Project no. **GOCE-CT-2003-505540**

Project acronym: **Euro-limpacs**

Project full name: **Integrated Project to evaluate the Impacts of Global Change on European Freshwater Ecosystems**

Instrument type: **Integrated Project**

Priority name: **Sustainable Development**

# Deliverable No. 318
# Presentation of climate change related long-term data series to the US EPA at a climate change workshop (Task 2.5)

Due date of deliverable: **Month 49**
Actual submission date: **Month 59**

Start date of project: **1 February 2004** Duration: **5 Years**

Organisation name of lead contractor for this deliverable: **Alterra**

Revision **FINAL**


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|---|---|---|
| **Dissemination Level (tick appropriate box)** | | |
| **PU** | Public | |
| **PP** | Restricted to other programme participants (including the Commission Services) | |
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| **CO** | Confidential, only for members of the consortium (including the Commission Services) | |

**Integrated Project to evaluate the Impacts of Global Change on**

**European Freshwater Ecosystems**

WP2: Climate-hydromorphology interactions

Task 2: Hydromorphological changes and aquatic and riparian biota

Subtask 2.5: Examination of existing time-series data

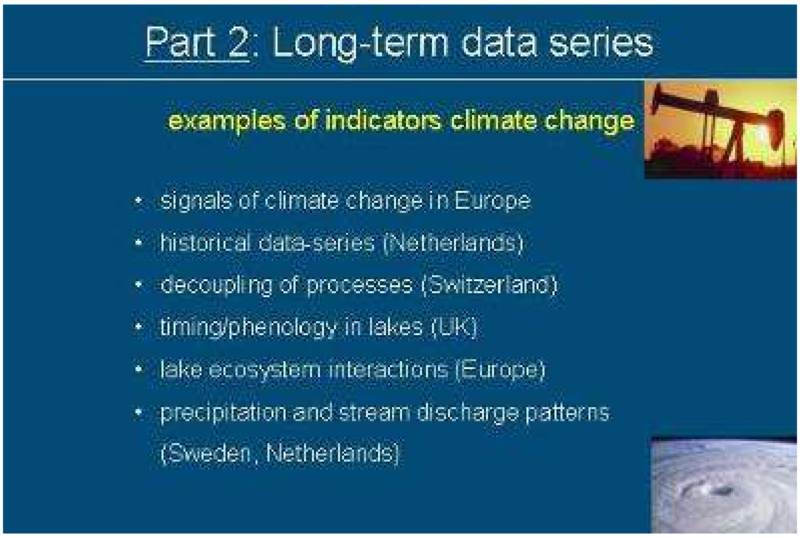
**Deliverable No. 318**

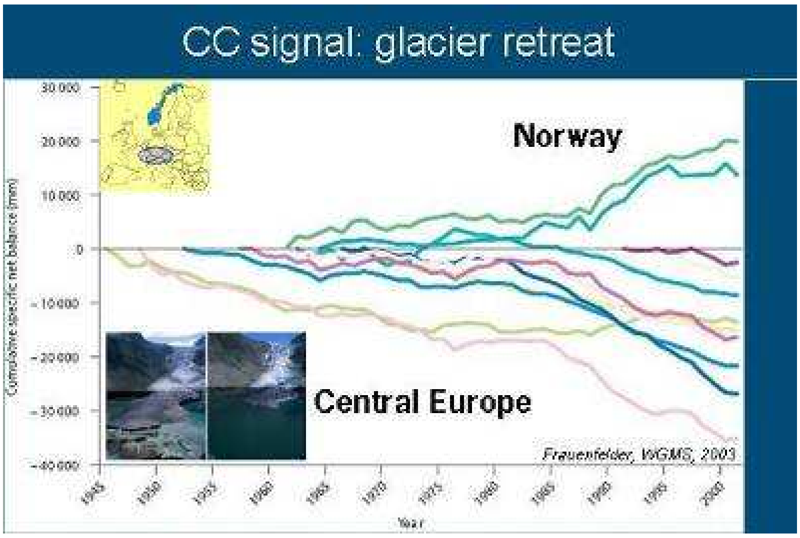
# Presentation of climate change related long-term data series will be presented to the US EPA at a climate change workshop (Task 2.5)

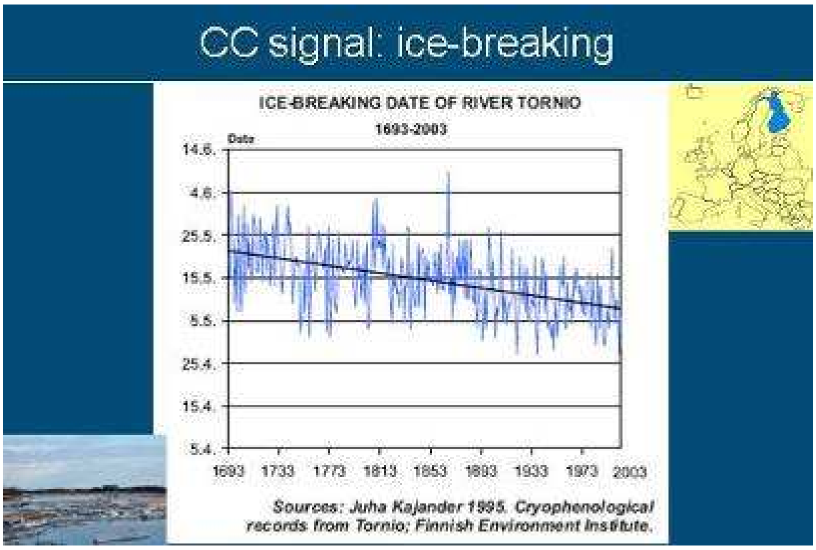
Compiled by


Piet Verdonschot

ALTERRA, Green World Research, Wageningen, The Netherlands


Part 2: Long-term data series
examples of indicators climate change
• signals of climate change in Europe
• historical data-series (Netherlands)
• decoupling of processes (Switzerland)
• timing/phenology in lakes (UK)
• lake ecosystem interactions (Europe)
• precipitation and stream discharge patterns (Sweden, Netherlands)


CC signal: glacier retreat
Norway
Central Europe
Frauenfelder, WGMS, 2003
30 000
20 000
10 000
0
-10 000
-20 000
-30 000
-40 000
Year

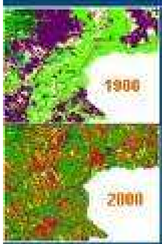

CC signal: ice-breaking
ICE-BREAKING DATE OF RIVER TORNIO
1693-2003
Date
14.6.
4.6.
25.5.
15.5.
5.5.
25.4.
15.4.
5.4.
1693
1733
1773
1813
1853
1893
1933
1973
2003
Sources: Juha Kajander 1995. Cryophenological records from Tornio; Finnish Environment Institute.

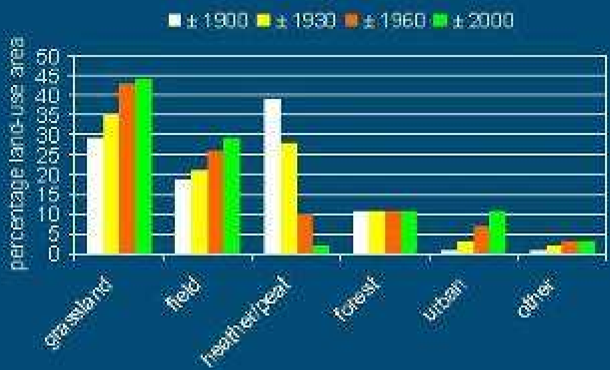
## past changes at catchment scale

Analysis of historical data (existing knowledge 100 yrs) from the Vecht catchment (The Netherlands)

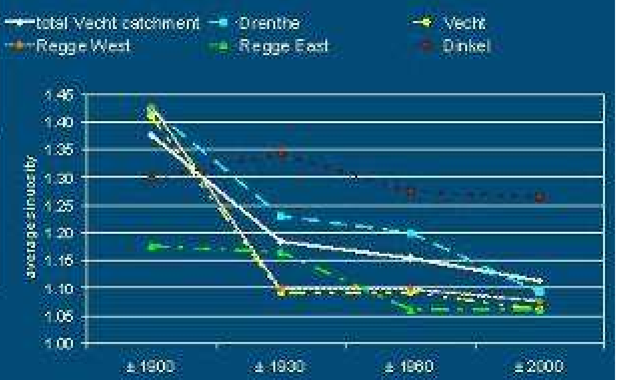
- ✓ developments and interactions in land-use, hydrology and morphology
- ✓ impact of climate (change)
- ✓ ecosystem responses

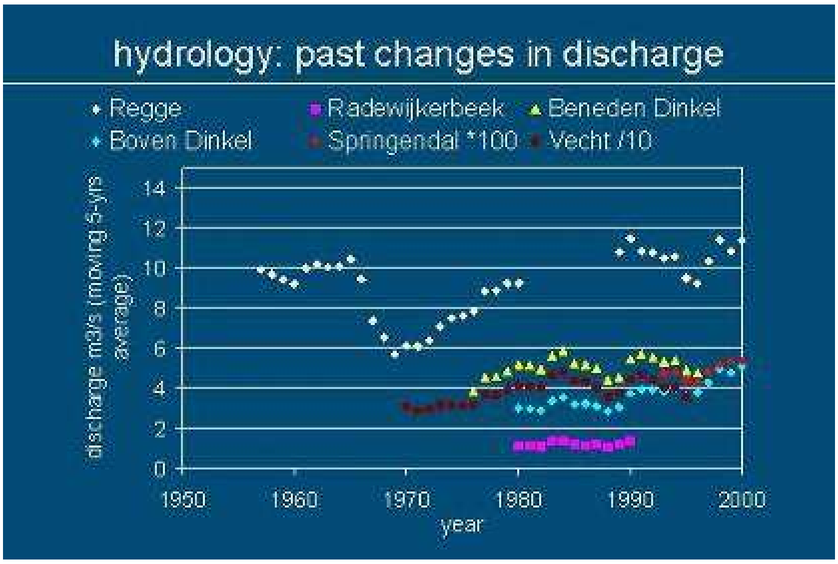
## past changes in land-use

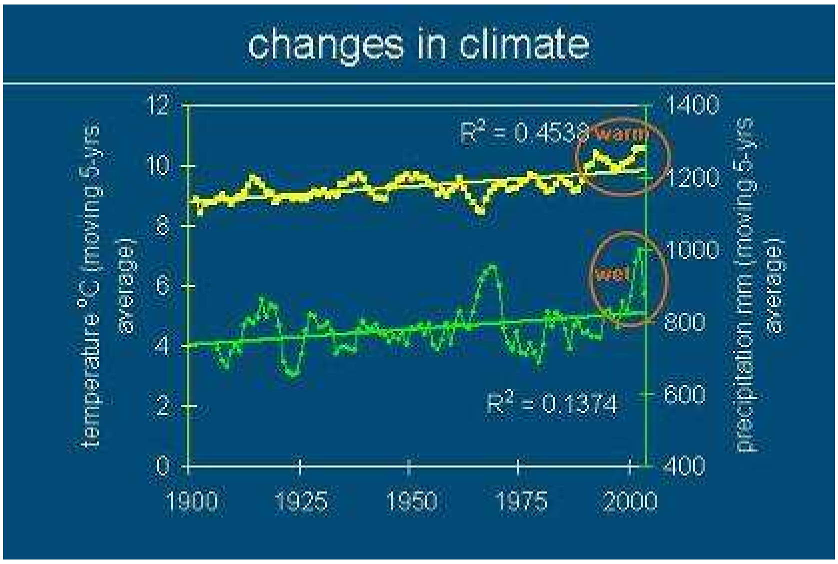


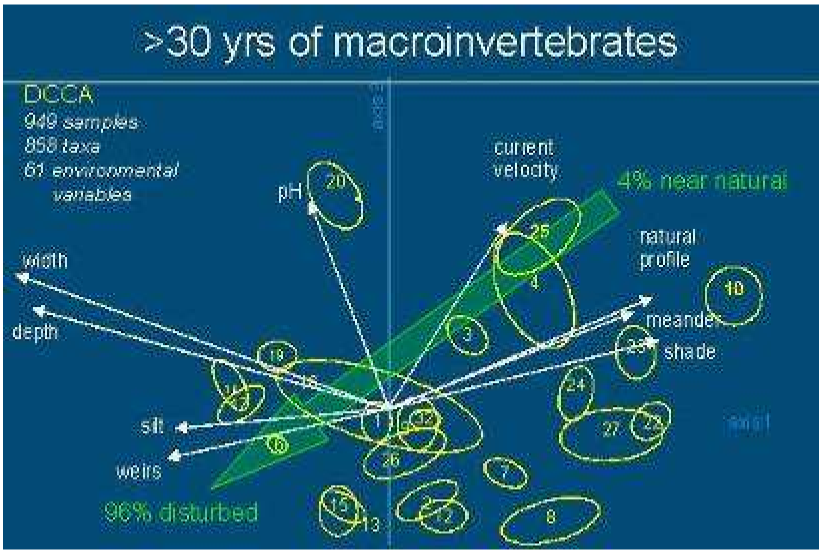




## morphology: past changes in sinuosity


hydrology: past changes in discharge
Regge
Radewijkerbeek
Beneden Dinkel
Boven Dinkel
Springendal *100
Vecht /10
discharge m3/s (moving 5-yrs average)
year
0
2
4
6
8
10
12
14
1950
1960
1970
1980
1990
2000

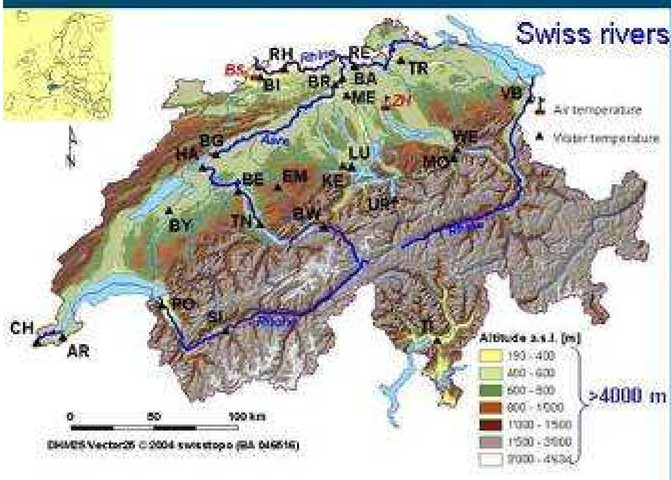

changes in climate
temperature °C (moving 5-yrs average)
precipitation mm (moving 5-yrs average)
R² = 0.4538
R² = 0.1374
warm
wet
0
2
4
6
8
10
12
400
600
800
1000
1200
1400
1900
1925
1950
1975
2000


>30 yrs of macroinvertebrates
DCCA
949 samples
858 taxa
61 environmental variables
current velocity
4% near natural
pH
natural profile
width
depth
meander
shade
silt
weirs
96% disturbed

## past changes: conclusions

- hydrological processes were poorly documented and showed little change after the 1970's, increase in the 90's
- morphology changed strongly (3 periods) due to changes in land-use not climate (mostly 1900-1930)
- changes in climate increased especially over the last 20-30 years
- anthropogenic change >>> climate change (until now)

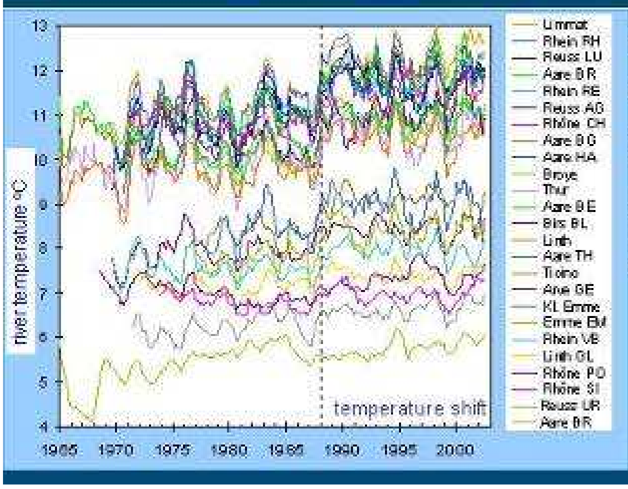
## decoupling: warming Swiss rivers




- 25 rivers
- different altitudes

*Hari et al 2006*

## warming Swiss rivers




25 stations/rivers

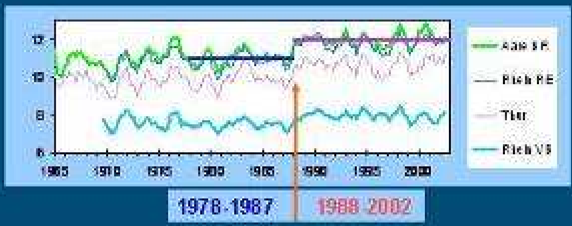
period 1965-2002

1 yr running mean of 1 min measurements

top->bottom increase in altitude and decrease in temperature

*Hari et al 2006*

# warming of Swiss rivers

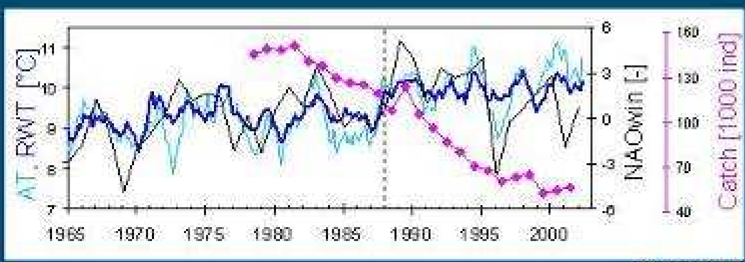



- warming: about 1°C increase
- synchronised temperature shift: 1987/88
- related to air temperature (not to discharge, precipitation, cloud cover, air pressure) and winter NAO (+)

*Hari et al 2006*

# warming and brown trout

in rivers brown trout decreased by >50% over the last 50 years

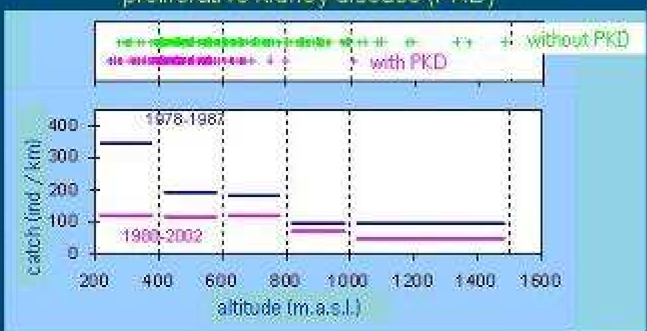



*Hari et al 2006*

AT = air temperature
RWT = river water temperature (mean of all rivers)


# warming and brown trout

proliferative kidney disease (PKD)

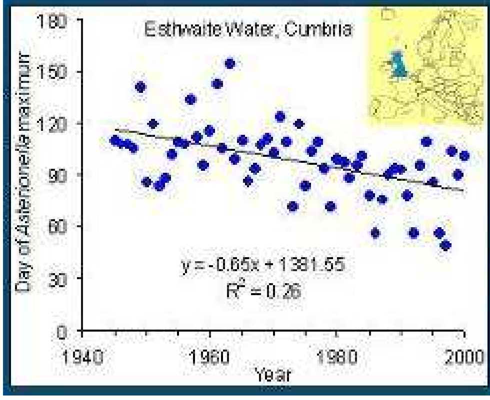


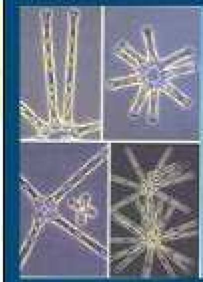

- thermal habitat shift: no upstream movement due to barriers
- effect PKD (increase by thermal shift)
- angler activity (decrease 20%)

*Hari et al 2006*

# timing of algal spring bloom

- advancement of spring events (seasonal timing or phenology)
- example: timing of the peak spring phytoplankton (primarily diatoms) bloom



*Asterionella formosa*

*data R.C. Maberly (CEH, UK)*

# timing of algal spring bloom

Is an earlier bloom due to a direct impact of climate change alone or are there other non-climate drivers?

climate processes:

- thermal stratification
- timing of ice-break up
- NAO (+, winter)

biological processes:

- replication vs sedimentation rate
- high overwintering population
- earlier grazing by zooplankton

climate drivers:

- temperature
- light

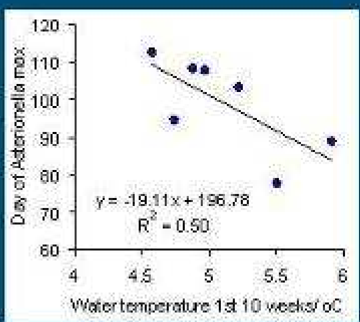
non-climate drivers:

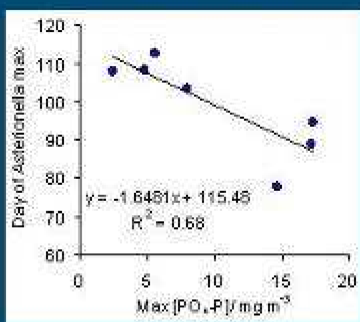
- nutrient availability
- silica availability

*Thackeray et al (in prep.)*

# timing of algal spring bloom

relating change to possible environmental drivers



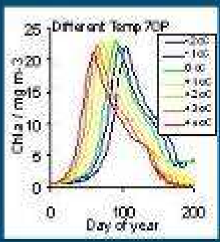

mean values in 10-year blocks

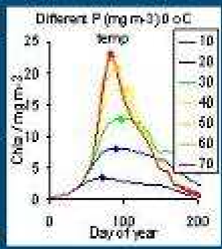
*data R.C. Maberly (CEH, UK)*

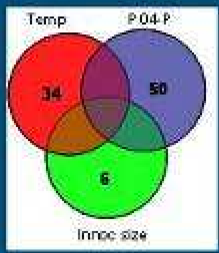
## timing of algal spring bloom

245 model simulations
(PROTECH=Phytoplankton RespOnses To Environmental CHange)

- inflow $PO_4$-P concentration: 10-70 $mg/m^3$ (7 concentrations)
- water temperatures: -2 to +4°C of average (7 temperatures)
- winter inoculum: 1-5 mg chl-a/$m^3$ (5 concentrations)

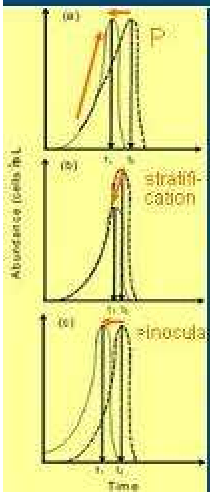



*data R.C. Maberly (CEH, UK)*

## timing of algal spring bloom




potential mechanisms driving earlier spring blooms

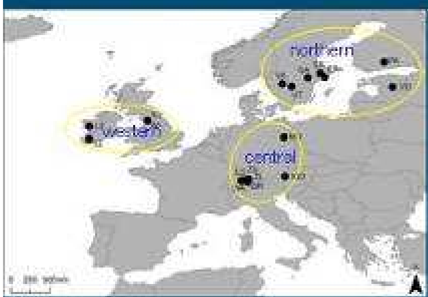
higher phosphorus availability reduces the period of slower phosphorus limited growth after the light limited phase (winter) (in case of *Astrionella*)

earlier stratification causes sinking losses to exceed replication earlier in the year (in case of *Cyclotella*)

a higher over-wintering population allows the maximum population size to be reached earlier (in case of both)

*Thackeray, Jones & Maberly 2007*

## climate signal in European lakes




- 18 lakes distributed over Europe (large geographical range)
- 23 year period
- wide range of lakes (shallow to deep, oligo- to eutrophic, short to long residence time, ice-cover yes/no)

meta data analysis to find coherence in response to the climate signal

*Blenckner et al 2007*

# climate signal in European lakes

Meta Data Analysis = a quantitative analysis of a collection of studies/data series

independent variable:

- winter NAO index

dependent (target) variables

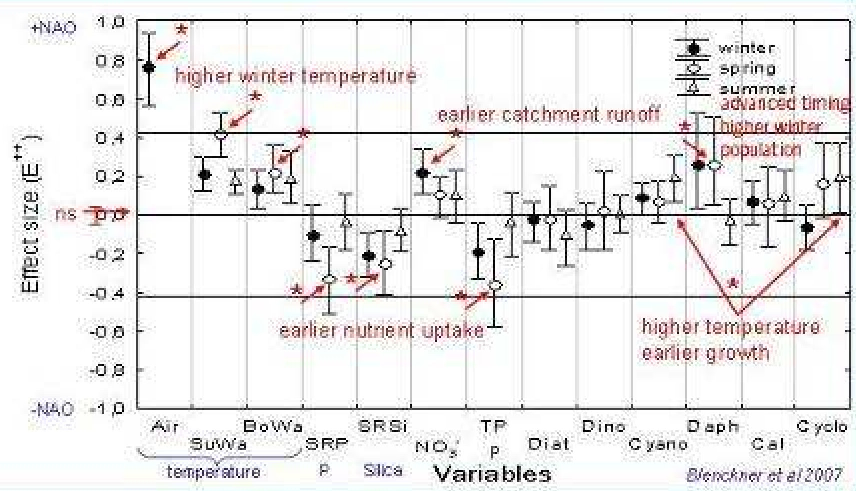
- physical: air and water temperature
- chemical: phosphorus, nitrate, silicate
- biological: diatoms, cyanobacteria, dinoflagellates, copepods

analysis steps:

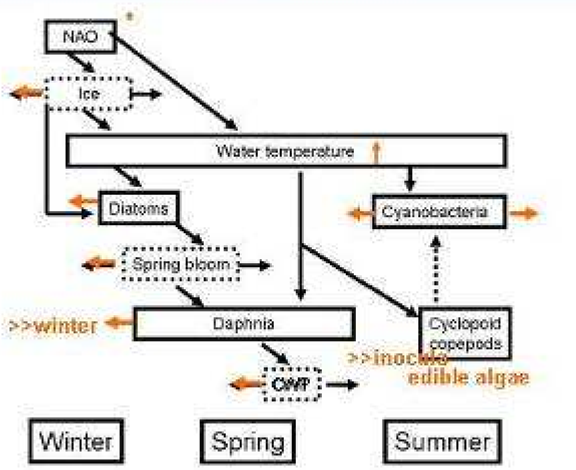
1. standardisation (detrending linear or log)
2. target variable effect size (E): Pearson's correlation coefficient *r*
3. overall effect size (E⁺⁺): sum of weighted effect sizes

*Blenckner et al 2007*

# climate signal in European lakes




# cascading effects over ± 5 months




*Blenckner et al 2007*

## persistence and stability in Swedish streams

- 5 streams (north-south gradient)
- 11 years (1 per yr)
- macroinvertebrates
- chemistry
- discharge

*Sandin 2007*

## persistence and stability in Swedish streams

macroinvertebrates

*persistence (constancy in taxon composition)*

- Sorensen similarity ratio
- presence/absence data
- in consecutive years

*stability (constancy in number of organisms)*

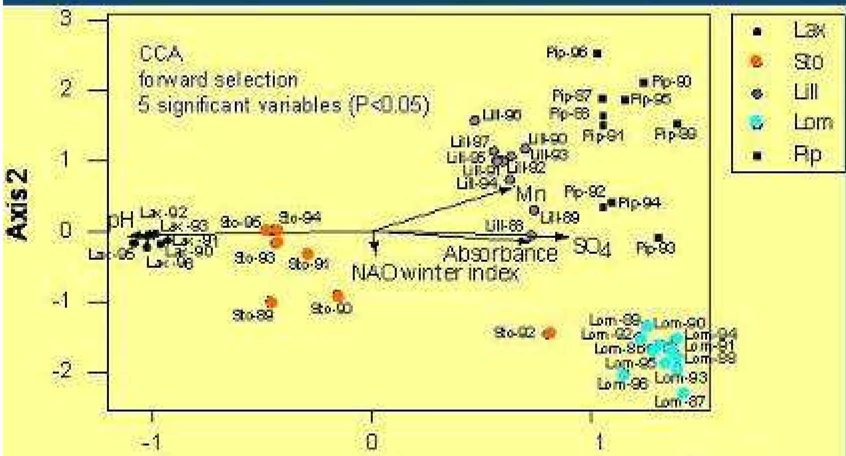
- Spearman's rank correlation
- species abundance data

climate

- winter NAO
- coefficient of variation (CV) winter discharge

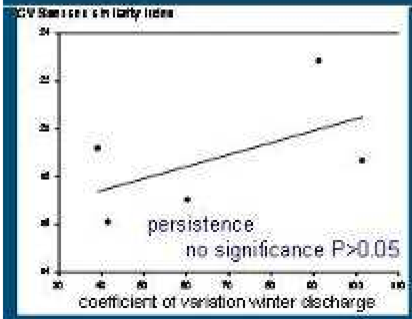
*Sandin 2007*

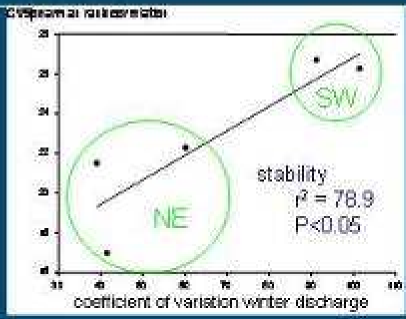
## persistence and stability in Swedish streams




*Sandin 2007*

## persistence and stability in Swedish streams

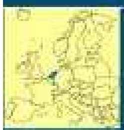


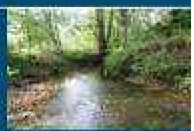



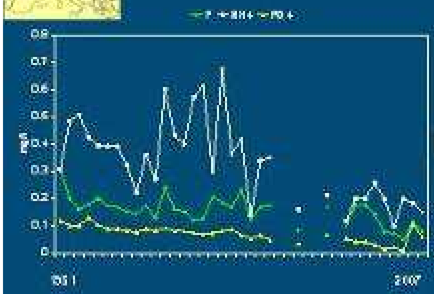

- high cv winter discharge => unstable macroinvertebrate community
- large scale climate affects regional natural variability

*Sandin 2007*

## long-term quality score in a Dutch stream



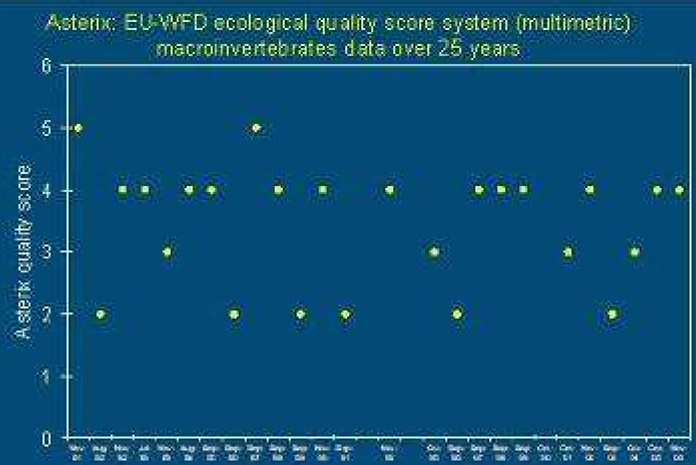


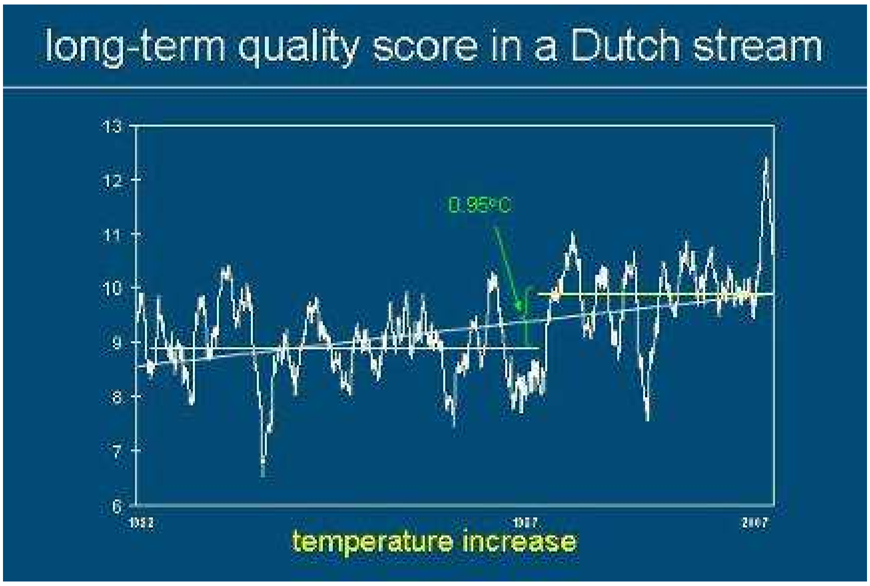


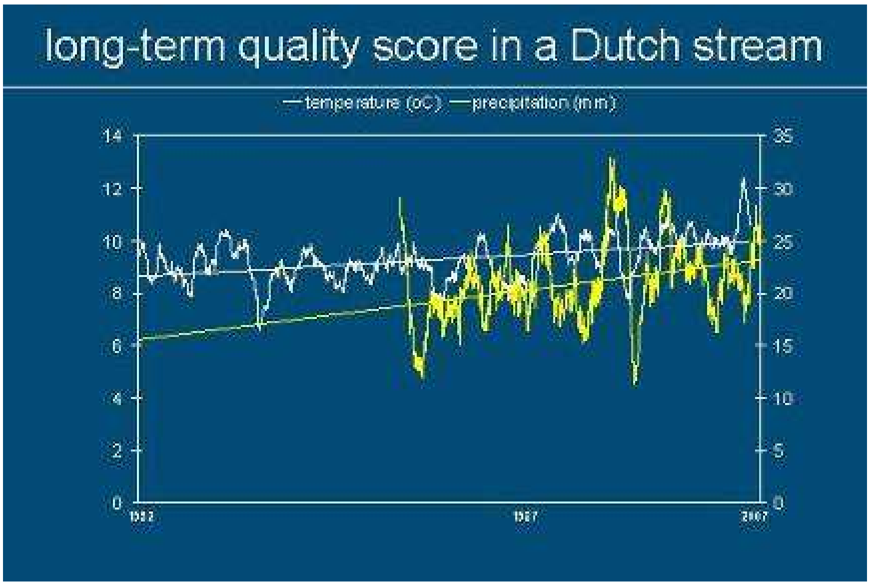

**nutrients decrease**

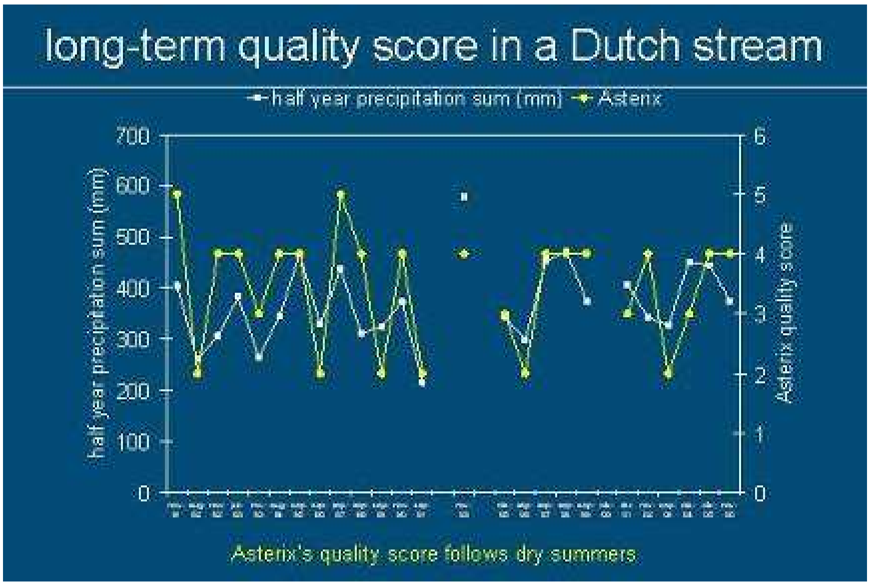

**chloride decrease**

## long-term quality score in a Dutch stream

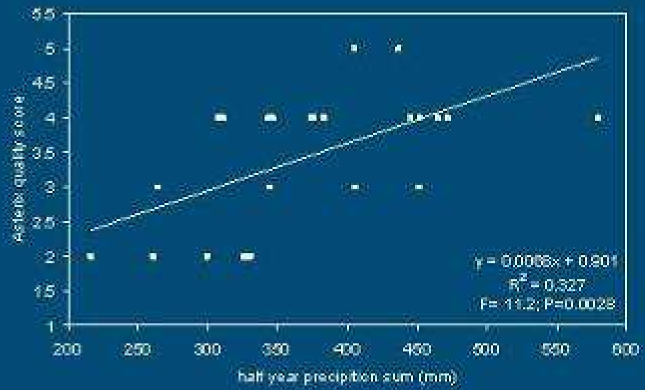



long-term quality score in a Dutch stream
0.95ºC
temperature increase


long-term quality score in a Dutch stream
— temperature (oC) — precipitation (mm)

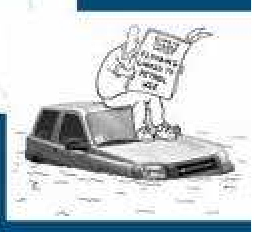

long-term quality score in a Dutch stream
half year precipitation sum (mm) Asterix
half year precipitation sum (mm)
Asterix quality score
Asterix's quality score follows dry summers

## long-term quality score in a Dutch stream




## conclusions overall

- historically anthropogenic impact >>> climate impact
- temperature change occurs discontinuous? (thresholds?)
- temperature rise has direct and indirect biotic interaction effects
- seasonal shifts change ecosystem functioning also throughout the year
- precipitation/discharge changes do alter stream ecosystems composition and functioning
- current assessment can have 'overlooked' other signals, like climate

*Thank you for your attention*