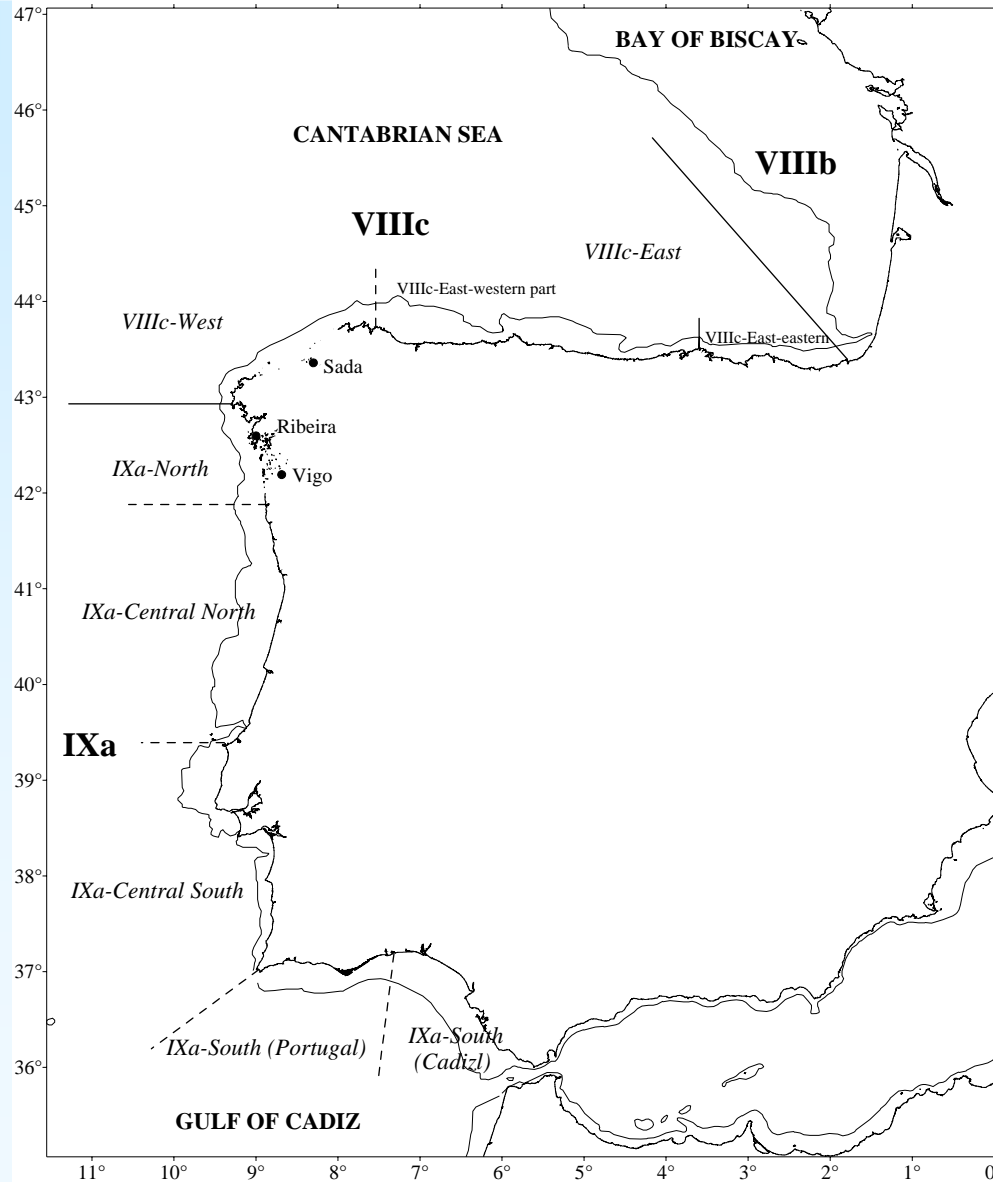# The effect of environmental changes in the NE Atlantic sardine (*Sardina pilchardus*) fishery

Carmela Porteiro, J.M. Cabanas, P. Carrera, M.B. Santos, M. Bernal and G.J. Pierce

Instituto Español de Oceanografía
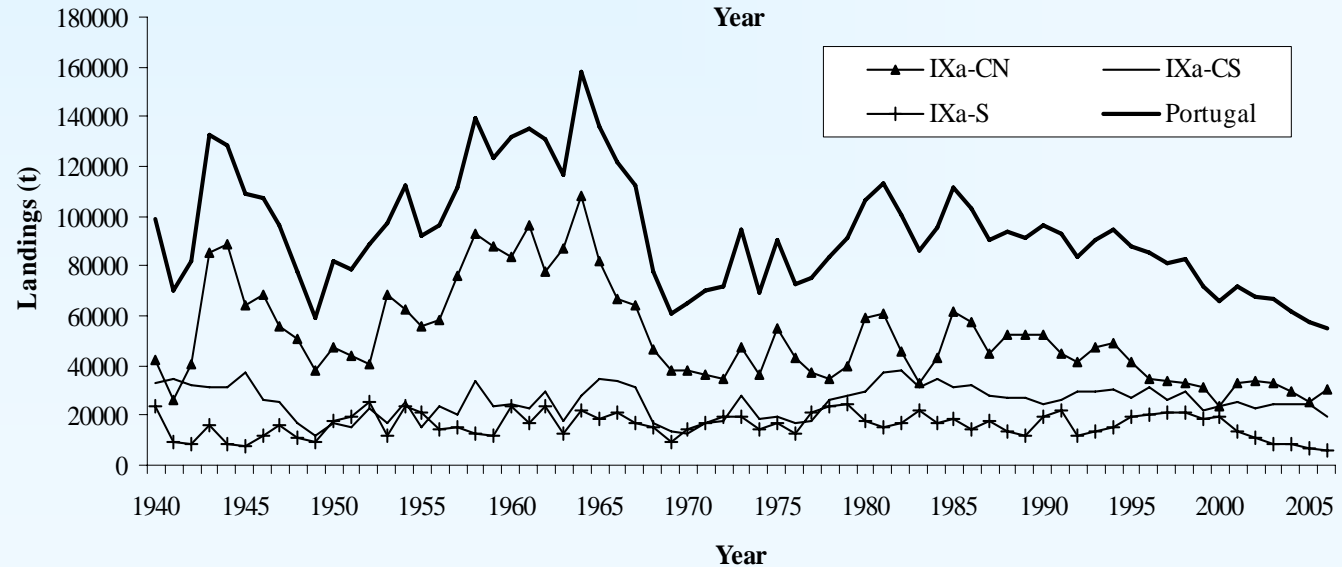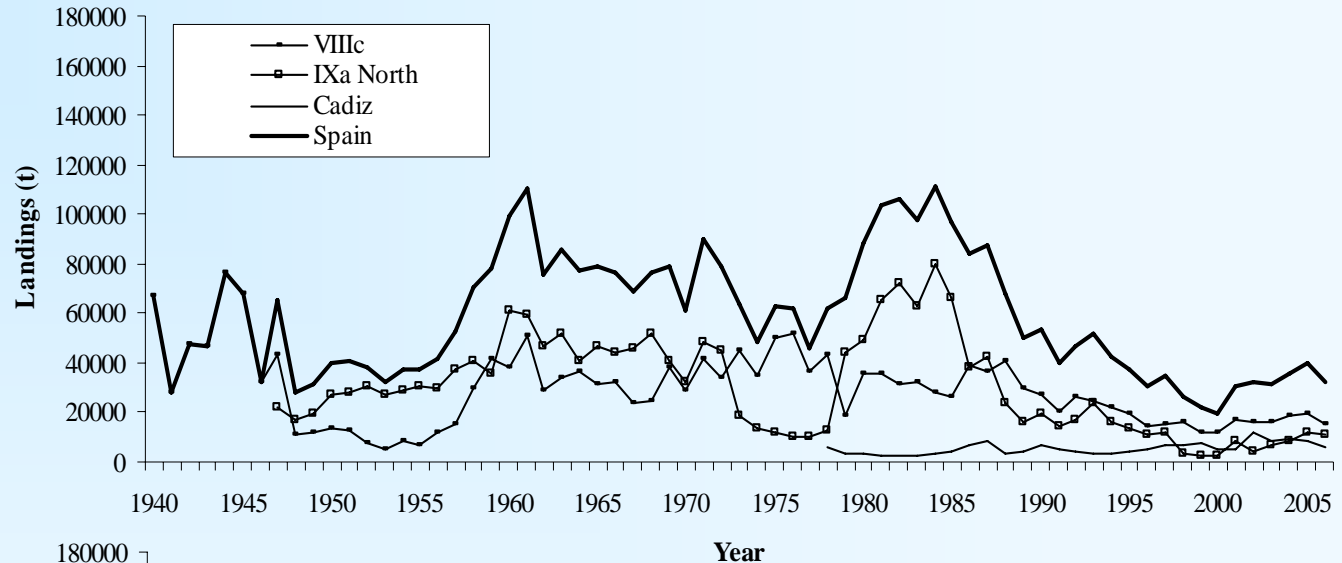
Atlanto-Iberian Stock of Sardine

The sardine fishery

- **Highest catches in ICES IXa (Portuguese and S Galician waters)**

- **Important fluctuations in landings over the time series**

- **Several "crises", landings in mid-1990s down 50% since mid-1980s (mainly due to reduction in northern Spain)**

Atlanto-Iberian Stock of Sardine

- Single stock, delimited by Spanish-French border and Strait of Gibraltar

- Supports important fishery in Spain and Portugal

- Sardine shows rapid growth rate, short generation time, long spawning season and females produce high number of eggs

- Survival of offspring highly dependent on favourable environmental conditions (concentration of eggs/larvae in suitable areas)

- Recruitment therefore influenced by number of adults but also by the environment
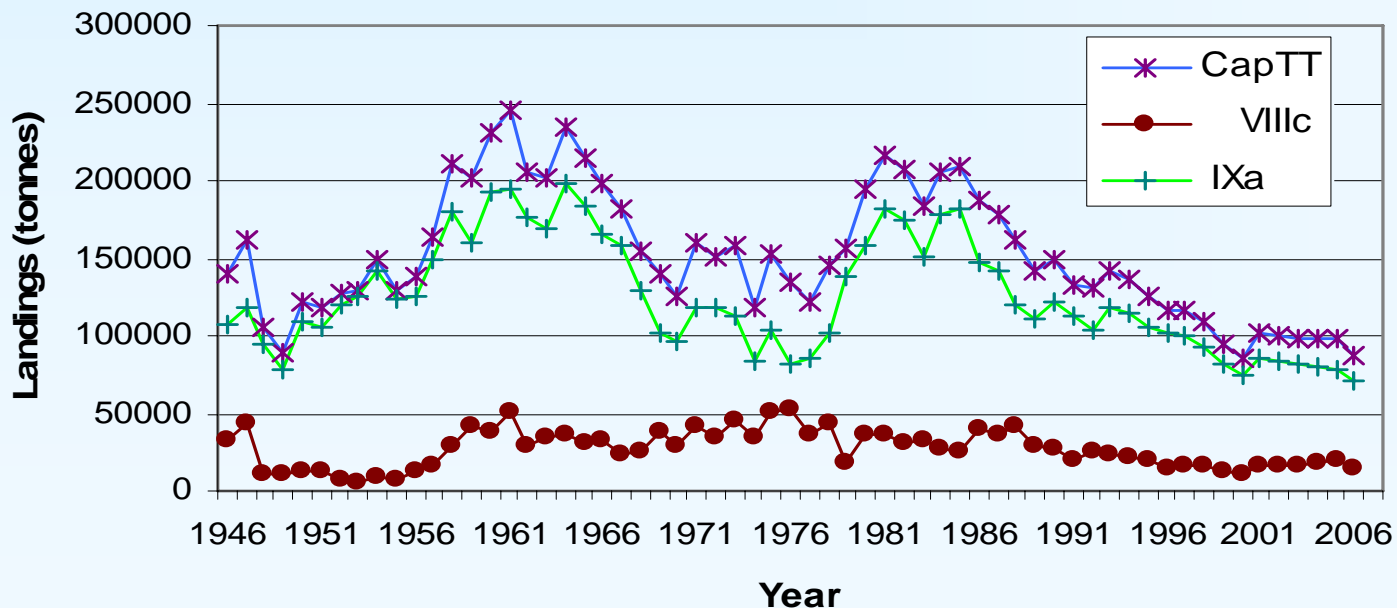
The sardine stock

– Good recruitments in 1983, 1991–92, 2000 and 2004

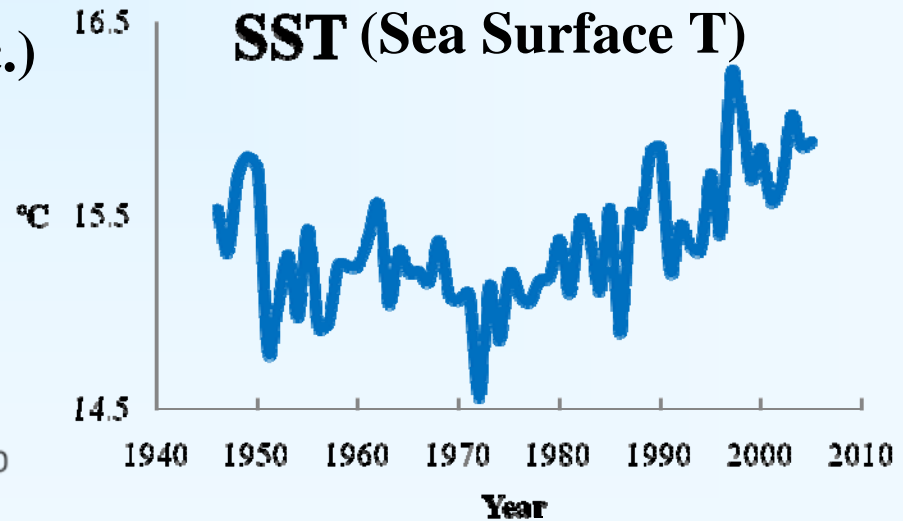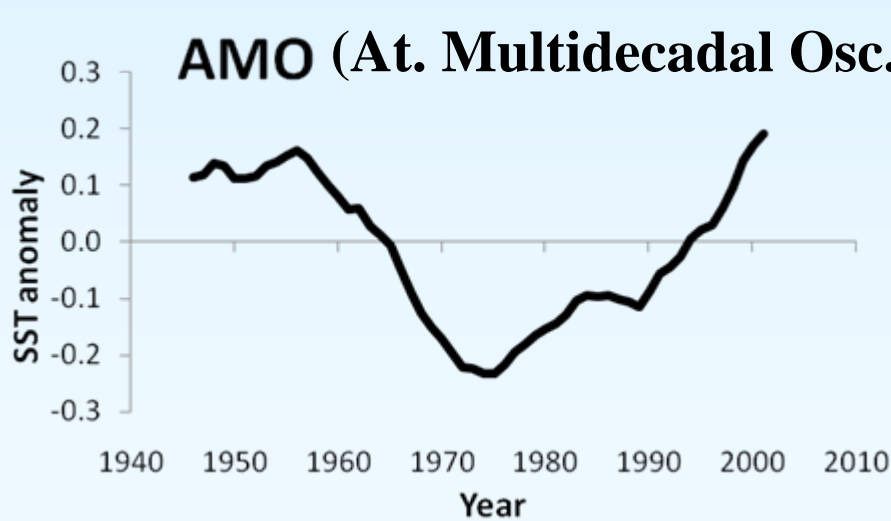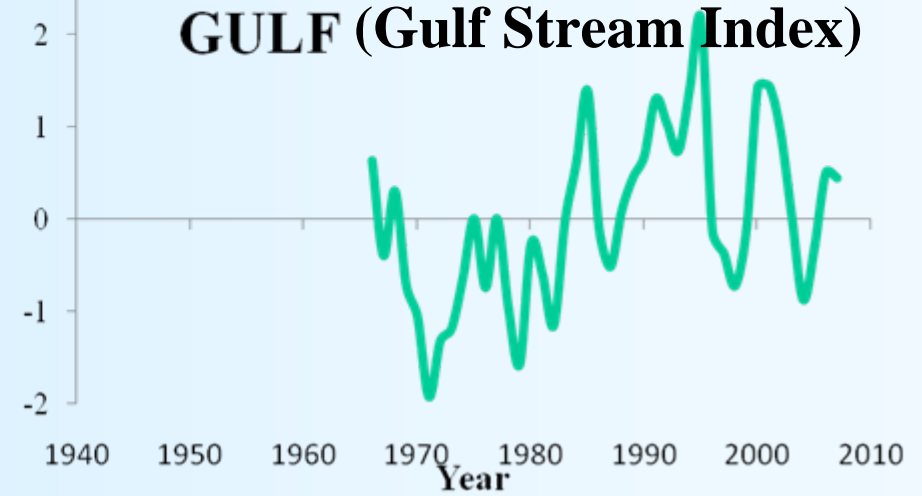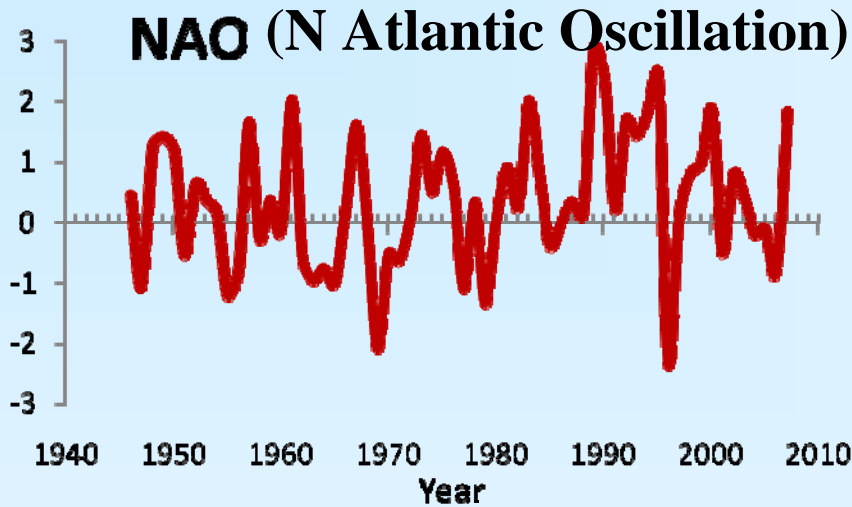- Can we explain recruitment variability?
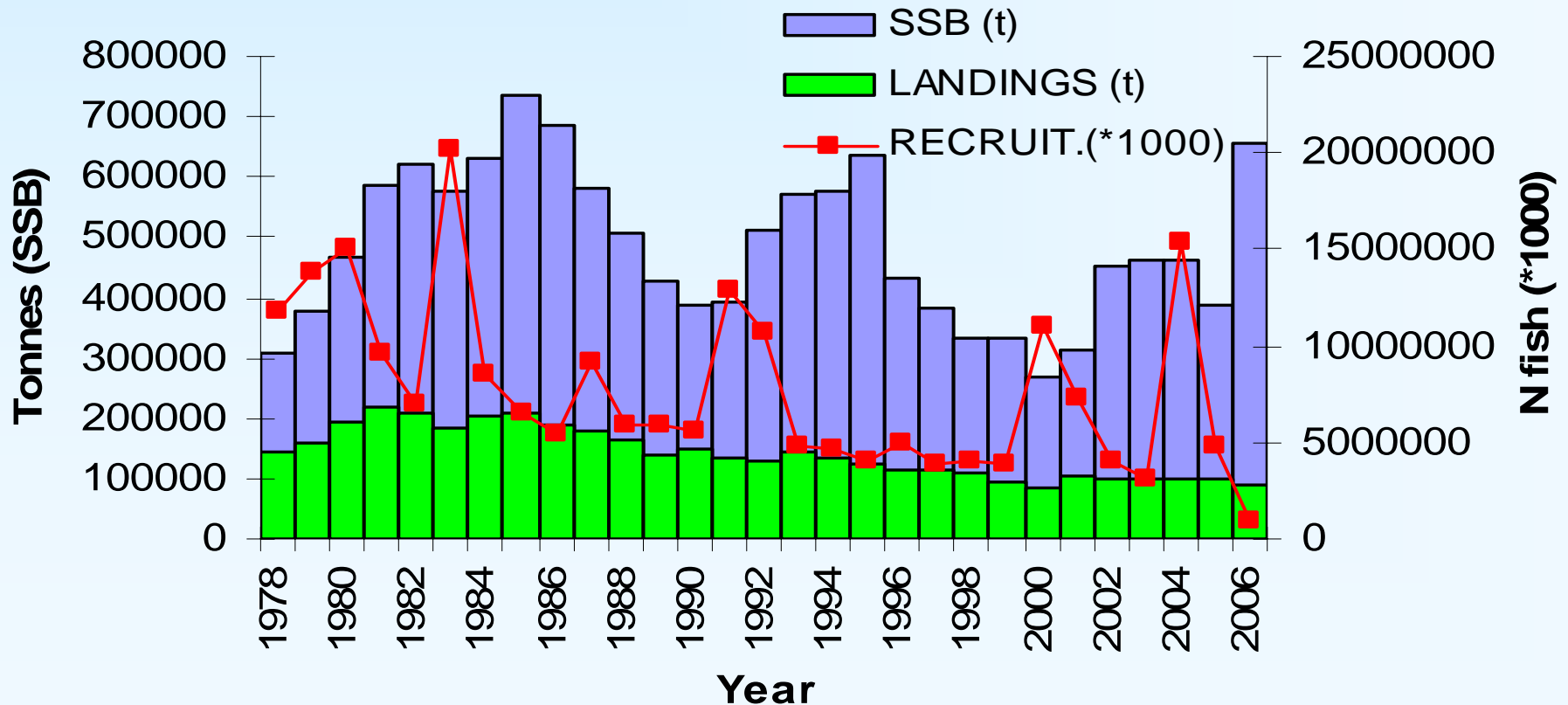
Data & Methods

Sardine stock: Landings (Total, VIII, IXa), SSB, Recruitment
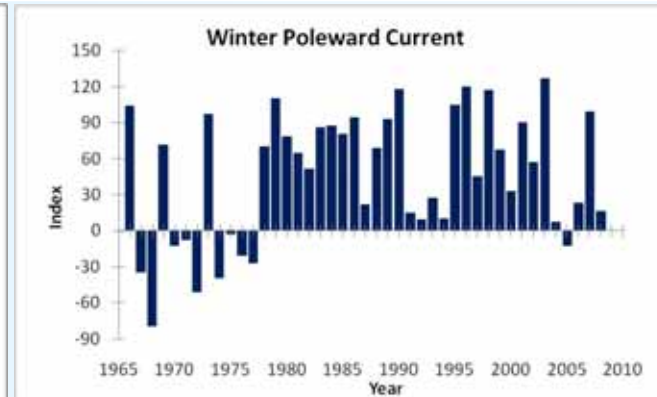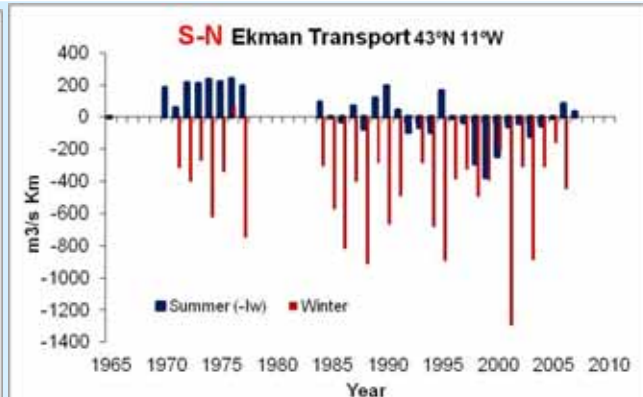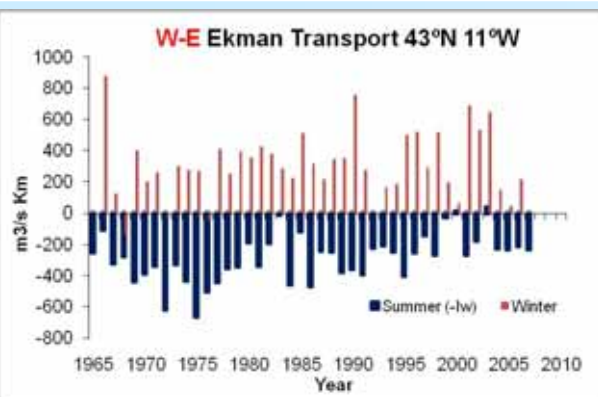
Climatic indices: NAO_w, NAO_mam, Gulf Stream, AMO

Local oceanographic conditions: SST_Annual; SST_ Apr-Sep; SST_Oct_Mar; AT_Annual; AT_ Apr-Sep; AT_Oct_Mar; W_Annual; W_ Apr-Sep; W_Oct_Mar; U_Annual; U_ Apr-Sep; U_Oct_Mar;V_Annual; V_ Apr-Sep : V_Oct_Mar; Iw 43_11 (Apr-Sep)

The climatic index

Local oceanographic conditions

|	Iw (- Qx Ap-Sp)	Qx Oct-Mar	Qy Ap-Sp	Qy Oct-Mar
1970-1979	441	254	**193**	-368
1980-1989	**264**	341	**30**	-554
1990-1999	**251**	340	**-57**	-466
2000-2007	**162**	337	**-52**	-548

Change in wind regime.
        Less north wind in summer and more in winter.
The major changes observed are in the upwelling period:
   Decrease in the eighties and a shift in the alongshore current

What are the environmental trends?

Dynamic Factor Analysis (summarises common trends in multiple time series) using NAO and annual AT, U, V, W, SST as response variables
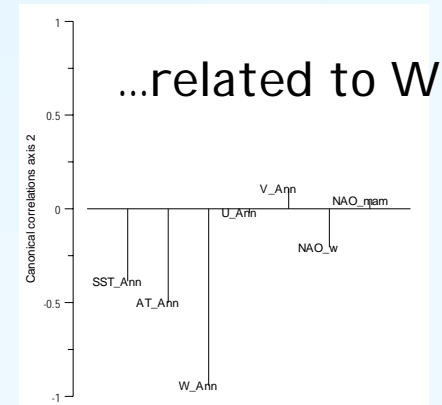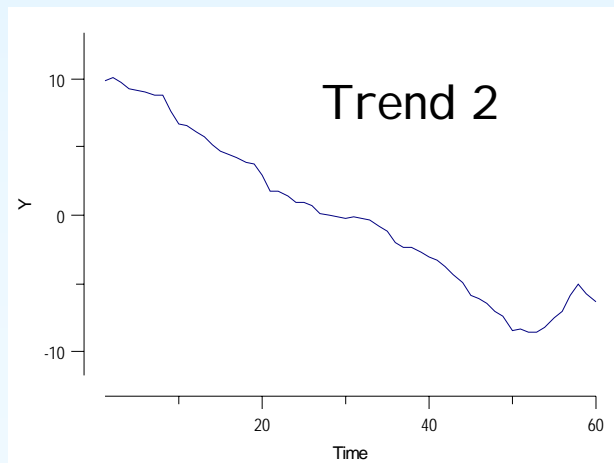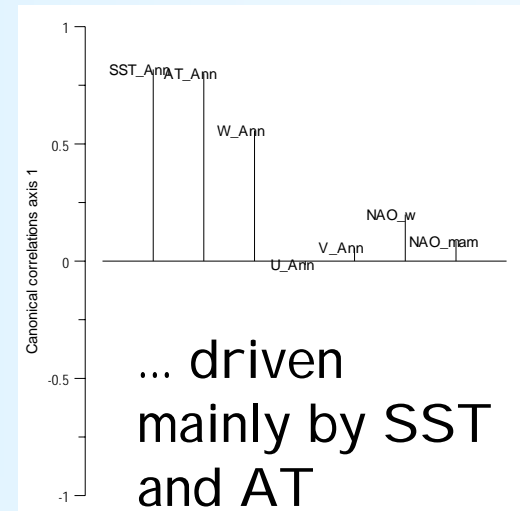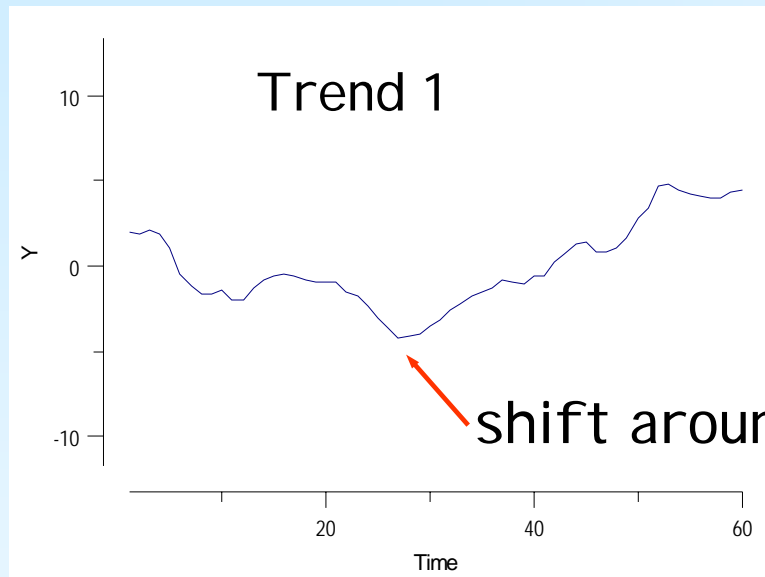
What are the trends in landings?

Min_Max Autocorrelation Factor Analysis (MAFA) (another technique to identify common trends) using VIIIc and IXa landings series as response variables

Peaks around **1965** and **1985**

Shift around **1975**
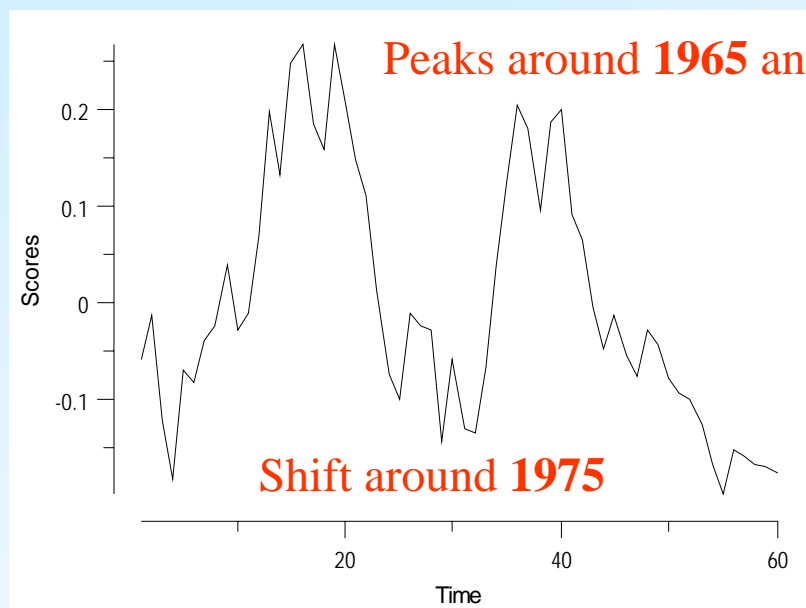
MAFA results indicate that this trend is negatively correlated with SST
(R = -0.34, P < 0.05)

Cross-correlation analysis

- negative correlation between landings and annual SST at lags of 1 and 7 years (lag = 4 years in area VIIIc)
- negative correlation between landings and annual wind index at lag of 10 years

Modelling landings and recruitment series

1. Landings 1946-2005

- Significant autocorrelation at lag of 1 year.
- Putting this into a time series (ARIMA) model, landings are a function of landings in the previous year.
- Adding environmental predictors does not improve the model.

Partial Autocorrelation Function for LandingsTT
(with 5% significance limits for the partial autocorrelations)
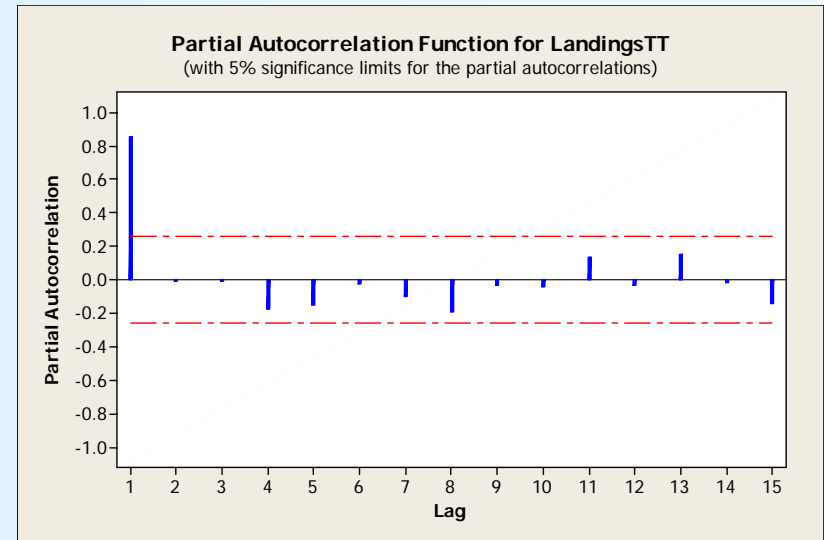
2. Recruitment 1978-2005

- No autocorrelation
- A generalised additive model fitted to recruitment data suggests a weak negative relationship with annual SST (P=0.056, variance explained = 13%)
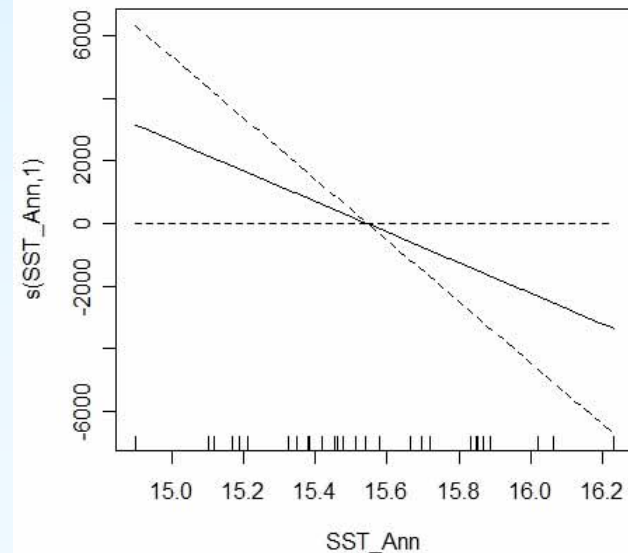
Conclusions

- A change in the trend in sardine landings in 1975 corresponded with a shift in environmental conditions
- Exploratory analysis suggests negative correlation between landings and SST
- There is strong autocorrelation in the landings data, relating to the dynamics of the stock
- Taking into account autocorrelation, results suggest that all environmental effects on landings are weak
- There is a marginally significant negative relationship between recruitment and annual SST
- Our results are consistent with previous analysis that suggests that sardine has a wide temperature tolerance: it is not blind, deaf or insensible to climate change but it is able to adapt to changing conditions

Thank you for your attention

- We would like to thank all our Portuguese and Spanish colleagues working on sardine, all the crew and participants in the acoustic surveys, all the people who collect the landings data, and Alain Zuur (Highland Statistics) for statistical advice