When enough is too little

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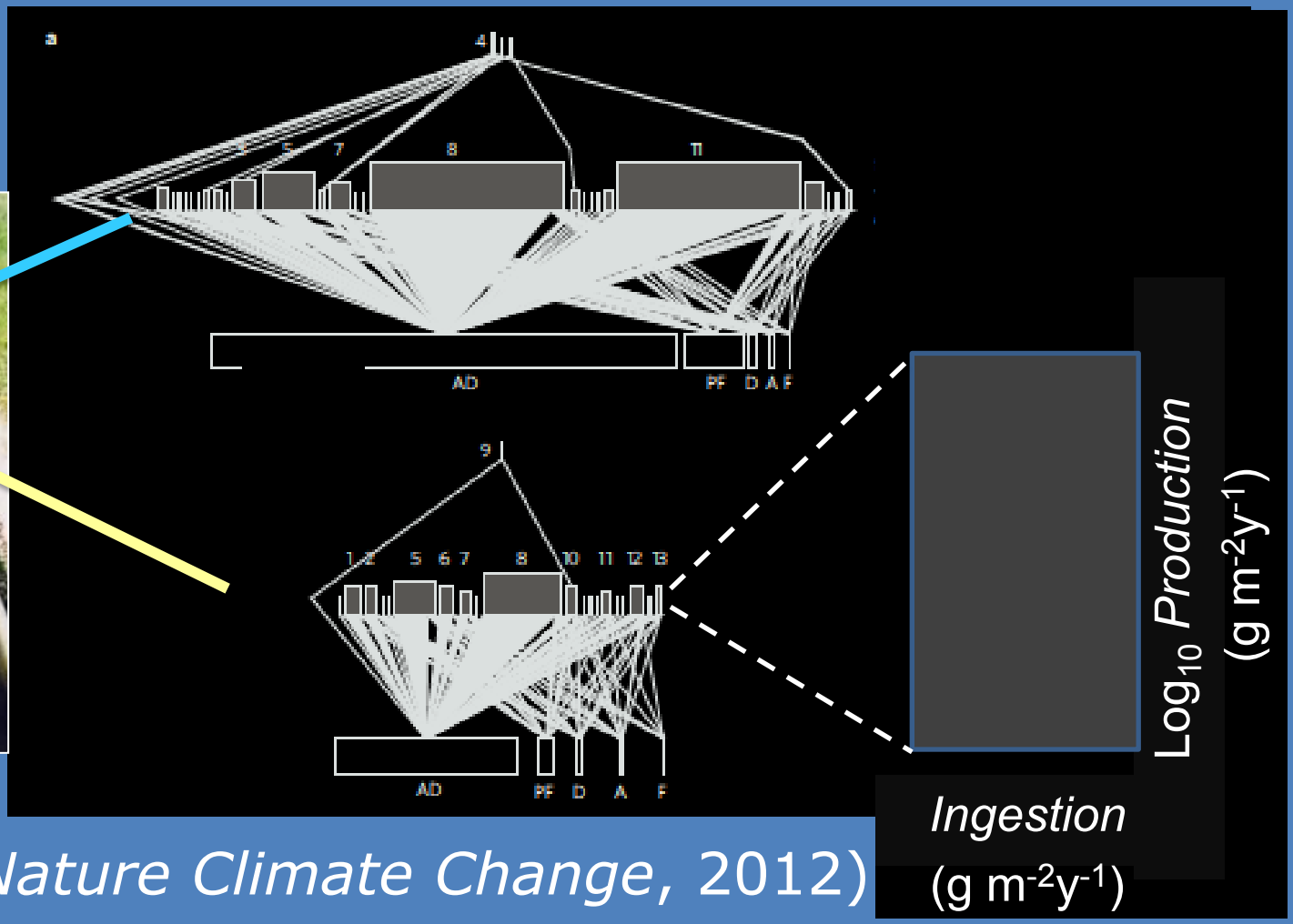
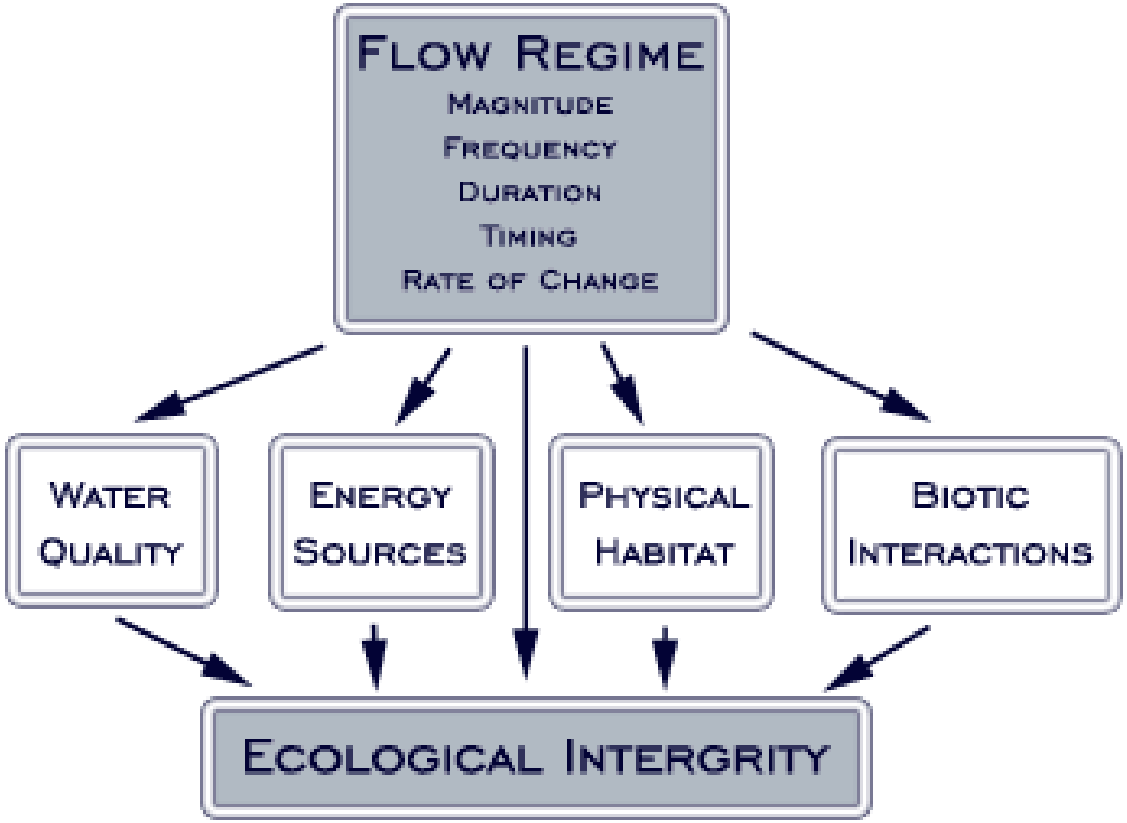
Sometimes enough is too little…

Effects are complex: an experiment at the food web (ecosystem) scale

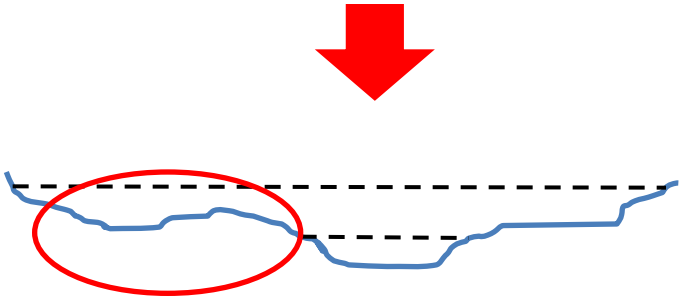


Ledger et al (*Nature Climate Change*, 2012)

THE RIVER FLOW PARADIGM…. (Poff et al 1996)

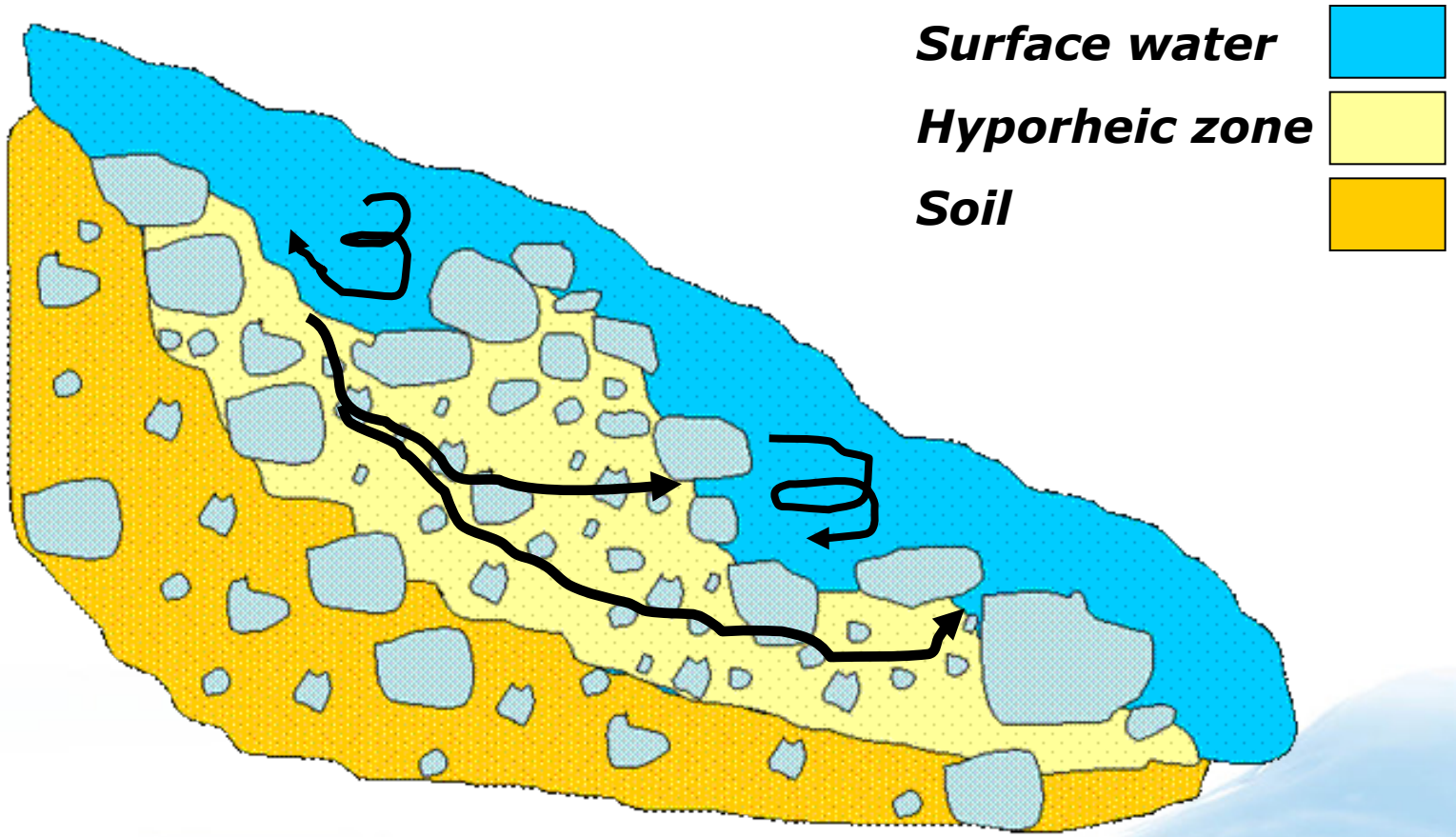


Ecological impacts of low flow



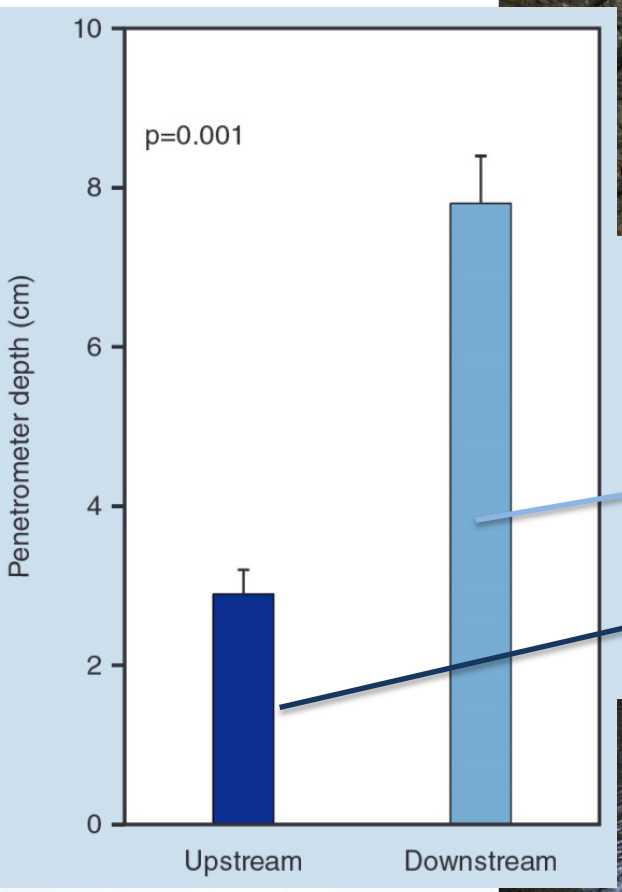
Loss of lateral and longitudinal habitats

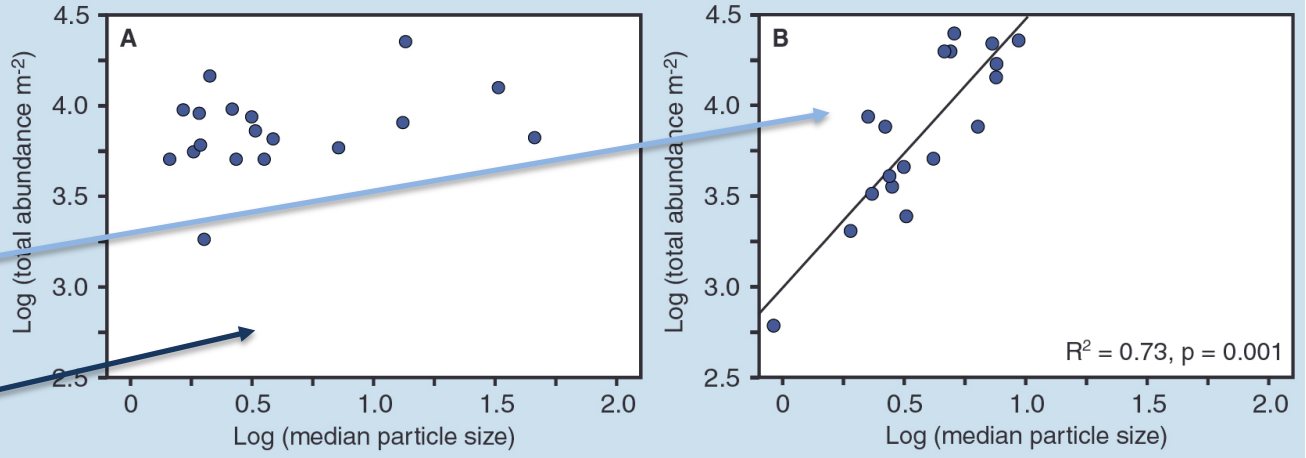
Ecological impacts of low flow



Stream longitudinal section

Fortification of the river bed and loss of interstitial habitats = fewer macroinvertebrates





Potential links – HYMO stress

- *Loss of hyporheric zone (macroinverts, fish)*
- *Low oxygen levels*
- *(macroinvertebrates)*
- *Scouring at high flows*
- *(perifyton)*
- *Changes in biotic interactions such as predation*

Drivers

Discharge/ gradient

Geology

Flow

Substrate

Fines

Terr/aqua

Macro features:
Channel form
Pool-riffle sequence

O_2 / Temp

Effects on biota

Colonization potential

NIVA

What do we know?

- *Review of 165 peer review papers by Poff & Zimmerman (2010) on ecological responses to changes in river flow*

Freshwater Biology

Freshwater Biology (2010) 55, 194–205 doi:10.1111/j.1365-2427.2009.02272.x

Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows

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SUMMARY

1. In an effort to develop quantitative relationships between various kinds of flow alteration and ecological responses, we reviewed 165 papers published over the last four decades, with a focus on more recent papers. Our aim was to determine if general relationships could be drawn from disparate case studies in the literature that might inform environmental flows science and management.

2. For all 165 papers we characterised flow alteration in terms of magnitude, frequency, duration, timing and rate of change as reported by the individual studies. Ecological responses were characterised according to taxonomic identity (macroinvertebrates, fish, riparian vegetation) and type of response (abundance, diversity, demographic para-

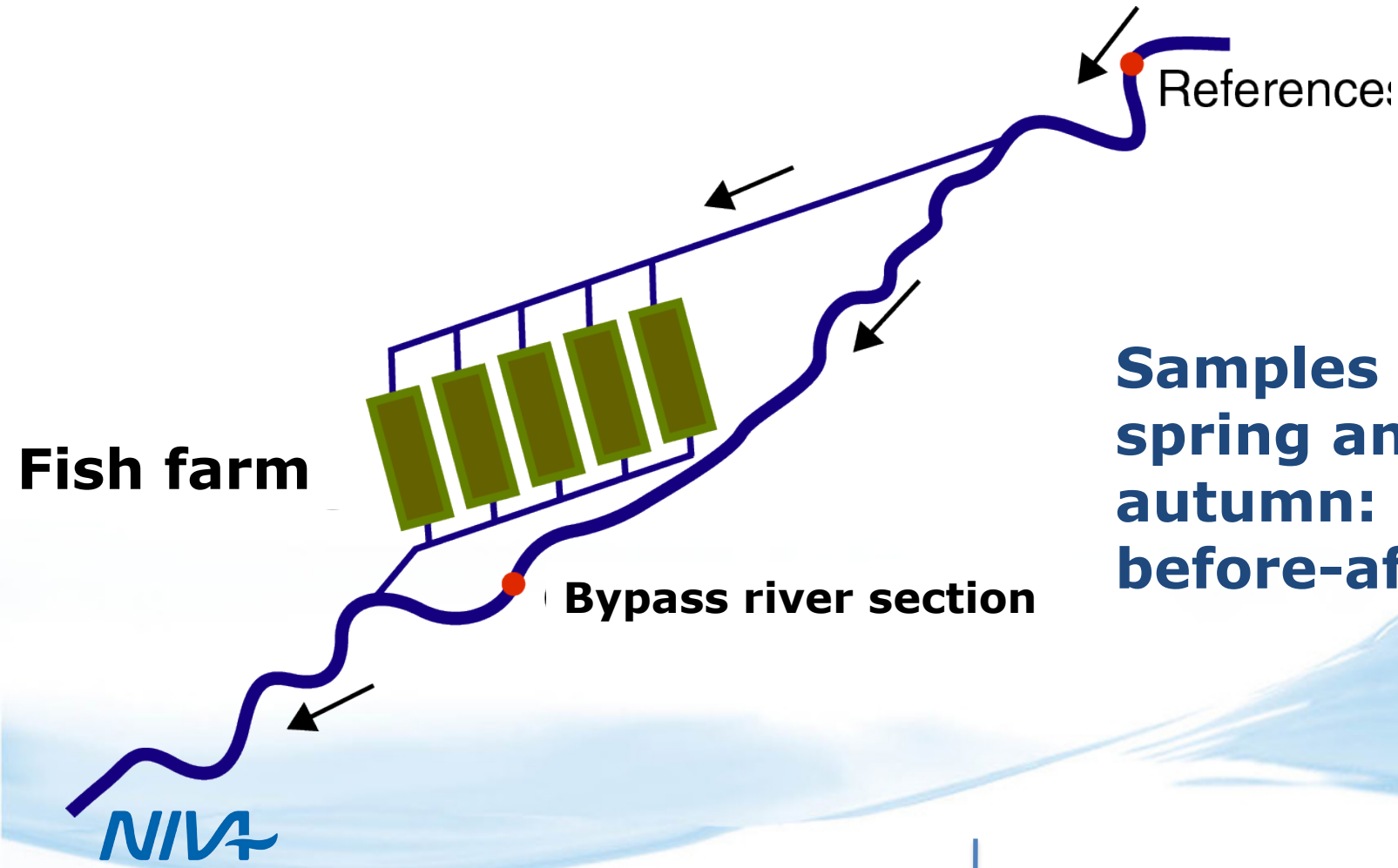
The review found that:

- Macroinvertebrates showed a variable response with both reduced and increased density/diversity with changes in flow
- Fish showed in contrast a consistent negative response in relation to both low and high flow **if** there was an effect
- The overall conclusion was, however, that is was not possible to establish a consistent quantitative response between biota and flow

Ecological impacts of low flow

- Extremely few suitable data sets and almost none with a robust statistically design (e.g. BACI)
- A small study at Danish fish farms can illustrate some of the issues with low flow
- Five inland fish farms where summer discharge in bypass stream sections was reduced to less than 50 % of median minimum

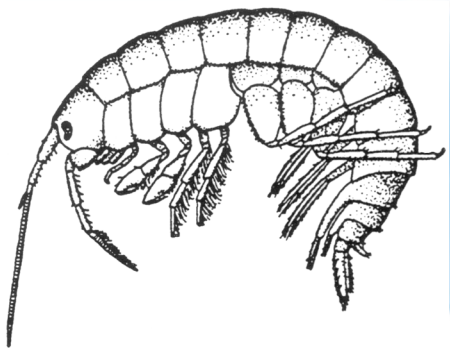
Impacts of low flow: control-impact design



Samples in spring and early autumn: before-after

WFD compliant metric

- Danish Stream Fauna Index (DSFI) is the only metric used to assess Ecological Status in Denmark independent of stressor type
- Has 7 classes from 1 (bad) to 7 (High). GES is achieved at fauna class 5



Impact on ecological status measured using DSFI

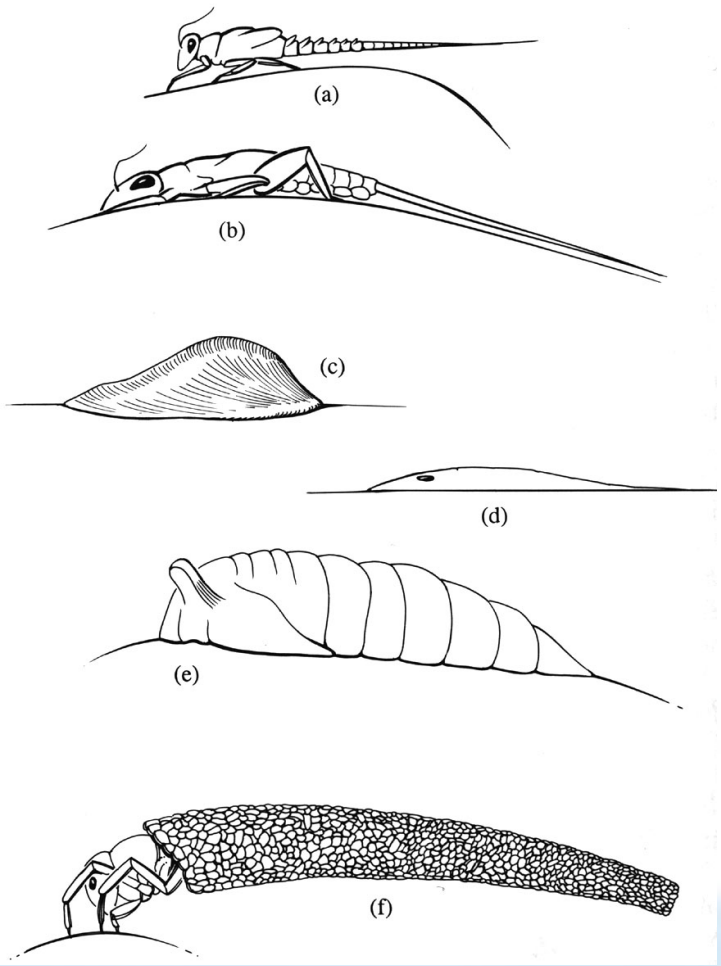
Stream	Reference May	Bypass May	Reference September	Bypass September
Sunds Nørre Å	7	6 ↓	7	6 ↓
Haller Å	5	5	5	5
Linå	7	5 ↓	5	4 ↓
Tågelund Bæk	5	7 ↑	7	5 ↓
Odder Bæk	5	5	5	5

- **Small impact of low flows – least in spring**
- **Only one reach did not meet GES – the bypass in stream Linå in September (fauna class 4)**

Influence of flow-substrate interactions

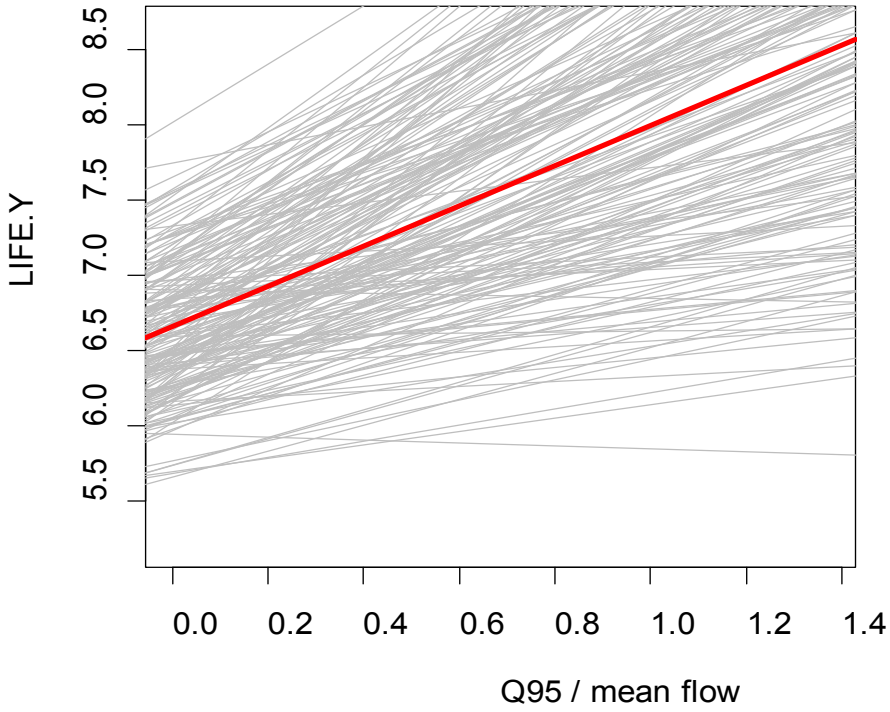
- Study of the combined effects of discharge (time series), channel plan form and substrate conditions in 33 Danish lowland streams.
- Use of benthic invertebrates and the LIFE Score (*Lotic Invertebrate index for Flow Evaluation* (LIFE))(Extence et al, 1999), where high scores (max. 12) signifies undisturbed, or only slightly impacted flow conditions, while low values (min. 1) indicates a negative effect of flow
- Data from Dunbar et al. (2010) *Freshwater Biology*

LIFE Score: A low flow sensitive metric



Flow (velocity) group		Abundance in sample			
		A 1-9	B 10-99	C 100-999	D 1000+
I	Rapid	9	10	11	12
II	Moderate/fast	8	9	10	11
III	Slow/sluggish	7	7	7	7
IV	Flowing/standing	6	5	4	3
V	Standing	5	4	3	2
VI	Drought resistant	4	3	2	1

LIFE-score and hydrology



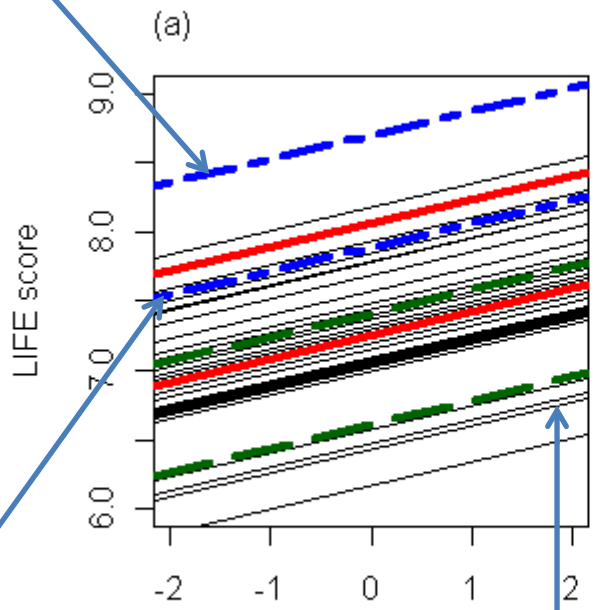
Each line (greyish) represent a simple regression from one stream, the red line all streams using mixed effect models

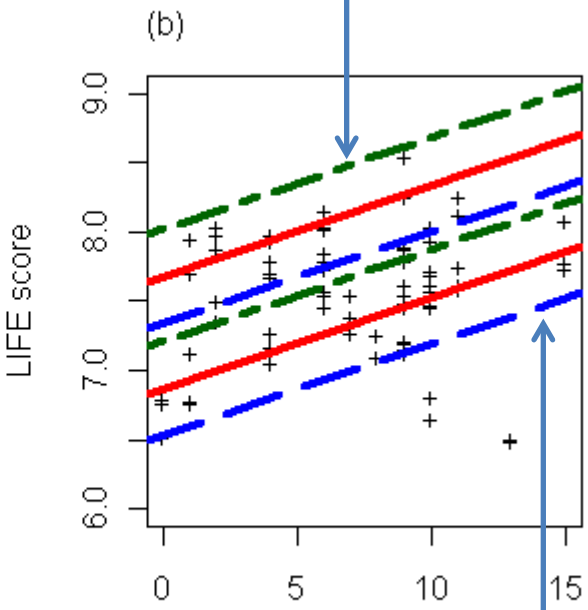
LIFE score increases (indicating a less disturbed community) significantly when low flow increases

Flow-HYMO intercations

Meandering – high substrate quality

Meandering - improved low flow





Channelised – high Substrate quality

Low flow intensitet

Substrate quality (DHQI)

Channelised – low Substrate quality

Channelised – low flow

There is some gains from using specific merics

Stream	LIFE Score Reference September	LIFE Score Bypass September	DSFI Reference September	DSFI Bypass September
Sunds Nørre Å	7,8	7,2	7	6
Haller Å	8,3	7,4	5	5
Linå	7,8	7,1	5	4
Tågelund Bæk	7,3	7,2	7	5
Odder Bæk	7,3	7,3	5	5

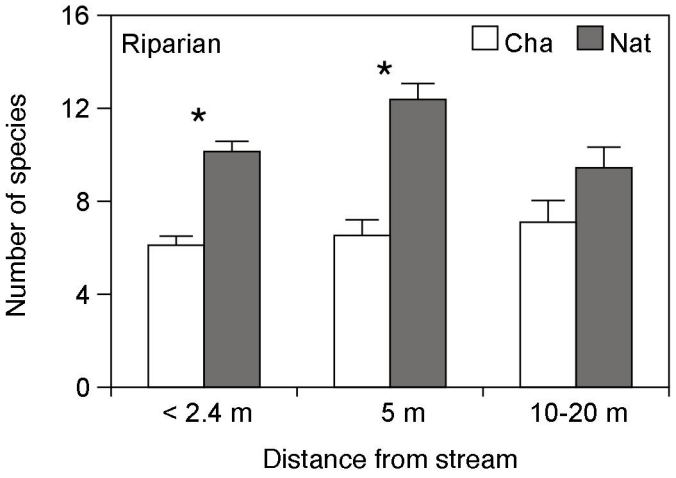
- **Calculation of LIFE Score increased sensitivity from 3 to 4 streams that showed a negative effect of low flow i.e. 20 % increase**
- **Sampling methods the same as DSFI i.e. targeting organic pollution with a non-proportional habitat sampling**

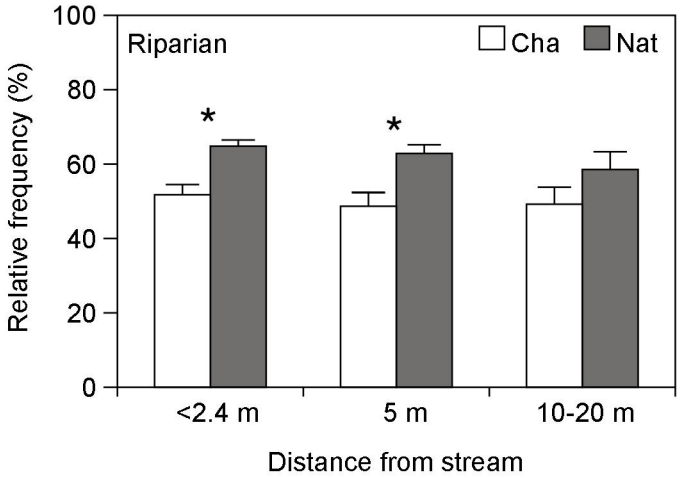
Metrics sensitive to hydrological alterations vs. other stressor specific metrics

	MESH	LIFE	ASPT (organic)	EPT (general)	SPEAR (pesticides)
Normal flow	0.61	0.52	0.59	0.44	0.6
Low flow	-0.58	-0.47	-0.52	-0.43	-0.55

high positives = good/low negatives = bad (+1 to – 1)

Plants are sensitive as well





Higher riparian plant diversity and frequency along natural streams

From Baattrup-Pedersen at al. 2005

NIVA

A general challenge….

BQE	Sampling method (often CEN standards)	HYMO diagnostics?
Algae (diatoms)	Single stones/macrophytes	No
Macroinvertebrates	1-3 m^2 stratified by «habitat» types along 20 to 50 m «reaches»	Yes e.g. LIFE, DFI, Mesh **but none intercalibrated**
Macrophytes	Reach scale assessments (50-100 m); coverage and species/taxa composition	No
Fish	Reaches (100 m or more)	Partly – the guilds approach relates to overall HYMO conditions

Why is it so difficult to assess consequences of low flow?

- Interactions with other HYMO conditions are complex including sediments
- Other stressor such as organic pollution or pesticides will also interact with effects of low discharge and often overule these
- Few hydrological stations compared with biological monitoring stations and often not at the same place

Possible indicators

- Use of species traits: habitat template theory
- Riparian organisms (ground beetles, amphibians)
- Ecosystem functioning (as secondary productions)
- Alternative sampling strategies

Recommendations

- BQEs can primarily inform on the impact of other stressors, which are relevant in multiple stress scenarios
- Fish is likely the most sensitive BQE with regard to flow;
- Alternative/new methods (not standardised; not IC'ed) should be developed to assess impacts of environmental flowsring

Thank you!