

# Atelier « Analyse des données »

## Ecological time series

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# Data analysis: why?

- The question
  - Why do you want to do a time series analysis?
  - What are you trying to find out?
- Posing a research question is perhaps most important part of scientific method
  - Methods & results depend on question

# This atelier

- Objectives:
  - to learn to perform time series analysis
  - to learn to formulate research question
  - to learn to interpret results of data analysis
- Using
  - SSA-MTM toolkit
  - the provided data sets (or your own)

# Ecological time series

- Population dynamics: a dynamical system  
 $\frac{d\mathbf{x}}{dt} = f(\mathbf{x})$ , where  $\mathbf{x}$  is the *state* of the system  
e.g.  $\mathbf{x}$ =prey and predator numbers (Lotka-Volterra)
- Coupled to external forcing factors
  - Climate
  - Pollution, eutrophication
  - Exploitation (e.g. fisheries)  
 $\frac{d\mathbf{x}}{dt} = f(\mathbf{x}, \mathbf{E})$ , where  $\mathbf{E}$  is an environmental influence
  - Can we explain the dynamics of  $\mathbf{x}$  and  $\mathbf{E}$  ?
  - How does  $\mathbf{x}(t)$  depend on  $\mathbf{E}(t)$ ?
  - Is there feedback between  $\mathbf{x}$  and  $\mathbf{E}$ ?

# Background information on the three systems

## 1. Lake Windermere

(with Eric Edeline)

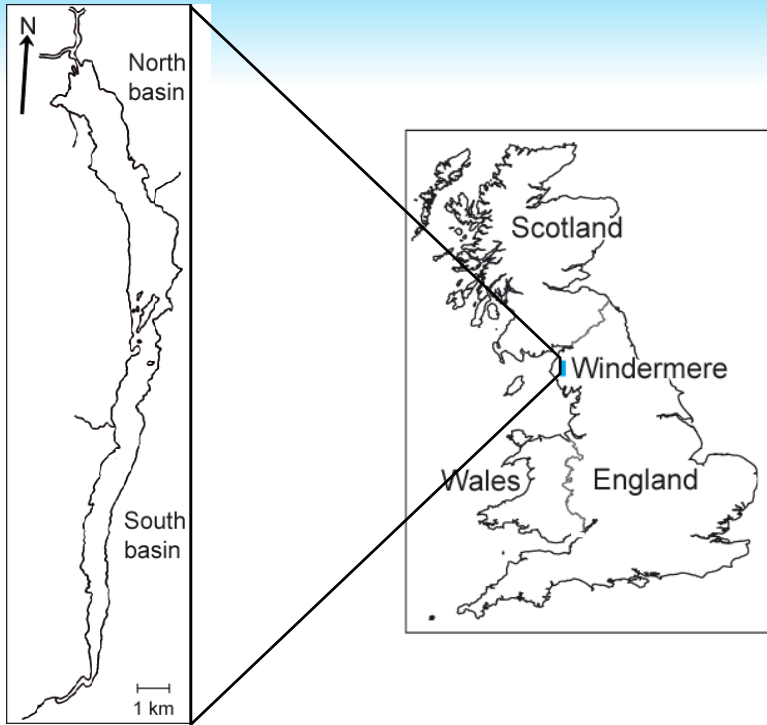
### Refs:

E. Edeline, S. M. Carlson, L. C. Stige, I. J. Winfield, J. M. Fletcher, J. B. James, T. O. Haugen, L. A. Vøllestad, N. C. Stenseth. Trait changes in a harvested population are driven by a dynamic tug-of-war between natural and harvest selection. *Proceedings of the National Academy of Sciences of the USA* 140:15799-15804.

T. Haugen, I. J. Winfield, Asbjørn Vøllestad, J. M. Fletcher, J. B. James, Nils Christian Stenseth. Density dependence and density independence in the demography and dispersal of pike over four decades. *Ecological Monographs*, volume 77. 2007; 483 - 502

From: Eric Edeline

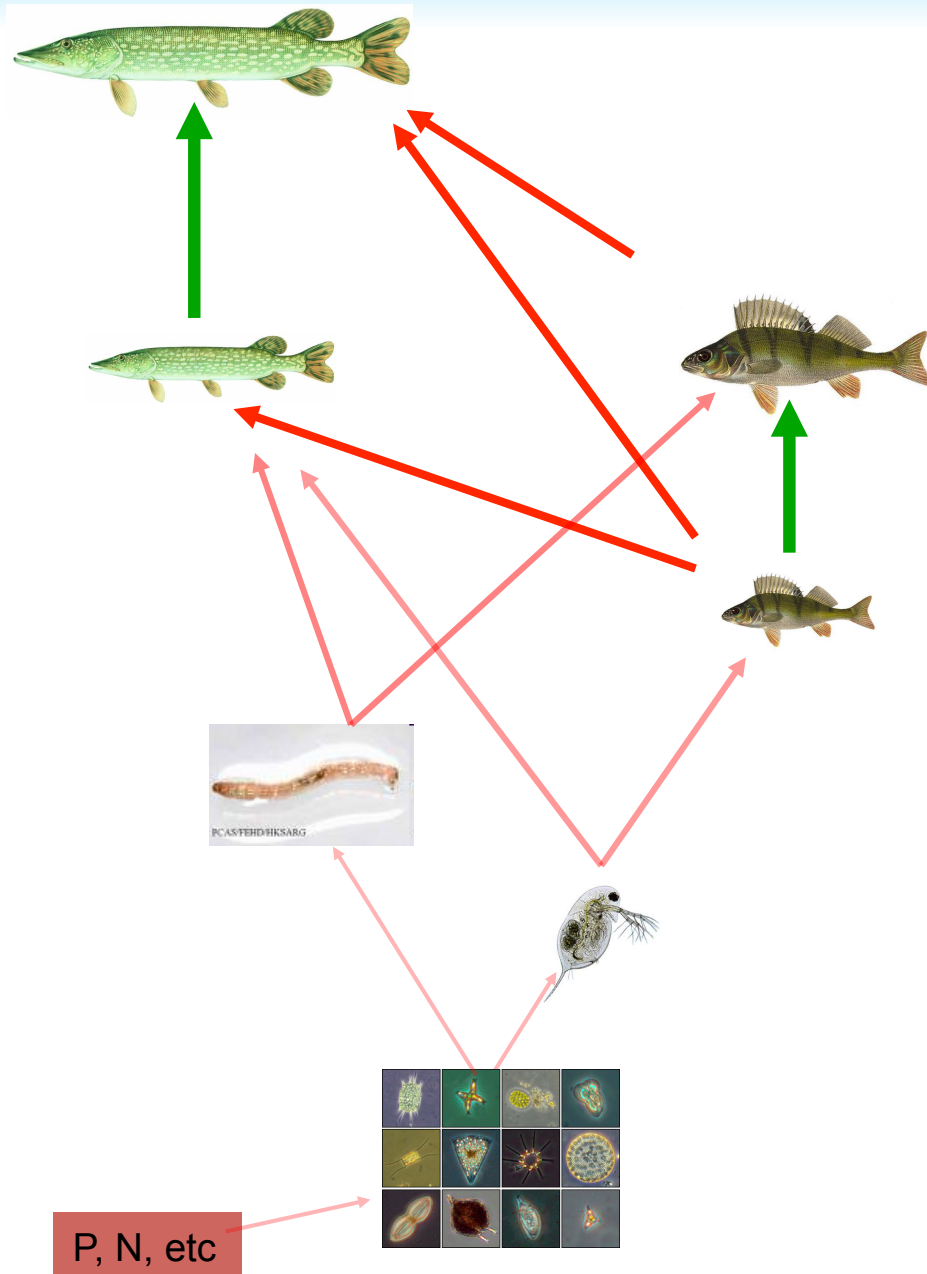
# The Windermere fish species



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Large body size

Small body size



piscivorous fish

benthivorous fish

planktivorous fish

macroinvertebrates

zooplankton

phytoplankton

nutrients

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## The pike and perch long-term monitoring programme



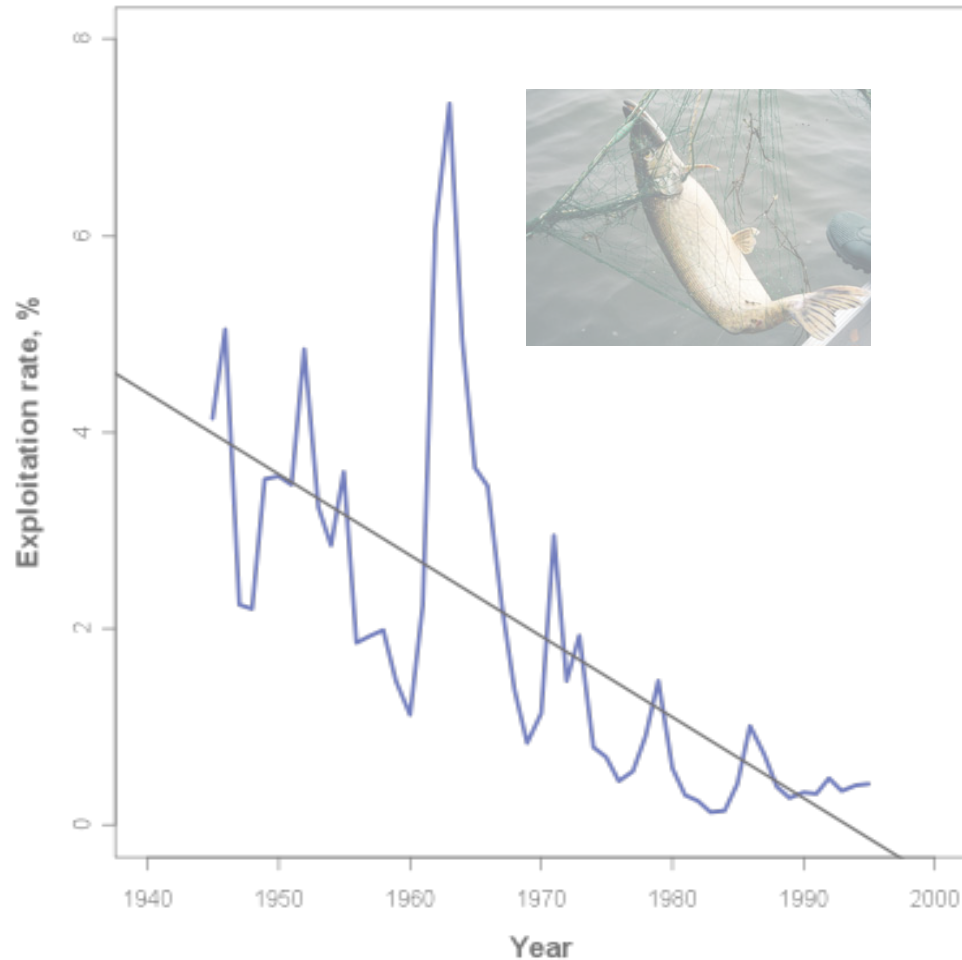
Environmental covariates:

- Pike and perch numbers from 1945 to 1995 in both basins
- Phosphorus concentration since 1945 (North) and 1946 (South)
- Chlorophyll a and phytoplankton data since 1947 in both basins
- Zooplankton abundance since 1945 in the North basin only

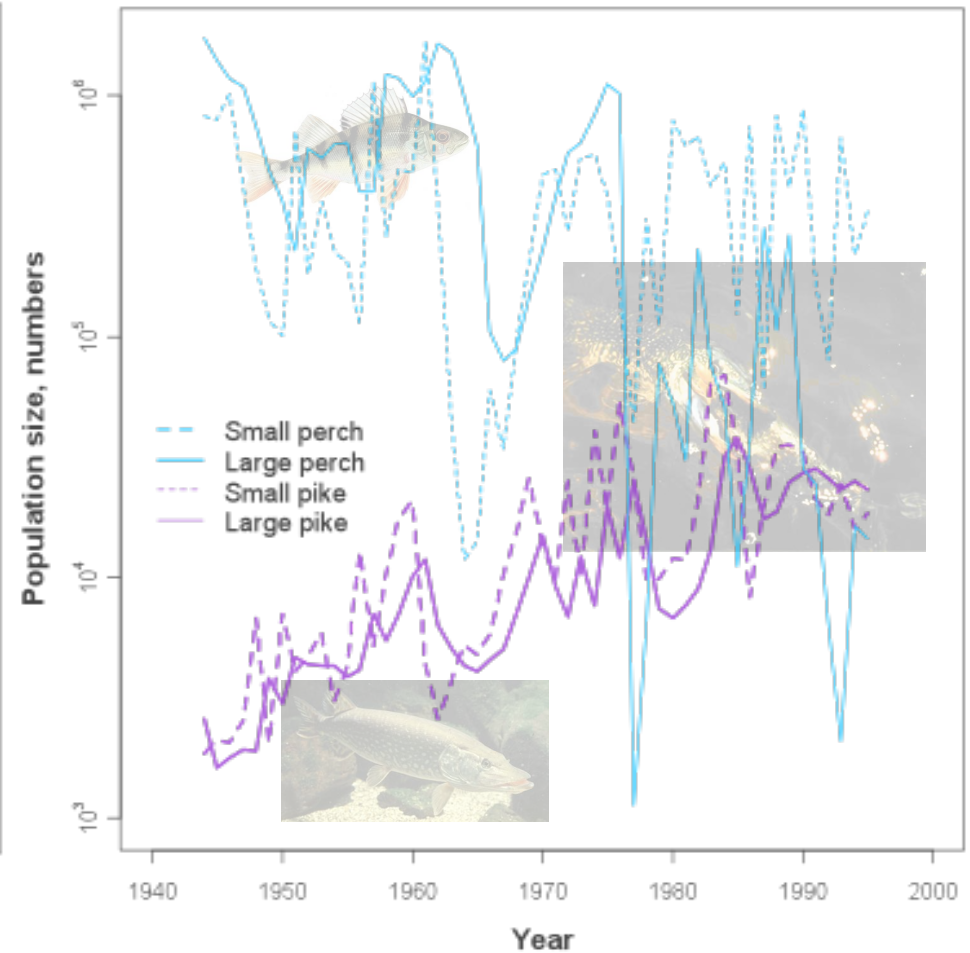
PHOSPHORUS



## Windermere background data

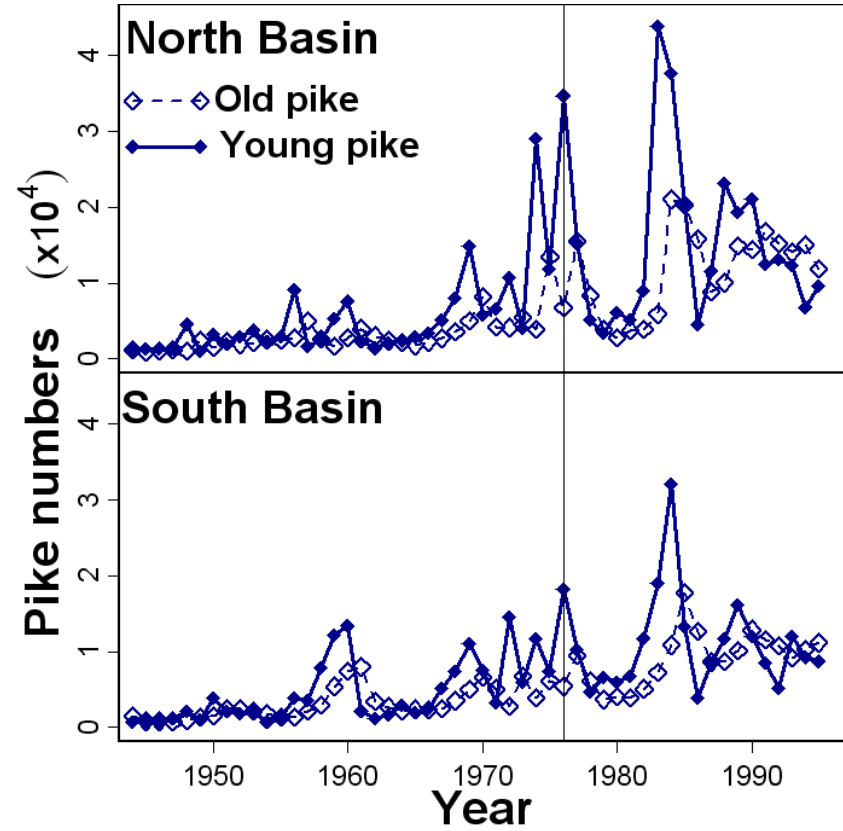
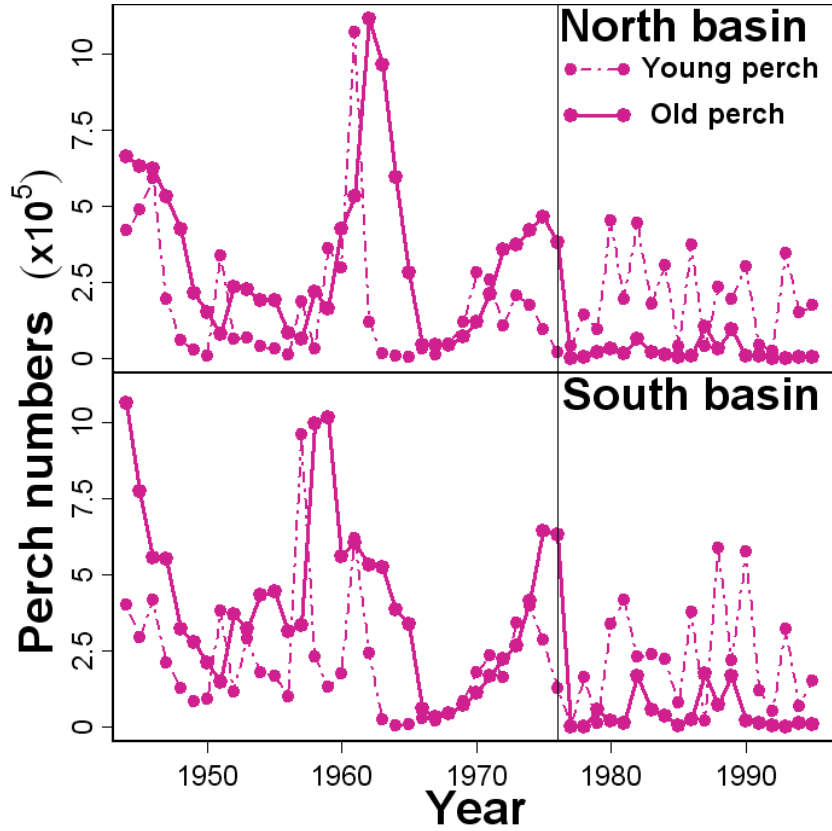


The strength of fishery selection decreased over time



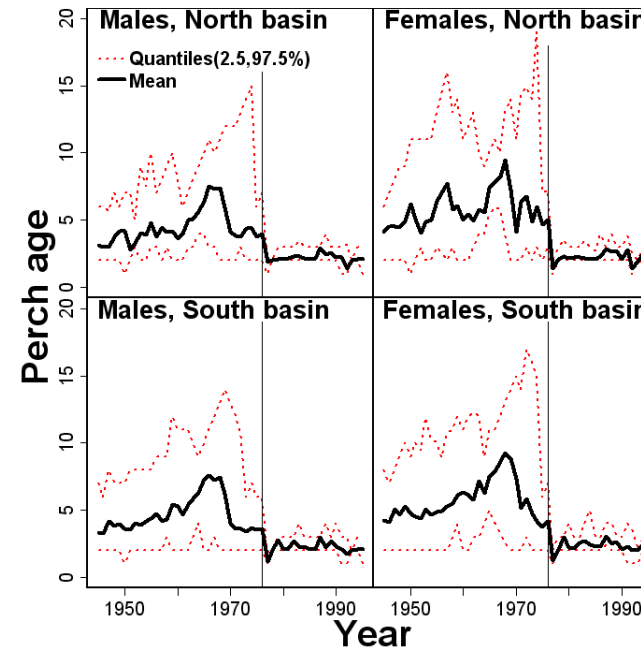
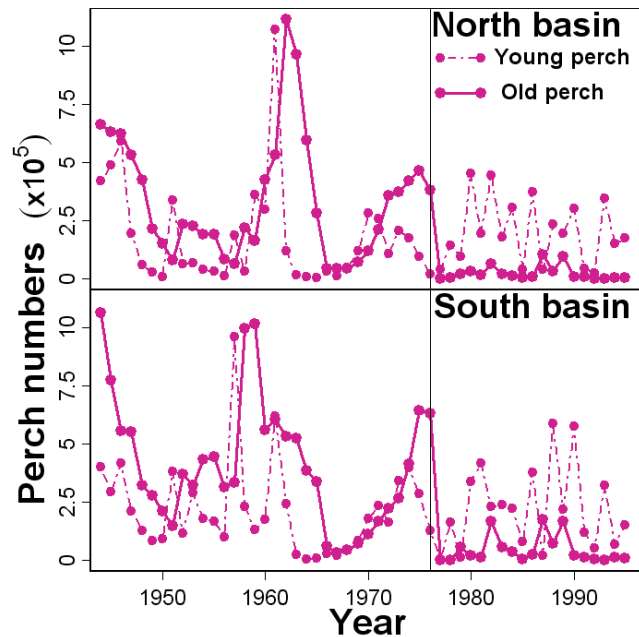
Pike numbers increased, while perch numbers decreased, presumably increasing cannibalism in pike

From: Eric Edeline



## Pathogen-induced trait changes alter trophic hierarchy

Eric Edeline, Tamara Ben Ari, Ian J. Winfield, Janice M. Fletcher, J. Ben James, L. Asbjørn Vøllestad and Nils C. Stenseth



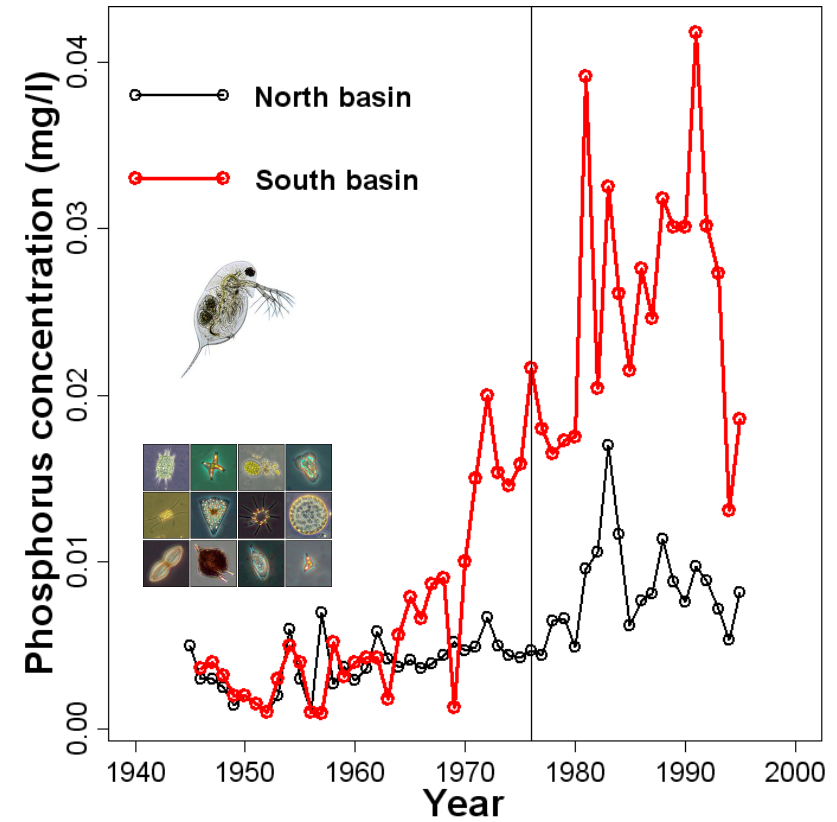
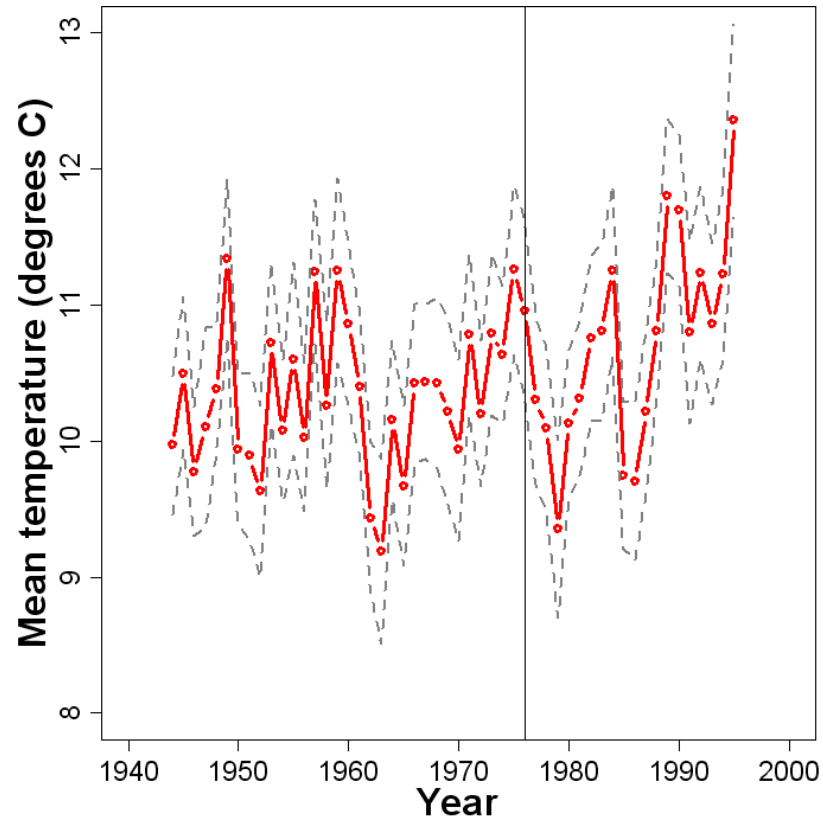
In 1976, 98% of the adult perch population was killed (Bucke et al. 1979).

The pathogen was more prevalent on mature than on immature perch, and was more prevalent on fast growing perch (Bucke et al. 1979), setting the stage for selection against large, fast growing perch.



From: Eric Edeline

## Effects of temperature and eutrophication?



... as well as NAO, precipitations and other climatic parameters?

# Projects

- Characterise the time series
  - Perch
  - Pike
- Interactions?
  - Between populations
  - With environmental factors