LONG-TERM CHANGES IN A FINE SAND MACROBENTHIC COMMUNITY FROM THE BAY OF MORLAIX (WESTERN ENGLISH CHANNEL): THIRTY YEARS OF SAMPLING

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« Time-series analysis in Marine science and applications for industry »

Conference in Logonna-Daoulas, France, 17-22 sept. 2012

Introduction

Benthic long-term series – Which interests?

- ✓ A useful tool to understand the responses of marine systems to local and regional environmental variability
- ✓ A major tool to assess the effects of human disturbances on marine systems and to estimate the recovery rate
- ✓ A major tool to evaluate the ecological quality status of coastal habitats in the context of European directives (e.g. WFD, MSFD))

Introduction

Benthic long-term series – Which limits?

- ✓ Sampling and sample treatment are time-consuming so that benthic long-term series (> 20 years) are rare
- ✓ The problem of continuous funding
- ✓ Require a taxonomic expertise which tends to disappear
- ✓ Disentangle the role of local factors mainly due to anthropogenic drivers and regional factors mainly related to climate variations remains a major challenge

Study area

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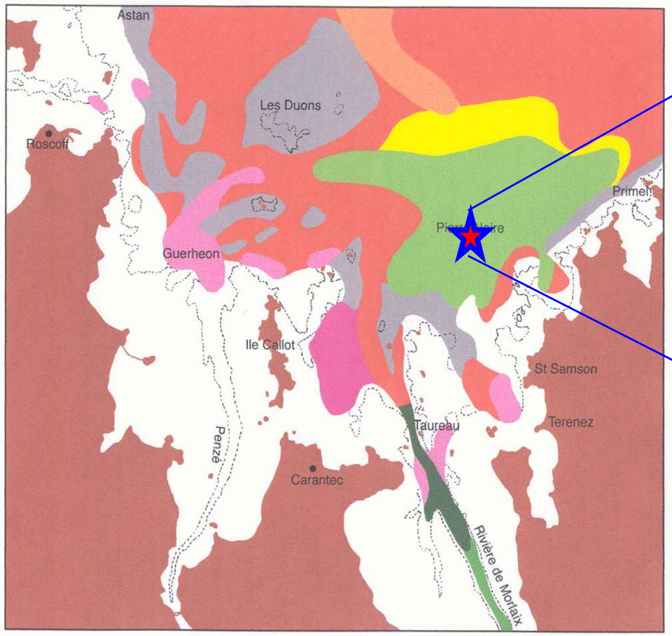
Sampling



Carte biosédimentaire des communautés benthiques de la Baie de Morlaix (d'après Cabioch 1968).

- ✓ A benthic survey of temporal changes in a fine sand community initiated in 1977
- ✓ Data available : 1977 to 2010

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Sampling

✓ Same methodology used through time:

- 10 replicate samples using a Smith McIntyre grab at each date
- Sampling frequency ranging from 12 samples per year to 5 samples per year (only 1 sample per year available from 2007 to 2010)

Environmental setting

- ✓ **Local environmental data:**
  - ➢ Temperature and salinity at each sampling date
  - ➢ Temperature and salinity measured every two weeks (data provided by P. Morin) north of the Bay (1977-2007)
  - ➢ Freshwater inputs (1977-2009)
  - ➢ Wind conditions (UK Metoffice)
  - ➢ Sediment grain size measured occasionally

Environmental setting

✓ **Regional climatological data:**

- **North Atlantic Oscillation index: a basin-scale alternation of atmospheric masses between the subtropical and the Arctic Atlantic**

- **The Northern Hemisphere temperature anomalies relative to the period 1961-1990** (from the Hadley Centre for Climate Prediction and Research)

- **The Atlantic Multidecadal Oscillation which is a large scale oceanic phenomenom** (from http://www.esr1.noaa.gov/psd/data/)

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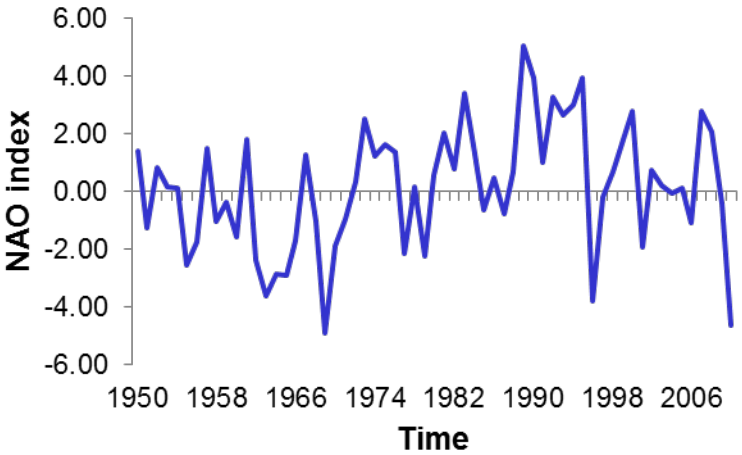
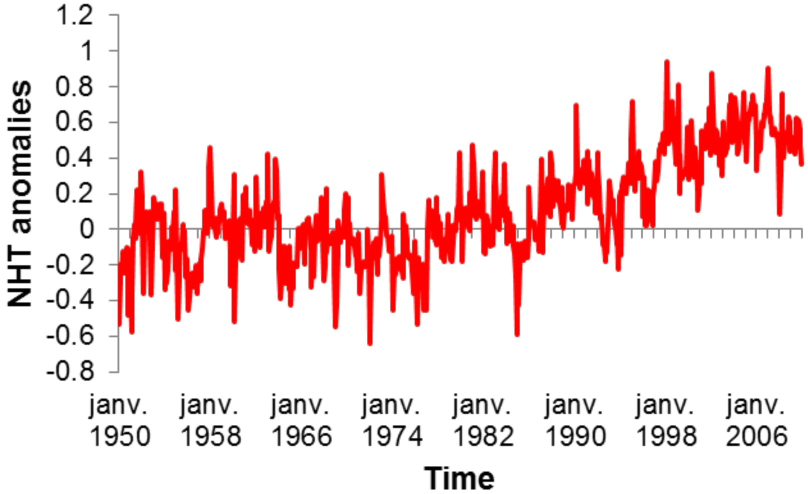
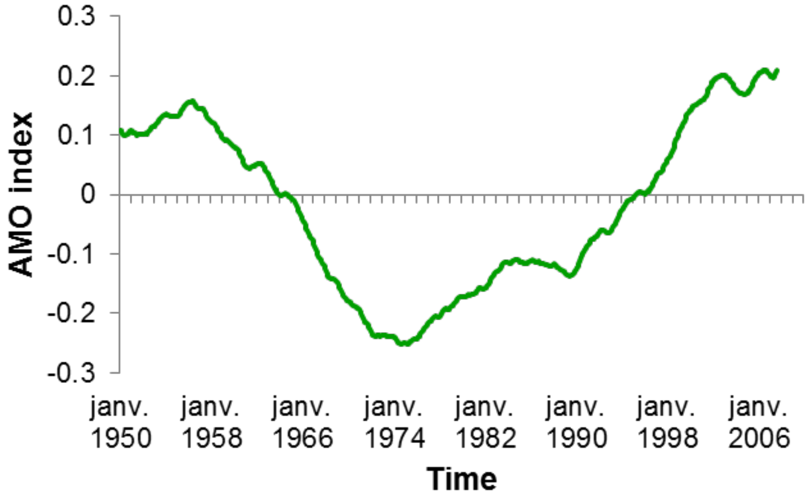
Environmental setting







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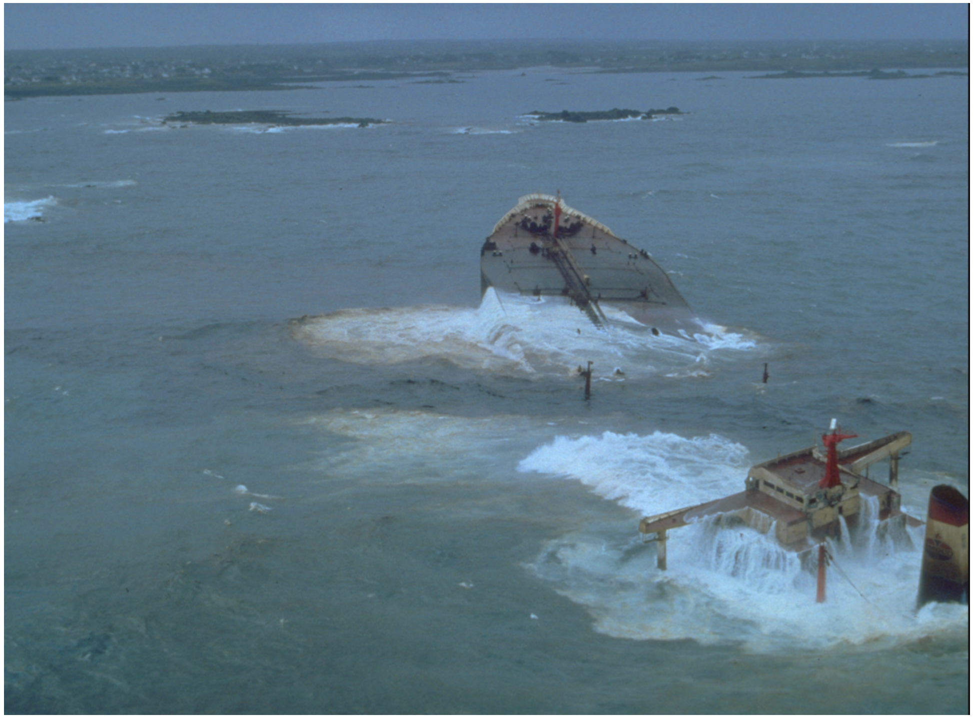
Environmental setting



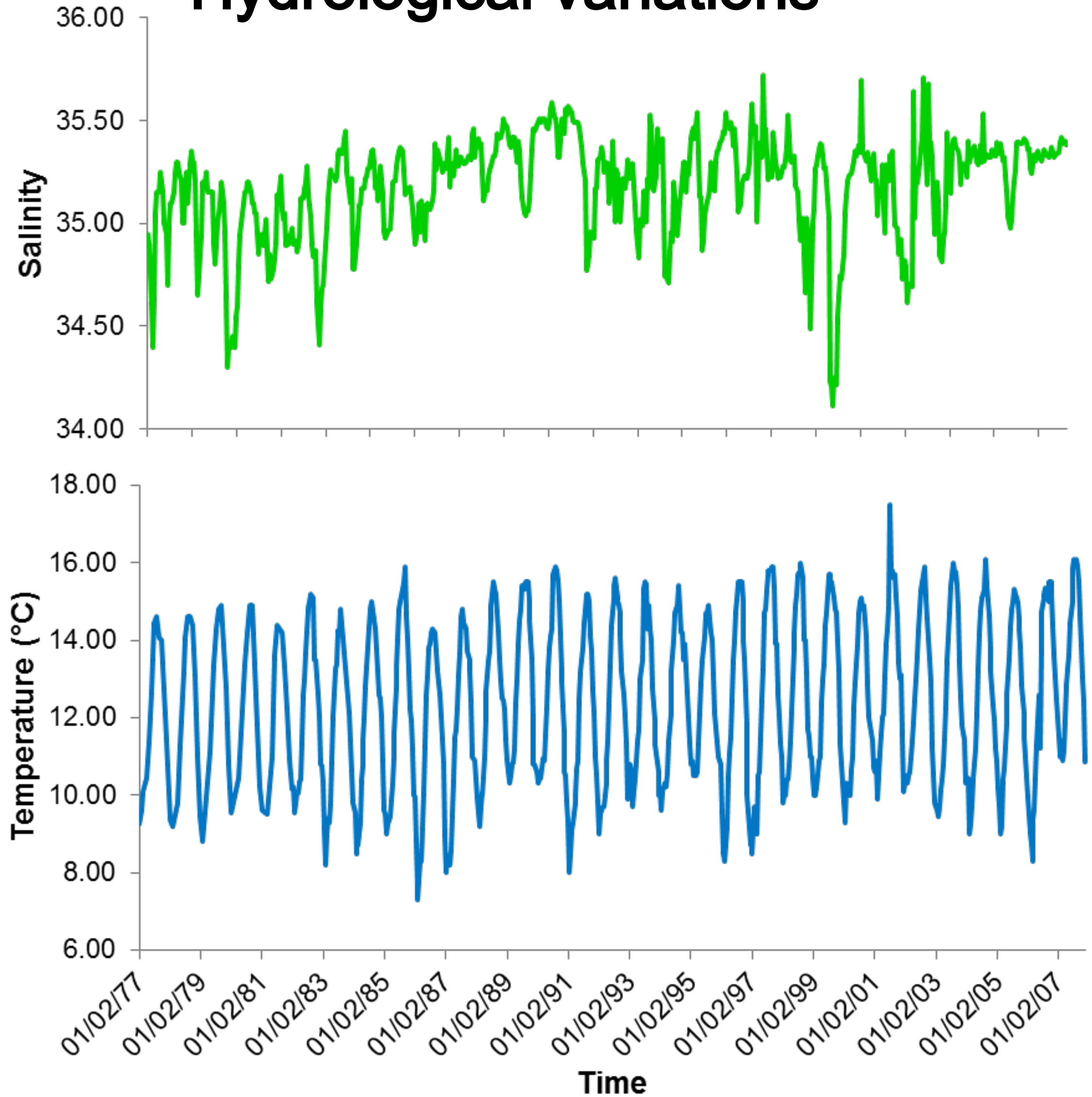
➢ The Amoco Cadiz oil spill occurred in March 1978, 60 km in the west of the Bay

➢ During two weeks, 223 000 t of oil were released into the marine environment and polluted littoral and sublittoral zones

➢ In the Bay of Morlaix, significant levels of hydrocarbons in the sediments were reported during about 3 years from April 1978 to March 1981

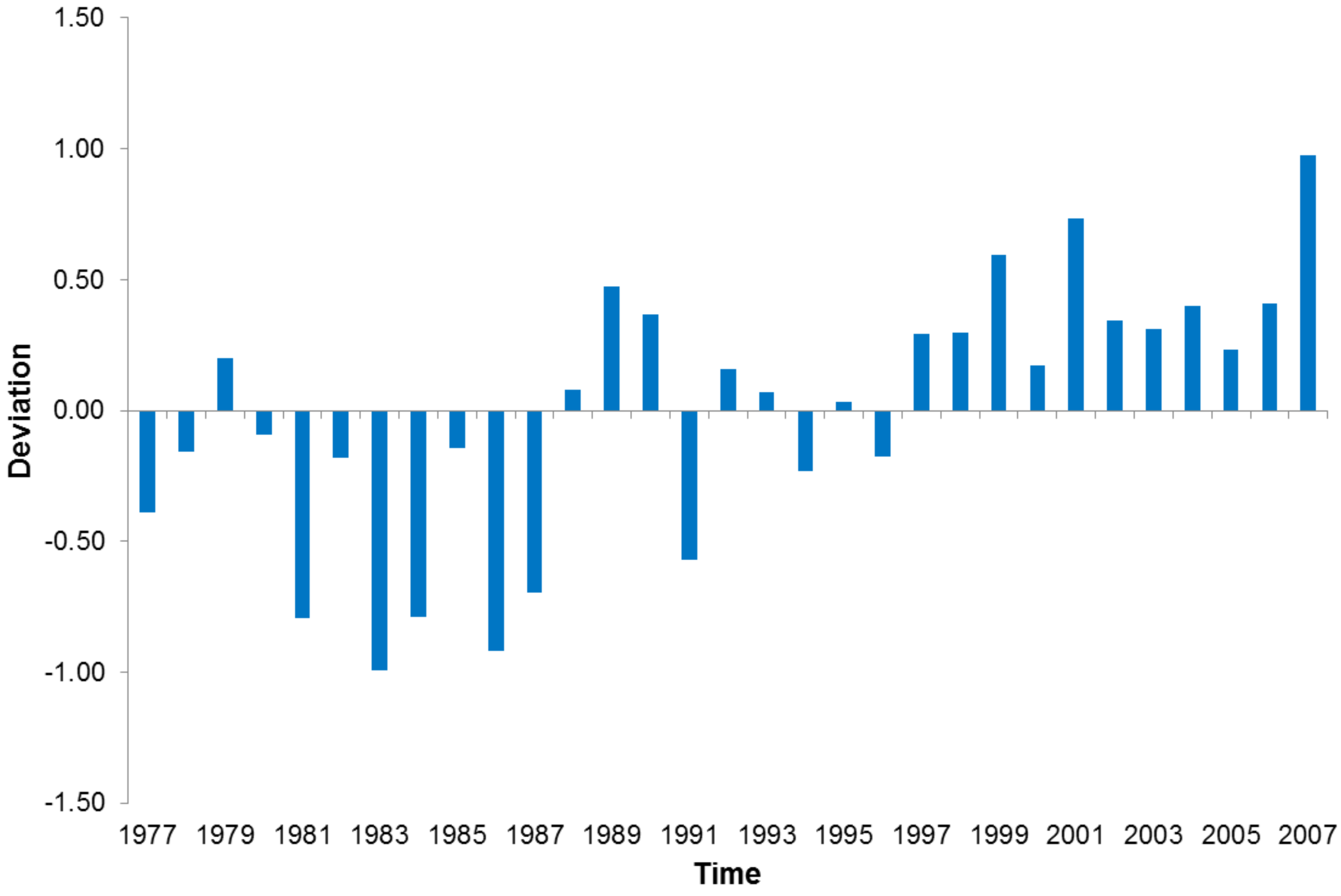
Environmental changes

Hydrological variations



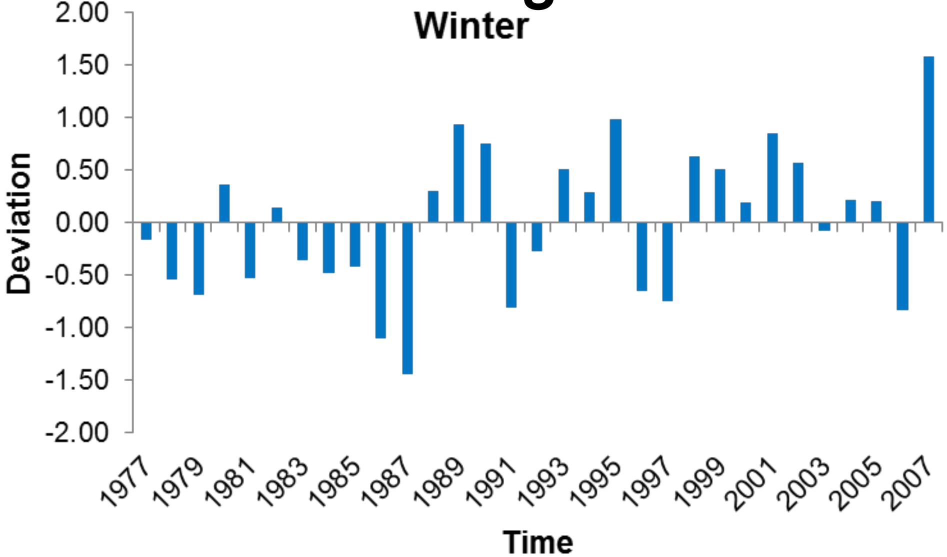
Environmental changes

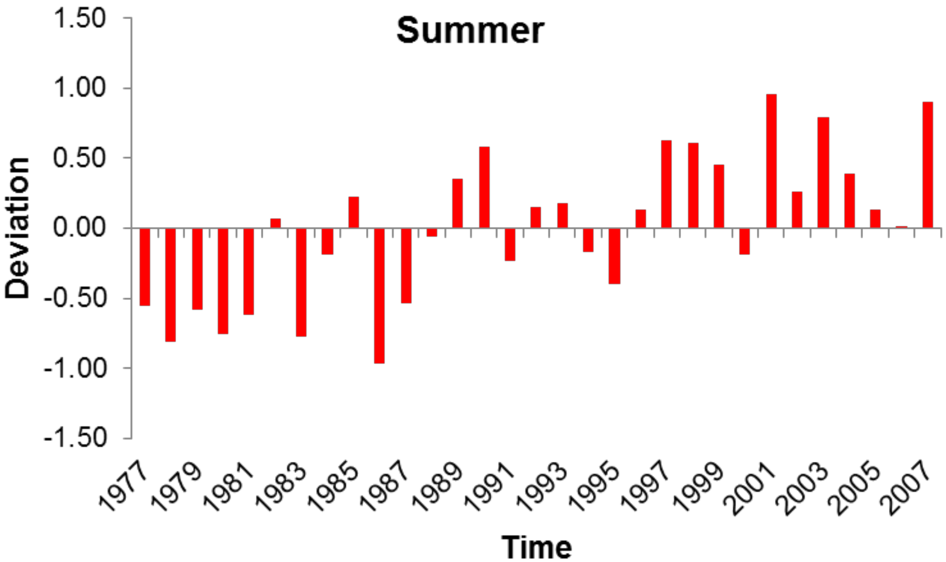
A rising of bottom temperatures



Environmental changes

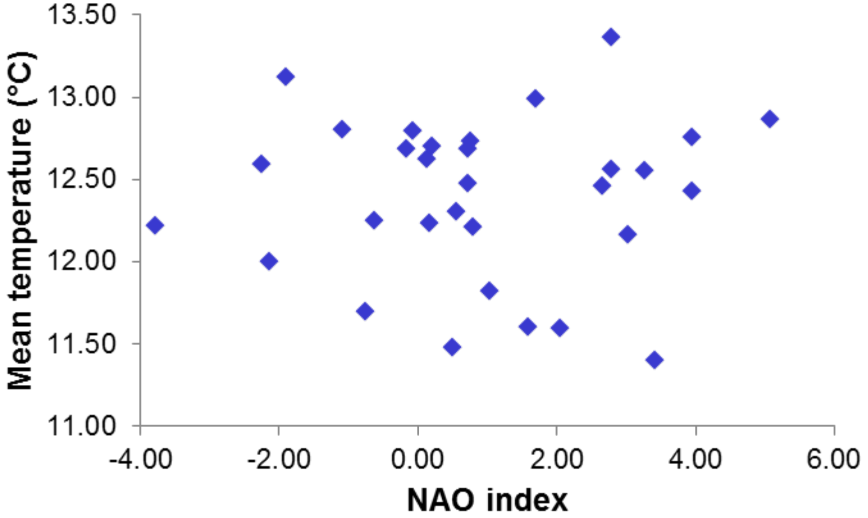
A rising of bottom temperatures

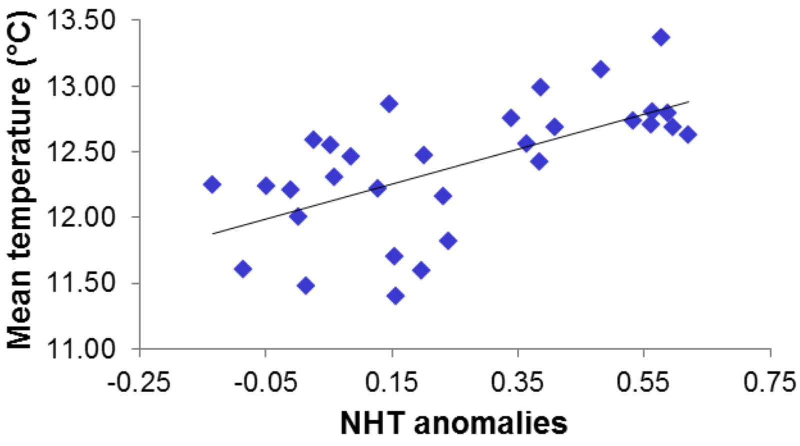


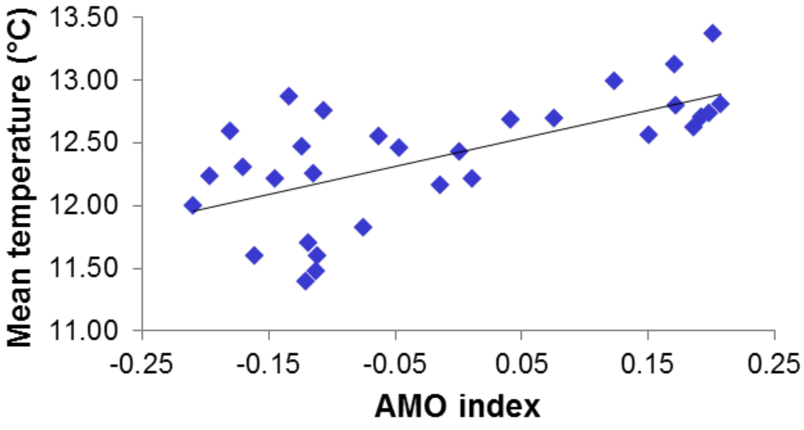


Environmental changes

Local temperature vs. climatic indices

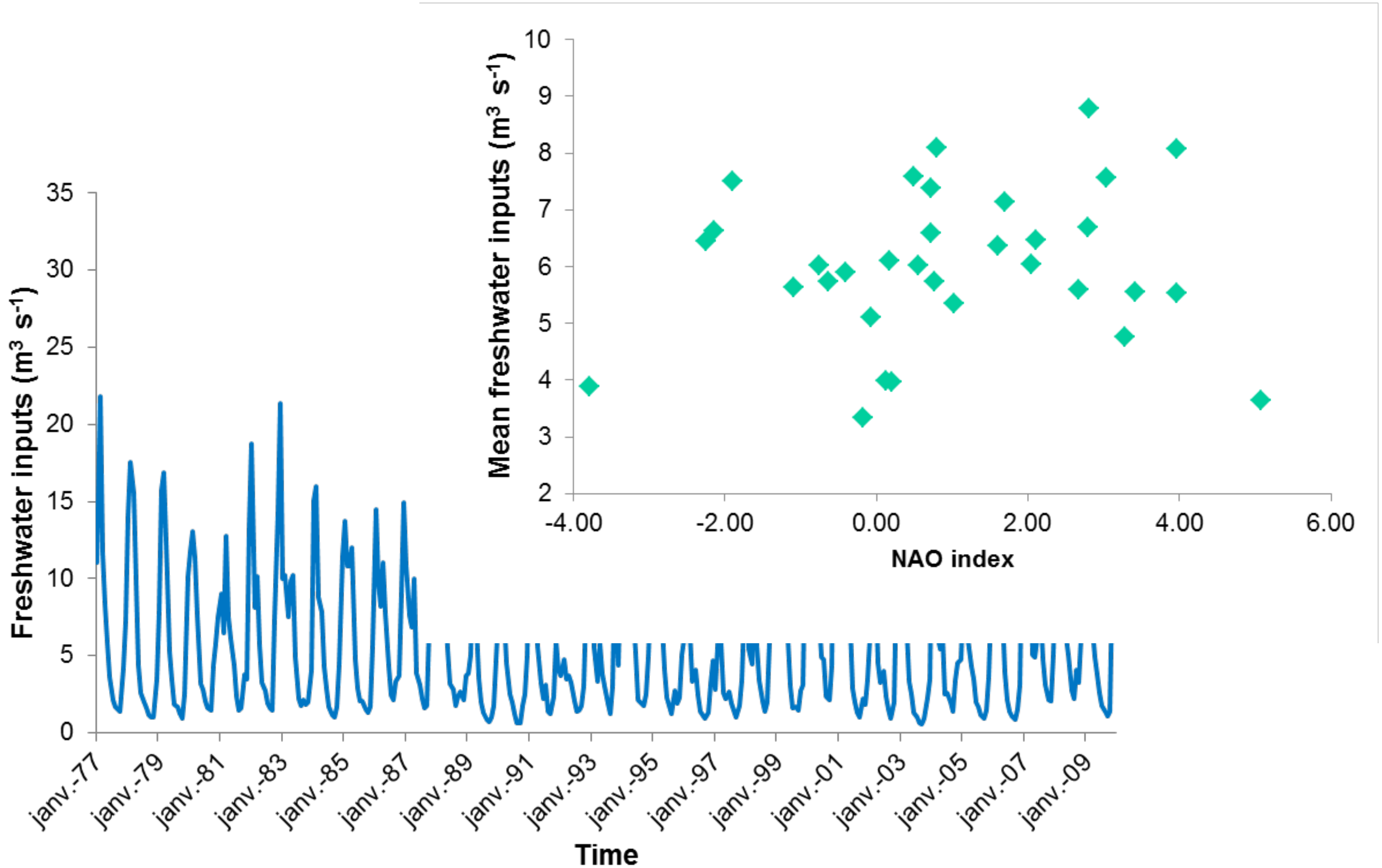






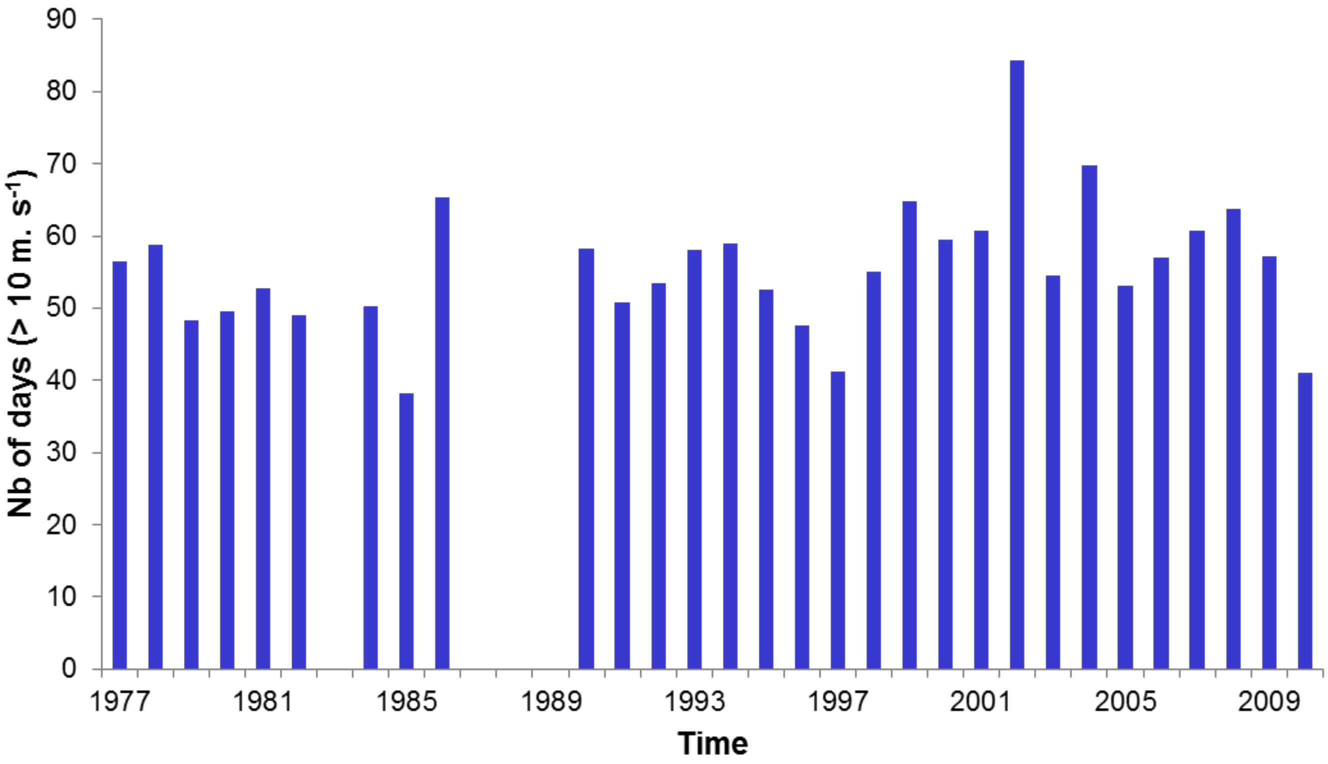
Environmental changes

Freshwater inputs



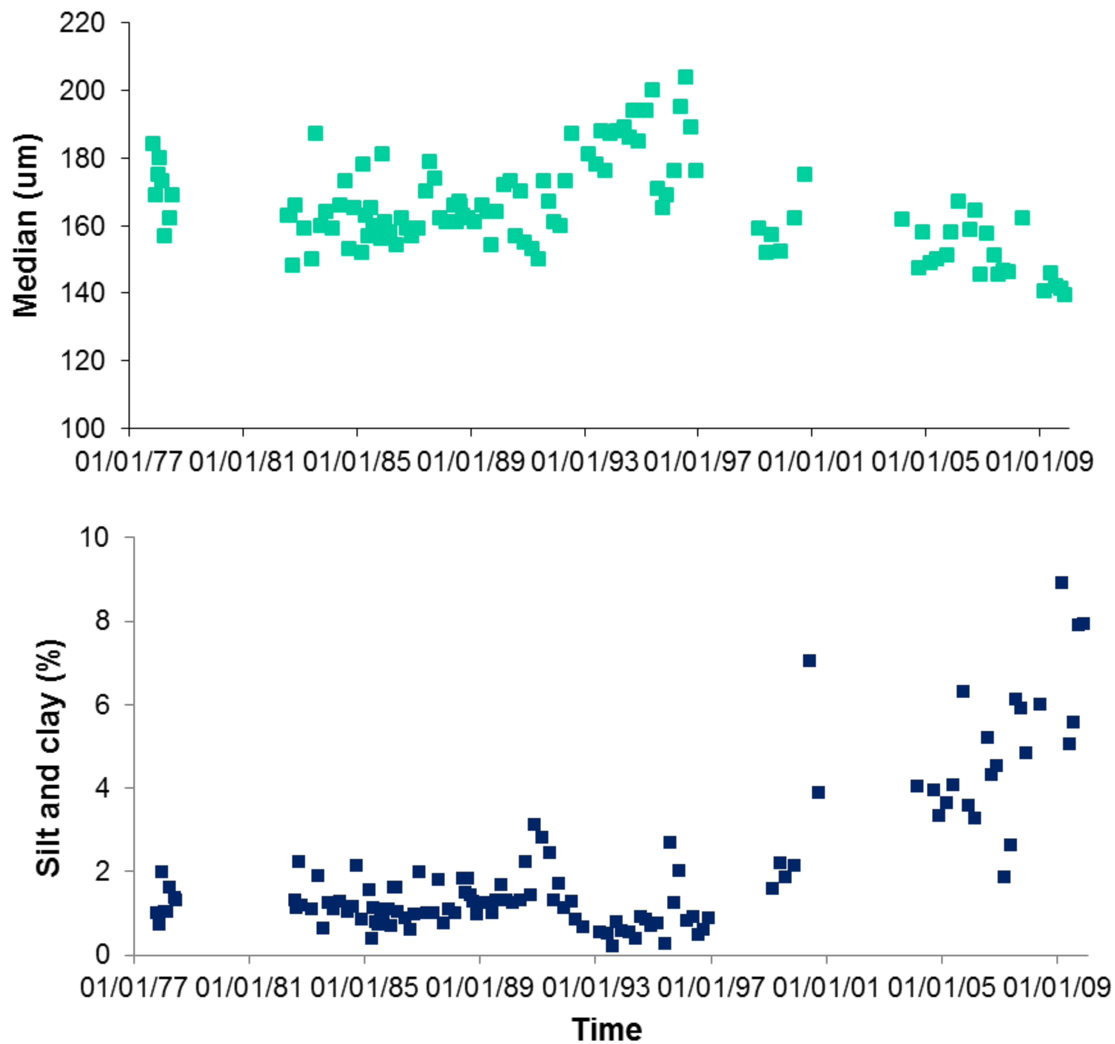
Environmental changes

Wind regime

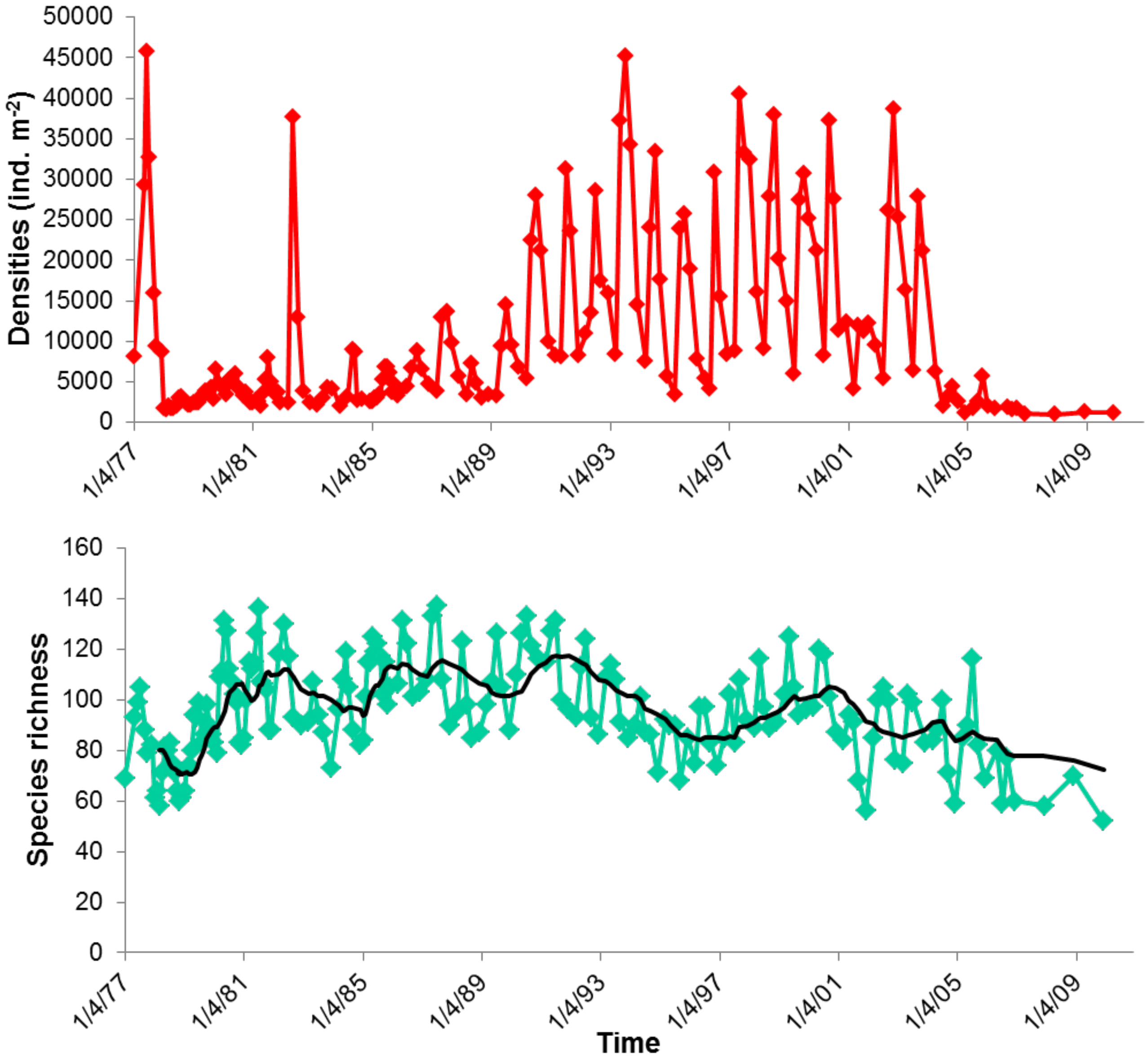


Environmental changes

A silting up of the bay



Results – Diversity changes



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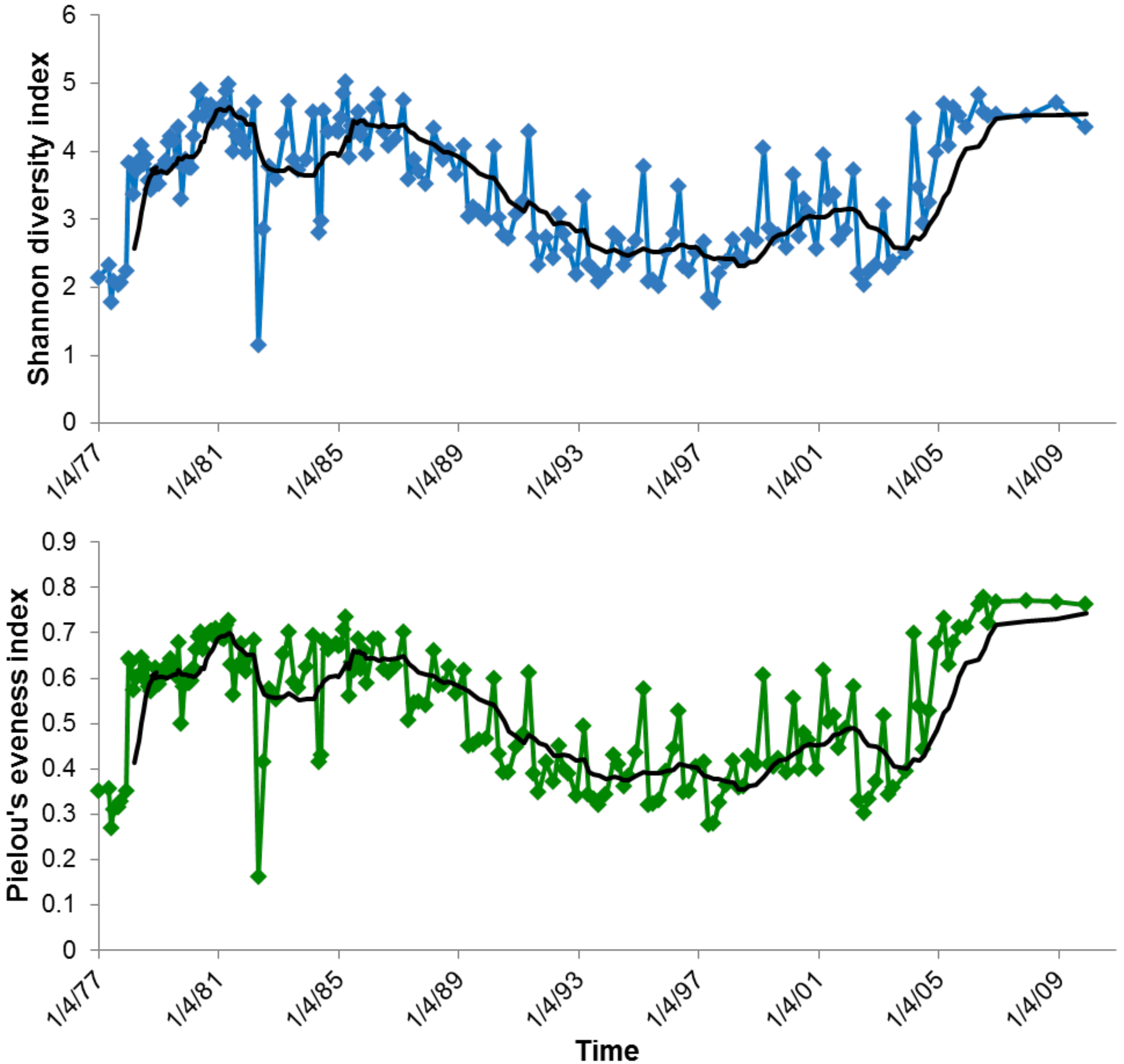
Results – Diversity changes



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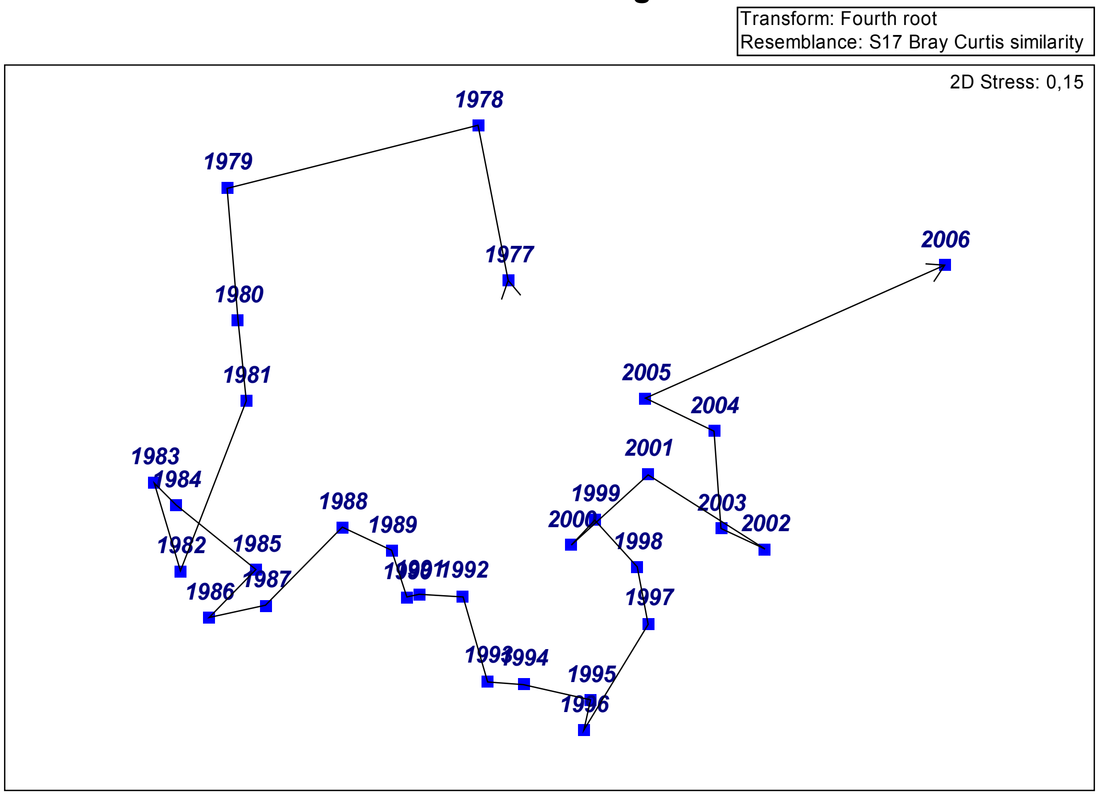
Results – Community structure

Annual average



➢ from the beginning of the sampling period until 1982, large temporal variations in the community structure due to direct and indirect effects of the oil spill

➢ relatively small changes between years corresponding both to the recovery period and to changes due to other forcing factors from 1983 to 2005

➢ a major shift between 2005 and 2006

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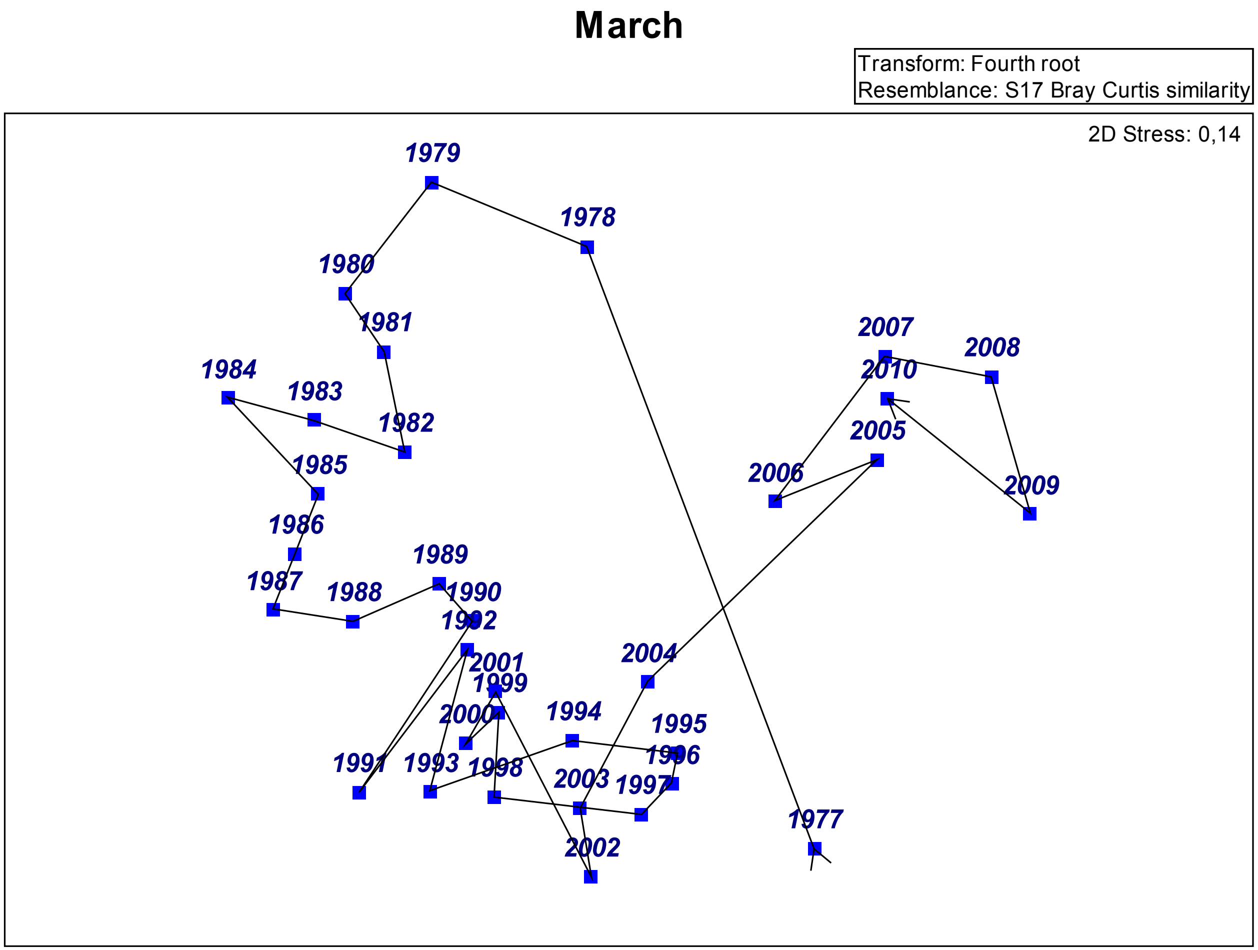
Results – Community structure



- a pattern close to this reported on the annual average
- suggests the occurrence of two alternative states for the community

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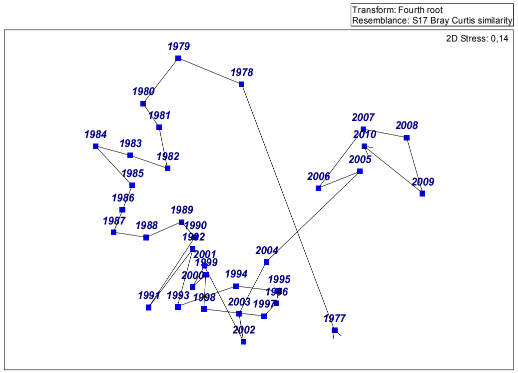
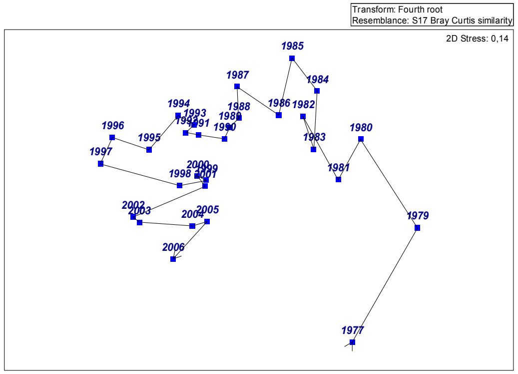
Results – Community structure

Different responses at different seasons ?

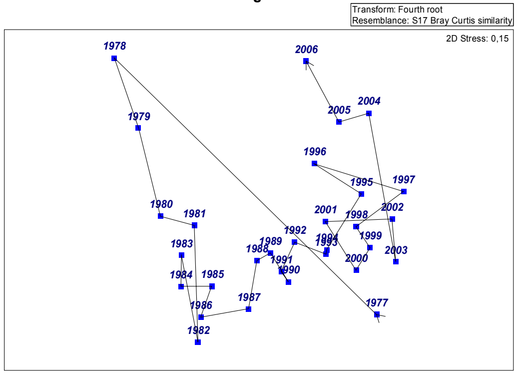
March



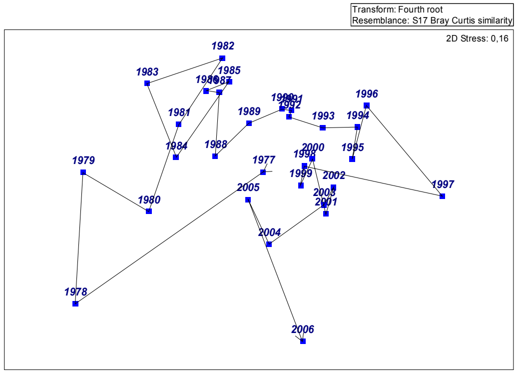
June



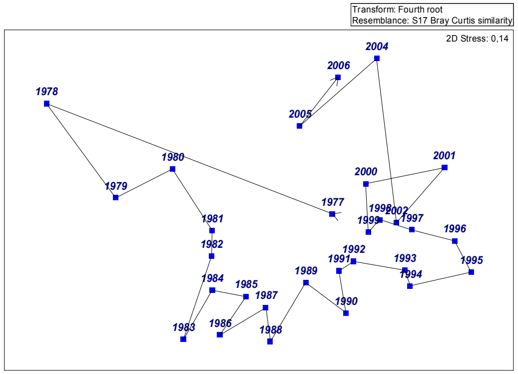
August



October



December



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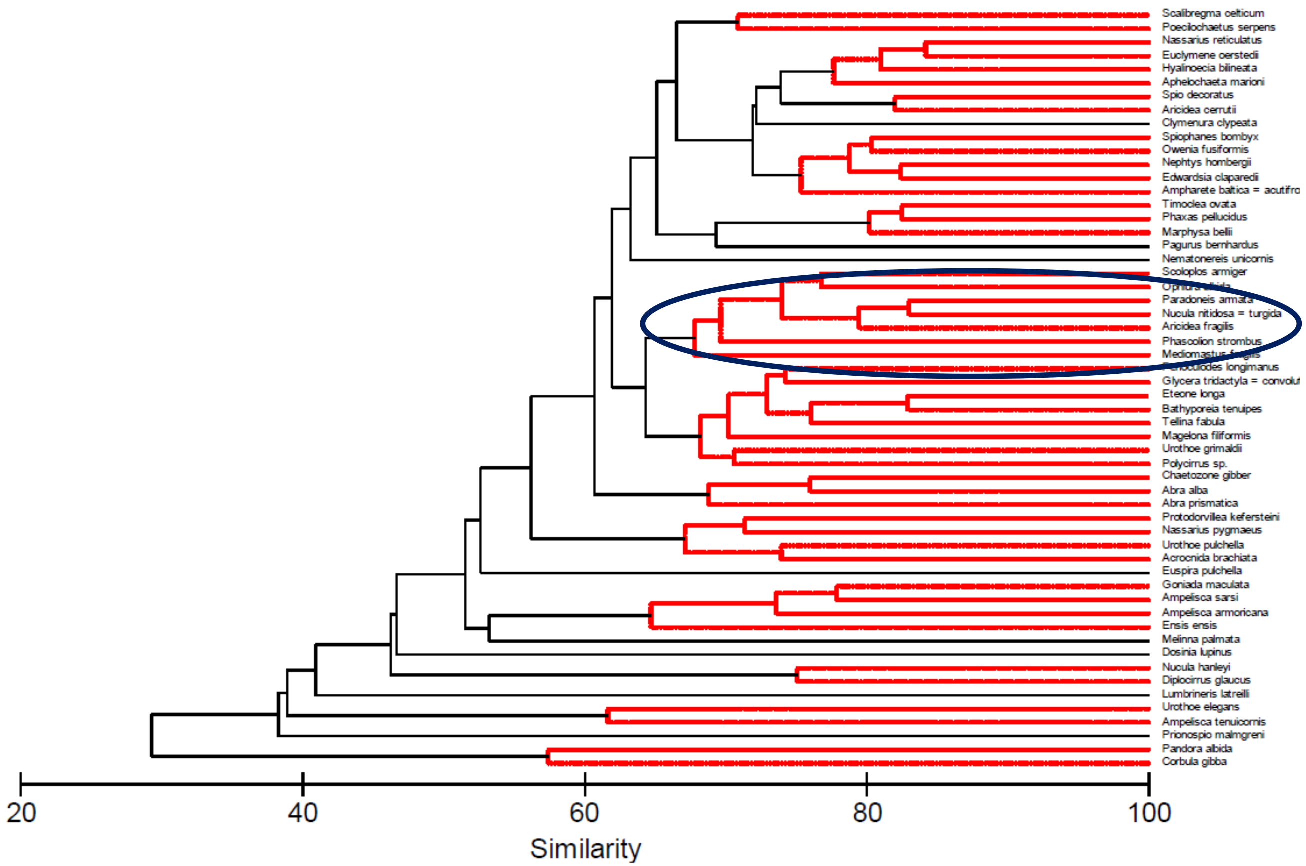
Results – Typology of species responses

- ✓ **Cluster analysis between the dominant species**
  - ➢ **Data previously transformed to downweight the influence of numerically dominant species and species exhibiting highly erratic densities**
  - ➢ **The statistical significance of clusters has been tested using a 'similarity profile' permutation test**

Results – Typology of species responses



- ✓ A high variety of temporal changes among species suggesting that responses to environmental changes are mainly species-specific
- ✓ Some common responses among species

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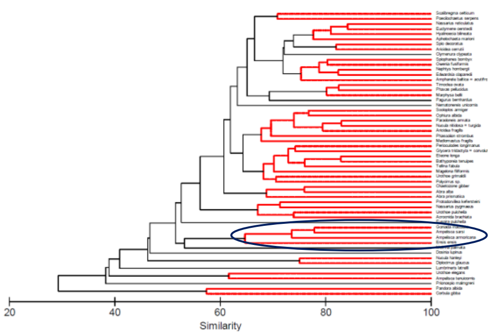
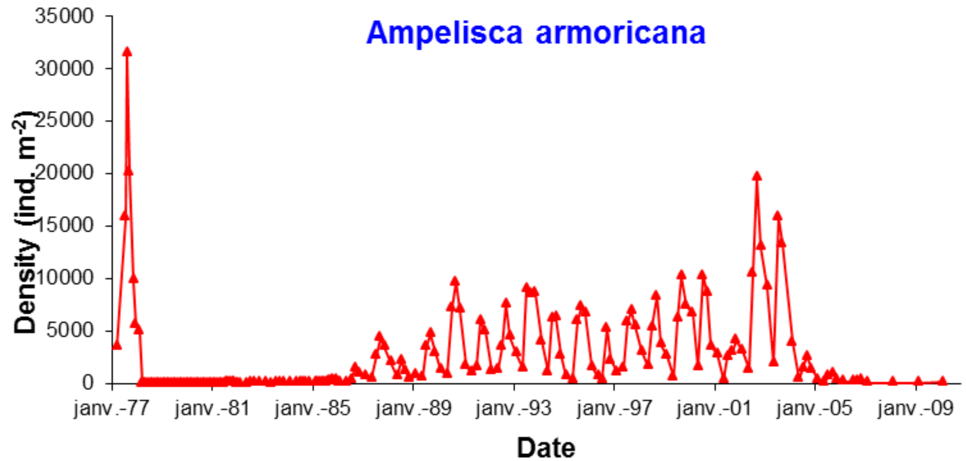
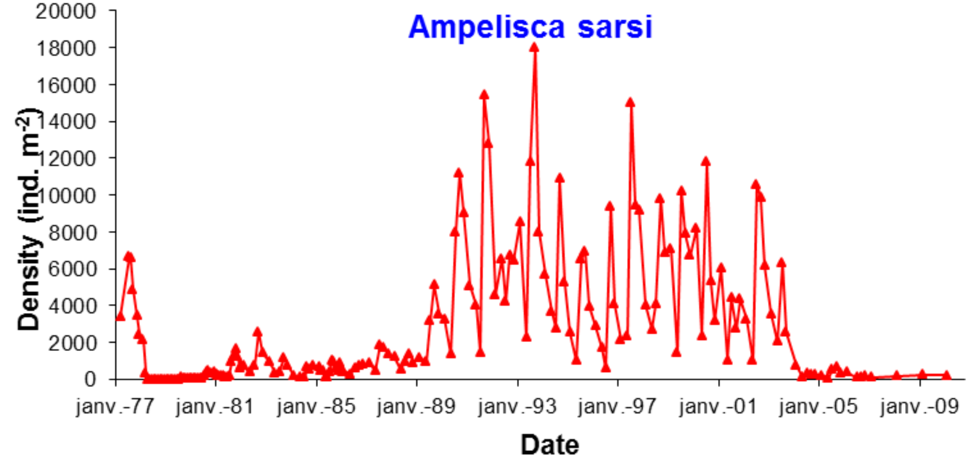
Results – Typology of species responses

Highly sensitive taxa to pollution







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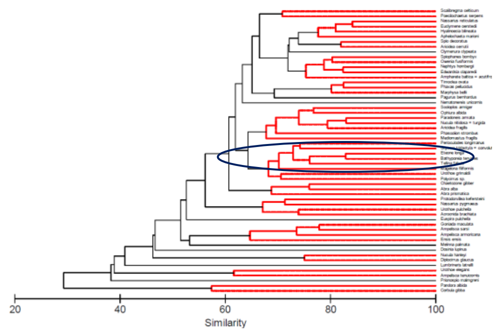
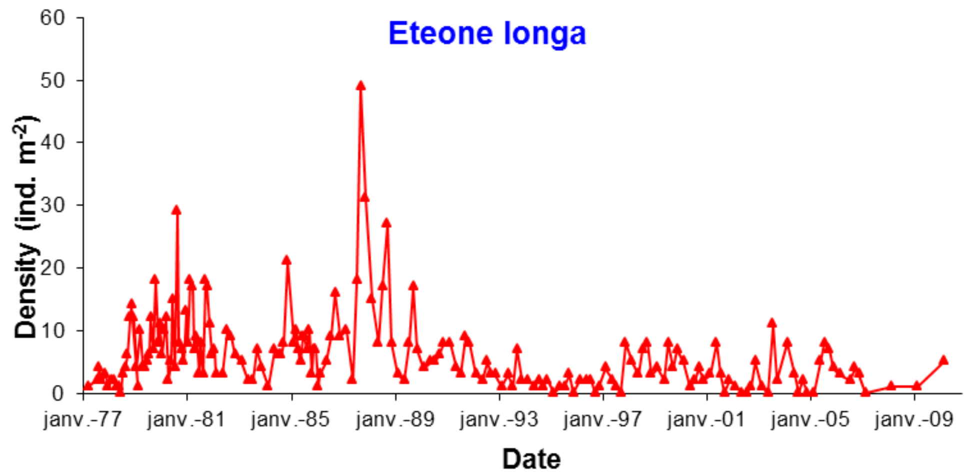
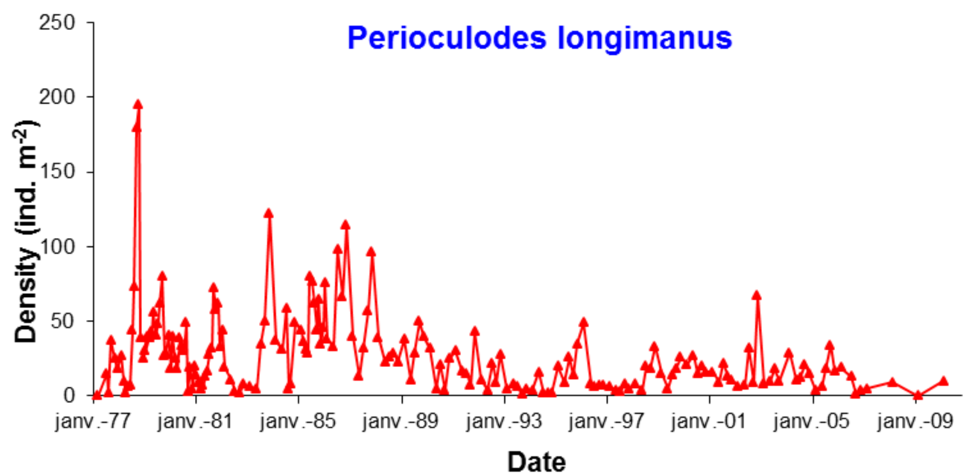
Results – Typology of species responses

Species mainly present during the 80s





Eteone lona
Magelona mirabilis
Tellina fabula
Perioculodes longimanus



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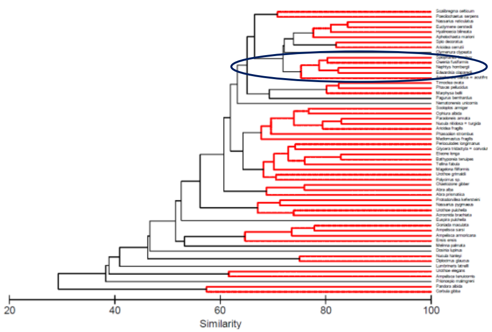
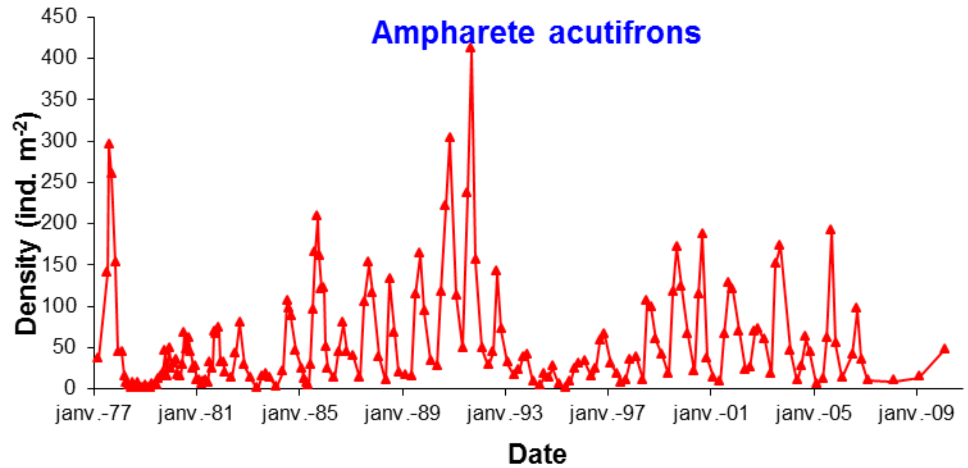
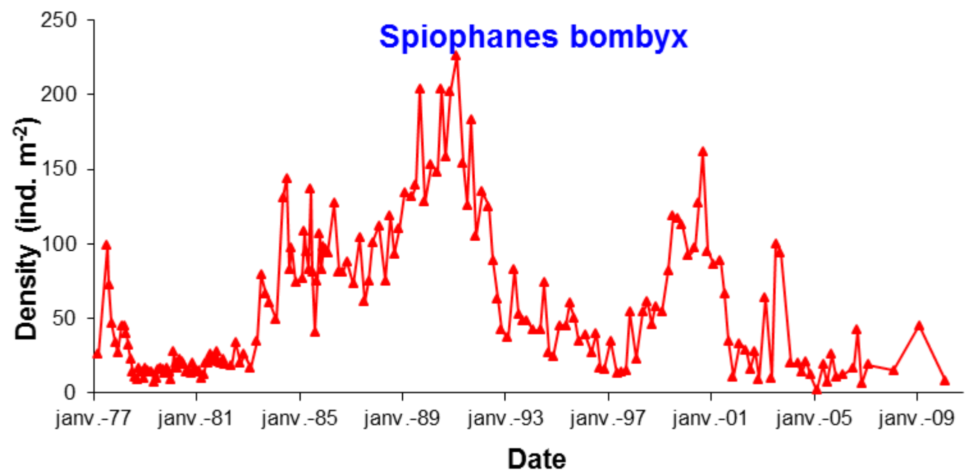
Results – Typology of species responses

Common species with decadal changes



Nephtys kervalensis
Spiophanes bombyx
Ampharete acutifrons





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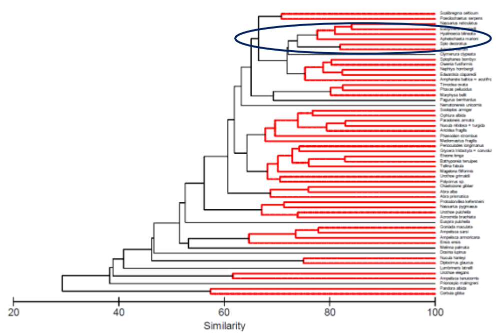
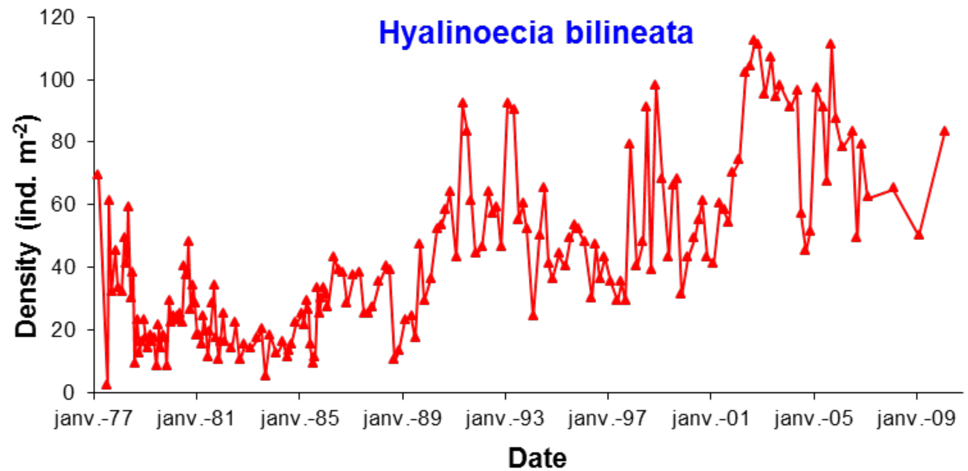
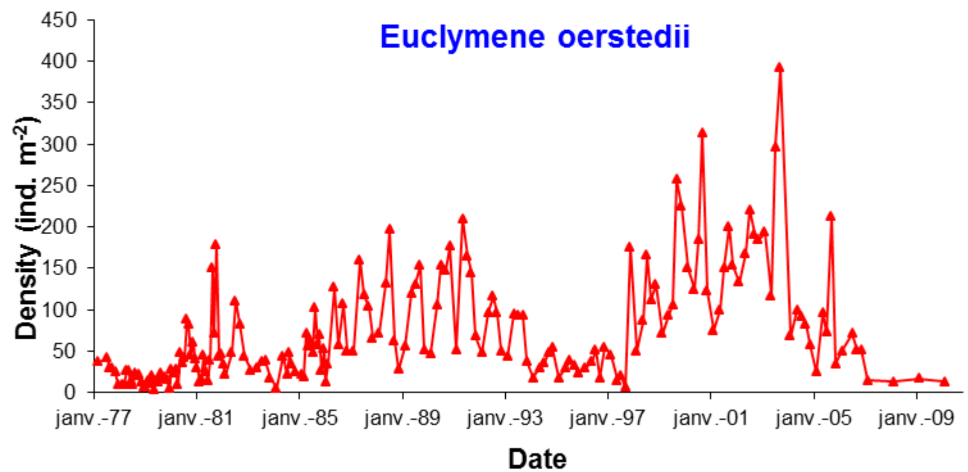
Results – Typology of species responses

Species increasing since mid-80s



Nassarius reticulatus
Euclymene oerstedii
Hyalinoecia bilineata
Aphelochaeta marioni





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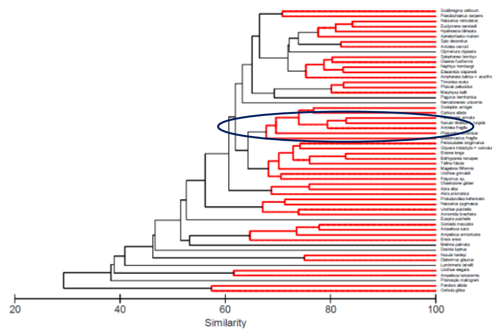
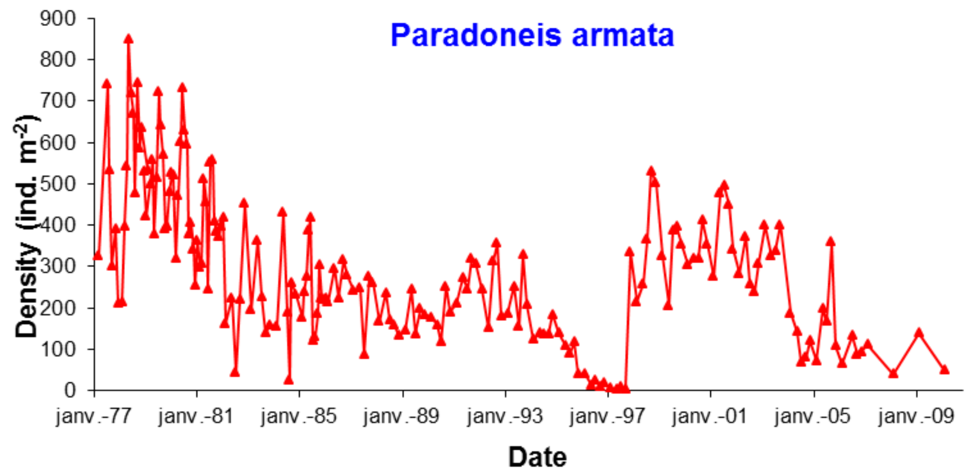
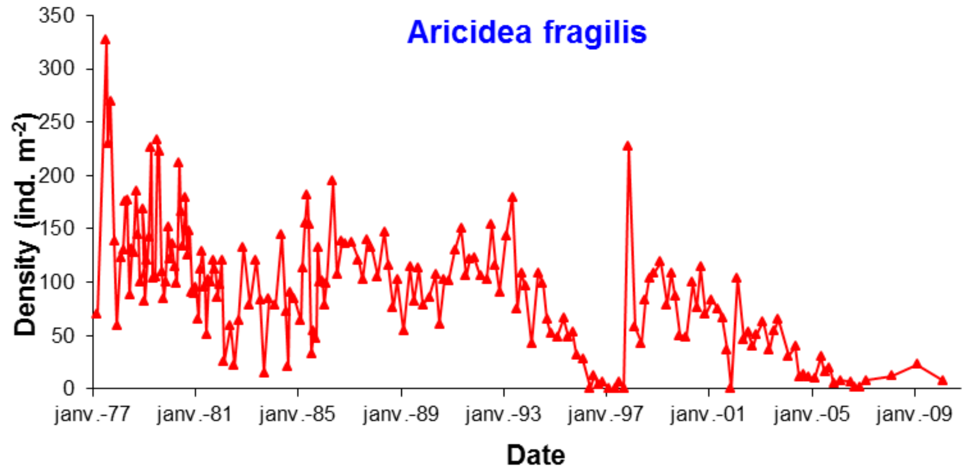
Results – Typology of species responses

Species decreasing since early 80s





Scoloplos armiger
Ophiura albida
Paradoneis armata
Aricidea fragilis



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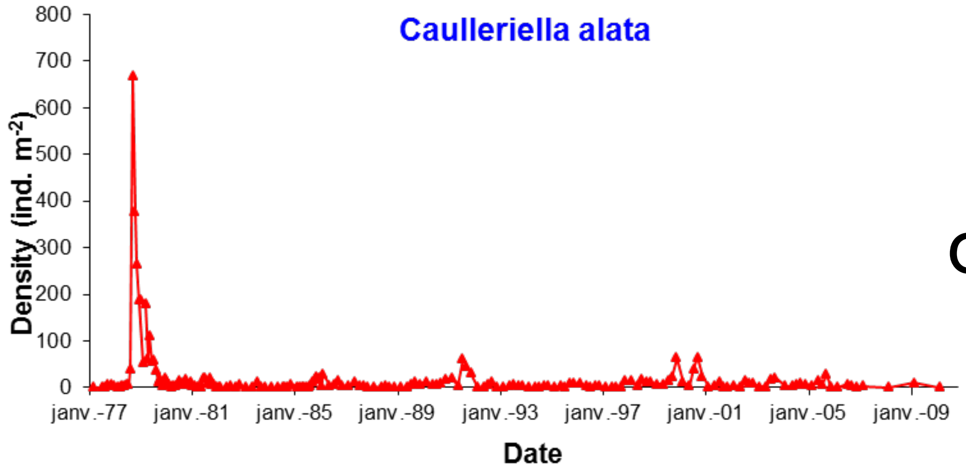
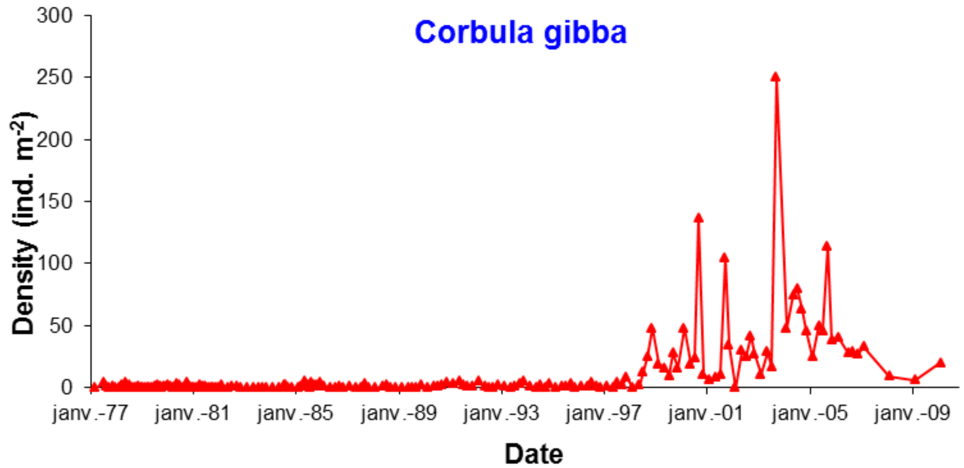
Results – Typology of species responses

Species with erratic fluctuations



Opportunistic species



Bioindicator of sediment disturbance

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Results – Links with environmental changes

Variables	SS	Pseudo-F	R^2	p-value
Hydrocarbons	1216.6	2.5979	0.00977	0.0006
NAO	675.03	1.3752	0.00542	0.1533
NHT	2213.9	5.1878	0.17774	0.0001
AMO	2383	5.6778	0.19132	0.0001
Freshwater inputs	479.96	0.96187	0.00385	0.4597
Mean temperature	1691.5	3.7714	0.1358	0.0005
Wind regime	783.18	1.6103	0.00629	0.083

Best model : 35.3 %

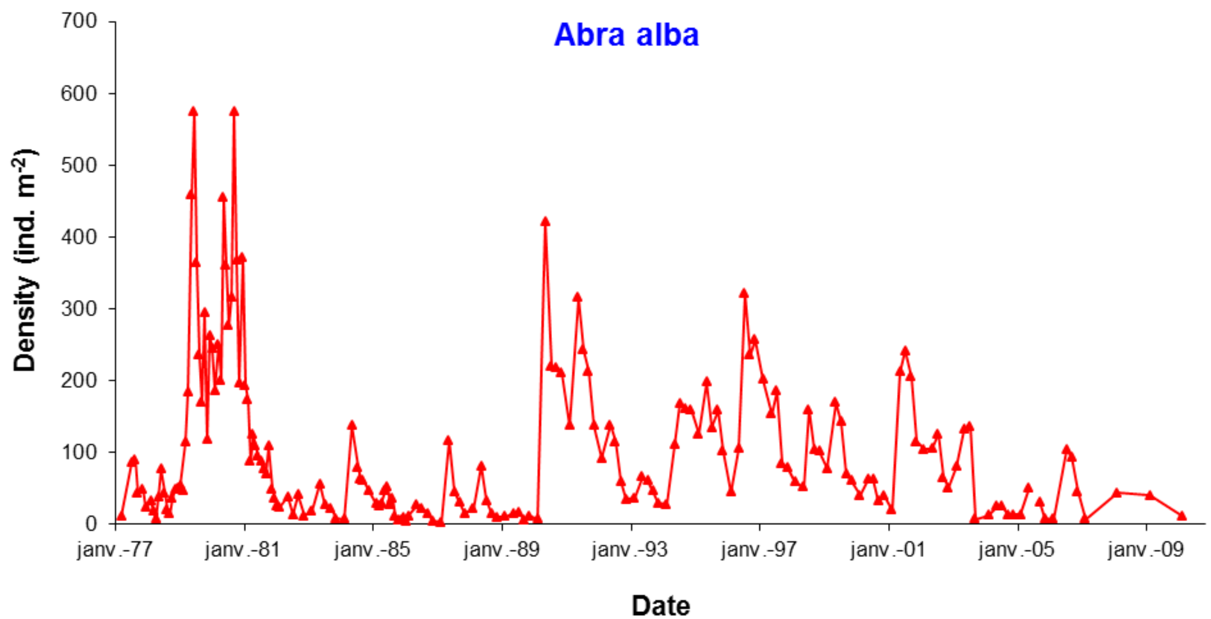
Conclusions

- ✓ a complex dynamics with two sudden changes in the community structure in 1978 after the Amoco Cadiz oil spill and in 2005
- ✓ two quite different changes
- ✓ the first one followed by a long recovery of about 15 years
- ✓ the second one leading to a new state characterized by low densities and species richness
- ✓ the complex dynamics of the community poorly explained by the available environmental factors for diverse reasons including the lack of some environmental variables, a lag in the responses of species to environmental changes, non-linear responses of the biological systems, the role of biotic interactions

For managers, these results raise the question of the reference status to assess the ecological quality status of a community.

Suggestions

✓ A need to maintain long-term benthic series as our understanding of ecosystems dynamics changes over time.

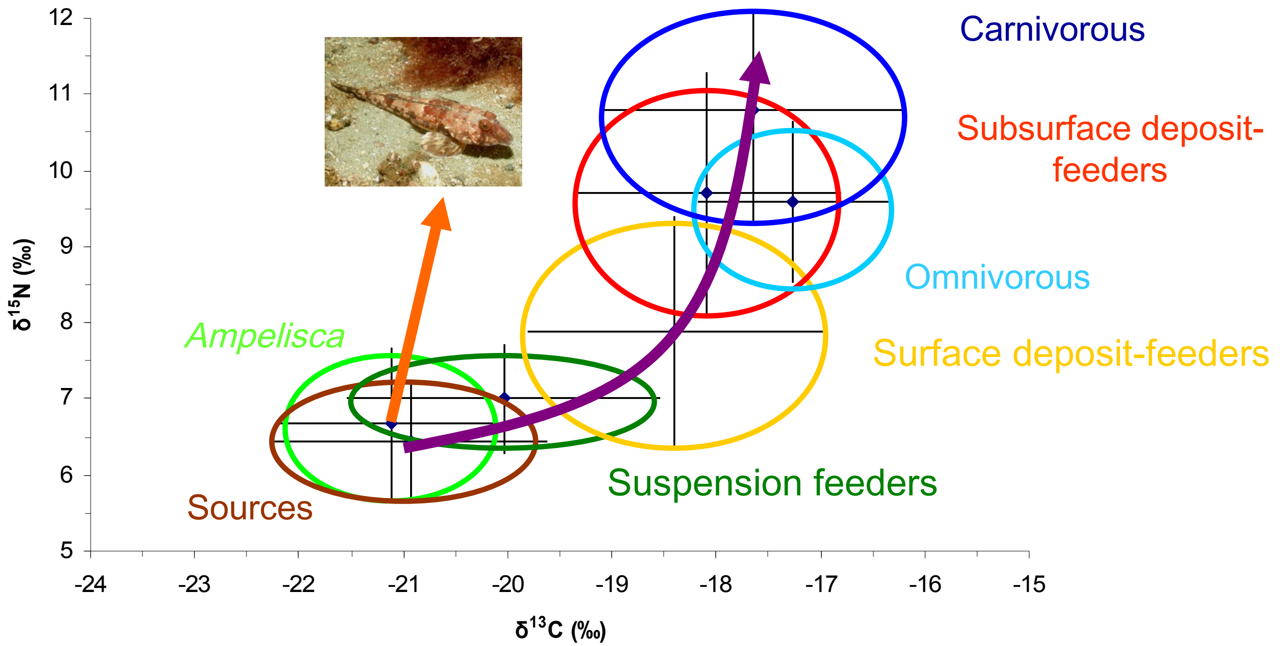


Dauvin (1984) : a biostimulation due to the oil spill

Dauvin et al. (1992) : decadal changes related to the solar activity

Suggestions

✓ **Long-term benthic series are a major support for the analysis of ecosystem processes**



Changes in the community structure induced changes in the community functioning

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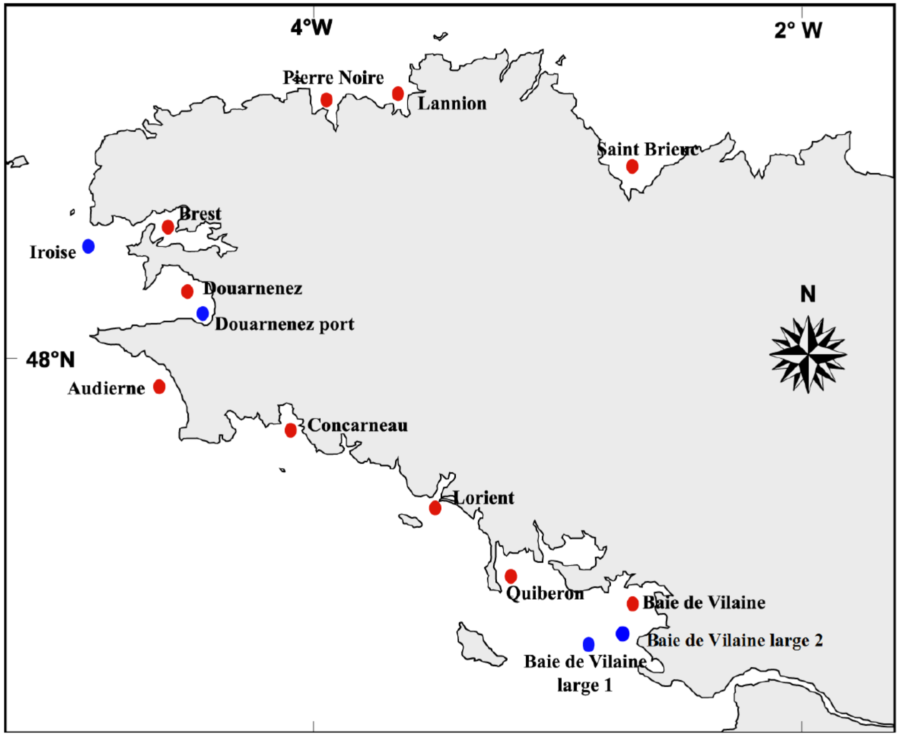
Suggestions

- ✓ **A need to develop a European scale monitoring network to disentangle the relative effects of local and regional factors**



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Thanks for your attention