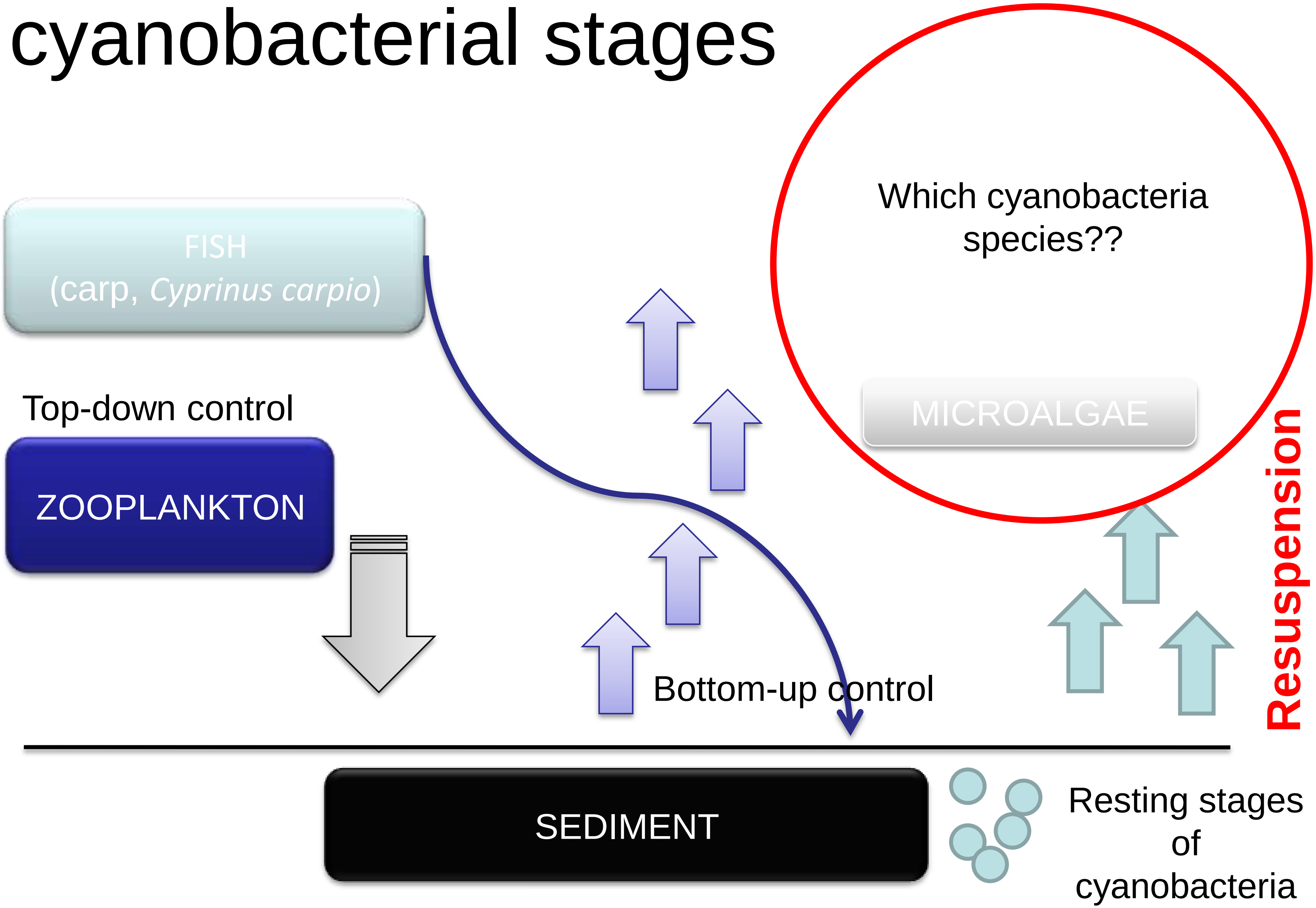


The effect of common bream (*Abramis brama*) on resuspension of sediments by bioturbation may be twice as great as that of carp

(Breukelaar et al. 1994)

Even bioturbation caused by ruffe (*Gymnocephalus cernuus*) has been described as quite significant (Tarvainen et al. 2005)

Bioturbation of resting cyanobacterial stages



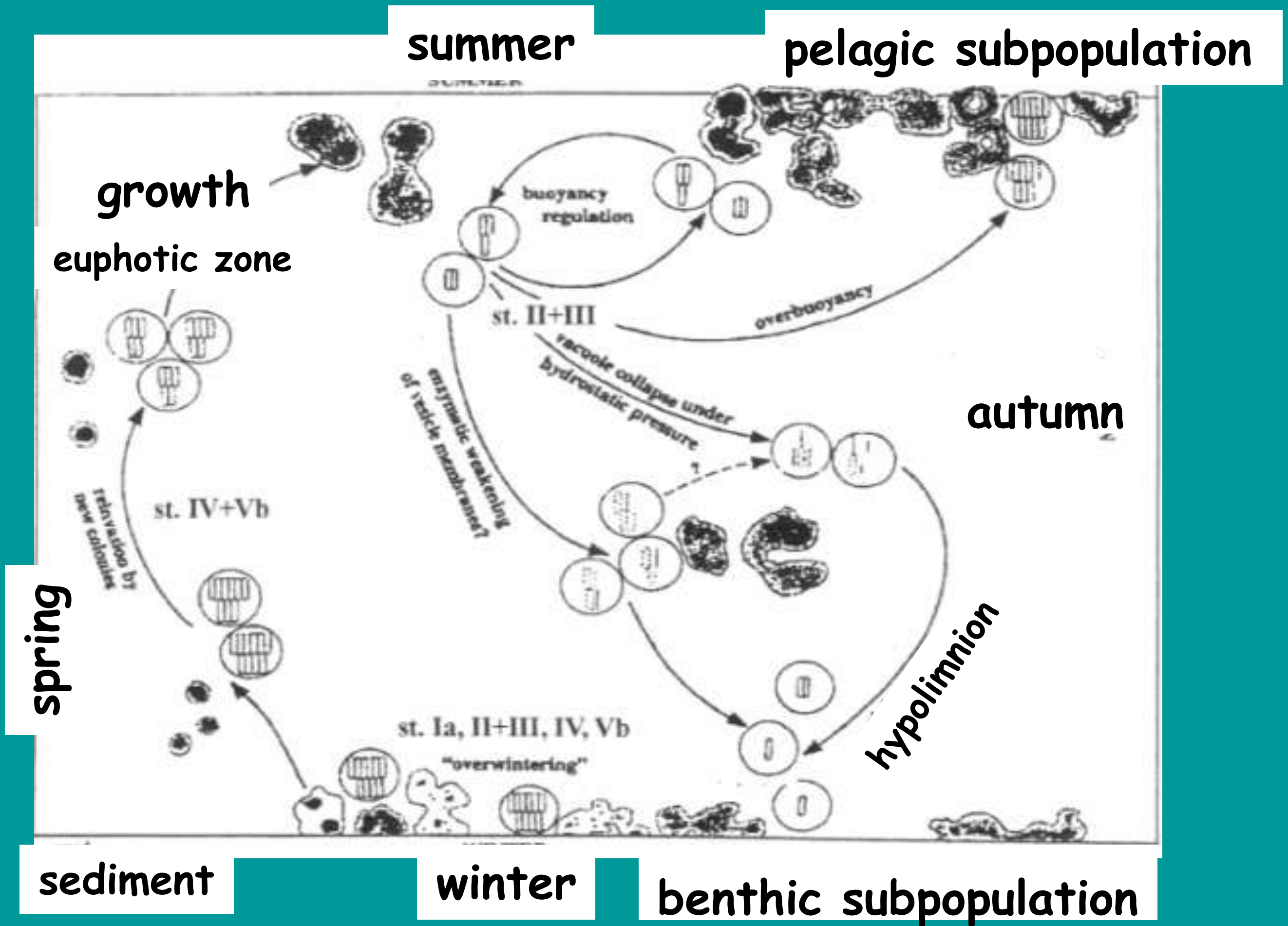
Bioturbation effects upon liberation and releasing of phytoplankton (and zooplankton) resting stages from mudddy substrates

– a special issue of extra high importance

Resting stages of many phyto- (and zooplankton) species are redistributed from the sediment by bioturbating animals. Bioturbation may transport them either deeper down in the sediment or, more frequently, closer to the surface and to create conditions favorable for their hatching (Brönmark & Hansson 2005).

However, benthic invertebrates may have a negative effect on algal recruitment by destroying them through digestion (Stahl-Delblanco & Hansson 2002).

Microcystis yearly life cycle



Reynolds et al. 1981

Besides a considerable bioturbating role of benthivorous fish (carp, bream & cyprinids in general) in liberation and releasing of cyanobacterial resting stages, also many invertebrates are able to provide a strong impact upon their transfer from the sediments into the water column.

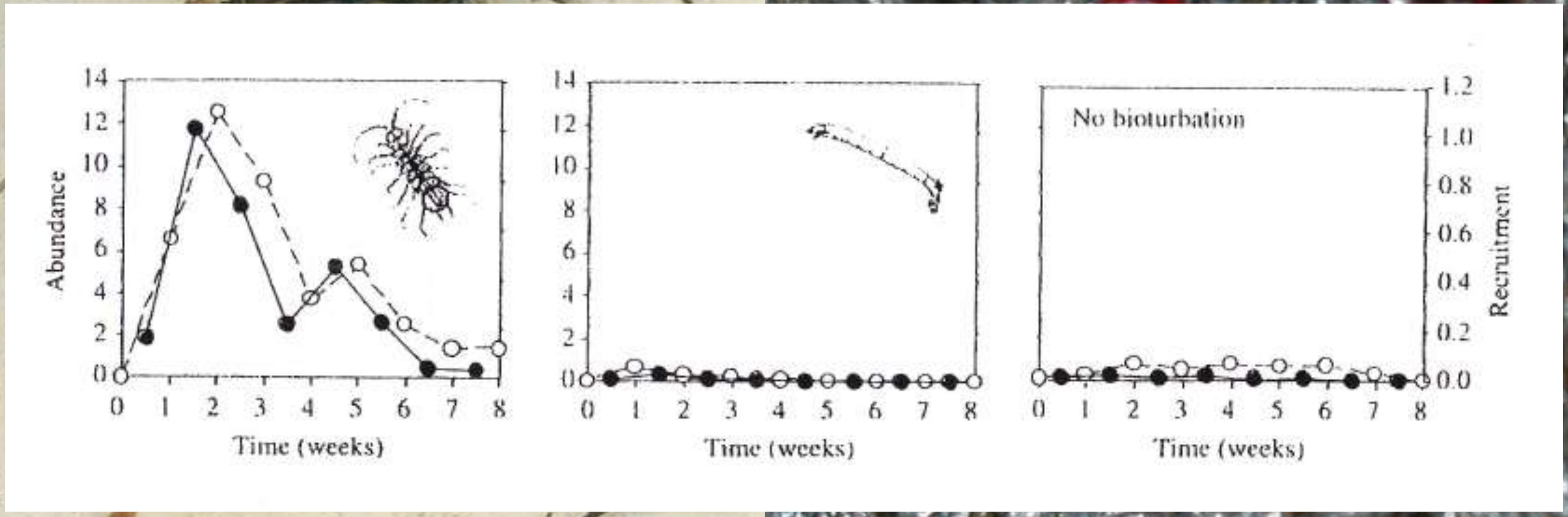
These effects were described in e.g.

chironomid larvae
(Stahl-Delblanco & Hansson 2002)

water louse (*Asellus aquaticus*)
(Stahl-Delblanco & Hansson 2002)

red swamp crayfish (*Procambarus clarkii*)
(Yamamoto 2010).

Surprisingly, compared to chironomids, the bioturbation activities of water louse (*Asellus aquaticus*) may be of considerably higher efficiency in liberation and shift of resting cyanobacteria (*Anabaena*) stages from the sediments into the water column (Stahl-Delblanco & Hansson 2002)



Many results indicate that algal recruitment rate might be more pronounced in littoral areas which are often dominated by *Asellus*, rather than in profundal areas of lakes, generally dominated by chironomids.

Shallow pond & lake areas may be crucial to the dynamics of phytoplankton (cyanobacteria in particular) as inoculation sites for pelagic populations (Brunberg & Blomqvist 2003). Thus not only macroinvertebrates but also benthivorous fish, predominantly searching for food in shallow littoral parts can be with certainty considered as one of the crucial factors contributing to their recruitment.

Indeed, the bioturbation processes are obviously of much higher importance than considered formerly and certainly deserve our future careful attention in studies of carp pond ecosystems functioning.

Thank you for your attention!

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