Disruption of sediment transport in rivers – Ecological impacts

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(1) Natural reference – The role of sediments in the river ecosystem & continuum

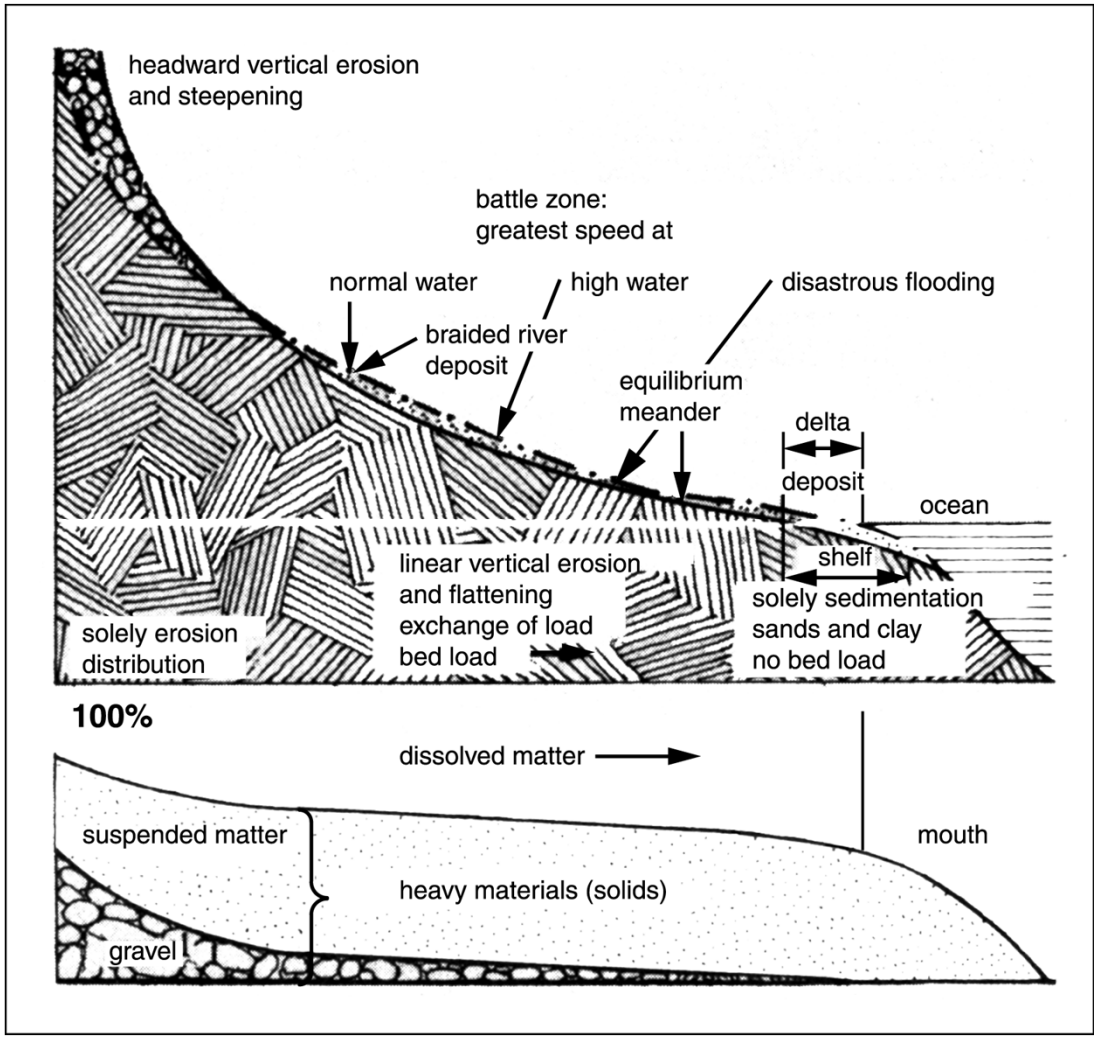
(2) Human impacts by dams – The effects on sediment transportation and the biota (benthos and fish)

(3) Advice to mitigate these impacts

Ideal equilibrium profile of a river

Above: gradient curve, erosion, accretion

Below: composition of the load



Slope & geology matter

Hydrolological dynamics

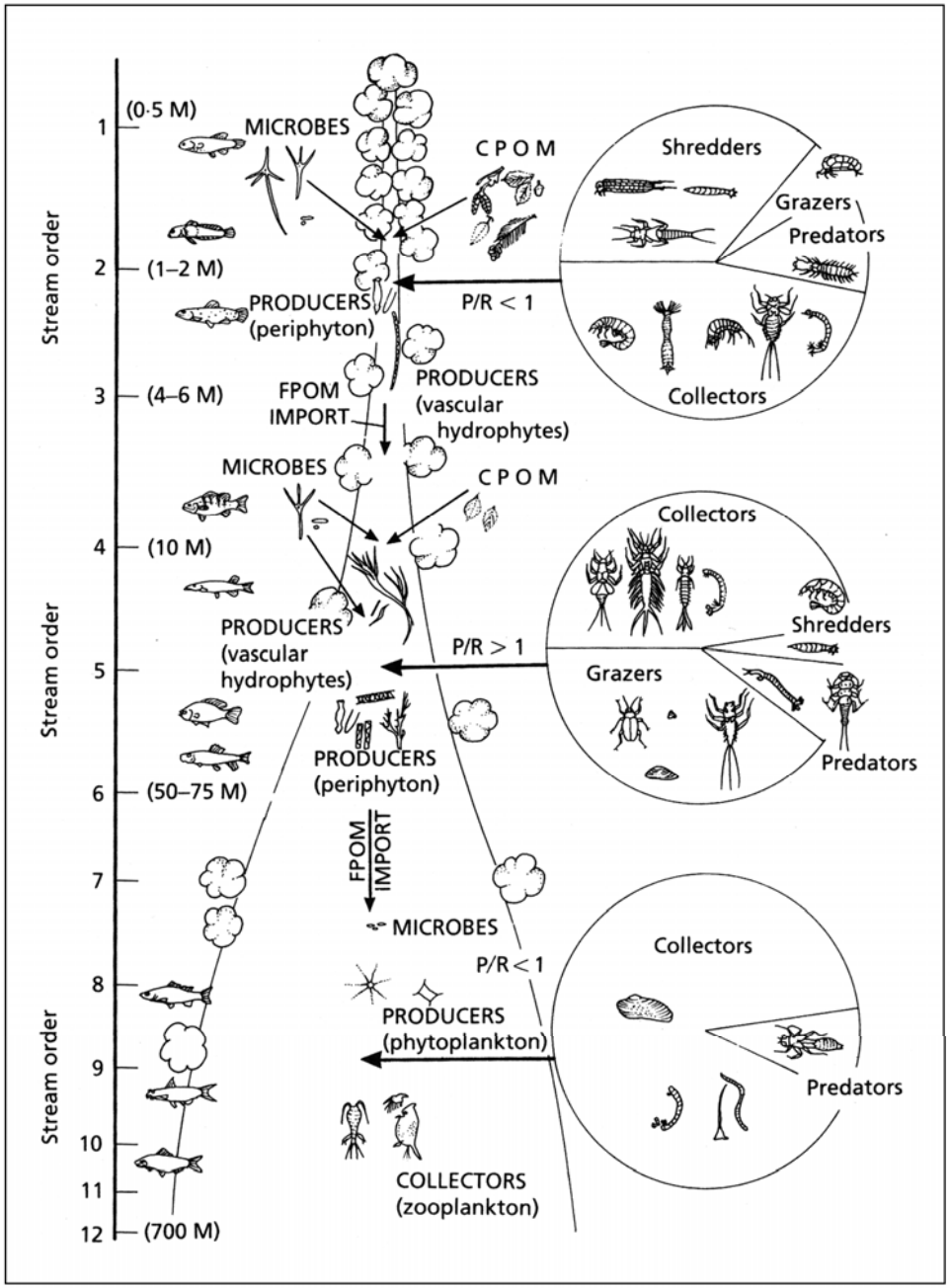
Erosion / Accumulation / Islands

Bedload / Suspended matter

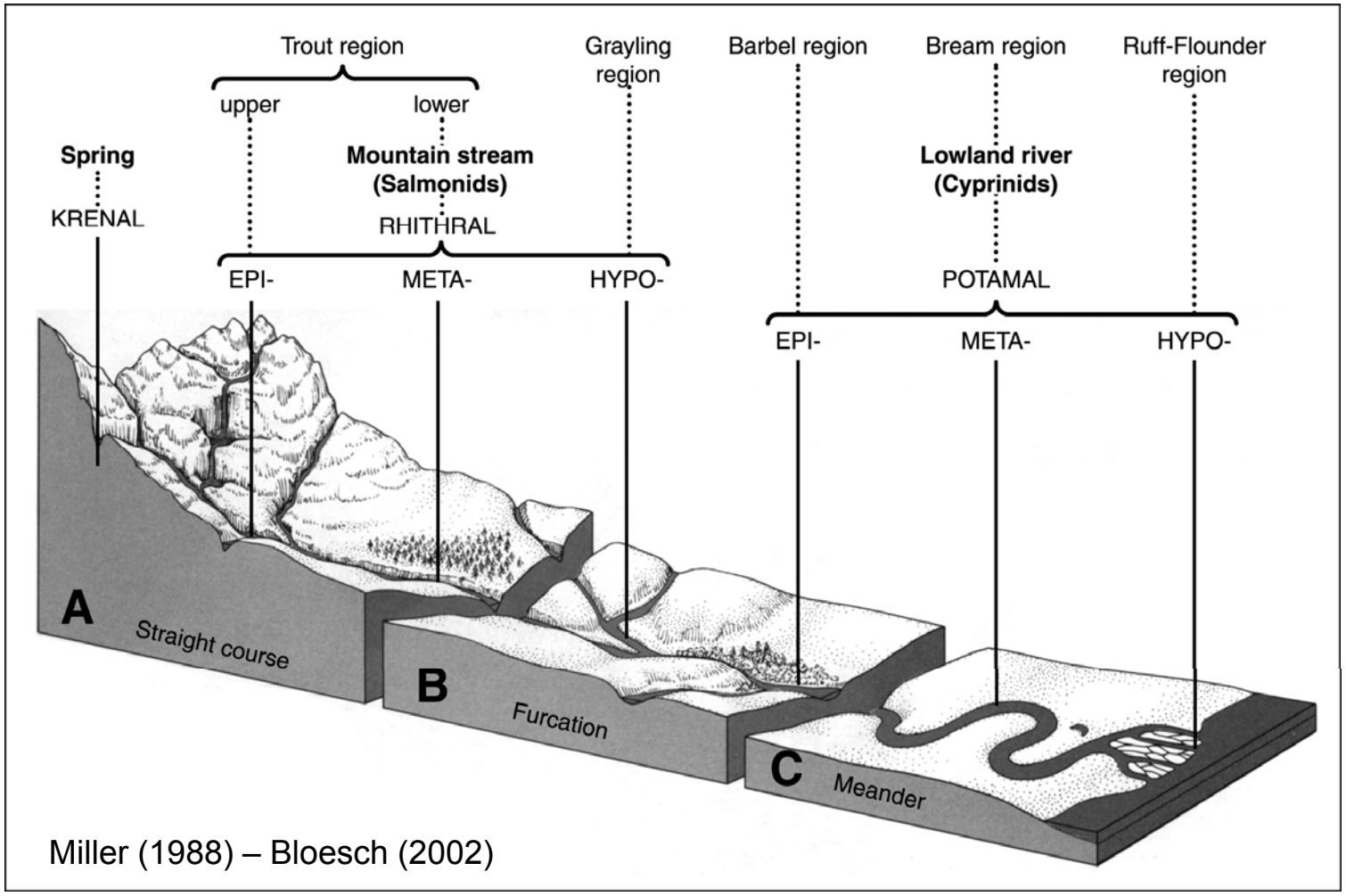
Riverbed is habitat for biota

River continuum concept (Vannote et al. 1980)

Substratum, POM & Biota change along the river



Biocoenotic river zonation (Illies 1961, 1978)
Fish river zonation (Huet 1949)



Miller (1988) – Bloesch (2002)

→ Reference sites

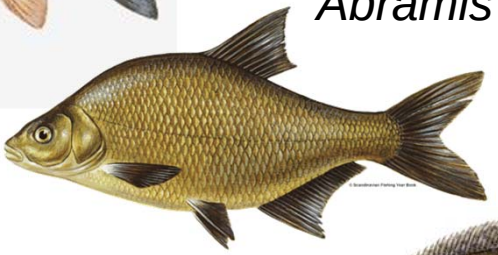
with undisturbed natural aquatic communities

Fish Regions – Key Species

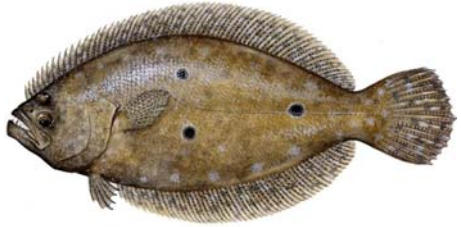
Brown Trout
Salmo trutta

Grayling
Thymallus thymallus

Barbel
Barbus barbus



Bream
Abramis brama

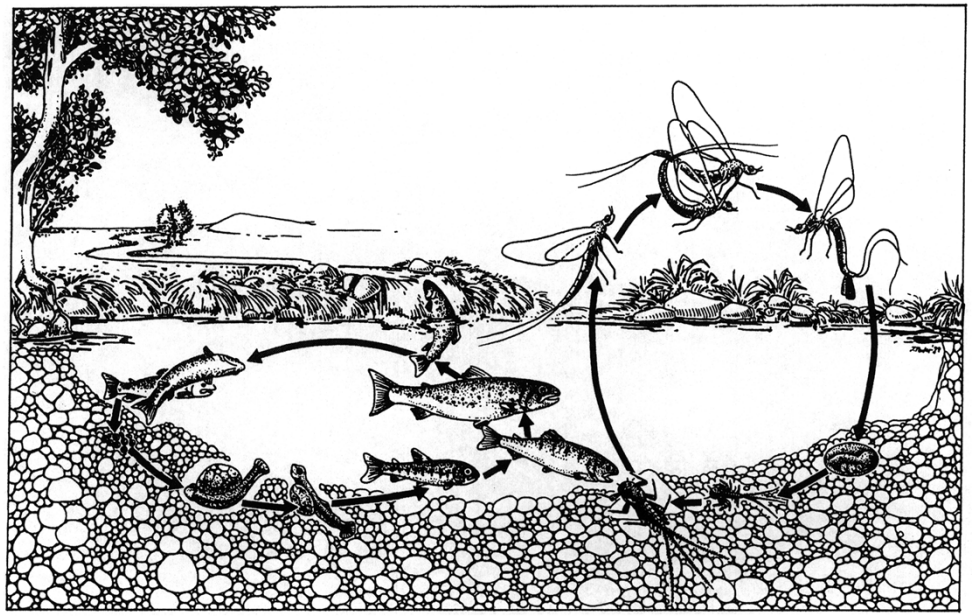


Flounder
Platichthys flesus

Regelsbrunn/Danube: morphological structure of the side arm system during low flow

Heterogeneity of sediments/ habitats fosters biodiversity

River sediments are habitats for biota



Bloesch (1994) – Drawing J. Peter

The needs of invertebrates & fish for living in a river

Reproduction	Substrate, Riparian zone
Development Growth	Oxygen, Temperature
Food intake	Substrate, Prey
Movement Migration	Adaption to current, Continuum
Energy & Metabolism (Respiration)	Current, Oxygen, Temperature

Sediment is habitat

Caddis fly (Trichoptera)

Sediment is habitat: Depth profile (Freeze core)

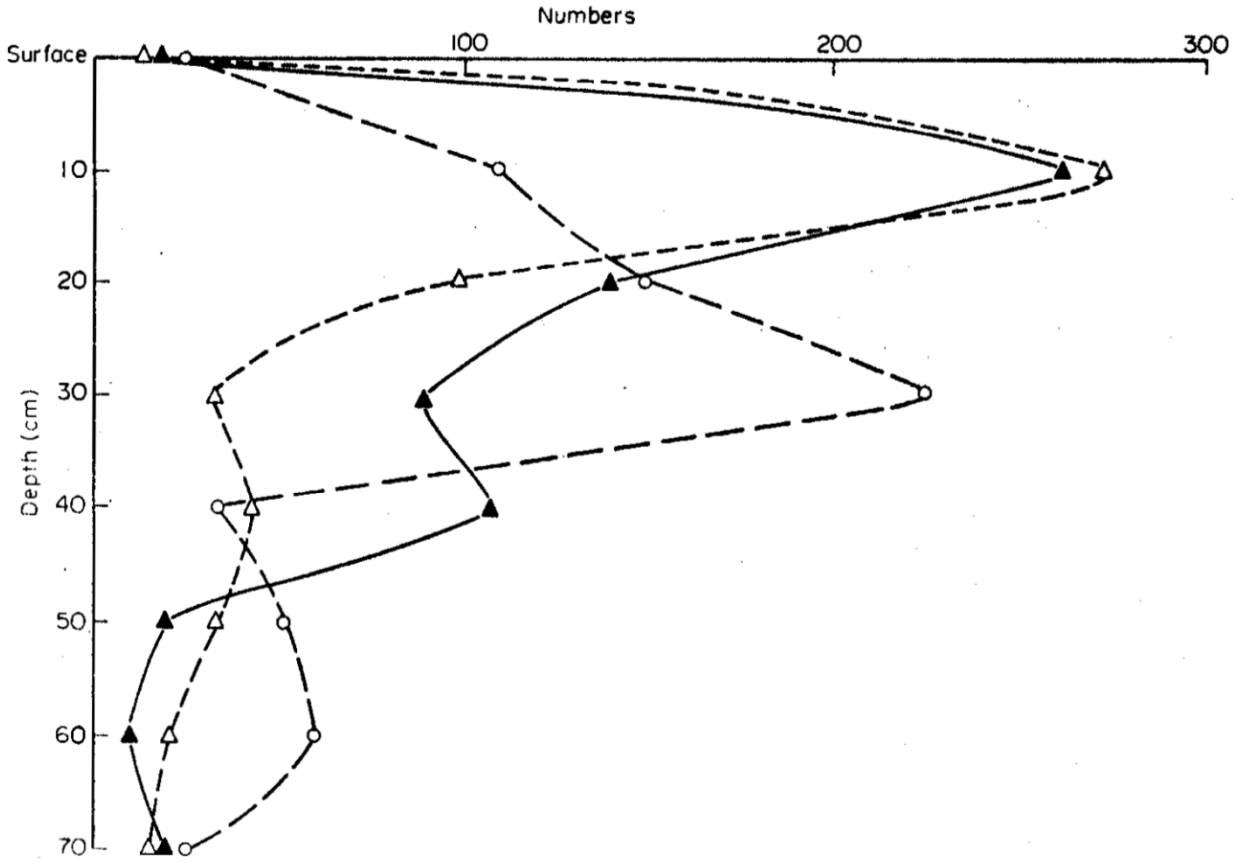


Fig. 10. Plot of the total number of animals/125 ml core unit *vs.* depth in the substrate for May (▲——▲), June (○— — —○) and July (△- - - △) 1971. (Speed River).

Williams & Hynes, Freshwat. Biol. 1974

Interstitial needs flow-through and oxygen (benthos, fish eggs)

Q dynamics: high flow events clean the interstitial, prevent colmation

Sediment is habitat

Chub (Leuciscus cephalus) spawning – Sava River

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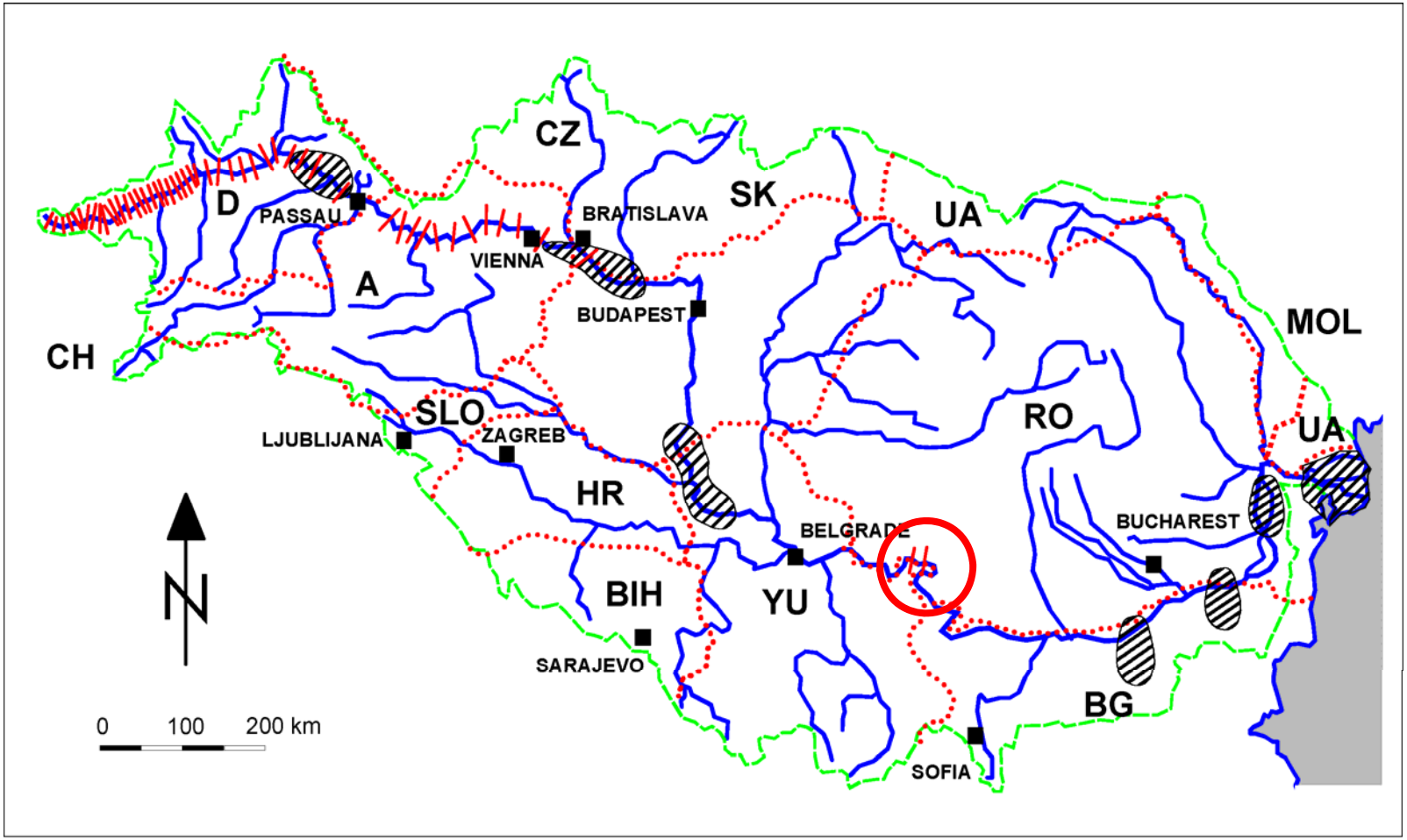
(2) Human impacts by dams – The effects on sediment transportation and the biota (benthos and fish)

Sediment transport and budgets
Human regulations & impacts

- River continuum accepted in WFD
  (sediment transport, migration)
- Sediments are not SWMI in the DRBMP (ICPDR)
- Sediment budgets are difficult to achieve
  (e.g. Rhine, Danube)
- The Iron Gate reservoir retains about two-thirds of the suspended solids, and sediment delivery to the Delta decreased from 53 to 18 million tons/yr (WWF 2008)

Dams in the Danube River and 59 major tributaries

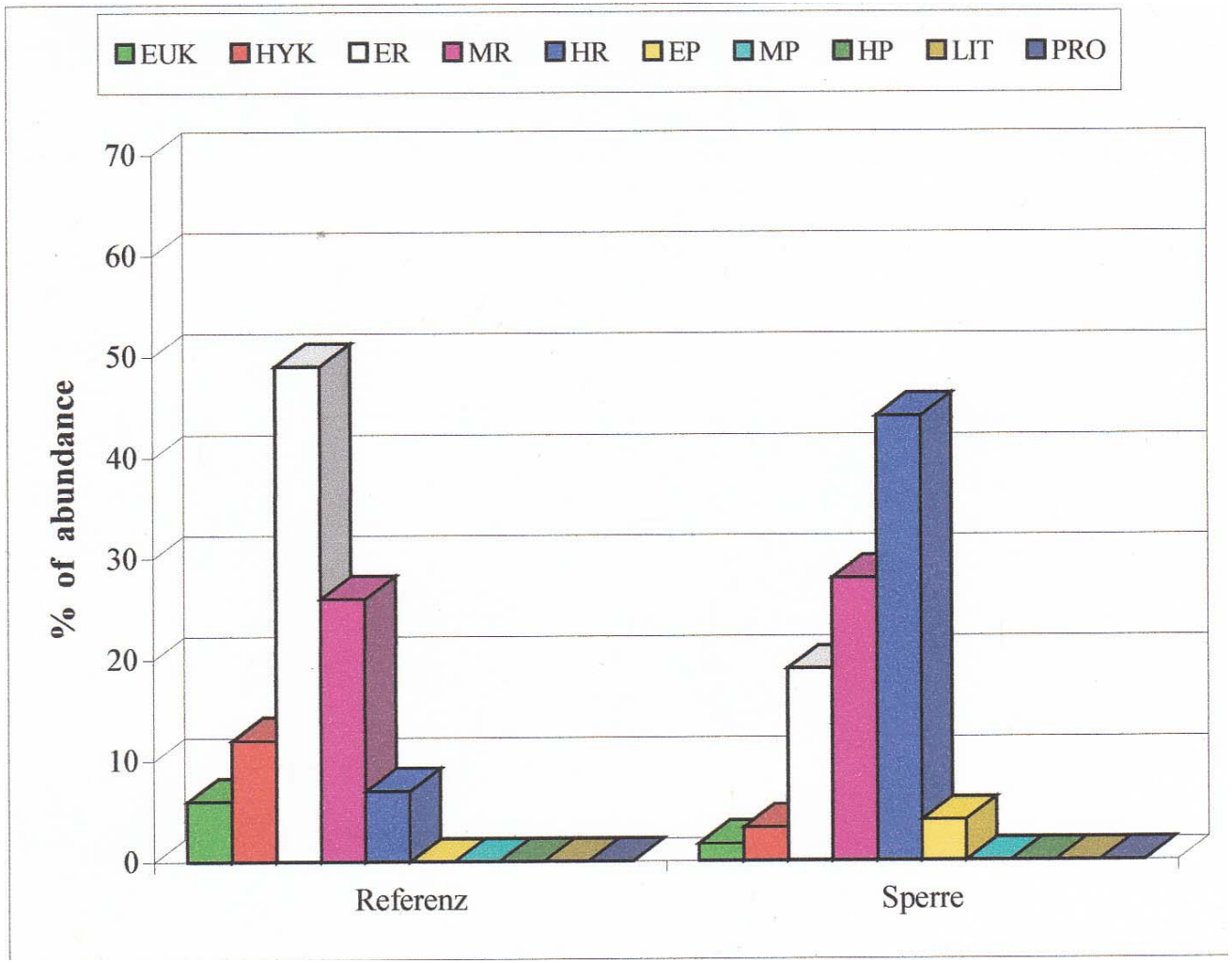


848 dams (156 hydropower) in the DRB (Reinartz 2002)
free flowing sections: 8818 km = 51%

Effects of dams: Sediment quantity

- Disruption of the continuum (longitudinal connectivity: sediments, benthos, fish migration)
- Abiotic effects: upstream (reservoir) siltation, accumulation (adsorption) of contaminants; downstream river bed incision, lowering of groundwater table
- Biotic effects: upstream rheophilic (lotic) benthos and fish replaced by lentic species; downstream drying out of floodplains (e.g. Gabcikovo, Danube)
- River basin lacks sediment supply

Change of biocoenotic regions due to bedload retention by dams for flood protection



Ebniter Aach (Bregenz) – Moog: Fauna Austriaca 1995

Effects of dams: Sediment quality

- Suspended and retained fine sediments (< 63 µm) adsorb and accumulate contaminants)
- Bioaccumulation & biomagnification in the food chain

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(3) Advice to mitigate these impacts

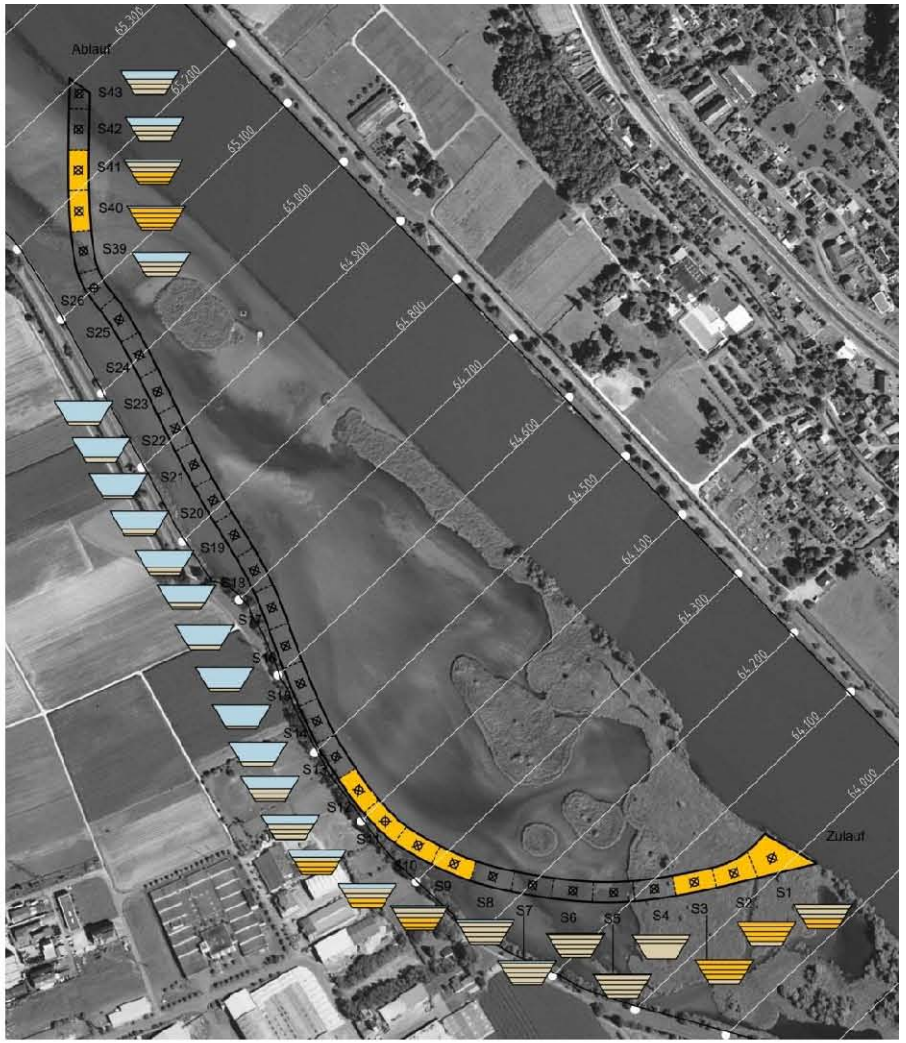
Mitigation of impacts

- Use high flow events to transport bedload sediments across weirs and dams (e.g. Masterplan High Rhine)
- Contaminated sediments need to be extracted and disposed as solid waste in specific treatments
- Local gravel deposition in hydropower chains (erosive and non-erosive sediment bars)
- Sediment spills of reservoirs: controlled and monitored: high turbidity kills fish (clogging the gills), extraction of contaminated sediments
- Technical fish passes or near natural by-passes

Projekt Stand Mai 2013

- Rinne ca. 1500m lang / 2m tief / 24m breit

- Sedimentmenge 28’266 m^3
- Einleitung 20’178 m^3
- Entsorgung 8’088 m^3 nach Aushubrichtlinie ARL und Technischer Verordnung für Abfälle TVA

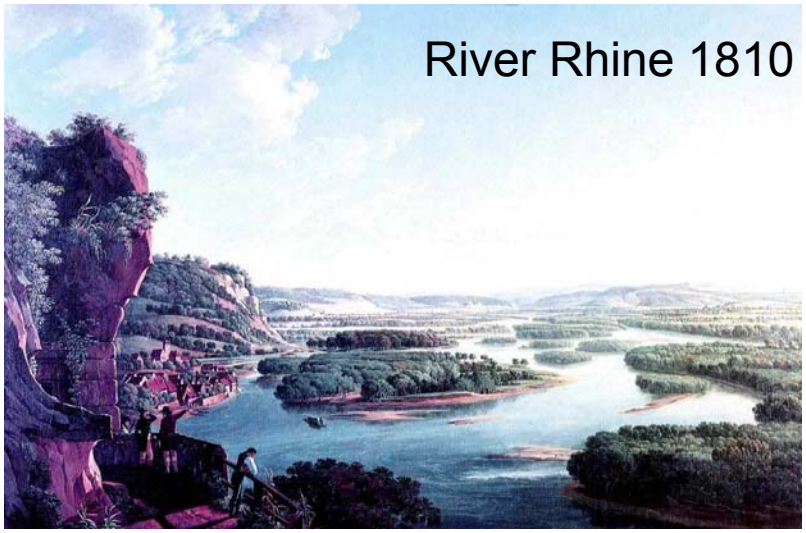


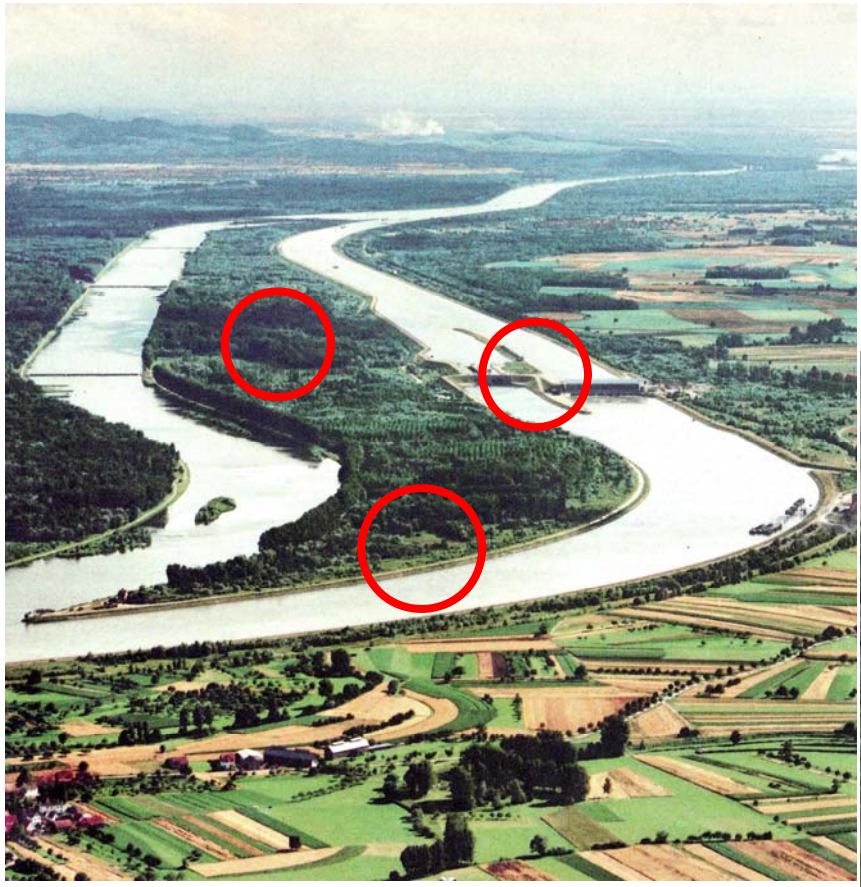
Zulauf

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	39	40	41	42	43
-	-	-	-	0.10	0.10	0.20	0.20	0.20	0.40	0.58	0.75	1.00	1.60	1.75	1.70	1.65	1.45	1.35	1.45	1.80	1.60	1.70	> 2.0	> 2.0	> 2.0	0.80	0.20	0.20	0.70	0.70
456	456	456	456	444	444	432	432	432																			432	432		
408	408	408	310	396	396	384	384	384	408	386	366																384	384	372	372
360	360	360		348	348	336	336	336	360	338	318	336														360	336	336	324	324
312	312	312	1034	300	300	288	288	288	312	290	270	288														312	288	288	276	338
264	264	264		194	194	126	126	126	264	140	30	126	264	160	194	228	376	454	376	126	264	194				264	126	126	62	
1800	1800	1800	1800	1682	1682	1566	1566	1566	1344	1154	984	750	264	160	194	228	376	454	376	126	264	194	0	0	0	936	1566	1566	1034	1034

Ablauf

Ecological function
Vision: back into the future





River Rhine 1997

Lower Mura 2005