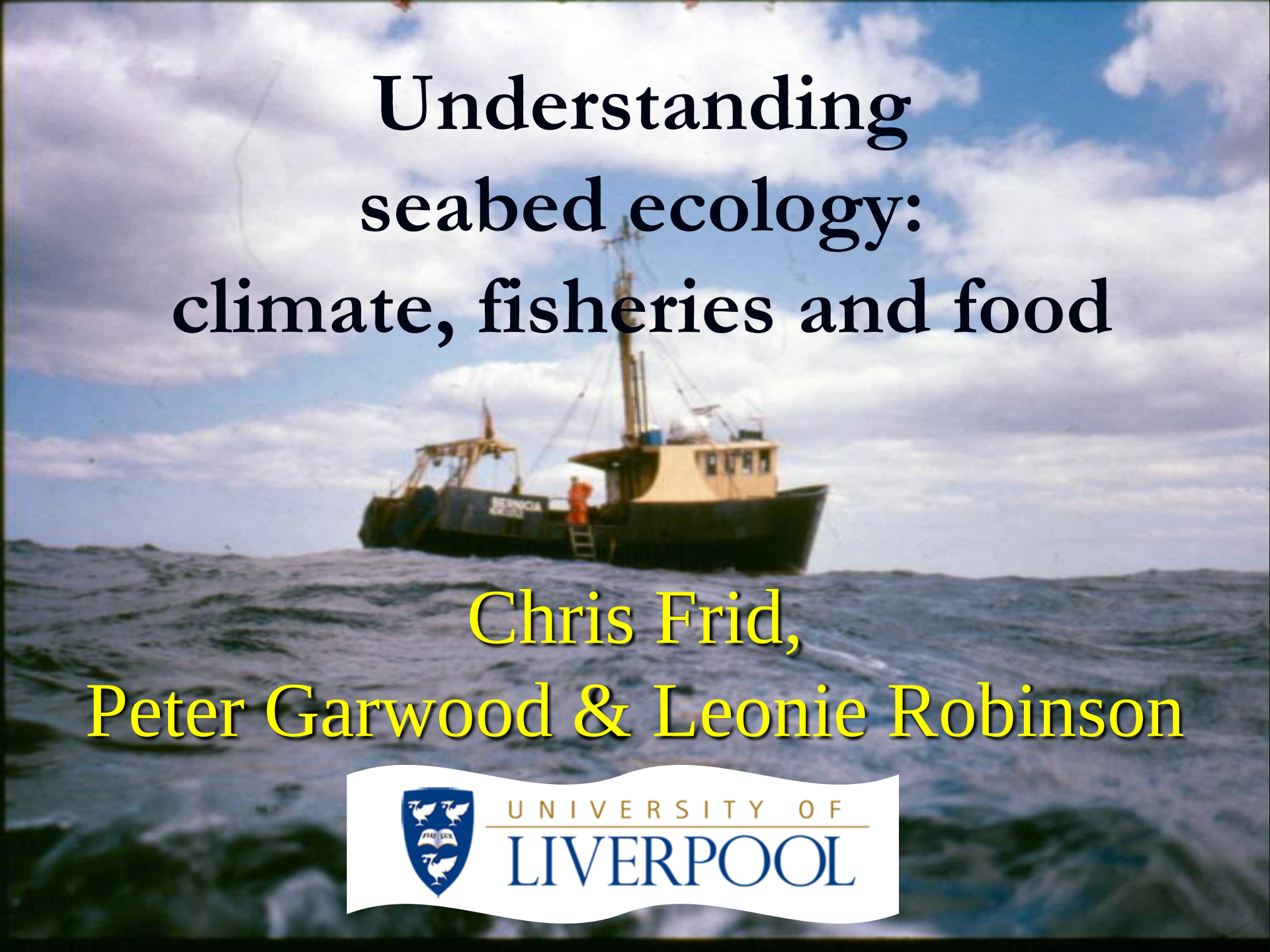

Understanding seabed ecology: climate, fisheries and food

Chris Frid,
Peter Garwood & Leonie Robinson

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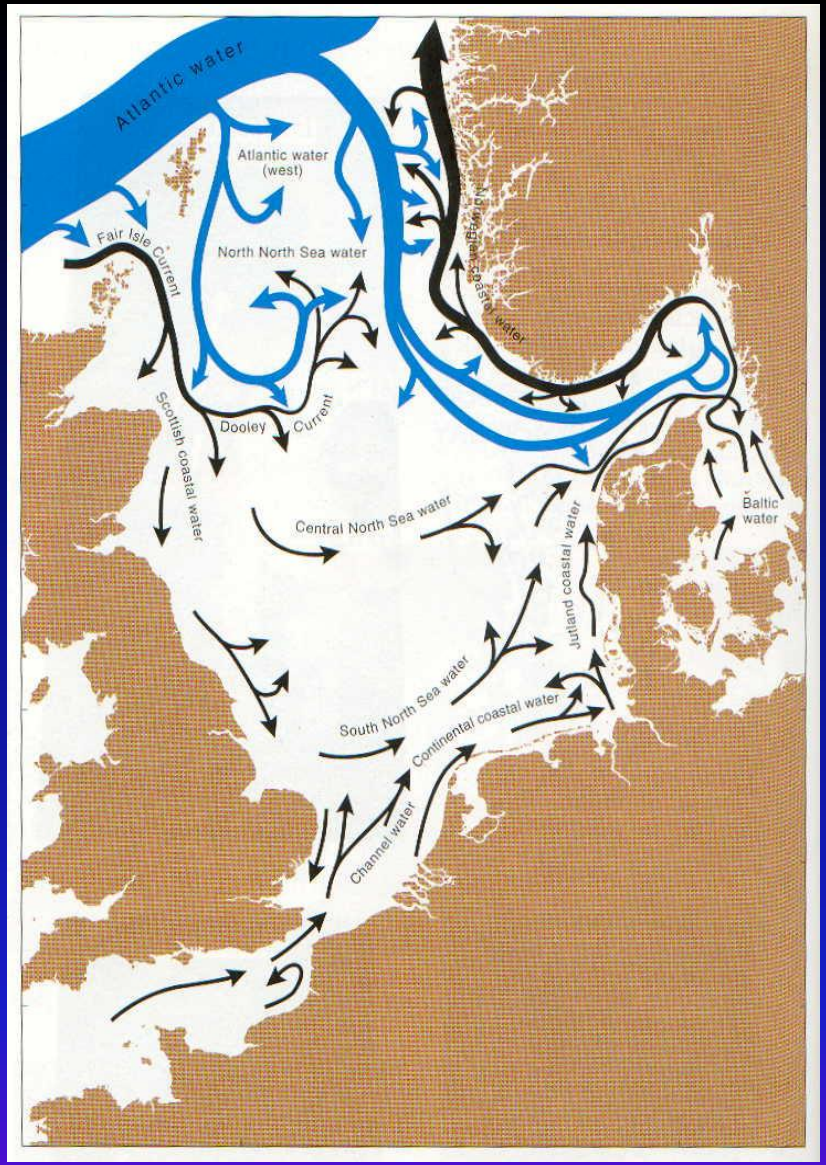

The North Sea

The North Sea is a semi-enclosed, highly productive (>300 g C m^{-2} yr^{-1}), relatively shallow, temperate sea.

A variety of human activities affect the marine ecosystem:

- nutrient enrichment,
- coastal developments,
- the fisheries.

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Fish as food

- World catch
  - Around 85-90 million tonnes per year
- Importance as protein
  - Globally accounts for around 15% of the protein in the diet (7-8% in industrial countries)
  - Other major health benefits
    - PUFA, Omega-3
- Global population
  - Growing at around 1.8% per annum
- North Sea
  - accounts for around 5% of global catch

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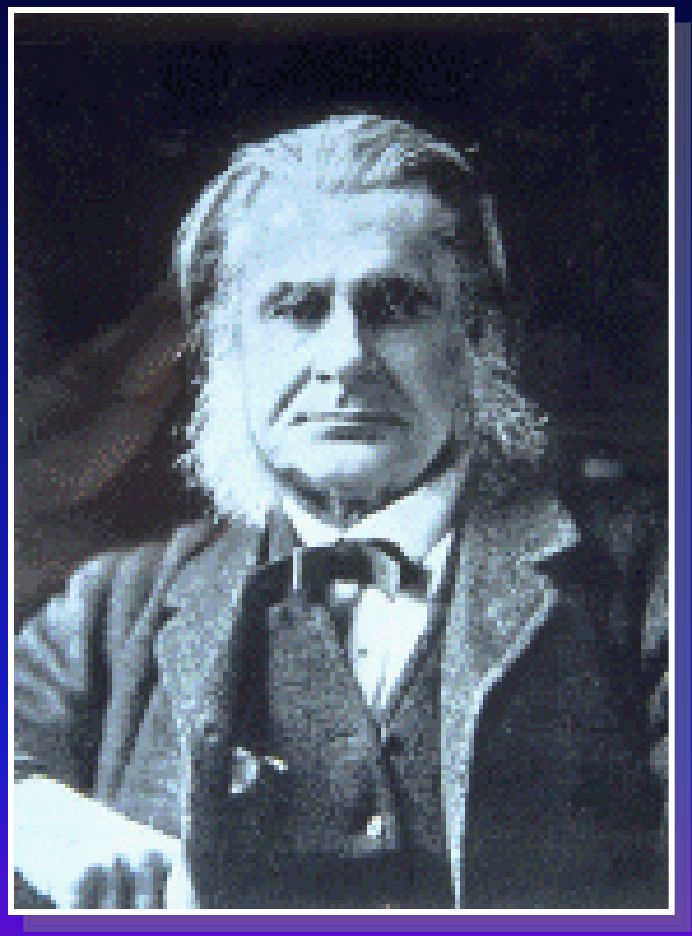
Infamous quotes

"The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible".



Thomas Henry Huxley, (1825-1895)
President of the Royal Society, 1884.

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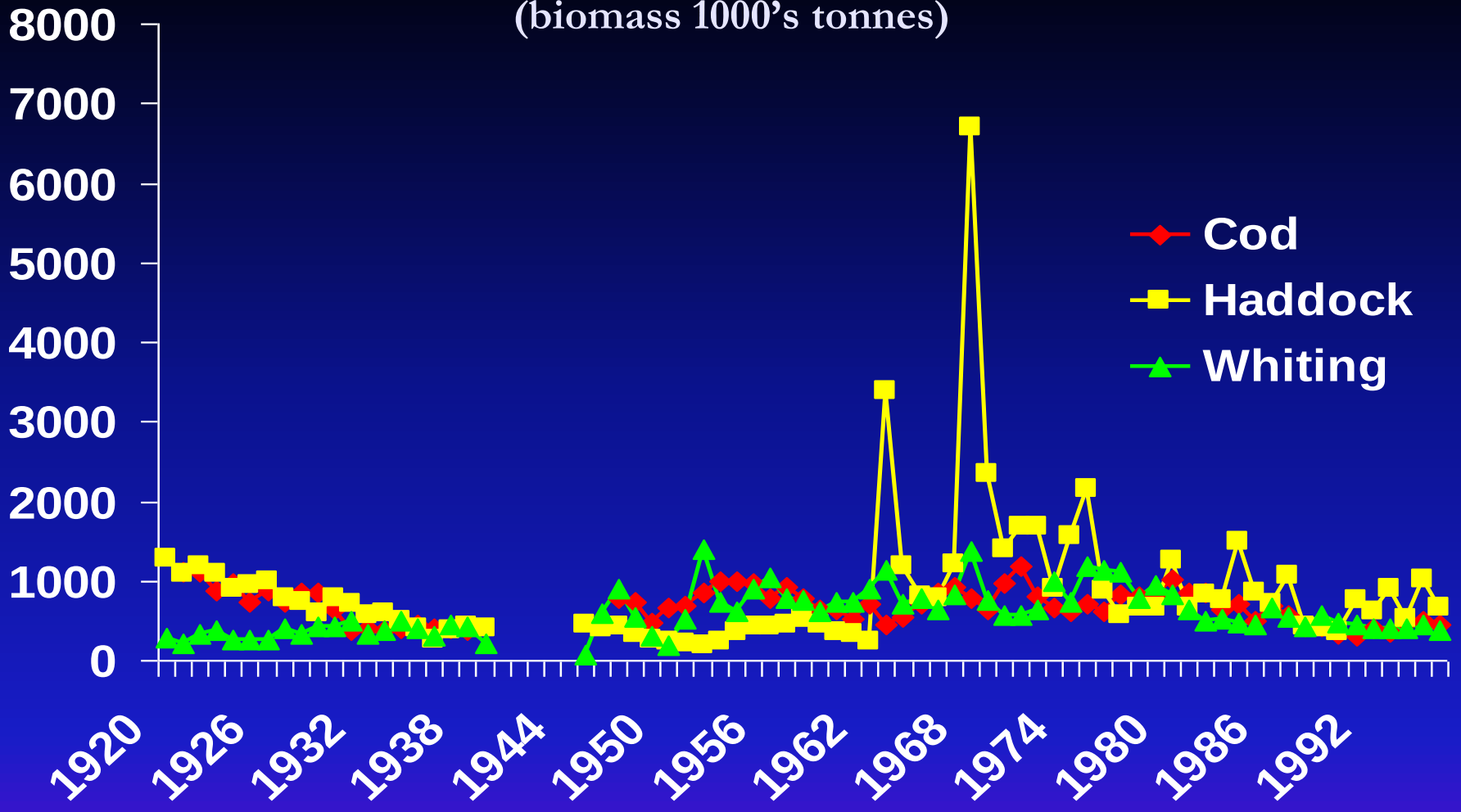
North Sea Gadoid population sizes in the 20th Century

(biomass 1000's tonnes)



- Gadoid outburst in 1960's main change in terms of numbers.
- Continual shift towards smaller size.

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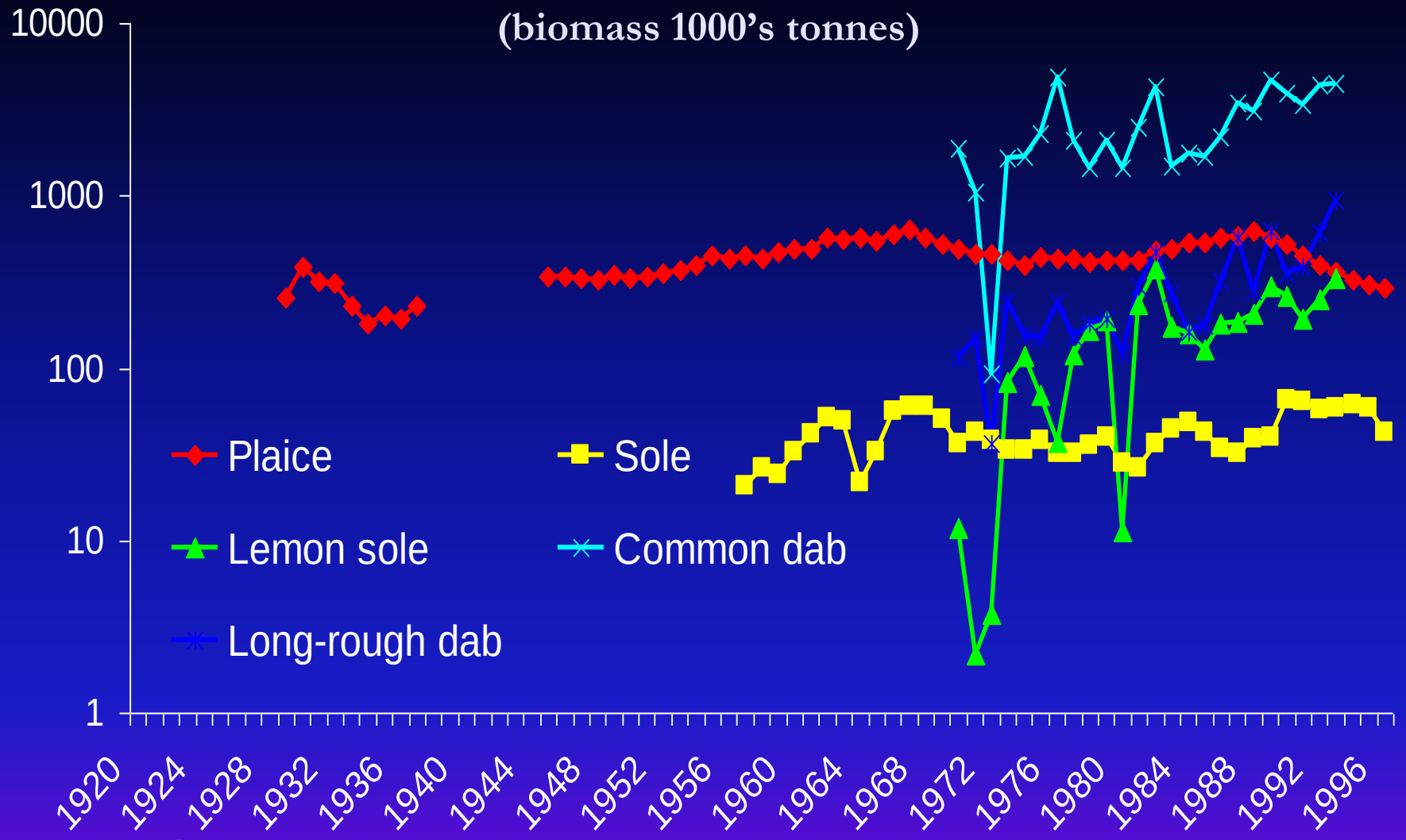
North Sea flat-fish population sizes in the 20th Century

(biomass 1000's tonnes)



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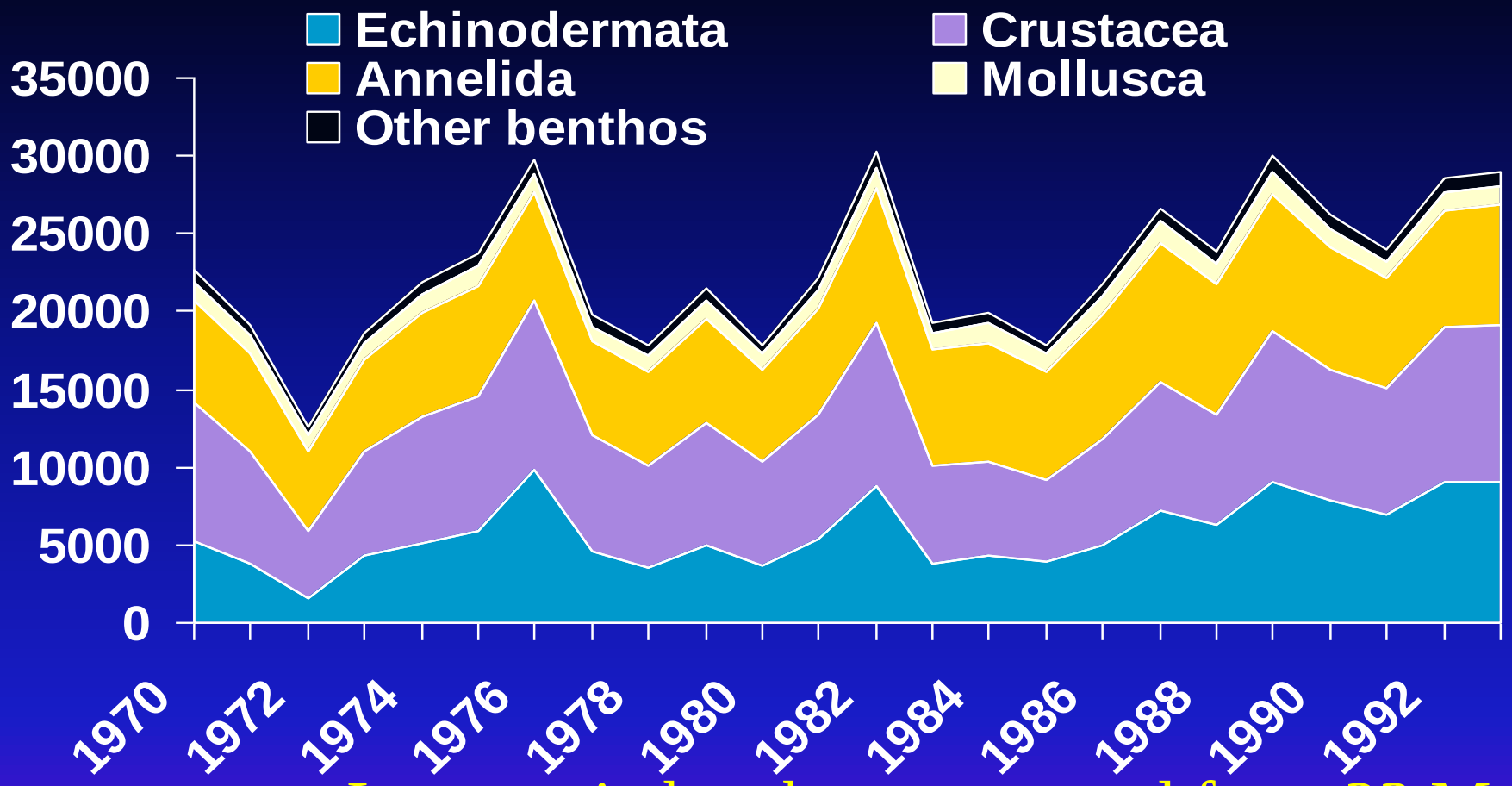
Sole and plaice populations fairly stable

Common dab, LR dab and lemon sole increase

Benthos (10^3 tonnes) consumed by 8 demersal fish species



Increase in benthos consumed from 23 Mt in 1970 to 29Mt in 1993

Due to altered stock sizes and size spectrum

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Variation

- Fishing pressure varies
- Fish stocks (predation) varies
- Climate varies
- Productivity varies

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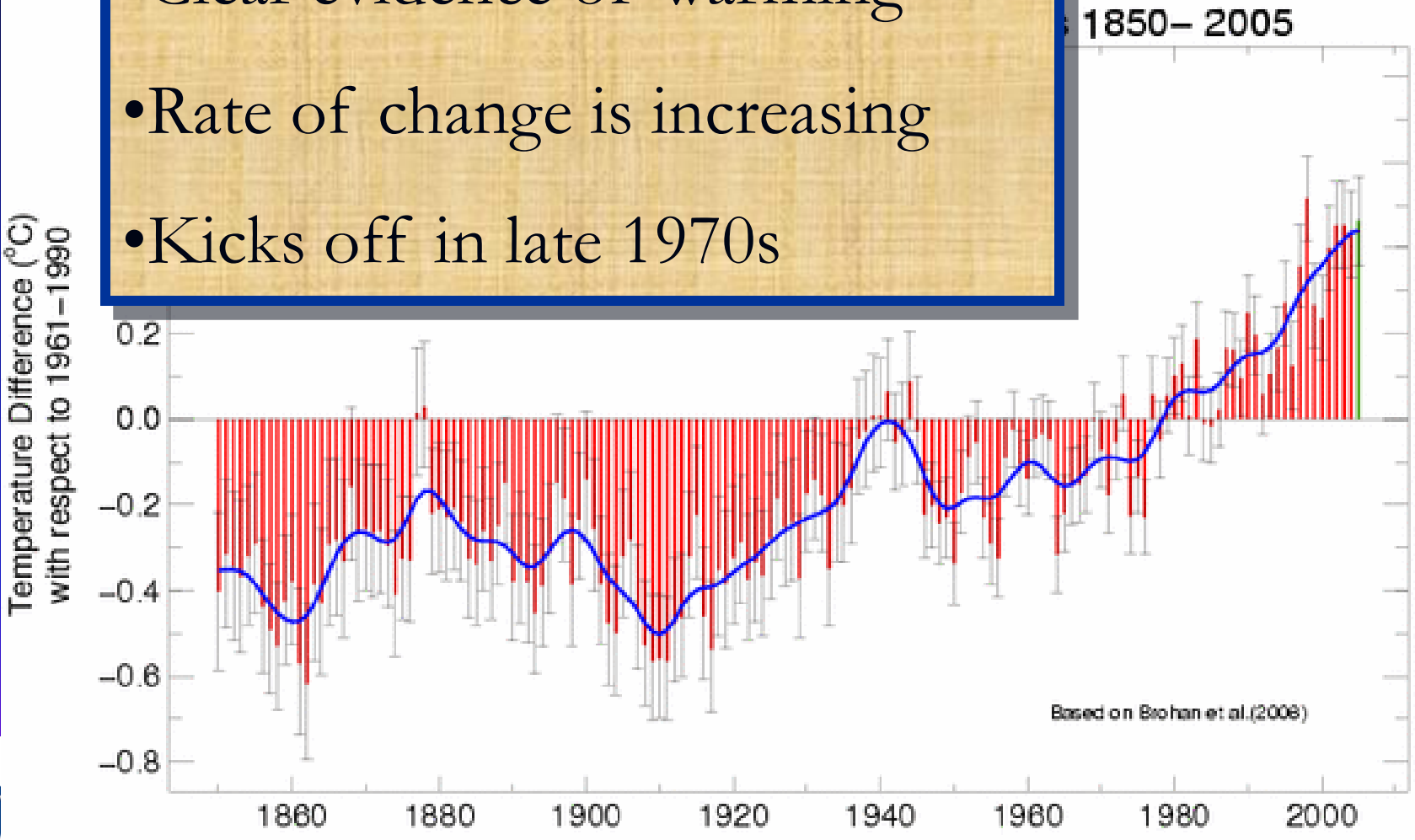
Global Climate Change

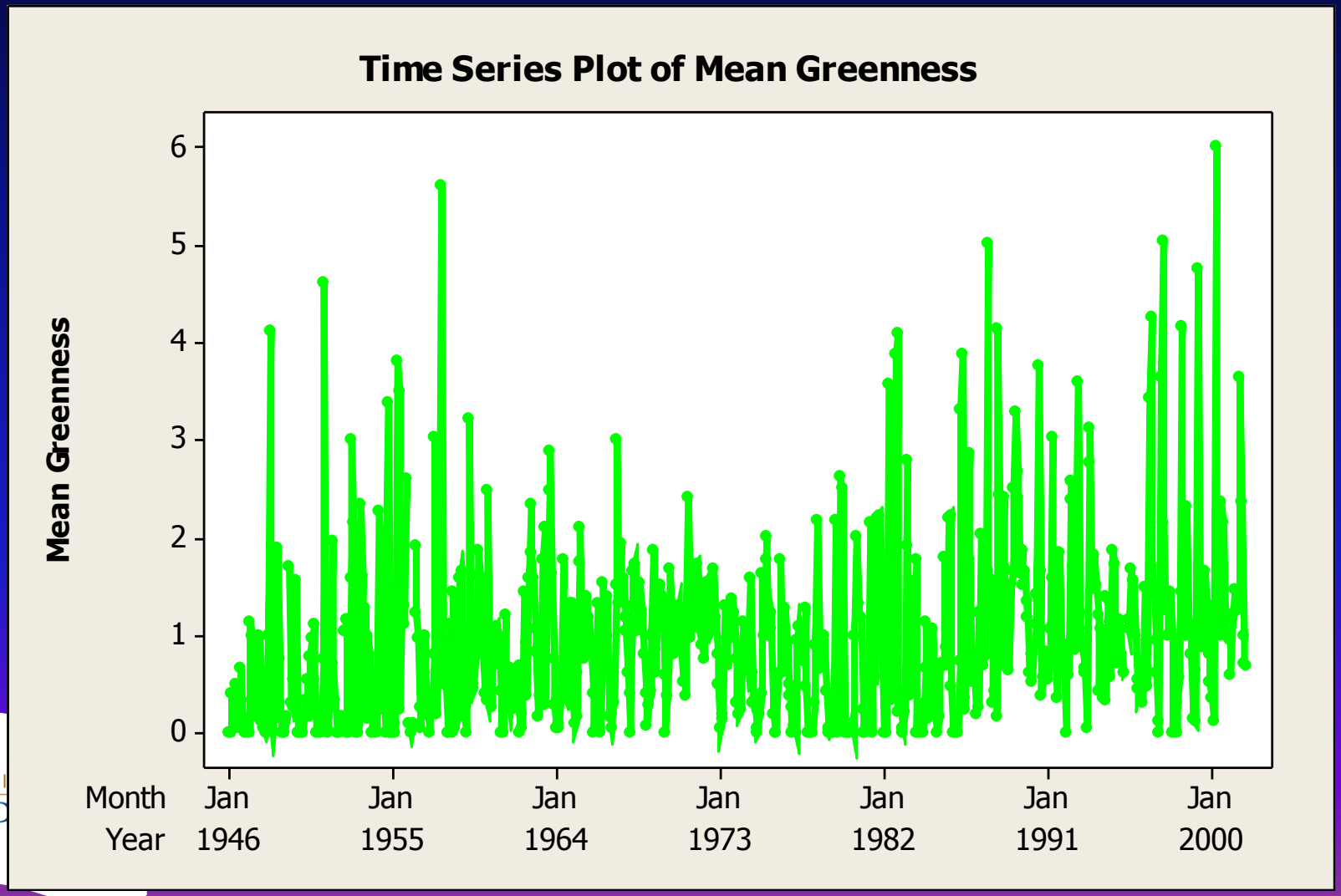
- Clear evidence of warming
- Rate of change is increasing
- Kicks off in late 1970s



Met Office

Hadley Centre for Climate Prediction and Research and CRU, University of East Anglia

CPR silk greenness – index of phytoplankton



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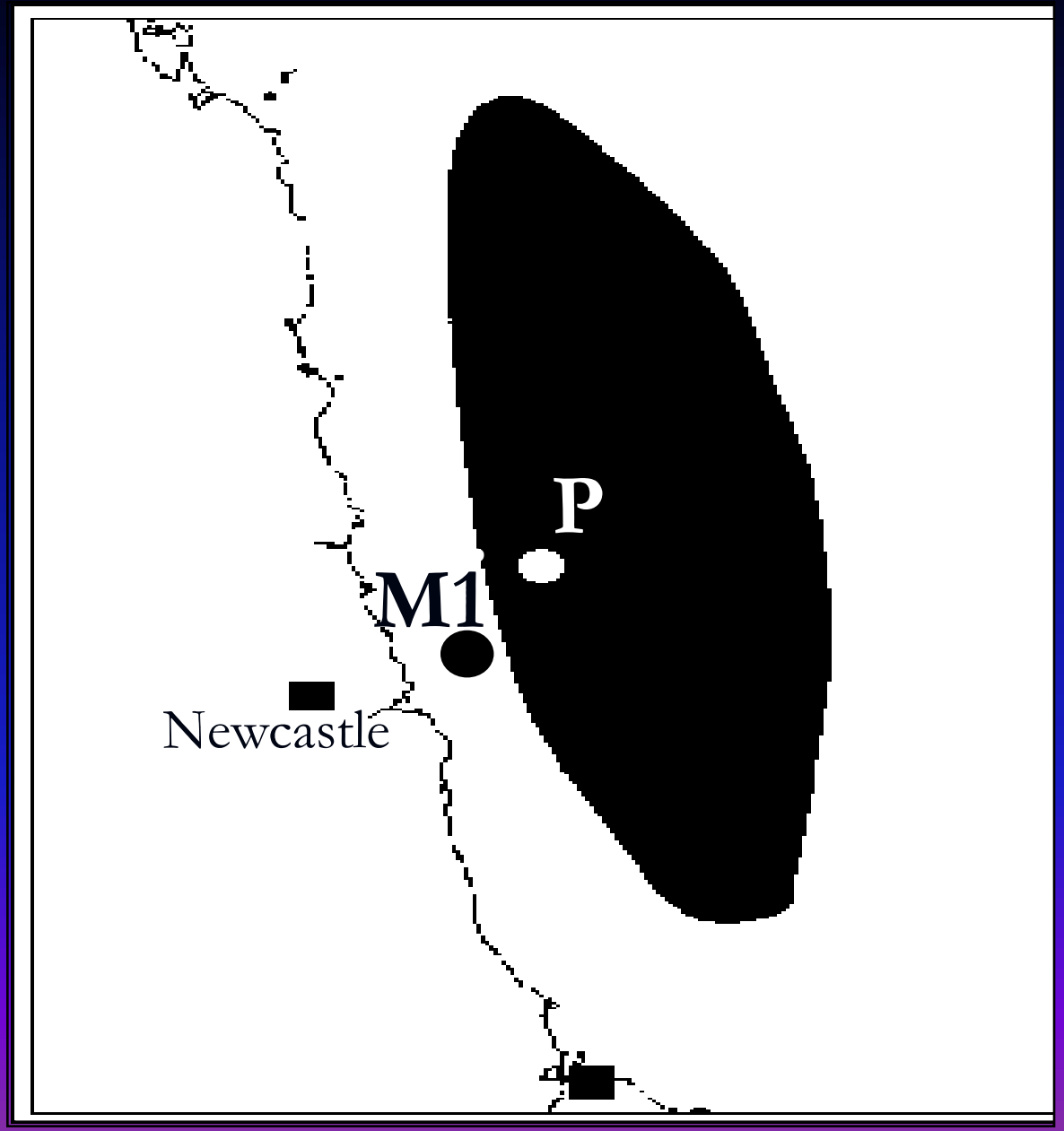
The Dove Time Series:

- **Macro-benthos – two stations M1 and P**



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Benthos

- Buchanan initiated in 1971-72
- Two stations remain from an extensive grid
- 6 and 12 miles offshore
- 50 and 70 m deep
- M1 sampled March and September
- P sampled March

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M1- 35 years of "natural" variation

Since September 1972

- Have missed 3 September (1987,1991, 2002) and 1 March (1998) sampling
- 516 taxa recorded
- Genera richness: Sept: mean 105 (70-129)
  Mar: mean 94 (63-124)
- Abundance: Sept: mean 605 (224-1310) (per grab) Mar: mean 380 (104-720)

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Some biology

Worms dominate,
with brittlestars,
burrowing urchins and
clams (bivalve molluscs)

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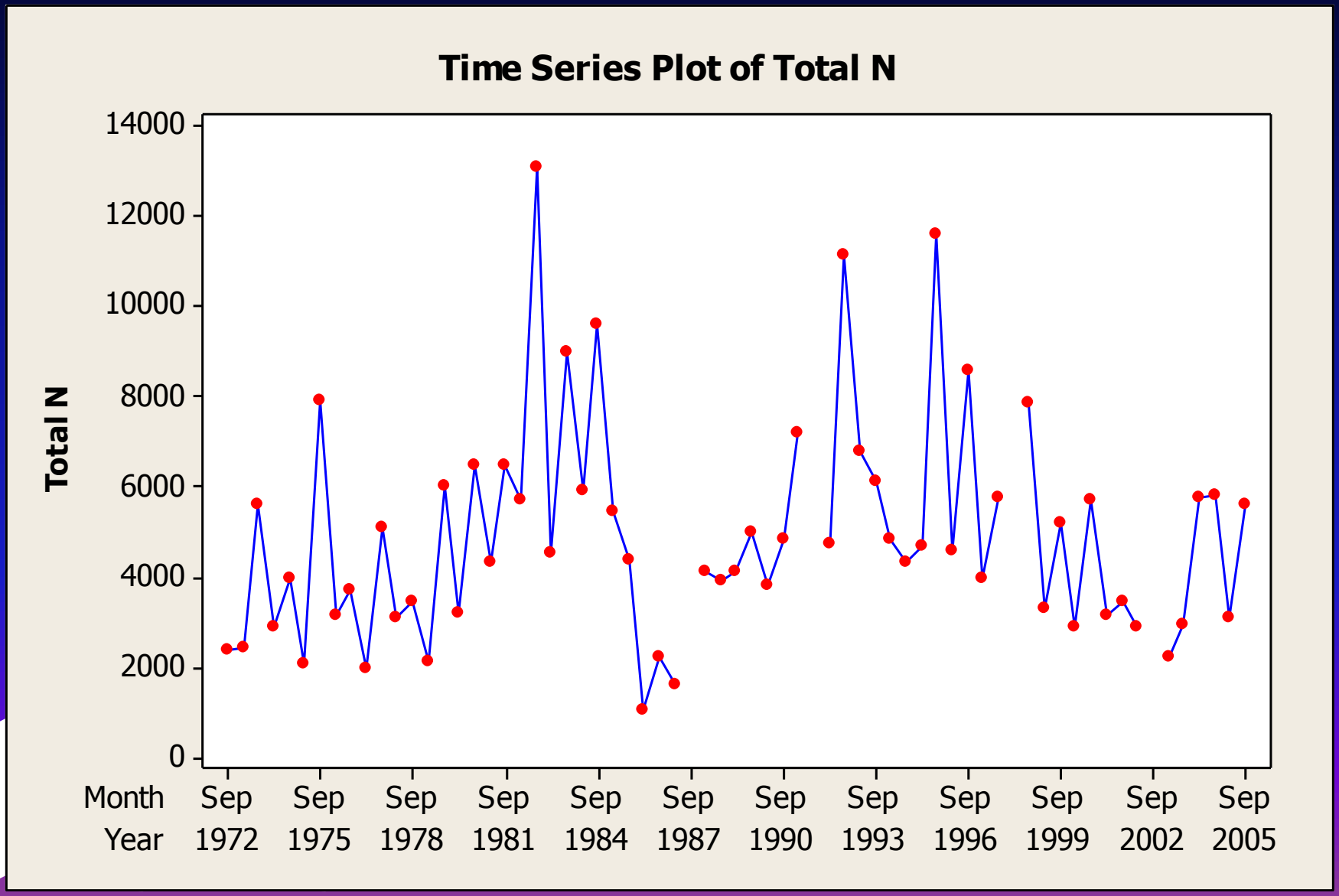
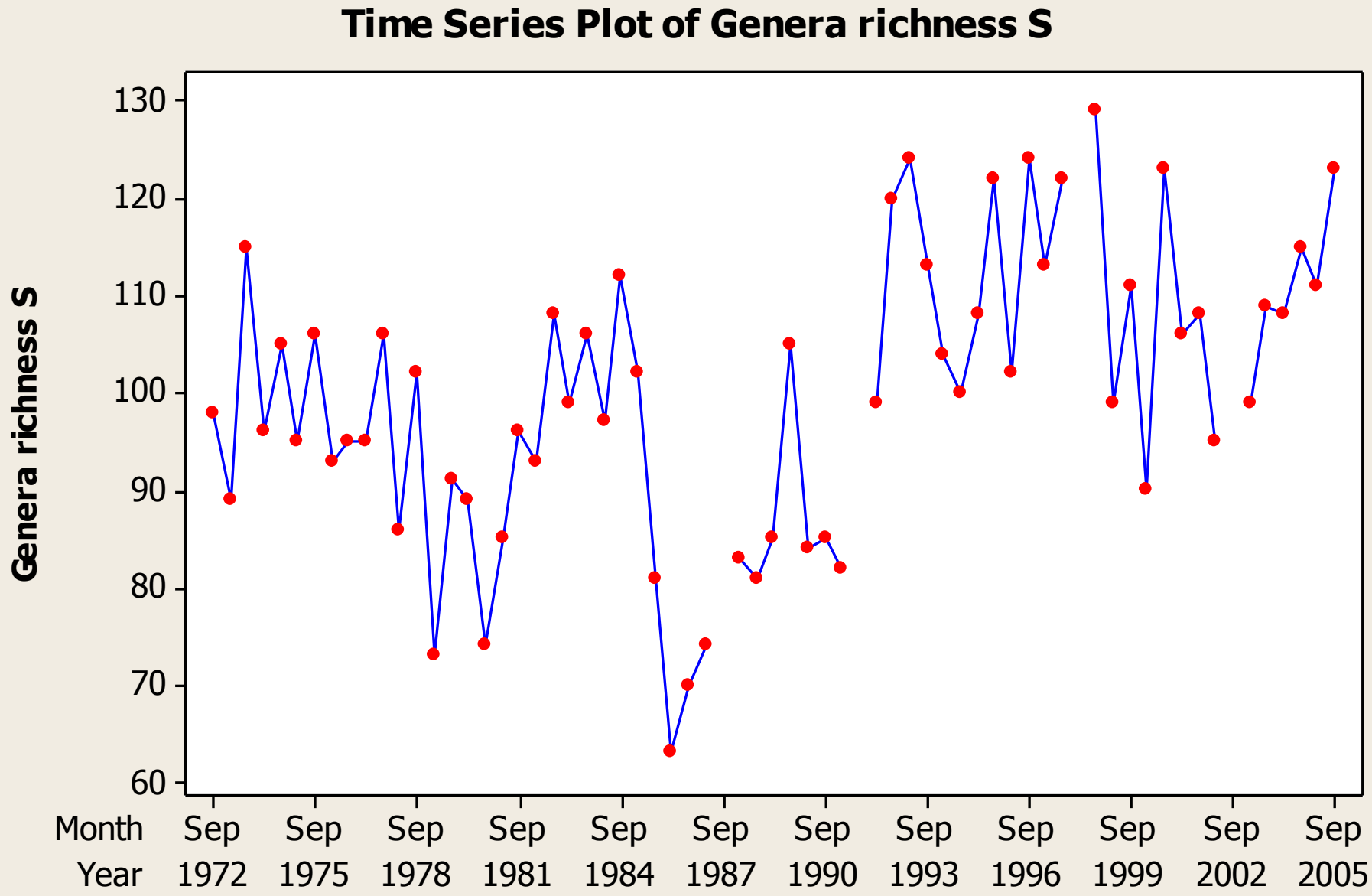
M1 After 35 years: Top genera

		Mean indiv. m^2	
1	*Prionospio*	495.11	10.09%
2	*Levinsenia gracilis*	257.79	5.26%
3	*Chaetozone setosa*	198.19	4.04%
4	*Amphiura*	193.54	3.95%
5	*Thyasira*	191.03	3.89%
6	*Abra*	186.98	3.81%
7	*Mysella bidentata*	158.62	3.23%
8	*Phoronis muelleri*	153.67	3.13%
9	*Pholoe*	150.86	3.08%
10	*Nuculoma tenuis*	140.81	2.87%
	TOTAL	4906.64	43.35%

M1 Total Abundance – altered variability and mean?



M1 Genera Richness – A shifted baseline



Changes in time: M1

- No significant change in total abundance over time nor between decades
- Indication of altered variability and multi-annual shifts

- Significant change (ANOVA $p<0.001$) in genera richness, significantly higher in the 1990s and 2000s.

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P- 36 years of variation

Since 1971

- Have missed sampling once (1998)
- 262 taxa recorded from 183 genera (or higher)
- Genera richness: mean 53 (35-76)
- Abundance: mean 454 (165-1023) (per grab)

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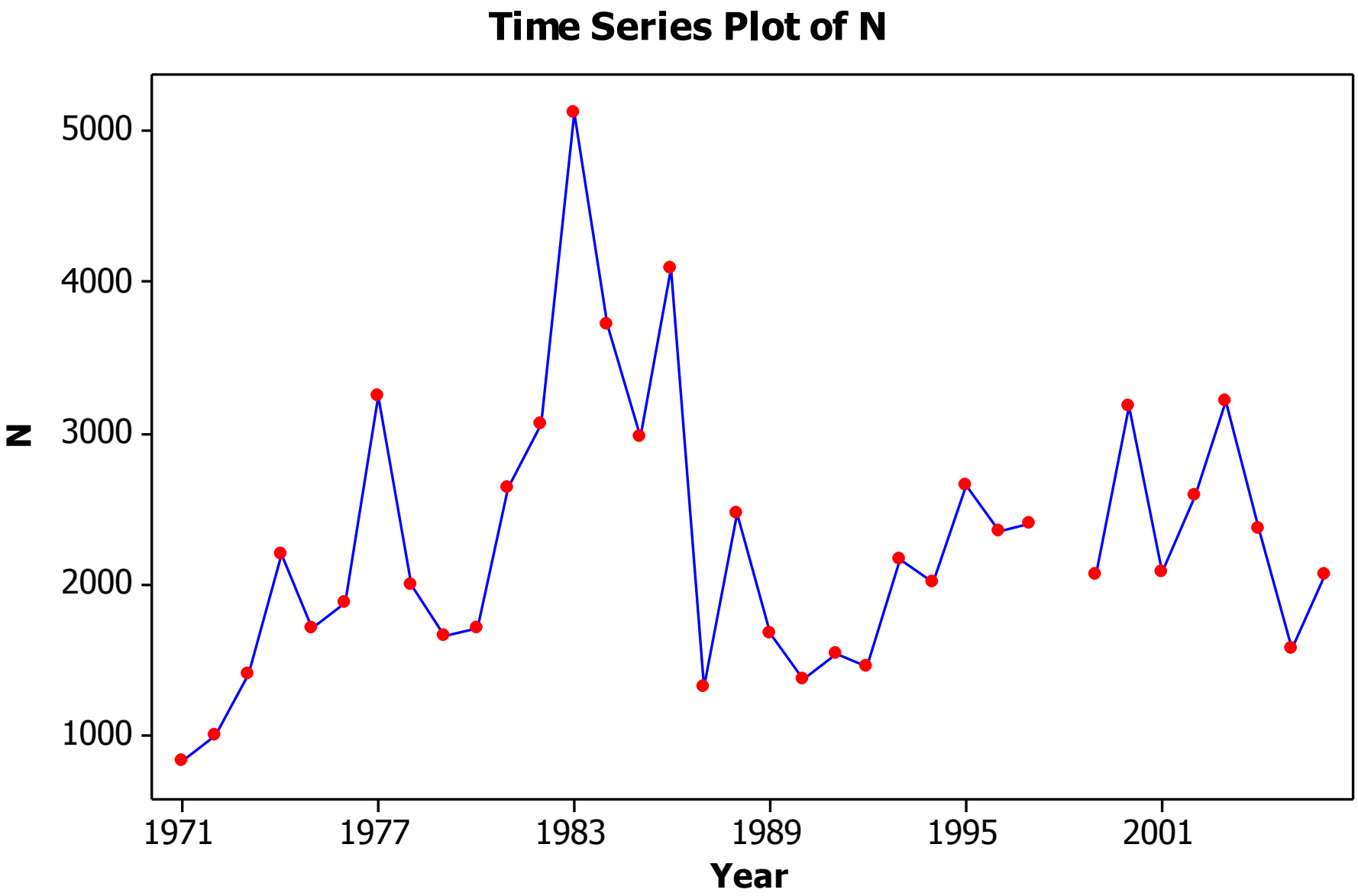
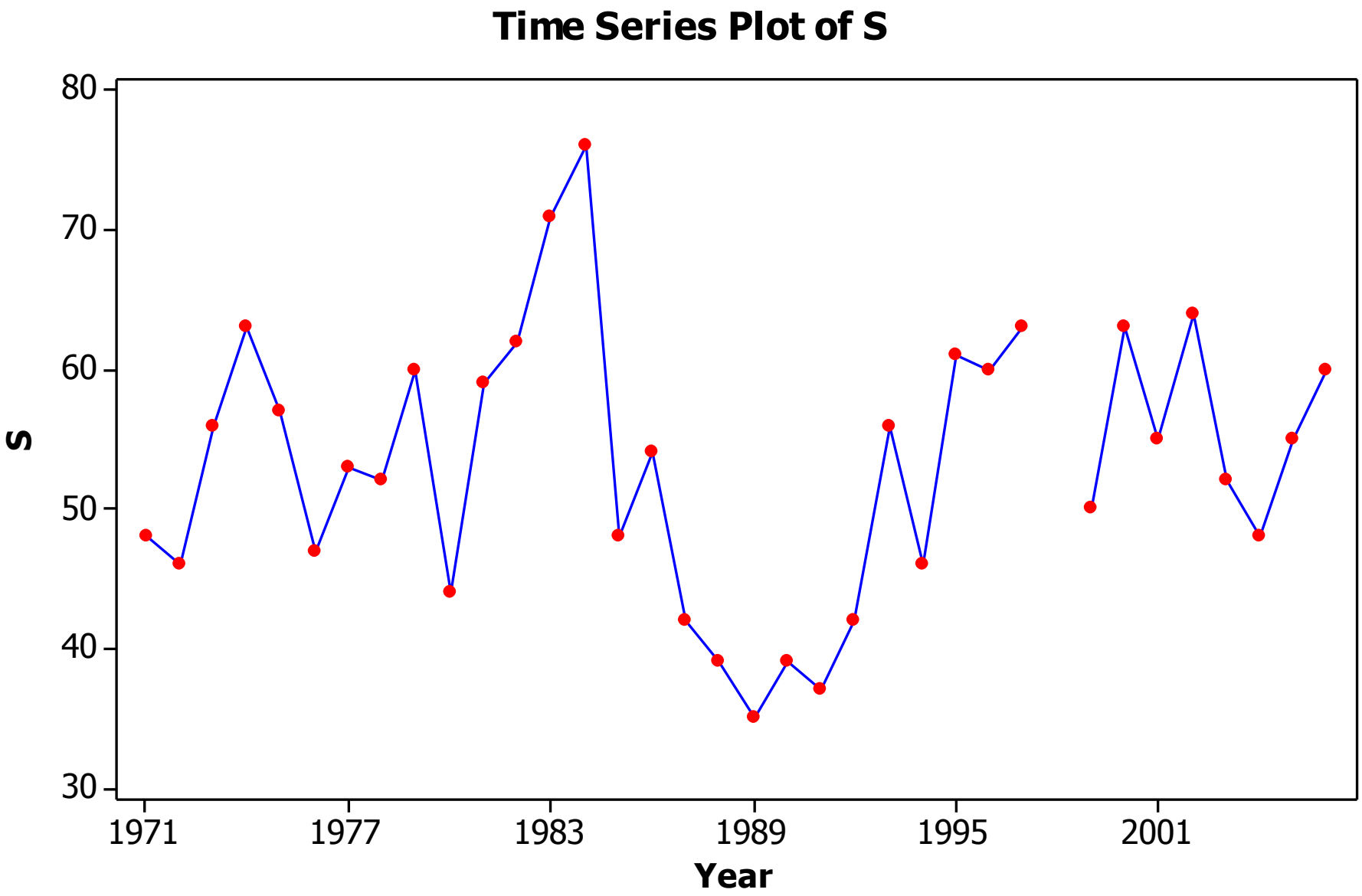
The Top Ten

	Taxon	Mean Abundance (ind. m^{-2})	SD	% contribution	cumulative % contribution
1	*Heteromastus*	659.44	360.87	29.01	29.01
2	*Levinsenia*	208.09	190.38	9.15	38.16
3	*Prinospio*	151.11	136.02	6.65	44.81
4	*Chaetozone*	101.60	89.67	4.47	49.28
5	*Paramphinome*	97.77	243.66	4.30	53.58
6	*Ophelina*	90.21	69.99	3.97	57.55
7	Nemertea spp.	73.99	51.24	3.25	60.80
8	*Harpinia*	73.40	52.79	3.23	64.03
9	*Abra*	70.24	56.15	3.09	67.12
10	*Amphiura*	61.46	97.22	2.70	69.83

P Total abundance (ind. m^2)



P Genera Richness



Changes in time: P

- Abundance was high in the early 1980s
- Both abundance and richness show a decline in the late 1980s-early 1990s (?regime shift)
- Both abundance and richness in the 00s were similar to the 70s

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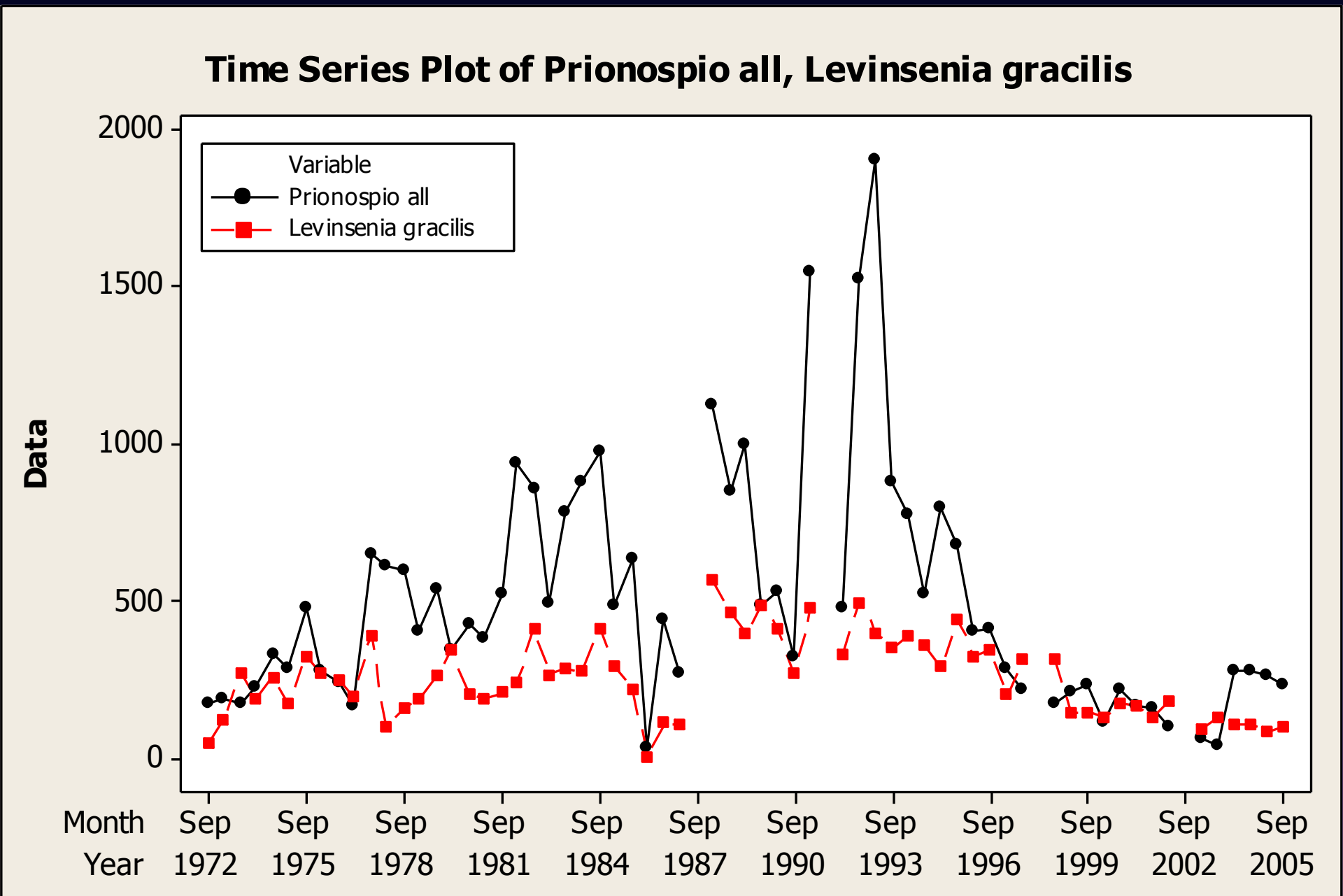
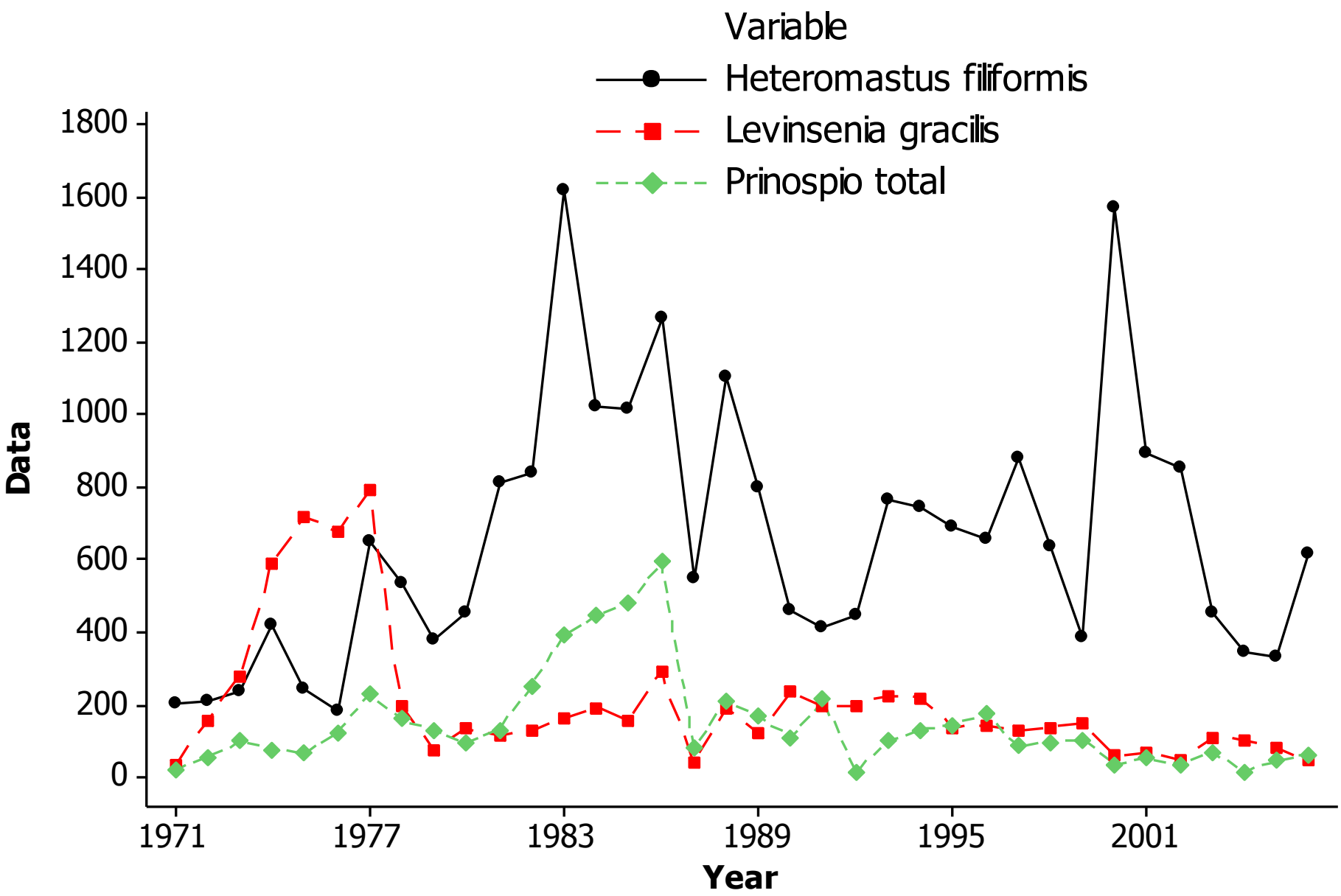
Biological detail

Top 2 taxa at M1



The top three at P



The North Sea Phase Shift

- A widely described change in the planktonic components occurred around 1987-8
- Was there a phase shift in the benthos?
- Journey into Phase Space..

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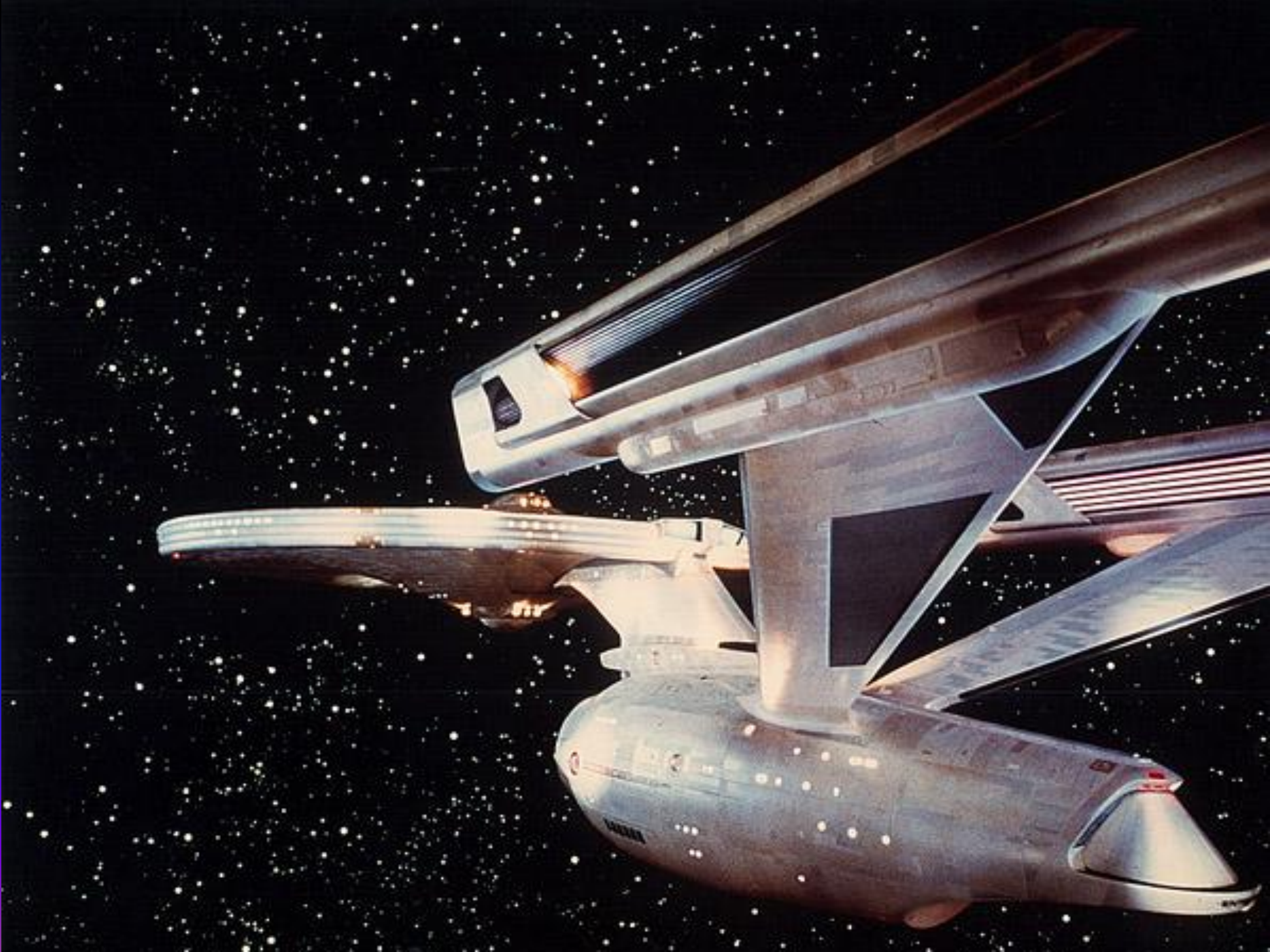
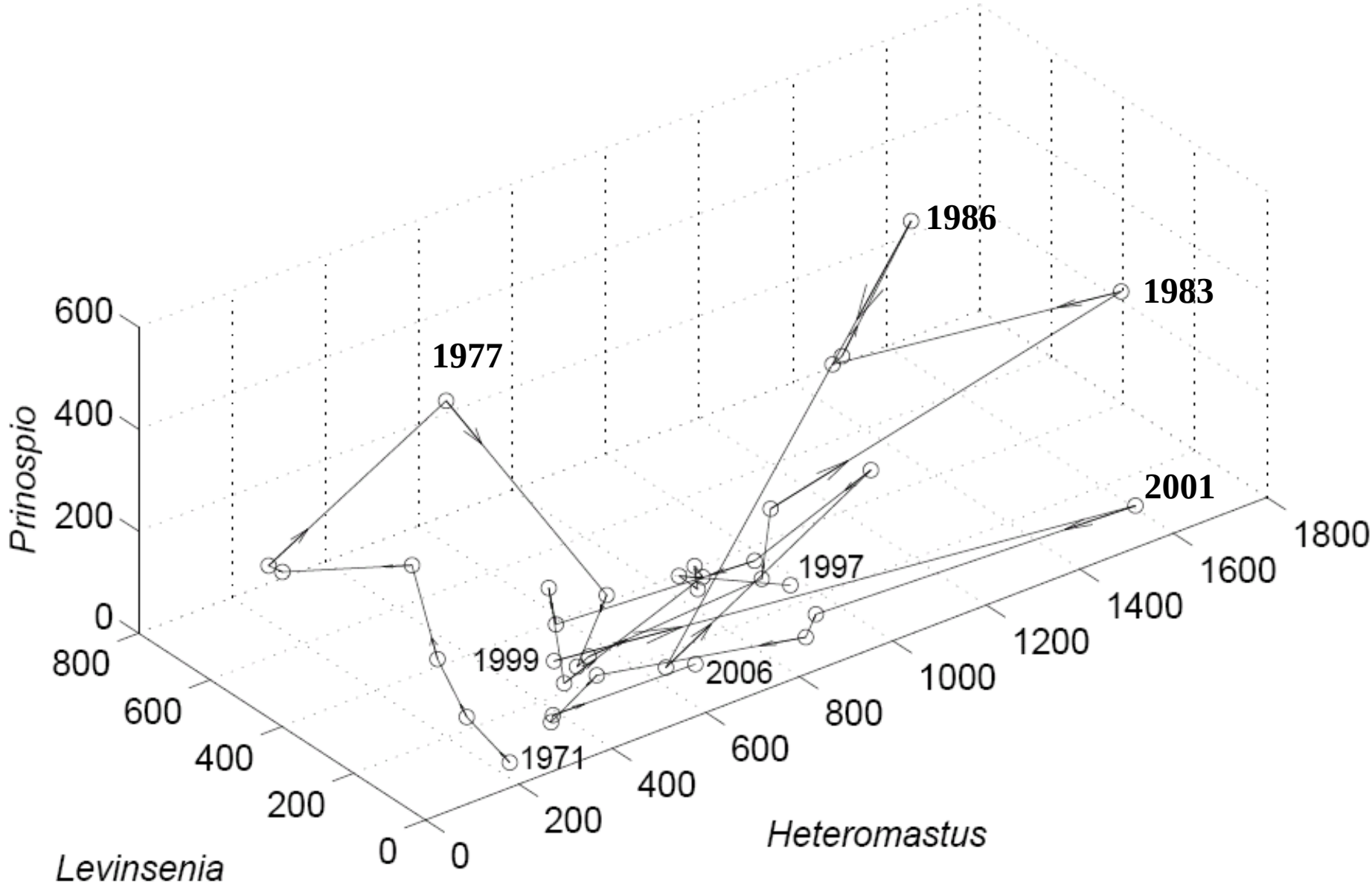


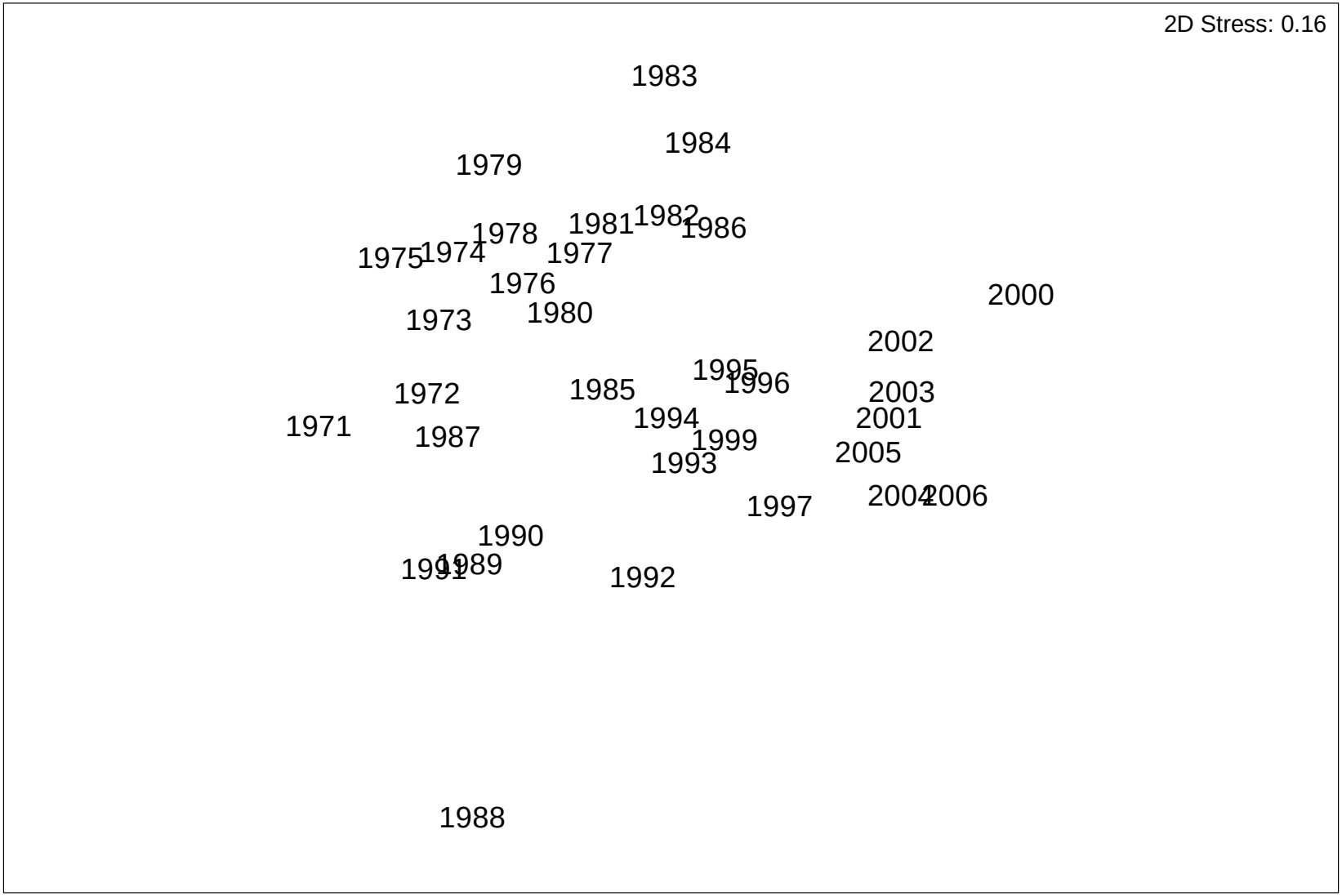
Looking in *Phase Space*



MDS ordination for P

Stn P 1971-2006

Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity



Shifts in community structure at P

- The clearest pattern is the trend from 1970s to 2000s from left to right
- The 1980s are the most dispersed decade with 1988 an outlier
- The biological assemblage has changed over time and is now distinct from that at the start of the series

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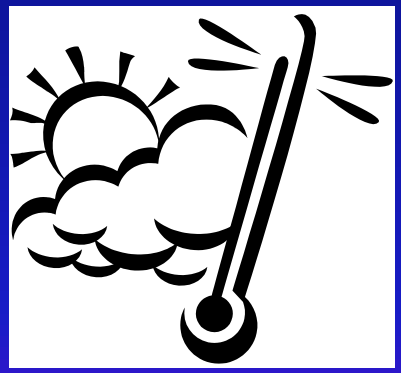
Drivers of Change

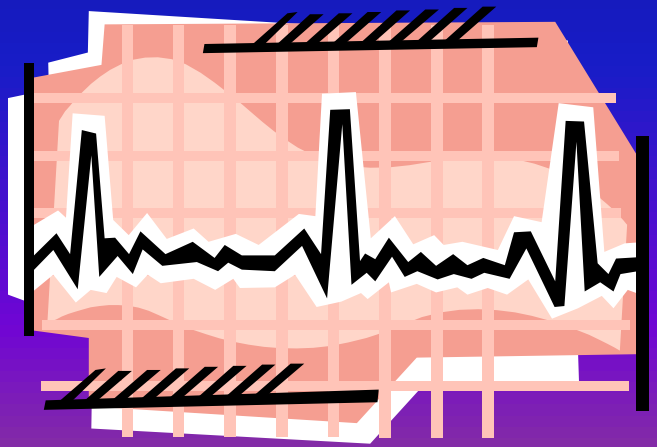
- Food

- Fishing

- Climate change



- Climate variation



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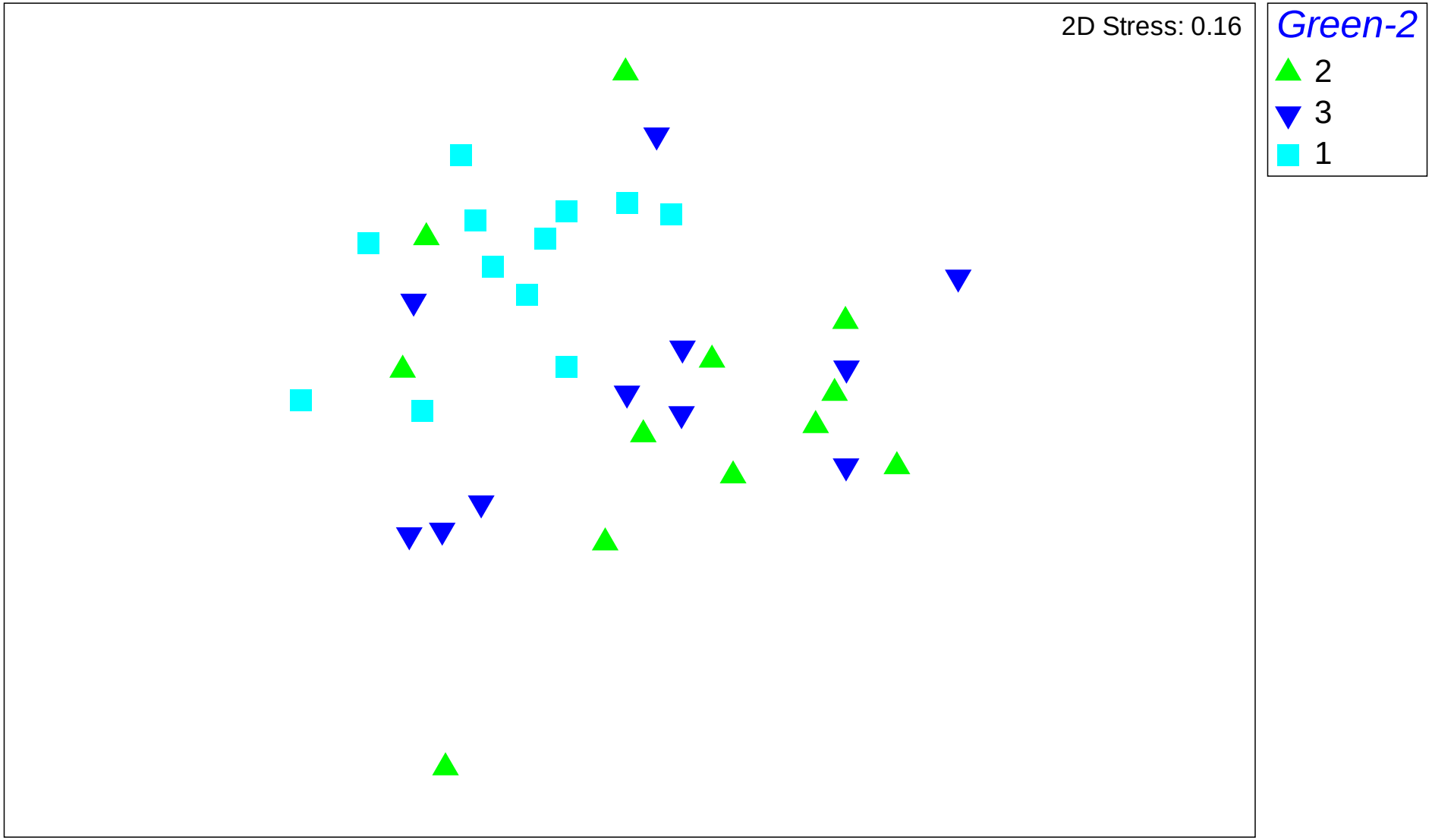
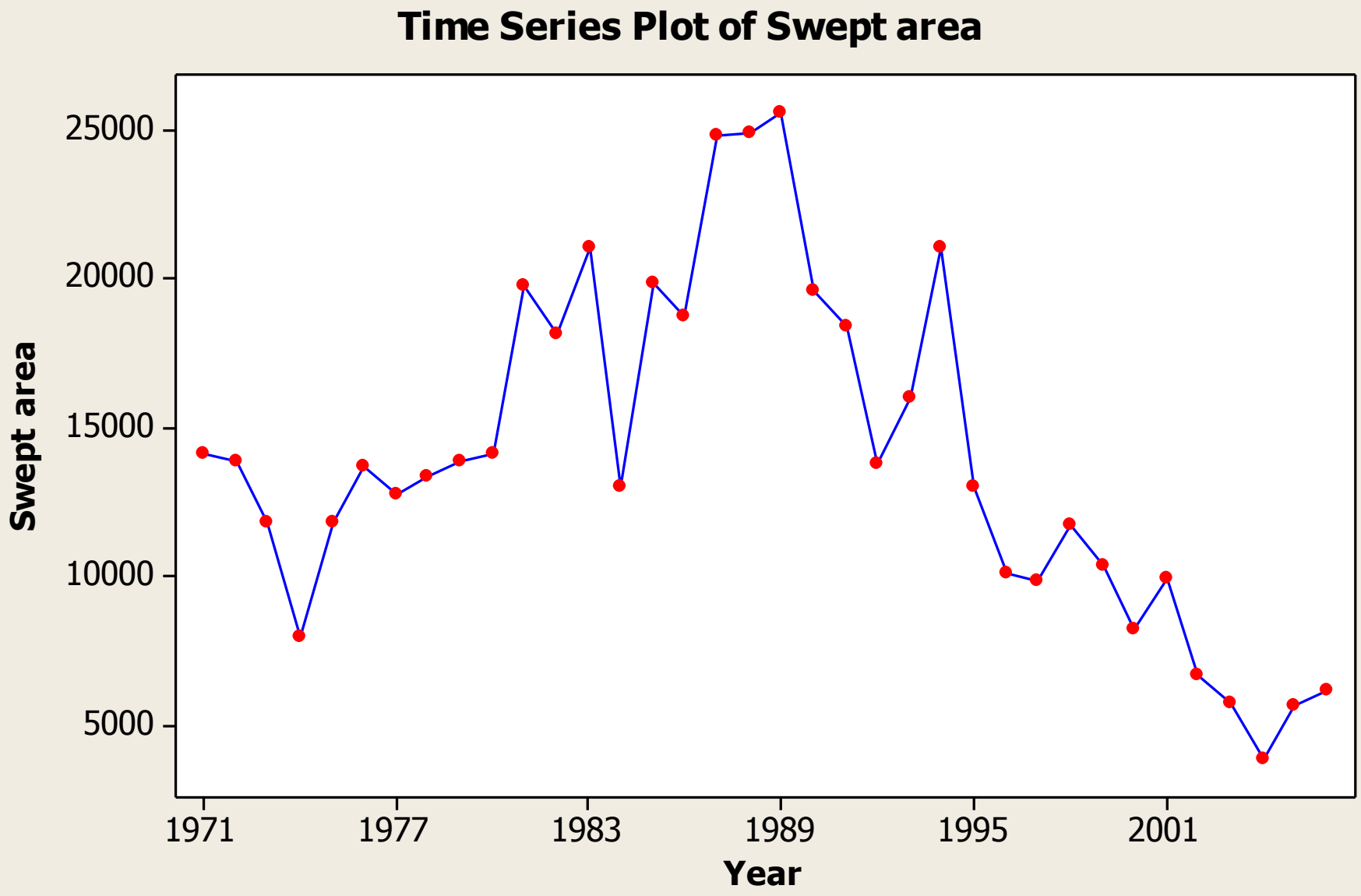
Food as a driver?

Stn P 1971-2006

Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity



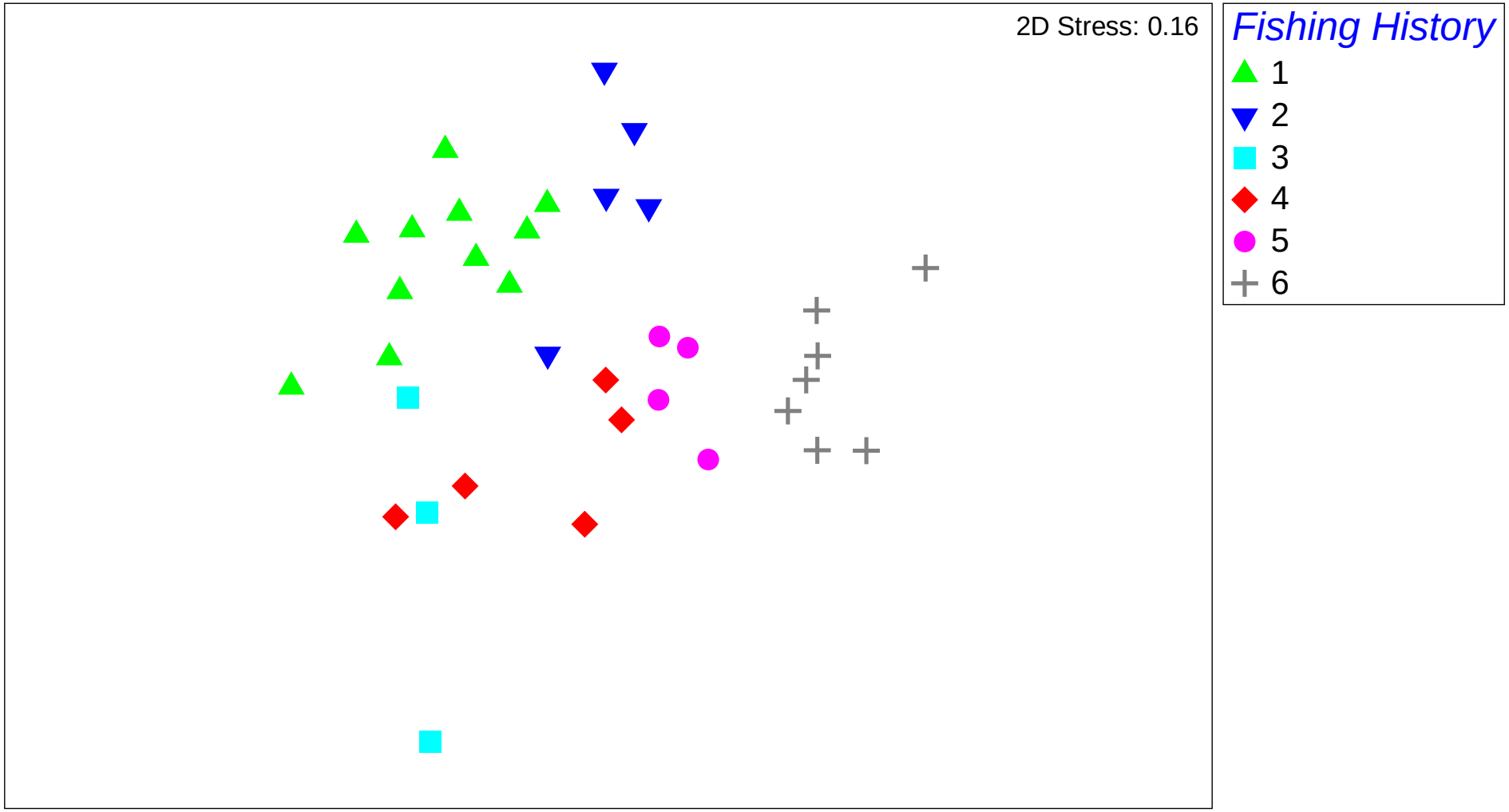
Fishing History - ICES 39E8 (Stn P)



Fishing Pressure

Stn P 1971-2006

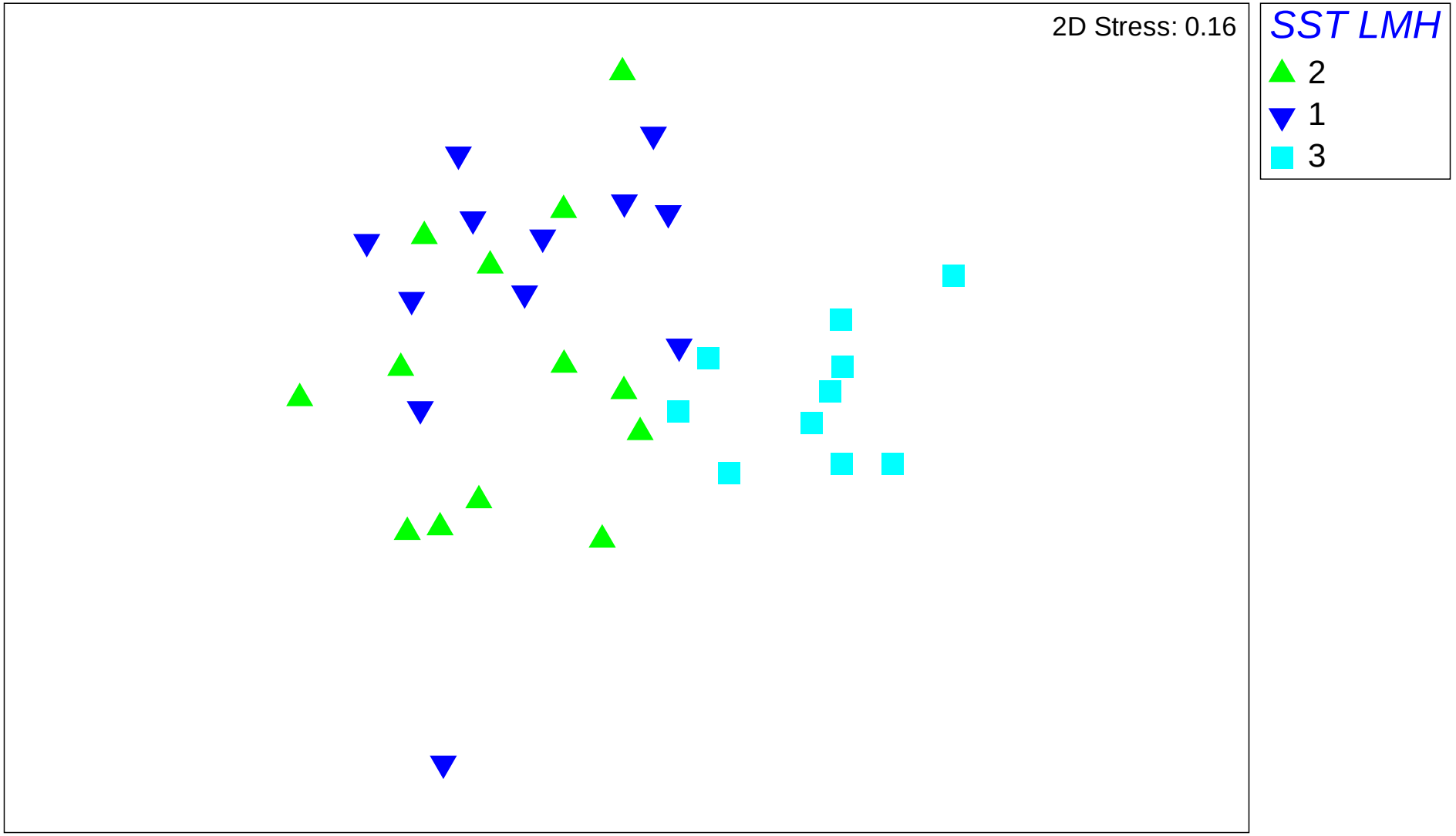
Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity



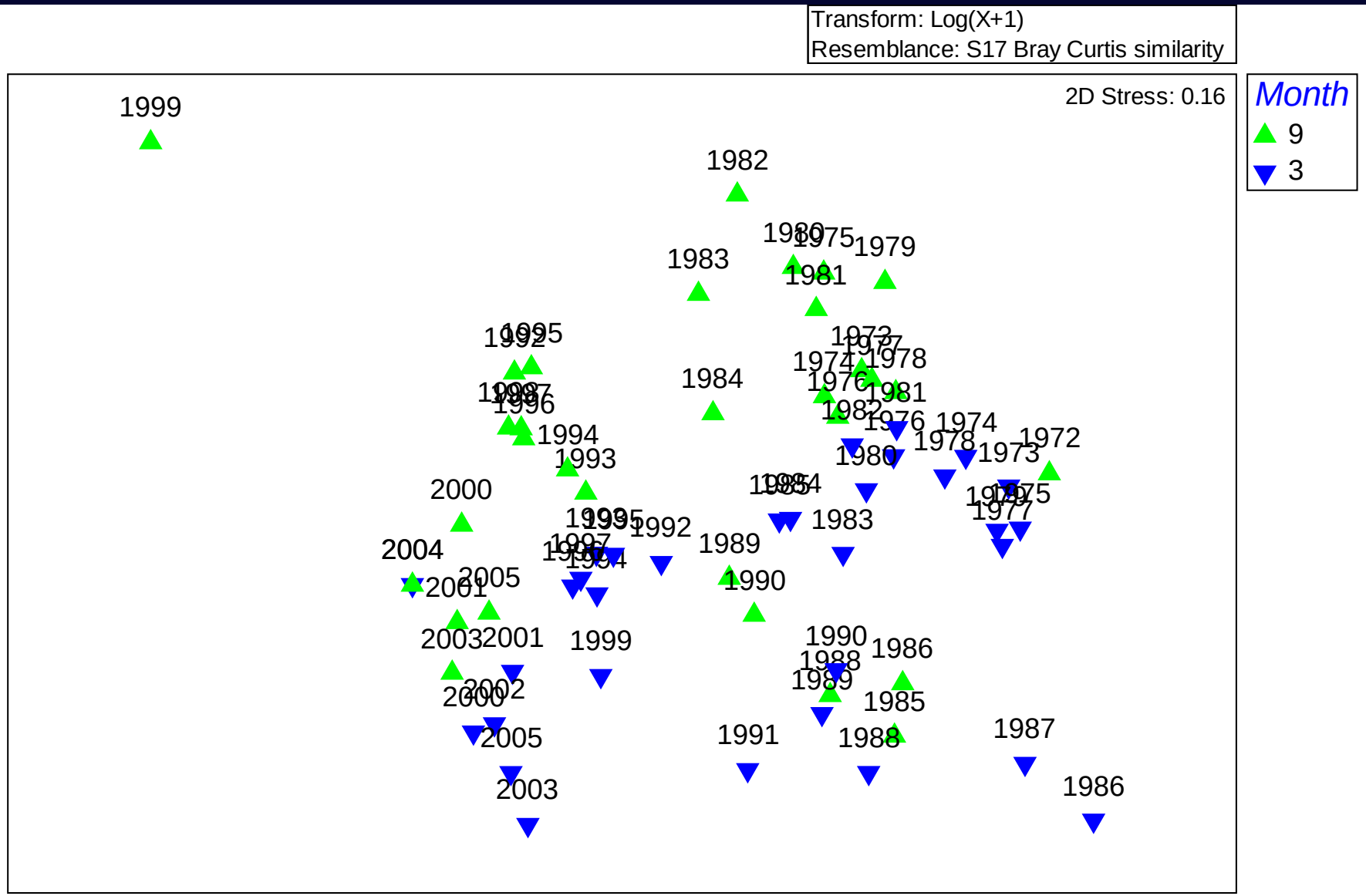
Climate change - SST

Stn P 1971-2006

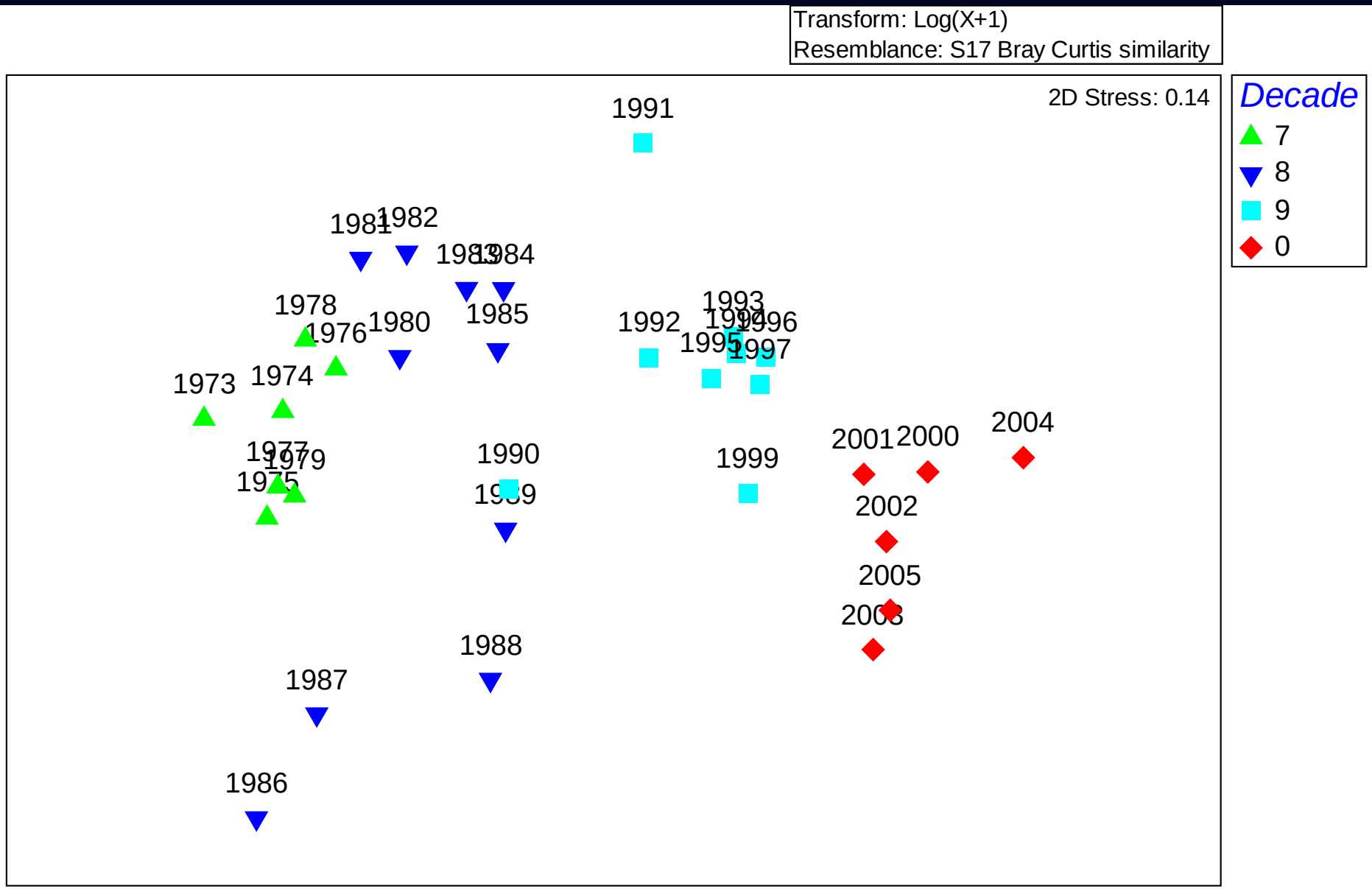
Transform: Log(X+1)
Resemblance: S17 Bray Curtis similarity



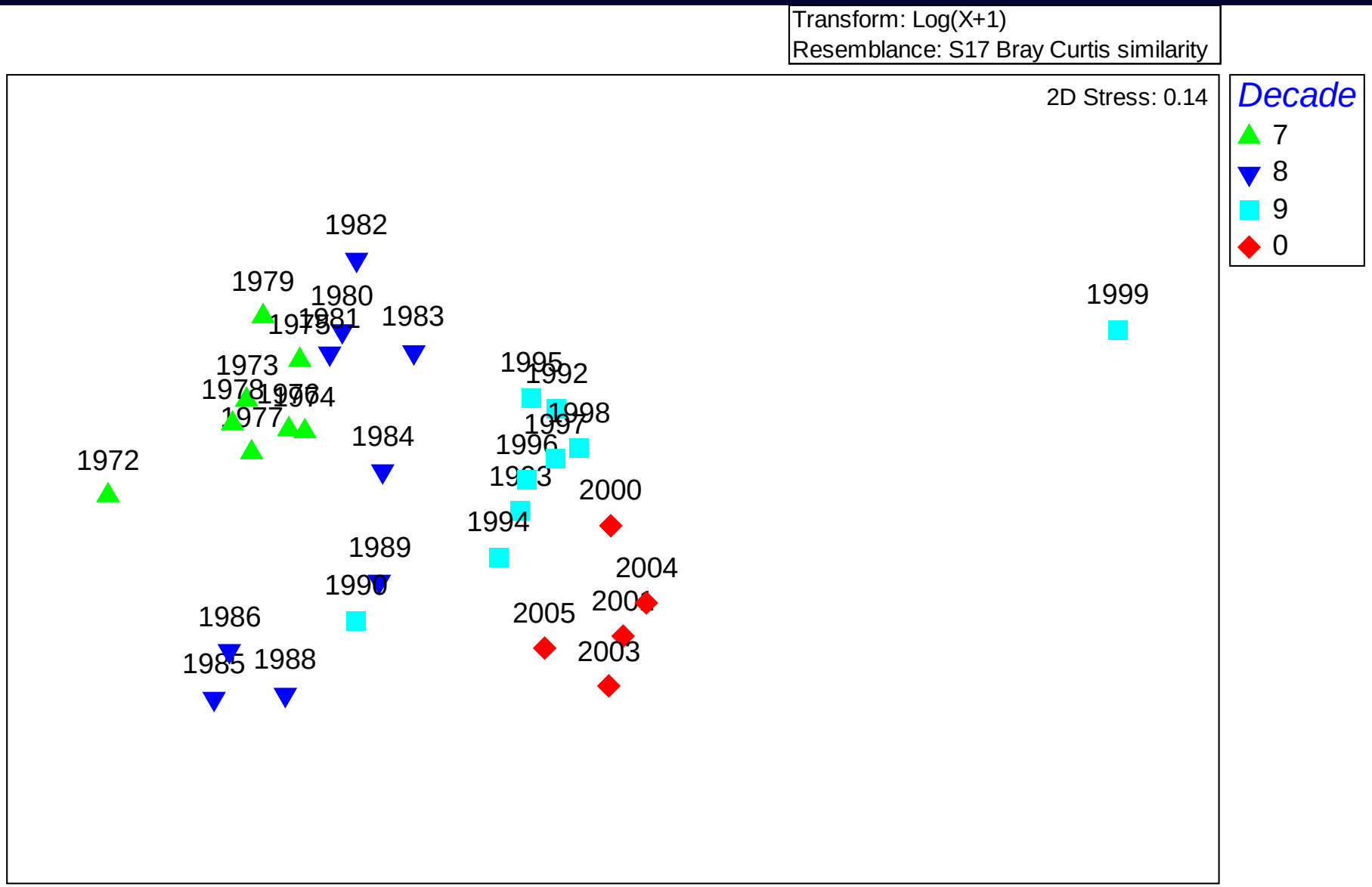
MDS ordination for M1



March – Decadal progression



September – Decadal progression



35 years of study shows..

- Decadal scale variation in total abundance, species richness and community composition at both stations
- No trend in abundance i.e. due to warming or eutrophication at either station
- 'Trend' in community composition and hence deliver of ecological functions at both stations
- Indication of importance of fishing (P), climatic drivers and/or food supply in setting limits on abundance and richness

And where next?

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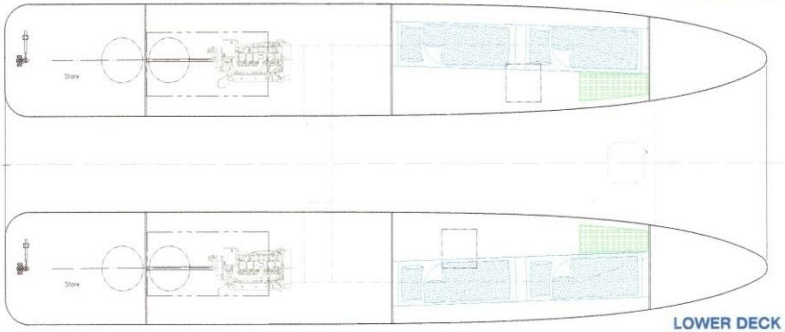
PROTECTOR CATAMARANS

13m Catamaran
for Liverpool University

PROFILE

MAIN DECK PLAN



LOWER DECK PLAN

13m CATAMARAN
GENERAL ARRANGEMENT

PARTICULARS

Length Overall	13.0m
Length Waterline	11.8m
Beam Overall	5.2m
Beam Mid	1.75m
Draught, aprox.	1.0m

PRELIMINARY

CAMARC DESIGN

CAMARC Ltd

Acknowledgements

- For initiating the series Jack Buchanan and for collecting the data: various PhD students and Peter Garwood, masters and crew of the *RV Bernicia*
- For funding it at various times: DEFRA (DoEnv, DETR), NERC, University of Newcastle
- For intellectual input: Robin Clark, Kirsty Nicholas, Odette Paramor.

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